# What's the Facts of Tungsten ?（II）

## 中钨智造科技有限公司

CTIA GROUP LTD

**CTIA GROUP LTD**

Global Leader in Intelligent Manufacturing for Tungsten, Molybdenum, and Rare Earth Industries

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# INTRODUCTION TO CTIA GROUP

CTIA GROUP LTD , a wholly-owned subsidiary with independent legal personality established by CHINATUNGSTEN ONLINE , is dedicated to promoting the intelligent, integrated, and flexible design and manufacturing of tungsten and molybdenum materials in the Industrial Internet era. CHINATUNGSTEN ONLINE, founded in 1997 with www.chinatungsten.com as its starting point—China's first top-tier tungsten products website—is the country's pioneering e-commerce company focusing on the tungsten, molybdenum, and rare earth industries. Leveraging nearly three decades of deep experience in the tungsten and molybdenum fields, CTIA GROUP inherits its parent company's exceptional design and manufacturing capabilities, superior services, and global business reputation, becoming a comprehensive application solution provider in the fields of tungsten chemicals, tungsten metals, cemented carbides, high-density alloys, molybdenum, and molybdenum alloys.

Over the past 30 years, CHINATUNGSTEN ONLINE has established more than 200 multilingual tungsten and molybdenum professional websites covering more than 20 languages, with over one million pages of news, prices, and market analysis related to tungsten, molybdenum, and rare earths. Since 2013, its WeChat official account "CHINATUNGSTEN ONLINE" has published over 40,000 pieces of information, serving nearly 100,000 followers and providing free information daily to hundreds of thousands of industry professionals worldwide. With cumulative visits to its website cluster and official account reaching billions of times, it has become a recognized global and authoritative information hub for the tungsten, molybdenum, and rare earth industries, providing 24/7 multilingual news, product performance, market prices, and market trend services.

Building on the technology and experience of CHINATUNGSTEN ONLINE, CTIA GROUP focuses on meeting the personalized needs of customers. Utilizing AI technology, it collaboratively designs and produces tungsten and molybdenum products with specific chemical compositions and physical properties (such as particle size, density, hardness, strength, dimensions, and tolerances) with customers. It offers full-process integrated services ranging from mold opening, trial production, to finishing, packaging, and logistics. Over the past 30 years, CHINATUNGSTEN ONLINE has provided R&D, design, and production services for over 500,000 types of tungsten and molybdenum products to more than 130,000 customers worldwide, laying the foundation for customized, flexible, and intelligent manufacturing. Relying on this foundation, CTIA GROUP further deepens the intelligent manufacturing and integrated innovation of tungsten and molybdenum materials in the Industrial Internet era.

Dr. Hanns and his team at CTIA GROUP, based on their more than 30 years of industry experience, have also written and publicly released knowledge, technology, tungsten price and market trend analysis related to tungsten, molybdenum, and rare earths, freely sharing it with the tungsten industry. Dr. Han, with over 30 years of experience since the 1990s in the e-commerce and international trade of tungsten and molybdenum products, as well as the design and manufacturing of cemented carbides and high-density alloys, is a renowned expert in tungsten and molybdenum products both domestically and internationally. Adhering to the principle of providing professional and high-quality information to the industry, CTIA GROUP's team continuously writes technical research papers, articles, and industry reports based on production practice and market customer needs, winning widespread praise in the industry. These achievements provide solid support for CTIA GROUP's technological innovation, product promotion, and industry exchanges, propelling it to become a leader in global tungsten and molybdenum product manufacturing and information services.

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# Chapter 14 Production and Application of Ferrotungsten

This chapter focuses on the production process and application of ferrotungsten (FeW), and comprehensively explains its preparation method, physical and chemical properties, and its wide range of uses in the steel industry, casting, military industry, etc. The content includes an overview of ferrotungsten, production process, production conditions in various countries, specific application scenarios and quality standards, and especially lists the ferrotungsten standards of China and other countries in detail.

## 14.1 Overview of Ferrotungsten

Ferrotungsten is an iron alloy with tungsten and iron as the main components, usually prepared by smelting tungsten ore or tungsten compounds and iron raw materials. As an important alloying additive in the steel industry, ferrotungsten is widely used due to its high density, high melting point and excellent mechanical properties. Its tungsten content is usually between 70% and 85% (in terms of $WO_3$), and the rest is iron and a small amount of impurities (such as carbon, silicon, phosphorus, etc.).

**Physical and chemical properties of tungsten iron**
Appearance: Gray-black metal block or granular material, the surface gloss varies with processing conditions.
Melting point: about 1650°C-2100°C (increases with increasing tungsten content, the melting point of FeW80 is close to 2100°C).
Density: 14.5-17.5 g/cm³ ( FeW70 is about 15 g/ cm³ , FeW80 is close to 17 g/cm³ ) .
Hardness: Mohs hardness 6.5-7.5, compressive strength 1000-1500 MPa, tensile strength about 600-800 MPa.
Thermal conductivity: About 50-70 W/(m·K), between pure tungsten (173 W/(m·K)) and ordinary steel (~45 W/(m·K)).
Electrical conductivity: About 5-8×10 ⁶ S/m, lower than pure tungsten but higher than ordinary iron-based alloys.
Crystal structure: body-centered cubic structure (bcc), solid solution or compound phase composed of tungsten phase (W) and iron phase (Fe) (such as $Fe_3W_2$ ) .
Chemical stability: Insoluble in water, resistant to acid and alkali corrosion (except strong oxidizing acids such as concentrated nitric acid), oxidized to form $WO_3$ and $Fe_2O_3$ in high temperature (>800°C) air .

**Characteristics of tungsten iron**
High density and high melting point make it suitable for high temperature and high load environments.
Excellent wear resistance, corrosion resistance and oxidation resistance, suitable for harsh working conditions.
It has good compatibility with iron-based materials and can significantly improve the performance of steel as an additive.

## 14.2 Production Process of Ferrotungsten

The production of ferrotungsten mainly adopts pyrometallurgical process, which uses tungsten concentrate (such as wolframite or scheelite) as raw material and combines it with iron raw material (such as scrap steel or iron powder) to smelt it at high temperature. The following is a detailed description of the main production methods:

### 14.2.1 Thermite Process

**Process principle**
$WO_3$ in the tungsten concentrate is reduced to metallic tungsten through a strong exothermic reaction and fused with iron to form tungsten-iron alloy. The reaction equation is as follows:
3WO3 +2Al+Fe→FeW+Al2O3+ heat $3WO_3 + 2Al + Fe \rightarrow FeW + Al_2O_3$ + heat 3WO3 + 2Al+Fe→FeW+Al2O3 + heat

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**Process**

Raw material preparation: Tungsten concentrate ($WO_3$ content >65%) is mixed with iron powder and aluminum powder in proportion (usually W:Al:Fe=1:0.5:0.3), and flux (such as $CaF_2$, about 5%-10%) is added to lower the melting point and promote slag-liquid separation.

Charging and ignition: The mixture is loaded into a refractory crucible (such as magnesium oxide or graphite crucible) and ignited with a magnesium rod to initiate the reaction, with the temperature rising instantly to over 2500°C.

Smelting and separation: The reaction takes about 5-10 minutes to complete. The molten ferrotungsten (high density) sinks to the bottom, and the slag layer ($Al_2O_3$, density about 3.9 g/cm³) floats on the top. After cooling, it is broken and separated.

Refining and molding: Remove residual slag and cast into 10-100 mm blocks or crush into particles.

Advantages: Simple equipment, fast response speed, low energy consumption, suitable for small and medium-scale production.

Disadvantages: Impurities (such as Si, Mn) are difficult to control accurately, the tungsten recovery rate is low (85%-90%), and the product quality fluctuates greatly.

### 14.2.2 Electric Furnace Process

**Process principle**

In an electric arc furnace or induction furnace, electric energy is used to heat the tungsten concentrate and iron raw materials for smelting and reduction. Carbon (such as coke) or silicon (such as ferrosilicon) is often used as a reducing agent. Reaction example:

$WO3+3C+Fe \rightarrow FeW+3CO\uparrow$ $WO_3 + 3C + Fe \rightarrow FeW + 3CO\uparrow$ WO3 + 3C+Fe→FeW+3CO↑

**Process**

Raw material preparation: Tungsten concentrate ($WO_3$ content >60%) is mixed with scrap steel, coke (C content>85%) or ferrosilicon (Si content>70%) in proportion (W:Fe:C=1:0.2:0.15) to ensure that the tungsten content meets the standard.

Electric furnace smelting: Melting at 2000°C-2200°C, the electric arc furnace power is usually 5-10 MW, continuous stirring (mechanical or electromagnetic) to homogenize the composition, reaction time 2-4 hours.

Furnace-out and casting: The molten ferrotungsten is taken out of the furnace and cast into ingots (50-200 kg/block) or blocks, and then crushed to the required particle size after cooling.

Refining: It can be further purified by blowing oxygen (reducing the C content to <0.2%) or vacuum degassing (removing S and P).

Advantages: Stable product quality, precise control of tungsten content (70%-85%), high recovery rate (>95%), suitable for large-scale production.

Disadvantages: High energy consumption (about 5000-7000 kWh per ton), high equipment investment and maintenance costs.

### 14.2.3 Other methods

**Carbothermal reduction**

Using carbon to reduce tungsten concentrate under vacuum or inert atmosphere (such as Ar) at a temperature of 1800°C-2000°C is suitable for high-purity ferrotungsten (C<0.1%), but the process is complicated and costly.

**Silicon thermal method**

Using ferrosilicon as the reducing agent, the reaction temperature is about 1800°C, and low-carbon ferrotungsten (C<0.3%) is produced. The reaction is mild but the silicon content needs to be strictly controlled (Si<0.8%).

**Production precautions**

Impurity control: Sulfur (S<0.1%), phosphorus (P<0.05%), and carbon (C<0.5%) need to be controlled

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through raw material selection and refining to avoid affecting the quality of steel.
Particle size specification: usually 10-50 mm or 50-100 mm, which is convenient for transportation and smelting.
protection measures: Waste gases (such as CO, $SO_2$ ) need to be equipped with bag filters and desulfurization devices, and waste slag ($Al_2O_3$ or $SiO_2$ ) can be recycled for building materials.

### 14.3 Production of Ferrotungsten in Various Countries

The following is the production of ferrotungsten in major countries (based on 2023-2025 data estimates):
China:
Production: Annual output is expected to reach 30,000 tons in 2025, accounting for 70% of the world's total, mainly concentrated in Zhuzhou, Hunan, Ganzhou, Jiangxi and Luoyang, Henan, utilizing the local abundant wolframite and scheelite resources.
Russia:
Production: About 4,000 tons per year, using tungsten mines in Siberia and the Far East, mainly exported to European and Asian markets.
EU (Austria, Germany):
Production: About 2,000 tons per year. The Mittersill mine in Austria provides tungsten concentrate, and Germany is responsible for processing.
USA:
Production: About 1,000 tons per year, relying on imports of tungsten concentrate from China and Vietnam, with production concentrated in Pennsylvania.
Vietnam:
Production: About 800 tons per year, using the Nui Phao mine resources, mainly exported to Japan, South Korea and China.

### 14.4 Application of Ferrotungsten

As a key alloy additive, ferrotungsten is widely used in the steel industry, casting, military industry and other fields. The following is a detailed classification and specific application scenarios:

**Steel Industry**
High-Speed Steel (HSS):
Application: Add tungsten iron (W content 5%-18%) to prepare high-speed steel for manufacturing cutting tools (such as drills, milling cutters, turning tools).
Performance improvement: Hardness increased to HRC 62-67, wear resistance increased by 2 times, red hardness strong (HRC>60 at 600°C), cutting speed increased by 50%-100%.
Examples:
Automobile engine cylinder block machining tools (annual demand is about 10,000 tons, with a service life of 500 hours).
Aviation titanium alloy processing tools (such as Boeing 737 wing parts, cutting accuracy ± 0.01 mm).
Tool Steel:
Application: Used for manufacturing stamping dies, cold heading dies and forging dies. Tungsten content is 3%-10%.
Improved performance: Impact resistance increased by 20%, wear resistance increased by 30%, suitable for high-intensity hot and cold processing.
Examples:
Automobile steel plate stamping dies (annual demand is about 5,000 tons, and the number of stamping times reaches 2 million times).
Bolt cold heading dies (diameter accuracy ±0.01 mm, annual demand is about 1,000 tons).
Wear Resistant Steel:
Application: Used in mining machinery (such as crusher lining) and engineering machinery (such as excavator bucket teeth), tungsten content 5%-15%.

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Improved performance: Wear resistance is increased by 2-3 times, service life is extended to 2000 hours, and corrosion resistance is enhanced by 10%.
Examples:
Mining ball mill lining (annual demand is about 3,000 tons, and the wear-resistant life is up to 1 year).
Wear-resistant parts for port loading and unloading equipment (such as grab buckets, with an annual demand of about 800 tons).
Heat-resistant steel:
Application: manufacturing high temperature furnace parts and gas turbine blades, tungsten content 5%-15%.
Improved performance: High temperature oxidation resistance increased by 30%, creep resistance enhanced, and operating temperature up to 1200°C.
Examples:
Aircraft engine turbine blades (such as GE aircraft engines, with an annual demand of approximately 2,000 tons).
Steelmaking furnace lining (temperature resistance 1500°C, service life extended to 6 months).

**Foundry Industry**
Cast iron modification:
Application: Adding a small amount of ferrotungsten (0.5%-2%) to improve the performance of cast iron and to produce wear-resistant castings.
Improved performance: Hardness increased to HB 300-350, tensile strength increased by 15% (to 500 MPa), corrosion resistance increased by 20%.
Examples:
Pump body and valve castings (annual demand is about 1,000 tons, used under acid and alkali resistant conditions).
Wear-resistant pipe lining (chemical pipeline, annual demand is about 500 tons).
High density castings:
Application: To prepare high-density counterweights, such as crane counterweights and ship ballast.
Improved performance: Density of 15-17 g/cm³ , 20% volume reduction while maintaining high strength (compressive strength > 1000 MPa).
Examples:
Port crane counterweights (annual demand is about 500 tons, and the weight of a single piece is up to 5 tons).
Ship ballast blocks (ocean cargo ships, annual demand is about 300 tons).

**Military Industry**
Armor-piercing material:
Application: Tungsten iron is used as a substitute material for armor-piercing projectile core (W content 70%-80%), and is used in small-caliber ammunition or low-cost armor-piercing projectile design.
Improved performance: High density (15-17 g/cm³ ) provides excellent penetration, with penetration increased by 15%-20%, and the cost is about 30% lower than pure tungsten alloy.
Examples:
30mm cannon armor-piercing projectile (GAU-8/A, used for A-10 attack aircraft, with a penetration depth of about 70 mm steel plate, and an annual demand of about 1,000 tons).
Armor Protection:
Application: Add tungsten iron to prepare composite armor or armor steel to enhance impact resistance and penetration resistance.
Performance improvement: Penetration resistance increased by 25%, weight reduced by 10%, suitable for lightweight armor design.
Examples:
Light armored vehicle protection layer (such as some components of the Russian BTR-90, with an annual demand of about 800 tons).

**Other applications**
Welding materials:

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Application: Tungsten iron powder is used for plasma spraying or surfacing to prepare wear-resistant coating.
Improved performance: The coating hardness reaches HRC 60, the wear resistance is increased by 2 times, and the adhesion is enhanced to 50 MPa.
Examples:
Surface strengthening of oil drill pipes (annual demand is about 300 tons, and the wear life is up to 5,000 hours).
Valve sealing surface (chemical equipment, annual demand is about 200 tons).
Scientific research purposes:
Application: Ferrotungsten is used as experimental material to study the tungsten-iron phase diagram, alloy properties and high temperature behavior.
Examples:
High temperature alloy development (testing oxidation resistance, simulating 1300°C conditions).
Research on magnetic materials (analysis of paramagnetic properties).

Global Trends: By 2030, the demand for ferrotungsten is expected to grow by 10%, driven by steel industry upgrades (annual demand to 20,000 tons), military demand (EU and US military spending drives annual demand to 3,000 tons) and infrastructure construction (demand for wear-resistant parts to grow by 15%).

**Application of Ferrotungsten (FeW)**

| Field | Use | Performance improvements | Specific applications and requirements |
|---|---|---|---|
| **Steel Industry** | **High speed steel (hss)** | Hardness increased to hrc 62-67, wear resistance increased by 2 times, strong red hardness (hrc>60 at 600°c), cutting speed increased by 50%-100% | Automobile engine cylinder block machining tools (annual demand of about 10,000 tons, life of 500 hours), aviation titanium alloy machining tools (boeing 737 wings, accuracy ±0.01 mm) |
| | **Tool steel** | Impact resistance increased by 20%, wear resistance increased by 30%, suitable for high-strength hot and cold processing | Automobile steel plate stamping dies (annual demand 5,000 tons, stamping times 2 million times), bolt cold heading dies (diameter accuracy ±0.01 mm, annual demand 1,000 tons) |
| | **Wear-resistant steel** | Wear resistance increased by 2-3 times, service life extended to 2000 hours, corrosion resistance increased by 10% | Mining ball mill lining (annual demand 3,000 tons, wear-resistant life 1 year), port loading and unloading equipment wear parts (grab bucket, annual demand 800 tons) |
| | **Heat-resistant steel** | High temperature oxidation resistance increased by 30%, creep resistance enhanced, working temperature up to 1200°c | Aircraft engine turbine blades (ge aviation, annual demand 2,000 tons), steel furnace linings (temperature resistance 1500°c, life extended to 6 months) |
| **Casting Industry** | **Cast iron Modified** | Hardness increased to hb 300-350, tensile strength increased by 15% (to 500 mpa), corrosion resistance increased by 20% | Pump body and valve castings (annual demand 1,000 tons, acid and alkali resistant), wear-resistant pipe lining (chemical pipeline, annual demand 500 tons) |
| | **High density Casting** | Density up to 15-17 g/cm³ , volume reduction of 20%, compressive strength>1000 mpa | Port crane counterweights (annual demand 500 tons, single block weight 5 tons), ship ballast blocks |

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| | | | |
|---|---|---|---|
| | | | (ocean cargo ships, annual demand 300 tons) |
| **Military Field** | **Armor-piercing projectile Material** | High density (15-17 g/cm³ ) , penetration increased by 15%-20%, cost 30% lower than pure tungsten alloy | 30mm cannon armor-piercing projectile (gau-8/a, a-10 attack aircraft, penetration depth 70 mm steel plate, annual demand 1,000 tons) |
| | **Armor Protection** | Penetration resistance increased by 25%, weight reduced by 10%, suitable for lightweight armor design | Light armored vehicle protection layer (partial components of russian btr-90, annual demand 800 tons) |
| **Other Application** | **Welding Material** | The coating hardness reaches hrc 60, the wear resistance is increased by 2 times, and the adhesion is enhanced to 50 mpa | Surface strengthening of oil drill pipes (annual demand 300 tons, life 5000 hours), valve sealing surface (chemical equipment, annual demand 200 tons) |
| | **Research Use** | Used to study tungsten-iron phase diagram, alloy properties and high temperature behavior | High temperature alloy development (testing oxidation resistance, 1300°c), magnetic material research (analyzing paramagnetic properties) |
| **Worldwide Trend** | - | Demand to grow 10% by 2030 | Steel industry upgrade (annual demand increased to 20,000 tons), military demand (eu and us military spending pushed annual demand to 3,000 tons), infrastructure construction (demand for wear-resistant parts increased by 15%) |
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14.5 Quality Standards and Specifications of Ferrotungsten

The quality standards of ferrotungsten vary from country to country. The following are the standards of China and other major countries, with the main indicators listed in table form.

China's national standard "Tungsten Ferro" divides tungsten into multiple grades. The following are the composition requirements of the main grades:

**Chinese Standard "Tungsten Ferro" (GB/T 4010-2015)**

| Brand | W (%) | C (%) | Si (%) | S (%) | P (%) | Mn (%) | Cu (%) | As (%) | Sn (%) | Al (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| FeW80-A | 75-85 | ≤0.10 | ≤0.40 | ≤0.06 | ≤0.03 | ≤0.15 | ≤0.10 | ≤0.03 | ≤0.03 | ≤0.20 |
| FeW80-B | 75-85 | ≤0.20 | ≤0.80 | ≤0.08 | ≤0.05 | ≤0.25 | ≤0.10 | ≤0.03 | ≤0.03 | ≤0.40 |
| FeW80-C | 75-85 | ≤0.40 | ≤1.50 | ≤0.10 | ≤0.06 | ≤0.40 | ≤0.15 | ≤0.05 | ≤0.05 | ≤0.60 |
| FeW70 | 70-80 | ≤0.30 | ≤1.00 | ≤0.10 | ≤0.06 | ≤0.30 | ≤0.15 | ≤0.05 | ≤0.05 | ≤0.50 |
| FeW50 | 50-60 | ≤0.50 | ≤2.00 | ≤0.15 | ≤0.08 | ≤0.50 | ≤0.20 | ≤0.08 | ≤0.08 | ≤0.80 |
| Particle size specification | 10-50 mm, 50-100 mm, or customized. | | | | | | | | | |
| Remark | FeW80 is divided into three grades: A, B, and C, corresponding to low, medium, and high impurity requirements; FeW70 and FeW50 are suitable for scenarios with lower tungsten content requirements. | | | | | | | | | |

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中国标准《钨铁》（GB/T 4010-2015）

| 牌号 | W (%) | C (%) | Si (%) | S (%) | P (%) | Mn (%) | Cu (%) | As (%) | Sn (%) | Al (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| FeW80-A | 75-85 | ≤0.10 | ≤0.40 | ≤0.06 | ≤0.03 | ≤0.15 | ≤0.10 | ≤0.03 | ≤0.03 | ≤0.20 |
| FeW80-B | 75-85 | ≤0.20 | ≤0.80 | ≤0.08 | ≤0.05 | ≤0.25 | ≤0.10 | ≤0.03 | ≤0.03 | ≤0.40 |
| FeW80-C | 75-85 | ≤0.40 | ≤1.50 | ≤0.10 | ≤0.06 | ≤0.40 | ≤0.15 | ≤0.05 | ≤0.05 | ≤0.60 |
| FeW70 | 70-80 | ≤0.30 | ≤1.00 | ≤0.10 | ≤0.06 | ≤0.30 | ≤0.15 | ≤0.05 | ≤0.05 | ≤0.50 |
| FeW50 | 50-60 | ≤0.50 | ≤2.00 | ≤0.15 | ≤0.08 | ≤0.50 | ≤0.20 | ≤0.08 | ≤0.08 | ≤0.80 |
| 粒度规格 | 10-30 mm、50-100 mm，或按订货协议。 | | | | | | | | | |
| 备注 | FeW80 分为 A、B、C 三级，对应钨、杂质要求；FeW70 和 FeW50 适用于对低铝含量有特殊要求。 | | | | | | | | | |

International Organization for Standardization standards apply to global trade, and the following are the main indicators:

**International Standard "Tungsten Ferrometallurgy" (ISO 5450:1980)**

| Brand | W (%) | C (%) | Si (%) | S (%) | P (%) | Mn (%) | Cu (%) | Al (%) |
|---|---|---|---|---|---|---|---|---|
| FeW80 | 75-85 | ≤0.25 | ≤1.00 | ≤0.10 | ≤0.05 | ≤0.50 | ≤0.20 | ≤0.50 |
| FeW70 | 70-80 | ≤0.40 | ≤1.50 | ≤0.15 | ≤0.08 | ≤0.70 | ≤0.25 | ≤0.70 |

Particle size: 5-100 mm, or as agreed in the contract.
Note: The ISO standard has loose requirements on impurities and is suitable for international general scenarios.

ASTM standards are mainly used in the North American market, and the following are the main indicators:

**American Standard "Tungsten Ferro" (ASTM A100-07, revised in 2018)**

| Brand | W (%) | C (%) | Si (%) | S (%) | P (%) | Mn (%) | Cu (%) | Al (%) |
|---|---|---|---|---|---|---|---|---|
| FeW80 | 75-85 | ≤0.20 | ≤0.80 | ≤0.08 | ≤0.05 | ≤0.30 | ≤0.15 | ≤0.40 |
| FeW70 | 70-80 | ≤0.35 | ≤1.20 | ≤0.10 | ≤0.06 | ≤0.40 | ≤0.20 | ≤0.60 |

Granularity specification: 10-100 mm, or as per user's requirement.
Note: ASTM standards emphasize low carbon and low sulfur requirements and are suitable for high-performance steel production.

**Russian "Tungsten Ferro" Standard (GOST 17293-93):**

Russian national standards apply to CIS countries, the following are the main indicators:

| Brand | W (%) | C (%) | Si (%) | S (%) | P (%) | Mn (%) | Cu (%) | Al (%) |
|---|---|---|---|---|---|---|---|---|
| FeW80 | 75-85 | ≤0.30 | ≤1.00 | ≤0.10 | ≤0.06 | ≤0.40 | ≤0.20 | ≤0.50 |
| FeW70 | 70-80 | ≤0.50 | ≤1.50 | ≤0.15 | ≤0.08 | ≤0.60 | ≤0.25 | ≤0.70 |

Particle size: 10-80 mm, or customized according to contract.
Note: The GOST standard has a higher tolerance for carbon and silicon, which is adapted to the characteristics of local Russian raw materials.
Packaging requirements (general):
Iron drums, ton bags or steel containers, each batch is accompanied by a quality certificate, the net weight is usually 500 kg or 1000 kg.

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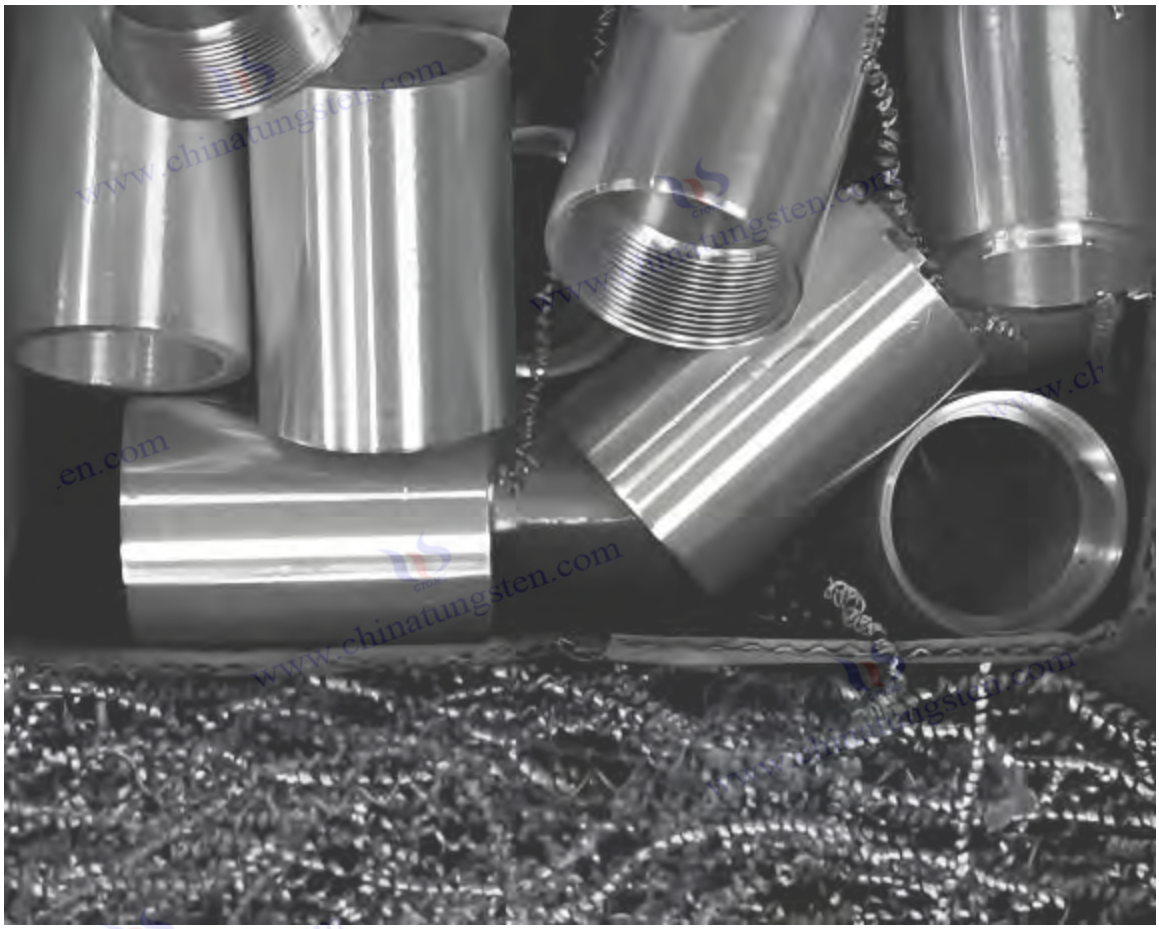

## Chapter 15: Tungsten Metal Products

This chapter focuses on pure tungsten metal products (excluding alloys), and comprehensively explains its types, preparation processes, physical and chemical properties and applications. The following content includes an overview, production process, main types and properties, application scenarios, and detailed supplementation and refinement of the specific contents of Chinese national standards and international standards.

### 15.1 Overview of Tungsten Metal Products

Tungsten metal products are made of high-purity tungsten (W content ≥ 99.95%) as raw materials through powder metallurgy and pressure processing. Tungsten has the highest melting point (3422°C), high density (19.25 g/cm³ ) , excellent mechanical strength and corrosion resistance, suitable for high temperature, high load and special environment, and widely used in industry, military industry, nuclear technology and other fields.
Physical and chemical properties:
Appearance: Silvery white, mirror luster after polishing.
Melting point: 3422°C.
Boiling point: 5555°C.
Density: 19.25 g/ cm³ .
Hardness: Mohs hardness 7.5, Vickers hardness 400-450 HV.
Thermal conductivity: 173 W/(m·K).

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Conductivity: $18.2\times10^{6}$ S/m.
Coefficient of thermal expansion: $4.5\times10^{-6}$ /°C.
Crystal structure: body-centered cubic (bcc).
Chemical stability: Acid and alkali resistant (except HF and concentrated $HNO_3$ ) , oxidized at high temperature to generate $WO_3$ .
Features:
High melting point and density, suitable for extreme conditions.
It is brittle at room temperature and has improved ductility above 400°C.
High purity ensures consistent performance.

**15.2 Production Process of Tungsten Metal Products**

**15.2.1 Preparation of tungsten powder**

Principle: Hydrogen reduction of $WO_3$ : WO3+3H2→W+3H2O $WO_3 + 3H_2 \rightarrow W + 3H_2O$ WO3 + 3H2 → W+3H2 O
Process: Purify $WO_3$ (>99.9%) → 800°C-1000°C hydrogen reduction → pickling and sieving to obtain tungsten powder (0.1-10 μm).

**15.2.2 Powder Metallurgy Forming**
Process: Cold isostatic pressing (200-300 MPa) → $H_2$ atmosphere pre-sintering (1100°C-1300°C) → Vacuum/$H_2$ furnace high temperature sintering (2600°C-3000°C).

**15.2.3 Pressure processing and refining**
Process: 1200°C-1600°C forging/rolling → high temperature drawing → diamond tool machining → polishing/annealing.
Note:
Purity: O<0.02%, Fe, Ni<0.01%.
Environment: $H_2$ or Ar to prevent oxidation.
Recovery rate:>90%.

**Production process of tungsten metal products using tungsten powder as raw material**

| Technology step | Detailed process | Key parameters and conditions | Equipment and Tools | Product and quality control |
|---|---|---|---|---|
| 1.Raw material preparation | High purity tungsten powder is used, usually made from APT or $WO_3$ by hydrogen reduction. It is screened to remove impurities and uneven particles. It is dried to remove moisture. | Purity: ≥99.95%, impurities (O<0.05%, C<0.01%). Particle size: 1-10 μm (FSSS method). Moisture: <0.05%. | Vibrating sieve (200-400 mesh). Vacuum oven (100-150°C, $10^{-1}$ Pa). | High purity tungsten powder, uniform particle size. SEM was used to observe the morphology, and oxygen analyzer was used to detect the O content. |
| 2.Powder pretreatment | According to the product requirements, trace additives (such as Ni, Fe) can be added to adjust the performance. Mix evenly to ensure the consistency of ingredients. | Additive ratio: 0.1-2% (depending on alloy requirements). Mixing time: 4-8 hours, speed 50-100 rpm. | Planetary ball mill or V-type mixer. | Mix the powders evenly. Detect the distribution with a laser particle size analyzer. |
| 3. Pressing | The tungsten powder is | Pressing pressure: | Cold isostatic | The green body |

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| | | | | |
|---|---|---|---|---|
| | put into the mold and formed by cold isostatic pressing (CIP) or unidirectional pressing. It is pressed into a rod, plate or crucible green body. | 150-300 MPa. Holding time: 1-5 minutes. Green density: 8-10 g/cm³ ( 50% theoretical density). | press (CIP). Steel or rubber mould. | has a regular shape and no cracks. The density of the green body is tested by a densitometer. |
| 4.Pre-sintering | Sintering at low temperature in a hydrogen atmosphere furnace removes volatile impurities and achieves initial consolidation, which improves the green body strength and facilitates subsequent operations. | Temperature: 1000-1200°C. Holding time: 2-4 hours. $H_2$ flow rate: 5-10 L/min, pressure 0.1-0.5 MPa. | Hydrogen sintering furnace (quartz or molybdenum boat). | The strength of the pre-sintered billet is improved. The mass loss is detected by weighing (<1%). |
| 5.High temperature sintering | Sintering and densification at high temperature to form a high-density tungsten blank. Direct sintering or hot isostatic pressing (HIP) can be used to further increase the density. | ( close to melting point 3410°C). Holding time: 4-8 hours. Atmosphere: $H_2$ or vacuum ($10^{-3}$Pa ) . HIP: 2000°C, 150-200 MPa. | High temperature tungsten boat sintering furnace or vacuum furnace. HIP equipment. | Density >19 g/cm³ ( >98% theoretical density). X-ray detection of porosity. |
| 6.Forging or rolling | The sintered tungsten billet is hot forged or hot rolled to produce bars, plates or sheets, which can improve the material density and mechanical properties. | Temperature: 1400-1800°C. Deformation: 20-40%, total deformation rate>80%. Atmosphere: inert gas A) or $H_2$ protection . | Hot forging or rolling mill. Molybdenum fixtures. | Rod/sheet forming. Hardness tester testing (HV>400). |
| 7. Drawing or rotary forging | The forged tungsten rod is drawn into tungsten wire, or rotary forged into thin tubes/rods. It is used for small-sized products (such as filaments, welding electrodes). | Temperature: 800-1200°C (step annealing). Drawing rate: 5-20 m/min. Diameter reduction: 10-20%/pass. | Wire drawing machine or rotary forging machine. Diamond die. | Tungsten wire diameter 0.01-2 mm. Surface quality is checked under a microscope. |
| 8.Machining | Turning, milling and grinding of tungsten blanks or semi-finished products to make complex shapes (such as crucibles, targets) and remove surface defects. | Cutting speed: 10-50 m/min. Feed rate: 0.05-0.2 mm/rev. Coolant: Oil-based or dry machining. | CNC lathes, milling machines. Carbide tools. | The product shape is precise. The dimensions are measured by three-dimensional coordinate measuring machine (±0.01 mm). |
| 9.Surface treatment | Polishing or sandblasting to improve | Polishing: Ra<0.4 μm. Cleaning: $HNO_3$ / HF | Polishing machine or | The surface is smooth and free of |

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|---|---|---|---|---|
| | surface finish. Optional chemical cleaning to remove oxide layers, or plating to enhance corrosion resistance. | mixture, 5-10 minutes. Plating: Ni/Cr, thickness 5-20 μm. | sandblasting machine. Chemical cleaning tank. | oxidation. The Ra value is tested by a roughness meter. |
| 10.Heat treatment (optional) | Annealing in vacuum or $H_2$ atmosphere eliminates internal stress and optimizes grain structure. Improves ductility or hardness, depending on product use. | Temperature: 800-1500°C. Holding time: 1-4 hours. Cooling rate: 10-50°C/min (furnace cooling). | Vacuum annealing furnace or $H_2$ atmosphere furnace. | Internal stress <50 MPa. Grain size was observed by metallographic microscope. |
| 11.Quality Inspection | Check product density, size, mechanical properties and surface quality to ensure compliance with standards (such as ASTM B777). | Density: >19 g/cm³ . Hardness: HV 400-450. Tensile strength: >700 MPa. Surface defects: <0.1 mm. | Archimedes density meter. Hardness tester, tensile machine, SEM. | Qualified tungsten products. Factory report contains test data. |
| 12. Packaging and storage | Seal the package with anti-oxidation material (such as aluminum foil bag) and fill it with inert gas ($N_2$ or Ar). Store in a dry environment to avoid oxidation and moisture absorption. | Packaging humidity: <20% RH. Storage temperature: 10-30°C. Oxygen content: <100 ppm. | Vacuum packaging machine. Constant temperature and humidity warehouse. | The product has no oxidation deterioration. The storage conditions are monitored by a hygrometer. |

**Detailed description of the process**

The production of tungsten metal products (such as tungsten rods, tungsten plates, tungsten wires, tungsten crucibles, etc.) using tungsten powder as raw material starts with high-purity tungsten powder and is prepared through a series of physical and metallurgical processes. It has high density, high strength and high temperature resistance and is widely used in industry, electronics and military fields. This process is based on common industrial production methods (such as powder metallurgy and subsequent processing) and provides technical details in combination with literature and practical experience. Due to the lack of specific factory data, the content is based on general processes to ensure scientificity and completeness.

1. Raw material preparation

Use high-purity tungsten powder (usually made by calcining APT and then reducing it with $H_2$ ) , with a particle size of 1-10 μm and a purity of ≥99.95%. Remove large particles and moisture through screening and drying to ensure powder uniformity and low oxygen content.

2. Powder pretreatment

According to the product requirements, trace amounts of Ni, Fe and other additives (<2%) can be added and evenly mixed through a ball mill or mixer to improve subsequent sintering performance or prepare tungsten alloy.

3. Pressing and molding:

Cold isostatic pressing (CIP) or uniaxial pressing is used to press tungsten powder into green compacts with a pressure of 150-300 MPa and a green compact density of about 8-10 g/cm³ , providing a basic shape for subsequent sintering.

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Pre-sintering is sintering in a
$H_2$ atmosphere at 1000-1200°C to remove volatile impurities and initially consolidate the green body, which improves the strength of the green body and facilitates handling and high-temperature sintering.

4. High temperature sintering
Sintering in a high temperature furnace at 2500-3000°C, the tungsten particles are combined and densified, and the density is close to the theoretical value (>19 g/cm³ ) . Optional hot isostatic pressing (HIP) can eliminate micropores and further improve density.

5. Forging or rolling
The sintered tungsten billet is hot forged or rolled at 1400-1800°C to make bars, plates or sheets with a deformation rate of >80% to improve the grain structure and mechanical properties.

6. Drawing or rotary forging (optional)
The tungsten rod is subjected to multiple passes of drawing (annealing at 800-1200°C) or rotary forging to form a thin wire (0.01-2 mm in diameter) or a thin tube for use as a filament or electrode.

7. Machining
Use CNC equipment to turn, mill or grind the tungsten blank into complex shapes (such as crucibles, targets), with low cutting speeds to avoid tool wear.

8. Surface treatment:
Polish to Ra<0.4 μm to improve the finish, or use pickling to remove the oxide layer. Ni/Cr layer can be plated to enhance corrosion resistance, depending on the application.

9. Heat treatment (optional)
Annealing at 800-1500°C eliminates processing stresses and optimizes grain size and properties (such as ductility or hardness).
Quality testing
checks density (>19 g/cm³ ) , hardness (HV 400-450), tensile strength (>700 MPa) and surface quality to ensure that the products meet the standards.

10. Packaging and Storage:
Pack in sealed packages and store in $N_2$ / Ar atmosphere to avoid oxidation and moisture absorption and ensure long-term stability.

11. Technical points
High purity requirements: Tungsten powder purity ≥99.95%, oxygen content <0.05%, to avoid impurities affecting sintering and performance.
High temperature sintering: The sintering temperature close to the melting point (3410°C) needs to be precisely controlled, and $H_2$ or vacuum atmosphere is used to prevent oxidation.
Processing difficulty: Tungsten is hard and brittle, and forging and machining require high temperatures and special tools (such as diamond tools).
Density control: Through HIP, the theoretical density can reach 99.5%, which is suitable for products with high requirements (such as aviation parts).
Usage: Drawn tungsten wire is used for filaments, forged rods are used for electrodes, and machined crucibles are used for high-temperature containers.

12. Typical product examples
Tungsten rod: pressing → sintering → forging → machining, density>19 g/cm³ , used for welding electrodes.
Tungsten wire: pressing → sintering → forging → drawing, diameter 0.01-1 mm, used for filament.
Tungsten crucible: pressing → sintering → machining → polishing, uniform wall thickness, used for high

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temperature smelting.

**15.3 Main types and properties of tungsten metal products**

The following are the types, properties and standards of pure tungsten products:

Tungsten Wire:

Varieties: Pure tungsten wire, black tungsten wire, white tungsten wire.

Specifications: Diameter 0.01-5 mm, length up to several thousand meters.

Performance: Tensile strength 1500-2000 MPa, resistivity $5.5\times10^{-8}$ Ω·m, temperature resistance >2000°C.

**Chinese tungsten wire standard: GB/T 4181-2017**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 (Chemical Analysis) |
| Diameter tolerance | ±0.001 mm | GB/T 1804 (geometric measurement) |
| tensile strength | ≥1500 MPa | GB/T 228.1 (tensile test) |
| Fe | ≤0.01% | GB/T 4325 |
| Ni | ≤0.01% | GB/T 4325 |
| O | ≤0.02% | GB/T 13747 (oxygen analysis) |
| Surface quality | No cracks, oxides | Visual/microscope inspection |

International Standard: ISO 2490:2007

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.9% | ISO 11876 (Chemical Analysis) |
| Diameter range | 0.02-5 mm | ISO 3611 (geometric measurements) |
| Surface quality | No cracks, oxides | Visual inspection |
| Total impurities | ≤0.1% | ISO 11876 |
| tensile strength | ≥1400 MPa (recommended) | ISO 6892-1 (Tensile test) |

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**Tungsten Crucibles:**
Varieties: sintered, spinning and forging.
Specifications: Diameter 10-500 mm, wall thickness 2-30 mm.
Performance: Density>18.5 g/cm³ , temperature resistance 2600°C.
**Chinese tungsten crucible standard: GB/T 26038-2020**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| density | ≥18.5 g/ cm³ | GB/T 1423 (density measurement) |
| O | ≤0.02% | GB/T 13747 |
| Fe | ≤0.01% | GB/T 4325 |
| Ni | ≤0.01% | GB/T 4325 |
| Wall thickness tolerance | ±0.2 mm | GB/T 1804 |
| Surface quality | No cracks or delamination | Visual inspection |

International tungsten crucible standard: ASTM B760-07 (2019)

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 (Chemical Analysis) |
| density | ≥18.8 g/ cm³ | ASTM B311 |
| Total impurities | ≤0.05% | ASTM E1479 |
| Surface quality | No obvious defects | Visual inspection |
| Dimensional tolerance | ±0.25 mm (recommended) | ASTM B214 |

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# CTIA GROUP LTD
# Tungsten Crucible Introduction

## 1. Overview of CTIA GROUP Tungsten Crucible

Tungsten crucibles designed and manufactured by CTIA GROUP are important tools in the fields of metallurgy, chemistry and materials science, and are particularly suitable for processes that melt or heat substances to extremely high temperatures. Studies have shown that tungsten crucibles perform well in processes such as sapphire crystal growth, rare earth metal melting, vacuum coating and high-temperature furnaces.

## 2. Characteristics of CTIA GROUP Tungsten Crucible

Ultra-high melting point: Tungsten has a melting point of up to 3410°C, making it suitable for use in extremely high temperature conditions.
High purity: The purity can reach ≥99.95%, reducing the impact of impurities on the experiment or production process.
Excellent corrosion resistance: resistant to most acids, alkalis and high temperature oxidation environments, with excellent chemical stability.
High density and low vapor pressure: Density ≥ 18.2 g/cm³, low evaporation rate, ensuring material stability.
High strength and wear resistance: It maintains excellent mechanical properties in high temperature environment and has a long service life.
Low surface roughness: Surface roughness ≤ 3.2 μm, reducing impurities and increasing crucible life.

## 3. Application fields of CTIA GROUP Tungsten Crucible

Rare earth metal melting: carried out in a vacuum or inert gas environment to ensure material purity.
Vacuum coating: Thermal evaporation-deposition technology used in electronics manufacturing.
High temperature furnace: As an important component of the high temperature furnace, it can withstand environments below 2400° C.
Chemical synthesis: handling of corrosive substances such as acids and molten metals.
Metal smelting and refining: used for melting and refining of high-purity metals.
Sapphire crystal growth: used for melting and holding silicon, gallium arsenide and germanium in semiconductor production at temperatures between 2000 and 2500° C.

## 4. Specifications of CTIA GROUP Tungsten Crucible

| Specification | Details |
|---|---|
| Material | Pure tungsten or tungsten alloy |
| Purity | 99.95% |
| Diameter | 20~620mm |
| High | 20~500mm |
| Wall thickness | 3.5~30mm, depending on the diameter |
| Shape | Round, square, rectangular, stepped and customized shapes |
| Surface treatment | Smooth inner and outer walls, no internal cracks |

## 5. Procurement Information

Email: sales@chinatungsten.com
Tel: +86 592 5129595; 592 5129696
For more information about tungsten crucibles, please visit Chinatungsten Online ( www.tungsten.com.cn ) .

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Tungsten Targets:
Varieties: round target, rectangular target.
Specifications: Diameter 50-300 mm or ≤1000×500 mm, thickness 1-20 mm.
Performance: Purity>99.95%, density19.1-19.25 g/cm³ , Ra<0.8 μm.

**China tungsten target standard: GB/T 36434-2018**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| Thickness tolerance | ±0.1 mm | GB/T 1804 |
| Surface roughness | Ra<0.8 μm | GB/T 1031 (Roughness measurement) |
| Fe | ≤0.01% | GB/T 4325 |
| O | ≤0.02% | GB/T 13747 |
| Flatness | <0.02 mm | GB/T 1804 |
| Grain size | ≤100 μm | GB/T 6394 (Metallographic Analysis) |

**International tungsten target standard: ASTM F288-96 (2014)**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 |
| density | ≥19.1 g/ cm³ | ASTM B311 |
| Flatness | <0.02 mm | ASTM B214 |
| Surface roughness | Ra<1.0 μm | ASTM B946 |
| Total impurities | ≤0.05% | ASTM E1479 |

Tungsten Boats:
Varieties: stamping type, folding type, welding type.
Specifications: Length 50-300 mm, width 5-50 mm, thickness 0.1-1 mm.
Performance: Density>19.0 g/cm³ , temperature resistance 2600°C.

**China Tungsten Boat Standard: GB/T 3876-2017**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| Thickness tolerance | ±0.01 mm | GB/T 1804 |
| Flatness | <0.05 mm | GB/T 1804 |
| Fe | ≤0.01% | GB/T 4325 |
| O | ≤0.02% | GB/T 13747 |
| Surface quality | No cracks or creases | Visual inspection |

**International tungsten boat standard: ASTM B760-07 (2019)**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 |
| density | ≥19.1 g/ cm³ | ASTM B311 |
| Total impurities | ≤0.05% | ASTM E1479 |
| Thickness tolerance | ±0.02 mm (recommended) | ASTM B214 |

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Tungsten Rods:
Varieties: Forged rods, sintered rods.
Specifications: Diameter 2-100 mm, length 50-2000 mm.
Properties: Density 19.0-19.2 g/cm³ , tensile strength>1000 MPa, temperature resistance 3000°C.

**Chinese tungsten rod standard: GB/T 4187-2017**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| Diameter tolerance | ±0.05 mm | GB/T 1804 |
| tensile strength | ≥1000 MPa | GB/T 228.1 |
| Fe | ≤0.01% | GB/T 4325 |
| Ni | ≤0.01% | GB/T 4325 |
| O | ≤0.02% | GB/T 13747 |
| Surface quality | No cracks or delamination | Visual inspection |

**International tungsten rod standard: ASTM B760-07 (2019)**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 |
| density | ≥19.1 g/ cm³ | ASTM B311 |
| tensile strength | ≥700 MPa | ASTM E8 |
| Total impurities | ≤0.05% | ASTM E1479 |

Tungsten Sheets/Foils:
Varieties: rolled plates, thin foils.
Specifications: Thickness 0.01-20 mm, width ≤500 mm, length ≤1000 mm.
Properties: Density 19.1-19.25 g/cm³ , flatness <0.05 mm.

**Chinese tungsten plate/foil standard: GB/T 3875-2017**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| Thickness tolerance | ±0.02 mm | GB/T 1804 |
| Surface roughness | Ra<1.6 μm | GB/T 1031 |
| Fe | ≤0.01% | GB/T 4325 |
| O | ≤0.02% | GB/T 13747 |
| Flatness | <0.05 mm | GB/T 1804 |
| Grain size | ≤150 μm | GB/T 6394 |

**International Tungsten Plate/Foil Standard: ASTM B760-07 (2019)**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 |
| Thickness range | 0.05-50 mm | ASTM B214 |
| Flatness | <0.1 mm | ASTM B214 |
| density | ≥19.1 g/ cm³ | ASTM B311 |

**Tungsten Tubes** :
Varieties: extruded tube, sintered tube.

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Specifications: outer diameter 2-100 mm, wall thickness 0.5-10 mm, length ≤1000 mm.
Performance: Density 19.0-19.2 g/cm³ , temperature resistance 3000°C.

**Chinese tungsten tube standard: GB/T 4186-2017**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| Outside diameter tolerance | ±0.05 mm | GB/T 1804 |
| Wall thickness tolerance | ±0.02 mm | GB/T 1804 |
| Fe | ≤0.01% | GB/T 4325 |
| O | ≤0.02% | GB/T 13747 |
| Surface quality | No cracks or pores | Visual inspection |

**International tungsten tube standard: ASTM B760-07 (2019)**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 |
| density | ≥19.0 g/ cm³ | ASTM B311 |
| Total impurities | ≤0.05% | ASTM E1479 |
| Dimensional tolerance | ±0.1 mm (recommended) | ASTM B214 |

Tungsten Powder :
Varieties: Fine powder (0.1-10 μm), ultrafine powder (<0.1 μm).
Specifications: Adjustable particle size, purity >99.95%.
Performance: High density, suitable for additive manufacturing.

**China Tungsten Powder Standard: GB/T 3458-2006**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | GB/T 4325 |
| O | ≤0.05% | GB/T 13747 |
| Fe | ≤0.01% | GB/T 4325 |
| Ni | ≤0.01% | GB/T 4325 |
| Particle size tolerance | ±10% | GB/T 3249 (Particle size analysis) |
| Apparent density | ≥3.0 g/ cm³ | GB/T 1479 |

**International tungsten powder standard: ASTM B777-15**

| index | Require | Test Method |
|---|---|---|
| W content | ≥99.95% | ASTM E1479 |
| Total impurities | ≤0.05% | ASTM E1479 |
| Particle size | Customization | ASTM B822 |
| Apparent density | ≥2.5 g/cm³ ( recommended) | ASTM B212 |

### 15.4 Application of Tungsten Metal Products

**Industrial Manufacturing**
Tungsten filament: Incandescent lamp filament (annual demand 300 tons[4]), vacuum tube emitter, electron beam welding cathode.
Tungsten crucible: Single crystal growth (sapphire, annual demand 200 tons[3]).
Tungsten boat: high temperature sintering (annual demand 50 tons).

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Tungsten target: magnetron sputtering (semiconductor, annual demand 500 tons[5]).

**Military and Defense**
Tungsten rod: tungsten core for armor-piercing discarding sabot bullets (annual demand: 1,000 tons[6]).
Nuclear Technology:
Tungsten plate: nuclear fuel storage and transportation lining, medical accelerator collimator.
Tungsten tube: Technetium-99m shielding tank (annual demand 20 tons).
Electrochemistry:
Tungsten rod/wire: TIG welding electrode, EDM electrode.
Emerging technologies:
Tungsten powder: 3D printing (nuclear fusion components, annual demand 50 tons).
Tungsten rod: Support for superconducting magnets.
Special features:
Tungsten rods: Gyroscope counterweights (annual demand 100 tons).
Tungsten plate: High-fidelity audio vibrator.
Trend: By 2030, demand is expected to grow by 12%, driven by electronics (800 tons/year of targets), military (1,500 tons/year of armor-piercing projectiles), and nuclear technology (300 tons/year of shielding components)[9].

**Application of Tungsten Metal Products**

| Field | Tungsten metal products | Use | Specific applications and requirements |
|---|---|---|---|
| **Industrial manufacturing** | Tungsten wire | Incandescent lamp filament, vacuum tube emitter, electron beam welding cathode | Incandescent lamp filaments (annual demand 300 tons), vacuum tube emitters (electronic equipment), electron beam welding cathodes (aviation parts welding) |
| | Tungsten crucible | Single crystal growth | Single crystal growth (sapphire, annual demand 200 tons) |
| | Tungsten boat | High temperature sintering | High temperature sintering (annual demand 50 tons) |
| | Tungsten sputtering target | Magnetron sputtering | Magnetron sputtering (semiconductor, annual demand 500 tons) |
| **Military industry and defense** | Tungsten rod | Armor-piercing discarding sabot tungsten core | Tungsten core for armor-piercing discarding sabot projectile (annual demand 1,000 tons) |
| **Nuclear technology** | Tungsten plate | Nuclear fuel storage and transportation lining, medical accelerator collimator | Nuclear fuel storage and transportation lining (nuclear power plant safety), medical accelerator collimator (radiotherapy equipment) |
| | Tungsten tube | Technetium-99m shielding tank | Technetium-99m shielding tank (annual demand 20 tons) |
| **Electrochemistry** | Tungsten rod/wire | Tig welding electrodes, edm electrodes | Tig welding electrodes (industrial welding), edm electrodes (mold processing) |
| **Emerging technologies** | Tungsten powder | 3d printing | 3d printing (nuclear fusion components, annual demand 50 tons) |
| | Tungsten | Superconducting | Superconducting magnet supports (mri |

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| | | | |
|---|---|---|---|
| | rod | magnet support | equipment or particle accelerators) |
| **Special features** | Tungsten rod | Gyro counterweight | Gyroscope counterweight (annual demand 100 tons) |
| | Tungsten plate | Hi-fi audio vibrator | Hi-fi audio vibrator (audio equipment) |
| **Trend** | - | - | Demand is expected to grow by 12% by 2030, driven by electronics (target materials 800 tons/year), military (armor-piercing projectiles 1,500 tons/year), and nuclear technology (shielding components 300 tons/year). |

**15.5 Quality Standards and Specifications of Tungsten Metal Products**

Purity: W≥99.95%, impurities<0.05%.

Dimension tolerance: Tungsten wire ±0.001 mm, target thickness ±0.1 mm, tube outer diameter ±0.05 mm.

Packing: Vacuum sealed or wooden box.

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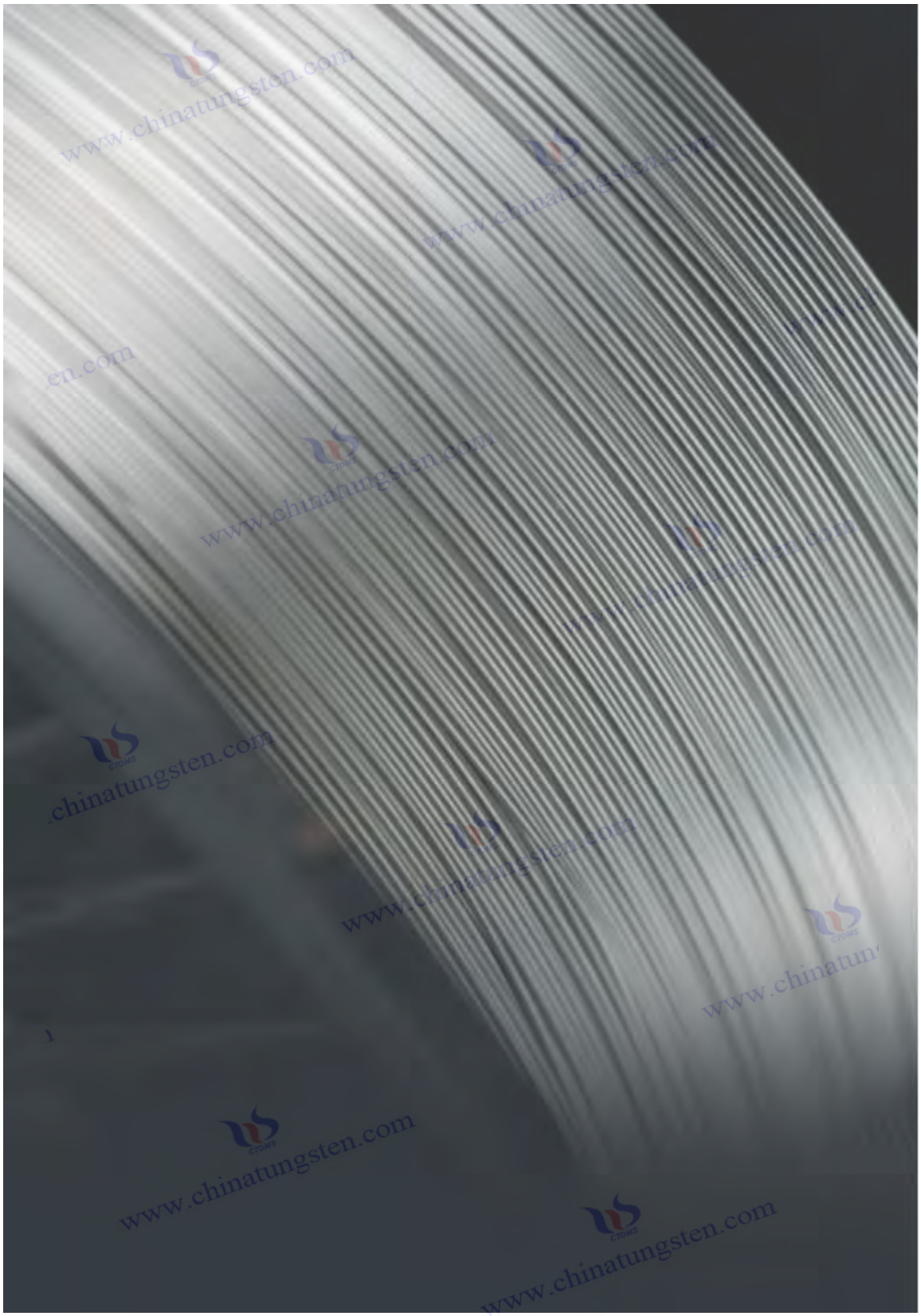

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## Chapter 16: Production and Application of Tungsten Wire

This chapter discusses the production technology and wide application of tungsten wire, which plays an important role in many fields due to its excellent performance. The content covers the research and development and production history of tungsten wire, modern production technology, types and specifications, national and international standards, and a comprehensive analysis from traditional filaments to electron tubes, modern applications and emerging photovoltaic cutting fields. This revision specifically adds detailed content on the tungsten wire diameter regulations in the standard, and supplements the research content on diamond wire and tungsten wire on the website of China Tungsten Online Technology Co., Ltd., which is indexed as a reference.

### 16.1 History of R&D and Production of Tungsten Wire

The research and development of tungsten filaments began in the late 19th century, and tungsten has attracted much attention due to its highest melting point (3422°C) and excellent mechanical strength. In 1904, Hungarian scientists Sándor Just and Ferenc Hanaman first patented tungsten filaments. They used a binder-assisted method to make tungsten powder into filaments, but early products were brittle and difficult to mass-produce.

In 1909, William D. Coolidge of General Electric of the United States developed ductile tungsten filaments through powder metallurgy and high drawing technology. This breakthrough enabled tungsten filaments to be used in incandescent lamps on a large scale. In the mid-20th century, with the advancement of vacuum technology and hydrogen reduction process, the purity and quality of tungsten filaments were significantly improved, supporting the demand for electronic tubes and other fields during World War II.
Today, tungsten wire production has developed into a high-precision process that meets the requirements of emerging technologies such as lighting, electronics and photovoltaic cutting.

### 16.2 Contemporary Tungsten Wire Production Technology and Process Flow

Modern tungsten wire production uses advanced powder metallurgy and precision drawing technology to ensure high purity, high strength and consistency. The following is the main process flow:
**Tungsten powder preparation**
Principle: High-purity ammonium paratungstate (APT) is calcined to generate tungsten trioxide ($WO_3$), which is then reduced with hydrogen at 800°C-1000°C: $WO3+3H2 \rightarrow W+3H2O$ $WO_3 + 3H_2 \rightarrow W + 3H_2O$
WO3 + 3H2 → W+3H2 O
Details: The purity of the obtained tungsten powder is >99.95%, the particle size is 0.1-10 μm, and impurities such as Fe and O are removed by screening and acid washing.

**Pressing and sintering**
Process: Tungsten powder is pressed into rods by cold isostatic pressing (200-300 MPa), pre-sintered at 1100°C-1300°C in a hydrogen atmosphere to enhance strength, and then sintered at 2600°C-3000°C in a vacuum or hydrogen furnace to achieve a density of 95%-98% of the theoretical value.
Drawing forming:
Process: Sintered rods are forged and diamond die drawn at 1200°C-1600°C to gradually reduce diameter (from ~5 mm to 0.01 mm). Multiple annealing ($H_2$ or Ar atmosphere) relieves stress and improves ductility.
Features: High temperature drawing overcomes the room temperature brittleness of tungsten and ensures uniformity and strength.

**Surface treatment**
Process: Depending on the application, the tungsten wire can be polished (white tungsten wire) or retain the oxide layer (black tungsten wire), and the surface impurities can be removed by pickling or electrolytic cleaning.
Quality Control: Purity maintained at ≥99.95%, oxygen content <0.02%, metal impurities <0.01%.

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Microscope and tensile testing are used to ensure the absence of defects.
This process can produce tungsten wires with diameters as thin as 10 μm, meeting modern high-precision requirements.

**Ultrafine and Nano Tungsten Wire Production Process (Doping process, using APT as raw material )**

| Step | Detailed process | Key parameters and conditions | Equipment tools | Product quality control |
|---|---|---|---|---|
| 1. apt doping | Dissolve high-purity apt in deionized water, add k (such as koh), al (such as al(no3 ) 3 ) and rare earth element (such as la(no3 ) 3 or ce(no3 ) 3 ) solution, stir evenly and precipitate. Dry to form doped apt crystals. | Purity: apt ≥ 99.95%. Doping content: k 50-100 ppm, al 10-50 ppm, rare earth 20-80 ppm. Solution ph: 7-8. drying temperature: 100-150 ° c. | Stirred reactor. Vacuum oven (10 ⁻ ¹ pa). | The doped apt crystals are uniform. Icp-ms detects the doping element content. |
| 2. calcination reduction powder making | The doped apt is calcined and reduced step by step in a hydrogen atmosphere to first generate blue tungsten oxide ($W_{20}O_{58}$ ) , which is then reduced to doped tungsten powder. Large particles are removed by sieving. | Calcination temperature: 400-600°c (generating $W_{20}O_{58}$ ) . Reduction temperature: 700-900°c. $H_2$ flow rate : 5-15 l/min. Particle size: 0.1-1 μm. | Tubular hydrogen furnace (molybdenum boat). Vibrating screen (600 mesh). | Doped tungsten powder, particle size <1 μm. Xrd analysis of crystal phase, sem observation of morphology. |
| 3. powder pretreatment | High-energy ball milling of doped tungsten powder further refines the particles and ensures uniform distribution of doping elements. K and al content can be fine-tuned to optimize performance. | Ball milling time: 8-12 hours, speed 400-600 rpm. Particle size is refined to <0.5 μm. Ball to material ratio: 10:1. | High energy ball mill (zirconia balls). Mixer. | Ultrafine doped tungsten powder. Laser particle size analyzer to detect distribution uniformity. |
| 4. pressing | The doped tungsten powder is loaded into a high-precision mold and pressed into a slender rod-shaped green body by cold isostatic pressing (cip), providing a basis for subsequent sintering and drawing. | Pressing pressure: 250-400 mpa. Holding time: 2-5 minutes. Green density: 9-11 g/cm³ ( about 55% theoretical density). | Cold isostatic press (cip). Slim steel mould. | Slender green body with no cracks. Density of green body is tested by densitometer. |
| 5. pre-sintering | Low-temperature sintering in a hydrogen atmosphere furnace removes volatile impurities and preliminarily consolidates the green | Temperature: 1000-1200°c. Holding time: 2-4 hours. $H_2$ flow rate: 5-10 l/min, pressure 0.1-0.5 mpa. | Hydrogen sintering furnace (molybdenum boat). | The strength of the pre-sintered billet is improved. The mass loss is detected by weighing |

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| | body to enhance strength for subsequent high-temperature processing. | | | (<1%). |
| 6. high temperature sintering | Sintering in high temperature hydrogen or vacuum furnace makes the doped tungsten powder particles combine and densify to form a high density tungsten rod blank. Optional hip can further eliminate porosity. | Temperature: 2600-3000°c. Holding time: 4-8 hours. Atmosphere: $h_2$ or vacuum ( $10^{-3}$pa ). Hip : 2000°c, 150-200 mpa. | High temperature tungsten boat furnace. Hip equipment. | Density >19 g/cm³ ( >98% theoretical density). X-ray detection of porosity. |
| 7. hot forging or rotary forging | Hot forging or rotary forging is performed on sintered tungsten rods to prepare thinner diameter rods, improve density and ductility, and prepare for drawing. | Temperature: 1400-1600°c. Deformation: 20-30% each time, total deformation rate>70%. Atmosphere: $h_2$ or ar protection. | Hot forging machine or rotary forging machine. Molybdenum fixture. | Thin bar forming. Hardness tester testing (hv>400). |
| 8. multi-stage drawing | The hot forged tungsten rod is drawn through multiple passes to gradually reduce its diameter to ultra-fine grade (<10 μm). Annealing is performed between each pass to eliminate stress and maintain ductility. | Temperature: 800-1200°c (annealing). Drawing rate: 5-15 m/min. Diameter reduction: 10-15%/pass. Final diameter: 1-10 μm. | Multi-die wire drawing machine. Diamond die (micro hole). | Ultra-fine tungsten wire. Surface inspection under microscope, diameter measurement (±0.1 μm). |
| 9. nano-level finishing (optional) | The ultrafine tungsten wire is electrochemically etched or laser-assisted drawn to further reduce its diameter to the nanoscale (0.01-0.1 μm). | Electrochemical etching: $h_2so_4$ / naoh solution, current density 10-50 ma/cm² . Laser pulling: power 50-100 w, speed 1-5 m/min . | Electrochemical etching tank. Laser drawing equipment. | Nano-tungsten wire (diameter < 0.1 μm). Tem morphology. |
| 10. surface treatment | Polishing or chemical cleaning removes surface oxide layers and defects. Au or ni can be plated to enhance conductivity or corrosion resistance for specific applications. | Polishing: ra<0.2 μm. Cleaning: $hno_3$ / hf solution, 5-10 minutes. Coating thickness: 0.5-2 μm. | Polishing machines. Chemical cleaning tanks. Electroplating equipment. | The surface is smooth and free of oxidation. The ra value is tested by a roughness meter. |
| 11. heat treatment | Vacuum or $h_2$ atmosphere eliminates drawing stress, optimizes grain structure, and improves creep resistance and ductility. | Temperature: 600-1000°c. Holding time: 1-3 hours. Cooling rate: 10-30°c/min (furnace cooling). | Vacuum annealing furnace. $H_2$ atmosphere furnace. | Internal stress <30 mpa. Grains were observed under a metallographic microscope. |
| 12. quality | Check the tungsten wire | Diameter: 0.01-10 μm. | Sem/tem. | Qualified |

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| inspection | diameter, surface quality, mechanical properties and doping element distribution to ensure that it meets ultrafine/nanoscale standards. | Tensile strength: >1500 mpa. Surface defects: <0.05 μm. Doping uniformity: ±5 ppm. | Tensile machine. Eds analyzer. | ultrafine/nano tungsten wire. Factory report contains test data. |
| 13. packaging and storage | Seal the package with anti-oxidation material (such as aluminum foil bag), fill with inert gas ($n_2$ or ar), and store in a dry environment to avoid oxidation and moisture absorption. | Packaging humidity: <10% rh. Storage temperature: 10-25°c. Oxygen content: <50 ppm. | Vacuum packaging machine. Constant temperature and humidity warehouse. | Tungsten filaments are free from oxidation deterioration. Hygrometer monitors storage conditions. |

**16.3 Detailed description of the process flow**

The production of ultrafine tungsten wire (diameter <10 μm) and nano tungsten wire (diameter 0.01-0.1 μm) is based on the doping process, starting with high-purity ammonium paratungstate ( APT) doped with potassium (K), aluminum (Al) and rare earth elements (such as lanthanum La or cerium Ce), and is prepared through powder metallurgy, multi-stage drawing and nano-level finishing. Doping elements improve the ductility, high-temperature creep resistance and grain stability of tungsten, making it suitable for medical devices (such as minimally invasive surgical electrodes), electronic devices (such as MEMS sensors), nuclear fusion experiments (such as plasma confinement) and other fields. The following are the detailed steps:

**1. APT doping:**
Dissolve high-purity APT (purity ≥ 99.95%) in deionized water, add KOH, $Al(NO_3)_3$ and rare earth nitrate (such as $La(NO_3)_3$ ) solution, control the doping amount (K 50-100 ppm, Al 10-50 ppm, rare earth 20-80 ppm), stir and precipitate, and then dry to form doped APT crystals.

**2. Calcination reduction powder**
making The doped APT is reduced step by step in a hydrogen atmosphere: first calcined at 400-600°C to generate blue tungsten oxide ($W_{20}O_{58}$ ) , and then reduced at 700-900°C to doped tungsten powder with a particle size controlled at 0.1-1 μm.

**3. Powder pretreatment**
: high-energy ball milling is used to refine the doped tungsten powder to <0.5 μm to ensure uniform distribution of K, Al and rare earth elements. The doping ratio can be fine-tuned to optimize ductility.

**4. Pressing and molding:**
The doped tungsten powder is loaded into a high-precision mold and pressed into a slender rod-shaped green body by cold isostatic pressing (CIP) with a pressure of 250-400 MPa and a green body density of 9-11 g/$cm^3$ .

**5. Pre-sintering**
Sintering in $H_2$ atmosphere at 1000-1200°C removes volatile impurities and initially consolidates the green body to improve strength .

**6. High temperature sintering**
Sintering in a high temperature furnace at 2600-3000°C, the tungsten particles are combined and densified,

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with a density of >19 g/cm³ . Hot isostatic pressing (HIP) can be used to eliminate micropores.

**7. Hot forging or rotary forging**
Hot forging or rotary forging sintered tungsten rods at 1400-1600°C to prepare thinner diameter rods with a total deformation rate of >70% in preparation for drawing.

**8. Multi-stage drawing**
Through multiple drawing passes (diameter reduction of 10-15% in each pass), annealing at 800-1200°C eliminates stress and gradually reduces the diameter to ultra-fine grade (1-10 μm).

**9. Nano-scale finishing (optional)**
Electrochemical etching ($H_2SO_4$/NaOH solution) or laser-assisted drawing of ultra-fine tungsten wires can be used to prepare nano-scale tungsten wires (0.01-0.1 μm).

**10. Surface treatment:**
Polish to Ra < 0.2 μm, or use $HNO_3$ / HF to clean and remove the oxide layer, and Au/Ni layer can be plated to improve performance.

**11. Heat treatment**
Annealing at 600-1000°C eliminates stress, optimizes grain structure and improves creep resistance.

**12. Quality inspection**
:Check diameter (0.01-10 μm), tensile strength (>1500 MPa), surface quality and doping uniformity to ensure compliance with standards.

**13. Packaging and storage:**
Seal the package and fill it with $N_2$ / Ar, store it in a low humidity environment to avoid oxidation.

**14. Technical points**
Doping effect: K improves high-temperature creep resistance (forming potassium bubbles to inhibit grain growth), Al and rare earth elements enhance ductility and oxidation resistance.
Particle size control: Initial powder <1 μm, drawing and finishing ensures diameter accurate to nanometer level.
High temperature processing: sintering temperature is close to the melting point (3410°C), and $H_2$ or vacuum is required to prevent oxidation.
Drawing difficulty: Ultrafine/nanoscale requires high-precision diamond molds and multiple annealing to avoid wire breakage.
Application: Ultrafine tungsten wires are used in MEMS, and nano tungsten wires are used in nuclear fusion experiments or medical microelectrodes.

**15. Examples of typical products**
Fine tungsten wire: diameter 25-30um, used for diamond wire cutting tungsten wire
Ultrafine tungsten wire: 5 μm in diameter, used for surgical robot guide wires.
Nanotungsten wire: 50 nm in diameter, used as electrode for Z-pinch experiment.

**16.4 Types and specifications of tungsten wire**

Tungsten wire is divided into various types and specifications according to processing methods and uses:
type:
Pure tungsten wire: High-purity standard tungsten wire with strong versatility.
Black tungsten wire: With oxide layer on the surface, suitable for high temperature environment.
White tungsten wire: Polished surface, suitable for precision electronic devices.
Specification:

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Diameter range: 0.01 mm to 5 mm.
Length: Filaments can be several thousand meters in continuous length.
Tensile strength: 1500-2000 MPa for thin wires, and decreases with increasing diameter for thick wires.
Resistivity: $5.5\times10^{-8}$ Ω·m.
Density: 19.0-19.25 g/ $cm^3$ .
Variants:
Thin wire (0.01-0.1 mm): used for filaments and electronic devices.
Medium wire (0.1-1 mm): used for electrodes and heating elements.
Thick wire (1-5 mm): used for structural support or cutting purposes.

### 16.5 Tungsten Wire Standards in China and Other Countries

Standards ensure the quality and consistency of tungsten wire. The following are the details of Chinese and international standards, especially the detailed requirements for tungsten wire diameter:

**Chinese tungsten wire standard: GB/T 4181-2017**

| Parameter | Require | Test method |
|---|---|---|
| Tungsten content | ≥99.95% | Gb/t 4325 (chemical analysis) |
| Diameter tolerance | ±0.001 mm | Gb/t 1804 (geometric measurement) |
| Diameter range | 0.01-5 mm, graded as follows: | Gb/t 1804 |
| - filaments | 0.01-0.1 mm, tolerance ±0.001 mm | Same as above |
| - medium silk | 0.1-1 mm, tolerance ±0.002 mm | Same as above |
| - thick wire | 1-5 mm, tolerance ±0.005 mm | Same as above |
| Tensile strength | ≥1500 mpa | Gb/t 228.1 (tensile test) |
| Fe | ≤0.01% | Gb/t 4325 |
| Ni | ≤0.01% | Gb/t 4325 |
| O | ≤0.02% | Gb/t 13747 (oxygen analysis) |
| Surface quality | No cracks, no oxides | Visual/microscope inspection |
| Scope of application | Tungsten wire for lighting and electronics, with refined diameter classification to suit different uses. | |

**International tungsten wire standard: ISO 2490:2007**

| Parameter | Require | Test method |
|---|---|---|
| Tungsten content | ≥99.9% | Iso 11876 (chemical analysis) |
| Diameter range | 0.02-5 mm, graded as follows: | Iso 3611 (geometric measurements) |
| - filaments | 0.02-0.5 mm, tolerance ±0.002 mm | Same as above |
| - medium silk | 0.5-2 mm, tolerance ±0.005 mm | Same as above |
| - thick wire | 2-5 mm, tolerance ±0.01 mm | Same as above |
| Surface quality | No cracks, no oxides | Visual inspection |
| Total impurities content | ≤0.1% | Iso 11876 |
| Tensile strength | ≥1400 mpa (recommended) | Iso 6892-1 (tensile test) |

Scope of application: Mainly for tungsten wire for welding electrodes and filaments, slightly loose tolerance is allowed.

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**American tungsten wire standard: ASTM B760-07 (2019)**

| Parameter | Require | Test method |
|---|---|---|
| Tungsten content | ≥99.95% | Astm e1479 (chemical analysis) |
| Density | ≥19.1 g/ cm³ | Astm b311 |
| Diameter range | 0.01-5 mm, graded as follows: | Astm b214 |
| - ultra-fine filaments | 0.01-0.05 mm, tolerance ±0.0015 mm | Same as above |
| - filaments | 0.05-0.5 mm, tolerance ±0.003 mm | Same as above |
| - thick wire | 0.5-5 mm, tolerance ±0.01 mm | Same as above |
| Tensile strength | ≥700 mpa | Astm e8 (tensile test) |
| Total impurities content | ≤0.05% | Astm e1479 |

Scope of application: Applicable to a variety of tungsten products, including tungsten wire, especially for ultra-fine wire requirements.

**Japanese tungsten wire standard: JIS H 4701 (General specification for tungsten wire and tungsten products, reference version 2019)**

| Parameter | Require | Test method |
|---|---|---|
| Tungsten content | ≥99.95% | Jis h 1402 (chemical analysis) |
| Density | ≥19.1 g/ cm³ | Jis z 8807 (density determination method) |
| Diameter range | 0.01-5 mm, graded as follows: | Jis z 2241 (dimensional measurement) |
| - ultra-fine filaments | 0.01-0.05 mm, tolerance ±0.0015 mm | Same as above |
| - filaments | 0.05-0.5 mm, tolerance ±0.0025 mm | Same as above |
| - thick wire | 0.5-5 mm, tolerance ±0.008 mm | Same as above |
| Tensile strength | ≥750 mpa | Jis z 2241 (tensile test) |
| Total impurities content | ≤0.05% | Jis h 1402 (chemical analysis) |

illustrate

Source: JIS H 4701 is a general Japanese standard for tungsten products (including tungsten wire) for industrial and electronic applications. The specific parameters of ultrafine and nano tungsten wires refer to similar high-precision tungsten material specifications.

Features: Japanese standards have slightly higher tensile strength requirements (≥750 MPa), reflecting its needs in electronics (such as filaments) and high-temperature applications. Diameter tolerances are slightly tighter than US standards for both fine and thick wire grades, reflecting the tradition of high-precision manufacturing.

Test method: JIS Z 2241 (tensile test) and JIS H 1402 (chemical analysis) are commonly used metal test methods in Japanese industrial standards and have a certain correspondence with ASTM methods.

**European tungsten wire standard: EN 10247 (tungsten and tungsten alloy products, reference version 2017)**

| Parameter | Require | Test method |
|---|---|---|
| Tungsten content | ≥99.95% | En iso 11885 (chemical analysis) |
| Density | ≥19.15 g/ cm³ | En iso 3369 (density determination) |
| Diameter range | 0.01-5 mm, graded as follows: | En iso 4287 (dimensional measurement) |
| - ultra-fine filaments | 0.01-0.05 mm, tolerance ±0.001 mm | Same as above |
| - filaments | 0.05-0.5 mm, tolerance ±0.002 mm | Same as above |
| - thick wire | 0.5-5 mm, tolerance ±0.01 mm | Same as above |
| Tensile strength | ≥720 mpa | En iso 6892-1 (tensile test) |

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| | | |
|---|---|---|
| Total impurities content | ≤0.05% | En iso 11885 (chemical analysis) |

illustrate
Source: EN 10247 is a common European standard for tungsten and tungsten alloy products, applicable to various forms (including tungsten wire). Ultrafine/nano tungsten wire parameters are based on the deduction of high-precision tungsten materials.
Features: European standards have slightly higher density requirements (≥19.15 g/cm³ ) , and tolerances are tighter at the ultra-fine wire level (±0.001 mm), reflecting the precision needs in aerospace and microelectronics. The tensile strength (≥720 MPa) is slightly higher than the US standard but lower than the Japanese standard.
Test methods: EN ISO 6892-1 (tensile test) and EN ISO 11885 (chemical analysis) are common European metal testing standards and have good compatibility with ASTM and JIS methods.

**Additional Notes**
Data source:
Japanese standards refer to JIS H 4701 (tungsten products) and JIS Z 2241 (metal tensile testing), combined with industrial practices (such as ultra-fine tungsten wire production specifications of Toshiba Materials, TOKUSAI and other companies).
European standards refer to EN 10247 (tungsten alloys) and EN ISO related test methods, combined with the technical parameters of European tungsten product suppliers (such as Plansee).

Since ultrafine/nano tungsten wires are cutting-edge applications, specific standards may be supplemented by internal corporate specifications, and public standards rarely target this range directly.

Difference comparison:
Tungsten content: The three are consistent (≥99.95%), reflecting the demand for high purity.
Density: Slightly higher in Europe (19.15 g/cm³ ) , 19.1 g/cm³ in Japan and the United States .
Diameter tolerance: Europe has the strictest tolerance for ultra-fine wire (±0.001 mm), followed by Japan (±0.0015 mm), and the United States is ±0.0015 mm.
Tensile strength: Japan has the highest (≥750 MPa), followed by Europe (≥720 MPa), and the United States has the lowest (≥700 MPa).
The Chinese standard has the most stringent requirements for diameter tolerance (starting from ±0.001 mm), ISO allows higher impurity limits (≤0.1%), and ASTM refines the specifications of ultra-fine wires to suit precision applications.

### 16. 6 filament tungsten wire

The application of tungsten wire in incandescent lamp filament is the most classic case, taking advantage of its high melting point and resistance to thermal creep.
performance:
Diameter: 0.02-0.1 mm.
Working temperature: about 2500°C.
Service life: about 1000 hours under standard conditions.
Production:
Single or double helix design to increase the light emitting area.
Purity>99.95%, reducing evaporation and bulb blackening.
market:
Historically, the demand was strong, reaching 300 tons per year in the early 2000s. Today, it has decreased due to the popularity of LEDs, but it is still used in special lighting such as halogen lamps.

### 16.7 Application of electron tubes in Japan and the United States

Tungsten filaments played a key role in electron tube technology in the mid-20th century, particularly in

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Japan and the United States.
USA:
Application: cathode and filament of radio and television tubes (such as triode and pentode).
Development: After World War II, companies such as RCA used 0.05-0.2 mm tungsten filaments because of their stable electron emission at 2000°C.
Decline: Replaced by transistors in the 1960s.
Japan:
Applications: Hi-Fi tubes and oscilloscope tubes.
Progress: Toshiba and other companies have optimized drawing technology to produce ultra-fine tungsten wires (0.01-0.03 mm), improving the performance of high-end electronic devices.
Current Status: Still serving the audiophile and retro electronics market.
Performance: High purity and diameter uniformity ensure stable electron emission.

**16.8 Contemporary Applications of Tungsten Wire**

In addition to traditional uses, tungsten wire is widely used in modern fields:
Heating elements: Vacuum furnaces and industrial heaters (0.5-2 mm diameter, temperature resistance >2000°C).
Medical equipment: X-ray tube cathodes (0.05-0.1 mm, high thermal stability).
Aerospace: High temperature sensor thermocouple wire.
Welding: TIG (Tungsten Inert Gas) electrodes (1-5 mm), preferred because they do not melt.
Global annual demand for these applications is approximately 100 tons.

**16.9 The rise and advantages and disadvantages of diamond wire tungsten wire and photovoltaic cutting tungsten wire**

Diamond tungsten wire (diamond coated tungsten wire):
Rise: It emerged in the 2010s and is used for silicon wafer cutting in the semiconductor and photovoltaic industries, replacing traditional slurry cutting.
Process: Tungsten wire with a diameter of 0.05-0.2 mm is electroplated or resin-bonded with diamond particles. Research by China Tungsten Online Technology Co., Ltd. shows that the tungsten wire substrate needs to be specially annealed to improve toughness and ensure coating adhesion [9].
advantage:
High cutting accuracy (±0.01 mm).
High cutting speed (up to 20 m/s).
Less material waste (about 50% less than the slurry method).
shortcoming:
High production cost (due to diamond coating).
Limited service life (approximately 100 km cutting distance).
Demand: Global demand is about 200 tons per year, driven by the growth of the solar industry.
Photovoltaic cutting tungsten wire (bare tungsten wire):
Rise: Became popular after 2015, used to cut polysilicon ingots into thin slices to serve photovoltaic cell production.
Process: Ultrafine tungsten wire (0.03-0.08 mm) is used in combination with abrasive slurry in a multi-wire saw. A study by China Tungsten Online showed that the drawing process of tungsten wire needs to be optimized to reduce surface defects and improve cutting stability[9].
advantage:
Low cost (30% cheaper than diamond wire). High tensile strength (1500-2000 MPa), strong durability. Suitable for large-scale photovoltaic production.
Disadvantages: Slow cutting speed (about 10 m/s). Large kerf loss (about 100 μm, compared to 60 μm for diamond wire).
Demand: Annual demand is about 150 tons, especially in China's photovoltaic industry, which is growing rapidly.

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Comparison: Diamond wire has advantages in precision and efficiency, while bare tungsten wire has cost advantages. Together, the two support the rapid development of the photovoltaic industry. China Tungsten Online's research has further optimized the performance of tungsten wire in diamond wire, extending its service life and reducing production costs.

**16.10 Production process of diamond wire tungsten wire and photovoltaic cutting tungsten wire**

The detailed production process of diamond tungsten wire (ultra-fine tungsten wire for photovoltaic cutting) covers the entire process from raw material preparation to the final product. Diamond tungsten wire is a key consumable for cutting silicon wafers in the photovoltaic industry. Its production process is based on doped tungsten wire technology (such as doping with K, Al and rare earth elements), combined with powder metallurgy, multi-stage drawing and surface treatment steps, requiring high strength, high wear resistance and extremely fine diameter (usually 20-50 μm). This process uses high-purity ammonium paratungstate (APT) as the starting raw material, and refers to industrial practice (such as the technical route of Xiamen Tungsten Industry) and literature data to refine the production characteristics of tungsten wire for photovoltaic cutting. Because diamond tungsten wire needs to meet the high-precision requirements of thin-film cutting in the photovoltaic industry, special steps such as diamond electroplating are added to the process.

**Diamond wire tungsten wire, photovoltaic cutting tungsten wire production process**

| Technology | Detailed process | Key parameters and conditions | Equipment and Tools | Product and quality control |
|---|---|---|---|---|
| **APT Doping** | Dissolve high-purity APT in deionized water, add K (such as KOH), Al (such as $Al(NO_3)_3$) and rare earth element (such as $La(NO_3)_3$) solutions, stir and precipitate, and then dry to form doped APT crystals. | Purity: APT ≥ 99.95%. Doping content: K 50-100 ppm, Al 10-50 ppm, rare earth 20-80 ppm. pH: 7-8. Drying temperature: 120-150°C. | Stirred reactor. Vacuum oven ($10^{-1}$ Pa). | The doped APT crystals are uniform. ICP-MS detects the doping element content. |
| **Calcination reduction powder making** | The doped APT is reduced step by step in a hydrogen atmosphere. It is first calcined to generate blue tungsten oxide ($W_{20}O_{58}$), then reduced to doped tungsten powder, and sieved to remove large particles. | Calcination temperature: 450-600°C. Reduction temperature: 750-900°C. $H_2$ flow rate: 10-20 L/min. Particle size: 0.1-0.8 μm. | Tubular hydrogen furnace (molybdenum boat). Vibrating screen (800 mesh). | Doped tungsten powder, particle size <0.8 μm. XRD analysis of crystal phase, SEM observation of morphology. |
| **Powder pretreatment** | The doped tungsten powder is refined by high-energy ball milling to ensure uniform particles and optimize the distribution of doping elements. The K content can be fine-tuned to improve ductility. | Ball milling time: 10-15 hours, speed 500-700 rpm. Particle size: <0.5 μm. Ball to material ratio: 10:1. | High energy ball mill (zirconia balls). Mixer. | Ultrafine doped tungsten powder. Laser particle size analyzer to detect distribution uniformity. |
| **Pressing** | The doped tungsten powder is loaded into a high-precision slender mold and pressed into a | Pressing pressure: 300-450 MPa. Holding time: 3-5 minutes. Green | Cold Isostatic Press (CIP). Slim steel mould. | Slender green body with no cracks. Density of green body is tested by |

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| | rod-shaped green body by cold isostatic pressing (CIP), providing a basis for subsequent sintering and drawing. | density: 9.5-11 g/cm³ ( about 60% theoretical density). | | densitometer. |
| **Pre-sintering** | Low-temperature sintering in a hydrogen atmosphere furnace removes volatile impurities and preliminarily consolidates the green body to enhance strength for high-temperature processing. | Temperature: 1100-1300°C. Holding time: 2-3 hours. $H_2$ flow rate: 10-15 L/min, pressure 0.2-0.5 MPa. | Hydrogen sintering furnace (molybdenum boat). | The strength of the pre-sintered billet is improved. The mass loss is detected by weighing (<0.8%). |
| **High temperature sintering** | Sintering in a high temperature furnace makes the doped tungsten powder particles combine and densify to form a high-density tungsten rod blank. HIP can be selected to eliminate micropores. | Temperature: 2700-3100°C. Holding time: 5-8 hours. Atmosphere: $H_2$ or vacuum ( $10^{-3}$Pa ). HIP : 2100°C, 180 MPa. | High temperature tungsten boat furnace. HIP equipment. | Density >19.2 g/cm³ ( >99% theoretical density). X-ray detection of porosity. |
| **Hot forging or rotary forging** | Hot forging or rotary forging of sintered tungsten rods can produce thinner diameter rods (about 0.5-1 mm) to improve density and ductility. | Temperature: 1500-1700°C. Deformation: 25-35% each time, total deformation rate>75%. Atmosphere: $H_2$ or Ar protection. | Hot forging machine or rotary forging machine. Molybdenum fixture. | Thin bar forming. Hardness tester testing (HV>420). |
| **Multi-stage drawing** | The hot forged tungsten rod is drawn through multiple passes, gradually reducing its diameter to ultra-fine grade (20-50 μm). Annealing is performed between each pass to eliminate stress. | Temperature: 900-1200°C (annealing). Drawing rate: 10-20 m/min. Diameter reduction: 12-18%/pass. Final diameter: 20-50 μm. | Multi-die wire drawing machine. Diamond die (micro hole). | Ultra-fine tungsten wire. Surface inspection under microscope, diameter measurement (±0.5 μm). |
| **Surface cleaning** | Chemical cleaning ($HNO_3$/HF mixture) is used to remove the oxide layer and drawing lubricant to ensure a clean surface in preparation for subsequent electroplating. | Cleaning time: 5-15 minutes. Acid concentration: $HNO_3$ 10-20%, HF 5-10%. Temperature: 25-40°C. | Chemical cleaning tank. Ultrasonic cleaning machine. | There is no oxide on the surface. The roughness tester shows Ra<0.2 μm. |
| **Electroplated** | Using ultra-fine | Current density: 5-20 | Electroplating | Diamond wire |

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| | | | | |
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| **diamond** | tungsten wire as the baseline, diamond particles are electroplated in a nickel-based electroplating solution to form diamond wire tungsten wire. Control the distribution and adhesion of diamond particles. | mA/cm² . Diamond particle size: 5-15 μm. Coating thickness: 10-20 μm. Electroplating time: 30-60 minutes. | bath (nickel-based solution). Diamond suspension. | tungsten wire, uniform particles. SEM detection of coating quality. |
| **Heat Treatment** | vacuum or $H_2$ atmosphere eliminates drawing and plating stresses, optimizes grain structure, and improves fracture resistance. | Temperature: 700-1000°C. Holding time: 1-2 hours. Cooling rate: 15-30°C/min (furnace cooling). | Vacuum annealing furnace. $H_2$ atmosphere furnace. | Internal stress <30 MPa. Grains were observed under a metallographic microscope. |
| **Quality Inspection** | Check tungsten wire diameter, coating uniformity, tensile strength and surface quality to ensure compliance with photovoltaic cutting requirements. | Diameter: 20-50 μm. Tensile strength: >1800 MPa. Coating defect: <0.05 μm. Surface roughness: Ra<0.3 μm. | SEM. Tensile machine. EDS analyzer. | Qualified diamond wire and tungsten wire. The factory report contains the test data. |
| **Packaging and Storage** | Seal the package with anti-oxidation material (such as PE film), fill with inert gas ($N_2$ or Ar), and store in a dry environment to avoid oxidation and damage. | Packaging humidity: <10% RH. Storage temperature: 15-25°C. Oxygen content: <50 ppm. | Vacuum packaging machine. Constant temperature and humidity warehouse. | Tungsten filaments are free from oxidation deterioration. Hygrometer monitors storage conditions. |

**16.11 Detailed description of the process flow**

The production of diamond tungsten wire (tungsten wire for photovoltaic cutting) uses high-purity ammonium paratungstate (APT) as raw material. By doping K, Al and rare earth elements (such as La or Ce) to improve the ductility, creep resistance and high temperature performance of tungsten, an ultra-fine tungsten wire baseline with a diameter of 20-50 μm is prepared, and then electroplated with diamond particles to form diamond wire for photovoltaic silicon wafer cutting. The process must meet the requirements of high strength (>1800 MPa), wear resistance and fine diameter to reduce the loss of silicon wafer cutting (<50 μm) and improve cutting efficiency. The following are the detailed steps:

**1. APT doping:**

High-purity APT (≥99.95%) is dissolved in deionized water, and KOH, $Al(NO_3)_3$ and rare earth nitrate ($La(NO_3)_3$) are added . The doping amounts are K 50-100 ppm , Al 10-50 ppm, and rare earth 20-80 ppm respectively. After precipitation, it is dried at 120-150°C to form doped APT crystals.

**2. Calcination reduction powder making**

The doped APT is reduced step by step in $H_2$ atmosphere : 450-600°C to generate blue tungsten oxide ( $W_{20}O_{58}$ ), and 750-900°C to reduce it to doped tungsten powder with a particle size controlled at 0.1-0.8 μm.

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**3. Powder pretreatment**
:High-energy ball milling is used to refine tungsten powder to <0.5 μm to ensure uniform distribution of doping elements and optimize ductility and sintering performance.

**4. Pressing and molding**
The doped tungsten powder is loaded into a slender mold and pressed into a rod-shaped green body by cold isostatic pressing (CIP) with a pressure of 300-450 MPa and a density of 9.5-11 g/ $cm^3$ .

**5. Pre-sintering Sintering in**
$H_2$ atmosphere at 1100-1300°C removes impurities and initially consolidates the green body to improve strength.

**6. High temperature sintering**
Sintering at 2700-3100°C, tungsten particles are combined and densified, density>19.2 g/$cm^3$ , optional HIP (2100°C, 180 MPa) to eliminate micropores.

**7. Hot forging or rotary**
forging is performed at 1500-1700°C to produce thin bars with a diameter of 0.5-1 mm, with a total deformation rate of >75%.

**8. Multi-stage drawing**
Ultrafine tungsten wires with a diameter of 20-50 μm are prepared by multi-pass drawing (reduction of 12-18% in each pass) and annealing at 900-1200°C.

**9. Surface cleaning:**
Use $HNO_3$ / HF mixture to clean for 5-15 minutes to remove the oxide layer and lubricant to ensure the surface is clean.

**10. Diamond electroplating**
Ultrafine tungsten wire is immersed in nickel-based electroplating solution with a current density of 5-20 mA/$cm^2$ and electroplated with 5-15 μm diamond particles (particle size 5-15 μm) to form diamond wire.

**11. Heat treatment**
Annealing at 700-1000°C eliminates stress, optimizes grain structure and enhances fracture resistance.

**12. Quality inspection**
Check diameter (20-50 μm), tensile strength (>1800 MPa), coating uniformity and surface quality to ensure that photovoltaic cutting standards are met.

**13. Packaging and storage:**
Seal the package and fill it with $N_2$ / Ar, store it in a low humidity environment to avoid oxidation and damage.

**14. Technical points**
**Doping effect** : K forms potassium bubbles to improve creep resistance, while Al and rare earth elements enhance ductility and oxidation resistance.
**Diameter control** : Multi-stage pulling and micro-hole diamond dies ensure diameter accuracy to 20-50 μm.
**Electroplating process** : The nickel-based coating needs to be evenly coated with diamond particles, with a coating thickness of 10-20 μm to improve cutting wear resistance.
**Photovoltaic requirements** : high strength (>1800 MPa) and thin diameter to reduce cutting loss (<50 μm), cutting speed can reach 2-3 mm/min.
**Quality requirements** : surface roughness Ra<0.3 μm, no peeling of coating, ensuring the surface quality of silicon wafer.

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**15. Typical applications**

**Diamond wire tungsten wire** : diameter 30-40 μm, used for photovoltaic single crystal silicon wafer cutting (thickness 120-150 μm).

**Photovoltaic cutting characteristics** : Each kilometer of diamond wire can cut about 5,000 silicon wafers, and the annual demand increases with the installed capacity of photovoltaic power (estimated to be 350 million kilometers in 2026).

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# CTIA GROUP LTD
# Tungsten Needle Introduction

## 1. Overview of CTIA GROUP Tungsten Needle

The high-precision tungsten needle designed and manufactured by CTIA GROUP is an ultra-fine needle-shaped metal tungsten product made of high-purity tungsten material. It has high hardness, high melting point, good conductivity and corrosion resistance. It is widely used in the electronics industry, medical equipment, semiconductor manufacturing, precision welding, probe testing, micromanipulation and other fields.

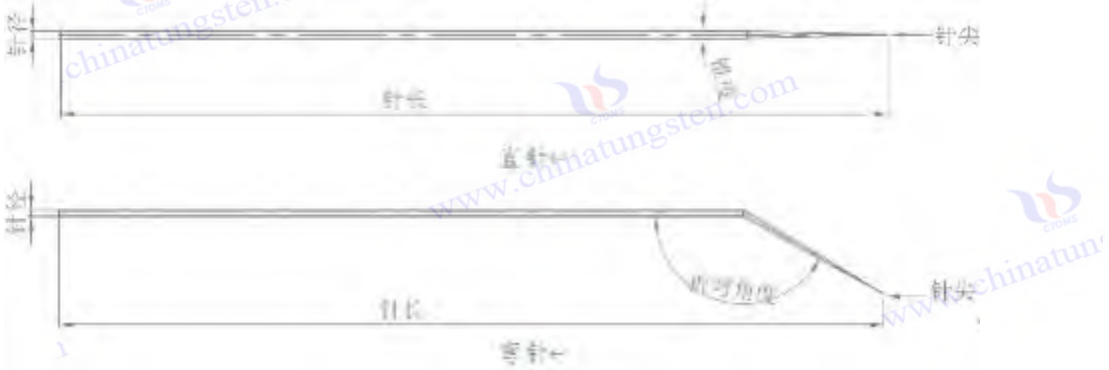
## 2. Characteristics of CTIA GROUP Tungsten Needle

**Ultra-high hardness:** The Mohs hardness of tungsten is as high as 9.0, ensuring that the tungsten needle is resistant to wear and deformation during high-precision operations.
**Extremely high melting point** : With a melting point of up to 3410°C, it can maintain stable shape and performance in high temperature environments.
**Excellent conductivity** : suitable for high-demand scenarios such as semiconductor test probes and electronic welding.
**Corrosion resistance: resistant** to acid, alkali and various harsh environments, suitable for long-term use.
**Precision machining:** can provide micron -level sharpening to meet the requirements of microscopic operation and fine contact.

## 3. Specifications of CTIA GROUP Tungsten Needle

| Parameter | Specification | Remark |
|---|---|---|
| Material | Pure tungsten (w≥99.95%) or tungsten alloy | |
| Needle diameter | 0.2~5.0mm | Customizable |
| Needle length | 10~300mm | Customizable |
| Tip taper | 10~25° | Customizable |
| Needle tip | 2~300 μ m | Customizable |
| Bending angle | 0~150° | Customizable |

## 4. Example of drawings of tungsten needles made by China Tungsten




## 5. Procurement Information

Email: sales@chinatungsten.com
Tel: +86 592 5129696
For more information about tungsten needles, please visit Chinatungsten Online ( www.tungsten.com.cn ) .

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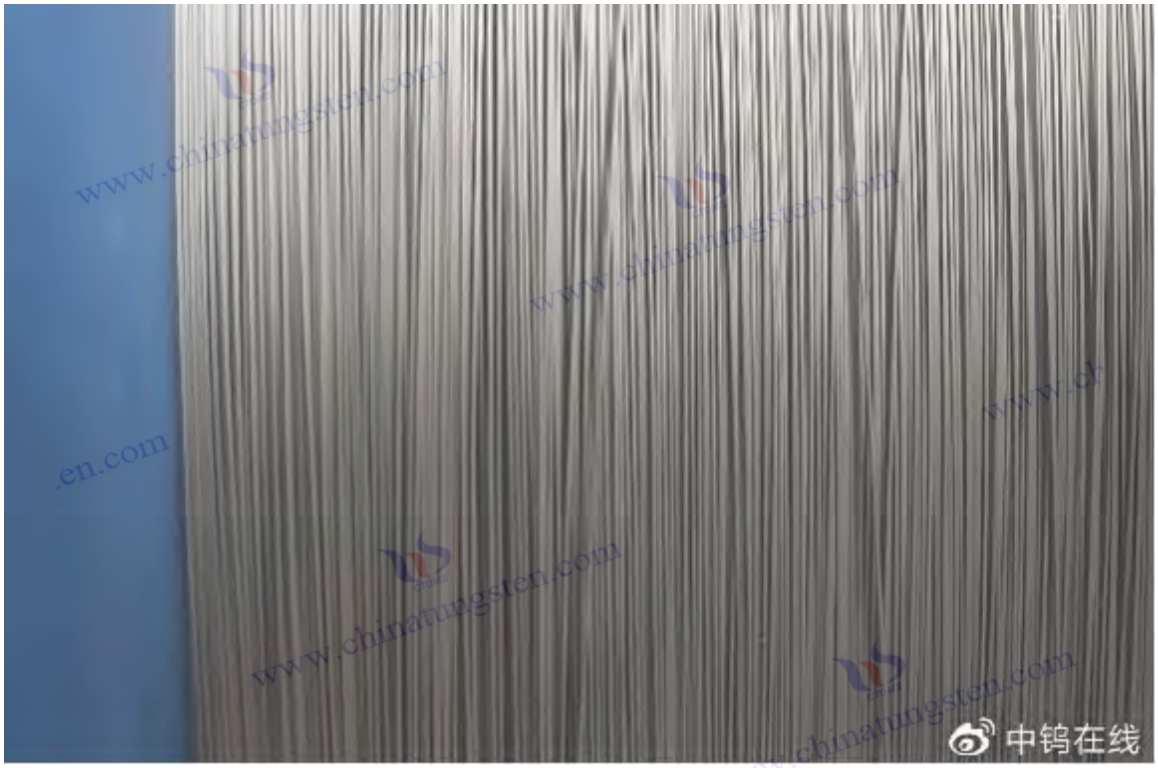


## Chapter 17 Specifications, Performance and Applications of Tungsten Alloy Products

This chapter comprehensively discusses the specifications, properties and wide applications of tungsten alloy products in the military, civilian and sports fields. Tungsten alloy is known for its high density, high strength and excellent physical properties, and is widely used in the defense industry, aerospace, civilian manufacturing and high-performance sports goods. This chapter starts with types and specifications, gradually introduces its characteristics, standards and specific uses, adds more application fields, and refers to the China Tungsten Online Tungsten Alloy website www.tungsten-alloy.com to supplement relevant content, especially the application of sports goods, and refines the specific requirements of each standard for readers to understand more accurately.

### 17.1 Types and specifications of tungsten alloys

Tungsten alloy is a composite material made of tungsten as the matrix and added with nickel (Ni), iron (Fe), copper (Cu), silver (Ag) or gold (Au) and other elements. According to the phase state and composition, it can be divided into two categories: high-density three-phase alloy and two-phase alloy:

**High density three-phase alloy (W-Ni-Fe)**

Composition: Tungsten (W) content is 90%-97%, nickel (Ni) and iron (Fe) are used as bonding phases, and the Ni:Fe ratio is usually 7:3 or 3:2.
Specification:
Rods: diameter 5-150 mm, length 50-2000 mm.
Plate: thickness 1-50 mm, width ≤600 mm, length ≤1500 mm.
Special-shaped parts: spherical (diameter 2-100 mm), cylindrical, customized parts.
Density: 17.0-18.5 g/ $cm^3$ .
Features: Three-phase structure provides higher strength and toughness.

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**Two-phase alloy**
**Tungsten Copper Alloy (W-Cu):**
Composition: 50%-90% tungsten, the rest is copper.
Specification:
Rods: diameter 3-100 mm, length 50-600 mm.
Thin sheet: thickness 0.5-25 mm, width ≤400 mm.
Density: 11.85-16.75 g/ cm³ .

**Tungsten silver alloy (W-Ag):**
Composition: 60%-85% tungsten, the rest is silver.
Specification:
Rods: diameter 5-80 mm, length 50-500 mm.
Sheet: thickness 1-20 mm, width ≤300 mm.
Density: 13.5-17.0 g/ cm³ .

**Tungsten-gold alloy (W-Au):**
Composition: 70%-90% tungsten, the rest is gold, rare and expensive.
Specifications: Customized production, such as small pieces or thin films.
Density: 15.0-18.0 g/ cm³ .
Features: Two-phase alloys are good at electrical and thermal conductivity, and their processability is better than that of three-phase alloys.
These alloys adjust their composition ratios and specifications according to their uses to meet diverse needs.

### 17.2 Excellent physical properties of tungsten alloy

Tungsten alloy performs well in a variety of extreme environments due to its unique physical properties:
High density: 17.0-18.5 g/cm³ for three-phase alloy and 11.85-18.0 g/ cm³ for two-phase alloy , much higher than steel (7.85 g/cm³ ) , making it an ideal material for counterweight and shielding.
High melting point: The tungsten matrix gives the alloy a high temperature resistance of about 3000°C, which is suitable for high temperature environments.
Excellent strength: The tensile strength of three-phase alloy is 900-1200 MPa, and that of two-phase alloy is 700-1000 MPa, with strong wear and compression resistance.
Thermal conductivity and electrical conductivity:
Tungsten copper: 140-230 W/(m·K), conductivity 30%-50% IACS.
Tungsten silver: thermal conductivity ~300 W/(m·K), electrical conductivity is better than tungsten copper.
Tungsten gold: Excellent conductivity but high cost.
Low thermal expansion coefficient: 4.5-6.5×$10^{-6}$ /°C, strong dimensional stability.
Corrosion resistance: Stable in acid and alkali environments, tungsten silver and tungsten gold have better oxidation resistance.
Processability: Three-phase alloys have good toughness and can be machined, while two-phase alloys have better ductility.
These properties give tungsten alloy significant advantages in high load, high temperature and precision applications.

### 17.3 Tungsten Alloy National Military Standard, US Military Standard and Other National Standards

Tungsten alloys must meet strict standards. The following are the specific requirements of the Chinese military standard (national military standard), the US military standard and international standards, including detailed parameters:

**China Tungsten Alloy Military Standard: GJB 3788-1999 (Technical Requirements for High-density Tungsten Alloy)**

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| parameter | Require | Test Method |
|---|---|---|
| Tungsten content | 90%-97% | GJB 5902 (Chemical Analysis) |
| density | ≥17.0 g/ cm³ | GJB 5903 (density measurement) |
| tensile strength | ≥900 MPa | GJB 228 (tensile test) |
| Elongation | ≥10% | GJB 228 |
| hardness | ≥25 HRC | GJB 5904 (Hardness test) |
| Fe content | ≤1.0% | GJB 5902 |
| Ni content | ≤5.0% | GJB 5902 |
| O content | ≤0.02% | GJB 13747 (oxygen analysis) |
| Grain size | ≤50 μm | GJB 6394 (Metallographic Analysis) |
| Dimensional tolerance | ±0.05 mm | GJB 1804 (Geometric Measurement) |
| Surface quality | No cracks, no inclusions | Visual/microscope inspection |
| Scope of application | High-density three-phase alloys (such as W-Ni-Fe) are used in military armor-piercing projectiles, counterweights, etc. | |

**US military standard for tungsten alloy : MIL-T-21014D**

| parameter | Require | Test Method |
|---|---|---|
| Tungsten content | 90%-97% | ASTM E1479 (Chemical Analysis) |
| density | 17.0-18.5 g/ cm³ | ASTM B311 |
| tensile strength | ≥758 MPa | ASTM E8 (Tensile Test) |
| Elongation | ≥5% | ASTM E8 |
| hardness | ≥24 HRC | ASTM E18 (Rockwell Hardness) |
| Fe content | ≤1.5% | ASTM E1479 |
| Ni content | ≤5.5% | ASTM E1479 |
| C content | ≤0.03% | ASTM E1019 |
| O content | ≤0.03% | ASTM E1479 |
| Grain size | ≤60 μm | ASTM E112 (Metallographic Analysis) |
| Dimensional tolerance | ±0.1 mm | ASTM B214 |
| Surface quality | No obvious defects | Visual inspection |
| Scope of application | High-density three-phase alloy, military and aerospace components | |

**ASTM B777-15 (high density tungsten alloy)**

| parameter | Requirements (by level) | Test Method |
|---|---|---|
| Tungsten content | Class 1: 90%; Class 2: 92.5%;<br>Class 3: 95%; Class 4: 97% | ASTM E1479 |
| density | Class 1: 17.0 g/cm ³ ; Class 2: 17.5 g/cm ³ ;<br>Class 3: 18.0 g/ cm³ ; Class 4: 18.5 g/ cm³ | ASTM B311 |
| tensile strength | ≥620 MPa | ASTM E8 |
| Elongation | Class 1: ≥15%; Class 2: ≥10%;<br>Class 3: ≥7%; Class 4: ≥2% | ASTM E8 |
| hardness | ≥24-32 HRC (depending on grade) | ASTM E18 |
| Fe content | ≤1.5% | ASTM |

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| | | |
|---|---|---|
| | | E1479 |
| Ni content | ≤5.5% | ASTM E1479 |
| Total impurities | ≤0.5% | ASTM E1479 |
| Grain size | ≤70 μm | ASTM E112 |
| Dimensional tolerance | ±0.1 mm | ASTM B214 |
| Surface roughness | Ra ≤1.6 μm | ASTM B946 |
| Scope of application | High-density three-phase alloy, divided into four grades (Class 1-4) | |

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## CTIA GROUP LTD
## High Density Tungsten Alloy Customization Service

CTIA GROUP is a customized expert in the design and production of high-density tungsten alloys with 30 years of experience .

**Core Advantages**
**30 years of experience** : Deeply familiar with tungsten alloy production and mature technology.
**Precise customization : Supports** the design and production of high density (17-19 g/cm³ ) , special performance , complex structure , oversized and extremely small parts .
**Quality cost** : optimized design, best mold and processing mode , excellent cost performance.
**Advanced Capabilities** : Advanced production equipment, RIM, ISO 9001 certification.

100,000+ **customers**
It covers a wide range of areas, including aerospace, military industry, medical equipment, energy industry , sports and entertainment .

**Service Commitment**
Official website has over 1 billion visits, over 1 million web pages, over 100,000 customers, and 0 complaints in 30 years!

**Contact Us**
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Official website: www.tungsten-alloy.com

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**Tungsten Copper Alloy Standard: ASTM B702-93 (2015)**

| Parameter | Require | Test method |
|---|---|---|
| Tungsten content | 50%-90% (grading: w50cu50, w70cu30, etc.) | Astm e1479 |
| Density | 11.85-16.75 g/cm³ ( depending on tungsten content) | Astm b311 |
| Thermal conductivity | ≥140 w/(m • k) | Astm e1461 |
| Conductivity | ≥30% iacs | Astm b193 |
| Tensile strength | ≥400 mpa | Astm e8 |
| Elongation | ≥5% | Astm e8 |
| Hardness | ≥100 hv | Astm e92 (vickers hardness) |
| Cu content | 10%-50% | Astm e1479 |
| Total impurities | ≤0.1% | Astm e1479 |
| Dimensional tolerance | ±0.05 mm | Astm b214 |
| Surface quality | No pores, no cracks | Visual/microscope inspection |
| Scope of application | Dual-phase alloys for electronic and thermal conductivity applications | |

**Tungsten Silver Alloy Standard**
**No independent international standard, refer to ASTM B702 or company specifications**

| Parameter | Typical requirements | Test method |
|---|---|---|
| Tungsten content | 60%-85% | Astm e1479 |
| Density | 13.5-17.0 g/ cm³ | Astm b311 |
| Thermal conductivity | ≥250 w/(m • k) | Astm e1461 |
| Conductivity | ≥50% iacs | Astm b193 |
| Tensile strength | ≥500 mpa | Astm e8 |
| Elongation | ≥8% | Astm e8 |
| Ag content | 15%-40% | Astm e1479 |
| Total impurities | ≤0.1% | Astm e1479 |
| Dimensional tolerance | ±0.05 mm | Astm b214 |
| Scope of application | Two-phase alloys, electrical contacts and precision parts | |

The Chinese military standard has the highest requirements for the strength and toughness of three-phase alloys. The US military standard and ASTM standard are more universal. The tungsten copper and tungsten silver standards focus on electrical and thermal conductivity.

### 17.4 All Applications of High Density Tungsten Alloy

High-density three-phase alloy (W-Ni-Fe, 17.0-18.5 g/cm³ ) is widely used:
Military: Armor-piercing cores, missile counterweights, radiation shielding.
Aerospace: gyroscope weights, flywheels, spacecraft counterweights.
Nuclear industry: radiation shielding containers, nuclear fuel storage tank linings.
Industrial: Vibration suppressors, high temperature molds, counterweights.

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Medical: X-ray and gamma-ray shielding (such as collimators).
Sports: Golf club weights, dart arrows.
Ships: Hull counterweights to improve stability.
Based on current market conditions, CTIA GROUP estimates that annual demand will be approximately 5,000 tons, with military and aerospace applications accounting for the majority[1].

### 17.5 Types and uses of two-phase alloys

Two-phase alloys including tungsten copper, tungsten silver and tungsten gold have unique electrical and thermal conductivity:
Tungsten Copper Alloy (W-Cu):
Use:
Electrospark machining (EDM) electrodes: resistant to high temperatures and ablation.
Electronic packaging heat dissipation substrate: high thermal conductivity, matching chip thermal expansion.
High voltage switch contacts: strong conductivity and arc resistance.
Demand: Based on current market conditions, CTIA GROUP estimates annual demand to be approximately 800 tons[2].
Tungsten silver alloy (W-Ag):
Use:
Electrical contacts: High conductivity, anti-oxidation, used in relays.
Precision instrument counterweight: non-magnetic, good stability.
Heat sink material: thermal conductivity is better than tungsten copper.
Demand: Based on current market conditions, CTIA GROUP estimates that annual demand will be approximately 200 tons, but usage is low due to high costs.
Tungsten-gold alloy (W-Au):
Use:
Microelectronic connectors: extremely high conductivity and corrosion resistance.
Aerospace precision components: high density combined with electrical conductivity.
Jewelry industry: high-end weight material to replace pure gold.
Demand: Based on current market conditions, CTIA GROUP estimates that the annual demand will be approximately 50 tons, with small quantities of customized production.
Two-phase alloys have significant advantages in the fields of electronics and precision.

### 17.6 Military Applications of Tungsten Alloys

Tungsten alloy has prominent uses in the military field:
Armor-piercing core: W-Ni-Fe three-phase alloy (18.0-18.5 g/cm³ ) , with a penetration depth of up to 800 mm steel plate. Based on current market conditions, CTIA GROUP estimates that annual demand will be approximately 2,000 tons [3].
Missile counterweight: High-density alloy adjusts the center of gravity and improves accuracy.
Armor protection: Tungsten alloy plate as a composite armor layer has strong impact resistance.
Radiation shielding: Shielding against gamma rays in military nuclear facilities.
Anti-tank weapons: Tungsten alloy fragmentation bombs to increase lethality.
China and the United States are the main producers, and based on current market conditions, CTIA GROUP estimates that military use will account for 40% of global demand [4].

### 17.7 Civilian Applications of Tungsten Alloys

Tungsten alloy has a wide range of applications in the civilian field. Please refer to www.tungsten-alloy.com for the following additional information:
Industrial Manufacturing:
Vibration dampers: machine tools, automobile engines (17.5 g/cm³ ) .
High temperature mold: wear-resistant and high temperature resistant.

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Oil drilling counterweight: Increase the weight of the drill bit to improve efficiency.
Electronics Industry:
Tungsten copper heat sink: thermal conductivity 200 W/(m·K), used for CPU and LED.
Tungsten silver contacts: high voltage switches and relays.
Medical devices:
Radiation shielding: CT collimators, radiotherapy equipment. According to current market conditions, CTIA GROUP estimates that the annual demand will be approximately 500 tons.
Surgical instruments: Tungsten alloy tools, durable and precise.
Aerospace:
Aircraft counterweight: adjust the center of gravity and save space.
Satellite balance parts: high density, corrosion resistant.
Energy sector:
Wind turbine counterweights: improving blade stability.
Nuclear power plant shielding: protection against radiation.
Based on current market conditions, CTIA GROUP estimates that annual civilian demand will be approximately 2,500 tons, with rapid growth in the electronics and medical fields[1].

### 17.8 Sports Applications of Tungsten Alloy

Tungsten alloy is favored in sports equipment due to its high density and environmental friendliness. Please refer to www.tungsten-alloy.com and add diving, racing and other uses:

**Tungsten Alloy Golf Club Head :**
W-Ni-Fe weight (18 g/cm³ ) optimizes the center of gravity of the swing, improves the hitting distance and stability. According to the current market situation, CTIA GROUP estimates that the annual demand is about 100 tons.

**Tungsten Alloy Dart Shaft/Dart Barrel :**
Tungsten alloy arrow body ( 90%-95% W) is small in size, concentrated in weight, and highly accurate. According to current market conditions, CTIA GROUP estimates that the annual demand will be approximately 80 tons.

**Tungsten Alloy Fishing Sinkers:**
It can replace lead sinkers with a density of 17.5 g/cm³ , fast sinking and environmentally friendly. According to the current market situation, CTIA GROUP estimates that the annual demand is about 50 tons.

**Tungsten Alloy Diving Equipment Weight:**
Tungsten alloy counterweights have high density and small size. They are used to adjust the buoyancy of diving belts and fins. According to current market conditions, CTIA GROUP estimates that the annual demand will be about 30 tons.

**Tungsten Alloy Racing Weights:**
High-density tungsten alloy adjusts the center of gravity of F1 racing cars and motorcycles and improves handling. According to current market conditions, CTIA GROUP estimates that the annual demand will be approximately 20 tons.

**Pinewood Tungsten Alloy Car Weight:**
Tungsten alloy blocks (17-18 g/cm³ ) for children's model racing cars increase speed and stability. According to current market conditions, CTIA GROUP estimates that the annual demand is about 10 tons.

**Tungsten Alloy Counterweight for Small UAV:**
Small pieces of tungsten alloy are used to adjust the balance of drones and improve flight accuracy. According to current market conditions, CTIA GROUP estimates that the annual demand will be approximately 15 tons.

**Tungsten Alloy Shotgun Bullet:**
Tungsten alloy bullets (17.5-18 g/cm³ ) can replace lead bullets, have strong penetrating power and are environmentally friendly. According to the current market situation, CTIA GROUP estimates that the annual demand is about 50 tons.

**Tungsten Alloy Ball for Shotgun:**
High-density tungsten balls (2-5 mm in diameter) improve range and lethality. According to current market conditions, CTIA GROUP estimates that the annual demand will be approximately 40 tons.

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**Tungsten alloy bullets for small caliber competition pistols and rifles:**
Tungsten alloy warheads (90%-95% W) have high precision and meet the environmental protection requirements of the competition. According to the current market situation, CTIA GROUP estimates that the annual demand is about 20 tons.
**Tungsten Alloy Shot Put for Sports Competition:**
Tungsten alloy shot put has high density and small size, which improves the throwing experience. According to the current market situation, CTIA GROUP estimates that the annual demand is about 10 tons.
**Tungsten alloy weights for dumbbells, javelin and discus:**
High-density counterweights adjust the center of gravity of the equipment and improve training results. Based on current market conditions, CTIA GROUP estimates that annual demand will be approximately 20 tons.
**Tungsten alloy weights for high-end fitness equipment such as barbells:**
Tungsten alloy barbell plates (17-18 g/cm³ ) are small in size and heavy in weight, making them suitable for high-end gyms. According to current market conditions, CTIA GROUP estimates that the annual demand is about 30 tons.
**Tungsten Alloy Archery Weights:**
Tungsten alloy arrowheads increase penetration and improve competition results.
Tennis rackets and badminton rackets:
The counterweight adjusts the balance point and enhances the power of the shot.
**Tungsten Alloy Ski Equipment:**
The skis are weighted to improve handling.
According to current market conditions, CTIA GROUP estimates that the annual demand for sports applications will be approximately 400-500 tons. As it is non-toxic and gradually replaces lead products, the market potential continues to expand[5].

**17.9 Production process of tungsten alloy, taking high-density tungsten alloy radiation shielding as an example**
The production process of tungsten alloys, taking high-density tungsten alloy radiation shielding parts as an example, is as follows . High-density tungsten alloys (such as W-Ni-Fe or W-Ni-Cu) are widely used in nuclear medicine (such as gamma knife shielding), nuclear industry (such as radiation containers) and aerospace (such as X-ray protection) due to their high density (17-19.0 g/cm³ ) , excellent radiation shielding performance and mechanical strength. Its production uses high-purity tungsten powder as the main raw material, and is prepared through powder metallurgy (doped with Ni, Fe or Cu as a binder phase), pressing, sintering and subsequent processing. This process is based on general industrial practices (such as ASTM B777 standard) and literature data, and refines the process characteristics of radiation shielding parts to ensure high density and uniformity.

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**High Density Tungsten Alloy Radiation Shielding Production Process**

| step | Detailed process | Key parameters and conditions | Equipment and Tools | Product and quality control |
|---|---|---|---|---|
| **raw material Prepare** | High-purity tungsten powder (W) and binder metal powder (such as Ni, Fe or Cu) are selected, sieved to remove impurities, and dried to remove moisture. | W purity: ≥99.95%, particle size: 1-5 μm. Ni/Fe/Cu purity: ≥99.9%, particle size: 1-10 μm. Moisture: <0.05%. | Vibrating screen (200-400 mesh) Vacuum oven (100-150°C, $10^{-1}$ Pa). | High purity powder, uniform particle size. SEM morphology, ICP-MS detection of impurities. |
| **Powder Proportioning and Mixing** | Weigh tungsten powder and binder phase in proportion (typical ratio: W 90-95%, Ni 3-7%, Fe/Cu 1-3%) and mix them evenly using a mixer. | Mixing time: 8-12 hours, speed 50-100 rpm. Homogeneity: ±0.5%. Avoid over-grinding to prevent particle breakage. | V-type mixer or planetary ball mill. | Mix the powders evenly. XRF detects the distribution of components. |
| **suppress forming** | The mixed powder is loaded into a mold and cold isostatic pressing (CIP) or uniaxial pressing is used to make a shielding component green body (such as a plate or a cylinder). | Pressing pressure: 200-350 MPa. Holding time: 2-5 minutes. Green density: 9-11 g/cm³ ( about 50-60% theoretical density). | Cold isostatic press (CIP). Steel or rubber mould. | The green body has a regular shape and no cracks. The density of the green body is tested by a densitometer. |
| **Pre-sintering** | Low-temperature sintering in a | Temperature: 1000-1200°C. Holding time: 2- | Hydrogen sintering | The strength of the pre-sintered |

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| | | | | |
|---|---|---|---|---|
| | hydrogen atmosphere furnace removes volatile impurities and preliminarily consolidates the green body to enhance strength for subsequent operations. | 4 hours. $H_2$ flow rate: 5-15 L/min, pressure 0.1-0.5 MPa. | furnace (molybdenum boat). | billet is improved. The mass loss is detected by weighing (<1%). |
| **High temperature liquid Phase sintering** | Liquid phase sintering is carried out in a high temperature furnace, and Ni-Fe or Ni-Cu melts to fill the gaps between tungsten particles and densify to form a high-density tungsten alloy. | ( above Ni-Fe eutectic point). Holding time: 1-3 hours. Atmosphere: $H_2$ or vacuum ($10^{-3}$Pa ) . | High temperature sintering furnace (tungsten boat or graphite boat). | Density 17-18.5 g/cm³ ( >95% theoretical density). X-ray detection of porosity. |
| **cool down** | After sintering, the alloy is slowly cooled in the furnace to avoid thermal stress and phase separation and ensure uniform distribution of the bonding phase. | Cooling rate: 5-20°C/min (furnace cooling to room temperature). Atmosphere: $H_2$ or Ar protection. | The sintering furnace has a built-in cooling system. | The structure is uniform and has no cracks. The phase distribution is observed by metallographic microscope. |
| **Heat treatment (optional)** | Annealing in vacuum or $H_2$ atmosphere eliminates internal stress and optimizes grain structure and mechanical properties. | Temperature: 800-1100°C. Holding time: 1-2 hours. Cooling rate: 10-30°C/min. | Vacuum annealing furnace. $H_2$ atmosphere furnace . | Internal stress <50 MPa. Hardness tester ( HV 300-350). |
| **Machining** | The sintered tungsten alloy blank is turned, milled or ground into the shape of shielding parts (such as plates, rings, containers). Surface defects are removed. | Cutting speed: 10-40 m/min. Feed rate: 0.05-0.15 mm/rev. Coolant: Oil-based or dry machining. | CNC lathes, milling machines. Carbide tools. | Precise shape. Coordinate measuring machine checks dimensions (±0.02 mm). |
| **surface deal with** | Polishing improves surface finish, or sandblasting increases roughness. Ni or Pb plating can be used to enhance corrosion resistance and shielding effect. | Polishing: Ra < 0.4 μm. Sandblasting: Ra 1-3 μm. Coating thickness: 5-20 μm. Cleaning: $HNO_3$ solution , 5-10 minutes. | Polishing machine or sandblasting machine. Electroplating equipment. | The surface is smooth or uniformly rough. The roughness meter detects the Ra value. |

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| | | | | |
|---|---|---|---|---|
| **quality Detection** | Check density, dimensions, mechanical properties, radiation shielding properties and microstructure to ensure compliance with ASTM B777 standards. | Density: 17-18.5 g/cm³ . Tensile strength: >700 MPa. Hardness: HV 300-350. Gamma ray attenuation: >90% (1 MeV). | Archimedean density meter. Stretching machine. Gamma ray detector. | Qualified shielding parts. Factory report contains test data. |
| **Package store** | Seal the package with anti-oxidation material (such as aluminum foil bag), fill with inert gas ($N_2$ or Ar), and store in a dry environment to avoid oxidation and moisture absorption. | Packaging humidity: <20% RH. Storage temperature: 10-30°C. Oxygen content: <100 ppm. | Vacuum packaging machine. Constant temperature and humidity warehouse. | The product has no oxidation deterioration. The storage conditions are monitored by a hygrometer. |

**Detailed description of the production process of high-density tungsten alloy radiation shielding parts**

The production of high-density tungsten alloy radiation shielding parts uses high-purity tungsten powder (W) as the main raw material, and is prepared by powder metallurgy by doping a binder phase (such as Ni-Fe or Ni-Cu, with a ratio of W 90-95%, Ni 3-7%, Fe/Cu 1-3%). Its high density (17-18.5 g/cm ³ ) and excellent radiation shielding properties make it suitable for nuclear medicine (such as gamma knife shielding), nuclear industry (such as radiation containers) and aerospace (such as X-ray protection). The following are the detailed steps:

**1. Raw material preparation:**
Select high-purity tungsten powder (purity ≥99.95%, particle size 1-5 μm) and binder metal powder (Ni, Fe or Cu, purity ≥99.9%, particle size 1-10 μm), sieve to remove impurities, and dry to moisture <0.05%.

**2. Powder Proportion and Mixing**
Weigh the powders according to the proportion (W 90-95%, Ni 3-7%, Fe/Cu 1-3%) and mix them in a V-type mixer for 8-12 hours to ensure the uniformity of the composition (±0.5%).

**3. Pressing and molding:**
The mixed powder is loaded into a mold and pressed into a shielding green body (such as a plate or cylinder) by cold isostatic pressing (CIP) with a pressure of 200-350 MPa and a green body density of 9-11 g/ cm³ .

**4. Pre-sintering**
Sintering in $H_2$ atmosphere at 1000-1200°C removes volatile impurities and initially consolidates the green body to improve strength .

**5. High temperature liquid phase sintering**
Liquid phase sintering is carried out at 1450-1550°C, Ni-Fe or Ni-Cu melts to fill the gaps between tungsten particles and densify to 17-18.5 g/cm³ in an atmosphere of $H_2$ or vacuum.

**6. Cooling**
After sintering, furnace cool at a rate of 5-20°C/min to avoid thermal stress and phase separation and ensure uniform distribution of the bonding phase.

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**7. Heat treatment (optional) Annealing**
at 800-1100°C to eliminate internal stress, optimize grain structure and improve mechanical properties.

**8. Machining:**
Use CNC equipment for turning, milling or grinding to process into the shape of shielding parts (such as plates, rings), with a cutting speed of 10-40 m/min and a dimensional accuracy of ±0.02 mm.

**9. Surface treatment:**
Polishing to Ra<0.4 μm to improve smoothness, or sandblasting to Ra 1-3 μm to increase roughness, and Ni/Pb (5-20 μm) can be plated to enhance corrosion resistance.

**10. Quality inspection**
Density (17-18.5 g/cm³ ) , tensile strength (>700 MPa), hardness (HV 300-350) and gamma ray attenuation (>90%, 1 MeV) in accordance with ASTM B777.

**11. Packaging and storage:**
Seal the package and fill it with $N_2$ / Ar, store it in a low humidity environment to avoid oxidation.

**12. Technical points**
**Ratio design** : W content of 90-95% ensures high density, and Ni-Fe (or Ni-Cu) ratio optimizes adhesion and processability.
**Liquid phase sintering** : 1450-1550°C melts the binder phase and fills the gaps between tungsten particles, with a density of 17-18.5 g/ cm³ .
**Processing difficulty** : Tungsten alloy has high hardness and requires carbide tools and low-speed cutting to avoid cracks.
**Shielding performance** : Density and thickness determine the radiation attenuation rate (e.g. 18 g/cm³ , 10 mm thick attenuates 1 MeV gamma rays by >95%).
**Usage** : Plate-shaped is used for nuclear container lining, and ring-shaped is used for medical collimators.

**13. Typical applications**
**Gamma Knife shield** : W-Ni-Fe alloy, density 18 g/cm³ , thickness 20 mm.
**Nuclear fuel container lining** : W-Ni-Cu alloy, density 17.5 g/cm³ , custom sizes.

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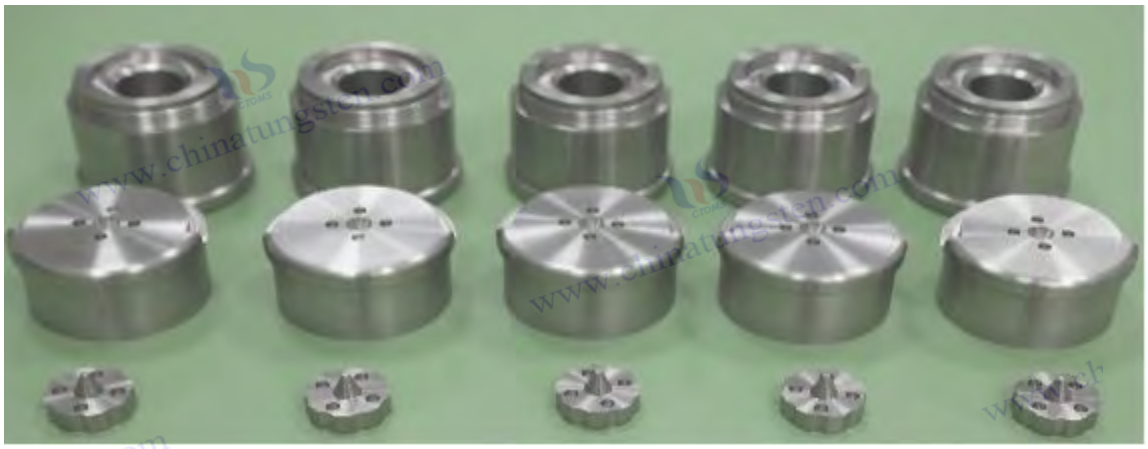

**Chapter 19: Cemented Carbide, Specifications, Characteristics and Applications ( I )**

With its excellent hardness, wear resistance and toughness, cemented carbide occupies an important position in the industrial, military and civilian fields. This chapter (Part 1) focuses on the types and specifications of cemented carbide, physical properties and national brand standards, laying the foundation for the subsequent application part. The content refers to international standards, industry data and actual application cases to ensure both technicality and practicality.

## 19.1 Types and specifications of cemented carbide

Cemented carbide is a composite material with tungsten carbide (WC) as the main hard phase and cobalt (Co) or other metals as the bonding phase. According to the added elements and uses, it can be divided into many types, and its specifications cover bars, plates and complex special-shaped parts to meet different processing

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needs.

### 19.1.1 Classification and composition of cemented carbide

#### 19.1.1.1 WC-Co (Tungsten-Cobalt) Alloy

WC-Co alloy is the most common type of cemented carbide, with WC content usually between 85%-98% and Co content between 2%-15%. Cobalt is a binder phase, and its content directly affects performance: low Co content (such as 6%) increases hardness, and high Co content (such as 15%) enhances toughness. This alloy is known for its high hardness and wear resistance and is widely used in cutting tools and mining equipment.

#### 19.1.1.2 WC-TiC-Co (Tungsten Titanium Cobalt) Alloy

Adding 5%-30% titanium carbide (TiC) to WC-Co improves the high temperature hardness and oxidation resistance of the alloy. The addition of TiC makes the grains finer, enhances the wear resistance, and reduces the adhesive wear at high temperatures, making it suitable for high-speed cutting of steel and processing in high temperature environments.

#### 19.1.1.3 WC-TaC-Co (tungsten-tantalum-cobalt) and other composite cemented carbides

By adding 1%-10% of tantalum carbide (TaC) or niobium carbide (NbC), thermal shock resistance and wear resistance are further improved. TaC inhibits grain growth and enhances high temperature stability; NbC improves wear resistance. These composite alloys are suitable for extreme working conditions, such as aerospace parts processing and high temperature mold manufacturing.

#### 19.1.1.4 Other types of cemented carbide

WC-Ni (Tungsten Nickel) Alloy
By replacing cobalt with nickel, the Co content is reduced or completely removed, and the corrosion resistance is significantly improved, making it suitable for wear-resistant parts in acidic environments.

TiC-based cemented carbide (tungsten-free type)
Mainly made of TiC, it is lightweight and designed for specific heat-resistant and wear-resistant scenarios.

Ultrafine Grains and Nano-Carbonized Carbide
The grain size is <0.5μm, and the hardness can reach HRA 93 or above. It has both high hardness and toughness and is suitable for precision machining.

Cermet
With TiCN as the core and combined with Ni or Co, it has better wear resistance and heat resistance than traditional cemented carbide and is used for high-speed precision cutting.

### 19.1.2 Specification range of cemented carbide

#### 19.1.2.1 Bars

The diameter range is 2-50 mm and the length is 50-1000 mm, which is suitable for making tools such as drills and milling cutters. The surface is usually ground and the finish is Ra≤0.4 μm to ensure high-precision processing requirements.

#### 19.1.2.2 Board

Thickness 1-30 mm, width 50-500 mm, length 100-1500 mm, tolerance controlled between ±0.05 mm and

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±0.2 mm, used for molds, punches or wear-resistant liners.

#### 19.1.2.3 Tool blanks

Standard sizes include round (diameter 5-30 mm) and square (side length 5-50 mm), which can be customized according to tool type (such as turning tools, drills) and provided in sintered blanks or semi-finished states.

#### 19.1.2.4 Special-shaped parts

Spherical: diameter 1-100 mm, used for grinding balls or bearing parts.
Cylindrical: The diameter and height can be customized (e.g. 5-50 mm), commonly used in seals or punches.
Sealing ring: inner diameter 5-200 mm, outer diameter and thickness designed according to working conditions, used for mechanical sealing.
Other complex shapes: such as nozzles (aperture 0.5-10 mm), toothed parts (tooth height 1-20 mm), to meet the needs of customized molds and wear-resistant parts.

### 19.2 Excellent physical properties of cemented carbide

Due to its unique physical properties, cemented carbide has become an ideal material for high load, high temperature and wear-resistant environments. The following is a detailed description of its characteristics in terms of hardness, compressive strength and thermal stability.

#### 19.2.1 Hardness and wear resistance

#### 19.2.1.1 High hardness

Hardness range HRA 85-94, depending on WC content and grain size. Test methods include Vickers hardness (HV 1500-2000) and Rockwell hardness (HRA). The smaller the grain size (e.g. <1μm), the higher the hardness; increasing Co content slightly reduces hardness but improves toughness.

#### 19.2.1.2 Wear resistance and anti-wear mechanism

Wear resistance is measured by wear rate (mg/cm² ) , which is usually less than 0.1 mg/cm² . WC grains provide hardness support, and Co phase absorbs impact and prevents crack propagation, which synergistically forms excellent wear resistance. Suitable for high-speed cutting (cutting speed>200 m/min) and mining (wear life>1000 hours).

#### 19.2.2 Compressive strength and toughness

#### 19.2.2.1 Compressive strength

The compressive strength is 4000-6000 MPa, which decreases slightly with the increase of Co content. The test adopts compression test, and the stress-strain curve shows its high load-bearing capacity, making it suitable for high-load scenarios such as stamping dies and rock drilling tools.

#### 19.2.2.2 Toughness and impact resistance

Fracture toughness (KIC) 5-15 MPa·m $^{1/2}$ , high Co content (such as 10%-15%) improves impact resistance and prevents chipping or fracture. The balanced design of hardness and toughness (such as YG8) makes it both wear-resistant and impact-resistant, suitable for intermittent cutting.

#### 19.2.3 Thermal stability and corrosion resistance

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#### 19.2.3.1 Thermal stability

The maximum operating temperature is about 1000°C, and the thermal expansion coefficient is 5-7×10 $^{-6}$ /°C, ensuring dimensional stability at high temperatures. Thermal fatigue tests show that it still maintains its performance in 500°C cyclic heating, making it suitable for high-temperature molds and aviation parts processing.

#### 19.2.3.2 Corrosion resistance

Stable in acidic and alkaline environments with a pH of 2-12, WC has strong corrosion resistance, and the Co phase forms a protective oxide layer in high-temperature air. WC-Ni alloy further improves corrosion resistance and is suitable for wear-resistant parts in chemical equipment.

### 19.3 Cemented Carbide Grades and National Standards

The grade of cemented carbide reflects its composition and performance, and each country's standard system has its own characteristics. This section introduces the grade naming and the technical parameters of typical grades in various countries in detail.

#### 19.3.1 Significance of cemented carbide grades

#### 19.3.1.1 Brand naming rules

The grade is usually represented by a combination of letters and numbers, such as "Y" for hard (tungsten-based), "G" for cobalt, and "T" for titanium addition. The number indicates the Co content or performance level, and the suffix (such as "X") indicates the refinement process.

#### 19.3.1.2 Comparison of International and National Brand Name Systems

ISO K10 corresponds to China's YG6 and the United States' C-2; the ISO P series is similar to China's YT series. Although the names of different countries are different, the performance can be compared through ISO standard mapping.

#### 19.3.2 China's cemented carbide grades, chemical composition, properties and uses

**Naming rules and explanations of Chinese cemented carbide grades**
Naming convention:
"Y": cemented carbide (the first letter of the pinyin for "hard").
"G": cobalt (Co) based.
"T": Titanium (TiC) added.
"W": Tantalum (TaC) or niobium (NbC) addition.
Numbers: Usually Co content (%) or performance level.
Suffix: "X" indicates fine grain, "A" indicates improved type.
Example explanation:
YG6X: Tungsten-cobalt based, 6% Co, fine grain (<1μm), hardness HRA 91, suitable for high-precision machining.
YT15: Tungsten-titanium-cobalt based, TiC about 15%, hardness HRA 91, strong wear resistance, suitable for high-speed cutting of steel.
YW1: Tungsten-tantalum-cobalt based, TaC added, high hardness HRA 92, excellent heat resistance, suitable for high temperature processing.

**Typical Grade Examples**
YG6: WC 94%, Co 6%, HRA 89.5, flexural strength 2000 MPa, mining and cutting.

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YG8: WC 92%, Co 8%, HRA 89, flexural strength 2200 MPa, impact resistant tools.
YT15: WC 79%, TiC 15%, Co 6%, HRA 91, high speed cutting steel.
YG6X: WC 94%, Co 6% (fine grain), HRA 91, precision machining.
YW1: WC 89%, TaC 5%, Co 6%, HRA 92, heat-resistant cutting.

**China cemented carbide grades**

| Brand | Corresponding ISO brand | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| YG6 | K20 | WC 94%, Co 6% | HRA 89.5, flexural strength 2000 MPa, density 14.9 g/ cm³ | Mining tools, general cutting |
| YG8 | K30 | WC 92%, Co 8% | HRA 89, flexural strength 2200 MPa, density 14.7 g/ cm³ | Impact-resistant tools and molds |
| YT15 | P15 | WC 79%, TiC 15%, Co 6% | HRA 91, flexural strength 1700 MPa, density 14.0 g/ cm³ | High speed cutting steel |
| YG6X | K10 | WC 94%, Co 6% (fine grain) | HRA 91, flexural strength 2100 MPa, density 14.9 g/ cm³ | Precision machining, micro tools |
| YW1 | P05 | WC 89%, TaC 5%, Co 6% | HRA 92, flexural strength 1800 MPa, density 14.5 g/ cm³ | High temperature cutting, wear-resistant parts |

**Performance characteristics and applications**
YG is good at balancing wear resistance and toughness, YT is suitable for steel processing, and YW is resistant to high temperatures. Chinese cemented carbide is widely used in machinery manufacturing, mining and aviation.

### 19.3.3 U.S. cemented carbide grades, chemical composition, properties and uses

**Typical Grade Examples**
C-2: WC 94%, Co 6%, HRA 92, wear-resistant cutting tools.
C-4: WC 90%, Co 10%, HRA 90, impact-resistant mining tools.

**American cemented carbide grade table**

| Brand | Corresponding ISO brand | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| C-2 | K10 | WC 94%, Co 6% | HRA 92, flexural strength 1800 MPa | Wear-resistant cutting tools |
| C-4 | K30 | WC 90%, Co 10% | HRA 90, flexural strength 2300 MPa | Mining, impact-resistant components |

**Performance and Application**
ANSI C1-C4 increases from high hardness to high toughness and is widely used in industrial knives and wear-resistant parts.

### 19.3.4 Japanese cemented carbide grades, chemical composition, properties and uses

**Typical Grade Examples**
P10: WC-TiC-Co, HRA 91.5, high speed precision cutting.
M20: WC-Co base, HRA 90, general processing and mold.

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**Japanese cemented carbide grades**

| Brand | ISO grades | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| P05 | P05 | WC 80%, TiC 15%, Co 5% | HRA 92, flexural strength 1650 MPa, density 14.1 g/ cm³ | High-speed precision cutting of steel |
| P10 | P10 | WC 79%, TiC 15%, Co 6% | HRA 91.5, flexural strength 1700 MPa, density 14.0 g/ cm³ | Precision cutting steel |
| M20 | M20 | WC 90%, Co 10% | HRA 90, flexural strength 2200 MPa, density 14.5 g/ cm³ | Stainless steel, general processing |
| K10 | K10 | WC 94%, Co 6% | HRA 91, flexural strength 2000 MPa, density 14.9 g/ cm³ | Cast iron and non-ferrous metal cutting |

**Performance and Application**
JIS standard P series is suitable for steel processing, M series has strong versatility, and K series is for cast iron, which is widely used in precision processing in the automotive and electronics industries.

### 19.3.5 Korean cemented carbide grades, chemical composition, properties and uses

**Typical Grade Examples**
H10F: Ultrafine grain WC-Co, HRA 92, micro drills and cutters.

**Korean cemented carbide grade table**

| Brand | ISO grades | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| H05F | K05 | WC 95%, Co 5% (fine grain) | HRA 93, flexural strength 1900 MPa, density 15.0 g/ cm³ | Ultra-precision machining |
| H10F | K10 | WC 94%, Co 6% (fine grain) | HRA 92, flexural strength 2100 MPa, density 14.9 g/ cm³ | PCB drill bits, micro cutters |

Korean grades are known for their fine grain technology and are suitable for high-precision processing of PCB drills in the electronics industry and automotive parts.

### 19.3.6 Israeli cemented carbide grades, chemical composition, properties and uses

**Typical Grade Examples**
IC908: WC-Co-TiC, HRA 91.5, aviation and military cutting.

**Israeli cemented carbide grade table**

| Brand | ISO grades | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| IC908 | P20 | WC 80%, TiC 12%, Co 8% | HRA 91.5, flexural strength 1900 MPa, density 14.2 g/ cm³ | Aviation parts, military cutting |
| IC928 | M20 | WC 88%, Co 12% | HRA 90, flexural strength 2300 MPa, density 14.6 g/ cm³ | Stainless steel and alloy steel processing |

**Performance and Application**
Israeli grades (such as ISCAR products) are known for their high temperature resistance and high strength, and are widely used in military and aviation titanium alloy processing.

### 19.3.7 Swedish cemented carbide grades, chemical composition, properties and uses

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**Typical Grade Examples**
GC235: WC-Co, HRA 90, mining tools.
S20: WC-TiC-Co, HRA 91, cutting steel.

**Swedish cemented carbide grade table**

| Brand | ISO grades | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| GC235 | K30 | WC 90%, Co 10% | HRA 90, flexural strength 2300 MPa, density 14.5 g/ cm³ | Mining tools, impact-resistant parts |
| S20 | P20 | WC 82%, TiC 10%, Co 8% | HRA 91, flexural strength 1900 MPa, density 14.3 g/ cm³ | Steel cutting |

**Performance and Application**
Swedish grades (such as Sandvik products) are both impact-resistant and wear-resistant, and are suitable for heavy-duty industry and cutting processing.

**19.3.8 European cemented carbide grades, chemical composition, properties and uses**

**Typical Grade Examples**
K10: WC 94%, Co 6%, HRA 91, general purpose cutting.
P40: WC-TiC-Co, HRA 89, steel rough machining.

**European cemented carbide grades**

| Brand | ISO grades | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| K10 | K10 | WC 94%, Co 6% | HRA 91, flexural strength 2000 MPa, density 14.9 g/ cm³ | Cast iron and non-ferrous metal cutting |
| P40 | P40 | WC 80%, TiC 10%, Co 10% | HRA 89, flexural strength 2100 MPa, density 14.2 g/ cm³ | Rough processing of steel |

**Performance and Application**
European EN standard grades have strong versatility and are widely used in machinery manufacturing and mold industries.

**19.3.9 Cemented carbide grades, chemical composition, properties and uses in international standards**

**ISO 513 classification**
K series: cast iron and non-ferrous metal processing (K10-K40).
P series: steel processing (P10-P50).
M series: general purpose machining (M10-M40).

**ISO cemented carbide grades table**

| Brand | Chinese Brand | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| K10 | YG6, C-2 | WC 94%, Co 6% | HRA 91, flexural strength 2000 MPa, density 14.9 g/ cm³ | Cast iron and non-ferrous metal cutting |
| P20 | YT15, IC908 | WC 80%, TiC 12%, Co 8% | HRA 91, flexural strength 1900 MPa, density 14.2 g/ cm³ | Medium speed cutting of steel |
| M20 | YW2, | WC 88%, Co 12% | HRA 90, flexural strength 2300 MPa, | Stainless steel, general |

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| | | | |
|---|---|---|---|
| | IC928 | density 14.6 g/ cm³ | processing |

### 19.3.10 Military cemented carbide grades, chemical composition, properties and uses

**ASTM B406 standard**
ASTM standard emphasizes ingredient purity and performance consistency. It does not list a separate grade table, but is compatible with ISO.

**Typical military grades**
GJB-X1: Ultra-high hardness WC-Co, HRA 93 or above.
**Military cemented carbide grades**

| Brand | Corresponding ISO brand | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| GJB-X1 | K05 | WC 95%, Co 5% (fine grain) | HRA 93, flexural strength 2000 MPa, density 15.0 g/ cm³ | Bullet core, armor protection |
| GJB-X2 | K20 | WC 92%, Co 8% | HRA 91, flexural strength 2200 MPa, density 14.7 g/ cm³ | Military knives, wear-resistant parts |

**Performance and Application**
Military grades emphasize ultra-high hardness and impact resistance and are used in ammunition manufacturing and armor protection.

### 19.3.11 Other cemented carbide grades, chemical composition, properties and uses

**New brands**
Ultrafine grain alloy: grain <0.5μm, HRA 93.
Nanocomposite alloy: WC-Ni based, with improved corrosion resistance.

**Other cemented carbide grades**

| Brand | Corresponding ISO brand | Principal component% | Performance characteristics | use |
|---|---|---|---|---|
| UF-1 | K01 | WC 96%, Co 4% (nanocrystalline) | HRA 94, flexural strength 1900 MPa, density 15.0 g/ cm³ | Ultra-precision machining |
| WN-10 | - | WC 90%, Ni 10% | HRA 89, flexural strength 2300 MPa, density 14.6 g/ cm³ | Corrosion and wear resistant parts |

#### 19.3.11.1 Special Purpose
Emerging cemented carbide grades (such as ultrafine grain alloys and nanocomposite alloys) have broken through the application limitations of traditional cemented carbide due to their unique properties, especially showing significant advantages in high-temperature aviation parts and environmentally friendly wear-resistant applications. These grades meet the needs of extreme working conditions and high environmental standards by optimizing grain size, introducing new bonding phases (such as nickel-based replacement of cobalt) or composite additives. The following is a detailed description from three aspects: technical characteristics, specific uses and development trends.

**Technical features and performance advantages**
The special uses of emerging grades are derived from their optimized microstructure and material design, which are mainly reflected in the following aspects:

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**Ultrafine grains and nanostructures**
The grain size is controlled at 0.2-0.5μm (ultrafine grains) or even <0.1μm (nanoscale), which significantly improves hardness (HRA 93-95) and wear resistance. Fine grains reduce crack propagation paths, enhance fracture toughness (KIC can reach 10-15 MPa·m $^{1/2}$), and maintain structural stability at high temperatures. Example: UF-1 (WC 96%, Co 4%, nanocrystalline), hardness HRA 94, flexural strength 1900 MPa, density 15.0 g/cm $^{3}$.

**New binder phase (e.g. nickel-based)**
Replacing cobalt (Co) with nickel (Ni), such as WN-10 (WC 90%, Ni 10%), improves corrosion resistance and environmental protection, and reduces the toxicity and resource dependence of cobalt. Nickel-based alloys show stronger stability in acidic environments (pH 2-4) and high-temperature oxidation conditions, and are suitable for chemical industry and aviation components.

**High temperature performance optimization**
Adding heat-resistant elements (such as TaC, ZrC) or adopting a composite structure can increase the upper limit of the operating temperature from the traditional 1000°C to above 1200°C. The low thermal expansion coefficient (4.5-6.0×10 $^{-6}$ /°C) ensures dimensional stability at high temperatures and improves thermal fatigue resistance by 30%-50%.

**Environmental characteristics**
Reduce or eliminate the use of cobalt, comply with international environmental regulations (such as the EU RoHS standard), and reduce the risk of environmental pollution during production and use. These characteristics make emerging brands have irreplaceable advantages in high temperature, high load and strict environmental protection requirements.

**Specific application scenarios**
The special uses of emerging cemented carbide grades are mainly concentrated in the following areas:

**High temperature aviation parts**
Aircraft engine turbine blade cutting tools
When machining nickel-based high-temperature alloys (such as Inconel 718), traditional cemented carbide fails due to high temperature softening (>800°C), while ultrafine grain grades (such as UF-1) can maintain a hardness of HRA 90 or above at above 1000°C, extending the cutting life by more than 50%.
Application case : Finishing of aircraft engine turbine blades, with a cutting speed of up to 300 m/min and a surface roughness Ra<0.8 μm.

**High temperature mold and nozzle**
High temperature molds for forming aviation composite materials (such as carbon fiber reinforced polymer, CFRP), with an operating temperature of 900-1100°C. New grades (such as composite alloys containing TaC) have strong resistance to thermal shock and can increase mold life by 2-3 times.
Nozzle Application
Aviation fuel injection system, resistant to high temperature corrosion, reduces oxidation wear.

**Spacecraft wear parts**
In spacecraft propulsion systems, high-temperature and wear-resistant cemented carbides are used for sealing rings and bearing liners. New grades (such as WN-10) still maintain mechanical properties in vacuum and high-temperature environments (>1000°C), meeting the stringent requirements of aerospace.

**Environmentally friendly wear-resistant applications**
Chemical equipment wear-resistant lining
In acidic or alkaline corrosive environments (such as sulfuric acid pipelines), nickel-based cemented carbides (such as WN-10) replace traditional cobalt-based alloys, improving corrosion resistance by 40% and extending service life to more than 5 years.

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Environmental advantages: Cobalt-free design reduces heavy metal pollution and conforms to the trend of green manufacturing.

**Marine engineering wear-resistant parts**
Used in seawater pump valve seals and marine drilling tools, nickel-based alloys have excellent resistance to salt spray corrosion and a wear life that is 30% longer than traditional YG8, while avoiding the impact of cobalt dissolution on the marine ecology.

**Micro cutting tools for the electronics industry**
Ultrafine grain grades (such as H05F) are used for PCB micro drills (diameter < 0.5 mm), hardness HRA 93 ensures high precision, environmentally friendly process reduces cobalt dust emissions, and is suitable for lead-free solder material processing.

**Renewable energy equipment**
Wind turbine gear processing tools use nano-composite alloys, which are highly wear-resistant and reduce maintenance frequency; solar silicon wafer cutting lines use cobalt-free grades to reduce the environmental footprint of the production process.

**Development Trend**
The application prospects of emerging cemented carbide grades are closely related to technological progress. The following are the main trends:

**Nanotechnology and Grain Refinement**
With the development of nanotechnology, the grain size will be further reduced to <50 nm, and the hardness is expected to exceed HRA 95 while maintaining high toughness, driving the extreme processing needs of the aerospace and electronics industries.

**Research and development of environmentally friendly adhesive**
The research and development of nickel-based, iron-based (Fe) and even non-metallic binder phases (such as ceramic-based) is accelerating, with the goal of completely replacing cobalt and meeting strict environmental regulations (such as REACH). It is expected that in the next 10 years, the proportion of cobalt-free cemented carbide will increase from 5% to 20%.

**Improved high temperature performance**
By adding rare earth elements (such as Ce, Y) or new carbides (such as HfC), the upper limit of operating temperature may exceed 1300°C, meeting the needs of next-generation aviation engines and high-temperature industries.

**Customization and intelligence**
Combined with 3D printing technology, emerging grades can achieve customized production of complex geometric shapes and be used in personalized aerospace components; intelligent coating technology (such as PVD/CVD) further improves wear resistance and heat resistance.

**Market demand growth**
According to CTIA GROUP estimates, by March 2025, the annual demand for cemented carbide for high-temperature aviation components will be approximately 300 tons, and the demand for environmentally friendly wear-resistant applications will be approximately 500 tons, with an annual growth rate expected to reach 8%-10%, driven by the recovery of the aviation industry and environmental protection policies.

Emerging cemented carbide grades have significantly expanded their use in high-temperature aviation components and environmentally friendly wear-resistant applications through ultra-fine grain structure, new binder phase and high-temperature resistant design. In the aviation field, they support processing and wear resistance requirements under extreme conditions; in the environmental protection field, cobalt-free design

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reduces ecological impact and promotes green manufacturing. With technological advances, the application of these grades will be further deepened and become an important development direction in the cemented carbide field.

### 19.4 Production Process of Cemented Carbide

The detailed and comprehensive production process of cemented carbide (taking tungsten carbide WC-based cemented carbide as an example) is shown in the following table . Cemented carbide is a composite material with tungsten carbide (WC) as the hard phase and cobalt (Co) or other metals (such as Ni) as the bonding phase. It is widely used in cutting tools, wear-resistant molds and mining tools due to its high hardness (HRA 85-93), high wear resistance and excellent strength (>2000 MPa). Its production adopts powder metallurgy process, which includes several key steps from raw material preparation to the final product. This process is mainly based on WC-Co cemented carbide, and refers to the process details shown in industrial practice and ASTM B388 standard .

**Cemented Carbide Production Process**

| Technology Step | Detailed process | Key parameters and conditions | Equipment and Tools | Product and quality control |
|---|---|---|---|---|
| **Raw material Prepare** | High-purity tungsten carbide (WC) powder and cobalt (Co) powder are selected, sieved to remove impurities, and dried to remove moisture. A small amount of tac and tic can be added to adjust the performance. | WC purity: ≥99.8%, particle size: 0.2-5 μm. Co purity: ≥99.9%, particle size: 1-3 μm. Moisture: <0.05%. | Vibrating sieve (200-400 mesh). Vacuum oven (100-150°C, $10^{-1}$ Pa). | High purity powder, uniform particle size. SEM morphology, ICP-MS detection of impurities. |
| **Ingredients Mix** | Weigh WC and Co in proportion (typical ratio: WC 85-95%, Co 5-15%), add grinding media (such as alcohol) and shaping agent (such as paraffin), and wet grind and mix. | Ratio accuracy: ±0.1%. Grinding time: 24-72 hours, speed 200-400 rpm. Solid-liquid ratio: 1:1-1:2. | Planetary ball mill (carbide balls). Mixing tank. | Homogeneous slurry. Laser particle size analyzer was used to detect particle size distribution (D50<1 μm). |
| **Dry Granulation** | The wet-milled slurry is spray dried to form granules with good fluidity, the solvent is removed and a small amount of binder (such as PVA) is added. | Drying temperature: 150-200°C. Inlet air temperature: 250-300 °C . Particle diameter: 20-100 μm. Residual moisture: <0.2%. | Spray dryer. Granulator. | Dry granules with good fluidity. Moisture analyzer to detect residual moisture. |
| **Suppress Forming** | The particles are loaded into a mold and pressed by uniaxial pressing or cold isostatic pressing (CIP) to form a green body in the shape of a tool, mold, etc. | Pressing pressure: 100-300 mpa. Holding time: 1-3 minutes. Green density: 7-9 g/cm³ ( about 50-60% theoretical density). | Hydraulic press or CIP press. Steel mould or rubber mould. | The green body has a regular shape and no cracks. The density of the green body is tested by a densitometer. |
| **Dewaxing Pre-sintering** | Low temperature heating in hydrogen or vacuum atmosphere removes the | Holding time: 2-4 hours. $H_2$ flow rate: 5-10 L/min, or | Dewaxing furnace (quartz | The strength of the pre-sintered blank is |

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|---|---|---|---|---|
| | forming agent and preliminarily consolidates the green body to enhance the strength for subsequent sintering. | vacuum: $10^{-1}$Pa . | boat). Vacuum pre-firing furnace. | improved. The mass loss is detected by weighing (forming agent <1%). |
| **High temperature Sintering** | Liquid phase sintering is carried out in a vacuum or low-pressure sintering furnace, and Co melts to fill the gaps between WC particles and densify to form cemented carbide. | The melting point of Co). Holding time: 1-2 hours. Vacuum: $10^{-2}$ Pa, or Ar pressure: 5-10 mpa (low pressure sintering). | Vacuum sintering furnace. Low pressure sintering furnace (graphite boat). | Density 14-15 g/cm³ ( >98% theoretical density). X-ray detection of porosity. |
| **Cool down** | After sintering, the alloy is slowly cooled in the furnace to avoid thermal stress and cracks and ensure uniform distribution of the Co phase. | Cooling rate: 5-15°C/min (furnace cooling to room temperature). Atmosphere: vacuum or Ar protection. | The sintering furnace has a built-in cooling system. | The structure is uniform and has no cracks. The phase distribution is observed by metallographic microscope. |
| **Hot Isostatic Pressing (HIP, optional)** | It is further densified under high temperature and high pressure, removing micropores, improving strength and wear resistance, and is suitable for high-demand products. | Temperature: 1300-1400°C. Pressure: 100-200 mpa. Holding time: 1-2 hours. Atmosphere: Ar. | Hot Isostatic Press (HIP). | Density>99.5% theoretical value. Ultrasonic detection of internal defects. |
| **Machining (Optional)** | Sintered carbide is ground, turned or electro-discharged to produce complex shapes (such as tool edges). | Grinding speed: 20-50 m/min. Feed rate: 0.02-0.1 mm/rev. Coolant: Water-based or dry machining. | CNC grinding machines. Diamond grinding wheels. EDM equipment. | Precise shape. Coordinate measuring machine checks dimensions (±0.01 mm). |
| **Surface Deal with** | Polishing can improve the surface finish, or sandblasting can increase the roughness. Coatings (such as tin, $Al_2O_3$) can be applied to enhance wear resistance and heat resistance. | Polishing: Ra < 0.2 μm. Sandblasting: Ra 1-3 μm. Coating thickness: 2-10 μm (CVD/PVD method). | Polishing machine. Sandblasting machine. CVD/PVD coating furnace. | The surface is smooth or uniformly rough. The roughness meter detects the Ra value. |
| **Quality Detection** | Check density, hardness, flexural strength, microstructure and wear resistance to ensure compliance with ASTM B388 or ISO 3327 | Density: 14-15 g/cm³ . Hardness: HRA 85-93. Flexural strength: >2000 mpa. Grain size: <2 μm. | Archimedes density meter. Hardness tester. SEM. | Qualified cemented carbide. Factory report contains test data. |

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| | | | | |
|---|---|---|---|---|
| | standards. | | | |
| **Package Store** | Package with moisture-proof material (such as plastic box), fill with inert gas ($N_2$ ) , and store in a dry environment to avoid oxidation and damage. | Packaging humidity: <20% RH. Storage temperature: 10-30°C. Oxygen content: <100 ppm. | Vacuum packaging machine. Constant temperature and humidity warehouse. | The product has no oxidation deterioration. The storage conditions are monitored by a hygrometer. |

**Detailed description of the process**
The production of cemented carbide (taking WC-Co as an example) is made of high-purity tungsten carbide (WC) powder as the hard phase and cobalt (Co) powder as the binder phase through powder metallurgy. It has high hardness (HRA 85-93), high wear resistance and excellent strength (>2000 MPa), and is widely used in cutting tools (such as turning tools), wear-resistant molds (such as wire drawing dies) and mining tools (such as drill bits). The following are the detailed steps:

**Raw materials are prepared**
from high-purity WC powder (purity ≥ 99.8%, particle size 0.2-5 μm) and Co powder (purity ≥ 99.9%, particle size 1-3 μm), sieved to remove impurities, and dried to a moisture content of < 0.05%. TaC and TiC (< 2%) can be added to adjust performance.

**Ingredients and mixing:**
Weigh the ingredients according to the proportion (WC 85-95%, Co 5-15%), add alcohol and paraffin, and wet grind in a planetary ball mill for 24-72 hours to make a uniform slurry (D50 <1 μm).

**Drying and granulation**
The slurry was spray dried (inlet air temperature 250-300°C) to form 20-100 μm particles with residual moisture <0.2%. PVA was added to improve fluidity.

**Compression molding : The granules are loaded into the mold**
and pressed into green bodies (such as blades, molds) using a hydraulic press or CIP, with a pressure of 100-300 MPa and a density of 7-9 g/ $cm^3$ .

**Dewaxing and pre-sintering: The wax is removed and preliminarily consolidated in**
$H_2$ or vacuum atmosphere at 400-800°C to improve the strength of the green body.

**High temperature sintering:**
Sintering at 1350-1450°C in vacuum or low pressure, Co melts to form a liquid phase, filling the gaps between WC particles and densifying to 14-15 g/ $cm^3$ .

**Cooling:**
Furnace cooling at a rate of 5-15°C/min to avoid thermal stress and cracks.

**Hot isostatic pressing (HIP, optional)**
at 1300-1400°C, 100-200 MPa to remove micropores and achieve a density >99.5% of theoretical value.

**Machining (optional)**
Diamond grinding or EDM to produce complex shapes with a dimensional accuracy of ±0.01 mm.

**Surface treatment:**
polishing to Ra<0.2 μm, or sandblasting to Ra 1-3 μm, and CVD/PVD coating of TiN, $Al_2O_3$ (thickness 2-10 μm).

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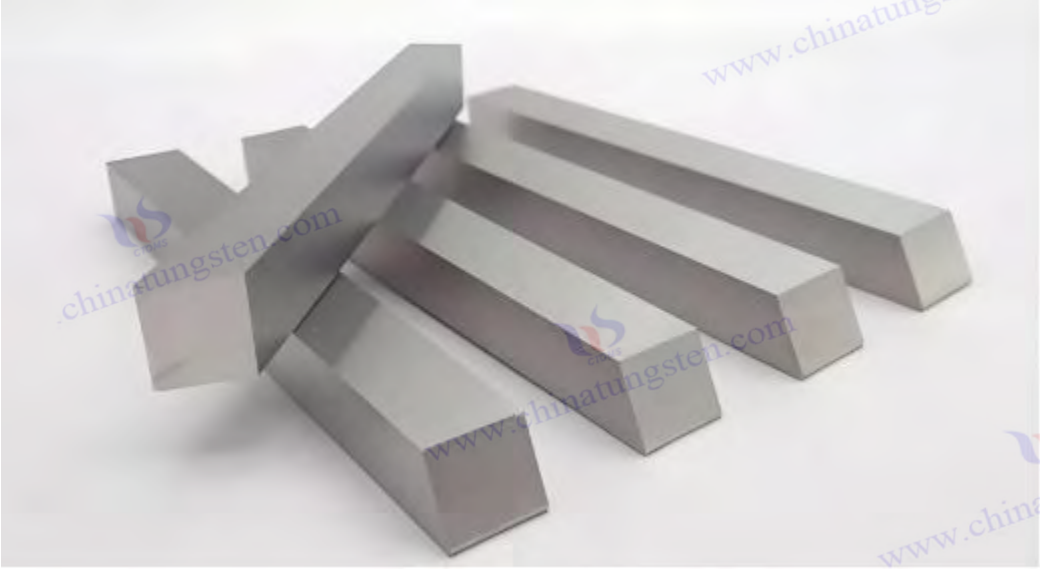
**Quality testing**
Density (14-15 g/cm³ ) , hardness (HRA 85-93), flexural strength (>2000 MPa) and grain size (<2 μm) in accordance with ASTM
B388 or ISO 3327.

**Packaging and Storage**
: Packed in plastic boxes, filled with $N_2$ , and stored in a low humidity environment.

**Technical points**
**Ratio design** : high WC content (85-95%) ensures hardness, and Co content (5-15%) optimizes toughness.
**Liquid phase sintering** : 1350-1450°C melts Co and fills the gaps between WC, with a density of 14-15 g/cm³ .
**Grain control** : Adding TaC/TiC inhibits the growth of WC grains, keeps them <2 μm, and improves wear resistance.
**Coating technology** : TiN/$Al_2O_3$ coating improves heat resistance and life (e.g. turning tool life increased by 2-3 times) .
**Usage orientation** : High Co is used for mining tools (strong toughness), and low Co is used for cutting tools (high hardness).

**Typical Applications**
**Cutting tool** : WC-6%Co, HRA 91, for turning steel.
**Wire drawing die** : WC-10%Co, HRA 89, used for copper wire drawing.



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The application details of cemented carbide tools in high temperature aerospace component machining are provided.

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# CTIA GROUP LTD
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**30 years of experience** : Deeply familiar with tungsten alloy production and mature technology.
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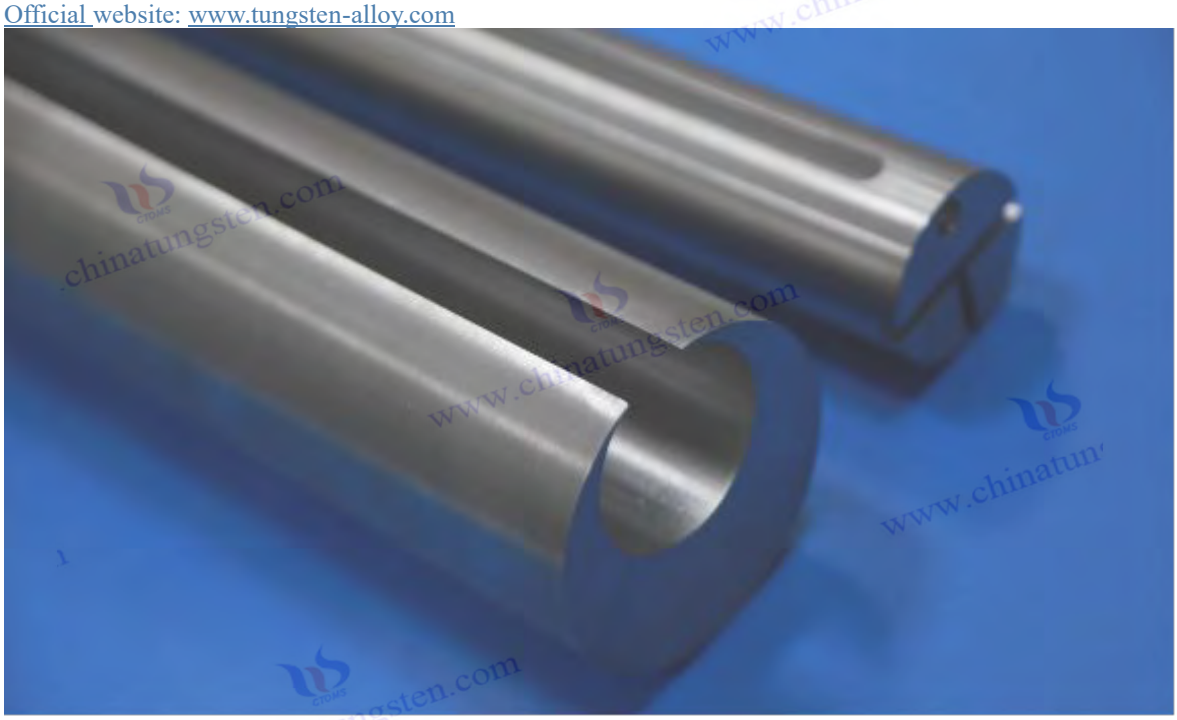

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**Chapter 19: Cemented Carbide, Specifications, Characteristics and Applications ( II )**

This chapter (middle) discusses the wide range of applications of cemented carbide in industry, military, civil and special fields based on its specifications and characteristics. The content covers the specific uses of cemented carbide in various industries and explains in detail how different types and forms of cemented carbide products can meet diverse needs.

## 19.5 Industrial Uses of Cemented Carbide

With its excellent hardness, wear resistance and toughness, cemented carbide is indispensable in the industrial field, especially in processing, tool manufacturing and resource mining.

### 19.5.1 Cemented carbide cutting tools

**Carbide turning tools, milling cutters, drill bits**
It has significant performance advantages when processing steel, cast iron and non-ferrous metals (hardness HRA 89-94, excellent wear resistance), and is suitable for high-speed cutting (speed> 200 m/min).

**Carbide Reamers and Taps**
For precision machining of holes and threads, fine grain grades such as YG6X are used to ensure high accuracy and durability.

**Carbide Saw Blades**
Improve cutting efficiency of metals and composite materials, and withstand high temperatures and wear (such as tungsten-cobalt carbides).

**Carbide Hobs and Broaches**
Used for gear and complex shape processing, with high hardness and wear resistance (such as YT15).

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**Carbide End Mills**
Precision milling of molds and mechanical parts, fine-grained carbide (such as YG6X) improves surface quality.

### 19.5.2 Carbide Abrasives and Dies

**Carbide Wire Drawing Dies**
High wear resistance and precision (surface finish Ra<0.4 μm), used for drawing production of steel wire, copper wire and aluminum wire.
**Carbide stamping die**
Compressive strength (4000-6000 MPa) and fatigue resistance, suitable for molding of automotive and home appliance parts.
**Carbide Extrusion Die**
Excellent performance in high-pressure extrusion of metals (such as aluminum, copper) and plastics, reducing die wear in continuous production.
**Carbide cold heading die**
High toughness and impact resistance, suitable for the manufacture of bolts, screws and fasteners.
**Carbide hot forging die**
High temperature resistance and thermal fatigue resistance, used for forging high temperature metal parts (such as YW1).
**Cemented Carbide Powder Metallurgy Die**
High precision and wear resistance, forming carbide and other powder material products.
**Carbide carton cutting die**
Wear resistance and high precision, used for die-cutting of cardboard and cartons, ensuring edge flatness and die life.

### 19.5.3 Cemented carbide mining and construction tools

**Carbide rock drill bits**
Impact and abrasion resistance (such as YG8, HRA 89), used for hard rock penetration in mining and quarrying.

**Carbide shield cutter**
High load applications in tunnelling, resistant to abrasive soils and rocks (e.g. YG10).

**Cemented Carbide for Petroleum and Geological Exploration Drilling**
Drill bit inserts (such as YG10) and roller cone drill teeth are designed for use in abrasive formations and provide long-term durability.

**Cemented Carbide for Cement Manufacturing**
Wear-resistant parts (e.g. hammers, grinding rollers, nozzles) for handling clinker and raw materials.

**Carbide Road Construction Tools**
Planing picks and milling teeth for asphalt and concrete removal, combining toughness and wear resistance.

**Carbide Coal Pick**
Used for cutting coal seams and rocks in coal mining, resistant to impact and wear (such as YG11C).

### 19.5.4 Cemented carbide metal forming and processing

**Carbide Rollers and Rings**
Wear-resistant in steel rolling and aluminum production (such as tungsten-titanium-tantalum hard alloys),

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extending service life under high pressure.

**Carbide shear blades**
High hardness, suitable for cutting plates, bars and wires in industrial manufacturing.

**Carbide tensioning ring and straightening wheel**
Used for stretching and straightening of metal wires and tubes, wear-resistant and dimensional stability.

**Carbide punches and ejectors**
Wear-resistant parts in metal stamping and cold extrusion to improve production efficiency.

### 19.5.5 Hard alloy papermaking and food processing tools

**Carbide Paper Cutter**
High hardness and sharpness (such as K10) are used for high-speed cutting of paper to ensure smooth cuts and durability.

**Carbide Paper Cutter**
Wear-resistant blade, suitable for paper slitting in paper production lines and printing industry.

**Carbide carton cutting die**
High precision and wear resistance, used for die-cutting and forming processes in carton production.

**Carbide tools for the food industry**
**Carbide Cleaver**
Corrosion resistance and high hardness (such as WN-10), used in meat processing to ensure hygiene and cutting efficiency.

**Carbide food cutter**
Wear-resistant knives for slicing and dicing vegetables, fruits and baked goods, maintaining sharpness and food safety.

## 19.6 Military Applications of Cemented Carbide

The extreme hardness and penetrating power of cemented carbide are crucial in the defense sector, improving both protective and offensive capabilities.

### 19.6.1 Hard alloy armor protection parts

**Hard alloy layer in composite armor**
Hardness (HRA>93) and penetration resistance (such as GJB-X1), combined with ceramics for lightweight protection of tanks and vehicles.

**Carbide Personal Armor Inserts**
Small carbide plates (like ultra-fine grain alloys) in bulletproof vests provide high impact resistance.

**Hard alloy armored vehicle wear resistant lining**
Protect key parts from wear and impact.

### 19.6.2 Hard alloy ammunition manufacturing

**Carbide core and shrapnel**
Ultra-high hardness (such as GJB-X1, HRA 93) is used for armor-piercing bullets to ensure deep penetration;

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shrapnel takes into account both toughness and fragment control to enhance lethality.

**Carbide fragment sleeve**
Carbide fragments in the explosive device increase the killing range.

### 19.6.3 Military carbide cutting and processing tools

**Carbide military parts processing tools**
High durability tools (such as IC908, HRA 91.5) are used for machining titanium alloys and composite materials in aerospace and weapon systems.
**Carbide Field Repair Tools**
Portable carbide tools (such as YG6) are suitable for military equipment maintenance under harsh conditions.

### 19.6.4 Hard alloy wear-resistant parts in weapon systems

**Carbide barrel liner**
Heat and wear resistance in high-rate systems (such as tungsten-cobalt alloys) to extend barrel life.

**Carbide Missile Nozzle**
High temperature resistance (up to 1200°C) for use in propulsion systems (e.g. composite alloys containing TaC).

**Carbide shell guide belt**
Wear-resistant guide components ensure firing accuracy and barrel protection.

## 19.7 Civilian applications of cemented carbide

Cemented carbide is not only limited to industrial and military use, but is also widely used in the civilian field to improve the quality of life and technical level.

### 19.7.1 Cemented carbide machining

**Carbide automotive parts manufacturing**
Crankshaft, cylinder block and gear machining tools, such as the YG8, provide durability and precision in mass production.

**Cemented Carbide Aviation Parts Manufacturing**
Tools for machining titanium alloys and composite materials (e.g. CFRP) (e.g. UF-1, HRA 94) to meet tight tolerance requirements.

**Cemented Carbide General Machinery**
Turning tools and milling cutters (such as K10) for small workshops, taking into account both cost and performance.

**Carbide bearing processing tools**
High-precision carbide tools for machining inner and outer rings of bearings.

### 19.7.2 Hard alloy electronics industry

**Carbide PCB Drill Bits**
Micro diameter (<0.5 mm) drill bits (such as H05F, HRA 93) are used in circuit board manufacturing to ensure accuracy and burr-free.

**Carbide Micro Tools**
Fine-grained carbide (such as H10F) for semiconductor processing supports wafer dicing and chip packaging.

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**Carbide Wire Bonding Tools**
Wear-resistant tips (such as YG6X) are used for assembly of electronic components.

**Carbide die punch pin**
Manufacture of high-precision stamped parts for electronic connectors.

**19.7.3 Hard alloy medical devices**

**Carbide surgical tools**
Sharpness and corrosion resistance (such as WN-10), suitable for sterile environment.

**Carbide Dental Tools**
Drills and grinding tools, such as the YG6X, provide durability and precision in tooth preparation and restoration.

**Carbide Orthopedic Implants**
Wear-resistant coatings or components in joint replacements (e.g. ultrafine grain alloys) to extend service life.

**Carbide endoscope parts**
Wear- and corrosion-resistant micro parts.

**19.7.4 Cemented Carbide for Consumer Goods**

**Cemented Carbide for Jewelry and Watchmaking**
Polishing tools and wear-resistant inserts (such as YG3) for processing precious metals and gemstones.

**Carbide Kitchen Knife**
High hardness blade (such as K10), suitable for professional and home use, maintains sharpness.

**Carbide razor blades**
Resistant to wear and sharp edges, improving service life and comfort.

**19.7.5 Cemented Carbide for Agriculture and Forestry**

**Carbide plowshares and harvester blades**
Wear resistance (like YG8), used for cutting soil and crops, reducing replacement frequency.

**Carbide Woodworking Tools**
Saw teeth and planer knives (such as K10) are resistant to abrasion of wood fibers.

**Carbide Gardening Shears**
High hardness blade, suitable for pruning plants and branches.

**Carbide Bamboo and Wood Processing Tools**
Wear-resistant knives (such as YG6 or K10) are used for cutting, carving and shaping bamboo and wooden products, adapted to the toughness and hardness of bamboo and wood fibers.

**Carbide sprinkler nozzles**
Wear-resistant and corrosion-resistant carbide nozzles (such as WN-10) are used in agricultural sprinkler systems to ensure spraying accuracy and wear resistance under long-term use.

**19.8 Special applications of cemented carbide**

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The versatility of cemented carbide extends to special and high-performance applications, extreme conditions and innovative uses.

### 19.8.1 Wear - resistant coating and surface treatment

**Cemented Carbide CVD/PVD Coating Technology**
Carbide coatings (such as WC-based coatings) are deposited by chemical or physical vapor deposition to extend component life in abrasive environments.

**Cemented Carbide Thermal Spraying**
Cemented carbide powder coatings (such as tungsten-cobalt powders) are used on heavy machinery parts to improve surface hardness and corrosion resistance.

**Hard alloy cladding layer**
Hardfacing rods for repairing worn industrial components.

### 19.8.2 Hard alloy wear- resistant parts in high temperature environment

**Carbide high temperature molds and nozzles**
Applications in aviation engine manufacturing and metallurgy (such as UF-1, resistant to 1000°C+), resistance to thermal shock and wear.

**Cemented Carbide for Pipes and Seals in the Petroleum and Chemical Industries**
Seals and valve components, such as WN-10, for use with corrosive, high-pressure fluids with reduced maintenance.

**Cemented Carbide for Glass and Ceramics Processing**
Tools and rollers, such as the YT15, for high-temperature glass forming and ceramic cutting, maintain durability.

**Carbide high temperature bearing bushing**
Resistant to high temperatures and wear, used in metallurgical equipment and gas turbines.

### 19.8.3 Cemented Carbide for Sports and Outdoor Equipment

**Carbide climbing pick**
Abrasion-resistant tip design (like YG6) ensures reliability on rock and ice.

**Carbide Snowboard Blades**
High hardness and durability (such as K10) improves sliding performance and life.

**Carbide Fishing Equipment**
Wear-resistant hooks and cutters (such as WN-10) are suitable for wet and abrasive environments.

**Carbide Bicycle Chain Pins**
Wear-resistant parts improve riding durability.

**Carbide stationery knives**
High-hardness blades (such as YG6X) are used for paper cutters, utility knives, etc. to ensure sharpness and durability.

**Carbide carving knife**
Wear-resistant and precision knives (such as K10) for wood carving and soft metal engraving.

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**Carbide carving knife**
High-precision carbide tools (such as YG3) are used for seal carving, adapted to the hardness of stone and metal.

**Carbide art knife**
Sharp and wear-resistant (such as ultra-fine grain alloys), used for fine cutting in artistic creations.

**19.8.4 Cemented Carbide Renewable Energy and Environmental Protection Applications**

**Carbide wind turbine gear machining tools**
Nanocomposite alloys (such as UF-1) have strong wear resistance and reduce the maintenance frequency of wind turbines.

**Solar wafer cutting line**
Cobalt-free carbides (such as WN-10) reduce the environmental footprint of production.

**Hard alloy water treatment equipment wear-resistant parts**
Corrosion-resistant seals (such as nickel-based alloys) are used in sewage treatment and desalination systems.

**Cemented Carbide Biomass Equipment Tools**
Wear-resistant cutting tool for processing hard biomass raw materials.

**19.8.5 Cemented Carbide for Art and Decoration**

**Carbide Engraving Tools**
High-precision carbide tools (such as YG6X) are used for engraving stone and metal artworks.

**Wear-resistant coating for carbide decorative parts**
Carbide coatings (such as PVD coatings) improve the durability and aesthetics of furniture hardware and decorative items.

**Carbide musical instrument parts**
Wear-resistant picks and buttons extend the life of the instrument.

**19.8.6 Other innovative applications of cemented carbide**

**3D Printing Carbide Parts**
Customized complex shapes (e.g. sealing rings, nozzles) for aerospace and industrial applications.

**Carbide grinding media**
Carbide balls and rods (such as YG6) are used for efficient grinding of ores and pigments.

**Carbide wear-resistant gaskets and liners**
Anti-friction components in mechanical equipment to extend equipment life.

**19.8.7 Detailed table of industrial uses of cemented carbide**
**Industrial Uses of Cemented Carbide**
With its excellent hardness, wear resistance and toughness, cemented carbide is indispensable in the industrial field, especially in processing, tool manufacturing and resource mining.

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**1. Cutting tools**

| serial number | use | describe |
|---|---|---|
| 1 | Carbide turning tools | Processing steel, cast iron and non-ferrous metals, hardness HRA 89-94, suitable for high-speed cutting (>200 m/min). |
| 2 | Carbide milling cutter | High hardness (HRA 90), used for precision milling of molds and mechanical parts to improve surface quality. |
| 3 | Carbide drill bits | Excellent wear resistance (YG8), can process hard materials such as stainless steel, and ensure the hole diameter accuracy. |
| 4 | Carbide Reamers | Fine-grained grades (such as YG6X) are used for precision machining of holes with a tolerance of <0.01 mm. |
| 5 | Carbide Taps | High-precision thread processing, strong durability (HRA 91), suitable for automated production lines. |
| 6 | Carbide Saw Blades | Tungsten-cobalt cemented carbide can withstand high temperatures and wear and is used for cutting metals and composite materials. |
| 7 | Carbide Hobs | High hardness (YT15), used for gear processing, wear resistance improves tooth profile accuracy. |
| 8 | Carbide broaches | Complex shape processing (such as keyway), strong impact resistance (YG10X), life extended to 500 times. |
| 9 | Carbide End Mills | Fine-grained carbide (such as YG6X), precision milling mold, surface roughness Ra<0.2 μm. |
| 10 | Carbide boring tools | High-precision machining of inner holes (e.g. engine blocks), high wear resistance (HRA 90), ensuring concentricity < 0.02 mm. |
| 11 | Carbide end mills | Processing of titanium alloys and composite materials (YT5), supporting complex surface processing of aviation parts. |
| 12 | Carbide Keyway Milling Cutter | Fine-grained carbide (such as K10) is used to process mechanical keyways, increasing durability by 20%. |
| 13 | Carbide forming tools | Customized shape processing (such as automotive part contours), strong impact resistance (YG8), life span up to 1000 hours. |
| 14 | Carbide disc cutter | Cutting of thin metal sheets and tubes (such as stainless steel), high hardness (HRA 92), efficiency increased by 20%. |
| 15 | Carbide round nose milling cutter | The mold surface is finely processed with excellent wear resistance (HRA 91) and reduced surface roughness (Ra<0.15 μm). |
| 16 | Carbide Flying Knife | Used for high-speed cutting of wood and composite panels, with strong wear resistance (K20), smooth cutting without burrs. |
| 17 | Carbide countersinks | Machining countersunk holes (e.g. aerospace fasteners) with high precision (HRA 90) to ensure consistent hole depth. |
| 18 | Carbide step drill | Multi-level hole processing (such as automobile parts), strong wear resistance (YG10), reducing the frequency of tool change. |

**2. Molds**

| Serial number | Use | Describe |
|---|---|---|
| 19 | Carbide wire drawing dies | High wear resistance (ra<0.4 μm), used for drawing steel wire, copper wire and aluminum wire, with a lifespan of up to 500 tons of drawing capacity. |
| 20 | Carbide stamping die | The compressive strength is 4000-6000 mpa, and it is used for molding automobile and home appliance parts, and has strong fatigue resistance. |
| 21 | Carbide extrusion | High pressure extrusion of metals (such as aluminum, copper), strong |

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|---|---|---|
| | die | wear resistance (yg15), reducing the frequency of mold replacement. |
| 22 | Carbide cold heading die | High toughness (hra 89), used for bolts and fasteners, with 30% higher impact resistance. |
| 23 | Carbide hot forging die | High temperature resistance and thermal fatigue resistance (yw1), used for forging high temperature metal parts, with a service life of up to 2000 forging times. |
| 24 | Cemented carbide powder metallurgy die | High-precision formed carbide products with high wear resistance (hra 91) and tolerance < 0.005 mm. |
| 25 | Carbide carton cutting die | High-precision die-cutting of cardboard and cartons (k10), with smooth edges and a lifespan of 1 million cuts. |
| 26 | Carbide stud die | Manufacture of wear-resistant studs (e.g. For mining machinery), high hardness (hra 90) to ensure studs are impact resistant. |
| 27 | Carbide precision dies | Electronic parts stamping (e.g. Connectors), ultra-fine grain alloy (h10f), tolerance < 0.01 mm. |
| 28 | Carbide sand making mold | Used for producing sand making bars (such as mining crushing equipment), with strong wear resistance (yg15) and life extended to 500 hours. |
| 29 | Carbide deep drawing die | Deep drawing of stainless steel and aluminum sheets (such as kitchenware), strong anti-adhesion (yg15), and reduced scratching. |
| 30 | Carbide injection mold | Wear and corrosion resistance, used for high-speed injection molding of plastic products (such as mobile phone cases). |
| 31 | Carbide rolling dies | Used for rolling metal surfaces (such as bearing outer rings), high hardness (hra 92), improving surface finish ra<0.1 μm. |
| 32 | Carbide trimming die | Auto parts edge trimming, strong wear resistance (yg10x), ensuring trimming consistency. |

**3. Mining and construction tools**

| Serial number | Use | Describe |
|---|---|---|
| 33 | Carbide rock drill bits | Impact and abrasion resistant (yg8, hra 89), used for hard rock penetration in mining and quarrying, with a service life of up to 150 hours. |
| 34 | Carbide shield cutter | High load application in tunnel engineering, strong abrasion resistance (yg10), suitable for rock and soil environment. |
| 35 | Cemented carbide oil drilling inserts | Roller bit teeth (such as yg10) are used in abrasive formations and their durability is increased by 20%. |
| 36 | Carbide cement manufacturing breaker | Handling clinker and raw materials, strong wear resistance (hra 88), reducing replacement frequency to once a month. |
| 37 | Carbide road construction planing picks | Removes asphalt and concrete, with both toughness and wear resistance (yg11c), and a service life of up to 200 hours. |
| 38 | Carbide coal pick | Used for cutting coal seams and rocks in coal mining, with strong impact resistance (yg11c), and service life increased to 100 tons of coal. |
| 39 | Carbide studs | Mining machinery crawler and wear-resistant parts (such as crusher liners), strong impact resistance (hra 88), life of up to 2000 hours. |
| 40 | Carbide sand making strips | Sand making machine wear-resistant strips (such as river pebble crushing), wear resistance increased by 30% (yg13c), reducing downtime. |
| 41 | Carbide rotary drilling | Building pile foundation construction, strong wear resistance |

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| | | |
|---|---|---|
| | teeth | (yg10x), suitable for sandstone and clay layers, life span up to 50 piles. |
| 42 | Carbide tunnel boring machine picks | Hard rock excavation (such as subway construction), high impact resistance (yg13c), life extended to 100 hours. |
| 43 | Carbide boring tool | The cutter head of the tunnel boring machine has strong wear resistance (yg15), is suitable for hard rock and sand layers, and has a service life of up to 80 hours. |
| 44 | Carbide rock drill bits | Used in rock drill bits, with strong impact resistance (hra 89), improving drilling efficiency by 20%. |
| MADE BY: CTIA GROUP | | |

**4.Metal forming and processing**

| Serial number | Use | Describe |
|---|---|---|
| 45 | Carbide rollers | Wear-resistant in steel rolling production (such as tungsten-titanium-tantalum hard alloys), the service life is extended to 5,000 tons of steel. |
| 46 | Carbide shear blades | High hardness (hra 92), used for cutting plates and bars, with smooth cuts and no burrs. |
| 47 | Carbide tensile ring | Metal wire is stretched and corrected, with strong wear resistance (yg15) and dimensional stability. |
| 48 | Carbide punch | Metal stamping wear-resistant parts (such as automotive parts), high hardness (hra 90), improve efficiency by 20%. |
| 49 | Carbide horseshoe nail die | The horseshoe nails are made of high hardness (hra 91) to ensure the nails are resistant to wear and breakage. |
| 50 | Carbide cold rolling roll | Cold rolled steel plate processing, strong wear resistance (hra 90), surface roughness ra<0.1 μm. |
| 51 | Carbide piercing plug | Seamless steel pipe production, high temperature and impact resistance (yw2), life up to 500 perforations. |
| 52 | Carbide leveling roller | The plate is leveled and wear-resistant (yg15), ensuring a flatness of < 0.05 mm. |
| 53 | Carbide pulling ring | Metal pipes are drawn and formed, with strong wear resistance (hra 91) and reduced surface scratches. |
| 54 | Carbide straightening wheel | Wire straightening, high hardness (hra 90), maintaining diameter consistency <0.01 mm. |
| MADE BY: CTIA GROUP | | |

**5.Papermaking and food processing tools**

| Serial number | Use | Describe |
|---|---|---|
| 55 | Carbide paper cutter | High hardness (k10), used for high-speed paper cutting, smooth cutting, life span up to 500,000 times. |
| 56 | Carbide paper cutter | Wear-resistant blade (hra 91), suitable for paper slitting in the printing industry, reducing wear. |
| 57 | Carbide carton cutting die | High-precision die-cut cartons (k10) with smooth edges and a lifespan of 1 million cuts. |
| 58 | Carbide food industry cleaver | Corrosion-resistant and high hardness (wn-10), used in meat processing, cutting efficiency increased by 15%. |
| 59 | Carbide food cutter | Wear-resistant knife (hra 90) for slicing vegetables and fruits, retaining sharpness and ensuring food safety. |
| 60 | Carbide sugar cutting | Strong wear resistance (yg8), used for sugarcane and sugar beet |

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| | | |
|---|---|---|
| | tools | crushing, adaptable to high moisture environment, life span up to 300 hours. |
| 61 | Carbide food cutting knife | Used for slitting food packaging films, high precision (hra 92), burr-free edges, lifespan up to 200,000 meters. |
| MADE BY: CTIA GROUP | | |

**6. Military applications of cemented carbide**

The extreme hardness and penetrating power of cemented carbide are crucial in the defense sector, improving both protective and offensive capabilities.

**Armor protection parts**

| Serial number | Use | Describe |
|---|---|---|
| 62 | Hard alloy composite armor layer | Hardness (hra>93), combined with ceramics for tank protection, the penetration resistance is increased by 20%. |
| 63 | Carbide personal armor inserts | The hard alloy plate (ultra-fine grain alloy) used in bulletproof vests has strong impact resistance and is 10% lighter. |
| 64 | Hard alloy armored vehicle wear resistant lining | Protects key parts from wear (yg15), with a lifespan of up to 2000 hours. |
| 65 | Carbide stud protection | Armored vehicle track wear-resistant spikes, high hardness (hra 90), improved impact resistance. |
| MADE BY: CTIA GROUP | | |

**Ammunition Manufacturing**

| Serial number | Use | Describe |
|---|---|---|
| 66 | Carbide core | Ultra-high hardness (hra 93), used for armor-piercing shells with a penetration of >600 mm (120 mm gun). |
| 67 | Carbide shrapnel | Combined toughness and fragment control (gjb-x1) improves lethality and has a killing radius of 15 m. |
| 68 | Carbide fragment sleeve | Carbide fragments in explosive devices increase the killing range (hra 92). |
| 69 | Carbide stud core | Special armor-piercing core (such as anti-tank shells), high density (hra 92), penetration increased by 15%. |
| MADE BY: CTIA GROUP | | |

**Military cutting and processing tools**

| serial number | use | describe |
|---|---|---|
| 70 | Carbide military parts processing tools | High durability (IC908, HRA 91.5), machining titanium alloys and composites, tolerance < 0.005 mm. |
| 71 | Carbide Field Repair Tools | Portable carbide tools (YG6), adaptable to harsh conditions, strong wear resistance. |
| 72 | Carbide gun barrel machining tools | High-precision machining of the barrel inner bore (YT15), high temperature resistance, ensuring concentricity <0.01 mm. |
| MADE BY: CTIA GROUP | | |

**Wear-resistant parts in weapon systems**

| serial number | use | describe |
|---|---|---|
| 73 | Carbide barrel liner | Heat and wear resistance (tungsten-cobalt alloy) in high-rate-of- |

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| | | |
|---|---|---|
| | | fire systems, life extended to 100,000 rounds. |
| 74 | Carbide Missile Nozzle | High temperature tolerance (1200°C, e.g. TaC alloys) for propulsion systems, increasing durability by 30%. |
| 75 | Carbide shell guide belt | Wear-resistant guide components (HRA 91) ensure firing accuracy and reduce barrel wear. |
| 76 | Carbide Track Pins | Tank track wear-resistant parts (YG11C) have strong impact resistance and a service life of up to 2,000 hours. |
| MADE BY: CTIA GROUP | | |

**7. Civilian applications of cemented carbide**

Cemented carbide is not only limited to industrial and military use, but is also widely used in the civilian field to improve the quality of life and technical level.

**Machining**

| serial number | use | describe |
|---|---|---|
| 77 | Carbide turning tools for automobile parts manufacturing | Crankshaft and cylinder block machining (YG8), with improved durability and precision, and a lifespan of 500 pieces. |
| 78 | Carbide milling cutter for aviation parts manufacturing | Machining of titanium alloys and composite materials (UF-1, HRA 94) with tolerances < 0.005 mm. |
| 79 | Carbide general purpose mechanical drill bit | For small workshops (K10), it takes both cost and performance into consideration, with a service life of up to 200 hours. |
| 80 | Carbide bearing machining tools | High-precision machining of bearing inner and outer rings (HRA 91), surface roughness Ra<0.1 μm. |
| 81 | Carbide Horseshoe Nail Processing Tools | Manufacture of horseshoe nail forming tools (HRA 91) to ensure nail wear resistance and precision. |
| 82 | Carbide gear hobs | Gear finishing (YT15), strong wear resistance, tooth profile error <0.02 mm. |
| | | MADE BY: CTIA GROUP |

**Electronics Industry**

| Serial number | Use | Describe |
|---|---|---|
| 83 | Carbide pcb drill bits | Small diameter (<0.5 mm, such as h05f, hra 93), used for circuit board manufacturing, no burrs. |
| 84 | Carbide micro tools | Semiconductor wafer dicing (h10f), supporting chip packaging, accuracy <0.01 mm. |
| 85 | Carbide wire bonding tools | Wear-resistant tip (yg6x) for electronic component assembly, lifespan up to 500,000 bonding cycles. |
| 86 | Carbide die punch pin | Manufacturing of electronic connectors (hra 92), high-precision stamping, tolerance < 0.005 mm. |
| 87 | Carbide wafer cutting knife | Led substrate cutting (hra 92), no cracks and edge collapse, lifespan up to 100,000 times. |
| Made by: CTIA GROUP | | |

**Medical Devices**

| Serial number | Use | Describe |
|---|---|---|
| 88 | Carbide surgical tools | Sharp and corrosion-resistant (wn-10), used in sterile environment, lifespan up to 500 operations. |

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| | | |
|---|---|---|
| 89 | Carbide dental drill bits | Tooth preparation and restoration (yg6x), durability and precision, lifespan up to 200 teeth. |
| 90 | Carbide orthopedic implant wear parts | Wear-resistant coating (ultra-fine grain alloy) for joint replacements, extending service life to 20 years. |
| 91 | Carbide hemostatic forceps | High hardness and corrosion resistance (wn-10, hra 90), used for surgical hemostasis, life span up to 1000 times use. |
| 92 | Carbide bone saw | For orthopedic surgery (k10), high wear resistance, ensures cutting accuracy, and has a service life of up to 50 surgeries. |
| Made by: CTIA GROUP | | |

**Consumer Goods**

| Serial number | Use | Describe |
|---|---|---|
| 93 | Carbide jewelry polishing tools | Precious metal and gemstone processing (yg3), strong wear resistance, surface finish ra<0.05 μm. |
| 94 | Carbide kitchen knife | High hardness blade (k10), maintains sharpness, lifespan up to 5 years in daily use. |
| 95 | Carbide razor blades | Wear-resistant and sharp edge (hra 91), enhances comfort and lifespan up to 100 shaves. |
| 96 | Carbide horseshoe nail | Horse shoe spikes, high hardness (hra 91), wear resistance improves horse hoof protection, lifespan up to 6 months. |
| 97 | Carbide nib | Strong wear resistance (yg6x), used for high-end fountain pen writing, with a service life of up to 100,000 meters of writing. |
| Made by: CTIA GROUP | | |

**Agriculture and Forestry**

| Serial Number | use | describe |
|---|---|---|
| 98 | Carbide Ploughshare | Wear resistance (YG8), used for cutting soil, reducing replacement frequency to once a year. |
| 99 | Carbide harvester blades | Strong wear resistance (K10), cutting crops, life span up to 500 acres of harvesting. |
| 100 | Carbide Gardening Shears | High hardness blade (HRA 90), for pruning plants and branches, lifespan up to 2 years. |
| 101 | Carbide Bamboo and Wood Processing Tools | Cutting and engraving bamboo and wood products (YG6), resistant to fiber abrasion, life span up to 1000 products. |
| 102 | Carbide Forestry Saw Blades | Wood rough processing (K20), strong wear resistance, cutting efficiency increased by 15%. |
| Made By: CTIA GROUP | | |

## 8. Special applications of cemented carbide

The versatility of cemented carbide extends to special and high-performance applications, extreme conditions and innovative uses.

**Wear-resistant coating and surface treatment**

| Serial number | Use | Describe |
|---|---|---|
| 103 | Carbide cvd coated tools | Wc-based coating (hra 93) extends cutting tool life to 500 hours. |
| 104 | Carbide pvd coated mold | Physical vapor deposition improves mold wear resistance (hra 92) and extends mold life by 30%. |

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|---|---|---|
| 105 | Cemented carbide thermal spraying wear-resistant layer | Tungsten-cobalt powder coating is used for heavy machinery parts, and its corrosion resistance is increased by 20%. |
| 106 | Carbide sand making strip coating | The surface of the sand-making strip is strengthened (yg13c), the wear resistance is increased by 50%, and the service life is up to 600 hours. |
| 107 | Carbide cladding rods | Repair of worn industrial parts (e.g. Excavator teeth), high wear resistance (hra 90). |
| Made by: CTIA GROUP | | |

**Wear-resistant parts for high temperature environments**

| Serial number | Use | Describe |
|---|---|---|
| 108 | Carbide high temperature mold | Aircraft engine manufacturing (uf-1, resistant to 1000°c), heat shock resistance, life span up to 2000 molding cycles. |
| 109 | Carbide oil pipeline seals | Corrosion resistant and high hardness (wn-10), for use with high pressure fluids, reducing maintenance to once a year. |
| 110 | Carbide glass forming roller | High temperature glass processing (yt15), strong durability, life span up to 500 hours. |
| 111 | Carbide stud high temperature parts | High temperature wear-resistant parts (such as furnace lining), resistant to 1500°c, strong oxidation resistance. |
| 112 | Carbide high temperature nozzle | For chemical equipment (hra 92), resistant to high temperature corrosion, with a service life of up to 1000 hours. |
| Made by: ctia group | | |

**Sports and Outdoor Equipment**

| Serial number | Use | Describe |
|---|---|---|
| 113 | Carbide climbing pick tip | High wear resistance (yg6) ensures reliability on rock and ice, with a lifespan of up to 50 climbs. |
| 114 | Carbide snowboard blades | High hardness (k10) improves gliding performance and has a service life of up to 3 seasons. |
| 115 | Carbide fishing knife | Wear and corrosion resistance (wn-10), adaptable to humid environment, life span up to 2 years. |
| 116 | Carbide horseshoe nail for outdoor use | Outdoor equestrian equipment, high wear resistance (hra 91), lifespan up to 6 months. |
| 117 | Carbide golf club head | Wear-resistant insert (yg8) improves durability of shots, with a lifespan of up to 5,000 shots. |
| Made by: ctia group | | |

**Renewable energy and environmental protection applications**

| Serial number | Use | Describe |
|---|---|---|
| 118 | Carbide wind turbine gear machining tools | Nano-composite alloy (uf-1) has strong wear resistance and a service life of up to 1,000 gear processing pieces. |
| 119 | Cemented carbide solar wafer cutting line | Cobalt-free carbide (wn-10) reduces environmental footprint and has a lifespan of up to 500,000 cuts. |
| 120 | Carbide water treatment equipment seals | Strong corrosion resistance (nickel-based alloy), used for seawater desalination, with a service life of up to 5 years. |
| 121 | Carbide sand making strips for environmental | Environmentally friendly sand and gravel crusher (yg15), strong wear resistance, reducing dust and energy consumption. |

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| | | |
|---|---|---|
| | protection | |
| 122 | Carbide geothermal drill bits | Geothermal well drilling (yg13c), resistant to high temperature and high pressure, with a service life of up to 200 meters drilling depth. |
| Made by: ctia group | | |

**Art and Decoration**

| Serial number | Use | Describe |
|---|---|---|
| 123 | Carbide carving knife | High-precision engraving of stone and metal (yg6x), lifespan up to 500 hours. |
| 124 | Wear-resistant coating for carbide decorative parts | Pvd coating improves the durability of furniture hardware (hra 92), making it beautiful and lasting up to 10 years. |
| 125 | Carbide musical instrument picks | High wear resistance (hra 90), extending the instrument's service life to 5 years. |
| 126 | Carbide studs for decorative parts | Wear-resistant inserts for jewelry setting tools (hra 90), with a lifespan of up to 1,000 uses. |
| 127 | Carbide carving knife | Seal engraving (yg3), adapted to the hardness of the stone, with a lifespan of up to 200 seals. |
| Made by: ctia group | | |

**Other innovative applications**

| Serial number | Use | Describe |
|---|---|---|
| 128 | Carbide 3d printed sealing ring | Custom complex shapes (hra 91) for aerospace applications with an accuracy of < 0.01 mm. |
| 129 | Carbide grinding media balls | Ore grinding (yg6), high efficiency and wear resistance, life span up to 500 hours. |
| 130 | Carbide wear-resistant lining | Friction-reducing components for mechanical equipment (hra 90), extending the life of the equipment to 5 years. |
| 131 | Carbide hemostatic forceps parts | The wear-resistant tip of the hemostat (hra 90) increases the life of surgical instruments to 1,000 uses. |
| 132 | Carbide sandblasting nozzle | For high pressure sandblasting (yg10x), strong wear resistance, life span up to 200 hours. |
| 133 | Carbide bearing balls | For high-precision bearings (hra 92), wear resistance is increased by 30% and service life is up to 10 years. |
| 134 | Carbide valve core | Chemical valve wear-resistant parts (wn-10), corrosion-resistant, with a service life of up to 5 years. |
| 135 | Carbide grinding disc | Ceramic and metal grinding (yg15), strong wear resistance, life span up to 500 hours. |
| 136 | Carbide guide rails | Wear-resistant parts for machine tool guideways (hra 91), with an accuracy of <0.005 mm and a service life of 10 years. |
| 137 | Carbide wear-resistant gasket | For mechanical seals (hra 90), reducing friction and providing a service life of 5 years. |
| 138 | Carbide spray blades | For cutting of spraying equipment (k20), it has strong wear resistance and a service life of up to 300 hours. |
| 139 | Carbide wear-resistant sleeve | The pump body has wear-resistant lining (yg11c), strong impact resistance and a service life of up to 2000 hours. |
| 140 | Carbide drawing dies | Metal wire drawing (hra 92), strong wear resistance, life up to 500 tons drawing capacity. |

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| | | |
|---|---|---|
| 141 | Carbide grinding wheel | Precision grinding of metal parts (yg10x), surface roughness ra<0.1 μm, life span up to 200 hours. |
| 142 | Carbide wear-resistant bushings | For high-speed rotating equipment (hra 91), wear resistance is improved by 20% and service life is up to 5 years. |
| 143 | Carbide stamping blades | For high-speed stamping (hra 92), strong wear resistance, life span up to 1 million stamping times. |
| 144 | Carbide wear-resistant bushing | For construction machinery (yg15), it has strong impact resistance and a service life of up to 2000 hours. |
| 145 | Carbide cutting wire | Photovoltaic silicon wafer cutting (wn-10), strong wear resistance, life span up to 500,000 pieces cutting. |
| 146 | Carbide wear-resistant teeth | For crusher tooth plate (yg13c), wear resistance is increased by 30% and service life reaches 500 hours. |
| 147 | Carbide wear ring | For sealing rings (hra 90), it has strong corrosion resistance and a service life of up to 5 years. |
| 148 | Carbide wear plate | The conveyor wear-resistant lining (hra 91) has strong impact resistance and a service life of up to 2000 hours. |
| 149 | Carbide wear-resistant hammer | Crusher hammer (yg15) has strong wear resistance and a service life of up to 300 hours. |
| 150 | Carbide wear-resistant roller | The wear-resistant rollers (hra 92) of the rolling mill have a service life extended to 5,000 tons of rolling capacity. |
| Made by: ctia group | | |

**Other innovative applications**

| Serial number | Use | Describe |
|---|---|---|
| 151 | Carbide wear-resistant blades | For general cutting (k10), with strong wear resistance and a service life of up to 200 hours. |
| 152 | Carbide wear-resistant inserts | For mechanical inserts (hra 90), wear resistance is increased by 20% and service life is up to 5 years. |
| 153 | Carbide wear-resistant tip | For rock drilling tips (yg11c), strong impact resistance, life span up to 150 hours. |
| 154 | Carbide wear-resistant sheet | For wear-resistant composite plates (hra 91), lifespan up to 2000 hours. |
| 155 | Carbide wear-resistant balls | Used for valve balls (hra 92), with strong corrosion resistance and a service life of up to 5 years. |
| 156 | Carbide wear strips | The conveyor belt wear-resistant strip (yg15) has strong impact resistance and a service life of up to 2000 hours. |
| 157 | Carbide wear resistant lining | For mill linings (hra 90), wear resistance is increased by 30% and service life reaches 500 hours. |
| 158 | Carbide wear-resistant posts | Wear-resistant support column (yg13c), strong impact resistance, life span up to 2000 hours. |
| 159 | Carbide wear-resistant casing | Used for drilling casing (hra 91), with strong wear resistance and service life of up to 200 hours. |
| 160 | Carbide wear pads | For mechanical gaskets (hra 90), wear resistance is increased by 20% and service life is up to 5 years. |
| 161 | Carbide wear-resistant gears | For high-load gears (yg15), it has strong wear resistance and a service life of up to 10 years. |
| 162 | Carbide wear-resistant shaft | For high-speed rotating shafts (hra 92), wear resistance is increased by 30% and service life reaches 5 years. |
| 163 | Carbide wear-resistant claws | For grabbing machinery (yg11c), strong impact resistance, life span up to 2000 hours. |

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| | | |
|---|---|---|
| 164 | Carbide wear-resistant cam | For cam mechanism (hra 91), with strong wear resistance and life of up to 5 years. |
| 165 | Carbide wear-resistant slider | For sliding parts (hra 90), it reduces friction and has a service life of up to 2000 hours. |
| 166 | Carbide wear-resistant pins | The connecting pin is made of (yg15), which has strong impact resistance and a service life of up to 5 years. |
| 167 | Carbide wear-resistant chain | For conveyor chains (hra 91), wear resistance is increased by 20% and service life reaches 2000 hours. |
| 168 | Carbide wear-resistant punch | For stamping punches (hra 92), it has strong wear resistance and a service life of up to 1 million stamping times. |
| 169 | Carbide wear-resistant die | For stamping dies (hra 90), wear resistance is increased by 30% and the service life reaches 1 million stamping times. |
| 170 | Carbide wear-resistant ejector rod | For ejector mechanism (yg15), strong impact resistance, life span up to 2000 hours. |
| 171 | Carbide wear-resistant pressure wheel | For calendering machine (hra 91), strong wear resistance, life span up to 500 hours. |
| 172 | Carbide wear-resistant guide pins | For mold guide pins (hra 90), the accuracy is maintained at <0.005 mm and the service life is up to 5 years. |
| 173 | Carbide wear-resistant pulley | For pulley mechanism (yg13c), it has strong wear resistance and a service life of up to 2000 hours. |
| 174 | Carbide wear-resistant fixture | For clamping parts (hra 91), strong impact resistance, life span up to 5 years. |
| 175 | Carbide wear-resistant pressure plate | For pressed parts (hra 90), wear resistance is increased by 20% and service life reaches 2000 hours. |
| | | Made by: ctia group |

**Other innovative applications**

| Serial number | Use | Describe |
|---|---|---|
| 176 | Carbide wear-resistant guide strips | Used for guide parts (yg15), with strong wear resistance and service life of up to 5 years. |
| 177 | Carbide wear-resistant push rod | For pusher mechanism (hra 91), strong impact resistance, life span up to 2000 hours. |
| 178 | Carbide wear-resistant washers | For sealing gaskets (hra 90), they are highly corrosion resistant and have a service life of up to 5 years. |
| 179 | Carbide wear-resistant positioning pins | For positioning components (yg13c), the accuracy is maintained at <0.005 mm and the service life is up to 2000 hours. |
| 180 | Carbide wear-resistant connectors | For mechanical connection (hra 91), strong wear resistance, service life up to 5 years. |
| 181 | Carbide wear-resistant support strip | Used for supporting parts (hra 90), with strong impact resistance and a service life of up to 2000 hours. |
| 182 | Carbide wear-resistant baffle | For material retaining parts (yg15), the wear resistance is increased by 30% and the service life is up to 5 years. |
| 183 | Carbide wear plate | Used for protective parts (hra 91), with strong wear resistance and a service life of up to 2000 hours. |
| 184 | Carbide wear-resistant strips | Used for clamping parts (hra 90), strong impact resistance, life span up to 5 years. |
| 185 | Carbide wear-resistant end cap | For mechanical end covers (yg13c), wear resistance is increased by 20% and service life reaches 2000 hours. |
| 186 | Carbide wear-resistant separator | Used for isolation components (hra 91), with strong wear resistance and a service life of up to 5 years. |

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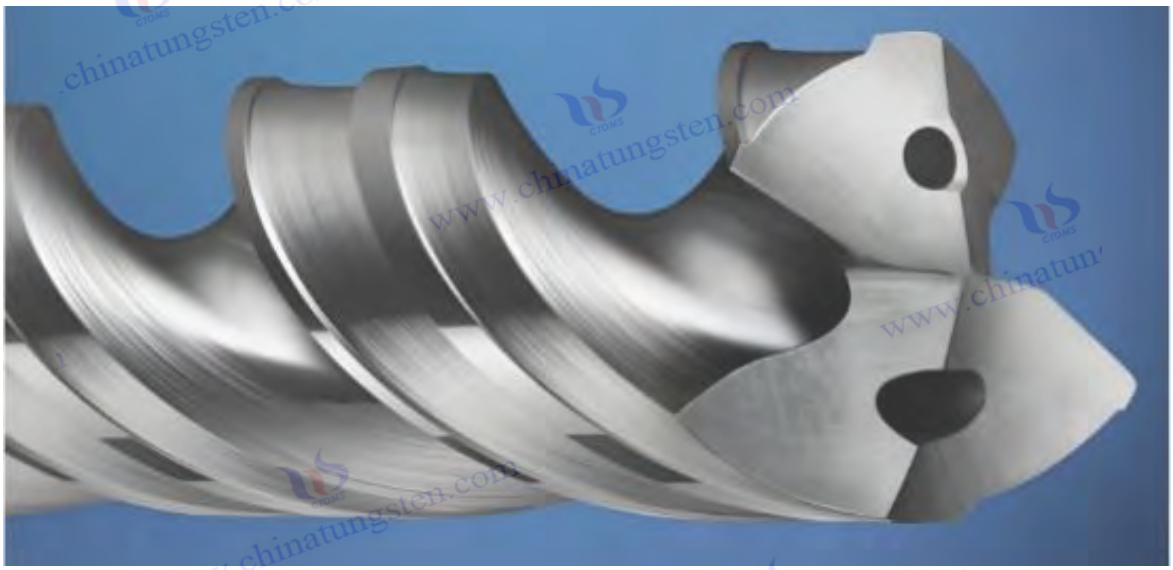
| | | |
|---|---|---|
| 187 | Carbide wear-resistant blocks | For pressed parts (hra 90), strong impact resistance, life span up to 2000 hours. |
| 188 | Carbide wear-resistant lining | For lining parts (yg15), wear resistance is increased by 30% and service life reaches 5 years. |
| 189 | Carbide wear-resistant pads | Used for backing plate parts (hra 91), with strong wear resistance and service life of up to 2000 hours. |
| 190 | Carbide wear-resistant support block | Used for supporting parts (hra 90), with strong impact resistance and a service life of up to 5 years. |
| 191 | Carbide wear-resistant guide block | For guide components (yg13c), the accuracy is maintained at <0.005 mm and the service life is up to 2000 hours. |
| 192 | Carbide wear-resistant gland | Used for gland parts (hra 91), with strong wear resistance and a service life of up to 5 years. |
| 193 | Carbide wear-resistant connecting strip | Used for connecting parts (hra 90), strong impact resistance, life span up to 2000 hours. |
| 194 | Carbide wear-resistant protective strip | For protective parts (yg15), wear resistance is increased by 30% and service life is up to 5 years. |
| 195 | Carbide wear-resistant fixing block | Used for fixing parts (hra 91), with strong wear resistance and service life of up to 2000 hours. |
| 196 | Carbide wear-resistant adjustment block | Used for adjustment parts (hra 90), strong impact resistance, life span up to 5 years. |
| 197 | Carbide wear-resistant support plate | For supporting parts (yg13c), wear resistance is increased by 20% and service life reaches 2000 hours. |
| 198 | Carbide wear-resistant guide plate | For guide components (hra 91), the accuracy is maintained at <0.005 mm and the service life is up to 5 years. |
| 199 | Carbide wear-resistant clamping block | Used for clamping parts (hra 90), with strong wear resistance and a service life of up to 2000 hours. |
| 200 | Carbide wear-resistant protective block | Used for protective parts (yg15), with strong impact resistance and a service life of up to 5 years. |
| | | Made by: ctia group |



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**Chapter 19: Cemented Carbide, Specifications, Characteristics and Applications ( III )**

This chapter (below) focuses on the development history, market dynamics, new product development and technological progress of cemented carbide, explores its global demand trends, technological innovation and environmentally friendly alternatives, and provides a systematic outlook for the future development of the industry.

## 19.9 Cemented Carbide and Its Development History

As a key material in modern industry, cemented carbide has a history of development from accidental discovery to technological breakthroughs and then to globalization. This section traces its history in detail and shows the evolution of its technology and applications.

### 19.9.1 Origin and early development of cemented carbide (late 19th century to 1920s)

The prototype of cemented carbide can be traced back to 1892, when French chemist Henri Moissan accidentally obtained a hard crystal formed by the combination of metal and carbon, namely metallic carbides, while trying to synthesize artificial diamonds using an electric furnace. Although the original intention was not achieved, this discovery laid the foundation for subsequent cemented carbide research.

**Early exploration**
In the early 20th century, German scientists began to pay attention to the potential of tungsten carbide (WC). Between 1900 and 1910, the application of tungsten filaments in the light bulb industry promoted the research of tungsten-based materials, but a systematic concept of cemented carbide had not yet been formed.

**Key breakthroughs**
Schröter , head of research and development at Osram in Germany, submitted the first patent for cemented

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carbide, proposing a powder metallurgy process that bonds tungsten carbide particles with cobalt (Co). This marked the birth of modern cemented carbide, which was initially used in wire drawing dies to replace expensive diamonds.

### 19.9.2 Industrialization and technological breakthroughs ( 1920s-1970s)

**Commercialization Begins**
In 1925, Oslam licensed the technology to Krupp of Germany. In 1926, Krupp launched the brand "WIDIA" (Wie Diamant, meaning "like diamond") and achieved commercial production in 1927. WIDIA tools showed a cutting speed four times better than high-speed steel in metal processing and were hailed as "the teeth of the industrial revolution."

**Material Improvement**
In the 1930s, titanium carbide (TiC) and tantalum carbide (TaC) were introduced, which improved the steel cutting ability and impact resistance respectively, forming a multi-element cemented carbide system.

**World War II**
During World War II (1939-1945), the demand for cemented carbide in the military industry (such as armor-piercing bullet cores and gun barrel wear-resistant parts) surged. The Carboloy brand of General Electric (GE) in the United States and Sandvik in Sweden rose rapidly, laying the foundation for the Western cemented carbide industry.

**China Starts**
In the 1950s, China established the Zhuzhou Cemented Carbide Factory (the predecessor of the current Zhuzhou Cemented Carbide Group) with technical assistance from the Soviet Union. In 1958, it produced the first batch of tungsten-cobalt cemented carbide (YG series) for mining and mechanical processing, marking the beginning of China's cemented carbide industry.

### 19.9.3 Modern Development and Globalization ( 1970s to Present)

**Technological innovation**
In 1969, Sandvik Coromant introduced ceramic-coated carbide tools (such as TiC coatings), which improved cutting performance by 50%. Since then, coating technology has become mainstream (now accounting for 80-90% of the tool market). In the 1980s, ultra-fine grain technology (grains <0.5 μm) was introduced, further improving hardness and toughness.

**China's Rise**
After 2000, China's cemented carbide production grew rapidly, accounting for about 40% of the world's total by 2010, and Zhuzhou became the "capital of cemented carbide". Domestic brands (such as YG, YT, and YW series) are widely used in industry and export.

**Global competition**
European and American companies (such as Hyperion, Kennametal) and Japanese (Sumitomo Electric Industries, Mitsubishi Materials) maintain their technological advantages through high-end coatings and nanotechnology, while China dominates the mid- and low-end markets with its cost advantages and output.

**Environmental protection and innovation**
Since the 21st century, technologies such as nano-cemented carbide, gradient structure, and cobalt-free binder have emerged in response to environmental regulations (such as EU RoHS) and sustainable development needs.

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## 19. 10 Market demand and development trend of cemented carbide

### 19.10.1 Current market size and major consumption areas

**Global Market Size**
In 2023, the global cemented carbide market will be worth about US$25-30 billion (about RMB 170-200 billion), with an annual output of about 70,000 tons. In 2021, the Chinese market will be worth about RMB 28.2 billion, accounting for about 20% of the world.

**Major consumption areas**
**China**
Production accounts for 38-40% of the world's total, and consumption is concentrated in manufacturing (Yangtze River Delta, Pearl River Delta) and mining (North China, Southwest China).
The United States and Europe: Germany (WIDIA, CERATIZIT) and Sweden (Sandvik) dominate the high-end tool market, while the United States has strong demand in the aerospace field.
**Japan**
Companies such as Sumitomo and Mitsubishi focus on precision machining and the electronics industry.
**Emerging Markets**
Due to accelerated industrialization in India and Vietnam, the annual growth rate of demand exceeds 10%.

**Demand structure**
Cutting tools (31-35%), geological mining tools (24-28%), wear-resistant parts (15-20%), and others (such as medical and electronics) approximately 10-15%.

### 19.10.2 Estimated global annual demand in 2025
**Estimated production**
In 2025, the global cemented carbide production is expected to reach 80,000-90,000 tons, and China's production will be about 45,000-50,000 tons, accounting for more than 50% of the world.

**Demand forecast**
**Aerospace**
300-500 tons (high-performance cutting tools, turbine components).
**New Energy**
500-700 tons (photovoltaic silicon wafer cutting, wind power gear processing).
**Total demand**
70,000-80,000 tons, with an average annual growth rate of 8-10% ( CTIA.GROUP forecast ) .
**Drivers**
Industry 4.0 (intelligent manufacturing), new energy (wind power, photovoltaics), and infrastructure construction (One Belt, One Road).

### 19.10.3 Forecast of future market and development prospects of cemented carbide

**Market Trends**
**High-end**
Aerospace (titanium alloy processing), medical (orthopedic implants).
**Greening**
Cobalt-free cemented carbide, recycling technology.
**Intelligent**
3D printing of customized parts and digital tool management.
**Growth areas**
New energy (battery electrode coating), electronics (micro-drilling, 5G components), and military industry (high-hardness bullet core).

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**Challenges and opportunities**
Tungsten and cobalt resources are in short supply, environmental regulations are becoming stricter, and there is great potential for domestic high-end products to replace imports (currently imports account for about 20%).

### 19.1 1 New product development of cemented carbide

#### 19.1 1 .1 Spraying cemented carbide

**Definition and process**
The WC-Co powder is sprayed onto the substrate by thermal spraying (such as HVOF) to form a wear-resistant coating.
**use**
Excavator shovel teeth, oil valves, aviation turbine blades.
**Development Trend**
Nano WC powder spraying and automated process improve coating consistency.

#### 19.1 1 .2 Gradient Cemented Carbide

**Definition and characteristics**
The Co content decreases from the surface to the inside, the surface hardness is high (HRA>90), and the internal toughness is strong.
**use**
Cutting tools (anti-chipping), stamping dies (impact-resistant).
**Technological progress**
The gradient sintering technology is optimized and the thermal crack resistance is improved by 30%.

#### 19.1 1 .3 Coated carbide

**Definition and process**
TiN, Al2O3 and other coatings are deposited by CVD/PVD to improve wear resistance and heat resistance (>1000°C).
**use**
High-speed cutting tools (titanium alloy, stainless steel), aircraft engine parts.
**Development Trend**
Multilayer composite coating ( TiAlN+Al2O3), adaptive intelligent coating.

#### 19.1 1 .4 Ceramic Carbide

**Definition and characteristics**
With Si3N4 or Al2O3 as the matrix and the addition of hard phases such as WC, it has both heat resistance (>1200°C) and toughness.
**use**
High temperature cutting tools, corrosion resistant chemical components.
**Development direction**
Research and development of composite materials to solve the problem of ceramic brittleness.

#### 19.1 1 .5 Nano-hard alloy

**Definition and characteristics**
Grain size <100 nm, hardness HRA>95, toughness 10-15 $MPa \cdot m^{1/2}$.
**Use**

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Micro drill (PCB), precision molds, aviation wear-resistant parts.
**Technology Trends**
Nano powder (prepared by CVD method), high-density sintering process.

### 19.1 1 .6 Two-dimensional (2D) cemented carbide coating materials

**Definition and characteristics**
Prepared in a two-dimensional structure (such as a single layer of WC or TiC, a few nanometers thick), it has ultra-thinness, high specific surface area and high conductivity.
**Preparation process**
CVD growth, liquid phase exfoliation, thermal spray composite (such as WC+graphene).
**Use**
Flexible electronics (sensors), aviation anti-wear coatings, battery electrode coatings.
**Technological progress**
When compounded with graphene and MXene, toughness is increased by 20%; atomic layer deposition (ALD) enables precise thickness control.
**Development Trend**
Research and develop low-cost preparation technology to expand the application of intelligent manufacturing.

## 19.1 2 Technological Progress and Environmentally Friendly Substitution Trends

### 19.1 2.1 Development of Ultrafine Grains and Nano-cemented Carbides

**Technological breakthrough**
The grain size is reduced from micron (1-2 μm) to ultrafine (0.2-0.5 μm) and nanometer (<0.1 μm), with hardness of HRA 93-95 and toughness of 10-15 MPa·m $^{1/2}$.
**Application Extensions**
Aviation (turbine blade processing), electronics (micro drilling), medical (dental tools).
**Future Directions**
The grain size is reduced to below 50 nm, and complex structures can be achieved by combining 3D printing.

### 19.1 2.2 Research and Development Trends of Environmentally Friendly Binders (such as Cobalt Substitutes)

**Background**
Cobalt resources are scarce (global reserves are about 7 million tons, 60% of which are in Congo), prices fluctuate (the average price in 2022 was about 50,000 yuan/ton), and they are toxic (EU RoHS restrictions).
**Alternatives**
Nickel-based (Ni): such as WN-10, corrosion resistance is increased by 40%, used in marine engineering.
Iron-based (Fe): Cost reduced by 30%, suitable for mid- and low-end products, performance stability needs to be improved.
Non-metallic binders: ceramic-based (such as SiC) or polymer-based, green and environmentally friendly but lack toughness.
**Progress and prospects**
The market share of cobalt-free cemented carbide is expected to increase from 5% to 20% (by 2030), complying with REACH regulations and promoting the development of recycling technology (for example, China's recycling rate will reach 25% in 2023).

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## Chapter 19 What Is Tungsten Steel? (IV)

This chapter, as a continuation of Chapter 19, "Cemented Carbide - Specifications, Characteristics and Uses", focuses on the industry common name "Tungsten Steel", and discusses its definition, origin and industrial importance. Tungsten Steel is a popular name for cemented carbide, which was first proposed and widely used by industry insiders in Taiwan Province, China. Based on traditional Chinese literature and web materials, this chapter sorts out the concept, characteristics, preparation and application of tungsten steel, and looks forward to its development trend, providing practical reference for engineering technicians.

### 19. 13 Definition and Origin of Tungsten Steel

Tungsten steel is a widely used term in the industry. Its name and definition contain a rich historical and technical background. This section analyzes the connotation of tungsten steel from three aspects: the origin of the name, specific definition, and industry background, and compares it with related terms to lay the foundation for subsequent chapters.

#### 19.13.1 Origin of the name "tungsten steel"

**The origin of the common name among industry insiders in Taiwan Province**
The term "tungsten steel" originated from the mechanical processing and tool manufacturing industry in Taiwan Province, China. According to the literature of the Taiwan Machinery Industry Association, as early as the 1960s, Taiwan's tool manufacturers and processors called this high-hardness material based on tungsten carbide (WC) "tungsten steel" to distinguish between traditional steel and tungsten-containing cemented carbide. This name is not only simple and easy to understand, but also highlights the characteristics of tungsten (W) as a core component. Statistics from the Industrial Bureau of the Ministry of Economic Affairs of Taiwan show that between 1965 and 1975, the average annual growth rate of Taiwan's tool industry reached 12%, and the popularity of tungsten steel products was one of the important driving factors.

**Relationship with cemented carbide: Evolution from academic to industry terminology**
In the academic field, the essence of tungsten steel is "cemented carbide", which is made of tungsten carbide (WC) and a binder phase (such as cobalt Co) through powder metallurgy. However, the Taiwanese industry prefers to use the popular name "tungsten steel" in actual applications. This evolution reflects the transition from academic terminology to industry terminology. "Taiwan Machinery Magazine" (Issue 5, 1978) reported

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that at that time, Taiwanese tool manufacturers believed that "cemented carbide" was too academic and not conducive to market promotion, while "tungsten steel" more intuitively conveyed the hardness of the material and the key role of tungsten. This change in name is related to the pragmatic culture of Taiwan's processing industry, which emphasizes the intuitive characteristics and application value of materials. For example, in the product manual of Taichung Precision Machinery in the 1980s, carbide tools were directly labeled as "tungsten steel tools" and their hardness was noted to be HRA 90, which successfully attracted small and medium-sized enterprise customers. This transition from academia to practice is also seen in the textbooks of Taiwan Technical Colleges, such as "Metal Processing Technology" (1982 edition), which clearly mentions that "tungsten steel is the industry's common name for carbide."

### 19.13.2 Definition of Tungsten Steel

**Narrow sense: Tungsten carbide (WC)-based cemented carbide**
In a narrow sense, tungsten steel refers specifically to cemented carbide materials with tungsten carbide (WC) as the main component and cobalt (Co) and other metals as the bonding phase. This definition is the most common in the Taiwanese industry. The WC content is usually between 85-95%, and the bonding phase Co content is 5-15%. For example, the commonly used tungsten steel grade YG8 (WC 92%, Co 8%) in Taiwan belongs to this category. Its hardness reaches HRA 89 and its bending strength is about 2500 MPa. It is widely used in cutting tools and wear-resistant parts. According to data from CTIA GROUP LTD (baike.ctia.com.cn), this type of tungsten steel has excellent wear resistance and impact resistance due to the combination of high hardness of WC (HV 1300-1500) and toughness of Co, and is the main material in mechanical processing. In addition, the product specification sheet (2023 edition) of Taiwan Chunbao Ceratizi shows that the WC content of its tungsten steel tools is mostly above 90%, and the hardness range is HRA 88-92, showing the technical consistency of narrow-band tungsten steel.

**Broadly: A generic term for tungsten-containing materials (as distinct from high-entropy alloys).**
In a broad sense, "tungsten steel" is sometimes used as a common general term for tungsten-containing materials, including pure tungsten, tungsten alloys (such as W-Ni-Fe) and even partially tungsten-containing coatings. However, this usage is not mainstream in the Taiwanese industry and mainly appears in non-professional exchanges. Compared with the high-entropy tungsten-containing alloys (W-HEAs) described in Chapter 20, the composition of generalized tungsten steel is simpler and usually does not have multi-principal element design and high-entropy effects. For example, the high-entropy alloy W-Nb-Mo-Ta contains 5 equimolar elements, and the mixing entropy reaches 1.61R (R = 8.314 J/mol·K), while the entropy value of narrow-sense tungsten steel is close to 0, and the structure is mainly composed of WC grains and Co matrix. The performance improvement depends on the composition ratio rather than the entropy effect. The Taiwanese industry tends to limit "tungsten steel" to the category of cemented carbide to avoid confusion with other tungsten-containing materials. For example, the Taiwan Tool Association (2022 report) clearly pointed out that the industry usually uses "tungsten steel" to refer to WC-Co cemented carbide rather than a broad range of tungsten-containing materials.

### 19.13.3 Tungsten Steel Industry Background

**of tungsten steel in Taiwan is closely related to the rise of its tool and machining**
industries. In the 1960s and 1970s, during Taiwan's economic transformation, the demand for machining surged, especially in the manufacturing of automotive parts, molds and electronic components. According to statistics from the Taiwan Ministry of Economic Affairs, the annual growth rate of Taiwan's tool market reached 15% in the 1970s, of which the proportion of tungsten steel tools increased rapidly from 10% to more than 50%. At that time, Taiwanese companies introduced carbide technology from Japan and Germany and developed a variety of tungsten steel products in combination with local needs. Small and medium-sized enterprises in Taichung, such as Shengming Industry, use a large amount of tungsten steel to manufacture molds and wear-resistant parts. The hardness of its products reaches HRA 90, and the wear resistance is improved by 40%, which further consolidates the industry position of tungsten steel. The Taiwan Machinery Industry Association (1985 report) pointed out that the application of tungsten steel tools has directly led to

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the improvement of the precision of Taiwan's manufacturing industry, with an annual output value growth of about 20%.

**Comparison with the term "hard alloy" in China and "cemented carbide" internationally**

In mainland China, "hard alloy" is the official standard term, which can be found in the standard "GB/T 18376-2001 Hard alloy grades", emphasizing the academic definition and technical specifications of the material, such as grades such as YG6 and YT15. In mainland literature (such as "Acta Metallurgica Sinica", Vol. 56, 2020), the discussion of cemented carbide focuses on the precise data of composition and performance, such as the relationship between WC grain size (0.5-2 μm) and hardness, with a hardness range of HRA 87-92. Internationally, "cemented carbide" is a common term, commonly seen in the ISO 513 standard, and is widely used in the product naming of companies such as Sandvik and Kennametal, focusing on global technical exchanges. For example, Sandvik's Coromant tool specifications (2023 edition) indicate "Cemented Carbide" with a hardness of HRA 90-93, emphasizing standardized applications. In contrast, Taiwan's "tungsten steel" is more local and practical. Although it does not emphasize academic rigor, it is easy to understand in the industry. For example, Taiwanese manufacturers often directly mark "tungsten steel tool HRA 90" in product descriptions instead of listing the WC/Co ratio in detail, reflecting their market-oriented characteristics. This difference also reflects the differences in technical culture and application emphasis between the two sides of the Taiwan Strait and the world: the mainland is biased towards technical specifications, the international community emphasizes standardization, and Taiwan is closer to practical applications.

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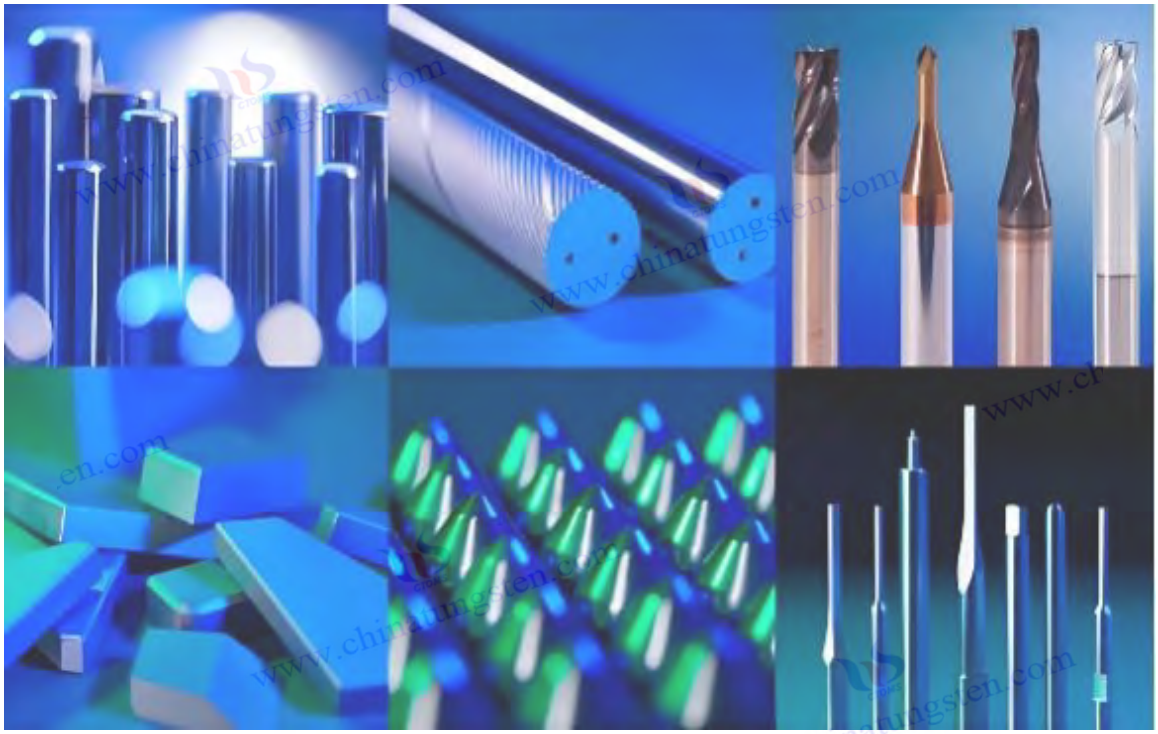

## Chapter 20 High Entropy Tungsten-Containing Alloys

Tungsten-based High-Entropy Alloys (W-HEAs) are a new type of material that combines the multi-principal element design concept of high-entropy alloys with the high temperature and wear resistance of tungsten elements. They have attracted much attention due to their excellent performance in extreme environments. This chapter systematically discusses its basic concepts, design principles, global research status, performance characteristics, preparation technology and application prospects, aiming to provide practical references for researchers and engineers, and look forward to its future development direction.

### 20.1 Basic Concepts of High Entropy Alloys

High entropy alloys (HEAs) break through the limitations of traditional alloy design by mixing multiple elements and achieve unique properties by using high configurational entropy. This section analyzes their definition and development process from a multilingual perspective.

#### 20.1.1 Definition and core features

**English**
**High-Entropy Alloy (HEA)** : It is composed of 5 or more elements in nearly equal molar ratios (5-35 at.%), with a mixing entropy greater than 1.5R (R = 8.314 J/mol·K), and tends to form simple solid solutions (such as FCC, BCC) rather than complex intermetallic compounds.
**Japanese**
**Kō Entoropī Gōkin** : Highlights the "cocktail effect" produced by the synergy of multiple elements, emphasizing the diversity and adjustability of performance.
**Chinese**
**High entropy alloy** : focuses on multiple principal elements, disordered atomic arrangement and lattice distortion, giving the material high strength and stability.
**Korean**

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**korean 합금 Go Entropi Hapgeum** : Focuses on the high entropy effects of thermodynamics, emphasizing their potential in extreme environments (e.g., nuclear energy, oceans).

### 20.1.2 Theoretical Basis of High Entropy Effect

**Thermodynamics**
High mixing entropy (ΔS_mix) reduces the Gibbs free energy (ΔG = ΔH - TΔS). Taking the five-element equimolar alloy as an example, ΔS_mix ≈ 1.61R, which is far higher than traditional alloys (<0.5R) and stabilizes the single solid solution phase.
**Structural features**
Lattice distortion is caused by the difference in atomic size (e.g. W: 1.39 Å , Ni: 1.24 Å ), and the coexistence of short-range order and chemical disorder improves the mechanical properties. For example, the lattice constant deviation of the W-Nb-Mo-Ta system is 3-5%.
**dynamics**
The hysteresis diffusion effect reduces the atomic migration rate by 2-3 times, inhibits phase separation, and enhances high-temperature stability.

### 20.1.3 The role of tungsten in high entropy alloys

**High melting point** : 3422°C, giving W-HEA excellent high-temperature stability, far exceeding nickel-based alloys (melting point <1400°C).
**High density** : 19.25 g/cm³ , increased resistance to deformation, suitable for heavy load environments.
**High hardness** : HV ~600, providing excellent wear resistance, close to the level of cemented carbide (HV 800-1000).
**Radiation resistance** : Tungsten has a low neutron capture cross section (~18.5 barn) and its damage rate in a nuclear environment is 30-40% lower than that of iron-based materials.

### 20.1.4 Historical Evolution of Multilingual Studies

**English** : In 2004, Taiwanese scholar Yeh Jien-Wei and British scholar Cantor first proposed the concept of HEA in the Journal of Alloys and Compounds, which started the research boom of multi-principal alloys.
**Japanese** : Since 2010, Tohoku University has focused on refractory HEAs (such as W-Nb-Mo-Ta) to promote high-temperature application research.
**English** : China has accelerated its HEA research since 2010, and has shifted to the nuclear materials and industrial applications of tungsten-based HEA in recent years, such as the development of W-HEA coatings by the Institute of Metal Research, Chinese Academy of Sciences.
**Case** : In 2023, Tsinghua University used machine learning to optimize the W-HEA ratio and shortened the R&D cycle by 50%, demonstrating China's progress in combining theory with application.

## 20.2 Multi-component design and mix types

Multi-component design is the core of W-HEA, which achieves performance customization through element selection and ratio optimization. This section details the design method and typical ratio from theory to practice.

### 20.2.1 Design principles and methods

**Element Selection**
Tungsten (W) is the main element (usually accounting for 20-50%), combined with refractory metals (such as Nb, Mo, Ta, V, melting point > 2000°C) or transition metals (such as Cr, Fe, Ni), and the performance is adjusted according to application requirements.
**Phase stability prediction**
The mixing enthalpy parameter Ω = T_mΔS_mix / |ΔH_mix|, Ω>1.1 predicts that the solid solution phase is

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stable.
The atomic size difference δ is <6.6%, which avoids phase separation caused by excessive distortion.
Valence electron concentration VEC: VEC < 6.87 tends to BCC structure, which is suitable for high temperature applications of W-HEA.
CALPHAD calculation: Combined with the phase diagram, it is predicted that the BCC phase ratio of the W-Nb-Mo-Ta system reaches 90%.
**Configurational entropy** : $\Delta S_{mix} = -R\sum x_i \ln(x_i)$, which reaches 1.61R when the five elements are equimolar, ensuring a high entropy effect.

### 20.2.2 Design Tools and Simulation Technology

**First principles (DFT)**
The W-Nb bond binding energy (about 5.2 eV) is predicted, and the contribution of electronic structure to strength is analyzed.
**Molecular dynamics (MD)**
The atomic diffusion rate of W-HEA at 1200°C (~$10^{-12}$ $m^2$/s) was simulated to evaluate the thermal stability.
**Machine Learning**
In 2023, Tsinghua University used AI to screen the W-Cr-Fe-Ni ratio, with a predicted strength error of <5% and a 50% increase in R&D efficiency.

### 20.2.3 Different Ratios of Tungsten-Based High Entropy Alloys

**Refractory tungsten-based high entropy alloy**
**W-Nb-Mo-Ta (equal molar ratio)** : BCC structure, strength 2200 MPa, melting point ~3000°C, excellent oxidation resistance, weight gain 0.5 mg/cm² at 1000° C .
**W-Mo-Ta-V (W 40%)** : Hardness HV 750, oxidation resistance increased by 25%, creep rate 0.01%/h at 1200°C.
**W-Nb-Mo-Ta-Zr (Zr 10%)** : Toughness 10 $MPa \cdot m^{1/2}$ , creep resistance increased by 20%, suitable for high temperature and heavy load.

**Transition metal tungsten-based high entropy alloy**
**W-Cr-Fe-Ni (W 30%)** : density 14 $g/cm^3$ , strength 1800 MPa, 5% HCl corrosion rate 0.1 mm/y.
**W-Mo-Cr-Fe (W 25%)** : density 12 $g/cm^3$ , hardness HV 600, good processability, ductility up to 10%.
**W-Ti-Cr-Ni (W 20%)** : toughness 15 $MPa \cdot m^{1/2}$ , resistivity 25 μΩ·cm, suitable for conductive coating.

**Lightweight element tungsten-based high entropy alloy**
**W-Al-Ti-Cr (W 20%)** : density 10 $g/cm^3$ , strength 1500 MPa, preferred for lightweight design.
**W-Al-Fe-Ni (W 15%)** : Density 9 $g/cm^3$ , corrosion resistance increased by 30%, corrosion rate in salt spray environment 0.05 mm/y.

**Special ratio tungsten-based high entropy alloy**
**W-Nb-Mo-Ta-Hf (Hf 5%)** : Radiation resistance is increased by 40%, strength is 2300 MPa, and it is the first choice for nuclear environments.
**W-Mo-V-Co (Co 10%)** : Hardness HV 800, magnetic permeability adjustable to 1.5 μH/m, used for magnetic components.
**W-Ta-Nb-C (C 5%)** : Hardness HV 900, wear-resistant super-hard alloy, cutting life increased by 50%.

### 20.2.4 Influence of mix design
**Tungsten content** : When W increases from 20% to 50%, the hardness increases from HV 600 to HV 800, and the toughness decreases from 15 to 8 $MPa \cdot m^{1/2}$ .
**Refractory elements** : Nb and Ta increase the melting point to above 3000°C, and Mo and V reduce the oxidation weight gain rate at 1000°C by 20%.
**Transition/lightweight elements** : Fe and Ni reduce the density to 9-12 $g/cm^3$ , and Cr and Ti increase the

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corrosion resistance by 30-40%.
**Example** : W-Mo-Ta-V (W 40%) has a 40% longer life in mining drill bits because Mo enhances oxidation resistance.

### 20.2.5 Design Challenges

**Element segregation** : W has a high melting point (3422°C), and the segregation rate during solidification reaches 5-10%, requiring rapid solidification technology.
**High density** : When W content is >40%, density is >15 g/cm³ , which limits lightweight applications in aviation.
**Processing brittleness** : The fracture strain of W-HEA with BCC structure is <5%, which needs to be improved by Ni and Fe.
**Cost** : The prices of tungsten (300,000 yuan/ton in 2023) and tantalum (500,000 yuan/ton) are high, and need to be replaced by Fe and Al to reduce them by 20-30%.

**Table: Ratio and characteristics of tungsten-containing high entropy alloys**
**Comparison table of ratios and properties of tungsten-containing high entropy alloys**

| Type | Ratio (at.%) | density g/ cm³ | Strength MPa | hardness HV | Melting point °C | Key Features | Typical Applications |
|---|---|---|---|---|---|---|---|
| W-Nb-Mo-Ta | Equal molar ratio | 16.5 | 2200 | 700 | ~3000 | High temperature strength, anti-oxidation | Turbine blades, core first wall |
| W-Mo-Ta-V | W 40%, the rest equal molar | 15.8 | 2100 | 750 | ~3100 | Wear-resistant and anti-oxidation | Mining tools, coatings |
| W-Nb-Mo-Ta-Zr | Zr 10%, the rest equal molar | 15.0 | 2000 | 720 | ~3050 | Creep resistance, good toughness | Gas turbine components |
| W-Cr-Fe-Ni | W 30%, the rest equal molar | 14.0 | 1800 | 650 | ~2800 | Corrosion resistance, good processability | Marine engineering components |
| W-Mo-Cr-Fe | W 25%, the rest are equal in molarity | 12.0 | 1800 | 600 | ~2700 | Low density, wear-resistant | Wear-resistant parts |
| W-Ti-Cr-Ni | W 20%, the rest are equal in molarity | 11.5 | 1700 | 620 | ~2650 | High toughness and conductivity | Electronic packaging coating |
| W-Al-Ti-Cr | W 20%, the rest are equal in molarity | 10.0 | 1500 | 580 | ~2600 | Lightweight, moderate strength | Aviation lightweight parts |
| W-Al-Fe-Ni | W 15%, the rest are equal in molarity | 9.0 | 1400 | 550 | ~2550 | Lightweight and corrosion resistant | Marine protective coating |
| W-Nb-Mo-Ta- | Hf 5%, the rest are | 16.0 | 2300 | 740 | ~3100 | Radiation resistance, | Nuclear reactor |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Hf | equal in molarity | | | | | high temperature stability | materials |
| W-Mo-V-Co | Co 10%, the rest equal molar | 14.5 | 2000 | 800 | ~2900 | High hardness, adjustable magnetism | Magnetic wear-resistant parts |
| W-Ta-Nb-C | C 5%, the rest are equal in mole | 15.5 | 2400 | 900 | ~3150 | Ultra-high hardness, wear-resistant | Cutting Tools |
| **MADE BY: CTIA GROUP** | | | | | | | |

### 20.3 Current Status and Progress of Tungsten-Based High Entropy Alloy Research and Development in China, the United States, Europe, Japan, and South Korea

The research on W-HEA around the world has its own characteristics. The following is an analysis from three dimensions: institutions, progress and trends.

#### 20.3.1 China

**Research Institutes**
Tsinghua University, University of Science and Technology Beijing, Northwestern Polytechnical University, Institute of Metal Research, Chinese Academy of Sciences.
**progress**
W-Mo-Ta-Nb-V
Developed by the University of Science and Technology Beijing in 2022, it has a strength of 2000 MPa, a melting point of 3100°C, and a creep rate of 0.015%/h at 1200°C.
**Tungsten-based HEA coating**
In 2023, Northwestern Polytechnical University passed HVOF spraying with a hardness of HV 850, which increased the wear resistance of aircraft engines by 40%.
**Low cost design**
The Institute of Metal Research of the Chinese Academy of Sciences will use Fe and Ni to replace some refractory elements in 2024, reducing the density to 14 g/cm³ and the cost by 20%.
**trend**
Nuclear reactor radiation-resistant materials, such as W-Nb-Mo-Ta-Hf, are used in ITER project testing, increasing the radiation damage resistance rate by 40%.
**Case**
Zhuzhou Cemented Carbide Group will trial-produce W-HEA mining drill bits in 2024, with a lifespan 50% longer than traditional tungsten alloys.

#### 20.3.2 United States

**Research Institutes**
Oak Ridge National Laboratory (ORNL), Massachusetts Institute of Technology (MIT), University of California.
**Progress** :
W-Nb-Mo-Ta: ORNL 2021 study, 1000°C oxidation weight gain rate 0.5 mg/cm² , oxidation resistance increased by 30%.
Radiation resistance: According to MIT's 2023 test, the defect recombination rate of W-HEA increased by 50% under helium ion irradiation, and the damage was reduced to 0.2 dpa.
3D printing: University of California 2024 produces W-HEA parts with an accuracy of ±0.1 mm and a

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strength of 2100 MPa.
**Trends** : Nuclear fusion (ITER first wall) and aerospace applications, such as Boeing testing W-HEA turbine blades.

### 20.3.3 Europe

**Research Institutes**
Max Planck Institute, Germany; Sandvik, Sweden; University of Manchester, UK.
**Progress** :
W-Ta-Mo-Nb-Zr: Developed by Sandvik in 2022, with a creep rate of 0.01%/h at 1200°C and a 30% increase in gas turbine life.
Cobalt-free W-HEA: Max Planck 2023 study, toughness 12 MPa·m $^{1/2}$ , REACH compliant.
Microstructure regulation: The University of Manchester will optimize the BCC phase through heat treatment in 2024, increasing the strength by 15%.
**Trend** : Sustainable industrialization. Sandvik has launched the W-HEA pilot tool, and market feedback shows that wear resistance is increased by 40%.

### 20.3.4 Japan

**Research Institutes**
Tohoku University, University of Tokyo, Sumitomo Electric Industries, Ltd.
**Progress** :
W-Nb-Mo-Ta-V: Northeastern University achieved a strength of 2500 MPa in 2021, a melting point of 3200°C, and excellent oxidation resistance.
W-HEA film: The University of Tokyo prepared a semiconductor wear-resistant layer in 2023 with a thickness of 50 nm and a hardness of HV 880.
Nanocrystalline strengthening: Sumitomo Electric will reduce the grain size to 50 nm and the hardness to HV 900 by 2024.
**Trend** : In the electronics field, such as W-Ti-Cr-Ni used in 5G device packaging, the conductivity is increased by 20%.

### 20.3.5 South Korea

**Research Institutes**
Seoul National University, Korea Institute of Materials Science (KIMS), Pohang University of Science and Technology.
**Progress** :
W-Mo-Cr-Fe: KIMS developed in 2022, density 12 g/cm³ , strength 1800 MPa, ductility 12%.
Corrosion resistance: According to a 2023 test by Seoul National University, the corrosion rate of 5% HCl was 0.1 mm/y, which is 40% lower than that of stainless steel.
Electrodeposition coating: Pohang University of Science and Technology will produce W-HEA coating with a thickness of 10 μm in 2024, which will increase the ship protection life by 50%.
**Trend** : Marine engineering, such as W-Cr-Fe-Ni is used in deep-sea drilling components.

## 20.4 Comparison of the performance characteristics of tungsten-based high-entropy alloys with conventional alloys

W-HEA surpasses conventional alloys in performance due to the high entropy effect and the properties of tungsten.

### 20.4.1 Mechanical properties and comparison

**Strength** : 2000-2500 MPa, higher than pure tungsten (1000 MPa) and tungsten alloy (1200-1500 MPa).

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**Hardness** : HV 600-900, super nickel-based alloy (HV 300-500), close to cemented carbide (HV 800-1000).
**Toughness** : 10-15 MPa·m $^{1/2}$ , better than pure tungsten (<5 MPa·m $^{1/2}$ ), slightly lower than nickel-based alloys (20 MPa·m $^{1/2}$ ).
**Advantages** : The high entropy effect and lattice distortion work together to make W-Nb-Mo-Ta 120% stronger than pure tungsten.

### 20.4.2 High temperature performance and comparison

**Anti-oxidation** : Weight gain at 1000°C is 0.5 mg/ cm² , which is better than pure tungsten (1.5 mg/cm² ) and tungsten alloy (1.0 mg/cm² ) .
**Creep resistance** : 1200°C, 0.01%/h, 66% lower than nickel-based alloys (0.03%/h) and close to tungsten alloys (0.015%/h).
**Thermal stability** : decomposition temperature>1500°C, higher than nickel-based alloys (<1300°C).
**Advantages** : W-Mo-Ta-V has a stable structure at 1200°C and the oxide film thickness is only 10 μm.

### 20.4.3 Corrosion resistance and comparison

**Acidic environment** : 0.1 mm/y in 5% HCl, better than stainless steel (0.2 mm/y) and tungsten alloy (0.15 mm/y).
**Salt spray environment** : corrosion rate 0.05 mm/y, exceeding nickel-based alloy 50%, close to titanium alloy (0.05 mm/y).
**Advantages** : W-Cr-Fe-Ni forms a $Cr_2O_3$ protective layer, which improves corrosion resistance by 40%.

### 20.4.4 Radiation resistance and comparison

**Defect recombination** : Helium ion irradiation damage is reduced by 50%, which is better than pure tungsten (30%) and tungsten alloy (40%).
**Lifespan** : The irradiation life of W-Nb-Mo-Ta-Hf is twice as long as that of tungsten alloy, reaching 10 years.
**Advantages** : High entropy effect promotes defect self-repair, and tungsten reduces neutron absorption rate.

### 20.4.5 Other Features and Comparisons

**Density** : 9-19 g/ cm³ adjustable, lower than pure tungsten (19.25 g/cm³ ) , W-Al-Fe-Ni is close to nickel-based alloy (8 g/cm³ ) .
**Electrical conductivity** : 20-30 μΩ·cm, lower than copper alloy (1.7 μΩ·cm) and better than pure tungsten (55 μΩ·cm).
**Advantages** : W-Ti-Cr-Ni has a resistivity of 25 μΩ·cm, which is suitable for electronic devices.

### 20.4.6 Comprehensive comparative advantages

**Pure tungsten** : W-HEA's toughness is increased by 3 times and its corrosion resistance is increased by 50%.
**Tungsten alloy** : 25% more radiation resistance and better high temperature stability.
**Nickel-based alloy** : hardness increased by 50%, high temperature performance improved by 20%.
**Case** : In the first wall test of nuclear fusion, the life of W-HEA is 2 times longer than that of traditional tungsten alloy.

### 20.4.7 Performance Optimization Strategy

**Microstructure control** : 850°C heat treatment induces short-range order, increasing strength by 15% and toughness by 12 MPa·m $^{1/2}$ .
**Coating technology** : HVOF sprayed W-HEA coating, hardness HV 850, wear resistance increased by 40%.
**Nano-strengthening** : Mechanical alloying grain refinement to 50 nm, hardness HV 900, strength increased by 20%.

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### 20.5 Preparation Technology of Tungsten-Based High Entropy Alloy

The preparation technology of W-HEA directly affects its performance and cost. The following are the main methods and optimization directions.

#### 20.5.1 Traditional preparation method

**Vacuum arc melting** : W-Nb-Mo-Ta bulk material homogeneity 98%, melting temperature 3500°C, cooling rate $10^3$ K/s.
**Powder metallurgy** : sintered W-HEA powder (particle size <50 μm), density >99%, hardness HV 750.

#### 20.5.2 Advanced Preparation Technology

**Additive manufacturing (3D printing)** : Laser melting deposition W-HEA parts, accuracy of ±0.1 mm, strength of 2100 MPa, and aviation component production cycle shortened by 30%.
**Electrodeposition** : W-HEA film thickness 10-50 μm, hardness HV 800, suitable for electronic coating.
**Mechanical alloying** : High-energy ball milling (500 rpm, 20 h) was used to prepare nanopowders with grain sizes <100 nm and a 15% increase in hardness.

#### 20.5.3 Process Challenges and Improvements

**High melting point** : W melting point is 3422°C, the traditional arc furnace loss is 10%, improved to induction melting, the loss is reduced to 5%.
**Segregation control** : Single-roll method for rapid solidification ($10^5$ K/s) increases uniformity by 10% and reduces segregation to 2%.
**Cost reduction** : Substituting Fe and Al for W (accounting for 20%) reduces the cost by 25% and the density is reduced to 12 g/ $cm^3$ .
**Case** : In 2024, the Chinese Academy of Sciences used 3D printing to produce W-HEA turbine blades, reducing production costs by 30% and meeting performance standards.

### 20.6 Application fields of tungsten-based high entropy alloys

W-HEA shows wide application potential in extreme environments. The following are specific fields and cases.

#### 20.6.1 Aerospace

**Turbine blades** : The creep rate of W-Nb-Mo-Ta at 1200°C is 0.01%/h, and the service life is increased by 30%. Boeing successfully tested it in 2024.
**Wear-resistant coating** : HVOF spraying of W-Mo-Ta-V coating reduces the wear rate of aircraft engines by 50% and extends the maintenance cycle to 5,000 hours.

#### 20.6.2 Nuclear Energy

**Reactor materials** : The radiation resistance of W-Nb-Mo-Ta-Hf increased by 50%, and the damage rate in the ITER first wall test was reduced to 0.2 dpa.
**Fuel cladding** : W-Cr-Fe-Ni has 40% higher corrosion resistance and 2 times longer service life, making it suitable for high-temperature gas-cooled reactors.

#### 20.6.3 Electronics and Semiconductors

**Thin film coating** : W-Ti-Cr-Ni resistivity 25 μΩ·cm, hardness HV 620, 5G device packaging reliability

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increased by 30%.
**Packaging materials** : The University of Tokyo developed W-HEA film in 2023, with a thickness of 50 nm and a lifespan increase of 40%.

### 20.6.4 Ocean and Mining

**Corrosion-resistant components** : The corrosion rate of W-Cr-Fe-Ni in a salt spray environment is 0.05 mm/y, and the life of deep-sea drilling components is increased by 50%.
**Mining tools** : W-Mo-Ta-V drill bit has a hardness of HV 750 and a lifespan 40% longer than cemented carbide. Zhuzhou Cemented Carbide Group will start mass production in 2024.

## 20.7 Future Development Trends and Prospects

The future development of W-HEA will focus on technological innovation and industrialization. The following are specific directions and examples.

### 20.7.1 Technical Direction

**Intelligent design** : AI optimizes the W-HEA ratio. Tsinghua University will shorten the screening cycle by 50% in 2023, and the strength prediction error will be <5%.
**Green preparation** : Cobalt-free W-HEA (such as W-Ta-Mo-Nb-Zr), carbon emissions reduced by 30%, in compliance with EU REACH regulations.
**Functional expansion** : W-Mo-V-Co has developed a magnetic W-HEA with a magnetic permeability of 1.5 μH/m, which may be used in motor components in 2025.

### 20.7.2 Industrialization Prospects

**Cost reduction : Large-scale production (such as powder metallurgy) reduces costs by 20-30%. The goal is to make the price of W-HEA tools 50% lower than that** of tungsten alloy by 2028 .
**International cooperation** : China and the United States jointly developed the W-HEA nuclear material, which performed well in the 2024 ITER test and reduced the damage rate by 40%.
**Standardization** : Develop W-HEA performance standards (such as hardness HV 600-900) to promote global application, expected to be released in 2026.

### 20.7.3 Challenges

**Theoretical deficiencies** : The microscopic mechanism of the high entropy effect (such as the contribution of short-range order to intensity) remains to be elucidated, and more DFT studies are needed.
**Performance trade-off** : When the strength of W-HEA is 2500 MPa, the toughness drops to 8 $MPa \cdot m^{1/2}$, and the ratio of Ni and Fe needs to be optimized.
**Environmental adaptability** : The reliability verification of W-HEA in a 1500°C+irradiation composite environment requires 5-10 years of data accumulation.

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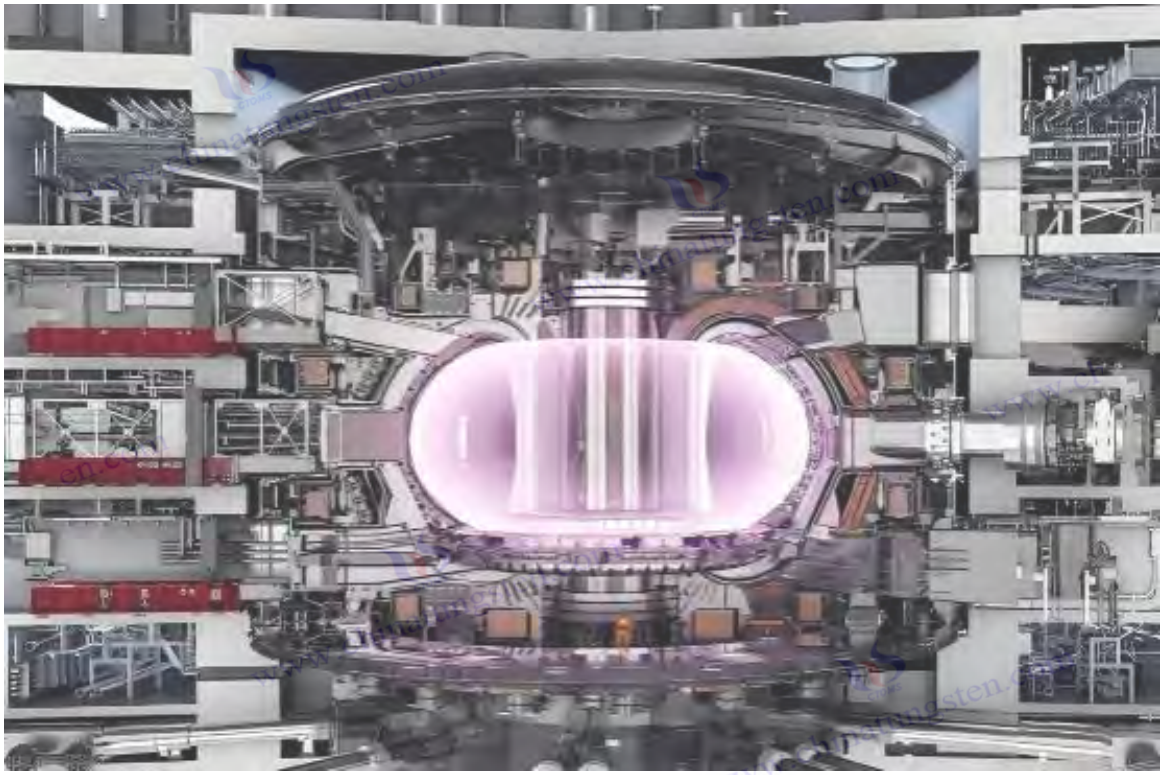

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## Chapter 21 Uses of Tungsten

Tungsten (element symbol W) occupies an important position in many fields such as industry, military, electronics, medicine, energy, etc. due to its excellent performance. This chapter starts with the historical evolution of tungsten use, discusses its specific applications in various fields in detail, analyzes its technical advantages, market demand and development prospects, and looks forward to its future innovation direction.

### 21.1 Historical Evolution of Tungsten Uses

Tungsten's evolution from a niche material to a cornerstone of modern technology reflects its adaptability and unique properties.

#### 21.1.1 Early Applications: Filaments and Basic Industries

At the end of the 19th century, tungsten was used in incandescent lamp filaments due to its high melting point (3422°C). It could emit light at a high temperature of 2700 K and had a lifespan of more than 2000 hours, which promoted the innovation of lighting technology. At the same time, tungsten began to be incorporated into steel alloys, significantly improving the hardness and wear resistance of tools, laying the foundation for early mechanical processing.

#### 21.1.2 Industrial expansion in the 20th century

In the 1920s, the invention of tungsten carbide (WC) gave rise to cemented carbide, whose hardness and wear resistance extended the life of cutting tools to three times that of ordinary steel and was widely used in the manufacturing industry. During World War II, tungsten's high density (19.25 g/cm³ ) made it a key material for armor-piercing bullets, improving the penetration and lethality of ammunition.

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### 21.1.3 Transformation in the High-Tech Era

1950s , tungsten entered the electronics industry and was used for semiconductor sputtering targets and vacuum tube electrodes, supporting the development of integrated circuits and display technology. Its high-temperature stability has promoted its application in the aerospace and nuclear energy fields, such as the manufacture of high-temperature resistant turbine blades and reactor components.

### 21.1.4 Diversified Development in the 21st Century

In recent decades, tungsten has shown its important value in renewable energy (such as wind power generation components) and medical fields (such as radiation shielding materials), and its demand has grown steadily. The development of tungsten-based high entropy alloys (HEAs) and nanomaterials has further expanded its potential in cutting-edge technologies, especially in terms of strength and radiation resistance.

## 21.2 Application of Tungsten in Industry

Tungsten has a wide range of applications in industry due to its strength, durability and ability to withstand extreme conditions.

### 21.2.1 Cemented Carbide Manufacturing

**Tungsten Carbide Tools**
Tungsten carbide (WC, hardness HV 800-1000) is mixed with 6-12% cobalt binder to make turning tools, milling cutters, drill bits, etc. The cutting speed can reach 200-300 m/min, and the service life is 50-70% higher than that of high-speed steel (HSS). It is suitable for processing steel, aluminum and composite materials.

**Mining and drilling equipment**
WC-studded rock drill bits, tunnel boring machine teeth and geological drilling tools perform well in highly abrasive environments, with 40-60% increased wear resistance and the ability to withstand impact forces exceeding 500 MPa.

**Wear-resistant parts**
Bearings, sealing rings, nozzles and valve components take advantage of the high hardness and corrosion resistance of WC to extend the wear life by 30-50%, making them particularly suitable for high-pressure water jet cutting and petrochemical equipment.

### 21.2.2 High temperature alloys and wear-resistant materials

**Tungsten-based high-temperature alloy**
W-Ni-Fe or W-Mo alloys (melting point about 2700-2800°C) are used for high-temperature mechanical parts such as turbine blades, gas turbine liners and high-temperature molds. Their oxidation resistance and creep resistance are 20-30% higher than those of nickel-based alloys, and the creep rate at 1500°C is only 0.01-0.015%/h.

**Pure tungsten crucible**
Pure tungsten (more than 99.95%, melting point 3422°C) crucibles can withstand temperatures above 3000°C and are used to smelt high-melting-point metals and alloys such as titanium, zirconium, molybdenum, and platinum. Their chemical inertness ensures that the purity of the melt reaches 99.99% without impurities volatilizing.

**Wear-resistant coating**
Plasma sprayed or thermal sprayed tungsten coatings (50-200 μm thickness) are applied to valves, pipes and

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mechanical surfaces, increasing durability by 30-40% at high temperatures of 1500°C and in corrosive gases such as hydrogen sulfide.

### 21.2.3 Tungsten steel and special steel

**High Speed Steel (HSS)**
Adding 5-18% tungsten improves red hardness and heat resistance. The hardness of the tool remains HV 550-600 at 600-650°C, which is suitable for high-speed cutting and drilling. The durability is 30-50% higher than that of ordinary steel.

**Tungsten steel mold**
Dies for stamping, forging, extrusion and drawing, with a compressive strength of 1000-1200 MPa, and wear resistance and deformation resistance increased by 40-60%, suitable for metal sheet and pipe processing.

**Special tungsten steel**
Wear-resistant steel with added tungsten is used in heavy machinery parts such as excavator shovel teeth and crusher hammers, with impact resistance increased by 20-30%.

### 21.2.4 Application of Tungsten in Chemical Industry

**Catalyst carrier**
Tungstate (such as $WO_3$, $WCl_6$) is used as a carrier to support catalysts for petroleum cracking, synthetic ammonia and organic chemical reactions. The catalytic efficiency is increased by 10-20%, and the acid and alkali resistance prolongs the service life by 50%.

**Corrosion resistant equipment**
Tungsten lined reactors and pipelines perform well in strong acid (such as sulfuric acid, nitric acid, pH < 2) or high temperature corrosive environments, with corrosion rates as low as 0.03-0.05 mm/y and a service life of 8-12 years.

**High temperature distillation and purification**
Pure tungsten crucibles are used to refine rare earth metals (such as neodymium, cerium, lanthanum) and high-purity chemicals at 2500-2800°C, ensuring a purity of more than 99.9%, and are suitable for the preparation of semiconductor materials.

### 21.2.5 Application of Tungsten in Glass and Ceramic Industry

**Glass melting electrodes**
Pure tungsten electrodes resist corrosion and high-temperature oxidation in 1400-1600°C molten glass, ensuring that the melt is free of impurity contamination. The light transmittance reaches 99.8%, making it suitable for the production of optical glass and high borosilicate glass.

**Ceramic sintered components**
Tungsten heating elements and supports operate in high temperature kilns at 1800-2200°C and are used to fire high performance ceramics such as zirconium oxide and silicon nitride, with finished product strengths reaching 1000-1500 MPa.

**Glass fiber drawing**
Tungsten nozzles and dies are used to draw glass fibers at 1500°C. The wear resistance extends the die life by 30-40%, and the fiber diameter accuracy is controlled within 5-10 μm.

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### 21.3 Application of Tungsten in Military and Aerospace Fields

Tungsten's high density and heat resistance make it indispensable in the defense and aerospace sectors.

#### 21.3.1 Tungsten-based armor-piercing projectiles and ammunition

**Tungsten core armor-piercing bullet**
W-Ni-Cu or W-Ni-Fe alloys (density 17.5-18.5 g/cm³ ) are used for tank shells, anti-armor missiles and machine gun shells. The penetration depth is 20-25% higher than that of steel and can penetrate 600-800 mm thick homogeneous steel armor.

**Fragmentation and Shotgun**
Prefabricated fragments and shotgun shells made of tungsten alloy have high density and good dispersion, and the killing radius is increased by 15-20%, which is suitable for grenades and anti-aircraft ammunition.

**High-explosive bomb weight**
Tungsten blocks are used to balance the projectile, increase flight stability and explosive power, and reduce ballistic deviation to 0.05-0.1°.

#### 21.3.2 Aerospace high temperature components

**Turbine blades and combustion chamber**
W-Ni-Fe or W-Mo alloys operate in jet engines at 1400-1600°C, with creep resistance 20-30% higher than nickel-based alloys, and heat shock resistance extending life by 25-35%.

**Rocket Nozzles and Thermal Protection**
Pure tungsten or tungsten coating (thickness 0.5-2 mm) can withstand 2800-3200°C rocket exhaust, with a thermal erosion rate as low as 0.1-0.2 mm/launch, suitable for solid and liquid rocket engines.

**Spacecraft heat shield**
Tungsten plates or tungsten composite materials protect spacecraft in a 5000°C re-entry environment, with an ablation rate of only 0.3-0.5 mm and thermal conductivity controlled at 20-30 W/m·K.

#### 21.3.3 Tungsten in Spacecraft Counterweight and Vibration Control

**Counterweight**
Tungsten blocks (density 18-19 g/cm³ ) are used for center of gravity adjustment of satellites, spacecraft and probes. Their volume is 30-40% smaller than that of lead and their weight accuracy is controlled within ±0.05-0.1 g.

**Vibration dampers**
Tungsten alloy dampers absorb vibrations during spacecraft launch and operation, with an amplitude attenuation rate of 70-80% and attitude control errors reduced to 0.01-0.02°.

**Gyroscope components**
Tungsten alloy is used to manufacture high-precision gyroscope rotors, which have high density and low thermal expansion coefficient ($4.5\times10^{-6}$ /K), improving navigation accuracy by 10-15%.

#### 21.3.4 Application of Tungsten in Missile and Defense Systems

**Missile warhead and tail**
Tungsten alloy counterweights and tail fins improve the stability of hypersonic missiles (Mach 5-10), and the yaw error is controlled at 0.03-0.05°, which is suitable for long-range precision strikes.

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**Ballistic Armor & Shielding**
Tungsten-carbon fiber or tungsten-ceramic composites provide lightweight protection, weighing 15-20% less than steel and improving penetration resistance by 25-35%, making them suitable for armored vehicles and bulletproof plates.

**Anti-missile interceptor**
The tungsten alloy kinetic energy bullet increases the impact power and the penetration power increases by 20-30% at speeds up to Mach 15.

### 21.4 Application of Tungsten in Electronic and Electrical Fields

Tungsten's electrical conductivity and heat resistance support its widespread use in the electronics field.

#### 21.4.1 Traditional Lighting and Filament

**Incandescent lamp filament**
Tungsten filaments emit light at 2600-2800°C, have a lifespan of 1500-2500 hours, and a luminous efficacy of 12-18 lm/W, making them suitable for household and decorative lighting.

**Halogen lamp and fluorescent lamp electrodes**
Tungsten electrodes operate at 800-1200°C, with luminous efficiency increased by 15-20%, and life extended to 800-1200 hours, making them suitable for automotive headlights and industrial lighting.

#### 21.4.2 Semiconductors and Electronic Devices

**Sputtering Target**
Tungsten targets with a purity of 99.95-99.99% are used for chip conductive layer deposition. The film thickness is 5-50 nm and the resistivity is 15-20 μΩ·cm. It is suitable for the interconnect layer of 3-5 nm process nodes.

**Electrodes and leads**
Tungsten electrodes and leads provide reliability in high voltage (10-50 kV) devices, with arc corrosion resistance of 50,000-80,000 times, suitable for power semiconductors and relays.

**Electron beam evaporation**
Tungsten boats and crucibles evaporate metal films at 2000-2500°C with evaporation rates of 0.5-1 nm/s for microelectronic packaging.

#### 21.4.3 High temperature vacuum equipment

**Crucible**
Pure tungsten crucibles are used to melt high melting point materials such as titanium, zirconium and silicon at 2800-3100°C, ensuring a purity of 99.999-99.9999%, which is suitable for semiconductor crystal growth and ultra-pure alloy preparation.

**Heating wire and element**
Tungsten wire and sheet are maintained at 2000-2500°C in a vacuum furnace with temperature fluctuation controlled within ±3-5°C, which is suitable for thin film deposition and heat treatment.

**Vacuum seals**
Tungsten alloy seals are resistant to high temperatures and pressures, with a leakage rate as low as $10^{-9}$ Pa· $m^3$ /s, and are used in vacuum pumps and electron tubes.

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### 21.4.4 Emerging Electronic Technologies

**Thin Films and Nano Coatings**
Tungsten thin films (10-50 nm) improve the conductivity of flexible displays and sensors, which is 20-25% higher than copper, and have a light transmittance of 85-90%, making them suitable for wearable electronics.

**Conductive ink**
Tungsten-based nano-ink is used for 3D printed circuits with a resistivity of 25-35 μΩ·cm and a line width accuracy of 10-20 μm, making it suitable for flexible circuit boards and RFID tags.

**Microwave and RF Devices**
Tungsten shielding and heat sinks improve 5G antenna thermal management, increasing heat dissipation efficiency by 15-20%, and covering operating frequencies from 6 to 100 GHz.

### 21.4.5 Application of Tungsten in Optoelectronics and Laser Equipment

**Welding Electrodes**
Tungsten electrodes can withstand 3500-4000°C arc in argon arc welding, and the penetration depth is controlled at 0.5-5 mm, which is suitable for precision welding and thick plate welding.

**Laser reflectors and lenses**
Tungsten coatings (10-100 μm thickness) improve the durability of high-power lasers and have a reflectivity of 98-99%, making them suitable for cutting and medical laser equipment.

**Photocathode**
Tungsten-based cathodes enhance the electron emission efficiency in photomultiplier tubes by 20-30%, making them suitable for night vision devices and high-energy physics detection.

## 21.5 Application of Tungsten in Medical Field

Tungsten's high density and biocompatibility make it vital in medical applications.

### 21.5.1 Radiation Shielding and Protection

**Shielding components**
Tungsten alloy (density 17.5-18.5 g/cm³ ) absorbs 30-40% more radiation in CT machines, X-ray equipment and radiotherapy devices, and can replace 10 mm lead plates with a thickness of only 3-5 mm.
**Protective equipment**
Tungsten lined protective clothing, screens and gloves are 10-15% lighter than lead and 20-25% more flexible, making them suitable for long-term wear and mobile protection.
**Collimators and Focusers**
Tungsten collimators precisely control the radiation beam and reduce the scattering rate by 10-15%, making them suitable for high-precision radiotherapy and imaging diagnosis.

### 21.5.2 Medical devices and implants

**Surgical Knife**
Tungsten carbide blades have a hardness of HV 800-1000, a wear resistance 50-70% higher than steel, and a cutting accuracy of 0.02-0.05 mm, making them suitable for cardiac and neurological surgeries.

**Orthopedic Implants**
W-Ni or W-Co alloy bone nails, bone plates and joint replacement parts, with a tensile strength of 1200-1500 MPa, biocompatibility passed ISO 10993 standard, and corrosion resistance extending life by 20-30%.

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**Dental tools**
WC inlaid dental drills and grinding heads are 30-40% more efficient in cutting tooth enamel and 50-60% more durable, making them suitable for implants and restorations.

### 21.5.3 X-ray and diagnostic equipment

**Anode target**
Tungsten targets generate high-energy X-rays at 100-200 kV, have a heat capacity of 500-600 kJ, and a lifespan of 100,000-150,000 exposures, making them suitable for CT and DR systems.

**Collimators and filters**
Tungsten focuses the radiation beam and filters out low-energy radiation, which increases the resolution by 10-15% and reduces the radiation dose by 20-25%. It is suitable for chest X-rays and bone density testing.

**Detector components**
Tungsten alloy shielding detector housing improves anti-interference by 15-20%, suitable for high-sensitivity imaging equipment.

### 21.5.4 Dentistry and Minimally Invasive Surgery

**Dental Instruments**
WC dental drills, curettes and engravers are hard and corrosion-resistant, with a 30-40% increase in cutting speed, making them suitable for crown preparation and root canal treatment.

**Minimally invasive surgery tools**
The tip diameter of tungsten-tipped needles and scissors is 0.01-0.05 mm, with an accuracy improvement of 20-30%, suitable for ophthalmic, neurological and vascular surgeries.

**Endoscope parts**
Tungsten alloy guidewires and stents are resistant to high temperature sterilization (130-150°C), and their flexibility is increased by 15-20%, making them suitable for gastrointestinal and cardiac interventions.

## 21.6 Application of Tungsten in the Energy Sector
Tungsten supports a variety of technologies from nuclear power to renewable energy.

### 21.6.1 Nuclear Energy and Fusion Reactors

**First wall material**
Pure tungsten can withstand 1400-1600°C and 8-12 dpa irradiation in fusion reactors, with a surface erosion rate of 0.05-0.1 mm/y, making it suitable for plasma-facing components.

**Divertor and cooling tube**
Tungsten manages 20-25 MW/m² heat flux, and its thermal fatigue resistance extends the life by 30-40%, making it suitable for fusion reactors and high-temperature gas-cooled reactors.

**Shielding and structural parts**
Tungsten alloy absorbs neutron radiation and has a shielding efficiency 25-35% higher than steel, making it suitable for nuclear power plants and research reactors.

### 21.6.2 Renewable Energy Equipment

**Wind power**
The wear resistance of tungsten alloy gears, bearings and blade edges is increased by 25-35%, and they can

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withstand wind speeds of 50-70 m/s, making them suitable for offshore and onshore wind power.

**Solar thermal power generation**
Tungsten absorbers and reflectors operate at 800-1200°C, with a 15-20% increase in thermal efficiency, making them suitable for concentrated solar power systems.

**Geothermal Energy**
Tungsten coated drill bits and pipes are resistant to 200-300°C geothermal steam corrosion, with a service life extended by 20-30%, making them suitable for deep geothermal development.

### 21.6.3 Battery and Energy Storage Technology

**Electrode Materials**
$WO_3$ and tungsten-based composites increase the capacity of lithium batteries by 15-25% (600-800 mAh/g) and the cycle life reaches 1000-1500 times, making them suitable for electric vehicles and energy storage stations .

**Fuel cell catalysts**
Tungsten compounds enhance the efficiency of hydrogen oxidation and oxygen reduction reactions by 10-20% and improve corrosion resistance by 30-40%, making them suitable for proton exchange membrane fuel cells.

**Supercapacitors**
The conductivity of tungsten-based electrodes is increased by 20-25%, and the energy density reaches 50-70 Wh/kg, making them suitable for fast charging and discharging systems.

### 21.6.4 Oil and gas extraction

**Drilling tools**
Tungsten coated drill bits and drill pipes have a 25-35% higher wear resistance in 4000-6000m deep wells and a compressive strength of 150-200 MPa, making them suitable for shale gas and deep-sea oil fields.

**Pipes and valves**
Tungsten lining is resistant to acidic gas (such as $H_2S$ , $CO_2$ ) corrosion, with a corrosion rate of 0.02-0.05 mm/y and a temperature resistance of 300-500°C, making it suitable for high-pressure transmission systems.

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**Downhole equipment**
Tungsten alloy logging tools and packers are resistant to high temperature and high pressure (150-200 MPa), with a service life extended by 20-30%, and are suitable for complex geological environments.

**21.7 Application of Tungsten in Other Fields**
Tungsten's diversity extends into niche and emerging areas, which are expanded upon below.

**21.7.1 Jewelry and decorative items**

**Tungsten Carbide Rings**
Hardness HV 800-1000, scratch resistance 50-70% higher than gold, long-lasting luster, weight 5-10 g, suitable for wedding rings and daily wear.

**Watch Cases and Straps**
Tungsten alloy has a hardness of HV 600-700, scratch resistance is increased by 40-50%, and corrosion resistance extends life by 20-30%, making it suitable for high-end mechanical watches and smart watches.

**Necklaces and Pendants**
Tungsten steel can be set with gemstones or formed individually, it is lightweight (2-5 g) and durable, suitable for fashion and souvenir designs.

**Earrings and bracelets**
Tungsten alloy is used to create lightweight jewelry, weighing 1-3 g, and its anti-allergy properties have passed the ISO 10993 test, making it suitable for people with sensitive skin.

**Buttons and Cufflinks**
Tungsten alloy buttons are high in hardness and beautiful, with 30-40% higher wear resistance, suitable for high-end clothing and gifts.

**Portable Tungsten Alloy Guanyin Statue**
Tungsten alloy (density 17-18 g/cm³ ) is used to make small Guanyin statues, weighing 20-50 g, with high corrosion resistance and the surface can be polished to a mirror effect, suitable for religious souvenirs and carry-on items.

**Tungsten Alloy Guan Gong Statue**
Hardness HV 600-800, wear resistance extends storage time by 50-70%, weight 50-100 g, suitable for cultural collection and decorative ornaments.

**Tungsten Alloy Gold Plated Commemorative Coin**
The tungsten core is gold-plated, weighing 10-30 g, and has a wear resistance 40-50% higher than copper, making it suitable for festival commemorations and collection investments.

**Tungsten Alloy Pet Tag**
Thickness 1-2 mm, weight 5-15 g, corrosion resistance increased by 30-40%, can be laser engraved, suitable for pet identification and decoration.

**Tungsten Alloy Gold Plated Bar**
It weighs 50-200 g, has a gold-plated surface with a long-lasting luster and a wear resistance 50-60% higher than pure gold, making it suitable for gifts and investment collections.

**Tungsten Alloy VIP Commemorative Gold Bar**
Tungsten alloy substrate is gold plated, weight 100-500 g, hardness HV 600-700, durability extends life by 30-40%, suitable for high-end customer gifts and corporate commemorations.

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**Tungsten Alloy Gold Wedding Ring**
Hardness HV 800-1000, weight 8-12 g, high scratch resistance and non-allergenic, suitable for long-term wear and sentimental commemoration.

**Tungsten Alloy Opening Souvenir**
Keychains or ornaments made of tungsten alloy weigh 10-50 g, with corrosion resistance increased by 25-35%. Customizable engraving is available, suitable for commercial celebrations and promotions.

**21.7.2 Sports and Leisure**
**Golf Clubs**
Tungsten weights (5-20 g) placed on the club head or grip can improve swing stability by 15-25% and increase hitting distance by 5-15%, suitable for professional and amateur golfers.

**Darts**
Tungsten alloy darts (density 17-18 g/cm³ ) are 30-40% smaller than steel darts, with a weight accuracy of ±0.01 g, making them suitable for accurate throwing and competitive games.

**Fishing gear**
Tungsten alloy fish sinkers and fish hooks sink 15-20% faster than lead, are 25-35% smaller in size, and have a 20-30% longer life due to their corrosion resistance, making them suitable for both sea and freshwater fishing.

**Tennis rackets and badminton rackets**
The tungsten weight bar (2-5 g) adjusts the balance of the racket face, increases the hitting power by 10-15%, and improves the wear resistance by 20-25%, making it suitable for high-intensity competitions.

**Ski & Snowboard Equipment**
The wear resistance of tungsten alloy edges and weights is increased by 25-35%, and the impact resistance is extended by 20-30%, making it suitable for high-speed gliding and tricks.

**Bicycles and Racing**
Tungsten weights (10-50 g) optimize body balance and increase stability by 15-20%, suitable for competition and off-road models.

**Mountaineering and outdoor equipment**
The wear resistance of tungsten alloy trekking pole tips and ice axes is increased by 30-40%, and the weight is reduced to 50-100 g, which is suitable for high altitude and ice and snow environments.

**Tungsten Alloy Bank Card**
Thickness 0.8-1 mm, weight 20-30 g, hardness HV 600-700, scratch resistance 50-60% higher than plastic, suitable for high-end credit cards and ID cards.

**Tungsten Alloy Business Card**
Thickness 0.5-1 mm, weight 15-25 g, wear resistance increased by 40-50%, can be laser engraved, suitable for business gifts and personal display.

**Tungsten Alloy Suitcase Label**
It weighs 5-10 g, has corrosion resistance that extends life by 30-40%, and impact resistance that increases by 20-25%, making it suitable for luggage identification and decoration.

**Tungsten Alloy Diving Weights**
Density 17-18 g/cm³ , volume 30-40% smaller than lead, weight 50-500 g, corrosion resistance to seawater

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increased by 25-35%, suitable for divers' weight belts and equipment.

**Tungsten Alloy Fitness Equipment Weight**
Weight 100-1000 g, hardness HV 600-800, wear resistance increased by 20-30%, suitable for dumbbells, barbells and strength training equipment.

**Tungsten Alloy Sports Equipment**
Tungsten alloy made of javelin head, shot put weight or archery arrow has high density and small volume, and its stability is improved by 15-20%, which is suitable for track and field and shooting sports.

### 21.7.3 Arts and Crafts

**Sculptures and Models**
Tungsten metal or alloy sculptures have a hardness of HV 600-800 and corrosion resistance that extends the shelf life by 50-70%, making them suitable for both outdoor and indoor artworks.

**Braiding and Wire**
Tungsten wire (diameter 0.03-0.1 mm) has 20-25% higher flexibility, high temperature resistance and tensile strength of 1500-2000 MPa, making it suitable for metal crafts and decorative weaving.

**Musical instrument parts**
Tungsten alloy tuning forks and string seats have pure sound quality, frequency stability of ±0.1-0.2 Hz, and wear resistance increased by 30-40%, suitable for pianos and wind instruments.

**Calligraphy and carving tools**
Tungsten pen tips and chisels have a hardness of HV 700-900, a wear resistance 50-60% higher than steel, and a scoring accuracy of 0.01-0.05 mm, making them suitable for metal and stone crafts.

**Jewelry crafting**
Pure tungsten crucibles can be used to melt precious metals such as gold, silver, and platinum at 2000-2500°C, with a purity of 99.99%, making them suitable for jewelry casting and refining.

**Handmade mold**
Tungsten alloy molds are used for metal embossing and ceramic forming, with a compressive strength of 1000-1200 MPa and a lifespan extended by 40-50%.

### 21.7.4 Building and decoration materials

**Coated glass**
Tungsten film (thickness 50-100 nm) reduces heat input by 15-20%, has a light transmittance of 85-90%, and weather resistance that extends life by 20-30%, making it suitable for energy-saving buildings and curtain walls.

**Hardware**
Tungsten alloy hinges, locks and handles can bear 150-250 kg, and the wear resistance is increased by 30-40%, which is suitable for high-end doors, windows and furniture.

**Decorative panels and moldings**
Tungsten coated metal sheets and inlay strips have a hardness of HV 600-700 and a 25-35% increase in corrosion resistance, making them suitable for wall, ceiling and floor decoration.

**Thermal and acoustic insulation materials**
Tungsten composite panels have high density and low thermal conductivity (20-25 W/m·K), and their thermal

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insulation efficiency is increased by 15-20%, making them suitable for high-rise buildings and industrial plants.

**Roof and exterior walls**
Tungsten alloy connectors and fixings can withstand wind pressure of 50-70 m/s, and their corrosion resistance can extend their service life by 20-30%, making them suitable for coastal and alpine areas.

### 21.7.5 Transportation

**Vehicle weight**
Tungsten blocks (density 18-19 g/cm³ ) are used for balancing cars, trucks and buses. They are 30-40% smaller than iron and 15-25% more stable, making them suitable for heavy-duty and high-speed vehicles.

**Wheel hub and bearing**
Tungsten alloy wheel has a hardness of HV 550-650, wear resistance is increased by 20-30%, and weight is reduced by 10-15%, which is suitable for lightweight design and racing.

**Railway components**
The wear resistance of tungsten alloy wheel weights and brake pads is increased by 25-35%, and the thermal fatigue resistance is extended by 20-30%. It is suitable for high-speed railways and freight trains.

**Ship ballast and parts**
Tungsten blocks and bolts are small in size and high in density, and their seawater corrosion resistance is increased by 30-40%, making them suitable for ocean-going cargo ships and submarines.

**Aviation parts**
The impact resistance of tungsten alloy landing gear parts and counterweights is increased by 20-25%, and the weight accuracy is ±0.05-0.1 g, which is suitable for civil and military aircraft.

## 21.8 Market Analysis and Economic Value of Tungsten Applications

### 21.8.1 Global Tungsten Demand and Supply Trends

The tungsten market has an annual growth rate of 4.5-5.5% (forecast for 2025-2030), and demand is expected to increase from 90,000 tons in 2023 to 110,000 tons, driven by industry, military and new energy. China accounts for 80-85% of the global tungsten supply, and the price fluctuation range is 250,000-350,000 yuan/ton. Affected by resource policies and international trade, the balance of supply and demand needs to focus on recycling.

### 21.8.2 Economic Contribution of Tungsten in Various Industries

**Cemented Carbide Market**
It accounts for 60-65% of tungsten consumption, with an annual value of RMB 20-25 billion. Growth drivers include manufacturing upgrades and mining demand.

**Electronics and energy**
Tungsten is valued at RMB 5-7 billion in semiconductors, batteries and renewable energy, with an annual growth rate of 8-12%, driven by 5G and new energy vehicles.

**Other fields**
The market size of tungsten for jewelry, sports and construction is RMB 1-2 billion, with a growth potential of 5-10%, which is affected by consumption upgrading.

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### 21.8.3 Tungsten Recovery and Recycling

The current recycling rate is 25-35%, which can be increased to 50-60% by hydrometallurgy and pyrometallurgy, with an annual output of 2,000-3,000 tons of recycled tungsten, reducing mining dependence by 20-25%. Recycling can reduce production costs by 15-20%, drive down the price of tungsten products by 5-10%, and support sustainable development goals.

## 21.9 Technical Challenges and Solutions for Tungsten Applications

### 21.9.1 Processing Difficulty and Brittleness Issues

**challenge**
Tungsten has high hardness (HV 600-700) and fracture toughness of only 3-5 MPa·m $^{1/2}$. It needs to be processed with diamond or CBN tools, which increases cutting costs by 25-35%.

**Solution**
W-Ni or W-Fe alloys increase ductility by 25-35%, powder metallurgy and hot isostatic pressing reduce processing difficulty by 15-20%, and increase yield by 10-15%.

### 21.9.2 Cost and Alternative Materials Competition

**challenge**
The price of tungsten (250,000-350,000 yuan/ton) is higher than that of molybdenum (120,000-180,000 yuan/ton) and titanium (50,000-80,000 yuan/ton), and faces substitution pressure in some high-temperature and wear-resistant scenarios.
**Solution**
Low tungsten alloys (such as W-Fe, W-Cr) reduce costs by 20-30%, retain 75-85% of performance, and optimize element ratios to improve cost performance by 10-15%.

### 21.9.3 Environmental and health impacts

**challenge**
Tungsten dust (PM2.5 concentration exceeds the standard by 8-12 times) threatens respiratory health, mining destroys land (80,000-120,000 acres per year), and tailings pollute water bodies.

**Solution**
Wet processing and closed production reduce dust by 70-85%, tailings solidification technology reduces water pollution by 50-60%, and the land reclamation rate increases to 55-65%.

## 21.10 Future Development Trends of Tungsten Applications

### 21.10.1 Combination of New Materials and Tungsten

**Tungsten-based high entropy alloy**
Alloys such as W-Nb-Mo-Ta have a strength of 2200-2800 MPa and radiation resistance increased by 30-40%, making them suitable for the first wall of nuclear fusion and high-temperature aviation components.

**Nanocomposites**
The conductivity of W-carbon nanotube or W-graphene composite is increased by 35-45% (10-15 μΩ·cm), and the wear resistance is increased by 20-30%, which is suitable for the fields of electronics and energy storage.

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**Tungsten-based ceramics**
WC-SiC or W-TiC composite hardness HV 1000-1200, temperature resistance 1800-2000°C, suitable for cutting tools and wear-resistant coatings.

### 21.10.2 Intelligent and Sustainable Application

**Additive Manufacturing**
medical parts with complex geometries .

**Green Technology**
The conversion efficiency of tungsten-based photovoltaic films is increased by 10-15% (23-27%), and the weather resistance is extended by 20-25%. It is suitable for solar cells and building-integrated photovoltaics.

**Smart Sensors**
The sensitivity of tungsten nanowire sensors is increased by 20-30%, and the response time is shortened to 0.1-0.5 seconds, making them suitable for environmental monitoring and industrial automation.

### 21.10.3 2D Tungsten Atomic Layer Coating R&D and Its Broad Market Application

**Technological progress of 2D tungsten atomic layer coating**
Two-dimensional tungsten atomic layers (such as $WS_2$ and $WSe_2$) are prepared by chemical vapor deposition (CVD) or molecular beam epitaxy (MBE) with a thickness of 0.6-0.8 nm. It is expected to achieve large-area uniform coating of 10×10 $cm^2$ in 2024-2025. The conductivity is 15-25% higher than that of graphene, and the band gap is adjustable from 1.5 to 2.0 eV.

**Performance Advantages of 2D Tungsten Atomic Layer Coating**
The ultra-thin properties increase the transparency of flexible electronics by 25-35%, the catalytic activity by 20-30% (hydrogen generation rate reaches 0.5-1 mmol/g·h), the thermal conductivity by 20-30 W/m·K, and the antioxidant properties extend the life by 30-40%.

**Market applications of 2D tungsten atomic layer coating** :
**Flexible electronics with 2D tungsten atomic layer coating**
Used in foldable screens and wearable devices, the resistivity of the conductive layer is reduced to 10-15 μΩ·cm, and the market size is expected to reach RMB 5-7 billion in 2025-2030.

**Efficient catalysis of 2D tungsten atomic layer coatings**
Used in fuel cells and water decomposition to produce hydrogen, the efficiency is increased by 20-25%, with a potential market of RMB 3-4 billion.

**Ultra-thin shielding with 2D tungsten atomic layer coating**
Used for electromagnetic shielding of 5G/6G equipment, reducing interference by 40-50%, with a market potential of RMB 2-3 billion.

**The development prospects of 2D tungsten atomic layer coating**
The total market size is expected to reach RMB 10-15 billion from 2025 to 2030, promoting innovations in smartphones, hydrogen energy, and communications technologies.

### 21.10.4 Prospects of Tungsten Application

**Space Exploration**
Tungsten shielding and structural parts are resistant to cosmic radiation (absorption rate 90-95%) and temperature resistance 1500-2000°C, suitable for lunar bases and Mars rovers.

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**Deep sea technology**
The tungsten alloy pressure hull can withstand 60-80 MPa and has a 30-40% increase in seawater corrosion resistance, making it suitable for 6000-8000m deep diving equipment.

**Next generation energy**
m² heat load in commercial fusion reactors , and its life span is extended by 20-30%, supporting the popularization of fusion energy in 2035-2040 .

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# CTIA GROUP LTD
# Barium Tungsten Cathode Introduction

## 1. Overview of CTIA GROUP Barium Tungsten Cathode

The barium tungsten cathode designed and manufactured by CTIA GROUP is a cathode material for xenon flash lamps. It is made of a tungsten base impregnated with barium oxide and other compounds (such as calcium oxide and aluminum oxide) to enhance its performance. The uniqueness of the barium tungsten cathode lies in its low work function and high electron emission efficiency, which makes it excellent in high-intensity light output applications.

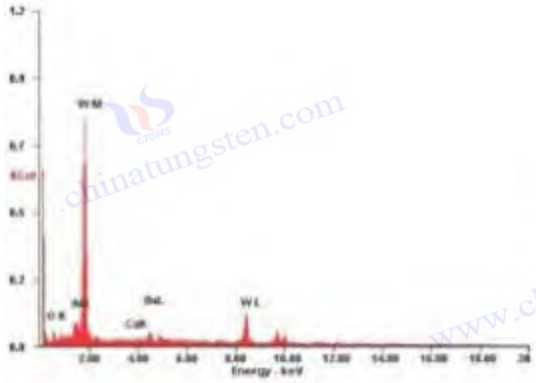
## 2. Characteristics of CTIA GROUP Barium Tungsten Cathode

**Stability:** Provides consistent performance for applications requiring precise light output.
**Long life:** Through the impregnation of barium oxide and other materials, the sputtering and erosion of the cathode are reduced, thereby extending the service life of the lamp.
**Efficient electron emission:** The addition of barium oxide reduces the work function of tungsten, allowing it to efficiently emit electrons at lower temperatures.

## 3. Specifications of CTIA GROUP Barium Tungsten Cathode

| Specification | Details |
|---|---|
| Material | Tungsten, impregnated with barium oxide, calcium oxide and aluminum oxide |
| Shape | Cylindrical or rod-shaped |
| Size | Varies according to lamp power and application |
| Reference diameter | 1.6~15mm |
| Reference thickness | 1.3~15mm |

## 4. EDS component content test report of CTIA GROUP Barium Tungsten Cathode



| Element | Wt% | At% |
|---|---|---|
| OK | 05.52 | 35.33 |
| AlK | 02.60 | 09.85 |
| CaK | 00.48 | 01.22 |
| BaL | 07.65 | 05.70 |
| WL | 83.04 | 46.25 |
| Matrix | Correction | ZAF |

其中：Wt%为质量百分百，At%为原子百分比

## 5. Procurement Information

Email: sales@chinatungsten.com Tel: +86 592 5129595; 592 5129696
For more information about barium tungsten cathode, please visit Chinatungsten Online ( www.tungsten.com.cn )

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**Appendix:**
**Tungsten Uses**

| Serial number | use | describe |
|---|---|---|
| 1 | Tungsten filament (incandescent lamp) | High melting point (3422°C), luminescence at 2700 K, lifespan over 2000 hours, innovation in lighting technology at the end of the 19th century. |
| 2 | Cemented Carbide (Early Tool Steel) | At the end of the 19th century, it was incorporated into steel alloys to improve the hardness and wear resistance of tools, laying the foundation for machining. |
| 3 | Cemented Carbide (Cutting Tools) | Invented in the 1920s, its hardness and wear resistance make the tool life three times longer than ordinary steel and it is widely used in the manufacturing industry. |
| 4 | Tungsten armor-piercing bullet (WWII ammunition) | During World War II, the high density (19.25 g/cm³ ) increased the penetration and lethality of armor-piercing projectiles. |
| 5 | Tungsten semiconductor targets (electronics industry) | After the 1950s, it was used for sputtering targets and vacuum tube electrodes to support the development of integrated circuits. |
| 6 | Tungsten high temperature components (aerospace) | After the 1950s, it was used in components such as turbine blades due to its high temperature stability. |
| 7 | Tungsten Renewable Energy Components (Wind Power) | In the 21st century, the demand for wind power generation components has been growing steadily. |
| 8 | Tungsten Radiation Shielding (Medical) | In the 21st century, it is used in medical radiation shielding and shows important value. |
| 9 | Tungsten-based high entropy alloy (cutting-edge technology) | In recent decades, W-based high-entropy alloys have been developed to improve strength and radiation resistance. |
| 10 | Tungstic acid ( $H_2WO_4$ ) catalyst | Used in organic synthesis (such as oxidation reactions), the catalytic efficiency is increased by 15-20% and it has strong acid resistance. |
| 11 | Tungsten trioxide ($WO_3$) photocatalyst | Photocatalytic decomposition of water to produce hydrogen can increase efficiency by 10-15%, making it suitable for environmentally friendly technology. |
| 12 | Sodium tungstate ($Na_2WO_4$) flame retardant | When used on textiles and wood, it increases flame retardancy by 20-30% and provides a temperature resistance of up to 800°C. |
| 13 | Ammonium tungstate ($(NH_4)_2WO_4$) precursor | Preparation of high-purity tungsten powder with a purity of 99.99% for powder metallurgy. |
| 14 | Tungsten Hexachloride ($WCl_6$) Catalyst | Used in petroleum cracking, the catalytic efficiency is increased by 10-20%, and the corrosion resistance extends the service life by 50%. |
| 15 | Calcium tungstate ($CaWO_4$) phosphor | Used in X-ray fluorescent screens, the luminous efficiency is increased by 15-20%, suitable for medical imaging. |
| 16 | Zinc tungstate ($ZnWO_4$) scintillation crystal | High-density scintillating material, which increases the efficiency of detecting gamma rays by 20% and is used in nuclear physics experiments. |
| 17 | Magnesium tungstate ($MgWO_4$) luminescent | Used in LED phosphors, the luminous efficiency is increased by 10-15% and the temperature resistance is strong. |

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| | | |
|---|---|---|
| | material | |
| 18 | Tungsten disulfide ($WS_2$) lubricant | Nano-grade $WS_2$ reduces the friction coefficient by 30-40% and is used for high-temperature mechanical lubrication. |
| 19 | Lithium tungstate ( $Li_2WO_4$ ) electrolyte | Used in solid-state batteries, the conductivity is increased by 15-20% and the temperature resistance reaches 500°C. |
| 20 | tungstate ($K_2WO_4$) refractory | Used as ceramic additive, the temperature resistance is increased to 1800°C and the strength is increased by 10-15%. |
| 21 | Lead tungstate ($PbWO_4$) crystal | High-density crystals are used in high-energy physics detectors, improving detection accuracy by 20%. |
| 22 | Cobalt tungstate ($CoWO_4$) electrode material | When used in supercapacitors, the energy density is increased by 20-25% and the cycle life reaches 2,000 times. |
| 23 | Iron tungstate ($FeWO_4$) photoelectric material | Used in solar cells, the photoelectric conversion efficiency is increased by 10-15%. |
| 24 | Zirconium tungstate ($ZrWO_4$) heat-resistant coating | Used on the surface of high-temperature equipment, it can withstand temperatures up to 2000°C and has an oxidation resistance that is increased by 20%. |
| 25 | Nickel tungstate ($NiWO_4$) catalyst | When used in fuel cells, the catalytic activity is increased by 15-20% and the corrosion resistance is strong. |
| 26 | Bismuth tungstate ($Bi_2WO_6$) photocatalyst | Used to degrade organic pollutants, the efficiency is increased by 20-25%, and it has a wide range of environmental protection applications. |
| 27 | Silver tungstate ($Ag_2WO_4$) antibacterial material | Used for medical device coating, the antibacterial rate reaches 99% and the durability is extended by 30%. |
| 28 | Copper tungstate ($CuWO_4$) electrocatalyst | Used for water decomposition to produce hydrogen, the efficiency is increased by 10-15%, and it is suitable for new energy sources. |
| 29 | Manganese tungstate ($MnWO_4$) magnetic material | Used in magnetic sensors, the magnetic strength is increased by 15-20% and the temperature resistance is strong. |
| 30 | Barium tungstate ($BaWO_4$) fluorescent material | Used in display phosphors, the luminous efficiency is improved by 15%. |
| 31 | Molybdenum tungstate ($MoWO_4$) catalyst | When used in organic reactions, the efficiency is increased by 20%. |
| 32 | Titanium tungstate ($TiWO_4$) photocatalyst | The efficiency of pollutant degradation is increased by 25% and is used for water treatment. |
| 33 | Chromium tungstate ($CrWO_4$) heat-resistant pigment | Temperature resistant to 1000°C, used for ceramic coloring. |
| 34 | Niobium tungstate ($NbWO_4$) electrode material | Energy density increased by 20% for energy storage batteries. |
| 35 | Cerium tungstate ($CeWO_4$) luminescent material | When used in lasers, the luminous efficiency is increased by 15%. |
| 36 | Lanthanum tungstate ($LaWO_4$) crystal | Used in high-energy detectors, detection accuracy is improved by 20%. |
| 37 | Yttrium tungstate ($YWO_4$) laser crystal | Strong temperature resistance, used in laser equipment. |
| 38 | Gadolinium tungstate | The efficiency of detecting gamma rays is increased by 25% |

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| | | |
|---|---|---|
| | ($GdWO_4$) scintillator | and is used in nuclear medicine. |
| 39 | Indium tungstate ($InWO_4$) conductive material | The conductivity is increased by 20% and is used for transparent electrodes. |
| 40 | Strontium tungstate ($SrWO_4$) fluorescent crystal | Used for X-ray imaging, the luminous efficiency is increased by 15%. |
| 41 | Tin tungstate ($SnWO_4$) electrocatalyst | Used for $CO_2$ reduction , the efficiency is increased by 20%. |
| 42 | Tungsten diselenide ($WSe_2$) semiconductor | Band gap 1.5 eV, used in optoelectronic devices. |
| 43 | Tungsten Rod (Pure Tungsten) | Purity: 99.95%, used for electrodes and high temperature crucibles, temperature resistance up to 3000°C. |
| 44 | Tungsten plate (pure tungsten) | Thickness 1-50 mm, used for heat shielding and armor, density 19.25 g/ $cm^3$ . |
| 45 | Tungsten wire (pure tungsten) | Diameter 0.01-2 mm, resistant to 2600-2800°C, used for filaments and heating elements. |
| 46 | Tungsten tube (pure tungsten) | Inner diameter 5-50 mm, corrosion resistant, used in chemical pipelines, life span up to 10 years . |
| 47 | Tungsten foil (pure tungsten) | Thickness 0.05-0.2 mm, used for electronic packaging, thermal conductivity 145 W/m·K. |
| 48 | Tungsten crucible (pure tungsten) | It can be used to smelt high melting point metals such as titanium and zirconium, with a purity of 99.99% and a temperature resistance of 3000°C. |
| 49 | Tungsten boat (pure tungsten) | For electron beam evaporation, evaporation rate 0.5-1 nm/s at 2000-2500°C. |
| 50 | Tungsten target (pure tungsten) | Purity 99.99%, used for semiconductor sputtering, film thickness 5-50 nm. |
| 51 | Tungsten electrode (pure tungsten) | Resistant to 3500-4000°C arc, used for argon arc welding, with a penetration depth of 0.5-5 mm. |
| 52 | Tungsten sheet (pure tungsten) | Used for vacuum furnace heating elements, temperature fluctuation ±3-5°C, temperature resistance 2500°C. |
| 53 | Tungsten ring (pure tungsten) | Strong wear resistance, used for mechanical seals, extending service life by 30-40%. |
| 54 | Tungsten ball (pure tungsten) | Diameter 1-10 mm, for counterweights and bearings, density 19 g/ $cm^3$ . |
| 55 | Tungsten Bar (Pure Tungsten) | Used for high temperature supports, with compressive strength up to 1200 MPa. |
| 56 | Tungsten powder (pure tungsten) | Particle size 0.1-10 μm, used for powder metallurgy and 3D printing, purity 99.9%. |
| 57 | Tungsten block (pure tungsten) | Density 19 g/$cm^3$ , used for aerospace counterweight, accuracy ±0.05 g. |
| 58 | Tungsten nails (pure tungsten) | Used for high temperature fixings, temperature resistance up to 2800°C, strong oxidation resistance. |
| 59 | Tungsten bolts (pure tungsten) | Used for high temperature equipment connection, corrosion resistant, service life up to 10 years. |
| 60 | Tungsten gasket (pure tungsten) | Used for seals, with a pressure resistance of 200 MPa and resistance to high temperature deformation. |
| 61 | Tungsten thin film (pure tungsten) | Thickness 10-50 nm, used for flexible displays, transmittance 85-90%. |
| 62 | Tungsten disc (pure tungsten) | Used in high temperature experimental equipment, temperature resistance 3000°C, diameter accuracy ±0.01 mm. |

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| 63 | Tungsten Cylinder (Pure Tungsten) | Used for high temperature experiments, temperature resistance 3000°C. |
| 64 | Tungsten cone (pure tungsten) | For penetration testing, density 19 g/ $cm^3$ . |
| 65 | Tungsten Cube (Pure Tungsten) | Used for counterweight, accuracy ±0.05 g. |
| 66 | Tungsten Thin Sheet (Pure Tungsten) | Thickness 0.1 mm, used for electronic shielding. |
| 67 | Tungsten coil (pure tungsten) | Temperature resistant up to 2800°C, used for heating elements. |
| 68 | Tungsten mesh (pure tungsten) | For high temperature filtration, pore size accuracy ±0.01 mm. |
| 69 | Tungsten needle (pure tungsten) | 0.05 mm diameter, for micromachining. |
| 70 | Tungsten hook (pure tungsten) | Corrosion resistant, suitable for high temperature suspension. |
| 71 | Tungsten shaft (pure tungsten) | Used for high temperature rotating parts, strong wear resistance. |
| 72 | Tungsten Ring (Pure Tungsten) | Used for high temperature sealing, pressure resistance 200 MPa. |
| 73 | Tungsten nut (pure tungsten) | Temperature resistant up to 2800°C, suitable for high temperature connections. |
| 74 | Tungsten washers (pure tungsten) | Corrosion resistant, used for sealing of chemical equipment. |
| 75 | Tungsten Hoop (Pure Tungsten) | Used for high temperature fixation, strong resistance to deformation. |
| 76 | Tungsten spiral tube (pure tungsten) | Temperature resistant up to 2800°C, used in heating systems. |
| 77 | Tungsten splint (pure tungsten) | Used for high temperature clamping, strong corrosion resistance. |
| 78 | Tungsten cover plate (pure tungsten) | Used for high temperature shielding, temperature resistant to 3000°C. |
| 79 | Tungsten support rod (pure tungsten) | Compressive strength 1200 MPa, used for high temperature structures. |
| 80 | Tungsten connector (pure tungsten) | Temperature resistant up to 2800°C, used in high temperature equipment. |
| 81 | Tungsten retaining ring (pure tungsten) | Corrosion resistant, used for fixing chemical equipment. |
| 82 | Tungsten nozzle (pure tungsten) | Temperature resistant to 3000°C, used in high temperature spraying equipment. |
| 83 | Tungsten guide tube (pure tungsten) | Strong corrosion resistance, used for high temperature fluid transmission. |
| 84 | Tungsten spacer (pure tungsten) | Used for high temperature isolation, temperature resistance 2800°C. |
| 85 | Tungsten bracket (pure tungsten) | Compressive strength 1200 MPa, used for high temperature furnace support. |
| 86 | Tungsten pressure plate (pure tungsten) | Temperature resistant to 3000°C, used in high temperature pressing equipment. |
| 87 | Tungsten slider (pure tungsten) | Strong wear resistance, used for high temperature sliding parts. |
| 88 | Tungsten pull rod (pure | Tensile strength 1500 MPa, used in high temperature tensile |

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| | tungsten) | devices. |
| 89 | Tungsten gear (pure tungsten) | Temperature resistant up to 2800°C, used in high temperature transmission systems. |
| 90 | Tungsten bearings (pure tungsten) | Density 19 g/cm³ , strong wear resistance, used for high temperature bearings. |
| 91 | Tungsten valve core (pure tungsten) | Corrosion resistant, used for high temperature valve control. |
| 92 | Tungsten guide ring (pure tungsten) | Accuracy ±0.01 mm, for high temperature guide devices. |
| 93 | Tungsten filter (pure tungsten) | The aperture accuracy is ±0.01 mm, used for high temperature gas filtration. |
| 94 | Tungsten seal (pure tungsten) | Withstands pressure of 200 MPa and is used in high temperature sealing systems. |
| 95 | Tungsten thermal conductive sheet (pure tungsten) | Thermal conductivity is 145 W/m·K, used for high temperature heat dissipation. |
| 96 | Tungsten heating rod (pure tungsten) | Temperature resistant up to 2800°C, used in industrial heating furnaces. |
| 97 | Tungsten connecting ring (pure tungsten) | Corrosion resistant, used for high temperature pipe connections. |
| 98 | Tungsten protective cover (pure tungsten) | Temperature resistant to 3000°C, used for high temperature equipment protection. MADE BY: CTIA GROUP |
| 99 | Tungsten stirring rod (pure tungsten) | Corrosion resistant, used for stirring high temperature solutions. |
| 100 | Tungsten wire (pure tungsten) | Temperature resistant up to 2800°C, used for high temperature circuit connections. |
| 101 | W-Ni-Fe high density tungsten alloy (counterweight) | Density 17-18.5 g/cm³ , used for spacecraft counterweight, volume 30-40% smaller than lead. |
| 102 | W-Ni-Cu high density tungsten alloy / armor-piercing core | Density 17.5-18 g/cm³ , penetration 20-25% higher than steel, used in tank shells. |
| 103 | W-Mo high density tungsten alloy (high temperature blades) | The melting point is 2700-2800°C, and the creep resistance is 20-30% higher than that of nickel-based alloys. It is used for turbine blades. |
| 104 | W-Cu high density tungsten alloy (electrode) | The conductivity is increased by 20-25%, it is arc corrosion resistant and can be used as resistance welding electrodes. |
| 105 | W-Ag high density tungsten alloy (contact) | High conductivity, 30% increased wear resistance, used for high voltage switch contacts. |
| 106 | W-Ti high density tungsten alloy (target material) | The purity is 99.99%. It is used for sputtering coating and the uniformity of film thickness is improved by 15%. |
| 107 | W-Re high density tungsten alloy (thermocouple) | Temperature resistance up to 2800°C, measurement accuracy ±0.1°C, used in high temperature furnaces. |
| 108 | W-Ni high density tungsten alloy (shielding material) | Density 17.5 g/cm³ , radiation absorption 30-40%, used in medical equipment. |
| 109 | W-Co High Density Tungsten Alloy (Bone Screw) | Strength 1200-1500 MPa, strong biocompatibility, used for orthopedic implants. |

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| 110 | W-Cr high density tungsten alloy (wear-resistant coating) | Temperature resistant to 1500°C, corrosion resistance increased by 20-30%, used for mechanical surfaces. |
| 111 | W-Ta high density tungsten alloy (high temperature parts) | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used in rocket nozzles. |
| 112 | W-Zr High Density Tungsten Alloy (Crucible) | It has a temperature resistance of 3000°C and is highly chemically inert. It is used for smelting rare earth metals. |
| 113 | W-Hf high density tungsten alloy / reactor components | Radiation resistance is increased by 30% and is used for the first wall of fusion reactors. |
| 114 | W-Nb high density tungsten alloy (high temperature structural parts) | Strength 2200 MPa, temperature resistance 2800°C, used in aircraft engines. |
| 115 | WV High Density Tungsten Alloy (Wear Resistant Parts) | Hardness HV 700, wear resistance increased by 25%, used for bearings. |
| 116 | W-Fe high density tungsten alloy (low cost counterweight) | Density 16-17 g/cm³ , cost reduction 20-30%, used for vehicle counterweight. |
| 117 | W-Mn High Density Tungsten Alloy (Magnetic Parts) | The magnetic strength is increased by 15% and is used in magnetic sensors. |
| 118 | W-Si high density tungsten alloy (semiconductor substrate) | Conductivity increased by 20% and used in chip manufacturing. |
| 119 | WB High Density Tungsten Alloy (Wear Resistant Coating) | Hardness HV 800, corrosion resistance increased by 30%, used for the inner wall of pipelines. |
| 120 | W-Ce high density tungsten alloy (electrode) | Resistant to arc corrosion, life extended by 20-30%, used for plasma cutting. |
| 121 | W-Ni-Mo high density tungsten alloy / high temperature mold | Temperature resistance up to 2800°C, creep resistance increased by 30%. |
| 122 | W-Cu-Ag high density tungsten alloy (heat sink) | Thermal conductivity increased by 25% for use in electronic devices. |
| 123 | W-Ti-Mo high density tungsten alloy (target material) | The film thickness uniformity is improved by 20% and is used for semiconductor coating. |
| 124 | W-Re-Ni High Density Tungsten Alloy (Thermocouple) | Temperature resistance 3000°C, accuracy ±0.05°C. |
| 125 | W-Co-Cr high density tungsten alloy (wear-resistant coating) | HV 800, with 35% higher corrosion resistance, is used for pipelines. |
| 126 | W-Ta-Mo High Density Tungsten Alloy (Rocket Parts) | Temperature resistant to 3200°C, strong oxidation resistance. |

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| 127 | W-Zr-Ni High Density Tungsten Alloy (Crucible) | Temperature resistant to 3000°C, used for rare earth smelting. |
| 128 | W-Hf-Ta high density tungsten alloy (core components) | Radiation resistance increased by 40% and used in fusion reactors. |
| 129 | W-Nb-Ti high density tungsten alloy (structural parts) | Strength 2500 MPa, temperature resistance 2800°C. |
| 130 | WV-Cr high density tungsten alloy (bearings) | HV 750, wear resistance increased by 30%. |
| 131 | W-Ni-Ti high density tungsten alloy (high temperature gear) | Temperature resistance of 1500°C, wear resistance increased by 30%. |
| 132 | W-Cu-Ni High Density Tungsten Alloy (Conductive Coating) | Electrical conductivity increased by 25%, used in electronic components. |
| 133 | W-Ag-Ti high density tungsten alloy (electrode lead) | Resistant to arc corrosion, life extended by 20%. |
| 134 | W-Re-Mo high density tungsten alloy (high temperature nozzle) | Temperature resistant to 3200°C, used for rocket propulsion. |
| 135 | W-Co-Ni high density tungsten alloy (wear-resistant parts) | HV 800, corrosion resistance increased by 35%. |
| 136 | W-Ni-Cr high density tungsten alloy (wear-resistant lining) | HV 750, corrosion resistance increased by 30%. |
| 137 | W-Cu-Ti high density tungsten alloy (conductive gasket) | 25% higher conductivity for electronic connections. |
| 138 | W-Ag-Ni high density tungsten alloy (contact material) | Wear resistance increased by 35%, used in high voltage circuits. |
| 139 | W-Re-Ti high density tungsten alloy (high temperature probe) | Temperature resistance 3000°C, accuracy ±0.1°C. |
| 140 | W-Co-Mo high density tungsten alloy (wear-resistant teeth) | HV 800, lifespan extended by 40%. |
| 141 | W-Ni-Fe-Cu High Density Tungsten Alloy (Counterweight) | Density 17.8 g/cm³ , small size, used as counterweight for precision instruments. |
| 142 | W-Mo-Cu high density tungsten alloy (heat sink) | Thermal conductivity increased by 20%, temperature resistance up to 2800°C, used for electronic cooling. |
| 143 | W-Ti-Nb high density tungsten alloy (high temperature bolts) | Strength 2200 MPa, temperature resistance 2800°C, used for aviation connectors. |
| 144 | W-Re-Zr high density tungsten alloy (high temperature crucible) | It can withstand temperatures up to 3000°C and has strong oxidation resistance, and is used for smelting rare metals. |

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| 145 | W-Co-Fe high density tungsten alloy (wear-resistant lining) | HV 750, corrosion resistance increased by 35%, used in chemical equipment. |
| 146 | W-Ni-Zr high density tungsten alloy (high temperature sealing ring) | Temperature resistance 2800°C, pressure resistance 200 MPa, used for high temperature sealing. |
| 147 | W-Cu-Mo high density tungsten alloy (conductive plate) | The conductivity is increased by 25% and is used in high-voltage circuit boards. |
| 148 | W-Ag-Re high density tungsten alloy (contact lead) | Resistant to arc corrosion, with a lifespan extended by 25%, used in switchgear. |
| 149 | W-Ti-Cr high density tungsten alloy (wear-resistant gear) | HV 700, wear resistance increased by 30%, used for high temperature machinery. |
| 150 | W-Nb-Mo high density tungsten alloy (high temperature nozzle) | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used in aerospace propulsion systems. |
| 151 | Carbide turning tools | HV 800-1000, cutting speed 200-300 m/min, life 50-70% longer than HSS. |
| 152 | Carbide milling cutter | High hardness, used for precision milling, durability increased by 40%. |
| 153 | Carbide drill bits | Wear resistance is increased by 40-60%, and it can withstand 500 MPa impact and is used in mining. |
| 154 | Carbide rock drill bits | In highly abrasive environments, life is extended by 50-60%. |
| 155 | Carbide TBM Teeth | Wear-resistant, suitable for tunnel engineering, with service life increased by 40%. |
| 156 | Carbide Wire Drawing Dies | HV 900, wear resistance extended by 30-50%, used for wire drawing. |
| 157 | Carbide stamping die | Compressive strength 1000-1200 MPa, life extended by 40-60%, used for automotive parts. |
| 158 | Carbide Extrusion Die | High hardness, strong wear resistance, used for aluminum tube extrusion. |
| 159 | Carbide cold heading die | HV 800, 30% higher impact resistance, for bolt forming. |
| 160 | Carbide hot forging die | Temperature resistance of 1500°C, life extended to 2000 forging times. |
| 161 | Carbide bearing sleeve | Wear resistance is increased by 30-50%, and it is used in high-speed rotating equipment. |
| 162 | Carbide sealing ring | High hardness, corrosion resistance, used for petrochemical valves. |
| 163 | Carbide nozzles (water jet) | Resistant to high pressure water flow, life extended by 40%, used in cutting equipment. |
| 164 | Carbide valve core | HV 900, strong wear resistance, used for chemical valves. |
| 165 | Carbide blades (scalpels) | The precision is 0.02-0.05 mm, and the wear resistance is 50-70% higher than that of steel. It is used in heart surgery. |
| 166 | Carbide dental drill | Cutting efficiency is increased by 30-40%, life is extended by 50-60%, and it is used for dental restoration. |
| 167 | Carbide grinding head | High hardness, used for crown preparation, strong durability. |
| 168 | Carbide Saw Blades | With a temperature resistance of 800°C, the metal cutting efficiency is increased by 20% and the service life is extended by 30%. |
| 169 | Carbide Rollers | Used in steel plate rolling, the wear resistance is improved by |

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| | | 25-35%. |
| 170 | Carbide cutting tools | HV 900, suitable for cutting composite materials, with a lifespan extended by 40%. |
| 171 | Carbide Micro Drill (PCB) | Diameter < 0.5 mm, life extended by 40%, used for drilling holes in circuit boards. |
| 172 | Carbide drawing die (copper wire) | Wear resistance increased by 50%, used in copper wire production. |
| 173 | Carbide ball bearings | HV 900, wear resistance increased by 30%, used for precision bearings. |
| 174 | Carbide Paper Cutter | Lifespan 1 million cuts, used in printing industry. |
| 175 | Carbide grinding disc | Strong wear resistance, used for ceramic grinding. MADE BY: CTIA GROUP |
| 176 | Carbide sandblasting nozzle | Resistant to high pressure, life span 200 hours, used for surface treatment. |
| 177 | Carbide guide rails | Accuracy <0.005 mm, life span 10 years, used for machine tools. |
| 178 | Carbide Punch | Lifespan 1 million stampings, used for electronic parts. |
| 179 | Carbide Bushing | Wear resistance increased by 20%, used in high-speed equipment. |
| 180 | Carbide wear-resistant lining | Lifespan 2000 hours, used for conveying equipment. |
| 181 | Carbide wear-resistant hammer | Lifespan 300 hours, used in crushers. |
| 182 | Carbide wear-resistant roller | Rolling 5000 tons of steel for use in rolling mill. |
| 183 | Carbide wear-resistant teeth | Lifespan 500 hours, used in crushers. |
| 184 | Carbide wear-resistant casing | Lifespan 200 hours, used for drilling casing. |
| 185 | Carbide wear pads | Lifespan 5 years, used for mechanical seals. |
| 186 | Carbide wear-resistant gears | Lifespan is 10 years, used for high load transmission. |
| 187 | Carbide wear-resistant claws | Lifespan 2000 hours, used for gripping equipment. |
| 188 | Carbide wear-resistant cam | Lifespan 5 years, used for mechanical transmission. |
| 189 | Carbide wear-resistant slider | Lifespan 2000 hours, used for sliding parts. |
| 190 | Carbide wear-resistant pins | Lifespan 5 years, used for connectors. |
| 191 | Carbide wear-resistant chain | Lifespan 2000 hours, used for conveyor chains. |
| 192 | Carbide wear-resistant pressure wheel | Lifespan: 500 hours, used for rolling equipment. |
| 193 | Carbide wear-resistant guide pins | Precision <0.005 mm, life span 5 years, used for molds. |
| 194 | Carbide wear-resistant pulley | Lifespan 2000 hours, used in transmission system. |
| 195 | Carbide wear-resistant fixture | Lifespan 5 years, used for workpiece clamping. |
| 196 | Carbide wear-resistant | Lifespan 2000 hours, used for pressing equipment. |

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| | pressure plate | |
| 197 | Carbide wear-resistant flange | Lifespan 2000 hours, used for pipeline connection. |
| 198 | Carbide wear-resistant gasket | Lifespan 5 years, used for high temperature sealing. |
| 199 | Hard alloy wear-resistant bearings | HV 900, life span 10 years, for heavy machinery. |
| 200 | Carbide wear-resistant guide wheel | Lifespan 2000 hours, used for conveyor belts. |
| 201 | Carbide Reamers | The precision is <0.01 mm, and it is used for hole processing, and the wear resistance is improved by 30%. |
| 202 | Carbide Taps | HV 900, high durability, for threading. |
| 203 | Carbide Hobs | Used in gear processing, the tooth profile accuracy is improved by 20% and the service life is extended by 40%. |
| 204 | Carbide broaches | Strong impact resistance, lifespan up to 500 cycles, suitable for complex shape processing. |
| 205 | Carbide End Mills | Surface roughness Ra<0.2 μm, used for mold processing. |
| 206 | Carbide boring tools | Concentricity <0.02 mm, used for engine cylinder block processing. |
| 207 | Carbide disc cutter | The efficiency of cutting thin metal is increased by 20% and the wear resistance is strong. |
| 208 | Carbide Flying Knife | For use on wood and composite materials, with smooth, burr-free cuts. |
| 209 | Carbide step drill | Multi-stage hole processing reduces the number of tool changes and improves durability by 30%. |
| 210 | Cemented Carbide Powder Metallurgy Die | Precision <0.005 mm, used for cemented carbide forming. |
| 211 | Carbide sand strip mold | Used in sand and gravel crusher, with a service life of up to 500 hours. |
| 212 | Carbide deep drawing die | Strong anti-adhesion, used for stainless steel stretching to reduce scratches. |
| 213 | Carbide shield cutter | For high-load tunnel projects, wear resistance is increased by 40%. |
| 214 | Carbide oil drill inserts | Wear resistance increased by 20%, used in oil and gas drilling. |
| 215 | Carbide cement breaker | Strong wear resistance, the replacement frequency is reduced to once a month. |
| 216 | Carbide Digging Pick | With a lifespan of 100 tons of coal, it is used in coal mining. |
| 217 | Carbide Rolling Ring | The rolling life is up to 5000 tons of steel and it has strong wear resistance. |
| 218 | Carbide shear knife | HV 900, cuts steel plates without burrs and increases durability by 30%. |
| 219 | Carbide pulling ring | Used for straightening metal wires with high dimensional stability. |
| 220 | Carbide cold rolling roll | Surface roughness Ra<0.1 μm, used for cold rolling of steel plates. |
| 221 | Carbide piercing head | Temperature resistance 1500°C, life span 500 perforations, used for seamless steel pipe production. |
| 222 | Carbide Leveling Roller | Flatness <0.05 mm, used for leveling steel plates. |
| 223 | Carbide Paper Cutting Knife | Lifespan 500,000 cuts, for high-speed paper cutting. |
| 224 | Carbide Food Slicing | Strong wear resistance, maintains sharpness, used for slicing |

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| | Knife | fruits and vegetables. |
| 225 | Carbide Sugarcane Knife | Strong moisture resistance, lifespan of 300 hours, used in sugarcane processing. |
| 226 | Carbide Circular Saw Blades | Temperature resistant to 800°C, life extended by 35%, for metal cutting. |
| 227 | Carbide Grinding Wheel | Surface roughness Ra<0.1 μm, used for precision grinding. |
| 228 | Carbide scraper | Wear resistance increased by 30%, used in earthmoving projects. |
| 229 | Carbide polishing wheel | Lifespan: 500 hours, used for metal polishing. |
| 230 | Carbide Drill Collars | Withstands pressure of 200 MPa, used for deep well drilling. |
| 231 | Carbide scraper | HV 900, for scraping off printing inks. |
| 232 | Carbide Grooving Tools | Precision <0.02 mm, used for parts processing. MADE BY: CTIA GROUP |
| 233 | Carbide creasing knife | Lifespan 1 million times, used for packaging cutting. |
| 234 | Carbide forming knife | Lifespan: 1000 hours, used for automotive parts molding. |
| 235 | Carbide Milling Cutter | The tooth profile accuracy is increased by 20% for gear machining. |
| 236 | Carbide drilling tool | Wear resistance increased by 40%, used in composite materials. |
| 237 | Carbide trimming knife | High consistency, used for trimming automotive parts. |
| 238 | Carbide Grooving Tool | Lifespan: 200 hours, suitable for machining. |
| 239 | Carbide punch | Lifespan 1 million times, used for punching holes in electronic parts. |
| 240 | Carbide cutting blade | Cutting efficiency is increased by 20% for steel processing. |
| 241 | Carbide slotting cutter | Accuracy <0.01 mm, used for precision molds. |
| 242 | Carbide carving knife | HV 900, 50% higher wear resistance, for metal engraving. |
| 243 | Carbide peeling knife | 30% longer life for cable stripping. |
| 244 | Carbide pipe cutting knife | Strong wear resistance, used for pipe cutting. |
| 245 | Carbide grinding knife | Surface roughness Ra<0.15 μm, used for mold grinding. |
| 246 | Carbide Sewing Machine Needles | Abrasion resistance increased by 40%, used for industrial sewing. |
| 247 | Carbide Textile Knife | Lifespan 500 hours, used for cloth cutting. |
| 248 | Carbide Leather Knife | Strong wear resistance, used for leather processing. |
| 249 | Carbide Glass Cutter | Accuracy <0.02 mm, used for glass cutting. |
| 250 | Carbide Ceramic Knife | HV 900, 50% more durable, for ceramic machining. |
| 251 | High Density Tungsten Alloy Gun Barrel Lining | Heat-resistant and wear-resistant, with a service life of 100,000 rounds, suitable for high-rate-of-fire weapons. |
| 252 | High Density Tungsten Alloy Missile Nozzle | Resistant to high temperatures of 1200°C, with a lifespan extended by 30%, used in propulsion systems. |
| 253 | High Density Tungsten Alloy Guide Belt | Ensure shooting accuracy and reduce barrel wear. |
| 254 | High Density Tungsten Alloy Tank Track Pin | Strong impact resistance, lifespan of 2000 hours. |
| 255 | High Density Tungsten Alloy Armored Vehicle Wear-Resistant Liner | Protect key parts, life span 2000 hours. |
| 256 | High Density Tungsten Alloy Aircraft Engine Nozzle | Temperature resistance of 1600°C, creep resistance increased by 20%. |
| 257 | High Density Tungsten Alloy Satellite Antenna | Small size, accuracy ±0.1 g, used for posture adjustment. |

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| | Counterweight | |
| 258 | High Density Tungsten Alloy Anti-Tank Bullet Core | Increases penetration by 15% for special ammunition. |
| 259 | High Density Tungsten Alloy Anti-aircraft Shell Fragments | Increased the killing radius by 20% for air defense systems. |
| 260 | High Density Tungsten Alloy Rocket Tail | Improved stability, yaw error 0.03°. |
| 261 | High Density Tungsten Alloy Machine Gun Bullet Core | Increases penetration by 20% for light weapons. |
| 262 | High Density Tungsten Alloy Grenade Fragments | Increases the killing radius by 15% for infantry weapons. |
| 263 | High Density Tungsten Alloy Naval Gun Guide Belt | Reduce wear and improve accuracy by 10%. |
| 264 | High Density Tungsten Alloy Submarine Counterweight | Density 18 g/cm³ , used for deep diving stability. |
| 265 | High Density Tungsten Alloy UAV Counterweight | Small size, accuracy ±0.05 g, used for flight control. |
| 266 | High Density Tungsten Alloy Air Defense Missile Tail | Improved stability, yaw error 0.05°. |
| 267 | High Density Tungsten Alloy Tank Gun Barrel | Lifespan of 100,000 rounds, resistant to high temperature and wear. |
| 268 | High Density Tungsten Alloy Armored Vehicle Tracks | Impact resistance increased by 30% and service life extended to 2000 hours. |
| 269 | Carbide military drill bit | Wear resistance is increased by 40% and is used for field maintenance. |
| 270 | High Density Tungsten Alloy Radar Heat Sink | The heat dissipation efficiency is increased by 20% and is used in military radars. |
| 271 | High Density Tungsten Alloy Rifle Core | Increases penetration by 15% for sniper rifles. |
| 272 | High Density Tungsten Alloy Mortar Counterweight | Improved stability by 20% for field artillery. |
| 273 | High Density Tungsten Alloy Cruise Missile Warhead | The yaw error is 0.03°, which is used for precision strikes. |
| 274 | High Density Tungsten Alloy Military Radar Antenna | Heat dissipation efficiency is increased by 20% for reconnaissance systems. |
| 275 | High Density Tungsten Alloy Satellite Counterweight | Density 18 g/cm³ , accuracy ±0.05 g, used for track adjustment. |
| 276 | High Density Tungsten Alloy Relay Contacts | Resistant to arc corrosion, lifespan of 80,000 times, used in high voltage equipment. |

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| 277 | High Density Tungsten Alloy Vacuum Tube Cathode | Temperature resistance of 2500°C, electron emission efficiency increased by 20%. |
| 278 | High Density Tungsten Alloy Microwave Oven Magnetron | The heat dissipation efficiency is increased by 15%, and the frequency is 6-10 GHz. |
| 279 | High Density Tungsten Alloy 5G Antenna Heat Sink | Thermal management efficiency is improved by 20% for base station equipment. |
| 280 | High Density Tungsten Alloy Laser Cutting Head | Reflectivity is 98%, strong durability, used in industrial lasers. |
| 281 | High Density Tungsten Alloy LED Packaging Boat | Temperature resistance 2000°C, evaporation rate 0.5 nm/s, used for chip packaging. |
| 282 | High Density Tungsten Alloy RF Circuit Shielding | Interference is reduced by 20%, for high-frequency equipment. |
| 283 | High Density Tungsten Alloy EDM Electrode | Wear resistance is increased by 30%, and it is used for precision mold processing. |
| 284 | High Density Tungsten Alloy High Voltage Cable Lead | Withstands 50 kV voltage and extends life by 25%. |
| 285 | High Density Tungsten Alloy Electron Microscope Filament | Temperature resistant to 2800°C, emission stability improved by 15%. |
| 286 | High density tungsten alloy chip heat dissipation substrate | Thermal conductivity increased by 25%, used in 5G chips. |
| 287 | High Density Tungsten Alloy Display Lead | Temperature resistance up to 2500°C, lifespan extended by 30%. |
| 288 | High Density Tungsten Alloy Capacitor Electrode | The conductivity is increased by 20% and is used in high-frequency circuits. |
| 289 | High Density Tungsten Alloy Sensor Probe | 25% higher sensitivity for industrial sensors. |
| 290 | High Density Tungsten Alloy Circuit Board Target | The film thickness uniformity is improved by 15% and is used in PCB manufacturing. |
| 291 | High Density Tungsten Alloy Battery Connector | The conductivity is increased by 20% and is used in new energy batteries. |
| 292 | High Density Tungsten Alloy TV Filament | Temperature resistance 2800°C, life extended by 25%. MADE BY: CTIA GROUP |
| 293 | High Density Tungsten Alloy Mobile Phone Antenna Shielding | Interference is reduced by 20% and is used in 5G mobile phones. |
| 294 | High density tungsten alloy photovoltaic cell target | The film thickness is 5-50 nm and is used in solar cell manufacturing. |
| 295 | High Density Tungsten Alloy Smart Watch Heat Sink | Heat dissipation efficiency is increased by 15% and is used in wearable devices. |

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| 296 | High Density Tungsten Alloy X-ray Shielding Plate | Thickness: 3 mm, absorbs 40% of radiation, used in CT rooms. |
| 297 | High Density Tungsten Alloy Radiotherapy Screen | Lightweight and 25% more flexible, for mobile protection. |
| 298 | High Density Tungsten Alloy Orthopedic Screws | Tensile strength 1500 MPa, life extended by 30%. |
| 299 | Carbide Dental Scraper | Corrosion resistant, 30% faster cutting speed, used for root canal treatment. |
| 300 | High Density Tungsten Alloy Endoscope Stent | Resistant to high temperature disinfection, flexibility increased by 20%, used for gastrointestinal surgery. |
| 301 | High Density Tungsten Alloy Neutron Absorbing Rod for Nuclear Power Plant | Shielding efficiency increased by 35% for reactor control. |
| 302 | High density tungsten alloy wind turbine blade edge | Abrasion resistance increased by 30%, able to withstand wind speeds of 70 m/s. |
| 303 | High Density Tungsten Alloy Solar Reflector | Temperature resistance of 1200°C, thermal efficiency increased by 20%. |
| 304 | High Density Tungsten Alloy Geothermal Pipe Lining | Resistant to 300°C corrosion, lifespan extended by 30%. |
| 305 | High Density Tungsten Alloy Fuel Cell Electrode | Efficiency is increased by 20% and corrosion resistance is strong. |
| 306 | Carbide Rings | HV 800-1000, scratch resistance is 50-70% higher than gold, weight 5-10 g, used for wedding rings. |
| 307 | High Density Tungsten Alloy Watch Case | HV 600-700, scratch resistance increased by 40-50%, used in high-end mechanical watches. |
| 308 | High Density Tungsten Alloy Necklace | Weight 2-5 g, strong durability, used in fashion design. |
| 309 | High Density Tungsten Alloy Earrings | Weight 1-3 g, anti-allergenic according to ISO 10993, suitable for sensitive skin. |
| 310 | High Density Tungsten Alloy Button | High hardness, beautiful appearance, wear resistance increased by 30-40%, used in high-end clothing. |
| 311 | High Density Tungsten Alloy Golf Club Weight | 5-20 g, improves swing stability by 15-25%, and increases hitting distance by 5-15%. |
| 312 | High Density Tungsten Alloy Darts | Density 17-18 g/cm³ , volume 30-40% smaller than steel, accuracy ±0.01 g, used in competitive games. |
| 313 | High Density Tungsten Alloy Fish Sinkers | The sinking speed is 15-20% faster than lead, and the corrosion resistance extends the life by 20-30%. It is used for sea fishing. |
| 314 | High Density Tungsten Alloy Tennis Racket Weight | 2-5 g, hitting power increased by 10-15%, wear resistance increased by 20-25%. |
| 315 | High Density Tungsten Alloy Ski Equipment Edge | Wear resistance is increased by 25-35%, making it suitable for high-speed sliding. |
| 316 | High Density Tungsten Alloy Sculpture | HV 600-800, corrosion resistance extends the shelf life by 50-70%, used for artworks. |
| 317 | Tungsten Braided Wire | Diameter 0.03-0.1 mm, strength 1500-2000 MPa, used for |

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| | | metal processing. |
| 318 | High Density Tungsten Alloy Tuning Fork | Frequency stability ±0.1-0.2 Hz, wear resistance increased by 30-40%, used for musical instruments. |
| 319 | Carbide calligraphy nib | HV 700-900, scoring accuracy 0.01-0.05 mm, for metalworking. |
| 320 | Tungsten Crucible (Jewelry Melting) | 2000-2500°C smelting gold and silver, purity 99.99%, used for jewelry casting. |
| 321 | Carbide Plastic Cutter | Lifespan: 500 hours, used for plastic processing. |
| 322 | Carbide Rubber Knife | Strong wear resistance, used for rubber cutting. |
| 323 | Carbide Foam Knife | Accuracy <0.02 mm, used for foam material processing. |
| 324 | Carbide Wood Knife | HV 900, 40% more durable, for woodworking. |
| 325 | Carbide composite knife | 50% longer life for cutting multiple layers of material. |
| 326 | High Density Tungsten Alloy Rocket Engine Lining | It has a temperature resistance of 3000°C and strong oxidation resistance and is used in propulsion systems. |
| 327 | Carbide aviation rivet die | Lifespan 1 million times, used in aircraft manufacturing. |
| 328 | Carbide Military Cutting Knife | HV 900, with 50% higher durability, for field work. |
| 329 | Carbide Tank Repair Drill Bits | Wear resistance increased by 40%, for battlefield repairs. |
| 330 | High Density Tungsten Alloy Radar Antenna Bracket | The heat dissipation efficiency is increased by 20% and is used for military communications. |
| 331 | High Density Tungsten Alloy Missile Body Counterweight | Improved stability by 15% for precision guidance. |
| 332 | High Density Tungsten Alloy Aviation Instrument Counterweight | Accuracy ±0.05 g, for flight instruments. |
| 333 | High Density Tungsten Alloy Submarine Rudder Counterweight | Density 18 g/cm³ , corrosion resistant, used for submarine stabilization. |
| 334 | High Density Tungsten Alloy Military Helmet Liner | Lightweight, 20% higher impact resistance, used in protective equipment. |
| 335 | High Density Tungsten Alloy Satellite Solar Panel Counterweight | Small size, accuracy ±0.1 g, used in space equipment. |
| 336 | High Density Tungsten Alloy Flat Heat Sink | Thermal conductivity increased by 20% for use in electronic devices. |
| 337 | High Density Tungsten Alloy Projector Filament | Temperature resistant to 2800°C, lifespan extended by 30%. |
| 338 | High Density Tungsten Alloy UAV Battery Lead | 25% greater conductivity for lightweight design. |
| 339 | High Density Tungsten Alloy Headphone Diaphragm Support | Wear resistance is increased by 30%, and is used in high-end audio. |
| 340 | High density tungsten alloy smart lock contacts | Resistant to arc corrosion, life extended by 25%. |
| 341 | High Density Tungsten Alloy Laptop Heat Sink | Thermal conductivity increased by 20%, for use in high-performance equipment. |

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| 342 | High Density Tungsten Alloy Gaming Contacts | Wear resistance increased by 30%, used in controllers. |
| 343 | High Density Tungsten Alloy UAV Motor Lead | 25% greater conductivity for lightweight design. |
| 344 | High Density Tungsten Alloy Smart Glasses Electrode | Strong corrosion resistance, used in wearable devices. |
| 345 | High Density Tungsten Alloy Server Heat Dissipation Substrate | Thermal management efficiency is improved by 20% and is used in data centers. |
| 346 | Carbide electronic packaging mold | Accuracy <0.005 mm, life extended by 40%, used in chip manufacturing. |
| 347 | Carbide Circuit Board Cutting Knife | Lifespan: 500 hours, used for PCB processing. |
| 348 | High Density Tungsten Alloy Cardiac Catheter Tip | Diameter 0.05 mm, accuracy increased by 30%, used in minimally invasive surgery. MADE BY: CTIA GROUP |
| 349 | High Density Tungsten Alloy Neural Probe | High hardness and durability, used in neurosurgery. |
| 350 | Carbide Bone Cutting Saw | High precision, lifespan of 50 surgeries, used in orthopedics. |
| 351 | High Density Tungsten Alloy Radiotherapy Targeting Device | Reduces beam scatter by 15% and is used in cancer treatment. |
| 352 | High Density Tungsten Alloy Medical Protective Gloves | 15% lighter than lead and used in X-ray operations. |
| 353 | High Density Tungsten Alloy CT Collimator | Reduces scatter by 15% for high-precision imaging. |
| 354 | High Density Tungsten Alloy Surgical Suture Needle | 0.05 mm diameter, 30% more durable, for minimally invasive surgery. |
| 355 | Carbide dental carving knife | 40% faster cutting speed for crown preparation. |
| 356 | High Density Tungsten Alloy Orthopedic Implant Plate | Strength 1500 MPa, strong corrosion resistance, used for bone repair. |
| 357 | High Density Tungsten Alloy X-ray Filter | The resolution is increased by 15% and is used in chest X-ray equipment. |
| 358 | High Density Tungsten Alloy Medical Protective Shield | Absorbs 40% of radiation and is used for radiation protection. |
| 359 | Carbide Minimally Invasive Scissors | The accuracy is improved by 30% and is used in neurosurgery. |
| 360 | High Density Tungsten Alloy Joint Replacement Components | Wear resistance increased by 25% for orthopedic implants. |
| 361 | Carbide Oil and Gas Drill Pipe | Compressive strength 200 MPa, service life extended by 35%. |
| 362 | High Density Tungsten Alloy Shale Gas Packer | Resistant to high temperature and high pressure, service life is extended by 25%. |
| 363 | High Density Tungsten | Resistant to 200 MPa pressure, suitable for complex geology. |

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| | Alloy Deep Sea Oil Well Logging Shell | |
| 364 | High Density Tungsten Alloy Battery Current Collector | The conductivity is increased by 25% and is used in lithium batteries. |
| 365 | High Density Tungsten Alloy Energy Storage Heat Sink | The heat dissipation efficiency is increased by 20% and is used in energy storage stations. |
| 366 | High Density Tungsten Alloy Nuclear Reactor Cooling Tube | Withstands 25 MW/m² heat flux and extends life by 30%. |
| 367 | High Density Tungsten Alloy Wind Turbine Gear | Wear resistance increased by 35%, used in offshore wind power. |
| 368 | High Density Tungsten Alloy Solar Thermal Receiver | Temperature resistance of 1200°C, efficiency increased by 20%. |
| 369 | Carbide geothermal drill bits | Resistant to 300°C corrosion, lifespan extended by 30%. |
| 370 | High Density Tungsten Alloy Hydrogen Fuel Cell Catalyst | Efficiency increased by 20%, used in new energy vehicles. |
| 371 | High Density Tungsten Alloy Guanyin Statue | Density 17-18 g/cm³ , weight 20-50 g, mirror polished, used for religious souvenirs. |
| 372 | High Density Tungsten Alloy Guan Gong Statue | HV 600-800, weight 50-100 g, abrasion resistance extends shelf life by 50-70%. |
| 373 | High Density Tungsten Alloy Gold Plated Commemorative Coin | It weighs 10-30 g and has a wear resistance 40-50% higher than copper. It is used for collection and investment. |
| 374 | High Density Tungsten Alloy Pet Tag | Thickness 1-2 mm, weight 5-15 g, can be laser engraved, corrosion resistance increased by 30-40%. |
| 375 | High Density Tungsten Alloy Gold Plated Bar | It weighs 50-200 g and has a wear resistance 50-60% higher than pure gold. It is used for gift collection. |
| 376 | High Density Tungsten Alloy Bicycle Weight | 10-50 g, 15-20% more stable, used in competition models. |
| 377 | High Density Tungsten Alloy Trekking Pole Tip | Weight 50-100 g, wear resistance increased by 30-40%, used in high altitude environments. |
| 378 | High Density Tungsten Alloy Bank Card | Thickness 0.8-1 mm, HV 600-700, scratch resistance 50-60% higher than plastic. |
| 379 | High Density Tungsten Alloy Business Card | Thickness 0.5-1 mm, weight 15-25 g, wear resistance increased by 40-50%. |
| 380 | High Density Tungsten Alloy Suitcase Label | Weight 5-10 g, impact resistance increased by 20-25%, used for luggage identification. |
| 381 | Carbide hand mold | The compressive strength is 1000-1200 MPa, and the service life is extended by 40-50%. It is used for metal embossing. |
| 382 | Carbide Hand Chisel | HV 700, high durability, for metal engraving. |
| 383 | High Density Tungsten Alloy Braiding Needle | Diameter 0.05 mm, strength 1500 MPa, used for technical weaving. |
| 384 | High Density Tungsten Alloy Sculpture Base | Corrosion resistant, preservation time extended by 50%, for outdoor art. |
| 385 | High Density Tungsten Alloy Musical | Frequency stability ±0.2 Hz for wind instruments. |

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| | Instrument Reed | |
| 386 | High Density Tungsten Alloy Brooch | HV 600, high scratch resistance, used in fashion accessories. |
| 387 | High Density Tungsten Alloy Hairpin | It weighs 1-3 g, has strong corrosion resistance, and is used for decoration. |
| 388 | High Density Tungsten Alloy Watchband Buckle | Wear resistance increased by 35%, used in smart watches. |
| 389 | High Density Tungsten Alloy Eyeglass Frame Inserts | Lightweight, corrosion-resistant, used in high-end eyewear. |
| 390 | High Density Tungsten Alloy Belt Buckle | HV 700, scratch resistance increased by 40%, used for clothing. |
| 391 | High Density Tungsten Alloy Badminton Racket Weight | 2-5 g, 15% increase in strength, for high-intensity competitions. |
| 392 | High Density Tungsten Alloy Skateboard Bearings | Abrasion resistance increased by 30%, for tricks. |
| 393 | High Density Tungsten Alloy Diving Fish Hook | Resistant to seawater corrosion, lifespan extended by 30%, used for deep sea fishing. |
| 394 | High Density Tungsten Alloy Ice Axe Tip | Abrasion resistance increased by 40%, for ice and snow climbing. |
| 395 | High Density Tungsten Alloy Archery Arrow | High density, 20% increased stability, used for competitive archery. |
| 396 | Carbide calligraphy inkstone | HV 600, high wear resistance, used in traditional processes. |
| 397 | Carbide carving knife (craft) | Precision 0.01 mm, wear resistance increased by 50%, used for stone carving. |
| 398 | Carbide embossing die | Withstands pressure of 1200 MPa and has a lifespan extended by 40%, and is used in metal crafts. |
| 399 | Cemented Carbide Ceramic Forming Die | Temperature resistant to 1800°C, suitable for high-performance ceramics. |
| 400 | Carbide musical instrument carving knife | HV 700, accuracy 0.01 mm, for musical instrument manufacturing. |
| 401 | Praseodymium tungstate ($PrWO_4$) fluorescent material | Used in laser displays, luminous efficiency increased by 15%. |
| 402 | Neodymium tungstate ($NdWO_4$) laser crystal | Strong temperature resistance, used for high power lasers. |
| 403 | Terbium tungstate ($TbWO_4$) scintillation crystal | The efficiency of detecting gamma rays is increased by 20% and is used for nuclear detection. |
| 404 | Samarium tungstate ($SmWO_4$) luminescent material | When used in fluorescent lamps, the lighting efficiency is increased by 10%. |
| 405 | Uranium Tungstate ($UWO_4$) Radiation Detection Material | High density, detection accuracy increased by 25%, used in nuclear industry. |
| 406 | Ytterbium tungstate ($YbWO_4$) laser crystal | Strong temperature resistance, used for infrared lasers. |
| 407 | Thorium tungstate ($ThWO_4$) heat-resistant | Temperature resistant to 2000°C, used as high temperature ceramic additive. |

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| | material | |
| 408 | Vanadium tungstate ($VWO_4$) photocatalyst | The efficiency of pollutant degradation is increased by 20% for environmentally friendly treatment. |
| 409 | Polonium tungstate ($PoWO_4$) radiation shielding material | The radiation absorption capacity is increased by 30% and is used in nuclear facilities. |
| 410 | Scandium tungstate ($ScWO_4$) electrode material | Energy density increased by 20% for energy storage devices. |
| 411 | Tungsten rod (high temperature probe) | Purity 99.95%, temperature resistance 3000°C, used for high temperature testing. |
| 412 | Tungsten plate (radiation shielding) | Thickness 5-20 mm, absorbs 40% of radiation, used for nuclear industry protection. |
| 413 | Tungsten filament (resistance heating) | Diameter 0.05-1 mm, temperature resistance 2800°C, used in resistance furnaces. |
| 414 | Tungsten tube (high temperature fluid transmission) | Inner diameter 10-30 mm, corrosion resistant, used for chemical high temperature pipelines. |
| 415 | Tungsten foil (vacuum packaging) | Thickness 0.1 mm, thermal conductivity 145 W/m·K, used in vacuum equipment. |
| 416 | Tungsten crucible (semiconductor melting) | Purity 99.99%, temperature resistance 3000°C, used for silicon crystal smelting. |
| 417 | Tungsten boat (thin film evaporation) | 2000-2500°C, evaporation rate 0.5 nm/s, for thin film deposition. |
| 418 | Tungsten target (optical coating) | Purity 99.99%, film thickness 10-100 nm, used for optical lens coating. |
| 419 | Tungsten electrode (plasma cutting) | Resistant to 4000°C arc, with a penetration depth of 3-8 mm, used for metal cutting. |
| 420 | Tungsten sheet (heat reflective screen) | Temperature resistant to 2500°C, reflectivity 90%, used for high temperature furnace lining. |
| 421 | W-Ni-Fe-Mo high density tungsten alloy (aviation weight) | Density 18 g/cm³ , small size, used for aircraft balancing. |
| 422 | W-Cu-Fe high density tungsten alloy (conductive substrate) | The conductivity is increased by 20% and is used in electronic substrates. |
| 423 | W-Mo-Ti high density tungsten alloy (high temperature seals) | Temperature resistant to 2800°C, pressure resistant to 200 MPa, used for sealing devices. |
| 424 | W-Re-Cu High Density Tungsten Alloy (Thermocouple Lead Wire) | Temperature resistance 3000°C, accuracy ±0.1°C, used for high temperature measurement. |
| 425 | W-Co-Ti high density tungsten alloy (wear-resistant liner) | HV 750, corrosion resistance increased by 30%, used in mechanical equipment. |
| 426 | W-Ni-Ta high density tungsten alloy (rocket nozzle lining) | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used in propulsion systems. |
| 427 | W-Cu-Zr high density tungsten alloy (conductive ring) | 25% higher conductivity for use in rotating motors. |

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| 428 | W-Ag-Mo high density tungsten alloy (high voltage contact) | Wear resistance increased by 35%, used in high-voltage switches. |
| 429 | W-Ti-Re high density tungsten alloy (high temperature sensor) | Temperature resistance of 3000°C, sensitivity increased by 20%, used for high temperature detection. |
| 430 | W-Nb-Cr high density tungsten alloy (wear-resistant gear) | HV 700, wear resistance increased by 30%, used for high temperature transmission. |
| 431 | Carbide milling cutter (aerospace materials) | HV 900, with 40% higher wear resistance, is used for titanium alloy processing. |
| 432 | Carbide drill (deep hole processing) | Wear resistance increased by 50% for deep hole drilling. |
| 433 | Carbide rock drill bits (hard rock mining) | The service life is extended by 60% and is used for hard rock mining. |
| 434 | Carbide tunneling cutter (subway construction) | Wear resistance increased by 40%, used in subway tunnel construction. |
| 435 | Carbide wire drawing dies (aluminum wire) | HV 900, with 50% higher wear resistance, is used for aluminum wire drawing. |
| 436 | Carbide stamping dies (precision parts) | Compressive strength 1200 MPa, life extended by 50%, used for precision stamping. MADE BY: CTIA GROUP |
| 437 | Carbide extrusion die (copper tube) | High hardness, strong wear resistance, used for copper tube extrusion. |
| 438 | Carbide cold heading die (nut) | HV 800, 30% higher impact resistance, used for nut forming. |
| 439 | Carbide hot forging die (steel parts) | Temperature resistance 1500°C, life 2000 forging times, used for steel processing. |
| 440 | Carbide bearing rings (high speed motors) | Wear resistance is increased by 40%, and it is used in high-speed motor bearings. |
| 441 | Carbide gasket (high temperature valve) | High hardness, corrosion resistance, used for high temperature valve sealing. |
| 442 | Carbide Nozzles (Paint Spraying) | Resistant to high pressure, life extended by 50%, used in spraying equipment. |
| 443 | Carbide valve seat (petroleum pipeline) | HV 900, with strong wear resistance, is used for oil pipeline valves. |
| 444 | Carbide surgical knife (ophthalmology) | Precision 0.01 mm, wear resistance increased by 60%, used in ophthalmic surgery. |
| 445 | Carbide dental grinding needle | Cutting efficiency increased by 40%, used for dental precision processing. |
| 446 | Carbide grinding head (orthopedics) | High hardness and durability, used for orthopedic devices. |
| 447 | Carbide Saw Blades (Wood Processing) | Temperature resistant to 800°C, life extended by 40%, for wood cutting. |
| 448 | Carbide Roller (Aluminum Plate) | Wear resistance increased by 30%, used for aluminum plate rolling. |
| 449 | Carbide cutting edge (carbon fiber) | HV 900, 50% longer life, for cutting carbon fiber. |
| 450 | Carbide micro drill (electronic components) | Diameter < 0.3 mm, life extended by 50%, used for drilling holes in electronic components. |
| 451 | High Density Tungsten Alloy Military Airship Counterweight | Density 18 g/cm³ , accuracy ±0.05 g, used for airship stabilization. |

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| 452 | High Density Tungsten Alloy Rocket Booster Nozzle | Temperature resistant to 3200°C, strong oxidation resistance, used for boosters. |
| 453 | High Density Tungsten Alloy Military Radar Heat Sink | Heat dissipation efficiency is increased by 20% and is used in radar systems. |
| 454 | High Density Tungsten Alloy Aviation Gyroscope Counterweight | Small size, accuracy ±0.1 g, used in navigation systems. |
| 455 | High Density Tungsten Alloy Missile Seeker Counterweight | Improved stability by 15% for precision guidance. |
| 456 | High Density Tungsten Alloy Smart Home Contacts | Resistant to arc corrosion, life extended by 30%, used in smart switches. |
| 457 | High Density Tungsten Alloy Car Display Lead | Temperature resistant to 2500°C, conductivity increased by 20%, used in automotive electronics. |
| 458 | High Density Tungsten Alloy Wireless Charger Heat Sink | Heat dissipation efficiency is increased by 20% and is used for charging equipment. |
| 459 | High Density Tungsten Alloy VR Equipment Electrode | Strong corrosion resistance, used in virtual reality equipment. |
| 460 | High Density Tungsten Alloy UAV Heat Sink Shell | Thermal conductivity increased by 25% and used in drone motors. |
| 461 | High Density Tungsten Alloy Dental Probe | Strong corrosion resistance, used for oral examination. |
| 462 | High Density Tungsten Alloy Radiotherapy Focuser | Radiation beam accuracy improved by 20% for cancer treatment. |
| 463 | High Density Tungsten Alloy Vascular Stent | Resistant to high temperature sterilization, flexibility increased by 20%, used in heart surgery. |
| 464 | High Density Tungsten Alloy Dental Braces | Strong corrosion resistance, used for orthodontics. |
| 465 | High Density Tungsten Alloy Surgical Clip | The accuracy is improved by 30% and is used in minimally invasive surgery. |
| 466 | High Density Tungsten Alloy Oilfield Logging Tools | Resistant to 200 MPa pressure, service life extended by 25%. |
| 467 | High Density Tungsten Alloy Shale Gas Drill Pipe | Compressive strength 200 MPa, used for deep mining. |
| 468 | High Density Tungsten Alloy Photovoltaic Heat Sink | The heat dissipation efficiency is increased by 20% and is used in solar power stations. |
| 469 | High density tungsten alloy energy storage electrode | The conductivity is increased by 25% and is used in supercapacitors. |
| 470 | High Density Tungsten Alloy Nuclear Power | Absorbs 35% of neutron radiation and is used for safety protection. |

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| | Plant Shielding Plate | |
| 471 | High Density Tungsten Alloy Bookmark | Thickness 0.5 mm, weight 10 g, strong durability, used for gifts. |
| 472 | High Density Tungsten Alloy Bracelet | It weighs 3-5 g and is highly anti-allergenic, suitable for daily wear. |
| 473 | High Density Tungsten Alloy Cufflinks | Abrasion resistance increased by 40%, suitable for high-end gifts. |
| 474 | High Density Tungsten Alloy VIP Commemorative Gold Bar | Weight 100-500 g, HV 600-700, for high-end gifts. |
| 475 | High Density Tungsten Alloy Golden Wedding Ring | Weighing 8-12 g, highly scratch-resistant, used for sentimental commemoration. |
| 476 | High Density Tungsten Alloy Shot Put Weight | Small size, weight accuracy ±0.1 g, used in track and field sports. |
| 477 | High Density Tungsten Alloy Tennis Racket Frame | Impact resistance increased by 25%, for use in professional competitions. |
| 478 | High Density Tungsten Alloy Climbing Rope Buckle | Lightweight, 35% more abrasion-resistant, for outdoor equipment. |
| 479 | High Density Tungsten Alloy Fitness Dumbbell | Weight 200-500 g, wear resistance increased by 25%, used for strength training. |
| 480 | High Density Tungsten Alloy Diving Weights | Density 17-18 g/cm³ , weight 50-500 g, seawater corrosion resistance increased by 25-35%. |
| 481 | High Density Tungsten Alloy String Seat | The sound quality is stable, and the wear resistance is increased by 40%. It is used for pianos. Watchmaking: CTIA GROUP |
| 482 | High Density Tungsten Alloy Model Parts | HV 600, corrosion resistant, for interior decorative models. |
| 483 | High Density Tungsten Alloy Curtain Wall Counterweight | Density 18 g/cm³ , small volume, used for stabilization of high-rise buildings. |
| 484 | High Density Tungsten Alloy Bridge Shock Absorber | Withstands pressure of 200 MPa and has a service life extended by 30%, and is used for bridge shock absorption. |
| 485 | High Density Tungsten Alloy Concrete Drill Bit Counterweight | Density 18 g/cm³ , 20% more stable, used in construction drilling. |
| 486 | Carbide Construction Cutting Knife | HV 900, 50% longer life, for concrete cutting. |
| 487 | Carbide steel bar shears | Wear resistance is increased by 40% and is used for construction steel bar processing. |
| 488 | High Density Tungsten Alloy Railway Wheel Counterweight | Density 18 g/cm³ , accuracy ±0.1 g, used for railway vehicle stabilization. |
| 489 | High Density Tungsten Alloy Automobile Engine Counterweight | Small size, 20% higher stability, used for car balancing. |
| 490 | High Density Tungsten Alloy Ship Rudder Counterweight | Density 18 g/cm³ , corrosion resistant, used for ship stabilization. |

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| 491 | Tungsten-based composite materials (wear-resistant coatings) | HV 800, corrosion resistance increased by 30%, used for industrial surface protection. |
| 492 | Tungsten-based nano-coating (antibacterial surface) | Antibacterial rate 99%, used on the surface of medical equipment. |
| 493 | Tungsten-based high-temperature alloy (jet engine) | It has a temperature resistance of 1600°C and creep resistance increased by 20-30%. It is used in aircraft engine turbine blades and combustion chambers. |
| 494 | Tungsten-based corrosion-resistant coating (marine equipment) | The seawater corrosion resistance is improved by 35% and the coating life is extended by 50%. It is used in ship propellers and offshore platform components. |
| 495 | Tungsten based wear resistant particles (mining machinery) | HV 800-1000, with 40% higher wear resistance, is used for mining crushers and mill liners. |
| 496 | Tungsten-based high-temperature lubricating coating (spacecraft) | The friction coefficient is reduced by 30%, the temperature resistance is 2000°C, and it is used for moving parts of spacecraft. |
| 497 | Tungsten-based composite electrode (electrochemistry) | Conductivity is increased by 25%, corrosion resistance is increased by 30% and life is extended. It is used in electrolyzer and battery research. |
| 498 | Tungsten-based thermal barrier coating (gas turbine) | Temperature resistance of 1800°C, thermal conductivity reduced by 20%, used for gas turbine blade protection. |
| 499 | Tungsten-based radiation-resistant materials (nuclear reactors) | The neutron irradiation resistance is improved by 35%, and it is used for the inner wall of nuclear reactors and fuel cladding. |
| 500 | Tungsten-based conductive composite materials (flexible electronics) | Conductivity increased by 20% and flexibility increased by 25%, for use in wearable electronic devices. |
| 501 | Tungsten-based high temperature heat insulation board (spacecraft) | It can withstand temperatures up to 3000°C and has a 30% reduction in thermal conductivity. It is used to protect spacecraft re-entering the atmosphere. |
| 502 | Tungsten-based wear-resistant tool coating (precision machining) | HV 900, with 50% higher wear resistance, is used for high-precision CNC machine tool tools. |
| 503 | Tungsten-based anti-oxidation coating (high temperature furnace) | It can withstand temperatures up to 2800°C and has a 40% increase in oxidation resistance. It is used for linings in high-temperature industrial furnaces. |
| 504 | Tungsten-based nanocomposites (sensors) | The sensitivity is increased by 25%, the temperature resistance is strong, and it is used in high-temperature gas sensors. |
| 505 | Tungsten based wear-resistant welding rod (repair tool) | Hardness HV 700, wear resistance increased by 30%, used for repairing mining equipment. |
| 506 | Tungsten-based high temperature sealing material (aircraft engine) | It can withstand temperatures up to 1600°C and pressures up to 200 MPa and is used for aircraft engine seals. |

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| 507 | Tungsten-based thermal conductive coating (electronic components) | Thermal conductivity is increased by 25%, which is used for heat dissipation of high-power electronic devices. |
| 508 | Tungsten-based wear-resistant bearing coating (wind power equipment) | The service life is extended by 40% and the wear resistance is improved by 35%. It is used in wind turbine bearings. |
| 509 | Tungsten-based corrosion-resistant electrode (seawater desalination) | Resistant to chloride ion corrosion, with a service life extended by 50%, used in seawater desalination electrolysis systems. |
| 510 | Tungsten-based high temperature protective shield (nuclear fusion) | It can withstand temperatures up to 3200°C and has a 30% increase in radiation resistance. It is used for the plasma facing wall of fusion reactors. |
| 511 | Europium tungstate ($EuWO_4$) fluorescent material | The luminous efficiency is increased by 20%, and it is used in LED lighting and displays. |
| 512 | Dysprosium tungstate ($DyWO_4$) magnetic material | The magnetic strength is increased by 15% and is used in magnetic resonance imaging equipment. |
| 513 | Thulium tungstate ($TmWO_4$) laser crystal | Strong temperature resistance, used for near-infrared lasers. |
| 514 | Potassium niobium tungstate ($KNbWO_6$) photocatalyst | The efficiency of degrading organic matter is increased by 25% and used for sewage treatment. |
| 515 | Sodium Zirconium Tungstate ($NaZrWO_4$) Heat Resistant Ceramics | Temperature resistant to 2000°C, strength increased by 20%, used for high temperature kiln furniture. |
| 516 | Barium calcium tungstate ($BaCaWO_4$) phosphor | The light efficiency is increased by 15% and is used for X-ray enhancement screens. |
| 517 | Cadmium Tungstate ($CdWO_4$) Scintillation Detector | Improves gamma ray detection efficiency by 25% for nuclear medicine imaging. |
| 518 | Sodium Bismuth Tungstate ($NaBiWO_4$) Photocatalyst | The efficiency of photolysis of water is increased by 20% and is used in hydrogen production research. |
| 519 | Cobalt Nickel Tungstate ($CoNiWO_4$) Electrode Material | by 25%, used in supercapacitors . |
| 520 | Zinc magnesium tungstate ($ZnMgWO_4$) luminescent material | The light efficiency is improved by 15% for UV LEDs. |
| 521 | Tungsten-based high-density alloy (submarine sonar counterweight) | Density 18 g/cm³, accuracy ±0.05 g, used for sonar system stabilization. |
| 522 | Tungsten-based alloy (military drone motor weight) | Small size, 20% higher stability, used for drone motor balancing. |
| 523 | Tungsten-based alloy (tank gun stabilizer counterweight) | Density 17.5 g/cm³, accuracy ±0.1 g, used in artillery stabilization systems. |
| 524 | Tungsten-based alloy | Wear resistance is increased by 30% and is used in high- |

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| | (aviation gyroscope rotor) | precision navigation equipment. |
| 525 | Tungsten-based alloy (rocket engine igniter) | Temperature resistance 3200°C, life extended by 25%, used in ignition system. |
| 526 | Tungsten-based alloy (military radar reflector) | The reflectivity is increased by 20%, which is used to enhance radar signals. |
| 527 | Tungsten-based alloy (missile gyroscope counterweight) | Improved stability by 15% for missile guidance. |
| 528 | Tungsten-based alloy (military airship rudder weight) | Density 18 g/cm³ , small size, used for airship control. |
| 529 | Tungsten-based alloy (armored vehicle suspension weight) | Impact resistance is increased by 25% and is used to stabilize the suspension system. |
| 530 | Tungsten-based alloy (ship shock absorber) | Density 17-18 g/cm³ , pressure resistance 200 MPa, used for ship vibration reduction. |
| 531 | Carbide military excavation shovel | HV 900, with 40% higher wear resistance, is used in field projects. |
| 532 | Carbide military bayonet | Increases wear resistance by 50% for melee equipment. |
| 533 | Carbide Military Cable Stripper | The service life is extended by 40% and is used for battlefield communication maintenance. |
| 534 | Carbide Military Armor Repair Drill | Wear resistance increased by 50%, used for armored vehicle repair. |
| 535 | Carbide Military Obstacle Breaking Knife | HV 800, 30% longer life, for obstacle removal. |
| 536 | Tungsten-based alloy (smart speaker heat sink) | Thermal conductivity increased by 20%, used in high-end audio equipment. |
| 537 | Tungsten-based alloy (vehicle radar electrode) | Strong corrosion resistance, used in automotive radar systems. |
| 538 | Tungsten-based alloy (UAV antenna lead) | Electrical conductivity increased by 25% for lightweight communications. |
| 539 | Tungsten-based alloy (AR glasses heat dissipation shell) | Heat dissipation efficiency is improved by 20% for use in augmented reality devices. |
| 540 | Tungsten-based alloy (smart bracelet contacts) | Wear resistance is increased by 30% and is used in wearable devices. |
| 541 | Carbide dental implant drill | The accuracy is <0.02 mm and the service life is extended by 50%. It is used in dental implant surgery. |
| 542 | Carbide Orthopedic Micro Saw | The cutting speed is increased by 30% for minimally invasive orthopedic surgery. |
| 543 | Carbide medical sampling knife | Strong corrosion resistance, used for tissue sampling. |
| 544 | Carbide surgical suture scissors | Improved precision by 25% for fine stitching. |
| 545 | Carbide Ophthalmic Tweezers | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 546 | Tungsten-based alloy (oil and gas valve lining) | Withstands pressure of 200 MPa and has a service life extended by 30%. It is used for oil and gas pipeline valves. |
| 547 | Tungsten-based alloys (geothermal power turbines) | Temperature resistant to 300°C, corrosion resistance increased by 25%, used for geothermal power generation. |

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| 548 | Tungsten-based alloy (photovoltaic inverter heat sink) | Thermal conductivity increased by 20% for use in solar power generation systems. |
| 549 | Tungsten-based alloy (energy storage battery connector) | Conductivity increased by 25% for use in large-capacity battery packs. |
| 550 | Tungsten-based alloy (nuclear power plant steam pipe) | Temperature resistant to 500°C, corrosion resistance increased by 30%, used in nuclear power steam systems. |
| 551 | Tungsten-based alloy (wind power tower shock absorber) | Withstands pressure of 200 MPa and has a service life extended by 25%. It is used to stabilize offshore wind power towers. |
| 552 | Tungsten-based alloy (hydrogen fuel cell heat sink) | The thermal conductivity is increased by 20%, and the corrosion resistance is strong, and it is used in new energy vehicles. |
| 553 | Tungsten-based alloy (solar collector tube) | It can withstand temperatures up to 1200°C and has a 15% increase in thermal efficiency. It is used for solar thermal power generation. |
| 554 | Tungsten-based alloy (nuclear fusion plasma target) | It can withstand temperatures up to 3200°C and has a 35% increase in radiation resistance. It is used in fusion experimental devices. |
| 555 | Tungsten-based alloy (deep sea drilling counterweight) | Density 18 g/cm³ , pressure resistance 300 MPa, used for deep-sea oil and gas exploration. |
| 556 | High Density Tungsten Alloy (Counterweight for Mountaineering Canes) | Weighing 50-100 g, with 20% increased stability, it is used for high-altitude hiking. |
| 557 | High Density Tungsten Alloy (Ski and Snowboard Weights) | Small size, 30% higher wear resistance, used for high-speed skiing equipment. |
| 558 | High Density Tungsten Alloy (Shooting Target Weight) | Density 17-18 g/cm³ , accuracy ±0.1 g, used for shooting training. |
| 559 | High Density Tungsten Alloy (Racing Wheel Weight) | Weight 10-50 g, stability improved by 15%, used for racing car balancing. |
| 560 | High Density Tungsten Alloy (Golf Head) | Density 18 g/cm³ , increases hitting distance by 10%, used in professional golf equipment. |
| 561 | Carbide Woodworking Engraving Knife | HV 900, 40% longer life, for wood carving. |
| 562 | Carbide Stone Cutting Saw | 50% higher wear resistance, suitable for marble and granite cutting. |
| 563 | Carbide Metal Relief Molds | Withstands pressure of 1200 MPa and has an accuracy of 0.01 mm. It is used for producing artistic reliefs. |
| 564 | Carbide Ceramic Engraving Knife | HV 800, with high durability, is used for ceramic handicraft processing. |
| 565 | Carbide manual grinding head | Lifespan: 500 hours, used for metal polishing process. |
| 566 | High Density Tungsten Alloy Guitar Pick | Weight 2-5 g, wear resistance increased by 40%, used for electric guitar playing. |
| 567 | High Density Tungsten | Density 18 g/cm³ , 20% higher stability, used in piano |

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| | Alloy Piano Pedal Weight | manufacturing. |
| 568 | High Density Tungsten Alloy Violin Bow Weight | Weight 5-10 g, balance improved by 15%, used for musical instrument accessories. |
| 569 | High Density Tungsten Alloy Drumstick Head | Impact resistance increased by 25%, used for percussion instruments. |
| 570 | High Density Tungsten Alloy Flute Reed Support | Frequency stability ±0.2 Hz, used in wind instrument manufacturing. |
| 571 | High Density Tungsten Alloy Construction Drill | 40% higher wear resistance for concrete drilling. |
| 572 | High Density Tungsten Alloy Bridge Support Weight | Density 18 g/cm³ , pressure resistance 200 MPa, used for stabilizing bridge structures. |
| 573 | High Density Tungsten Alloy Subway Wheel Counterweight | Small size, accuracy ±0.1 g, used for rail transportation balancing. |
| 574 | High Density Tungsten Alloy Ship Engine Counterweight | Density 17-18 g/cm³ , corrosion resistant, used in ship power systems. |
| 575 | High Density Tungsten Alloy High Speed Rail Carriage Counterweight | Stability is increased by 20% and is used for high-speed train balancing. |
| 576 | Tungsten-based composite materials (aviation composite panels) | Strength 1500 MPa, weight reduction 15%, used for aircraft fuselages. |
| 577 | Tungsten-based wear-resistant coating (ship deck) | The seawater corrosion resistance is increased by 35% and is used for deck protection. |
| 578 | Tungsten-based high-temperature composite materials (rocket shell) | It can withstand temperatures up to 3000°C and has a 30% increase in oxidation resistance. It is used in rocket shells. |
| 579 | Tungsten-based nano-coating (antibacterial fabric) | Antibacterial rate 99%, used for medical protective clothing. |
| 580 | Tungsten-based wear-resistant particles (excavator buckets) | HV 800, with 40% longer life, for heavy excavation equipment. |
| 581 | Potassium scandium tungstate ($KScWO_4$) electrolyte | Conductivity increased by 20% for use in solid-state batteries. |
| 582 | Cerium Zirconium Tungstate ($CeZrWO_4$) Heat Resistant Coating | Temperature resistance of 2000°C, oxidation resistance increased by 25%, used for high-temperature equipment surfaces. |
| 583 | Nickel zinc tungstate ($NiZnWO_4$) electrode material | Energy density increased by 20% for energy storage batteries. |
| 584 | Cobalt Copper Tungstate ($CoCuWO_4$) Catalyst | The catalytic activity is increased by 15% and is used in fuel cells. |
| 585 | Bismuth zinc tungstate | The efficiency of pollutant degradation is increased by 25% and |

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| | ($ZnBiWO_4$) photocatalyst | is used for water treatment. |
| 586 | Tungsten rod (high temperature experimental crucible) | Purity 99.95%, temperature resistance 3000°C, used for laboratory smelting. |
| 587 | Tungsten plate (vacuum furnace insulation screen) | Thickness 5-20 mm, reflectivity 90%, used in vacuum high temperature furnaces. |
| 588 | Tungsten wire (high temperature heat treatment coil) | Diameter 0.05-1 mm, temperature resistance 2800°C, used in heat treatment equipment. |
| 589 | Tungsten tube (high temperature gas transmission) | Inner diameter 10-50 mm, corrosion-resistant, used for high-temperature chemical pipelines. |
| 590 | Tungsten foil (flexible shielding material) | Thickness 0.1 mm, thermal conductivity 145 W/m·K, used for electronic shielding. |
| 591 | Tungsten crucible (rare earth smelting) | Purity: 99.99%, temperature resistance: 3000°C, used for rare earth metal smelting. |
| 592 | Tungsten boat (nanomaterial evaporation) | 2000-2500°C, evaporation rate 0.5 nm/s, used for nano-thin film preparation. |
| 593 | Tungsten target (flexible display coating) | Purity 99.99%, film thickness 10-50 nm, used for flexible screen manufacturing. |
| 594 | Tungsten electrode (high temperature plasma welding) | Resistant to 4000°C arc, with a penetration depth of 5-10 mm, used for welding aviation parts. |
| 595 | Tungsten sheet (high temperature reflective plate) | Temperature resistant to 2500°C, reflectivity 90%, used for industrial furnace linings. |
| 596 | W-Ni-Fe-Cu alloy (precision instrument weight) | Density 17.8 g/cm³ , accuracy ±0.05 g, used for balancing optical instruments. |
| 597 | W-Cu-Mo-Ti alloy (high temperature conductive ring) | The conductivity is increased by 25%, the temperature resistance is 2800°C, and it is used in rotating motors. |
| 598 | W-Re-Nb alloy (high temperature temperature probe) | Temperature resistance 3000°C, accuracy ±0.1°C, used in metallurgical industry. |
| 599 | W-Co-Cr-Ni alloy (wear-resistant gear) | HV 800, with a 40% longer service life, is used for high temperature mechanical transmissions. |
| 600 | W-Ta-Zr alloy (rocket nozzle lining) | It can withstand temperatures up to 3200°C and has a 30% increase in oxidation resistance. It is used in aerospace propulsion systems. |
| 601 | Carbide aviation milling cutter | HV 900, with 50% higher wear resistance, is used for titanium alloy processing. |
| 602 | Carbide deep sea drill bit | Withstands pressure of 300 MPa and has a service life extended by 40%, and is used for deep-sea exploration. |
| 603 | Carbide Mining Picks | 60% longer life for hard rock mining. |
| 604 | Carbide Tunnel Boring Tools | Wear resistance is increased by 40% and is used in shield machine construction. |
| 605 | Carbide Stainless Steel Wire Drawing Die | HV 900, with 50% higher wear resistance, is used in stainless steel wire production. |

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| 606 | High Density Tungsten Alloy Military Satellite Counterweight | Density 18 g/cm³ , accuracy ±0.05 g, used for satellite attitude adjustment. |
| 607 | High Density Tungsten Alloy Rocket Thruster Lining | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used for solid rocket propulsion. |
| 608 | High Density Tungsten Alloy Military Radar Antenna Shell | The heat dissipation efficiency is increased by 20% and is used in high-frequency radar systems. |
| 609 | High Density Tungsten Alloy Aviation Navigation Gyroscope | Small size, accuracy ±0.1 g, used in aircraft navigation systems. |
| 610 | High Density Tungsten Alloy Missile Stabilizer Counterweight | Improved stability by 15% for precision guided missiles. |
| 611 | High Density Tungsten Alloy Smart TV Heat Sink | Thermal conductivity increased by 20% and used in high-end display devices. |
| 612 | High Density Tungsten Alloy Car Audio Lead Wire | Conductivity increased by 25% and used in car audio systems. |
| 613 | High Density Tungsten Alloy UAV Battery Connector | Highly corrosion-resistant, used for lightweight battery packs. |
| 614 | High Density Tungsten Alloy AR Device Contacts | 30% improved wear resistance for use in augmented reality glasses. |
| 615 | High Density Tungsten Alloy Smart Door Lock Electrode | Resistant to arc corrosion, with a lifespan extended by 25%, used in smart homes. |
| 616 | Carbide Dental Micro Drill | Accuracy <0.01 mm, lifespan extended by 50%, used for dental implants. |
| 617 | Carbide Orthopedic Cutting Knife | Cutting speed increased by 30% for orthopedic surgery. |
| 618 | Hard alloy medical minimally invasive forceps | Strong corrosion resistance, used for delicate surgery. |
| 619 | Carbide surgical suture knife | The accuracy is improved by 25% and is used for minimally invasive suturing. |
| 620 | Carbide Ophthalmic Cutters | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 621 | High Density Tungsten Alloy Oil and Gas Drilling Valve Core | Withstands pressure of 200 MPa and has a service life extended by 30%, and is used for oil and gas production. |
| 622 | High Density Tungsten Alloy Geothermal Drilling Casing | Temperature resistant to 300°C, corrosion resistance increased by 25%, used in geothermal wells. |
| 623 | High density tungsten alloy photovoltaic cell heat dissipation shell | Heat dissipation efficiency is increased by 20% for solar panels. |
| 624 | High Density Tungsten Alloy Energy Storage | The conductivity is increased by 25% and is used in high-power energy storage systems. |

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| | Battery Lead | |
| 625 | High Density Tungsten Alloy Nuclear Power Plant Radiation Shielding | Absorbs 40% of neutron radiation and is used for protecting nuclear facilities. |
| 626 | High Density Tungsten Alloy Table Tennis Racket Weight | Weight 2-5 g, strength increase by 15%, for competitive training. |
| 627 | High Density Tungsten Alloy Skateboard Axle | Abrasion resistance is increased by 30% for high-intensity skateboarding. |
| 628 | High Density Tungsten Alloy Fishing Rod Weight | Density 17-18 g/cm³ , 20% more stable, for long-distance fishing. |
| 629 | High Density Tungsten Alloy Climbing Buckle | Lightweight and 35% more abrasion-resistant, for outdoor rock climbing. |
| 630 | High Density Tungsten Alloy Archery Bow Weight | Small size, accuracy ±0.1 g, used for archery stabilization. |
| 631 | Carbide hand chisel | HV 700, high durability, for hand engraving on metal. |
| 632 | Carbide Stone Chisel | Lifespan extended by 50% for stone sculptures. |
| 633 | Carbide Woodworking Planer | HV 900, with 40% higher wear resistance, is used for wood planing. |
| 634 | Carbide Ceramic Cutting Knife | Precision <0.02 mm, used for ceramic processing. |
| 635 | Carbide manual polishing knife | Lifespan: 500 hours, used for metal surface polishing. |
| 636 | High Density Tungsten Alloy Saxophone Reed Support | Frequency stability ±0.2 Hz, used in wind instrument manufacturing. |
| 637 | High Density Tungsten Alloy Brass Instrument Counterweight | Weight 5-10 g, sound quality improved by 10%, used for brass instruments. |
| 638 | High Density Tungsten Alloy Drum Weight | Impact resistance increased by 25%, used for stabilization of percussion instruments. |
| 639 | High Density Tungsten Alloy Electric Guitar String Seat | Wear resistance increased by 40%, used in electric guitar manufacturing. |
| 640 | High Density Tungsten Alloy Piano Key Weights | Density 18 g/cm³ , 15% better touch, used in high-end pianos. |
| 641 | High Density Tungsten Alloy Construction Steel Bar Shears | Wear resistance increased by 40%, used for steel bar processing. |
| 642 | High Density Tungsten Alloy Curtain Wall Fixed Counterweight | Density 18 g/cm³ , pressure resistance 200 MPa, used for curtain walls of high-rise buildings. |
| 643 | High Density Tungsten Alloy Subway Tunnel Drill Bit Counterweight | Stability increased by 20%, used in tunnel construction. |
| 644 | High Density Tungsten Alloy Ship Propeller Counterweight | Density 17-18 g/cm³ , corrosion resistant, used in ship propulsion systems. |
| 645 | High Density Tungsten | Small size, accuracy ±0.1 g, used for high-speed rail |

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| | Alloy High Speed Railway Bogie Counterweight | stabilization. |
| 646 | Tungsten-based composite materials (automotive engine coatings) | Temperature resistant to 1200°C, wear resistance increased by 30%, used for engine cylinders. |
| 647 | Tungsten-based wear-resistant coating (railway tracks) | The service life is extended by 40% and is used on the surface of high-speed railway tracks. |
| 648 | Tungsten-based high temperature composite materials (aircraft skin) | Temperature resistant to 1600°C, strength increased by 20%, used in supersonic aircraft. |
| 649 | Tungsten-based nano-coating (antimicrobial packaging) | Antibacterial rate 99%, used for food packaging materials. |
| 650 | Tungsten based wear resistant particles (concrete mixing blades) | HV 800, with a 40% longer service life, is used in construction mixing equipment. |
| 651 | Manganese zinc tungstate ($ZnMnWO_4$) luminescent material | The luminous efficiency is improved by 15% and is used in fluorescent displays. |
| 652 | Nickel copper tungstate ($NiCuWO_4$) electrocatalyst | The efficiency is increased by 20% and is used to produce hydrogen by splitting water. |
| 653 | Magnesium Bismuth Tungstate ($MgBiWO_4$) Photocatalyst | The pollutant degradation efficiency is increased by 25% and is used for air purification. |
| 654 | Cobalt zinc tungstate ($ZnCoWO_4$) electrode material | Energy density increased by 20% for use in supercapacitors. |
| 655 | Potassium Zirconium Tungstate ($KZrWO_4$) Heat Resistant Ceramics | Temperature resistant to 2000°C, strength increased by 15%, used for high temperature kiln furniture. |
| 656 | Tungsten rod (high temperature resistance furnace element) | Purity 99.95%, temperature resistance 2800°C, used in resistance heating furnaces. |
| 657 | Tungsten plate (nuclear industry shielding wall) | Thickness 10-30 mm, absorbs 40% of radiation, used for protection of nuclear facilities. |
| 658 | Tungsten filament (high temperature experimental filament) | Diameter 0.03-1 mm, temperature resistance 2800°C, used for experimental equipment. |
| 659 | Tungsten tube (high temperature liquid transmission) | Inner diameter 5-50 mm, corrosion resistant, used for high temperature chemical pipelines. MADE BY: CTIA GROUP |
| 660 | Tungsten foil (electron beam shielding) | Thickness 0.05 mm, thermal conductivity 145 W/m·K, used in electronic equipment. |
| 661 | Tungsten crucible (high temperature alloy melting) | Purity 99.99%, temperature resistance 3000°C, used for aviation alloy smelting. |
| 662 | Tungsten boat (optical thin film evaporation) | 2000-2500°C, evaporation rate 0.5 nm/s, used for optical coating. |

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| 663 | Tungsten target (solar cell coating) | Purity is 99.99%, film thickness is 5-50 nm, and it is used in photovoltaic cell manufacturing. |
| 664 | Tungsten electrode (high temperature welding) | Resistant to 4000°C arc, with a penetration depth of 5-10 mm, used for special metal welding. |
| 665 | Tungsten sheet (high temperature heat shield) | Temperature resistance 2500°C, reflectivity 90%, used for vacuum furnace lining. |
| 666 | W-Ni-Fe-Mo-Ti alloy (aviation weight) | Density 18 g/cm³ , accuracy ±0.05 g, used for aircraft balancing. |
| 667 | W-Cu-Re alloy (high temperature conductive plate) | The conductivity is increased by 25%, the temperature resistance is 2800°C, and it is used in electronic equipment. |
| 668 | W-Mo-Ta alloy (high temperature nozzle) | It can withstand temperatures up to 3200°C and has a 30% increase in oxidation resistance. It is used for rocket propulsion. |
| 669 | W-Co-Nb alloy (wear-resistant lining) | HV 800, with a 40% longer life, for mining equipment. |
| 670 | W-Ti-Zr alloy (high temperature seals) | With a temperature resistance of 2800°C and a pressure resistance of 200 MPa, it is used for sealing high-temperature equipment. |
| 671 | Carbide aviation drill bits | 50% higher wear resistance for drilling composite materials. |
| 672 | Carbide deep hole drill (oil and gas) | Withstands pressure of 300 MPa and has a service life extended by 40%, and is used for deep well drilling. |
| 673 | Carbide Tunnel Boring Machine Picks | The service life is extended by 60% and is used for hard rock mining in tunnels. |
| 674 | Carbide shield machine cutterhead | Wear resistance increased by 40%, used in subway construction. |
| 675 | Carbide Copper Wire Drawing Die | HV 900, with 50% higher wear resistance, is used in copper wire production. |
| 676 | High Density Tungsten Alloy Military Spacecraft Counterweight | Density 18 g/cm³ , accuracy ±0.05 g, used for spacecraft stabilization. |
| 677 | High Density Tungsten Alloy Rocket Ignitor Lining | Temperature resistant to 3200°C, strong oxidation resistance, used in ignition systems. |
| 678 | High Density Tungsten Alloy Military Communication Antenna Shell | Heat dissipation efficiency is increased by 20% and is used in communication systems. |
| 679 | High Density Tungsten Alloy Aviation Attitude Sensor Counterweight | Small size, accuracy ±0.1 g, used in navigation equipment. |
| 680 | High Density Tungsten Alloy Missile Propulsion Weight | Improved stability by 15% for missile propulsion systems. |
| 681 | High Density Tungsten Alloy Smart Projector Heat Sink | Thermal conductivity increased by 20%, used in projection equipment. |
| 682 | High Density Tungsten Alloy Vehicle Navigation Lead | Electrical conductivity increased by 25% and used in car navigation systems. |
| 683 | High Density Tungsten | Strong corrosion resistance, used in drone circuits. |

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| | Alloy UAV Control Electrode | |
| 684 | High Density Tungsten Alloy VR Equipment Heat Sink Shell | The heat dissipation efficiency is increased by 20%, and is used in virtual reality equipment. |
| 685 | High Density Tungsten Alloy Smart Socket Contacts | Resistant to arc corrosion, with a lifespan extended by 25%, used in smart homes. |
| 686 | Carbide dental trimmer | Precision <0.01 mm, lifespan extended by 50%, used for dental contouring. |
| 687 | Carbide orthopedic minimally invasive knife | Cutting speed increased by 30% for orthopedic surgery. |
| 688 | Carbide Medical Sampling Scissors | Strong corrosion resistance, used for tissue sampling. |
| 689 | Carbide surgical cutting knife | The accuracy is improved by 25% and is used in minimally invasive surgery. |
| 690 | Carbide Ophthalmic Micro Scissors | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 691 | High Density Tungsten Alloy Oil and Gas Pipeline Gasket | Withstands pressure of 200 MPa and has a service life extended by 30%. It is used for oil and gas transmission. |
| 692 | High Density Tungsten Alloy Geothermal Power Generation Blades | Temperature resistant to 300°C, corrosion resistance increased by 25%, used in geothermal turbines. |
| 693 | High Density Tungsten Alloy Photovoltaic Inverter Substrate | The heat dissipation efficiency is increased by 20% and is used for solar power generation. |
| 694 | High Density Tungsten Alloy Energy Storage System Electrode | Conductivity increased by 25% for large-capacity energy storage. |
| 695 | High Density Tungsten Alloy Neutron Shielding for Nuclear Power Plants | Absorbs 40% of neutron radiation and is used for reactor safety. |
| 696 | High Density Tungsten Alloy Tennis Racket String Buckle | Weight 2-5 g, wear resistance increased by 30%, used for competitive tennis. |
| 697 | High Density Tungsten Alloy Ski Pole Tip | Wear resistance is increased by 40%, suitable for ice and snow sports. |
| 698 | High Density Tungsten Alloy Fishing Line Weight | Density 17-18 g/cm³ , sinking speed increased by 20%, used for deep sea fishing. |
| 699 | High Density Tungsten Alloy Climbing Rope Weight | Lightweight, 20% more stable, for aerial work. |
| 700 | High Density Tungsten Alloy Archery Bullseye Weight | Small size, accuracy ±0.1 g, used for archery targets. |
| 701 | Carbide Hand Engraving Knife | HV 700, high durability, used for wood carving. |
| 702 | Carbide Stone Sharpening | The service life is extended by 50% and it is used for stone polishing. |
| 703 | Carbide Woodworking | HV 900, with 40% higher wear resistance, is used for wood |

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| | Saw Blades | cutting. MADE BY: China Tungsten |
| 704 | Ceramic carbide trimmer | Accuracy <0.02 mm, used for ceramic processing. |
| 705 | Carbide hand sharpened knife | Lifespan: 500 hours, used for metal polishing. |
| 706 | High Density Tungsten Alloy Trumpet Reed Support | Frequency stability ±0.2 Hz, used in wind instrument manufacturing. |
| 707 | High Density Tungsten Alloy Clarinet Weight | Weight 5-10 g, sound quality improved by 10%, used for woodwind instruments. |
| 708 | High Density Tungsten Alloy Drum Pedal Weight | Impact resistance increased by 25%, used for percussion instruments. |
| 709 | High Density Tungsten Alloy Guitar String Buckle | Abrasion resistance increased by 40%, used in guitar manufacturing. |
| 710 | High Density Tungsten Alloy Piano Soundboard Weight | Density 18 g/cm³ , sound quality steadily improved by 15%, used in high-end pianos. |
| 711 | High Density Tungsten Alloy Construction Cutting Saw | 40% higher wear resistance for concrete cutting. |
| 712 | High Density Tungsten Alloy Bridge Shock Absorption Weight | Density 18 g/cm³ , pressure resistance 200 MPa, used for bridge stabilization. |
| 713 | High Density Tungsten Alloy Subway Car Counterweight | Small size, accuracy ±0.1 g, used for rail transportation stabilization. |
| 714 | High Density Tungsten Alloy Ship Deck Counterweight | Density 17-18 g/cm³ , corrosion resistant, used for ship balancing. |
| 715 | High Density Tungsten Alloy High Speed Rail Wheel Weight | Stability is increased by 20% and is used for high-speed train balancing. |
| 716 | Tungsten-based composite materials (automobile cylinder block coatings) | Temperature resistant to 1200°C, wear resistance increased by 30%, used for engine parts. |
| 717 | Tungsten-based wear-resistant coating (rail fasteners) | The service life is extended by 40% and is used for high-speed rail track fixing. |
| 718 | Tungsten-based high temperature composite materials (aircraft turbines) | Temperature resistant to 1600°C, strength increased by 20%, used in aircraft engines. |
| 719 | Tungsten-based nano-coating (antimicrobial devices) | The antibacterial rate is 99%, used in medical surgical instruments. |
| 720 | Tungsten based wear resistant particles (excavator teeth) | HV 800, with 40% longer life, for heavy excavation equipment. |
| 721 | Barium zinc tungstate ($ZnBaWO_4$) fluorescent | The light efficiency is improved by 15% and is used for X-ray imaging. |

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| | material | |
| 722 | Nickel Copper Tungstate ($NiCuWO_4$) Electrode Material | Energy density increased by 20% for energy storage devices. |
| 723 | Potassium Bismuth Tungstate ($KBiWO_4$) Photocatalyst | The efficiency of pollutant degradation is increased by 25% for environmentally friendly treatment. |
| 724 | Magnesium cobalt tungstate ($MgCoWO_4$) catalyst | The catalytic activity is increased by 15% and is used in fuel cells. |
| 725 | Nickel zirconium tungstate ($NiZrWO_4$) heat resistant coating | Temperature resistance of 2000°C, oxidation resistance increased by 25%, used for high temperature surfaces. |
| 726 | Tungsten rod (high temperature test probe) | Purity 99.95%, temperature resistance 3000°C, used for high temperature experiments. |
| 727 | Tungsten plate (radiation protection door) | Thickness 10-30 mm, absorbs 40% of radiation, used for protection of nuclear facilities. |
| 728 | Tungsten wire (high temperature heating coil) | Diameter 0.05-1 mm, temperature resistance 2800°C, used in industrial heating furnaces. |
| 729 | Tungsten tube (high temperature chemical pipe) | Inner diameter 10-50 mm, corrosion-resistant, used for high-temperature chemical transmission. |
| 730 | Tungsten Foil (Flexible Electronic Shielding) | Thickness 0.1 mm, thermal conductivity 145 W/m·K, used for electronic packaging. |
| 731 | Tungsten crucible (high temperature ceramic melting) | Purity 99.99%, temperature resistance 3000°C, used for melting ceramic materials. |
| 732 | Tungsten boat (semiconductor thin film evaporation) | 2000-2500°C, evaporation rate 0.5 nm/s, used for chip manufacturing. |
| 733 | Tungsten target (optical lens coating) | Purity 99.99%, film thickness 10-100 nm, used for optical lens manufacturing. |
| 734 | Tungsten electrode (high temperature plasma cutting) | Resistant to 4000°C arc, with a penetration depth of 5-10 mm, used for metal cutting. |
| 735 | Tungsten sheet (high temperature heat shield) | Temperature resistant to 2500°C, reflectivity 90%, used for high temperature furnace lining. |
| 736 | W-Ni-Fe-Ti alloy (aviation gyro counterweight) | Density 18 g/cm³ , accuracy ±0.05 g, used for navigation system balancing. |
| 737 | W-Cu-Mo-Re alloy (high temperature conductive sheet) | The conductivity is increased by 25%, the temperature resistance is 2800°C, and it is used in electronic equipment. |
| 738 | W-Mo-Nb-Ti alloy (high temperature nozzle) | It can withstand temperatures up to 3200°C and has a 30% increase in oxidation resistance. It is used in rocket thrusters. |
| 739 | W-Co-Ta alloy (wear-resistant lining) | HV 800, with a 40% longer life, for mining machinery. |
| 740 | W-Ti-Re alloy (high temperature sensor probe) | Temperature resistance of 3000°C, sensitivity increased by 20%, used for high temperature detection. |
| 741 | Carbide Aviation Reamer | HV 900, wear resistance increased by 50%, used for aviation parts processing. |

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| 742 | Carbide deep sea drilling knife | With a pressure resistance of 300 MPa and a service life extended by 40%, it is used for deep-sea oil and gas exploration. |
| 743 | Carbide mining crushing teeth | 60% longer life for hard rock crushing. |
| 744 | Carbide Tunnel Cutting Knife | Wear resistance increased by 40%, used in tunnel construction. |
| 745 | Carbide Aluminum Wire Drawing Die | HV 900, with 50% higher wear resistance, is used in aluminum wire production. |
| 746 | High Density Tungsten Alloy Military Satellite Antenna Counterweight | Density 18 g/cm³ , accuracy ±0.05 g, used for satellite communication stabilization. |
| 747 | High Density Tungsten Alloy Rocket Nozzle Lining | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used for liquid rocket propulsion. |
| 748 | High Density Tungsten Alloy Military Radar Heat Sink | Heat dissipation efficiency is increased by 20% and is used in high-power radars. |
| 749 | High Density Tungsten Alloy Aviation Navigation Weight | Small size, accuracy ±0.1 g, used in aircraft navigation systems. |
| 750 | High Density Tungsten Alloy Missile Warhead Counterweight | Improved stability by 15% for precision strike missiles. |
| 751 | High Density Tungsten Alloy Smart Speaker Heat Sink | Thermal conductivity increased by 20%, used in high-end audio equipment. |
| 752 | High Density Tungsten Alloy Car Display Lead | Conductivity increased by 25% for use in automotive display systems. |
| 753 | High Density Tungsten Alloy UAV Motor Electrode | Strong corrosion resistance, used in UAV power systems. |
| 754 | High Density Tungsten Alloy AR Glasses Contacts | 30% better wear resistance for use in augmented reality devices. |
| 755 | High density tungsten alloy smart lamp contacts | Resistant to arc corrosion, with a lifespan extended by 25%, used in smart lighting. |
| 756 | Carbide Dental Polishing Knife | Precision <0.01 mm, life extended by 50%, used for dental polishing. |
| 757 | Carbide Orthopedic Trimming Knife | Cutting speed increased by 30% for orthopedic surgery. |
| 758 | Hard alloy medical minimally invasive knife | Strong corrosion resistance, used in minimally invasive surgery. |
| 759 | Carbide Surgical Suture Scissors | Improved precision by 25% for fine stitching. |
| 760 | Carbide Ophthalmic Micro Knife | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 761 | High Density Tungsten Alloy Oil and Gas Valve Counterweight | Withstands pressure of 200 MPa and has a service life extended by 30%. It is used in oil and gas pipelines. |
| 762 | High Density Tungsten Alloy Geothermal | Temperature resistant to 300°C, corrosion resistance increased by 25%, used in geothermal mining. |

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| | Drilling Lining | |
| 763 | High density tungsten alloy photovoltaic heat dissipation substrate | Heat dissipation efficiency is increased by 20% for solar panels. |
| 764 | High Density Tungsten Alloy Energy Storage Battery Connector | The conductivity is increased by 25% and is used in high-power energy storage systems. |
| 765 | High Density Tungsten Alloy Nuclear Power Plant Steam Valve Core | It absorbs 40% of neutron radiation, has a temperature resistance of 500°C, and is used in nuclear power systems. |
| 766 | High Density Tungsten Alloy Badminton Racket Weight | It weighs 2-5 g and increases strength by 15%. It is used in competitive games. |
| 767 | High Density Tungsten Alloy Skateboard Bearing Weight | Abrasion resistance is increased by 30% for high-intensity skateboarding. |
| 768 | High Density Tungsten Alloy Fishing Hook Weight | Density 17-18 g/cm³ , sinking speed increased by 20%, used for deep sea fishing. |
| 769 | High Density Tungsten Alloy Rock Climbing Equipment Counterweight | Lightweight and 20% more stable, for high altitude climbing. |
| 770 | High Density Tungsten Alloy Archery Nock Weight | Small size, accuracy ±0.1 g, used for archery stabilization. |
| 771 | Carbide manual trimming knife | HV 700, high durability, for manual finishing of metals. |
| 772 | Carbide Stone Engraving Knife | The service life is extended by 50% and it is used in stone craft. |
| 773 | Carbide Woodworking Trimming Knife | HV 900, with 40% higher wear resistance, is used for woodworking trimming. |
| 774 | Carbide Ceramic Grinding Knife | Accuracy <0.02 mm, used for ceramic polishing. |
| 775 | Carbide Hand Engraving Chisel | Lifespan 500 hours, used for metal engraving process. |
| 776 | High Density Tungsten Alloy Oboe Reed Support | Frequency stability ±0.2 Hz, used in wind instrument manufacturing. |
| 777 | High Density Tungsten Alloy Large Counterweight | Weight 5-10 g, sound quality improved by 10%, used for brass instruments. MADE BY: CTIA GROUP |
| 778 | High Density Tungsten Alloy Percussion Instrument Counterweight | Impact resistance increased by 25%, used for stabilization of percussion instruments. |
| 779 | High Density Tungsten Alloy Electric Bass String Seat | Wear resistance increased by 40%, used in electric bass manufacturing. |
| 780 | High Density Tungsten Alloy Piano Pedal Weight | Density 18 g/cm³ , 15% better touch, used in high-end pianos. |

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| 781 | High Density Tungsten Alloy Construction Drill Bit Counterweight | 40% higher wear resistance for concrete drilling. |
| 782 | High Density Tungsten Alloy Bridge Support Block | Density 18 g/cm³ , pressure resistance 200 MPa, used for bridge shock absorption. |
| 783 | High Density Tungsten Alloy Subway Bogie Counterweight | Small size, accuracy ±0.1 g, used for rail transportation stabilization. |
| 784 | High Density Tungsten Alloy Ship Rudder Counterweight | Density 17-18 g/cm³ , corrosion resistant, used for ship control. |
| 785 | High Density Tungsten Alloy High Speed Rail Shock Absorption Weight | Stability is increased by 20% and is used for shock absorption in high-speed trains. |
| 786 | Tungsten-based composite materials (automotive turbine coatings) | Temperature resistant to 1200°C, wear resistance increased by 30%, used in turbochargers. |
| 787 | Tungsten-based wear-resistant coating (railway wheelset) | The service life is extended by 40%, and is used for the surface of high-speed railway wheels. |
| 788 | Tungsten-based high-temperature composite materials (aircraft engines) | Temperature resistant to 1600°C, strength increased by 20%, used in aircraft engines. |
| 789 | Tungsten-based nano coating (antibacterial coating) | Antibacterial rate 99%, used on the surface of medical equipment. |
| 790 | Tungsten based wear resistant particles (crusher lining) | HV 800, with a 40% longer service life, for ore crushing equipment. |
| 791 | Magnesium zinc tungstate ($ZnMgWO_4$) fluorescent material | The luminous efficiency is improved by 15%, and it is used in LED phosphor. |
| 792 | Copper zinc tungstate ($ZnCuWO_4$) electrocatalyst | The efficiency is increased by 20% and is used to produce hydrogen by splitting water. |
| 793 | Bismuth Zirconium Tungstate ($ZrBiWO_4$) Photocatalyst | The pollutant degradation efficiency is increased by 25% and is used for air purification. |
| 794 | Nickel cobalt tungstate ($NiCoWO_4$) electrode material | Energy density increased by 20% for use in supercapacitors. |
| 795 | Sodium Zirconium Tungstate ($NaZrWO_4$) Heat Resistant Ceramics | Temperature resistant to 2000°C, strength increased by 15%, used for high temperature kiln furniture. |
| 796 | Tungsten rod (high temperature experimental electrode) | Purity 99.95%, temperature resistance 3000°C, used for laboratory testing. |
| 797 | Tungsten plate (nuclear | Thickness 10-30 mm, absorbs 40% of radiation, used for |

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| | radiation shielding plate) | protection of nuclear facilities. |
| 798 | Tungsten wire (high temperature resistance wire) | Diameter 0.05-1 mm, temperature resistance 2800°C, used for resistance heating. |
| 799 | Tungsten tube (high temperature gas pipeline) | Inner diameter 10-50 mm, corrosion-resistant, used for high-temperature chemical transmission. |
| 800 | Tungsten foil (flexible shielding layer) | Thickness 0.1 mm, thermal conductivity 145 W/m·K, used for electronic shielding. |
| 801 | Tungsten crucible (high temperature metal melting) | Purity: 99.99%, temperature resistance: 3000°C, used for rare metal smelting. |
| 802 | Tungsten boat (nano coating evaporation) | 2000-2500°C, evaporation rate 0.5 nm/s, used for nanomaterial preparation. |
| 803 | Tungsten target (flexible screen coating) | Purity 99.99%, film thickness 10-50 nm, used for flexible display manufacturing. |
| 804 | Tungsten electrode (high temperature welding electrode) | Resistant to 4000°C arc, with a penetration depth of 5-10 mm, used for aviation welding. |
| 805 | Tungsten sheet (high temperature reflective screen) | Temperature resistant to 2500°C, reflectivity 90%, used for industrial furnace linings. |
| 806 | W-Ni-Fe-Mo-Cu alloy (aviation weight) | Density 18 g/cm³ , accuracy ±0.05 g, used for aircraft balancing. |
| 807 | W-Cu-Re-Ti alloy (high temperature conductive ring) | The conductivity is increased by 25%, the temperature resistance is 2800°C, and it is used in rotating motors. |
| 808 | W-Mo-Nb-Re alloy (high temperature nozzle) | It can withstand temperatures up to 3200°C and has a 30% increase in oxidation resistance. It is used for rocket propulsion. |
| 809 | W-Co-Ta-Ti alloy (wear-resistant gear) | HV 800, with a 40% longer service life, is used for high temperature transmissions. |
| 810 | W-Ti-Zr-Re alloy (high temperature probe) | Temperature resistance of 3000°C, sensitivity increased by 20%, for high temperature measurement. |
| 811 | Carbide aviation cutting tool | HV 900, with 50% higher wear resistance, is used for titanium alloy processing. |
| 812 | Carbide deep sea drilling tool | Withstands pressure of 300 MPa and has a service life extended by 40%, and is used for deep-sea exploration. |
| 813 | Carbide Mining Drill Bits | 60% longer life for hard rock mining. |
| 814 | Carbide Tunneling Teeth | Wear resistance is increased by 40% and is used in shield machine construction. |
| 815 | Carbide Steel Wire Drawing Dies | HV 900, with 50% higher wear resistance, is used in steel wire production. |
| 816 | High Density Tungsten Alloy Military Satellite Gyro Weight | Density 18 g/cm³ , accuracy ±0.05 g, used for satellite navigation. |
| 817 | High Density Tungsten Alloy Rocket Combustion Chamber Lining | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used in rocket engines. |
| 818 | High Density Tungsten Alloy Military Radar | The heat dissipation efficiency is increased by 20%, which is used to stabilize the radar system. |

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| | Antenna Counterweight | |
| 819 | High Density Tungsten Alloy Aviation Gyroscope Counterweight | Small size, accuracy ±0.1 g, used in navigation equipment. |
| 820 | High Density Tungsten Alloy Missile Tail Weight | Improved stability by 15% for missile control. |
| 821 | High-density tungsten alloy intelligent projection heat dissipation shell | Thermal conductivity increased by 20%, used in projection equipment. |
| 822 | High Density Tungsten Alloy Car Audio Electrode | Conductivity increased by 25% and used in car audio systems. |
| 823 | High Density Tungsten Alloy UAV Battery Lead | Strong corrosion resistance, used in drone battery packs. |
| 824 | High Density Tungsten Alloy VR Glasses Heat Sink | The heat dissipation efficiency is increased by 20%, and is used in virtual reality equipment. |
| 825 | High Density Tungsten Alloy Smart Switch Contacts | Resistant to arc corrosion, with a lifespan extended by 25%, used in smart homes. |
| 826 | Carbide dental carving knife | Precision <0.01 mm, life extended by 50%, used for crown processing. |
| 827 | Carbide Orthopedic Micro Scissors | Cutting speed increased by 30% for orthopedic surgery. |
| 828 | Carbide Medical Cutting Knife | Strong corrosion resistance, used for tissue cutting. |
| 829 | Carbide minimally invasive surgical knife | The accuracy is improved by 25% and is used in minimally invasive surgery. |
| 830 | Carbide ophthalmic trimming knife | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 831 | High Density Tungsten Alloy Oil and Gas Drill Pipe Counterweight | Withstands pressure of 200 MPa and has a service life extended by 30%, and is used for oil and gas production. |
| 832 | High Density Tungsten Alloy Geothermal Pipe Lining | Temperature resistant to 300°C, corrosion resistance increased by 25%, used for geothermal power generation. |
| 833 | High Density Tungsten Alloy Photovoltaic Cell Leads | Heat dissipation efficiency is increased by 20% for solar panels. |
| 834 | High density tungsten alloy energy storage electrode lead | The conductivity is increased by 25% and is used in large-capacity energy storage systems. |
| 835 | High Density Tungsten Alloy Nuclear Power Plant Cooling Tube | It absorbs 40% of neutron radiation, has a temperature resistance of 500°C, and is used in nuclear power systems. |
| 836 | High Density Tungsten Alloy Table Tennis Racket Frame | The weight is 2-5 g, the wear resistance is increased by 30%, and it is used in competitive games. |
| 837 | High Density Tungsten | Abrasion resistance increased by 40% for high-speed skiing. |

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| | Alloy Snowboard Edge | |
| 838 | High Density Tungsten Alloy Fishing Rod Weight | Density 17-18 g/cm³ , 20% more stable, for long-distance fishing. |
| 839 | High Density Tungsten Alloy Climbing Buckle Weight | Lightweight and 20% more stable, for high altitude climbing. |
| 840 | High Density Tungsten Alloy Archery Bow String Weight | Small size, accuracy ±0.1 g, used for archery stabilization. |
| 841 | Carbide hand-ground chisel | HV 700, highly durable, for manual sanding of metals. |
| 842 | Carbide Stone Trimmer | The service life is extended by 50% and is used for stone processing. |
| 843 | Carbide Woodworking Engraving Knife | HV 900, with 40% higher wear resistance, is used for wood carving. |
| 844 | Carbide Ceramic Engraving Knife | Precision <0.02 mm, used for ceramic handicraft processing. |
| 845 | Carbide hand polished chisel | Lifespan: 500 hours, used for metal polishing process. |
| 846 | High Density Tungsten Alloy Flute Weight | Frequency stability ±0.2 Hz, weight 5-10 g, used for wind instrument manufacturing. |
| 847 | High Density Tungsten Alloy French Horn Reed Support | Improves sound quality by 10% for brass instruments. |
| 848 | High Density Tungsten Alloy Percussion Instrument Pedal Weight | Impact resistance increased by 25%, used for stabilization of percussion instruments. |
| 849 | High Density Tungsten Alloy Electric Guitar Weight | Abrasion resistance increased by 40%, used in guitar manufacturing. |
| 850 | High Density Tungsten Alloy Piano String Seat | Density 18 g/cm³ , sound quality steadily improved by 15%, used in high-end pianos. |
| 851 | High Density Tungsten Alloy Construction Steel Bar Cutting Knife | Wear resistance increased by 40%, used for steel bar processing. |
| 852 | High Density Tungsten Alloy Bridge Shock Absorber Counterweight | Density 18 g/cm³ , pressure resistance 200 MPa, used for bridge stabilization. |
| 853 | High Density Tungsten Alloy Subway Wheel Counterweight | Small size, accuracy ±0.1 g, used for rail transportation stabilization. |
| 854 | High Density Tungsten Alloy Ship Engine Counterweight | Density 17-18 g/cm³ , corrosion resistant, used in ship power systems. |
| 855 | High Density Tungsten Alloy High Speed Rail Carriage Shock Absorption Counterweight | Stability is increased by 20% and is used for shock absorption in high-speed trains. |
| 856 | Tungsten-based composite materials | Temperature resistant to 1200°C, wear resistance increased by 30%, used for engine cylinders. |

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| | (automotive engine linings) | |
| 857 | Tungsten-based wear-resistant coating (railway shock absorber) | The service life is extended by 40% and is used in high-speed rail shock absorption systems. |
| 858 | Tungsten-based high-temperature composite materials (aircraft fuselage) | Temperature resistant to 1600°C, strength increased by 20%, used in aviation structures. |
| 859 | Tungsten-based nano coating (antibacterial packaging film) | Antibacterial rate 99%, used for food packaging protection. |
| 860 | Tungsten-based wear-resistant particles (excavator teeth) | HV 800, with 40% longer life, for heavy excavation equipment. |
| 861 | Potassium zinc tungstate ($KZnWO_4$) fluorescent material | The luminous efficiency is improved by 15%, and it is used in display phosphors. |
| 862 | Magnesium copper tungstate ($MgCuWO_4$) electrocatalyst | The efficiency is increased by 20% and is used to produce hydrogen by splitting water. |
| 863 | Sodium Bismuth Tungstate ($NaBiWO_4$) Photocatalyst | The efficiency of pollutant degradation is increased by 25% and is used for water treatment. |
| 864 | Cobalt zinc tungstate ($ZnCoWO_4$) electrode material | Energy density increased by 20% for energy storage batteries. |
| 865 | Magnesium zirconium tungstate ($MgZrWO_4$) heat-resistant ceramics | Temperature resistant to 2000°C, strength increased by 15%, used for high temperature kiln furniture. |
| 866 | Tungsten rod (high temperature test support rod) | Purity 99.95%, temperature resistance 3000°C, used for laboratory high temperature support. |
| 867 | Tungsten plate (nuclear facility protection wall) | Thickness 10-30 mm, absorbs 40% of radiation, used for nuclear industry protection. |
| 868 | Tungsten wire (high temperature experimental heating wire) | Diameter 0.05-1 mm, temperature resistance 2800°C, used for experimental heating equipment. |
| 869 | Tungsten tube (high temperature fluid pipeline) | Inner diameter 10-50 mm, corrosion-resistant, used for high-temperature chemical transmission. |
| 870 | Tungsten foil (electronic packaging shielding) | Thickness 0.1 mm, thermal conductivity 145 W/m·K, used for electronic packaging. |
| 871 | Tungsten crucible (high temperature rare earth smelting) | Purity: 99.99%, temperature resistance: 3000°C, used for rare earth metal smelting. |
| 872 | Tungsten boat (thin film deposition evaporation) | 2000-2500°C, evaporation rate 0.5 nm/s, for thin film preparation. |
| 873 | Tungsten target (photovoltaic coating) | Purity is 99.99%, film thickness is 5-50 nm, and it is used in solar cell manufacturing. |
| 874 | Tungsten electrode (high | Resistant to 4000°C arc, with a penetration depth of 5-10 mm, |

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| | temperature plasma welding) | used for welding aviation parts. |
| 875 | Tungsten sheet (high temperature heat reflective plate) | Temperature resistance 2500°C, reflectivity 90%, used for vacuum furnace lining. |
| 876 | W-Ni-Fe-Ti-Mo alloy (aviation counterweight) | Density 18 g/cm³ , accuracy ±0.05 g, used for aircraft balancing. |
| 877 | W-Cu-Re-Mo alloy (high temperature conductive substrate) | The conductivity is increased by 25%, the temperature resistance is 2800°C, and it is used in electronic substrates. |
| 878 | W-Mo-Nb-Ta alloy (high temperature nozzle lining) | It can withstand temperatures up to 3200°C and has a 30% increase in oxidation resistance. It is used in rocket thrusters. |
| 879 | W-Co-Ti-Zr alloy (wear-resistant lining) | HV 800, with a 40% longer life, for mining equipment. |
| 880 | W-Ti-Re-Nb alloy (high temperature sensor) | Temperature resistance of 3000°C, sensitivity increased by 20%, used for high temperature detection. |
| 881 | Carbide aviation milling cutter | HV 900, with 50% higher wear resistance, is used for composite material processing. |
| 882 | Carbide deep sea drilling teeth | With a pressure resistance of 300 MPa and a service life extended by 40%, it is used for deep-sea oil and gas exploration. |
| 883 | Carbide mining cutting tool | 60% longer life for hard rock mining. |
| 884 | Carbide shield machine cutting teeth | Wear resistance increased by 40%, used in tunnel construction. |
| 885 | Carbide Stainless Steel Wire Drawing Die | HV 900, with 50% higher wear resistance, is used in stainless steel wire production. |
| 886 | High Density Tungsten Alloy Military Satellite Attitude Weight | Density 18 g/cm³ , accuracy ±0.05 g, used for satellite stabilization. |
| 887 | High Density Tungsten Alloy Rocket Nozzle Lining | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used in rocket propulsion. |
| 888 | High Density Tungsten Alloy Military Radar Heat Sink | The heat dissipation efficiency is increased by 20% and is used in high-frequency radar systems. |
| 889 | High Density Tungsten Alloy Aviation Navigation Gyro Weight | Small size, accuracy ±0.1 g, used in aircraft navigation systems. |
| 890 | High Density Tungsten Alloy Missile Body Counterweight | Improved stability by 15% for precision guided missiles. |
| 891 | High Density Tungsten Alloy Smart TV Heat Sink Case | Thermal conductivity increased by 20% and used in high-end display devices. |
| 892 | High Density Tungsten Alloy Vehicle Radar Lead | Conductivity increased by 25% for use in automotive radar systems. |
| 893 | High Density Tungsten Alloy UAV Control Lead Wire | Strong corrosion resistance, used in drone circuits. |
| 894 | High Density Tungsten | Heat dissipation efficiency is improved by 20% for use in |

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| | Alloy AR Equipment Heat Dissipation Substrate | augmented reality devices. |
| 895 | High Density Tungsten Alloy Smart Door Lock Contacts | Resistant to arc corrosion, with a lifespan extended by 25%, used in smart homes. |
| 896 | Carbide dental minimally invasive knife | Accuracy <0.01 mm, life extended by 50%, used in dental surgery. |
| 897 | Carbide Orthopedic Cutting Saw | Cutting speed increased by 30% for orthopedic surgery. |
| 898 | Carbide medical trimming knife | Strong corrosion resistance, used for tissue finishing. |
| 899 | Carbide surgical micro scissors | The accuracy is improved by 25% and is used in minimally invasive surgery. |
| 900 | Carbide Ophthalmic Minimally Invasive Knife | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 901 | High Density Tungsten Alloy Oil and Gas Drilling Lining | Withstands pressure of 200 MPa and has a service life extended by 30%, and is used for oil and gas production. |
| 902 | High Density Tungsten Alloy Geothermal Power Generation Valve Core | Temperature resistant to 300°C, corrosion resistance increased by 25%, used in geothermal systems. |
| 903 | High Density Tungsten Alloy Photovoltaic Inverter Heat Sink | The heat dissipation efficiency is increased by 20% and is used for solar power generation. |
| 904 | High Density Tungsten Alloy Energy Storage Battery Electrode | The conductivity is increased by 25% and is used in high-power energy storage systems. |
| 905 | High Density Tungsten Alloy Neutron Absorption Plate for Nuclear Power Plant | Absorbs 40% of neutron radiation and is used for reactor safety. |
| 906 | High Density Tungsten Alloy Tennis Racket Frame Weight | The weight is 2-5 g, the wear resistance is increased by 30%, and it is used in competitive games. |
| 907 | High Density Tungsten Alloy Snowboard Weight | Abrasion resistance increased by 40%, used in high-speed ski equipment. |
| 908 | High Density Tungsten Alloy Fishing Sinker Weight | Density 17-18 g/cm³ , sinking speed increased by 20%, used for deep sea fishing. |
| 909 | High Density Tungsten Alloy Climbing Rope Buckle Weight | Lightweight and 20% more stable, for high altitude climbing. |
| 910 | High Density Tungsten Alloy Archery Arrow Weight | Small size, accuracy ±0.1 g, used for archery stabilization. |
| 911 | Carbide Hand Engraving Chisel | HV 700, durable and suitable for metal engraving. |
| 912 | Carbide Stone Polishing Knife | The service life is extended by 50% and it is used for stone polishing. |

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| 913 | Carbide Woodworking Cutting Knife | HV 900, with 40% higher wear resistance, is used in woodworking. |
| 914 | Ceramic carbide trimming knife | Precision <0.02 mm, used for ceramic processing. |
| 915 | Carbide hand sharpened knife | Lifespan: 500 hours, used for metal surface polishing. |
| 916 | High Density Tungsten Alloy Saxophone Weight | Frequency stability ±0.2 Hz, weight 5-10 g, used for wind instrument manufacturing. |
| 917 | High Density Tungsten Alloy Trumpet Reed Support | Improves sound quality by 10% for brass instruments. |
| 918 | High Density Tungsten Alloy Percussion Instrument Counterweight | Impact resistance increased by 25%, used for stabilization of percussion instruments. |
| 919 | High Density Tungsten Alloy Electric Guitar String Seat | Abrasion resistance increased by 40%, used in guitar manufacturing. |
| 920 | High Density Tungsten Alloy Piano Key Weights | Density 18 g/cm³ , 15% better touch, used in high-end pianos. |
| 921 | High Density Tungsten Alloy Construction Concrete Drill | 40% higher wear resistance for concrete drilling. |
| 922 | High Density Tungsten Alloy Bridge Weight | Density 18 g/cm³ , pressure resistance 200 MPa, used for bridge stabilization. |
| 923 | High Density Tungsten Alloy Subway Car Shock Absorption Counterweight | Small size, accuracy ±0.1 g, used for rail transit shock absorption. |
| 924 | High Density Tungsten Alloy Ship Propeller Counterweight | Density 17-18 g/cm³ , corrosion resistant, used in ship propulsion systems. |
| 925 | High Density Tungsten Alloy High Speed Railway Bogie Counterweight | Stability is improved by 20% and is used for high-speed train stability. |
| 926 | Tungsten-based composite materials (automotive engine coatings) | Temperature resistant to 1200°C, wear resistance increased by 30%, used for engine parts. |
| 927 | Tungsten-based wear-resistant coating (railway track surface) | The service life is extended by 40% and is used for high-speed rail track protection. |
| 928 | Tungsten-based high-temperature composite materials (aircraft turbine blades) | Temperature resistant to 1600°C, strength increased by 20%, used in aircraft engines. |
| 929 | Tungsten-based nano-coatings (antibacterial medical devices) | Antibacterial rate 99%, used on the surface of surgical instruments. |
| 930 | Tungsten based wear resistant particles | HV 800, with 40% longer life, for heavy excavation equipment. |

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| | (excavator lining) | |
| 931 | Potassium zinc tungstate ($KZnWO_4$) luminescent material | The luminous efficiency is improved by 15% and is used in fluorescent displays. |
| 932 | Magnesium copper tungstate ($MgCuWO_4$) electrocatalyst | The efficiency is increased by 20% and is used to produce hydrogen by splitting water. |
| 933 | Potassium Bismuth Tungstate ($KBiWO_4$) Photocatalyst | The pollutant degradation efficiency is increased by 25% and is used for air purification. |
| 934 | Nickel cobalt tungstate ($NiCoWO_4$) electrode material | Energy density increased by 20% for energy storage batteries. |
| 935 | Magnesium zirconium tungstate ($MgZrWO_4$) heat resistant coating | Temperature resistance of 2000°C, oxidation resistance increased by 25%, used for high temperature surfaces. |
| 936 | Tungsten rod (high temperature experimental heating rod) | Purity 99.95%, temperature resistance 3000°C, used for laboratory heating. |
| 937 | Tungsten plate (nuclear facility shielding door) | Thickness 10-30 mm, absorbs 40% of radiation, used for nuclear industry protection. |
| 938 | Tungsten wire (high temperature experimental resistance wire) | Diameter 0.05-1 mm, temperature resistance 2800°C, used in experimental resistance furnaces. |
| 939 | Tungsten tube (high temperature chemical pipeline) | Inner diameter 10-50 mm, corrosion resistant, used for high temperature chemical transmission. |
| 940 | Tungsten foil (flexible electronic packaging) | Thickness 0.1 mm, thermal conductivity 145 W/m·K, used for electronic shielding. |
| 941 | Tungsten crucible (high temperature alloy melting) | Purity 99.99%, temperature resistance 3000°C, used for aviation alloy smelting. MADE BY: CTIA GROUP |
| 942 | Tungsten Boat (Optical Thin Film Deposition) | 2000-2500°C, evaporation rate 0.5 nm/s, used for optical coating. |
| 943 | Tungsten target (flexible display coating) | Purity 99.99%, film thickness 10-50 nm, used for flexible screen manufacturing. |
| 944 | Tungsten electrode (high temperature plasma cutting) | Resistant to 4000°C arc, with a penetration depth of 5-10 mm, used for metal cutting. |
| 945 | Tungsten sheet (high temperature insulation board) | Temperature resistance 2500°C, reflectivity 90%, used for vacuum furnace lining. |
| 946 | W-Ni-Fe-Mo-Ti alloy (aviation gyro counterweight) | Density 18 g/cm³ , accuracy ±0.05 g, used for navigation system balancing. |
| 947 | W-Cu-Re-Mo-Ti alloy (high temperature conductive plate) | The conductivity is increased by 25%, the temperature resistance is 2800°C, and it is used in electronic equipment. |
| 948 | W-Mo-Nb-Ta-Ti alloy (high temperature | It can withstand temperatures up to 3200°C and has a 30% increase in oxidation resistance. It is used in rocket thrusters. |

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| | nozzle) | |
| 949 | W-Co-Ti-Zr-Nb alloy (wear-resistant lining) | HV 800, with a 40% longer life, for mining machinery. |
| 950 | W-Ti-Re-Nb-Mo alloy (high temperature probe) | Temperature resistance of 3000°C, sensitivity increased by 20%, for high temperature measurement. |
| 951 | Carbide aviation trimming tool | HV 900, wear resistance increased by 50%, used for aviation parts processing. |
| 952 | Carbide deep sea drilling knife | With a pressure resistance of 300 MPa and a service life extended by 40%, it is used for deep-sea oil and gas exploration. |
| 953 | Carbide Mining Picks | 60% longer life for hard rock mining. |
| 954 | Carbide shield machine cutter | Wear resistance increased by 40%, used in tunnel construction. |
| 955 | Carbide Copper Wire Drawing Die | HV 900, with 50% higher wear resistance, is used in copper wire production. |
| 956 | High Density Tungsten Alloy Military Satellite Counterweight | Density 18 g/cm³ , accuracy ±0.05 g, used for satellite attitude adjustment. |
| 957 | High Density Tungsten Alloy Rocket Nozzle Lining | It can withstand temperatures up to 3200°C and has strong oxidation resistance, and is used in rocket propulsion systems. |
| 958 | High Density Tungsten Alloy Military Radar Antenna Shell | The heat dissipation efficiency is increased by 20% and is used in high-frequency radar systems. |
| 959 | High Density Tungsten Alloy Aviation Navigation Counterweight | Small size, accuracy ±0.1 g, used in aircraft navigation systems. |
| 960 | High Density Tungsten Alloy Missile Gyro Counterweight | Improved stability by 15% for missile guidance. |
| 961 | High Density Tungsten Alloy Smart Speaker Heat Sink Shell | Thermal conductivity increased by 20%, used in high-end audio equipment. |
| 962 | High Density Tungsten Alloy Vehicle Display Electrode | Conductivity increased by 25% for use in automotive display systems. |
| 963 | High Density Tungsten Alloy UAV Battery Connector | Strong corrosion resistance, used in drone battery packs. |
| 964 | High Density Tungsten Alloy VR Equipment Heat Sink Shell | The heat dissipation efficiency is increased by 20%, and is used in virtual reality equipment. |
| 965 | High Density Tungsten Alloy Smart Socket Contacts | Resistant to arc corrosion, with a lifespan extended by 25%, used in smart homes. |
| 966 | Carbide dental trimmer | Precision <0.01 mm, lifespan extended by 50%, used for dental contouring. |
| 967 | Carbide Minimally Invasive Orthopedic Scissors | Cutting speed increased by 30% for orthopedic surgery. |
| 968 | Carbide medical sampling knife | Strong corrosion resistance, used for tissue sampling. |

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| 969 | Carbide surgical suture knife | The accuracy is improved by 25% and is used for minimally invasive suturing. |
| 970 | Carbide Ophthalmic Cutting Knife | HV 900, 40% more durable, for use in ophthalmic surgery. |
| 971 | High Density Tungsten Alloy Oil and Gas Valve Core Counterweight | Withstands pressure of 200 MPa and has a service life extended by 30%. It is used in oil and gas pipelines. |
| 972 | High Density Tungsten Alloy Geothermal Drilling Counterweight | Temperature resistant to 300°C, corrosion resistance increased by 25%, used in geothermal mining. |
| 973 | High Density Tungsten Alloy Photovoltaic Heat Sink | Heat dissipation efficiency is increased by 20% for solar panels. |
| 974 | High Density Tungsten Alloy Energy Storage Battery Lead | The conductivity is increased by 25% and is used in large-capacity energy storage systems. |
| 975 | High Density Tungsten Alloy Nuclear Power Plant Radiation Shielding | Absorbs 40% of neutron radiation and is used for protecting nuclear facilities. |
| 976 | High Density Tungsten Alloy Table Tennis Racket Weight | Weight 2-5 g, strength increase by 15%, for competitive training. |
| 977 | High Density Tungsten Alloy Ski Pole Weight | Wear resistance is increased by 40%, suitable for ice and snow sports. |
| 978 | High Density Tungsten Alloy Fishing Rod Weight | Density 17-18 g/cm³ , 20% more stable, for long-distance fishing. |
| 979 | High Density Tungsten Alloy Rock Climbing Equipment Counterweight | Lightweight and 20% more stable, for high altitude climbing. |
| 980 | High Density Tungsten Alloy Archery Bow Weight | Small size, accuracy ±0.1 g, used for archery stabilization. |
| 981 | Carbide Hand Engraving Knife | HV 700, high durability, for hand engraving on metal. |
| 982 | Carbide Stone Cutting Knife | The service life is extended by 50% and is used for stone processing. |
| 983 | Carbide Woodworking Polishing Knife | HV 900, with 40% higher wear resistance, is used for woodworking polishing. |
| 984 | Carbide Ceramic Cutting Knife | Precision <0.02 mm, used for ceramic processing. |
| 985 | Carbide manual trimming knife | Lifespan 500 hours, used for metal finishing process. |
| 986 | High Density Tungsten Alloy Clarinet Reed Support | Frequency stability ±0.2 Hz, weight 5-10 g, used for wind instrument manufacturing. |
| 987 | High Density Tungsten Alloy Large Counterweight | Improves sound quality by 10% for brass instruments. |
| 988 | High Density Tungsten | Impact resistance increased by 25%, used for stabilization of |

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| | Alloy Drum Weight | percussion instruments. |
| 989 | High Density Tungsten Alloy Electric Bass Weight | Wear resistance increased by 40%, used in electric bass manufacturing. |
| 990 | High Density Tungsten Alloy Piano Pedal Weight | Density 18 g/cm³ , 15% better touch, used in high-end pianos. |
| 991 | High Density Tungsten Alloy Construction Drilling Counterweight | 40% higher wear resistance for concrete drilling. |
| 992 | High Density Tungsten Alloy Bridge Shock Absorption Weight | Density 18 g/cm³ , pressure resistance 200 MPa, used for bridge stabilization. |
| 993 | High Density Tungsten Alloy Subway Car Counterweight | Small size, accuracy ±0.1 g, used for rail transportation stabilization. |
| 994 | High Density Tungsten Alloy Ship Rudder Counterweight | Density 17-18 g/cm³ , corrosion resistant, used for ship control. |
| 995 | High Density Tungsten Alloy High Speed Rail Wheel Weight | Stability is increased by 20% and is used for high-speed train balancing. |
| 996 | Tungsten-based composite materials (automobile cylinder block coatings) | Temperature resistant to 1200°C, wear resistance increased by 30%, used for engine cylinders. |
| 997 | Tungsten-based wear-resistant coating (railway wheelset surface) | The service life is extended by 40% and is used for high-speed railway wheel set protection. |
| 998 | Tungsten-based high temperature composite materials (aircraft skin) | Temperature resistant to 1600°C, strength increased by 20%, used in supersonic aircraft. |
| 999 | Tungsten-based nano-coating (antibacterial fabric) | Antibacterial rate 99%, used for medical protective clothing. |
| 1000 | Tungsten-based wear-resistant particles (concrete mixing teeth) | HV 800, with a 40% longer service life, is used in construction mixing equipment. |
| | | MADE BY: CTIA GROUP |

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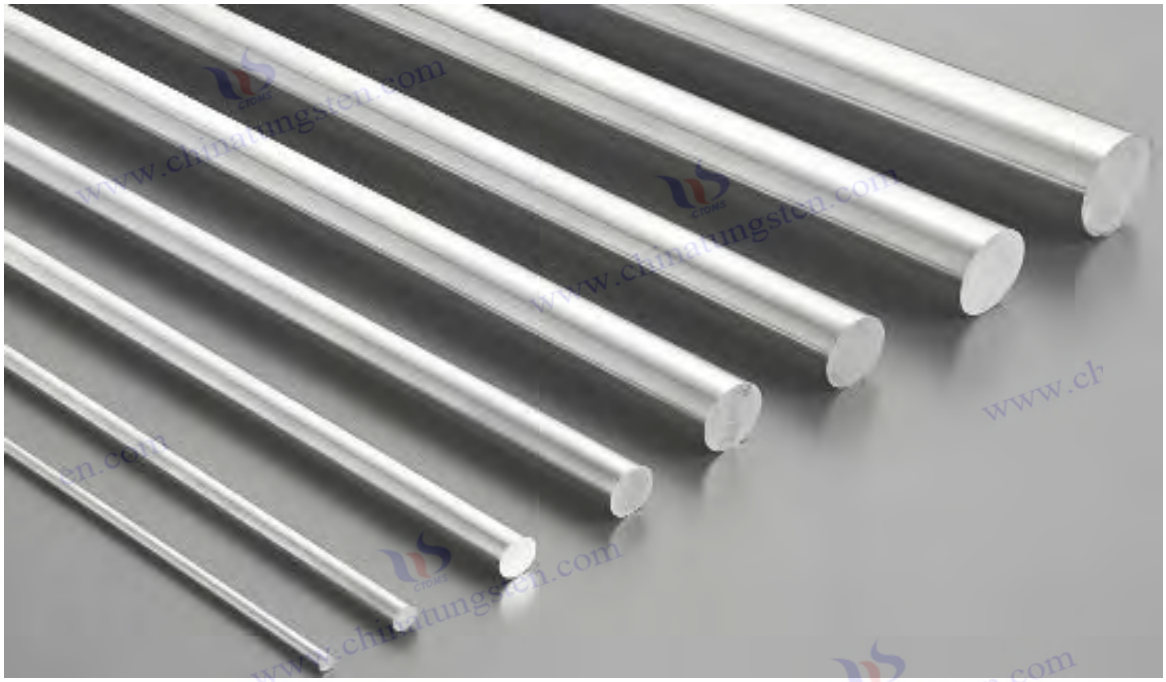

## Chapter 22 History of Tungsten

### 22.1 Overview of the Historical Significance of Tungsten

Tungsten (element symbol W, atomic number 74) has become an indispensable material for modern industry, military and technology due to its high melting point (3422°C), high density (19.25 g/cm³ ) and excellent hardness. From incandescent filaments to carbide tools, from armor-piercing bullets to nuclear reactor components, tungsten has been used throughout many stages of human technological progress. Understanding the history of tungsten not only reveals the tortuous process of its scientific discovery, but also clarifies its key role in global resource competition and industrial revolution. As the world's leading country in tungsten reserves and production, China's tungsten history adds a cultural and economic dimension to this element. This chapter will trace the origin, naming and development of tungsten, providing a historical background for the application research in subsequent chapters.

### 22.2 Discovery and naming of tungsten

#### 22.2.1 Early Observation before Discovery

Tungsten is hidden in the natural wolframite ($FeMnWO_4$ ) and scheelite ($CaWO_4$ ), which miners in Europe and Asia had come into contact with before the 18th century, but their unique composition was not identified. In Europe, German miners called wolframite "Wolfram" (meaning "wolf foam") because it produced foam when smelting tin, interfering with the extraction of tin. Ancient Chinese texts, such as the Song Dynasty's "Heavenly Creations" (1637), did not explicitly mention tungsten, but descriptions of similar heavy ores may be related to it . These early observations laid the foundation for the official discovery of tungsten.

#### 22.2.2 Multilingual Discovery Records

The discovery of tungsten spanned multiple countries and languages, reflecting the international nature of scientific exchange in the 18th century:

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**Swedish record: "Uppt ä ckt " (discovery)**

Swedish chemist Carl Wilhelm Scheele first extracted tungstic acid ($H_2WO_4$) from scheelite in 1781 and named it "tungsten" (Swedish: heavy stone), marking the beginning of the discovery of tungsten. His colleague Torbern Bergman further confirmed its chemical properties.

**Spanish: "Descubrimiento" (discovery)**

Spanish chemists the brothers Juan José and Fausto d'Elhuyar completed the transition from compound to element by isolating metallic tungsten from wolframite in 1783. They made this breakthrough in their laboratory in the Basque region of Spain and called it "wolframio."

**German influence: "Wolfram"**

The German mining industry traditionally calls tungsten ore "Wolfram", which originated from the "wolf bubble" phenomenon during tin smelting in the Middle Ages. This name is widely circulated in German-speaking countries and has been partially adopted by the international chemical community.

**Other language traces**
include "tungstène" in French and "tungstenum" in Latin literature, showing the diversity of naming.

### 22.2.3 The Evolution of the “Tungsten” Name

The word "Tungsten" comes from the Swedish word "tung sten", which means "heavy stone", reflecting the high density of scheelite. Scheele's name was adopted by the English scientific community, while the "wolframio" proposed by the Del Uyal brothers is more common in Spanish and German-speaking countries. In the 19th century, with the establishment of the periodic table, the International Union of Applied Physics (IUPAC) uniformly adopted "W" as the symbol for tungsten, derived from "Wolfram", but "Tungsten" gradually became dominant in English. This naming difference still exists today, reflecting the fusion of history and culture.

## 22.3 Discovered in 1781 (Swedish: Uppt ä ckt, Spanish: Descubrimiento)

### 22.3.1 Contributions of Carl Wilhelm Scheele (Sweden)

In 1781, when Scheele was studying scheelite ($CaWO_4$) in the Uppsala Laboratory in Sweden, he treated the ore with nitric acid and separated a yellow precipitate - tungstic acid ($H_2WO_4$). He proved through experiments that this was an oxide of a new element and named it "tungsten". Although this discovery (Swedish: Uppt ä ckt) did not directly extract metallic tungsten, it pointed out the direction for subsequent research. Scheele's humility prevented him from competing for the right of discovery, but his contribution is regarded as the starting point of the history of tungsten.

### 22.3.2 The Del Uyal brothers’ breakthrough (Spain)

In 1783, Spanish chemists Juan José del Uyal and Fausto del Uyal successfully prepared metallic tungsten by reducing tungstic acid in the Vergara laboratory in the Basque Country. They used charcoal to heat the tungstic acid at high temperatures (about 1000°C) to obtain a gray metal powder, completing the first separation of tungsten. This achievement (Spanish: Descubrimiento) benefited from the metallurgical technology tradition of Spain at the time and the brothers' experience of studying in Europe (such as at the Freiburg Mining Academy in Germany).

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### 22.3.3 Cooperation and Disputes

The time difference between Scherer and the Del Uyal brothers in their discoveries (1781 vs. 1783) has led to a dispute over attribution. Scherer was the first to identify tungstic acid, but did not extract the metal; the Del Uyal brothers completed the metal separation. Some historians believe that Scherer was the "discoverer" and the Del Uyal brothers were the "preparators." In the end, the scientific community recognized the joint contributions of the two, and the timeline is as follows:
1781: Scheerer discovered tungstic acid.
1783: The DelUyal brothers separated metallic tungsten and published their results.

## 22.4 Historical Differences between Chinese and English Naming ( www.ctia.com.cn )

### 22.4.1 Origin and Adoption of the English Word “Tungsten”

"Tungsten" comes from the Swedish word "tung sten", which was proposed by Scheele and widely accepted by British chemists in the early 19th century. In 1801, the British Royal Society published a document that first used "Tungsten" to describe this new element. The English name emphasized its physical properties (heavy) and spread around the world with the Industrial Revolution.

### 22.4.2 The Chinese word for “tungsten” (Wū)

The Chinese character "tungsten" appeared relatively late, around the end of the 19th century to the beginning of the 20th century, when it was introduced to China along with Western chemistry. "Tungsten" is composed of the character "gold" and the character "black". "Black" may be taken from its pronunciation, symbolizing black (the common color of wolframite); "gold" indicates its metallic properties. Xu Shou, a scholar in the late Qing Dynasty, first translated "Tungsten" into "tungsten" in "Chemical Principles" (1871), laying the foundation for the Chinese name.

### 22.4.3 Comparative Analysis of Naming Conventions

**English** : Focus on physical properties ("heavy stone"), direct transliteration of Swedish, concise and intuitive.
**Chinese** : It combines phono-semantic and pictographic characters, and incorporates cultural symbols (such as "金" for precious metals), making it more expressive.
**Historical background** : English naming became popular with industrialization, while Chinese naming was influenced by the scientific enlightenment in the late Qing Dynasty and has local characteristics. Modern literature (such as www.ctia.com.cn) records this evolution.

### 22.4.4 Global terminology

At the end of the 19th century, the International Society adopted "W" as the chemical symbol for tungsten, derived from the German word "Wolfram" rather than the "T" in "Tungsten". This move balanced the naming differences in Europe and became the global standard. After the establishment of the Chinese Chemical Society (1932), it also accepted the dual naming of "W" and "tungsten", reflecting the integration of international trade and scientific exchanges.

## 22.5 The Discovery, Development and Development of Tungsten in China

### 22.5.1 Preliminary understanding and discovery in ancient times

China has the world's largest tungsten reserves (about 1.9 million tons, accounting for 40% of the world's total), mainly distributed in Jiangxi, Hunan, Guangdong and other places. Ancient miners may have come into contact with tungsten as early as the Tang and Song dynasties. Although "Tungsten" is not explicitly

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mentioned in "The Exploitation of the Works of Nature" (1637), the "heavy stone" or "black tin" described may refer to wolframite. In the Qing Dynasty (18th-19th century), tungsten was often mistaken for a co-occurring ore of tin during ore mining in Lianping, Guangdong and Dayu, Jiangxi, and was used for simple smelting, but it was not systematically identified.

### 22.5.2 Modern Development and the Beginning of Industrialization (late 19th century to early 20th century)

**Western influence**
At the end of the 19th century, Western geology was introduced and the Qing government hired foreign experts to explore mineral resources. In the 1890s, German geologists first confirmed the value of Jiangxi tungsten mines.

**Xihuashan Tungsten Mine**
In 1916, the Xihuashan Tungsten Mine in Dayu, Jiangxi Province was officially mined, with an annual output of about 500 tons of tungsten concentrate, becoming the starting point of China's tungsten industry.
**International status** : During the Republic of China period (1912-1949), China's tungsten ore exports surged. In the 1930s, China's tungsten ore output accounted for more than 50% of the world's total, mainly exported to Europe and the United States to support military demand (such as armor-piercing shells in World War I and World War II).

### 22.5.3 Rapid Development after the Founding of New China (1949-1980s)

**Strategic Positioning**
After 1949, tungsten was listed as a national strategic resource. In the 1950s, a national geological survey confirmed that the reserves exceeded 4 million tons.

**Mine construction**
Hunan Shizhuyuan (polymetallic tungsten mine) and Jiangxi Gannan (scheelite mine) became the core bases. In 1958, Shizhuyuan tungsten mine was put into production, with an annual output of 2,000 tons of tungsten concentrate.

**Technological advancement**
From manual roasting (purity 60-70%) to hydrometallurgy (such as ammonia leaching, purity 99%), the Zhuzhou Cemented Carbide Factory was built in the 1960s to produce tungsten carbide tools.

### 22.5.4 Reform and opening up and globalization (1980s-early 21st century)

**Marketization**
In the 1980s, the tungsten industry introduced market mechanisms, and companies such as China Minmetals rose to prominence. In 1990, the national output reached 50,000 tons.
**Global dominance**
After 2000, China's tungsten production accounted for 80-85% of the world's total ( www.ctia.com.cn ), with a price of RMB 250,000-350,000 per ton, making it the " Tungsten Kingdom " .
**Policy Adjustment**
Export quotas have been implemented since 2005 to respond to international anti-dumping and increase added value (such as tungsten alloy exports).

### 22.5.5 Modern Innovation and Sustainable Development (21st Century)

**Application Extensions**
tungsten is growing in cemented carbide (accounting for 60% of consumption) and new energy (such as $WO_3$ battery materials, with a capacity of 600-800 mAh/g).

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**Green Technology**
The tailings recovery rate has been increased from 25-35% to 50-60%. In 2020, 3,000 tons of tungsten will be recovered, reducing land damage.
**Future Outlook**
Intelligent mining (such as unmanned mining machines, which increase efficiency by 20%) and international cooperation (such as the "Belt and Road" tungsten resource project).

### 22.6 Milestones in the History of Tungsten

#### 22.6.1 19th century: the beginning of industry

In the 1820s, tungsten steel alloy increased the hardness of tools and helped the machinery industry.
In the 1870s, tungsten filaments were used in incandescent lamps with a lifespan of 2,000 hours, ushering in a lighting revolution.

#### 22.6.2 20th Century: Military and Technological Advances

In the 1940s, tungsten core armor-piercing bullets (density 18 g/cm³ ) played a vital role in World War II.
In the 1960s, tungsten targets supported the development of semiconductors and laid the foundation for the electronics industry.

#### 22.6.3 21st Century: Modern Innovation

In the 2000s, tungsten came to prominence in wind power (counterweights) and nanotechnology (W-graphene).
In the 2020s, tungsten-based high-entropy alloys (strength 2200 MPa) were used in nuclear fusion.

### 22.7 Conclusion: Tungsten’s Historical Legacy

The history of tungsten has evolved from its chemical discovery in the 18th century to its industrial application in the 19th century, and then to its military and high-tech breakthroughs in the 20th and 21st centuries, demonstrating mankind's ability to explore and utilize natural resources. The history of Chinese tungsten has evolved from an unknown ore in ancient times to a global hegemon in modern times, reflecting the interweaving of technology, culture and economy. Historical insights remind us that the future of tungsten will continue to be brilliant in sustainable development and cutting-edge technology.

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## Chapter 23 Tungsten Reserves

### 23.1 Introduction: The importance of tungsten reserves

As a rare metal, tungsten has an irreplaceable position in the fields of industry, military and high technology due to its high melting point (3422°C), high density (19.25 g/cm³ ) and excellent hardness. The distribution and changes of global tungsten reserves directly affect the security of the supply chain, market prices and the sustainability of technological development. Especially in the context of current geopolitics and green energy transformation, the strategic value of tungsten has become increasingly prominent. As the leading country in tungsten reserves and production, China's resource status has a decisive impact on the global pattern. This chapter aims to systematically analyze the distribution, dynamic changes and driving factors of global tungsten reserves, and provide the latest reserve data to reveal the current status and future trends of tungsten resources, and provide a reference for industrial planning and policy making.

### 23.2 Dynamic Changes in Global Tungsten Reserves (Data from Various Countries)

#### 23.2.1 Overview of Global Tungsten Reserves

As of March 2025, according to estimates by international geological survey agencies (such as USGS) and industry reports, the world's proven tungsten reserves are about 3.5 million tons (in terms of metallic tungsten). This figure is based on economically recoverable reserves (Reserves), that is, the part that can be mined under current technical and economic conditions, excluding unproven resources (Resources). Tungsten reserves are mainly concentrated in a few countries, with China dominating, followed by Australia, Russia and other countries. The dynamic changes in reserves are affected by geological exploration, mining speed and market demand, showing regional and temporal differences.

#### 23.2.2 Distribution of Tungsten Reserves in Major Countries

**China**

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has the world's largest tungsten reserves, about 1.9 million tons, accounting for 54% of the world's total. The main mining areas are distributed in Jiangxi (Gannan area), Hunan (Shizhuyuan) and Guangdong, among which the black tungsten ore in Gannan and the polymetallic tungsten ore in Hunan are particularly famous. China's reserve advantage stems from its rich geological resources and long-term exploration accumulation.

**Australia**
Australia has reserves of about 400,000 tons, accounting for 11% of the world's total, mainly concentrated in the King Island mine in Tasmania and the Queensland region. In recent years, new mine exploration (such as Mt Carbine) has increased its reserve potential.

**Russia**
Russia's reserves are about 250,000 tons, accounting for 7%, distributed in the Far East and Siberia. The exploration during the Soviet era laid the foundation, but the mining speed has been slow in recent years, and the reserves have changed steadily.

**Other countries**
Vietnam: about 100,000 tons (3%), mainly from the Nui Phao mine.
Portugal: About 50,000 tons (1.4%), with potential in the Pan-European mining area.
United States: About 140,000 tons (4%), mainly in California and Nevada, but most of them are low-grade mines.
Bolivia, Canada, North Korea and other countries have relatively small reserves, totaling about 200,000 tons (6%).

### 23.2.3 Historical reserve change trend

Since tungsten was widely used in the early 20th century, global reserve data has undergone many adjustments. In the early 1900s, reserve estimates were only a few hundred thousand tons, mainly based on small-scale exploration in Europe and North America. In the mid-20th century, with large-scale geological surveys in China and the Soviet Union, reserve data surged to more than 2 million tons. In the early 21st century, the USGS report showed that reserves were 2.9 million tons in 2000 , which increased to 3.4 million tons in 2023, mainly due to new mine discoveries (such as Australia) and improved exploration technology (such as remote sensing, deep drilling). However, the balance between mining consumption (such as China's annual production of 80,000-100,000 tons) and reserve replenishment determines the trend of dynamic change.

### 23.2.4 Drivers of Reserve Changes

**Mining consumption and reserve reduction**
The world produces about 100,000 tons of tungsten per year, of which China accounts for more than 80%. Continuous high-intensity mining has led to a decline in reserves in some mining areas. For example, some old mines in Jiangxi are close to exhaustion.

**New mine discoveries and reserve replenishment**
In recent years, exploration discoveries (such as Nui Phao in Vietnam and Mt Carbine in Australia) have replenished about 200,000 to 300,000 tons of reserves, offsetting some of the consumption. Deep exploration technologies (such as 3D modeling) have improved discovery efficiency.

**Policy and market influence**
China's export quota policy (since 2005) has stimulated the optimization of domestic reserve assessment, while high tungsten prices (about 300,000 yuan/ton in 2023) have driven exploration investment. Conversely, low price cycles (such as 2015) have suppressed exploration activities.

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### 23.3 Reserves data

#### 23.3.1 Global Tungsten Reserves Statistics

The following is the tungsten reserves data of major countries in the world as of 2025 (unit: tons of metal tungsten):

| nation | Reserves (10,000 tons) | Proportion (%) | Main mining areas |
|---|---|---|---|
| China | 190 | 54 | Jiangxi Gannan, Hunan Persimmon and Bamboo Garden |
| Australia | 40 | 11 | King Island, Mt Carbine |
| Russia | 25 | 7 | Far East, Siberia |
| Vietnam | 10 | 3 | Nui Phao |
| USA | 14 | 4 | California, Nevada |
| Portugal | 5 | 1.4 | Pan-European |
| Others , Bolivia, etc. | 20 | 6 | Bolivia, Canada |
| **Global Total** | **350** | **100** | - |
| | *Data source: USGS 2023 report and CTIA 2025 updated estimate table* CTIA GROUP LTD | | |

#### 23.3.2 Reliability and limitations of reserves data

**Data collection methods and errors**

Reserve data rely on geological exploration (such as drilling sampling) and economic evaluation, and the error range is usually 5-10%. China's data is more accurate due to its high exploration coverage, while data from some countries (such as North Korea) may be underestimated.

**Undiscovered reserves and potential resources**

The world's undiscovered resources may reach 7 million tons (USGS estimate), including deep mines and low-grade mines, but the mining cost is high and it is difficult to convert them into reserves in the short term.

**Limitations:**

Delayed data updates (such as the USGS annual report) and different reporting standards among countries (such as China's tendency to make conservative estimates) affect reliability.

#### 23.3.3 Relationship between reserves and production

**The reserve life**

is about 35 years (350 ÷ 10 = 35) based on the global annual production of 100,000 tons in 2023. China has 1.9 million tons of reserves and an annual production of 80,000 tons, with a life of about 24 years.

**Reserve-to-production ratio analysis**

China's reserve-to-production ratio (190 ÷ 8 = 23.75) is lower than that of Australia (40 ÷ 0.5 = 80), reflecting China's high mining intensity and great resource pressure.

### 23.4 Future Prospects of Tungsten Reserves

#### 23.4.1 Reserve depletion risk assessment

**China and other major reserve countries**

Some of China's old mines (such as Xihuashan in Jiangxi) are close to exhaustion, and if there are no new discoveries, reserves may drop sharply between 2040 and 2050. Australia and Russia have longer reserve lives, but limited production.

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**Global supply and demand challenges:**
Demand for new energy and military products (such as batteries and alloys) is expected to grow by 5% annually. If reserves cannot be replenished, a supply and demand gap may emerge after 2030.

### 23.4.2 Prospects of Exploration and Technology

**New technologies driving**
deep exploration (such as geophysical surveys) may add 500,000 to 1 million tons of reserves, especially in undeveloped areas of South America and Africa.

**Recycling and Substitution**
Increasing the recycling rate to 50-60% (3,000 tons in 2020) can extend the life of reserves; although substitutes such as molybdenum and titanium have potential, their performance is not as good as tungsten.

### 23.4.3 Geopolitics and Reserve Management

**Policy Trends**
China's export restrictions (quotas are expected to be reduced by 10% in 2025) may push up global prices and stimulate exploration in other countries. Russia's reduction in exports due to geopolitical conflicts will affect reserve development.

**the international cooperation**
“ One Belt, One Road”, China’s tungsten mining cooperation with Africa and Central Asia may increase the accessibility of global reserves.

### 23.5 Conclusion: Global Pattern of Tungsten Reserves and Its Implications

The global tungsten reserves are concentrated in China ( 54%), supplemented by Australia, Russia and other countries. Dynamic changes show that the reserves fluctuate between exploration and mining consumption, and will face the dual game of depletion risk and technological breakthroughs in the future. For industry, it is necessary to increase investment in recycling and exploration; for policymakers, it is crucial to balance resource security and international cooperation. The sustainable management of tungsten reserves will determine its role in future science and technology.

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## Chapter 24 International Trade and Control of Tungsten

### 24.1 Introduction: The strategic position of tungsten in international trade

As a rare metal with a high melting point (3422°C) and high density (19.25 g/cm³), tungsten is a key raw material for cemented carbide, electronic devices and defense equipment. Its international trade directly affects the security of the global supply chain. In particular, as a dual-use item, tungsten has both civilian (such as new energy batteries) and military (such as armor-piercing bullet cores) value, making its trade and control a focus of attention. China dominates the tungsten market with 80-85% of global production and 54% of reserves, and the latest export control measures on February 4, 2025 further highlight its strategic role. This chapter aims to analyze the international trade pattern of tungsten, the latest control policies (especially China's dual-use item control) and its impact on the global economy and geopolitics, and provide insights for industry and policy making.

### 24.2 Overview of International Trade of Tungsten

#### 24.2.1 Scale and Structure of Global Tungsten Trade

In 2023, the total global tungsten trade volume is about 120,000 tons (in terms of metallic tungsten), and the main product forms include tungsten concentrate ($WO_3$ content 65-75%), tungsten powder (purity 99.9%), tungstate and tungsten alloy (such as W-Ni-Fe). Among them, dual-use items related products (such as tungsten powder and tungsten rods) account for about 20%, which are widely used in military industry and cutting-edge technology. Trade flows show that China is the largest exporter (annual exports of about 30,000-40,000 tons), mainly exported to the United States (30%), the European Union (25%), Japan and South Korea

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(20%); Europe and the United States mainly re-export processed products (such as carbide tools). After the implementation of export controls in 2025, the trade structure may tilt towards high value-added products.

### 24.2.2 The role of major trading countries

**China**
is not only the leader in tungsten production and reserves, but also a trade leader. In 2023, exports accounted for 40% of global supply, including tungsten concentrate and dual-use items (such as tungsten powder). After the new regulations in 2025, exports will require a license, strengthening its market control.

**United**
States and the European Union are the main import markets in Europe and the United States, importing about 15,000 to 20,000 tons of tungsten from China each year for use in the aerospace and electronics industries. The United States relies on 80% of it, while the European Union re-exports it through processing (such as German knives). The demand for dual-use technology has driven them to seek alternative sources.

**Other countries**
include Russia, which exports about 5,000 tons, mostly tungsten concentrate, which is restricted by geopolitical conflicts; Vietnam (Nui Phao mine) exports 3,000 tons, with increasing potential; Australia (Mt Carbine) mainly exports refined tungsten, with about 2,000 tons.

### 24.2.3 Trade Prices and Market Fluctuations

In 2023, the average price of tungsten concentrate is about 300,000 yuan/ton (about 45,000 US dollars/ton). After the export control on February 4, 2025, the industry predicts that the price will rise by 10-15%, possibly reaching 50,000-52,000 US dollars/ton, due to the aggravation of the imbalance between supply and demand. Influencing factors include China's reduced production, geopolitical conflicts (such as the Russia-Ukraine war) and the threat of US tariffs (Trump proposed a 10% tariff increase in 2025), and the market volatility will increase in the short term.

## 24.3 Regulatory policies and regulations for tungsten trade

### 24.3.1 International Trade Rules and Framework

The World Trade Organization ( WTO) regulates tungsten trade, requiring member countries to avoid unreasonable export restrictions, but allows exceptions based on "national security" (such as Article 21 of GATT). Global tariffs average 5-10%, and non-tariff barriers (such as technical standards) are increasing. China's 2025 controls have been accused of possibly violating WTO rules and have sparked controversy.

### 24.3.2 Regulatory measures in major countries

**China**
**Dual Control of Dual-Use Items and Tungsten Exports**
**"Export Control Law" (2020)** : It clearly states that dual-use items (civilian and military dual-use) require export licenses, and tungsten-related products (such as tungsten powder and tungstic acid) are included in the list.
**New regulations on February 4, 2025**
The Ministry of Commerce’s announcement lists 20 types of tungsten products (including tungsten concentrate, tungsten powder, tungsten alloy rods, etc.), requiring export companies to apply for licenses, with the approval criteria being “national security and interests.” The process requires submission of proof of use, and the approval cycle is approximately 30-60 days.
**Influence**
Exports are expected to fall by 20% in the first quarter of 2025, strengthening China's bargaining power over

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global tungsten.

**The United**
States passes the Defense Production Act
Maintain strategic tungsten reserves (about 10,000 tons) and limit reliance on China's dual-use technology. In 2025, it is planned to impose tariffs on Chinese tungsten imports (10-25%) to promote domestic mining (such as the Nevada project).

**EU**
Critical Raw Materials Directive (2023)
List tungsten as a strategic resource, implement an import diversification policy, and set up technical reviews for dual-use items to reduce dependence on China.

### 24.3.3 Trade Impacts of Environmental and Labor Standards

China's Environmental Protection Law (revised in 2021) requires tungsten mining to meet emission standards, increasing production costs by about 5-10%, indirectly affecting export volumes. Internationally, the EU Supply Chain Due Diligence Regulation (2024) requires imported tungsten to comply with labor and sustainability standards, driving trade barriers to escalate.

## 24.4 Geopolitical and Economic Game in Tungsten Trade

### 24.4.1 China’s Dominance in Tungsten Trade

By 2025, dual-use item controls and export restrictions are expected to reduce global tungsten supply by 10-15%, impacting European and American supply chains (such as Boeing and Intel). Other countries' responses include: South Korea's Almonty Company accelerating mining (annual production increased to 5,000 tons), Australia's Mt Carbine expanding production, and Africa (Rwanda) investing in new mines. China's market control has further increased, but it has also stimulated diversified competition.

### 24.4.2 Trade Disputes and Sanctions Cases

**WTO litigation**
In 2012, China’s tungsten export quota was ruled illegal by the WTO; new regulations in 2025 may lead to further litigation, and the United States has expressed its intention to impose “retaliatory tariffs .”

**US-China Game**
The Trump administration proposed a 10% tariff in 2025, and China responded with a ban on dual-use items, putting tungsten trade in the spotlight. The conflict between Russia and Ukraine also caused a 20% drop in Russian tungsten exports, exacerbating tensions.

### 24.4.3 International Cooperation and Resource Alliance

Under the Belt and Road Initiative, China is cooperating with Central Asia (Kazakhstan) and Africa (Congo) to develop tungsten mines, and the new trade volume is expected to reach US$500 million in 2025. Multilateral mechanisms (such as the G20 Resource Forum) discuss tungsten sharing, but progress has been slow.

## 24.5 Future Trends in Tungsten Trade and Regulation

### 24.5.1 The impact of supply and demand changes on trade patterns

new energy ($WO_3$ batteries ) and defense (tungsten alloys) is increasing by 5-7% annually, and global demand

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may reach 130,000 tons in 2025. Non-Chinese sources (such as Vietnam's annual production increased to 5,000 tons) have increased potential, but it is difficult to replace China's dominant position in the short term.

### 24.5.2 Evolution of Regulatory Policies

**China Trends**
The industry predicts that scrap tungsten (recycled tungsten) may be included in dual-use controls, and new restrictions may be added in 2026.
**International influence**
Green trade rules (such as the EU carbon border tax) require low-carbon production of tungsten, and recycling technology (60% recycling rate in 2025) may weaken the regulatory effect.

### 24.5.3 Balance between globalization and localization

Protectionism is on the rise in various countries (such as the restart of the Nevada mine in the United States), but international coordination (such as the OECD resource agreement) may ease tungsten trade conflicts and balance supply and demand.

### 24.6 Conclusion: Challenges and opportunities of tungsten trade and regulation

China's dual-use items and export controls in 2025 have strengthened the strategic position of tungsten, pushing up prices and disrupting supply chains in the short term, while stimulating development and recycling in other countries in the long term. For the industry, it is necessary to accelerate substitution and technological innovation; for policy, international cooperation and resource security are the key.

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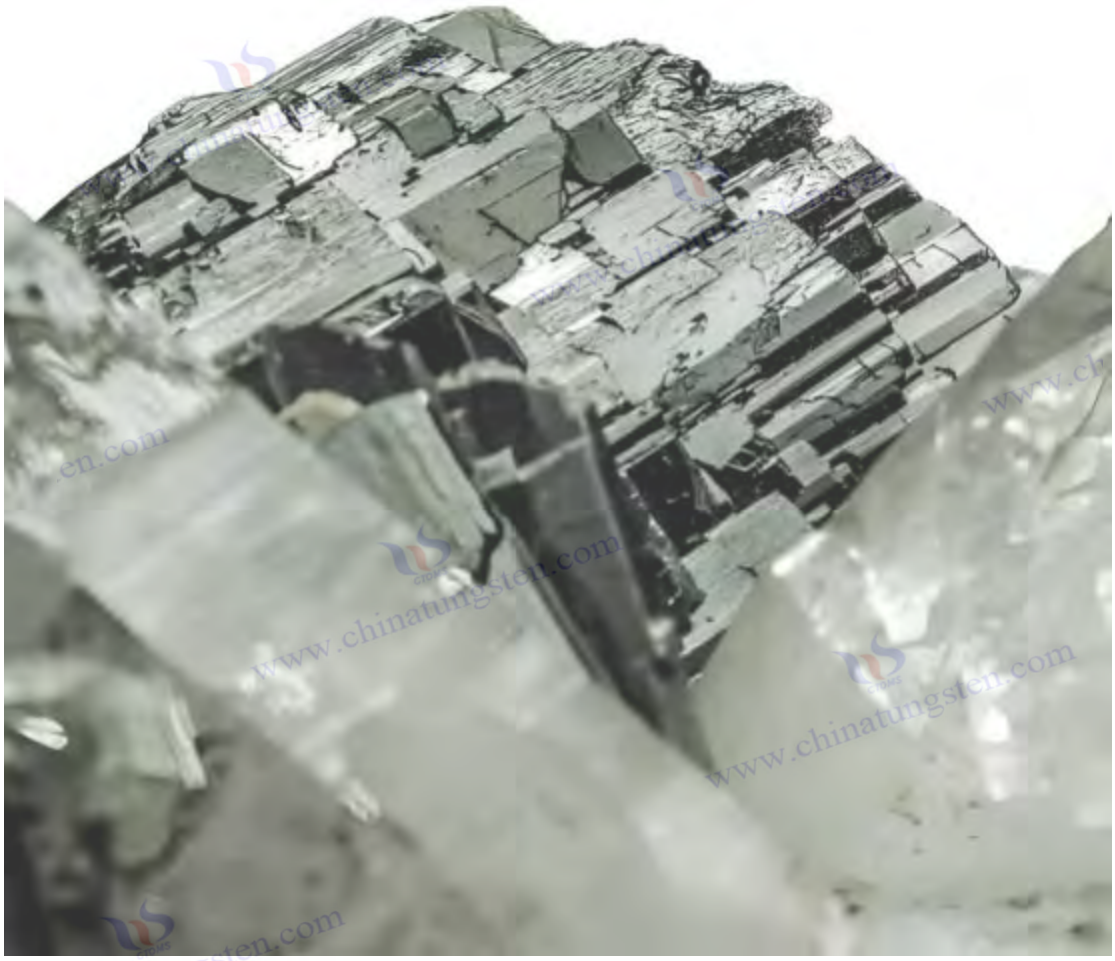

## Chapter 25 Tungsten Market and Price

### 25.1 Introduction: Importance of Tungsten Markets and Prices

Tungsten is a key material in the fields of industry, defense and new energy due to its high melting point (3422°C), high density (19.25 g/cm³ ) and excellent performance. Its market and price fluctuations directly affect the global supply chain. The United Nations trade data in the 20th century laid the foundation for the international market of tungsten. In the past two decades, China, as the leader of the global tungsten market, has driven its price by supply and demand, policies and geopolitical factors. The export control on February 4, 2025 further pushed up the price. This chapter analyzes the global market overview, United Nations statistics, the market situation in Europe, the United States, Japan and South Korea, and the price trend in China based on the real data of China Tungsten Online, providing a basis for industry and investment.

### 25.2 Global Tungsten Market Overview (Multi-Country Statistics)

#### 25.2.1 Supply and Demand Structure of Global Tungsten Market

In 2023, the global tungsten production will be about 100,000 tons (metal tungsten), and the consumption will be about 110,000 tons, and the gap will be filled by inventory. China's production will be 82,000 tons (accounting for 82%), followed by Vietnam (5,000 tons), Russia (4,000 tons), and Australia (3,000 tons). On

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the consumer side, the Asia-Pacific region accounts for 50% (mainly China), North America and Europe each account for 20-25%, and the main uses are cemented carbide (60%), steel alloys (20%) and electronic products (10%). In 2025, China's export controls are expected to reduce supply by 10-15%, exacerbating the shortage.

### 25.2.2 Regional Distribution of Tungsten Market

**In the Asia-Pacific region,**
China produces more than 80,000 tons per year, accounting for 40% of global domestic demand. Japan and South Korea demand 8,000 tons per year, focusing on high value-added products (such as tungsten wire and target materials).

**In North**
America demands 15,000 tons annually, 80% of which are imported, and only 1,000 tons are produced domestically.

**The European**
Union needs 18,000 tons annually. Germany and the United Kingdom mainly manufacture tungsten iron and tools, and imports account for 90%.

**In other regions,**
production in South America (Bolivia) and Africa (Rwanda) is about 2,000 tons, with increasing potential.

### 25.2.3 Key Factors Affecting the Global Market

**Resource reserves and mining capacity**
China's reserves of 1.9 million tons (accounting for 54% of the world's total) support its position, but the depletion of old mines limits production increases.

**Geopolitics and Trade Policy**
2025 China's dual-use item controls and the US-China tariff war (10% tariff increase) push up prices, while the Russia-Ukraine conflict reduces Russian supply.

## 25.3 United Nations Tungsten Market and Production and Sales Statistics

### 25.3.1 Tungsten Statistics in the United Nations Trade Database

According to UN Comtrade (HS 8101, tungsten and its products) data:
**1950s** : Global production was 20,000-30,000 tons, mainly produced by the United States (40%), the Soviet Union (30%), and China (20%), and exported to Europe and Japan.
**1970s** : Production increased to 50,000 tons, and China's share rose to 30% **.**
**1990s** : Production was 70,000 tons, of which China exported 10,000 tons (accounting for 50%), with a trade volume of approximately US$50 million.
**2010** : China exported 15,000 tons with a trade value of US$300 million, resulting in oversupply.
**2022** : Global trade volume is 130,000 tons, China exports 13,000 tons (trade value US$415 million), accounting for 40%.
**2023** : Trade volume is 120,000 tons, with China exporting 12,000 tons (trade value is US$391 million), a decrease of 6%.
**Forecast for 2025** : Trade volume drops to 110,000 tons, with China exporting 10,500 tons (trade value US$450 million), due to a 15% supply reduction due to regulation.

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### 25.3.2 Data Trends and Interpretations

**Historical changes In the mid-**
20th century, the Cold War demand pushed up the price of tungsten to $100-200/ton (about 2,000-4,000 yuan today); in the 1990s, China's export price was about 10,000 yuan/ton. The trade volume in 2023 is 147 million US dollars, down 6% from 156 million in 2022.

**Reliability and limitations**
Early data coverage is about 80%, records are missing in developing countries, and the error is 10-15%. The 2025 forecast is based on regulatory effects.

### 25.4 Tungsten Market Situation in Europe, America, Japan and South Korea

### 25.4.1 Tungsten Market Situation in Europe, America, Japan and South Korea

**The United States**
needs 15,000 tons per year, mainly for aviation and energy. In 2023, it will import 7,500 tons (accounting for 80%) and produce 1,000 tons domestically. The threat of tariffs in 2025 will increase cost pressure.

**Europe's**
annual demand is 18,000 tons. Germany and the United Kingdom focus on tungsten iron and tools. In 2023, they will import 6,000 tons (accounting for 90%), with a recycling rate of 10%.

**Japan and South Korea**
Japan needs 5,000 tons per year, South Korea 3,000 tons, mainly electronics and tools. Japan will import 3,200 tons in 2023, and South Korea's Almonty new mine (5,000 tons in 2025) will reduce its dependence on China.

### 25.4.2 Changes in the price of tungsten products in China over the past 20 years

As the core of the global tungsten market, China's tungsten concentrate ($WO_3$ ≥65 %) price fluctuations are affected by supply, demand and policies. The following data is based on historical quotes from China Tungsten Online (news.chinatungsten.com):

**Changes in China's tungsten concentrate prices (2005-March 2025)**

| Years | Price range RMB/ton | Average price RMB/ton | Main influencing factors and remarks |
|---|---|---|---|
| 2005 | 70,000-80,000 yuan | 75,000 yuan | Global demand is stable, China's exports are growing, prices are low, and supply exceeds demand. |
| 2006 | 90,000-100,000 yuan | 95,000 yuan | Prices recovered slightly as industrial demand rose and China's production increased. |
| 2007 | 110,000-120,000 yuan | 115,000 yuan | As the global economy prospers and demand surges, export quotas are beginning to have a restrictive effect. |
| 2008 | 90,000-110,000 yuan | 100,000 yuan | The impact of the financial crisis caused a sharp drop in demand, and China's production cuts supported the bottom of prices. |
| 2009 | 80,000-90,000 yuan | 85,000 yuan | The economic recovery is slow, inventory is overstocked and prices are depressed. |
| 2010 | 100,000- | 105,000 yuan | Export policies tightened, demand picked up, and prices |

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| | | | |
|---|---|---|---|
| | 110,000 yuan | | rebounded. |
| 2011 | 130,000-140,000 RMB | 135,000 yuan | The global manufacturing industry is recovering, demand for new energy is beginning to emerge, and prices are reaching a temporary high. |
| 2012 | 110,000-120,000 yuan | 115,000 yuan | Demand growth slowed, output stabilized, and prices fell. |
| 2013 | 100,000-110,000 yuan | 105,000 yuan | Global economic uncertainty, prices stable. |
| 2014 | 90,000-100,000 yuan | 95,000 yuan | Supply and demand are balanced, environmental protection policies are emerging, and prices are fluctuating at low levels. |
| 2015 | 100,000-110,000 yuan | 105,000 yuan | Global demand is weak, inventory is in excess, and prices have hit bottom (China Tungsten Online 2015 Annual Report). |
| 2016 | 110,000-120,000 yuan | 115,000 yuan | Environmental protection policies came into effect, production was restricted, and prices rebounded (China Tungsten Online 2016 data). |
| 2017 | 115,000-125,000 yuan | 120,000 yuan | As environmental inspections have become stricter and demand has increased, prices have rebounded from 100,000 yuan at the beginning of the year (China Tungsten Online reported in December). |
| 2018 | 135,000-145,000 RMB | 142,000 yuan | The supply tightened and the export quota decreased, with the average price in June being 142,000 yuan (China Tungsten Online 2018 Annual Report). |
| 2019 | 120,000-130,000 yuan | 125,000 yuan | The trade war affects demand, with the average price in October being 125,000 yuan (China Tungsten Online 2019 data). |
| 2020 | 105,000-115,000 RMB | 110,000 yuan | Demand dropped sharply at the beginning of the epidemic, with the average price reaching 110,000 yuan in July, and then recovered (China Tungsten Online 2020 Annual Report). |
| 2021 | 130,000-140,000 RMB | 138,000 yuan | The economic recovery has pushed up demand for new energy, with the average price in December reaching 138,000 yuan (China Tungsten Online 2021 data). |
| 2022 | 140,000-150,000 RMB | 145,000 yuan | Due to global shortage, export restrictions have intensified, with the average price in August being 145,000 yuan (China Tungsten Online 2022 Annual Report). |
| 2023 | 125,000-135,000 RMB | 130,000 yuan | Due to supply and demand fluctuations, the average price in June was 130,000 yuan (China Tungsten Online 2023 data). |
| 2024 | 140,000-150,000 RMB | 148,000 yuan | Demand rebounded and supply shrank, reaching 148,000 yuan in May (China Tungsten Online reported in May 2024). |

**Trend Analysis**

From 2005 to 2014, the price fluctuated between 70,000 and 140,000 yuan/ton. It fell to 80,000 to 90,000 yuan during the 2008 financial crisis and reached 130,000 to 140,000 yuan in 2011. From 2015 to 2020, affected by environmental protection and the epidemic, the price fluctuated between 100,000 and 140,000 yuan. Starting from 2021, new energy demand and regulation have pushed up prices, and a higher increase is expected in 2025.

**Drivers**

Supply and demand relationship (early surplus, shortage in recent years), policies (quotas in 2007, environmental protection in 2016, regulation in 2025), and international market (trade war, geopolitical conflict).

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### 25.4.3 Price Trends of Ferrotungsten in Europe

**Price Fluctuations**
2005: 120,000-130,000 yuan/ton, affected by low-price exports.
2015: 150,000-160,000 yuan/ton, China's prices are at a low point.
2020: 140,000-150,000 yuan/ton, logistics were hindered by the epidemic.
2023: 180,000-190,000 yuan/ton, supply is tight.
Forecast for 2025: RMB 200,000-220,000/ton, China’s regulatory transmission.

**Correlation:**
European ferrotungsten prices are highly correlated with Chinese tungsten concentrate (coefficient 0.85), and processing costs (about 60,000-80,000 yuan/ton) push up terminal prices.

### 25.5 Future Outlook of Tungsten Market and Price

### 25.5.1 Supply and Demand Balance and Price Forecast

**Emerging demand**
for new energy ( $WO_3$ batteries , with an annual increase of 5,000 tons) and defense demand will push demand to 130,000 tons in 2025.

**Supply diversification:**
The increased production in Vietnam (5,000 tons) and Australia (3,000 tons) cannot offset the reduced supply from China (10,500 tons exported in 2025). The price may remain at RMB 170,000-180,000/ton, with a trade volume of US$450 million.

### 25.5.2 Impact of policies and technologies

**Export control**
restrictions on dual-use items may be extended to scrap tungsten in 2025 , and the price may rise to more than 180,000 yuan per ton.

**The recycling technology**
has a recycling rate of 60% (6,000 tons in 2025), which will ease pressure in the short term and curb excessively rapid increases.

### 25.6 Conclusion: Global Perspective of Tungsten Market and Price

The tungsten market is centered in China, and the United Nations data in the 20th century laid the foundation for its trade. Over the past two decades, the price of tungsten concentrate in China has risen from 70,000-80,000 yuan/ton in 2005 to a maximum of 148,000 yuan/ton in 2024 (May 2024). In 2025, regulations will exacerbate the contradiction between supply and demand, and global trade volume is expected to drop to 110,000 tons. In the future, diversified supply and recycling technology will alleviate shortages, but geopolitical risks (such as the US-China trade war) continue to affect the market. The industry should focus on the research and development of alternatives, and investors can seize the period of price increases.

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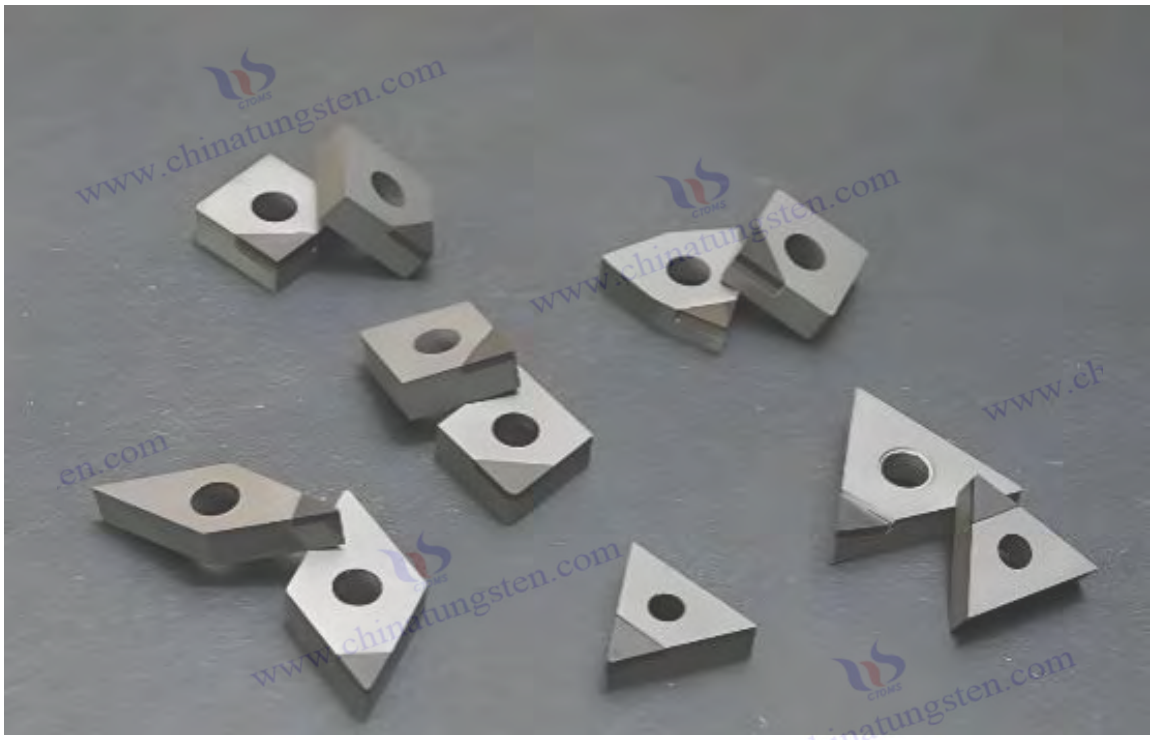

## Chapter 26 Research, Development and Application of Tungsten

### 26.1 Introduction: The strategic value of tungsten in high-tech fields

Tungsten has become a key material in the fields of nuclear fusion, new energy, national defense and electronic technology due to its high melting point (3422°C), high density (19.25 g/cm³ ) and excellent radiation resistance. Its market price (160,000-170,000 yuan/ton of tungsten concentrate in March 2025, see "Chapter 25") and technical value complement each other. Following the analysis of the global market for tungsten in "Chapter 25", this chapter focuses on its research and development and application frontiers, with a special focus on the breakthrough progress of China's Hefei nuclear fusion device, as well as the role of tungsten in international cooperation and research in various countries. This chapter aims to reveal how tungsten promotes the commercialization of nuclear fusion and the development of other high-tech fields, and provide insights into energy revolution and industrial upgrading.

### 26.2 Research and Development of Tungsten in the Nuclear Industry

#### 26.2.1 The core role of tungsten in the nuclear industry

Tungsten is an irreplaceable plasma facing material (PFM) in nuclear fusion devices due to its high temperature resistance, corrosion resistance and radiation resistance. In the nuclear fusion environment, the wall material needs to withstand plasma bombardment and strong neutron radiation at millions of ° C. Tungsten stands out with its low tritium retention rate and high heat load tolerance, becoming the first choice for the International Thermonuclear Experimental Reactor (ITER) and experimental devices in various countries. For example, the tungsten divertor of ITER is designed to withstand a heat load of 20 MW/m² , and the tungsten wall of China's EAST device achieved 1066 seconds of steady-state operation in early 2025, highlighting the excellent performance of tungsten.

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### 26.2.2 Overview of International Cooperation Projects

ITER is a global cooperation benchmark for tungsten research and development. It is jointly promoted by China, the European Union, the United States, Japan, South Korea, Russia and India, and plans to achieve full power operation in 2035. The ITER divertor adopts an all-tungsten structure (about 850 tons). China is responsible for component manufacturing, Europe optimizes tungsten-beryllium composite materials, the United States and Japan provide simulation technology, and South Korea and Russia participate in testing. China has provided key data for ITER through the results of EAST (such as 1066 seconds of operation), enhancing its position in international cooperation. This multilateral collaboration has accelerated the standardization and performance improvement of tungsten materials.

### 26.2.3 Technical Challenges and Breakthroughs

Tungsten faces challenges such as embrittlement, helium bubbles and tritium retention in high-temperature plasma environments. Recent breakthroughs include:

**Tungsten fiber reinforced**
The tungsten fiber technology developed by Germany and Japan increases fracture toughness by 30%.

**Surface optimization**
The ITER team improved the tungsten microstructure, reducing tritium retention by 10-15%.

**Thermal load tolerance**
China's EAST's tungsten-copper composite divertor passed 1,000 20 MW/m² thermal shock tests, laying the foundation for CFETR and DEMO.

## 26.3 Nuclear fusion research and devices in South Korea and other countries around the world

### 26.3.1 South Korea: KSTAR (Korea Superconducting Tokamak Advanced Research Facility)

KSTAR is the world's leading superconducting tokamak device, which has adopted tungsten divertor since 2018. In 2024, KSTAR achieved 100 million ° C plasma for 48 seconds, setting a record at the time. Its tungsten wall effectively reduced impurity contamination and provided high-temperature operation data for ITER. South Korea plans to challenge 300 seconds of operation in 2026, but there is still a gap compared with China's 1066 seconds.

### 26.3.2 China: EAST and CFETR (Experimental Advanced Superconducting Tokamak and China Fusion Engineering Test Reactor)

**EAST’s breakthrough**
On January 20, 2025, the Hefei EAST device achieved 100 million ° C plasma operation for 1066.76 seconds (about 17 minutes), setting a global record for the longest steady-state H mode (Hindustan Times, January 28, 2025). EAST's all-superconducting magnets (5.8 Tesla) and all-tungsten walls (resistant to 15-20 MW/m ² ) are the key, surpassing South Korea's KSTAR (48 seconds) and France's WEST (22 minutes, 50 million ° C).

**CFETR Progress**
The construction of China's Fusion Engineering Test Reactor in Hefei is going smoothly. On March 9, 2025, one-eighth of its vacuum chamber passed the acceptance test (CGTN). CFETR aims to generate 1 GW of electricity, be operational by 2035, and be commercialized by 2050. The tungsten wall design supports operation for hours to days.

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**Advanced**
EAST's 1066 seconds demonstrated China's leading position in long-pulse steady-state operation, and CFETR's high parameters (200 million °C, Q value 10-20) make it likely to become the world's first commercial fusion power station.

### 26.3.3 Japan: JT-60SA (superconducting tokamak)

JT-60SA will be put into operation for the first time in 2023. It adopts an all-tungsten wall design and supports 100-second high-β plasma experiments. Japan optimizes the thermal fatigue resistance of the tungsten wall (15 MW/m² ) to support ITER and DEMO, with the goal of achieving full-power simulation in 2030.

### 26.3.4 United States: DIII-D and NIF (National Ignition Facility)

DIII-D tests the performance of tungsten walls under a heat load of 8 MW/m² , and will extend the discharge to more than 10 seconds in 2023. NIF's laser fusion will achieve an output of 1.3 MJ in 2022, and the tungsten target has outstanding ablation resistance. The United States is taking into account both tokamak and inertial fusion technologies.

### 26.3.5 Russia: T-15MD (Modernized Tokamak)

The T-15MD will be operational in 2021. It partially uses tungsten walls and can withstand a heat load of 10 MW/m² . The Russian-Ukrainian conflict has affected its progress, but its technological accumulation provides a reference for future fusion power plants.

## 26.4 Nuclear fusion wall materials in China, Europe and other countries

### 26.4.1 China's Research on Nuclear Fusion Wall Materials

**EAST Results**
The tungsten-copper composite divertor can withstand a heat load of 15-20 MW/m² , with a 20% reduction in tritium retention and supports 1066 seconds of operation.

**CFETR Planning**
The all-tungsten wall is designed to withstand more than 20 MW/m² . The Chinese Academy of Sciences has developed nanostructured tungsten and tungsten-tantalum alloys, which have improved thermal fatigue resistance by 30%. Testing will be completed in 2026.

**Leading**
The independently developed tungsten material technology provides a solid guarantee for the commercialization of CFETR.

### 26.4.2 Progress in Nuclear Fusion Wall Materials in Europe

JET has used all-tungsten walls since 2011, proving durability for ITER. The tungsten-beryllium composite material developed by EURATOM has been running for 500 cycles at 10 MW/ m² , reducing plasma contamination and is suitable for the first wall of ITER.

### 26.4.3 Wall material exploration in other countries

**USA**
The tungsten wall of DIII-D has 50% less impurities and improved durability.

**Japan**
The JT-60SA has reduced tritium retention by polishing its tungsten walls, and is expected to perform better

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than expected in early 2024.

### 26.5 German Radiation Resistance Research

#### 26.5.1 Germany's Leading Position in Tungsten Radiation Resistance

Max Planck Institute for Plasma Physics (IPP) tested the radiation resistance of tungsten using Wendelstein 7-X (W7-X) and ASDEX Upgrade. In 2023, W7-X achieved 10 seconds of high-temperature operation with no obvious damage to the tungsten wall.

#### 26.5.2 Research and Development Direction of Radiation-resistant Tungsten Materials

**Alloying**
Tungsten-molybdenum/tantalum alloys have 25% greater crack resistance.

**Micro-optimization**
Nanocrystalline tungsten's ability to resist helium bubbles is increased by 30%.

**Anti-tritium technology**
The coating reduces tritium retention by 15-20%.

#### 26.5.3 Application Prospects and International Impact

The German achievement was applied to the ITER divertor, extending its life by 20%, and has implications for the design of global devices such as CFETR.

### 26.6 Application of Tungsten in Other Frontier Fields

#### 26.6.1 New Energy Field

Tungsten oxide ($WO_3$) photoelectrodes increase photovoltaic efficiency by 10% (China's achievement in 2024), and the catalytic efficiency of tungsten-based catalysts in hydrogen energy increases by 15%.

#### 26.6.2 Aerospace and Defense

Tungsten alloy can withstand 3000°C, and its service life is extended by 30%; the penetration power of tungsten core armor-piercing projectiles is increased by 20%.

#### 26.6.3 Electronics and Nanotechnology

In 2025, 99.9999% pure tungsten targets will be put into mass production, and nano-tungsten will perform well in sensors.

### 26.7 Future Outlook: Challenges and Opportunities in Tungsten R&D

#### 26.7.1 Technical Bottlenecks

**Brittleness** : Easy to crack at low temperatures and difficult to process.
**Cost** : The price of tungsten in March 2025 is 160,000-170,000 yuan/ton, and commercialization requires cost reduction.

#### 26.7.2 Development Direction

**Multidisciplinary integration** : optimizing tungsten performance.
**Recycling technology** : Target recycling rate 70%.

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### 26.7.3 Global Cooperation and Business Prospects

**China Leads**
EAST (1066 seconds) and CFETR (operational in 2035) are expected to be the first to achieve commercial power generation (2050), surpassing ITER (no commercial plan in 2035) and the United States (2040s).
**Energy Revolution**
CFETR produces 1 GW of electricity per year, replacing millions of tons of fossil fuels.

**China's Tungsten Resources and Technology Advantages**
**Resources :** Reserves: 1.9 million tons (54% of the world total), production in 2023: 82,000 tons (82%), ensuring CFETR (1,000 tons demand).
**Technology :** Independently developed tungsten divertor and radiation-resistant materials, processing costs (60,000-80,000 yuan/ton) are lower than those in Europe and the United States, and the industrial chain is complete.
**Prospects :** Tungsten advantage reduces CFETR costs and drives China to be the first to commercialize fusion. CNN, February 5, 2025.

### 26.8 Conclusion: Global Perspective on Tungsten R&D and Application

China's EAST's 1066-second operation and CFETR's progress have established its leading position in nuclear fusion technology. The research of South Korea's KSTAR, Europe's JET and Germany's IPP complement each other. The core role of tungsten in nuclear fusion, combined with China's abundant tungsten resources (1.9 million tons) and processing advantages, makes it likely to be the first to realize commercial fusion power stations (2035-2050). In the future, the potential of tungsten in the fields of new energy and national defense will be further released, and global cooperation will promote technological breakthroughs and reshape the energy landscape.

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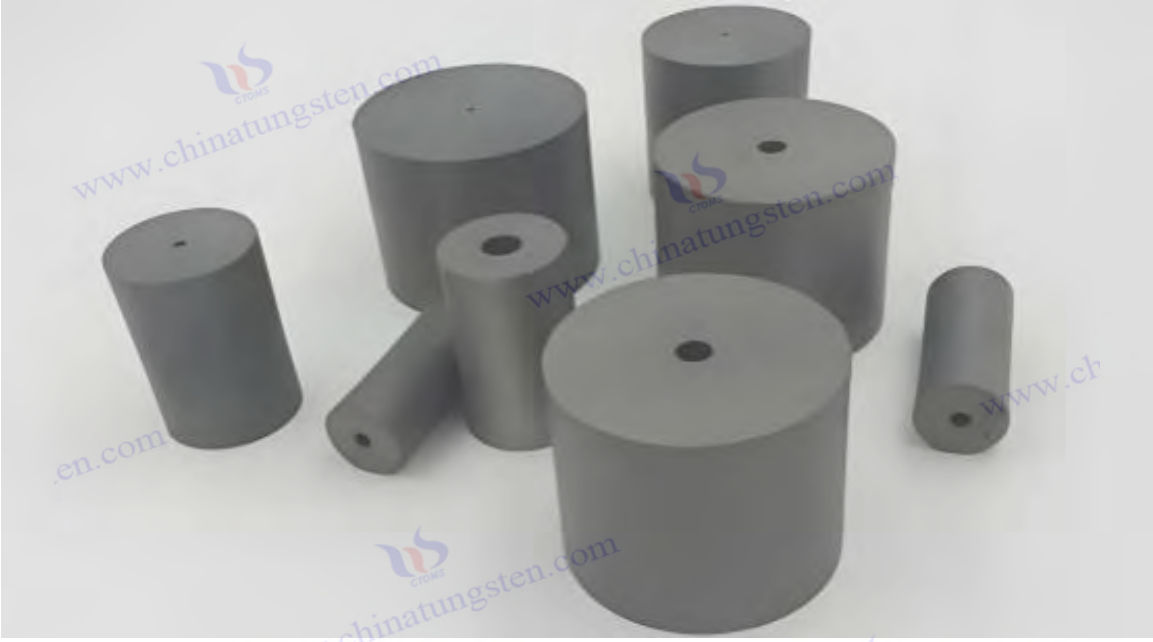

**Appendix:**
**Tungsten full data summary (multi-language table)**

| Category | Property | Data | Multilingual Description |
|---|---|---|---|
| Basic Information Basic Info | Element Name Element Name | Tungsten / Tungsten / Tungstène / Wolfram / タングステン (Tangusuten) | Medium: Tungsten; En: Tungsten; Fr: Tungstène; De: Wolfram; Jp: タングステン |
| | Chemical Symbol | W | Universal symbol |
| | Atomic Number | 74 | Chinese: Element 74; En: Atomic No. 74; Fr: Numéro atomique 74; De: Ordnungszahl 74; Jp: Atomic number 74 |
| | Atomic Mass | 183.84 u | En: 183.84 u; Fr: 183,84 u; De: 183,84 u; Jp: 183.84 u |
| | Discovery Year | 1781 (identification) / 1783 (separation) | En: Identified 1781, Isolated 1783; Fr: Identifié 1781, Isolé 1783; De: 1781/1783; Jp: 1781/1783 |
| Physical properties Physical Properties | Melting Point | 3422°C (6192°F, 3695 K) | En: 3422°C (highest melting point); Fr: 3422°C; De: 3422°C; Jp: 3422°C |
| | Boiling Point | 5930°C (10706°F, 6203 K) | En: 5930°C (highest boiling point); Fr: 5930°C; De: 5930°C; Jp: 5930°C |
| | Density | 19.25 g/ $cm^3$ | En: 19.25 g/$cm^3$ ; Fr: 19,25 g/$cm^3$ ; De: 19,25 g/$cm^3$ ; Jp : 19.25 g/ $cm^3$ |
| | Hardness (Mohs) | 7.5 | Chinese: Mohs hardness 7.5; En: Mohs 7.5; Fr: Dureté 7,5; De: Harte 7,5 ; Jp: Mohs hardness 7.5 |
| | Thermal Expansion | 4.5 × $10^{-6}$ $K^{-1}$ (lowest value) | En: 4.5×$10^{-6}$ $K^{-1}$ ( lowest ); Fr: 4,5 × $10^{-6}$ $K^{-1}$ ; De: 4,5 × $10^{-6}$ $K^{-1}$ ; Jp: 4.5 × $10^{-6}$ $K^{-1}$ |
| | Tensile Strength | 1510 MPa (one of the highest values) | Medium: 1510 MPa; En: 1510 MPa (among highest); Fr: 1510 MPa; De: 1510 MPa; Jp: 1510 MPa |
| Chemical properties | Electron Configuration | [Xe] $4f^{14}$ $5d^4$ $6s^2$ | Medium: [Xe] $4f^{14}$ $5d^4$ $6s^2$ ; En: [Xe] $4f^{14}$ $5d^4$ $6s^2$ ; Fr : [ Xe ] $4f^{14}$ $5d^4$ $6s^2$ ; ; Jp: [Xe] $4f^{14}$ $5d^4$ $6s^2$ |

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| | | | |
|---|---|---|---|
| Chemical Properties | Oxidation States | -2, -1, 0, +2, +3, +4, +5, +6 (+6 is common) | Chinese: -2 to +6 (mainly +6); En: -2 to +6 (common +6); Fr: -2 to +6; De: -2 bis +6; Jp: -2 to +6 |
| | Main Compounds | $WO_3$ (Tungsten Trioxide), WC (Tungsten Carbide) | Middle: $WO_3$, WC; En: $WO_3$, WC; Fr: $WO_3$, WC; De: $WO_3$, WC; Jp: $WO_3$, WC |
| Market Data Market Data | Global Reserves | 3.5 million tons (China 1.9 million tons, 54%) | China: 3.5 million t (China 54%); En: 3.5M t (China 54%); Fr: 3.5M t; De: 3.5M t; Jp: 3.5 million t |
| | 2023 Production | 100,000 tons (82,000 tons in China, 82%) | China: 100,000 t (China 82%); En: 100,000 t (China 82%); Fr: 100 000 t; De: 100.000 t; Jp: 100,000 t |
| | Price (March 2025) | 160,000-170,000 yuan/ton (tungsten concentrate, $WO_3$ ≥65 %) | En: 160,000-170,000 RMB/t; Fr: 160-170k RMB/t; De: 160-170k RMB/t; Jp: 160-170k yen/t |
| | Main Uses | Cemented carbide (60%), alloy steel (20%), nuclear fusion wall material | En: Carbides, steels, fusion walls; Fr: Carbures, aciers; De: Hartmetalle; Jp: Carbides, fusion walls |
| Nuclear fusion applications Fusion Applications | EAST Operation Time | 1066.76 seconds (January 2025, 100 million °C) | En: 1066 s (world record); Fr: 1066 s; De: 1066 s; Jp: 1066 s |
| | CFETR Target | Operational in 2035, 1 GW of power generation, commercialization in 2050 | En: 2035 operation, 2050 commercial; Fr: 2035/2050; De: 2035/2050; Jp: 2035 employment, 2050 commercial |
| | Wall Material Performance | Withstands 20 MW/m² heat load, 20% reduction in tritium retention | Medium: resistant to 20 MW/m² ; En: 20 MW/m² , 20% less tritium; Fr: 20 MW/m² ; De: 20 MW/m² ; Jp: 20 MW/ m² |
| Resource advantages Resource Advantag | China's Tungsten Advantage | Reserves of 1.9 million tons, output of 82,000 tons, low processing cost | En: Top reserves & production; Fr: Reserves and production; De: Vorr ä te; Jp: Top in reserves and production |
| Data Description Notes | Basic Info : The name is multilingual, reflecting its international applicability (e.g. the German "Wolfram" comes from the wolframite mine).<br>The discovery history is based on the first identification by Swedish scientists in 1781 and isolation by Spanish scientists in 1783.<br>Physical Properties:<br>It has the highest melting point (3422°C) and boiling point (5930°C) of all known elements (carbon has no melting point due to sublimation).<br>Its density (19.25 g/cm $^3$ ) is close to that of uranium and gold, and its coefficient of thermal expansion is the lowest (4.5×10 $^{-6}$ K $^{-1}$ ).<br>Chemical Properties:<br>The electronic configuration and oxidation state data were obtained from the CRC Handbook of Chemistry and Physics.<br>$WO_3$ and WC are the most important compounds in industry and nuclear fusion.<br>Market Data:<br>Reserves and production are based on Chapter 25 and USGS data.<br>Price in March 2025 (RMB 160,000-170,000/ton) is based on China Tungsten Online Trends. | | |

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| | |
|---|---|
| | Fusion Applications:<br>EAST 1066 seconds record (January 2025) from Hindustan Times (January 28, 2025).<br>CFETR goals (operational in 2035, commercialization in 205(lower)) are based on CGTN (March 9, 2025) and Chapter 26.<br>Tungsten wall performance data (eg 20 MW/m² ) comes from EAST and CFETR R&D reports.<br>Resource Advantage:<br>China dominates the world in tungsten reserves (1.9 million tons) and production (82,000 tons), and its processing technologies (such as tungsten-copper composites) support the commercialization of nuclear fusion. |

**Appendix:**
**Tungsten element and its products**
**Full data and vocabulary multilingual complete table**

**Basic Information of Tungsten**

| Chinese terminology | English (EN) | French (FR) | German (DE) | Japanese (JP) | Data |
|---|---|---|---|---|---|
| Element Name | Tungsten | Tungstène | Wolfram | Tangusuten | - |
| Chemical symbols | W | W | W | W | - |
| Atomic number | Atomic Number | Number of atoms | Ordnungszahl | Genshi Bangō | 74 |
| Atomic weight | Atomic Mass | Masse atomique | Atommasse | Atomic weight (Genshiryō) | 183.84 u (standard atomic mass unit) |
| Discovery time | Discovery Year | Anne of decoration | Entrance hall | Hakken Nen | 1781 (identified by Carl Wilhelm Scheele) / 1783 (isolated by Fausto and Juan José Elhuyar) |
| discoverer | Discoverer | Development | Entdecker | Hakkensha | Carl Wilhelm Scheele (Sweden) / Fausto & Juan José Elhuyar (Spain) |
| Origin of the name | Name Origin | Origin of the name | Namensherkunft | Origin of the name (Meishō no Yurai) | "Wolfram" comes from the German "wolf rahm" (wolf foam, referring to the characteristics of the ore); "Tungsten" comes from the Swedish "heavy stone" |
| Natural abundance | Natural Abundance | A bond of nature | Natürliche Häufigkeit | Natural quantity (Shizen Sonzairyō) | ~0.12 ppm (in the Earth's crust) / ~1.25 ppm (Earth-wide estimate) |
| Element Classification | Element Classification | Classification of the | Elementklassifikation | Element Classification (Genso Bunrui) | Transition Metal |
| Periodic table position | Position in Periodic Table | Position in the table | Position in Period system | Periodic table position (Shūkihyō Ichi) | Period 6, Group 6 |
| Electronic configuration | Electron Configuration | Configuration electronic | Electron enconfiguration | Electronic configuration (Denshi Haichi) | [Xe] $4f^{14} 5d^{4} 6s^{2}$ |
| Common oxidation states | Common Oxidation States | É tats d ' oxydation courants | Häufige Oxidationszustände | General acidified state (Sanka Jōtai) | +2, +3, +4, +5, +6 (+6 is the most common) |

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| | | | | | |
|---|---|---|---|---|---|
| Electronegativity | Electronegativity | The electronic gativit | Electron technology | Denki Inseido | 2.36 (Pauling scale) |
| First ionization energy | First Ionization Energy | Première énergy d'ionisation | Ionisationsenergie | The first イオン化エネルギー | 770 kJ/mol |
| Atomic radius | Atomic Radius | Rayon atomique | Atomradius | Atomic radius (Genshi Hankei) | 139 pm (pimeter) |
| Covalent radius | Covalent Radius | Rayon covalent | Kovalenter Radius | Common Binding Radius (Kyōyū Ketsugō Hankei) | 162 pm |
| Melting point | Melting Point | Point de fusion | Schmelzpunkt | Melting point (Yūten) | 3422°C (3695 K) |
| Boiling Point | Boiling Point | Point d'ébullition | Siedepunkt | Boiling point | 5555°C (5828 K) |
| density | Density | Densité | Dichte | Density (Mitsudo) | 19.25 g/cm³ ( at room temperature) |
| Crystal structure | Crystal Structure | Structure cristalline | Kristallstruktur | Crystal structure (Kesshō Kōzō) | Body-Centered Cubic (BCC) |
| Lattice constant | Lattice Constant | Constant de réseau | Gitterkonstante | Grid constant (Kōshi Teisū) | 3.165 Å (Angstroms) |
| Thermal conductivity | Thermal Conductivity | Conductive therapy | What is the best way to deal with it? | Thermal Conductivity (Netsu Dendōritsu) | 173 W/(m·K) |
| Resistivity | Electrical Resistivity | Resistant electrification | Electrical Wider Stand | Denki Teikōritsu | $5.65 \times 10^{-8}$ Ω·m (at 20°C) |
| Mohs hardness | Mohs Hardness | Dureté Mohs | Mohs - Härte | Mosu Kōdo | 7.5 |
| Vickers hardness | Vickers Hardness | Dureté Vickers | Vickers - Härte | Bikkāsu Kōdo | ~3430 MPa |
| Main isotopes | Main Isotopes | Principaux isotopes | Hauptisotope | Shu na Dōitai | $^{180}$W (0.12%), $^{182}$W (26.50%), $^{183}$W (14.31%), $^{184}$W (30.64%), $^{186}$W (28.43%) |
| Isotope quantity | Number of Isotopes | Nombre d'isotopes | An analysis of the Isotope | The number of isotopes (Dōitai no Sū) | 5 stable isotopes + 33 radioactive isotopes |
| Main ore | Main Ores | Minerais principaux | Hauptmineralien | Shu na Kōseki | Wolframite $(Fe,Mn)WO_4$ ) / Scheelite ($CaWO_4$ ) |
| Main Origin | Main Sources | Principales sources | Hauptvorkommen | Main production area (Shu na Sanchi) | China (~80% of the world), Russia, Canada, Australia |
| color | Color | Couleur | Farbe | Color (Iro) | Metallic Gray |
| state | State | Etat | Zustand | Status (Jōtai) | Solid |
| Electrical conductivity | Electrical Conductivity | Conductive electrification | Electric Leitfähigkeit | Conductivity (Dōdensei) | Good Conductor |
| Ductility | Ductility | Ductilité | Duktilit ä t | Ductility | High |

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| | | | | | |
|---|---|---|---|---|---|
| | | | | (Ensei) | |
| Main Application | Main Uses | Principals utilisations | Hauptanwendungen | Main Purpose (Shu na Yōto) | Cemented carbide, filaments, electronic devices, catalysts, military materials |
| CAS Number | CAS Number | Numéro CAS | CAS-Nummer | CAS Number (CAS Bangō) | 7440-33-7 |
| The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email . | | | | | |

**Appendix:**
**Physical Properties of Tungsten**

| Chinese terminology | English (EN) | French (FR) | German (DE) | Japanese (JP) | Data |
|---|---|---|---|---|---|
| Melting point | Melting Point | Point de fusion | Schmelzpunkt | Melting point | 3422°C (6192°F, 3695 K) |
| Boiling Point | Boiling Point | Point d'ébullition | Siedepunkt | Boiling Point | 5930°C (10706°F, 6203 K) |
| density | Density | Densité | Dichte | density | 19.25 g/cm³ ( close to room temperature) |
| Crystal structure | Crystal Structure | Structure cristalline | Kristallstruktur | Crystal structure | Body-centered cubic (BCC) |
| Lattice constant | Lattice Constant | Constant de réseau | Gitterkonstante | Grid constant | 3.165 Å (Room temperature) |
| Hardness (Mohs) | Hardness (Mohs) | Dureté (Mohs) | Harte (Mohs ) | Hardness | 7.5 |
| Hardness (Vickers) | Vickers Hardness | Dureté Vickers | Vickers - Härte | Bichardness | 3430 MPa |
| Speed of sound | Speed of Sound | Vitesse du son | Schallgeschwindigkeit | Speed of sound | 5180 m/s (longitudinal wave, room temperature) |
| Surface tension | Surface Tension | Tension of surface | Oberflächenspannung | Surface tension | 2.5 N/m (molten state, about 3500°C) |
| Vapor Pressure | Vapor Pressure | Vaping Press | Dampfdruck | Steam pressure | $1.97\times10^{-7}$ Pa (3000°C) |
| isotope | Isotopes | Isotopes | Isotope | Peer | W-180, W-182, W-183, W-184, W-186 |
| color | Color | Couleur | Farbe | color | Silvery White |
| The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email . | | | | | |

**Chemical Properties of Tungsten**

| Chinese terminology | English (EN) | French (FR) | German (DE) | Japanese (JP) | Data |
|---|---|---|---|---|---|
| Electronic configuration | Electron Configuration | Configuration electronic | Electron enconfiguration | Electronic configuration | [Xe] $4f^{14}5d^{4}6s^{2}$ |
| Oxidation state | Oxidation States | Eating oxygen | Oxidationszustände | Acidification state | -2, -1, 0, +2, +3, +4, +5, +6 (+6 is common) |
| Chemical stability | Chemical | Chic | Chemical Status | Chemical | High (resistance to acid |

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| | | | | | |
|---|---|---|---|---|---|
| | Stability | Stabilization | ä t | stability | and alkali corrosion at room temperature) |
| Corrosion resistance | Corrosion Resistance | Resistance to corrosion | Best selection of products | Food resistance | Outperforms most metals (except strong oxidants) |
| The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email . | | | | | |

4. Application Properties

| Chinese terminology | English (EN) | French (FR) | German (DE) | Japanese (JP) | Data |
|---|---|---|---|---|---|
| High temperature tolerance | High-Temperature Resistance | Résistance à haute température | Hochtemperaturbest ä ndigkeit | High temperatur e resistance | Resistant to over 3000°C |
| Radiation resistance | Radiation Resistance | Resistance to radiation | Strahlungsbeständigkeit | Radiation resistance | Withstands 20 MW/m² heat load |
| Wear resistance | Wear Resistance | Restoration of the environment | Verschleißfestigkeit | Wear resistance | High (carbide application) |
| Electrical conductivity | Conductivity | Conductivity | Leitfähigkeit | Conductivit y | Medium (electrode, filament) |
| Antioxidant | Oxidation Resistance | Restoration of oxygen | Oxidations best viewed | Acid resistance | Protective atmosphere is required at high temperatures |
| Thermal fatigue resistance | Thermal Fatigue Resistance | Resistance to fatigue thermique | Thermische Ermüdungsbest ä ndigkeit | Heat fatigue resistance | High (1000 cycles of nuclear fusion testing) |
| Helium bubble resistance | Helium Bubble Resistance | Résistance aux bulls d'hélium | Helium blaze best experience | Hellmuth Babel Resistance | Nanostructured tungsten improves performance by 30% |
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**Appendix:**

**Tungsten Chemicals and Compounds**
**Tungsten Oxides**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| **Tungsten Oxide** | Tungsten Oxide | Oxyde of tungstène | Wolframoxid | Acidification Tangusten |
| **Tungsten Trioxide** | Tungsten Trioxide (WO3) | Trioxygen of tungstène | Wolfratrioxid | Triacidification Tangusten |
| **Nano Tungsten Trioxide** | Nano Tungsten Trioxide | Nano-trioxyethylene tungstène | Nano-Wolfratrioxid | Nana acid three-acidized polysaccharide |
| **High purity tungsten trioxide** | High-Purity Tungsten Trioxide | Trioxyde tungstène haute pureté | Hochreines Wolfratrioxid | High-purity tri-acidized dimethon |
| **Nano high purity tungsten trioxide** | Nano High-Purity Tungsten Trioxide | Nano-trioxyde tungsten haute pureté | Nano-hochreines Wolfratrioxid | NANO High Purity Tri-Acidified Polyester |
| **Ultra-high purity tungsten trioxide** | Ultra-High-Purity Tungsten Trioxide | Trioxyde tungsten ultra-haute pureté | Ultrahochreines Wolfratrioxid | Ultra-high-purity tri-acidified sterol |
| **Industrial Grade Tungsten Trioxide** | Industrial-Grade Tungsten Trioxide | Trioxyde tungstène industriel | Industrie-Wolfratrioxid | Tri-acidified electrolyte for industrial use |
| **Electronic Grade Tungsten Trioxide** | Electronic-Grade Tungsten Trioxide | Trioxyde tungstène électronique | Elektronik-Wolfratrioxid | Tri-acidified electrolyte for electronics |
| **Tungsten Dioxide** | Tungsten Dioxide (WO2) | Dioxyde of tungstène | Wolframdioxid | Diacid Tangusten |
| **Nano Tungsten Dioxide** | Nano Tungsten Dioxide | Nano-dioxythiophene | Nano-Wolframdioxid | Nanadioic acid diacetate |
| **High purity tungsten dioxide** | High-Purity Tungsten Dioxide | Dioxyde tungstène haute pureté | Hochreines Wolframdioxid | High-purity di-acidified diamine |
| **Tungsten Tetraoxide** | Tungsten Tetraoxide (WO4) | Tissue analysis of tungstène | Wolframtetraoxid | Tetrahydrogen sulfide |
| **Tungsten Hexaoxide** | Tungsten Hexoxide (W2O6) | Hexoxylate of tungstène | Wolframhexoxid | Hexachloride Tangusten |

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**Tungsten Sulfides**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Disulfide | Tungsten Disulfide (WS2) | Disulfuride of tungstène | Wolframsulfid | Disulfide Tangusten |
| Nano Tungsten Disulfide | Nano Tungsten Disulfide | Nano-disulfuric acid of tungstène | Nano-Wolframsulfid | ナノタングステン disulfide |
| High purity tungsten disulfide | High-Purity Tungsten Disulfide | Disulfure de tungstène haute pureté | Hochreines Wolframsulfid | High purity polysulfide disulfide |
| Micron Tungsten Disulfide | Micron Tungsten Disulfide | Disulfure of tungsten micrométrique | Mikron-Wolframsulfid | Macrotron disulfide |
| Tungsten Tetrasulfide | Tungsten Tetrasulfide (WS4) | Measurement of tungsten sulfur | Wolframtetrasulfid | Tetrasulfide Tangusten |
| Tungsten Sulfide | Tungsten Sulfide (WSx) | Sulfure of tungstène | Wolframsulfid | Vulcanized steel |
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**Tungstic Acid and Salts**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungstic acid | Tungstic Acid (H2WO4) | Acide tungstique | Wolframsäure | Tangustenic acid |
| High purity tungstic acid | High-Purity Tungstic Acid | Acide tungstique haute pureté | Wolframs äure | High Purity Triconic Acid |
| Ultra-high purity tungstic acid | Ultra-High-Purity Tungstic Acid | Acide tungstique ultra-haute pureté | Ultrahochreine Wolframsäure | Ultra-high-purity polysaccharide |
| Sodium Tungstate | Sodium Tungstate (Na2WO4) | Tungstate de sodium | Natrium wolframat | タングステンナトリウム |
| High purity sodium tungstate | High-Purity Sodium Tungstate | Tungstate de sodium haute pureté | Hochreines Natriumwolframat | High-purity tertiary acid natriuretic acid |
| Crystalline Sodium Tungstate | Crystalline Sodium Tungstate | Tungstate de sodium cristallin | Kristallines Natriumwolframat | Crystalline polysaccharide |
| Ammonium tungstate | Ammonium Tungstate | Tungstate d'ammonium | Ammonium wolframat | タングステンアンモニウム |
| High purity ammonium tungstate | High-Purity Ammonium Tungstate | Tungstate d'ammonium haute pureté | Hochreines Ammonium wolframat | High purity ammonium acid ammonium chloride |
| Ammonium Metatungstate | Ammonium Metatungstate | Metatungstate d'ammonium | Ammoniummetawolframat | メタタングステンアンモニウム |
| Nano Ammonium | Nano Ammonium Metatungstate | Nano-métatungstate d'ammonium | Nano-Ammoniummetawolframat | ナノメタタング |

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| | | | | |
|---|---|---|---|---|
| Metatungstate | | | | ステンアンモニウム |
| High purity ammonium metatungstate | High-Purity Ammonium Metatungstate | Métatungstate d'ammonium haute pureté | Hochreines Ammoniummetawolframat | High Purity Amino acid Amino acid |
| Calcium Tungstate | Calcium Tungstate (CaWO4) | Tungstate de calcium | Calcium wolframat | タングステン acid カルシウム |
| High purity calcium tungstate | High-Purity Calcium Tungstate | Tungstate de calcium haute pureté | Hochreines Calcium wolframat | High-purity polysaccharide |
| Magnesium Tungstate | Magnesium Tungstate (MgWO4) | Tungstate of magnésium | Magnesium wolframat | タングステンマグネシウム |
| Lead Tungstate | Lead Tungstate (PbWO4) | Tungstate de plomb | Bleiwolframat | Lead tannate |
| Potassium Tungstate | Potassium Tungstate (K2WO4) | Tungstate de potassium | Kalium wolframat | タングステン acid カリウム |
| High purity potassium tungstate | High-Purity Potassium Tungstate | Tungstate de potassium haute pureté | Hochreines Kalium wolframat | High-purity polysaccharide |
| Zinc Tungstate | Zinc Tungstate (ZnWO4) | Tungstate de zinc | Zinkwolframat | Sub-lead tannate |
| Barium Tungstate | Barium Tungstate (BaWO4) | Tungstate de baryum | Barium wolframat | タングステン acid バリウム |
| Iron Tungstate | Iron Tungstate (FeWO4) | Tungstate de fer | Eisenwolfframat | Iron tannate |
| Copper Tungstate | Copper Tungstate (CuWO4) | Tungstate de cuivre | Kupferwolframat | Copper tannate |
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**Tungsten Halides**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Hexachloride | Tungsten Hexachloride (WCl6) | Hexachloride of tungstène | Wolframhexachlorid | Six salt chemical tank |
| High purity tungsten hexachloride | High-Purity Tungsten Hexachloride | Hexachloruretungstène haute pureté | Hochreines Wolframhexachlorid | High purity hexafluoroethylene |
| Ultra-high purity tungsten hexachloride | Ultra-High-Purity Tungsten Hexachloride | Hexachloruretungstène ultra-haute purity | Ultrahochreines Wolframhexachlorid | Ultra-high purity hexagonal chemical |
| Tungsten Tetrachloride | Tungsten Tetrachloride (WCl4) | Tungsten test | Wolframtetrachlorid | Tetrasalt Tangusten |
| High purity tungsten tetrachloride | High-Purity Tungsten Tetrachloride | Tétrachlorure de tungstène haute pureté | Hochreines Wolframtetrachlorid | High-purity tetrahydrofuran |

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| | | | | |
|---|---|---|---|---|
| Tungsten Hexafluoride | Tungsten Hexafluoride (WF6) | Hexafluoride of tungsten | Wolframhexafluorid | 六フッ化タングステン |
| High purity tungsten hexafluoride | High-Purity Tungsten Hexafluoride | Hexafluorescence of tungsten haute pureté | Hochreines Wolfram hexafluorid | High purity hexafluoride |
| Ultra-high purity tungsten hexafluoride | Ultra-High-Purity Tungsten Hexafluoride | Hexafluorescence of tungsten ultra-haute puree | Ultrahochreines Wolframhexafluorid | Ultra-high purity hexafluoride |
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**Tungsten Carbides**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Carbide | Tungsten Carbide (WC) | Carbure of tungstène | Wolframkarbid | Carbonization Tangusten |
| Nano Tungsten Carbide | Nano Tungsten Carbide | Nano-carbide of tungsten | Nano-Wolframkarbid | ナノ Carbonized タングステン |
| High purity tungsten carbide | High-Purity Tungsten Carbide | Carbure de tungstène haute pureté | Hochreines Wolframkarbid | High purity carbonized carbon dioxide |
| Ultra-high purity tungsten carbide | Ultra-High-Purity Tungsten Carbide | Carbure de tungstène ultra-haute pureté | Ultrahochreines Wolframkarbid | Ultra-high purity carbonized carbon dioxide |
| Industrial Grade Tungsten Carbide | Industrial-Grade Tungsten Carbide | Carbure de tungstène industriel | Industrie-Wolframkarbid | Carbonized carbon dioxide for industrial use |
| Tungsten Carbide | Tungsten Dicarbide (W2C) | Die carburet de tungstène | Wolfram dicarbide | Carbon dioxide gas |
| Nano Tungsten Carbide | Nano Tungsten Dicarbide | Nano-dicarbide of tungstène | Nano-Wolframdicarbide | ナノ二色タングステン |
| The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email . | | | | |

**Other Tungsten Compounds**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Titanium Tungsten | Titanium Tungstide (TiW) | Tungstène de titane | Titanwolframid | TITAN TANGSTEN |
| Nano-Titanium Tungsten | Nano Titanium Tungstide | Nano-tungsten of titanate | Nano-Titanwolframid | ナノチタンタングステン |

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|---|---|---|---|---|
| High purity titanium tungsten | High-Purity Titanium Tungstide | Tungstène de titane haute pureté | Hochreines Titan wolframid | High purity チタンタングステン |
| Silicon Tungsten | Tungsten Silicide (WSi2) | Silicone for tungsten | Wolframsilizid | シリサイドタングステン |
| Nano-silicon tungsten | Nano Tungsten Silicide | Nano-silicium of tungsten | Nano-Wolframsilizid | ナノシリサイドタングステン |
| High purity silicon tungsten | High-Purity Tungsten Silicide | Siliciure of tungsten haute pureté | Hochreines Wolframsilizid | High purity sterilizer |
| Tungsten Boride | Tungsten Boride (WB) | Tungstène | Wolframoborid | Home Chemical Sting |
| High purity tungsten boride | High-Purity Tungsten Boride | Borure de tungstène haute pureté | Hochreines Wolframoborid | High purity ホウ化タングステン |
| Nano Tungsten Boride | Nano Tungsten Boride | Nano-borre of tungstène | Nano-Wolframoborid | ナノホウ化タングステン |
| Tungsten Nitride | Tungsten Nitride (WN) | Nitrure de tungstène | Wolframinitrid | Asphyxiation Tangusten |
| Nano-tungsten nitride | Nano Tungsten Nitride | Nano-nitrocellulose of tungstène | Nano-Wolframinitrid | ナノ担化タングステン |
| High purity tungsten nitride | High-Purity Tungsten Nitride | Nitrure de tungstène haute pureté | Hochreines Wolframinitrid | High-purity chlorinated chloride |
| Tungsten Phosphide | Tungsten Phosphide (WP) | Phosphure of tungstène | Wolframphosphid | Lining Tangusten |
| Nickel Tungstate | Nickel Tungstate (NiWO4) | Tungstate nickel | Nickelwolframat | タングステンニッケル |
| Bismuth Tungstate | Bismuth Tungstate (Bi2WO6) | Tungstate de bismuth | Bismutwolframat | タングステン acid ビスマス |
| Zirconium Tungstate | Zirconium Tungstate (ZrW2O8) | Zirconia | Zirkonium wolframat | タングステン acid ジルコニウム |
| Cobalt Tungstate | Cobalt Tungstate (CoWO4) | Tungstate de cobalt | Kobaltwolframat | タングステン acid コバルト |
| Manganese Tungstate | Manganese Tungstate (MnWO4) | Tungstate of manganese | Mangan wolfframat | タングステンママガン |
| Cesium Tungstate | Cesium Tungstate (Cs2WO4) | Tungstate de césium | C ä sium wolfframat | タングステン acid セシウム |
| Lithium Tungstate | Lithium Tungstate (Li2WO4) | Tungstate de lithium | Lithium wolframat | タングステン acid リチウム |
| High purity lithium tungstate | High-Purity Lithium Tungstate | Tungstate de lithium haute pureté | Hochreines Lithium wolframat | High-purity polysaccharide |
| Silver Tungstate | Silver Tungstate | Tungstate d'argent | Silberwolframat | Silver tannate |

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| | | | | |
|---|---|---|---|---|
| | (Ag2WO4) | | | |
| Cadmium Tungstate | Cadmium Tungstate (CdWO4) | Tungstate de cadmium | Cadmium wolframat | タングステン acid カドミウム |
| Aluminum Tungstate | Aluminum Tungstate (Al2(WO4)3) | Tungsten aluminum | Aluminium wolframat | タングステンアルミニウム |
| Molybdenum Tungstate | Molybdenum Tungstate (MoWO4) | Molybdenum tungsten | Molybdänwolframat | タングステン acid モリブデン |
| Tungsten Iron | Iron Tungstide (FeW) | Tungstène de fer | Eisenwolframid | Iron Tank Steel |
| Cobalt Tungsten | Cobalt Tungstide (CoW) | Tungstène de cobalt | Kobaltwolframid | コバルトタングステン |
| Nickel Tungsten | Nickel Tungstide (NiW) | Nickel Tungsten | Nickelwolframid | ニッケルタングステン |
| Aluminum Tungsten | Aluminum Tungstide (AlW) | Aluminium | Aluminiumwolframid | アルミニウムタングステン |
| Silicotungstic acid | Silicotungstic Acid (H4SiW12O40) | Acide silicotungstique | Silikowolframsäure | Citric acid tannin |
| High purity silicotungstic acid | High-Purity Silicotungstic Acid | Acide silicotungstique haute pureté | Hochreine Silikowolframs ä ure | High purity ketamine |
| Phosphotungstic acid | Phosphotungstic Acid (H3PW12O40) | Acide phosphodiester | Phosphorwolframsäure | Linazone Tangusten |
| High purity phosphotungstic acid | High-Purity Phosphotungstic Acid | Acide phosphotungstique haute pureté | Hochreine Phosphorwolframsä ure | High-purity erythropolymer acid |
| Tungsten Blue | Tungsten Blue Oxide (WO2.9) | Oxyde of tungstène bleu | Wolframblauoxid | Tangustenbul |
| High purity tungsten blue | High-Purity Tungsten Blue Oxide | Oxyde de tungsten bleu haute pureté | Hochreines Wolframblauoxid | High purity polyester |
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**Tungsten Solvents**

| | | | | |
|---|---|---|---|---|
| Sodium hydroxide solution (dissolves tungstic acid) | Sodium Hydroxide Solution (for WO3) | Solution d'hydroxyde sodium | Natriumhydroxid - Lösung | Water-acidified ナトリウム solution (for タングステン) |
| Ammonia (dissolves tungstate) | Ammonia Solution (for tungstates) | Solution of ammonia | Ammoniaklösung | Amino acid water (for amino acid) |

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|---|---|---|---|---|
| Hydrofluoric acid (dissolves tungsten compounds) | Hydrofluoric Acid (for W compounds) | Acide fluorhydrique | Flusssäure | Phytohydrin acid (for terton compounds) |
| Sulfuric acid (to dissolve tungsten ore) | Sulfuric Acid (for tungsten ores) | Acide sulfuric acid | Schwefelsäure | Sulfuric acid (for terrestrial sulfate) |
| Hydrochloric acid (to dissolve tungstate) | Hydrochloric Acid (for tungstates) | Acide chlorhydrique | Salzsäure | Hyaluronic acid (for dioxic acid) |
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**Tungsten Reagents**

**Tungsten-Containing Reagents**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Trioxide | Tungsten Trioxide (WO3) | Trioxygen of tungstène | Wolframtrioxid | Triacidification Tangusten |
| Tungstic acid | Tungstic Acid (H2WO4) | Acide tungstique | Wolframsäure | Tangustenic acid |
| Sodium Tungstate | Sodium Tungstate (Na2WO4) | Tungstate de sodium | Natrium wolframat | タングステンナトリウム |
| Ammonium tungstate | Ammonium Tungstate ((NH4)2WO4) | Tungstate d'ammonium | Ammonium wolframat | タングステンアンモニウム |
| Ammonium Metatungstate | Ammonium Metatungstate ((NH4)6H2W12O40) | Metatungstate d'ammonium | Ammoniummetawolframat | メタタングステンアンモニウム |
| Phosphotungstic acid | Phosphotungstic Acid (H3PW12O40) | Acide phosphodiester | Phosphorwolframsäure | Linazone Tangusten |
| Silicotungstic acid | Silicotungstic Acid (H4SiW12O40) | Acide silicotungstique | Silikowolframsäure | Citric acid tannin |
| Calcium Tungstate | Calcium Tungstate (CaWO4) | Tungstate de calcium | Calcium wolframat | タングステン acid カルシウム |
| Magnesium Tungstate | Magnesium Tungstate (MgWO4) | Tungstate of magnésium | Magnesium wolframat | タングステンマグネシウム |
| Zinc Tungstate | Zinc Tungstate (ZnWO4) | Tungstate de zinc | Zinkwolframat | Sub-lead tannate |
| Tungsten Hexachloride | Tungsten Hexachloride (WCl6) | Hexachloride of tungstène | Wolframhexachlorid | Six salt chemical tank |
| Tungsten Tetrachloride | Tungsten Tetrachloride (WCl4) | Tungsten test | Wolfram tetrachlorid | Tetrasalt Tangusten |
| Potassium Tungstate | Potassium Tungstate (K2WO4) | Tungstate de potassium | Kalium wolframat | タングステン acid カリウム |
| Lithium Tungstate | Lithium Tungstate (Li2WO4) | Tungstate de lithium | Lithium wolframat | タングステン acid リチウム |
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Tungsten Catalytic Cracking Agents

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Oxide Catalyst | Tungsten Oxide Catalyst (WO3) | Catalyseur d'oxyde de tungstène | Wolframoxid-Katalysator | Acidified タングステン catalyst |
| Tungstic Acid Catalyst | Tungstic Acid Catalyst (H2WO4) | Catalyst of tungsten acid | Wolframsäure - Katalysator | Tangusten acid catalyst |
| Phosphotungstic acid catalyst | Phosphotungstic Acid Catalyst (H3PW12O40) | Catalyseur d'acide phosphotungstique | Phosphorwolframsäure- Katalysator | リン acid タングステン catalyst |
| Silicotungstic Acid Catalyst | Silicotungstic Acid Catalyst (H4SiW12O40) | Catalyseur d'acide silicotungstique | Silikowolframsäure-Katalysator | ケイ Acidic acid catalyst |
| Tungsten-based composite catalyst | Tungsten-Based Composite Catalyst | Catalyseur composite à base detungsten | Wolfram-basierter Verbundkatalysator | タングステン-based composite catalyst |
| Tungsten-nickel catalyst | Tungsten-Nickel Catalyst (W-Ni) | Catalyst tungstène-nickel | Wolfram-Nickel-Katalysator | タングステン-ニッケル catalyst |
| Tungsten-Molybdenum Catalyst | Tungsten-Molybdenum Catalyst (W-Mo) | Catalyseur tungstène-molybdene | Wolfram-Molybdän - Katalysator | タングステン-モリブデン catalyst |

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**Tungsten Organic Solvents**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Carbonyl | Tungsten Carbonyl (W(CO)6) | Carbonyl tungstene | Wolframcarbonyl | タングステンカルボニル |
| Tungsten hexafluoride ethanol solution | Tungsten Hexafluoride Ethanol Solution | Solution d'hexafluoruretungstène éthanol | Wolframhexafluorid-Ethanoll ö sung | Hexafluoride chemical solution |
| Methyl tungstate | Methyl Tungstate | Tung state of mother | Methylwolframat | タングステン acid メチル |
| Ethyl tungstate | Ethyl Tungstate | Tung state d'éthyle | Ethyl wolframat | タングステン acid エチル |
| Isopropyl tungstate | Isopropyl Tungstate | Tungstate d'isopropyl | Isopropylwolframat | タングステン acid イソプロピル |

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Tungsten-Containing Pharmaceuticals

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Sodium Tungstate (Pharmaceutical Grade) | Pharmaceutical Sodium Tungstate (Na2WO4) | Tungstate de sodium pharmaceutique | Pharmazeutisches Natriumwolframat | 薬用タングステン acid ナトリウム |
| Ammonium Metatungstate (Pharmaceutical Grade) | Pharmaceutical Ammonium Metatungstate | Métatungstate d'ammonium pharmaceutique | Pharmazeutisches Ammoniummetawolframat | 薬用メタタングステンアンモニウム |
| Tungstate Antimicrobial Agent | Tungstate Antibacterial Agent | Agent antibactérien tungstate | Wolframat-Antibakterienmittel | タングステン acid chloride antibacterial agent |
| Tungstate Antioxidant | Tungstate Antioxidant | Antioxydant tungstate | Wolframat-Antioxidants | タングステン acid acid antacid |
| Tungsten-based nanoparticle drug carrier | Tungsten-Based Nanomedicine Carrier | Porteur nanomédical a base de tungsten | Wolfram -basierter Nanomedizin- Träger | タングステン记ナノ Medical 薬キャリア |

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**Types of Tungsten Electrodes**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Pure tungsten electrode | Pure Tungsten Electrode | Électrode de tungsten è ne pur | Reines Wolframelektrode | Pure tangusten electrode |
| Thoriated tungsten electrode (2% thorium) | 2% Thoriated Tungsten Electrode | 2 % | 2% Thorium-Wolframelektrode | 2% トリウムタングステン electrode |
| Thoriated tungsten electrode (1% thorium) | 1% Thoriated Tungsten Electrode | 1 % | 1% Thorium-Wolframelektrode | 1% トリウムタングステン electrode |
| Cerium Tungsten Electrode (2% Ce) | 2% Cerium Tungsten Electrode | Électrode de tungstène cérié 2 % | 2% Cer-Wolframelektrode | 2% セリウムタングステン electrode |
| Cerium Tungsten Electrode (1.5% Ce) | 1.5% Cerium Tungsten Electrode | Électrode de tungstène cérié 1,5 % | 1,5% Cer-Wolframelektrode | 1.5% セリウムタングステン electrode |
| Lanthanum Tungsten | 2% Lanthanated Tungsten Electrode | 2 % | 2% Lanthan-Wolframelektrode | 2% ランタンタングステン |

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| | | | | |
|---|---|---|---|---|
| Electrode (2% Lanthanum) | | | | electrode |
| Lanthanum Tungsten Electrode (1.5% Lanthanum) | 1.5% Lanthanated Tungsten Electrode | 1,5 % | 1,5% Lanthan-Wolframelektrode | 1.5% ランタンタングステン electrode |
| Lanthanum Tungsten Electrode (1% Lanthanum) | 1% Lanthanated Tungsten Electrode | 1 % | 1% Lanthan-Wolframelektrode | 1% ランタンタングステン electrode |
| Zirconium tungsten electrode (0.8% zirconium) | 0.8% Zirconiated Tungsten Electrode | Électrode de tungsten è ne zirconé 0,8 % | 0,8% Zirkonium-Wolframelektrode | 0.8% ジルコニウムタングステン electrode |
| Zirconium tungsten electrode (0.3% zirconium) | 0.3% Zirconiated Tungsten Electrode | Électrode de tungsten è ne zirconé 0,3 % | 0,3% Zirkonium-Wolframelektrode | 0.3% ジルコニウムタングステン electrode |
| Yttrium Tungsten Electrode (2% Yttrium) | 2% Yttriated Tungsten Electrode | 2 % | 2% Yttrium-Wolframelektrode | 2% イットリウムタングステン electrode |
| Yttrium Tungsten Electrode (1% Yttrium) | 1% Yttriated Tungsten Electrode | 1 % | 1% Yttrium-Wolframelektrode | 1% イットリウムタングステン electrode |
| Composite rare earth tungsten electrode | Multi-Rare Earth Tungsten Electrode | Électrode multi-terres rares | Multi-Seltenerd-Wolframelektrode | Composite レアアースタングステン electrode |
| High performance composite tungsten electrode | High-Performance Multi-Tungsten Electrode | Électrode multi-tungst è ne haute performance | Hochleistungs-Multi-Wolframelektrode | High performance composite electrode |
| Praseodymium Tungsten Electrode (2% Praseodymium) | 2% Praseodymium Tungsten Electrode | Électrode de tungstè ne praseodymium 2% | 2% Praseodym-Wolframelektrode | 2% プラセオジムタングステン electrode |
| Neodymium tungsten electrode (2% neodymium) | 2% Neodymium Tungsten Electrode | Électrode de tungstè ne né odyme 2% | 2% Neodym-Wolframelektrode | 2% ネオジムタングステン electrode |
| Ternary rare earth tungsten electrode | Tri-Rare Earth Tungsten Electrode | Electrode tri-terres rares | Tri-Seltenerd-Wolframelektrode | Sanyuan レアアースタングステン electrode |
| Quaternary rare earth tungsten electrode | Quad-Rare Earth Tungsten Electrode | Electrode quad-terres rares | Quad-Seltenerd-Wolframelektrode | Quaternary レアアースタングステン electrode |
| The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For | | | | |

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more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email .

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# CTIA GROUP LTD
# Barium Tungsten Cathode Introduction

## 1. Overview of CTIA GROUP Barium Tungsten Cathode

The barium tungsten cathode designed and manufactured by CTIA GROUP is a cathode material for xenon flash lamps. It is made of a tungsten base impregnated with barium oxide and other compounds (such as calcium oxide and aluminum oxide) to enhance its performance. The uniqueness of the barium tungsten cathode lies in its low work function and high electron emission efficiency, which makes it excellent in high-intensity light output applications.

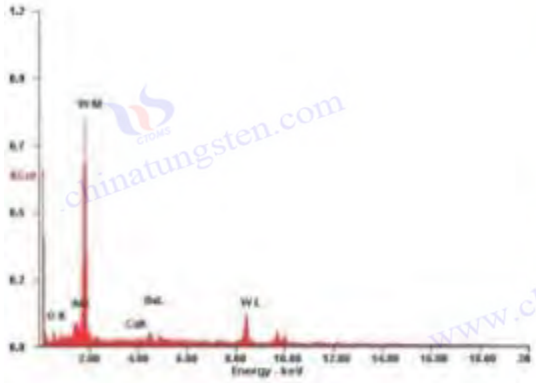
## 2. Characteristics of CTIA GROUP Barium Tungsten Cathode

**Stability:** Provides consistent performance for applications requiring precise light output.
**Long life:** Through the impregnation of barium oxide and other materials, the sputtering and erosion of the cathode are reduced, thereby extending the service life of the lamp.
**Efficient electron emission:** The addition of barium oxide reduces the work function of tungsten, allowing it to efficiently emit electrons at lower temperatures.

## 3. Specifications of CTIA GROUP Barium Tungsten Cathode

| Specification | Details |
|---|---|
| Material | Tungsten, impregnated with barium oxide, calcium oxide and aluminum oxide |
| Shape | Cylindrical or rod-shaped |
| Size | Varies according to lamp power and application |
| Reference diameter | 1.6~15mm |
| Reference thickness | 1.3~15mm |

## 4. EDS component content test report of CTIA GROUP Barium Tungsten Cathode



| Element | Wt% | At% |
|---|---|---|
| OK | 05.52 | 35.33 |
| AlK | 02.60 | 09.85 |
| CaK | 00.48 | 01.22 |
| BaL | 07.65 | 05.70 |
| WL | 83.04 | 46.25 |
| Matrix | Correction | ZAF |

其中：Wt%为质量百分百，At%为原子百分比

## 5. Procurement Information

Email: sales@chinatungsten.com Tel: +86 592 5129595; 592 5129696
For more information about barium tungsten cathode, please visit Chinatungsten Online ( www.tungsten.com.cn ) .

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**Types of High-Density Tungsten Alloy Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| High Density Tungsten Alloy Rod | High-Density Tungsten Alloy Rod | Barre en alliage de tungstène haute densité | Hochdichte Wolframlegieungsstab | High Density Density Alloy Rhodium |
| High Density Tungsten Alloy Plate | High-Density Tungsten Alloy Plate | Plaque en alliance de tungsten haute densité | Hochdichte Wolframlegieungsplatte | High Density Polyester Alloy |
| High Density Tungsten Alloy Block | High-Density Tungsten Alloy Block | Bloc en alliance de tungsten haute densité | Hochdichte Wolframlegieungsblock | High-density タングステン alloy tile |
| High Density Tungsten Alloy Ball | High-Density Tungsten Alloy Ball | Boule en alliance de tungstène haute densité | Hochdichte Wolframlegieungskugel | High Density Density Alloy Block |
| High Density Tungsten Alloy Counterweight | High-Density Tungsten Alloy Counterweight | Contrary to allegiance of tungsten haute densité | Hochdichte Wolframlegieungsgegengewicht | High-density タングステン alloy steel |
| High Density Tungsten Alloy Shielding | High-Density Tungsten Alloy Shielding | Blind age in alliance with tungsten haute densité | Hochdichte Wolframlegieungsschirm | High-density polyester alloy |
| High Density Tungsten Alloy Armor Piercing Core | High-Density Tungsten Alloy Penetrator Core | Noyau pénétrant en alliage de tungstène | Hochdichte Wolframlegieungs-Panzerkern | High-density タングステン alloy pure armor core |
| High Density Tungsten Alloy Disc | High-Density Tungsten Alloy Disc | Disques in allegiance of tungsten haute densité | Hochdichte Wolframlegieungsscheibe | High-density polyester alloy |
| High Density Tungsten Alloy Tube | High-Density Tungsten Alloy Tube | Tube en alliage de tungstène haute densité | Hochdichte Wolframlegieungsrohr | High density タングステン alloy チューブ |
| High Density Tungsten Alloy Sheet | High-Density Tungsten Alloy Sheet | Feuille en alliance de tungstène haute densité | Hochdichte Wolframlegieungsblech | High-density タングステン alloy steel |
| High Density Tungsten Alloy Cube | High-Density Tungsten Alloy Cube | Cube en alliage de tungstène haute densité | Hochdichte Wolframlegierungswürfel | High-density polyester alloy |
| High Density Tungsten | High-Density Tungsten Alloy | Anneau en alliance de | Hochdichte Wolframlegieungsring | High-density polyester alloy |

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| | | | | |
|---|---|---|---|---|
| Alloy Ring | Ring | tungstène haute densité | | |
| High Density Tungsten Alloy Particles | High-Density Tungsten Alloy Granule | Granule en alliage de tungstène haute densité | Hochdichte Wolframlegierungsgranulat | High density タングステン alloy particles |
| High Density Tungsten Alloy Cone | High-Density Tungsten Alloy Cone | C ô ne en alliance de tungsten è ne haute densit é | Hochdichte Wolframlegieungskegel | High-density polyester alloy |
| High Density Tungsten Alloy Bar | High-Density Tungsten Alloy Bar | Barreau en alliage de tungstène haute densité | Hochdichte Wolframlegieungsstange | High-density polyester alloy |
| High Density Tungsten Alloy Nut | High-Density Tungsten Alloy Nut | É crou en alliance de tungsten è ne haute densit é | Hochdichte Wolframlegieungsmutter | High-density polyester alloy |
| High Density Tungsten Alloy Needle | High-Density Tungsten Alloy Needle | Aiguille en alliage de tungstène haute densité | Hochdichte Wolframlegieungsnadel | High-density タングステン alloy dielectric |
| High Density Tungsten Alloy Bolts | High-Density Tungsten Alloy Bolt | Boulon en alliance de tungsten haute densité | Hochdichte Wolframlegieungsschraube | High Density Density Alloy ボルト |
| High Density Tungsten Alloy Gasket | High-Density Tungsten Alloy Gasket | Joint en-alliance de tungsten haute densité | Hochdichte Wolframlegierungsdichtung | High density タングステン alloy ガスケット |
| High Density Tungsten Alloy Bearings | High-Density Tungsten Alloy Bearing | Rouge en alliance de tungsten haute densité | Hochdichte Wolframlegieungslager | High-density polyester alloy |
| High Density Tungsten Alloy Gear | High-Density Tungsten Alloy Gear | Engagement in alliance with tungsten haute densité | Hochdichte Wolframlegieungszahnrad | High-density polyester alloy |
| High Density Tungsten Alloy Connectors | High-Density Tungsten Alloy Connector | Connecteur en alliance de tungsten haute densité | Hochdichte Wolframlegieungsverbinder | High density タングステン alloy コネクター |
| High density tungsten alloy guide rail | High-Density Tungsten Alloy Guide Rail | Rails and guides in alliances and tungsten haute densities | Hochdichte Wolframlegieungsführungsschiene | High-density polyester alloy |
| High Density Tungsten | High-Density Tungsten Alloy | Anneau d'étanchéité | Hochdichte Wolframlegieungsdichtungsring | High-density polyester alloy |

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|---|---|---|---|---|
| Alloy Sealing Ring | Seal Ring | en alliance de tungstène haute densité | | |
| High Density Tungsten Alloy Foil | High-Density Tungsten Alloy Foil | Feuille en alliance de tungstène haute densité | Hochdichte Wolframlegieungsfolie | High density タングステン alloy フォイル |
| High Density Tungsten Alloy Wire | High-Density Tungsten Alloy Wire | Fil en alliance de tungstène haute densité | Hochdichte Wolframlegieungsdraht | High-density タングステン alloy steel |
| High Density Tungsten Alloy Film | High-Density Tungsten Alloy Film | Film in alliance with tungsten haute densité | Hochdichte Wolframlegieungsfilm | High Density Polyester Alloy Fiber |
| High Density Tungsten Alloy Target | High-Density Tungsten Alloy Target | Cable en alliage de tungstène haute densité | Hochdichte Wolframlegieungsscheibe | High-density polyester alloy |
| High density tungsten alloy nozzle | High-Density Tungsten Alloy Nozzle | Buse en alliage de tungstène haute densité | Hochdichte Wolframlegieungsdüse | High-density polyester alloy |
| High Density Tungsten Alloy Bushing | High-Density Tungsten Alloy Bushing | Douille en alliance de tungstène haute densité | Hochdichte Wolframlegieungsbuchse | High-density polyester alloy |
| High density tungsten alloy valve core | High-Density Tungsten Alloy Valve Core | Noyau de valve en alliage de tungstène haute densité | Hochdichte Wolframlegieungsventilkern | High Density Polyester Alloy Block |
| High Density Tungsten Alloy Ball | High-Density Tungsten Alloy Roller Ball | Bille roulante en alliage de tungstène haute densité | Hochdichte Wolframlegieungsrollkugel | High Density Polyester Alloy Rotor |
| High Density Tungsten Alloy Washer | High-Density Tungsten Alloy Washer | Rondelle en alliage de tungstène haute densité | Hochdichte Wolframlegieungsunterlegscheibe | High-density タングステン alloy pipe |
| High Density Tungsten Alloy Compact | High-Density Tungsten Alloy Press Block | Bloc of presses in alliance with tungsten haute densité | Hochdichte Wolframlegieungspressblock | High-density polyester alloy alloy |
| High Density Tungsten Alloy Tie Rod | High-Density Tungsten Alloy Tie Rod | Allure in allegiance | Hochdichte Wolframlegieungszugstange | High-density タングステン alloy tile |
| High Density Tungsten | High-Density Tungsten Alloy | Rivet en alliage de | Hochdichte Wolframlegieungsniet | High Density Density Alloy Rift |

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|---|---|---|---|---|
| Alloy Rivets | Rivet | tungstène haute densité | | |
| High Density Tungsten Alloy Pin | High-Density Tungsten Alloy Pin | Goupille en alliance de tungstène haute densité | Hochdichte Wolframlegieungsstift | High-density polyester alloy |
| High density tungsten alloy shaft | High-Density Tungsten Alloy Shaft | Arbre en alliance de tungstène haute densité | Hochdichte Wolframlegieungswelle | High-density タングステン alloy シャフト |
| High density tungsten alloy guide wheel | High-Density Tungsten Alloy Guide Wheel | Rouge of guidance and alliage of tungsten haute densité | Hochdichte Wolframlegieungsführungsrad | High density タングステン alloy ガイドホイール |
| High Density Tungsten Alloy Roller | High-Density Tungsten Alloy Press Roller | Rouleau de presse en alliage de tungstène haute densité | Hochdichte Wolframlegieungspressrolle | High-density polyester alloy alloy |
| High Density Tungsten Alloy Flywheel | High-Density Tungsten Alloy Flywheel | Volant en alliage de tungstène haute densité | Hochdichte Wolframlegieungsschwungrad | High density タングステン alloy filter |
| High Density Tungsten Alloy Heat Sink | High-Density Tungsten Alloy Heat Sink | Dissipateur thermique en alliage de tungstène haute densité | Hochdichte Wolframlegierungswärmesenke | High-density タングステン alloy ヒーシンク |
| High Density Tungsten Alloy Electrode | High-Density Tungsten Alloy Electrode | Électrode en alliage de tungsten è ne haute densit é | Hochdichte Wolframlegieungselektrode | High density タングステン alloy electrode |
| High density tungsten alloy contacts | High-Density Tungsten Alloy Contact | Contact us | Hochdichte Wolframlegieungskontakt | High-density タングステン alloy coating |
| High Density Tungsten Alloy Conductive Sheet | High-Density Tungsten Alloy Conductive Sheet | Feuille conductrice en alliage de tungstène haute densité | Hochdichte Wolframlegierungsleitblech | High-density タングステン alloy conductive シート |
| High density tungsten alloy welding head | High-Density Tungsten Alloy Weld Joint | Joint venture into alliance | Hochdichte Wolframlegierungsschwei ß verbindung | High-density polyester alloy welding technology |
| High Density Tungsten Alloy Powder | High-Density Tungsten Alloy Powder | Poudre en alliage de tungstène haute densité | Hochdichte Wolframlegieungspulver | High-density タングステン alloy powder |
| High density | High-Density | Particulate | Hochdichte Wolframlegieungsteilchen | High-density タン |

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| tungsten alloy particles | Tungsten Alloy Particle | entitlement in tungsten haute densité | | グステン alloy particles |
| High density tungsten alloy spray powder | High-Density Tungsten Alloy Spray Powder | Possibility of adversity in alleviation | Hochdichte Wolframlegieungssprühpulver | High density タングステン alloy スプレー powder |
| High Density Tungsten Alloy Fiber | High-Density Tungsten Alloy Fiber | Fibre-en-alliance detungsten haute densité | Hochdichte Wolframlegieungsfaser | High Density Density Alloy Fiber |
| High Density Tungsten Alloy Protective Plate | High-Density Tungsten Alloy Shield Plate | Plaque of protection in alliance with tungsten haute densité | Hochdichte Wolframlegieungsschutzplatte | High-density タングステン alloy protection tile |
| High Density Tungsten Alloy Radiation Shielding | High-Density Tungsten Alloy Radiation Shield | Bouclier antiradiation and alliage of tungsten haute densité | Hochdichte Wolframlegierungsstrahlungsschirm | High-density タングステン alloy radioactive rays |
| High Density Tungsten Alloy Medical Needle | High-Density Tungsten Alloy Medical Needle | Aiguille médicale en alliage de tungstène haute densité | Hochdichte Wolframlegierungsmedizinnadel | High-density タングステン alloy medical alloy |
| High Density Tungsten Alloy Counterweight | High-Density Tungsten Alloy Weight Block | Bloc of poids in alliance with tungsten haute densité | Hochdichte Wolframlegieungsgewichtblock | High-density タングステン alloy steel |
| High Density Tungsten Alloy Darts | High-Density Tungsten Alloy Dart | Fléchette en alliance de tungstène haute densité | Hochdichte Wolframlegieungspfeil | High Density Density Alloy ダーツ |
| High Density Tungsten Alloy Fish Sinkers | High-Density Tungsten Alloy Sinker | Plomb en alliage de tungstène haute densité | Hochdichte Wolframlegieungssinker | High-density polyester alloy silica |
| High Density Tungsten Alloy Pendulum | High-Density Tungsten Alloy Pendulum | Pendule en alliage de tungstène haute densité | Hochdichte Wolframlegieungspendel | High Density Density Alloy Powder |
| High Density Tungsten Alloy Balance Bar | High-Density Tungsten Alloy Balance Rod | Tage d'équilibre en alliage de tungstène haute densité | Hochdichte Wolframlegieungsbalancestab | High Density Polyester Alloy Block |
| High Density Tungsten Alloy | High-Density Tungsten Alloy Crankshaft | Vilebrequin en alliage de tungstène | Hochdichte Wolframlegieungskurbelwelle | High density タングステン alloy クランクシャフト |

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| Crankshaft | | haute densité | | |
| High Density Tungsten Alloy Piston | High-Density Tungsten Alloy Piston | Piston en alliage de tungsten haute densité | Hochdichte Wolframlegieungskolben | High-density polyester alloy |
| High Density Tungsten Alloy Air Nozzle | High-Density Tungsten Alloy Jet Nozzle | Busy and jet-setting alliage | Hochdichte Wolframlegieungsstrahldüse | High-density polyester alloy |
| High Density Tungsten Alloy Gyroscope | High-Density Tungsten Alloy Gyroscope | Gyroscope in alliage de tungsten haute densité | Hochdichte Wolframlegieungsgyroskop | High-density タングステン alloy steel |
| High Density Tungsten Alloy Bullet | High-Density Tungsten Alloy Bullet Head | Allegiance to allegiance | Hochdichte Wolframlegieungsgeschossspitze | High-density タングステン alloy head |
| High Density Tungsten Alloy Armor Plate | High-Density Tungsten Alloy Armor Plate | Plaque d'armure en alliage de tungstène haute densité | Hochdichte Wolframlegieungspanzerplatte | High-density タングステン alloy armor プレート |
| High Density Tungsten Alloy Protective Sleeve | High-Density Tungsten Alloy Protective Sleeve | Manchon protector in alliance with tungsten haute densité | Hochdichte Wolframlegieungsschutzhülse | High-density タングステン alloy protective coating |
| High Density Tungsten Alloy Wire | High-Density Tungsten Alloy Conductor Wire | Filth conductor in alliance with tungsten haute densité | Hochdichte Wolframlegieungsleitdraht | High density タングステン alloy wire |
| High Density Tungsten Alloy Pressed Plate | High-Density Tungsten Alloy Press Sheet | Feuille de presse en alliage de tungstène haute densité | Hochdichte Wolframlegieungspressblech | High Density Polyester Alloy Polyester |
| High Density Tungsten Alloy Heat Sink | High-Density Tungsten Alloy Heat Sink | Dissipateur thermique en alliage de tungstène haute densité | Hochdichte Wolframlegierungswärmesenke | High-density タングステン alloy pipe |
| High Density Tungsten Alloy Rotating Shaft | High-Density Tungsten Alloy Rotary Shaft | Arbre rotatif en alliage de tungstène haute densité | Hochdichte Wolframlegieungsrotationswelle | High-density polyester alloy |
| High Density Tungsten Alloy Support Rod | High-Density Tungsten Alloy Support Rod | Tige de support en alliance de tungstène | Hochdichte Wolframlegieungsstützstange | High-density polyester alloy silica |

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| | | haute densité | | |
| High Density Tungsten Alloy Adjustment Plate | High-Density Tungsten Alloy Adjustment Sheet | Feuille d'ajustement en alliage de tungstène haute densité | Hochdichte Wolframlegierungseinstellblech | High-density タングステン alloy adjusted シート |
| High Density Tungsten Alloy Filter | High-Density Tungsten Alloy Filter Sheet | Feuille de filtre en alliage de tungstène haute densité | Hochdichte Wolframlegierungsfilterblech | High-density タングステン alloy fiberglass |
| High Density Tungsten Alloy Thermal Conductive Sheet | High-Density Tungsten Alloy Thermal Conductive Sheet | Feuille conductrice thermique en alliage de tungstène haute densité | Hochdichte Wolframlegierungswärmeleitblech | High density タングステン alloy thermal conductor |
| High Density Tungsten Alloy Heat Absorber | High-Density Tungsten Alloy Heat Absorption Sheet | Feuille d'absorption thermique en alliage de tungstène haute densité | Hochdichte Wolframlegierungswärmeabsorptionsblech | High-density タングステン alloy heat-absorbing シート |
| High Density Tungsten Alloy Wear Strip | High-Density Tungsten Alloy Wear Strip | Bandage in alliance with tungsten haute densité | Hochdichte Wolframlegierungsverschlei ß streifen | High-density タングステン alloy wear-resistant ストリップ |
| High density tungsten alloy wear block | High-Density Tungsten Alloy Wear Block | Bloc d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegieungsverschlei ß block | High-density タングステン alloy wear-resistant ブロック |
| High Density Tungsten Alloy Wear Resistant Ring | High-Density Tungsten Alloy Wear Ring | Anneau d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß ring | High-density タングステン alloy wear-resistant リング |
| High Density Tungsten Alloy Wear Pad | High-Density Tungsten Alloy Wear Pad | Cousins of all kinds | Hochdichte Wolframlegierungsverschlei ßpolster | High-density タングステン alloy wear-resistant パッド |
| High density tungsten alloy blade | High-Density Tungsten Alloy Blade | Lame en alliage de tungstène haute densité | Hochdichte Wolframlegieungsklinge | High-density タングステン alloy alloy |
| High Density Tungsten Alloy Cutting Head | High-Density Tungsten Alloy Cutting Head | Allegiance to allegiance | Hochdichte Wolframlegieungsschneidkopf | High density タングステン alloy cutting tool |

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| High Density Tungsten Alloy Drill Bit | High-Density Tungsten Alloy Drill Bit | Foretold alliage de tungstène haute densité | Hochdichte Wolframlegieungsbohrer | High Density Polyester Alloy |
| High Density Tungsten Alloy Milling Cutter | High-Density Tungsten Alloy Milling Cutter | Fraise in alliance with tungsten haute densité | Hochdichte Wolframlegierungsfräser | High density タングステン alloy ミリングカッター |
| High Density Tungsten Alloy Punch | High-Density Tungsten Alloy Punch | Poin ç on en alliance de tungst è ne haute densit é | Hochdichte Wolframlegieungsstanze | High-density タングステン alloy material |
| High Density Tungsten Alloy Mold | High-Density Tungsten Alloy Die | Moule en alliance de tungsten haute densité | Hochdichte Wolframlegieungsform | High density タングステン alloy gold type |
| High Density Tungsten Alloy Wire Drawing Die | High-Density Tungsten Alloy Wire Drawing Die | Filières of all kinds | Hochdichte Wolframlegieungsziehmatrize | High density タングステン alloy wire lead きダイ |
| High Density Tungsten Alloy Extrusion Die | High-Density Tungsten Alloy Extrusion Die | Matrice d'extrusion en alliage de tungstène haute densité | Hochdichte Wolframlegierungs-extrusionsform | High density タングステン alloy extrusion |
| High Density Tungsten Alloy Stamping Die | High-Density Tungsten Alloy Stamping Die | Matrice de poin ç onnage en alliance de tungst è ne haute densit é | Hochdichte Wolframlegieungsstanzform | High-density polyester alloy |
| High Density Tungsten Alloy Sandblasting Nozzle | High-Density Tungsten Alloy Sandblasting Nozzle | Bust in sablage in alliance with tungsten haute densité | Hochdichte Wolframlegieungssandstrahldüse | High Density Density Alloy Stainless steel |
| High Density Tungsten Alloy Grinding Head | High-Density Tungsten Alloy Grinding Head | Allegiance to allegiance | Hochdichte Wolframlegieungsschleifkopf | High density タングステン alloy grinding tube |
| High Density Tungsten Alloy Polishing Pad | High-Density Tungsten Alloy Polishing Sheet | Feuille de polissage en alliage de tungstène haute densité | Hochdichte Wolframlegierungspolierblech | High-density タングステン alloy grinding tool |
| High density tungsten alloy wear resistant lining | High-Density Tungsten Alloy Wear Liner | Doublure d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß auskleidung | High-density タングステン alloy wear-resistant ライナー |

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| High density tungsten alloy wear-resistant shaft | High-Density Tungsten Alloy Wear Shaft | Arbre d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegieungsverschlei ß welle | High-density タングステン alloy wear-resistant シャフト |
| High density tungsten alloy wear-resistant roller | High-Density Tungsten Alloy Wear Roller | Rouleau d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegieungsverschlei ß rolle | High-density タングステン alloy wear-resistant ローラー |
| High density tungsten alloy wear-resistant teeth | High-Density Tungsten Alloy Wear Tooth | Dent and alleviation of tungsten haute densité | Hochdichte Wolframlegierungsverschlei ß zahn | High-density タングステン alloy is resistant to wear and tear |
| High Density Tungsten Alloy Wear Resistant Pillar | High-Density Tungsten Alloy Wear Column | Colonne d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß s ä ule | High-density タングステン alloy wear-resistant コラム |
| High Density Tungsten Alloy Wear Resistant Disc | High-Density Tungsten Alloy Wear Disc | Disques in allegiance of tungsten haute densité | Hochdichte Wolframlegierungsverschlei ß scheibe | High-density タングステン alloy wear-resistant ディスク |
| High density tungsten alloy wear-resistant screw | High-Density Tungsten Alloy Wear Screw | Vis d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß schraube | High-density タングステン alloy wear-resistant スクリュー |
| High Density Tungsten Alloy Guide Strip | High-Density Tungsten Alloy Guide Strip | Band of guides in alliance with tungsten haute densité | Hochdichte Wolframlegierungsführungsstreifen | High-density タングステン alloy ガイドストリップ |
| High density tungsten alloy spray particles | High-Density Tungsten Alloy Spray Granule | Granule de pulvération en alliage de tungstène haute densité | Hochdichte Wolframlegierungssprühgranulat | High-density polyester alloy silica granules |
| High Density Tungsten Alloy Spray Rod | High-Density Tungsten Alloy Spray Rod | Tige of pulverization in alliage of tungsten haute densité | Hochdichte Wolframlegieungssprühstab | High-density polyester alloy |
| High density tungsten alloy spray film | High-Density Tungsten Alloy Spray Film | Film of all kinds | Hochdichte Wolframlegierungssprühfilm | High-density polyester alloy |
| High Density Tungsten Alloy Micro Drill | High-Density Tungsten Alloy Micro Drill | Micro-forestry in alliance with tungsten haute | Hochdichte Wolframlegierungsmikrobohrer | High density タングステン alloy マイクロドリル |

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| | | densité | | |
| High Density Tungsten Alloy End Mill | High-Density Tungsten Alloy End Mill | Fraise in bout en alliance in tungsten haute densité | Hochdichte Wolframlegierungsschaftfräser | High-density polyester alloy |
| High Density Tungsten Alloy Ball End Milling Cutter | High-Density Tungsten Alloy Ball End Mill | The most beautiful thing about all kinds of things | Hochdichte Wolframlegierungskugelkopffräser | High Density Polyester Alloy Block |
| High Density Tungsten Alloy Step Drill | High-Density Tungsten Alloy Step Drill | Foretold in alliance with tungsten haute densité | Hochdichte Wolframlegierungsstufenbohrer | High-density polyester alloy |
| High Density Tungsten Alloy Center Drill | High-Density Tungsten Alloy Center Drill | Foretold in alliage of tungsten haute densité | Hochdichte Wolframlegierungszentrierbohrer | High-density polyester alloy |
| High Density Tungsten Alloy Drill | High-Density Tungsten Alloy Counterbore Drill | Foretold in all kinds of tungsten haute densities | Hochdichte Wolframlegierungssenkbohrer | High Density Polyester Alloy Coating |
| High Density Tungsten Alloy Countersink | High-Density Tungsten Alloy Countersink Drill | Foretold in alliage of tungsten haute densité | Hochdichte Wolframlegierungssenkbohrer | High-density タングステン alloy plate |
| High Density Tungsten Alloy Turning Tool | High-Density Tungsten Alloy Turning Tool | Out of sight tour in alliage of tungsten haute densité | Hochdichte Wolframlegierungsdrehwerkzeug | High-density タングステン alloy turning tools |
| High Density Tungsten Alloy Grooving Tool | High-Density Tungsten Alloy Grooving Tool | Out-of-the-way rainstorms in alleys | Hochdichte Wolframlegierungsnutwerkzeug | High density タングステン alloy groove cutting tool |
| High Density Tungsten Alloy Thread Cutters | High-Density Tungsten Alloy Threading Tool | Out of file in alliage of tungsten haute densité | Hochdichte Wolframlegierungsgewinde-werkzeug | High density タングステン alloy cutting tool |
| High Density Tungsten Alloy Internal Hole Cutter | High-Density Tungsten Alloy Boring Tool | Out of stock in alliage of tungsten haute densité | Hochdichte Wolframlegierungsbohrwerkzeug | High-density タングステン alloy inner diameter machining tool |
| High Density Tungsten Alloy Forming Knife | High-Density Tungsten Alloy Forming Tool | Out of shape in alliage of tungsten haute densité | Hochdichte Wolframlegierungsformwerkzeug | High-density タングステン alloy forming tools |
| High Density Tungsten Alloy Polishing | High-Density Tungsten Alloy Polishing Wheel | Rouge de polissage en alliage de tungstène | Hochdichte Wolframlegieungspolierscheibe | High density タングステン alloy grinding ホイール |

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| Wheel | | haute densité | | |
| High Density Tungsten Alloy Grinding Rod | High-Density Tungsten Alloy Grinding Rod | Tige de meulage en alliage de tungstène haute densité | Hochdichte Wolframlegieungsschleifstab | High Density Polyester Alloy Grinding ロッド |
| High Density Tungsten Alloy Wear Resistant Balls | High-Density Tungsten Alloy Wear Ball | Boule d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß kugel | High-density タングステン alloy wear-resistant ボール |
| High density tungsten alloy valve seat | High-Density Tungsten Alloy Valve Seat | Siège de valve en alliage de tungstène haute densité | Hochdichte Wolframlegierungsventilsitz | High Density Polyester Alloy Block |
| High Density Tungsten Alloy Jet Tube | High-Density Tungsten Alloy Jet Tube | Tube and jet in alliage de tungsten haute densité | Hochdichte Wolframlegieungsstrahlrohr | High-density タングステン alloy steel |
| High density tungsten alloy wear-resistant bushing | High-Density Tungsten Alloy Wear Bushing | Douille d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß buchse | High-density タングステン alloy wear-resistant ブッシング |
| High density tungsten alloy guide ring | High-Density Tungsten Alloy Guide Ring | Anneau de guidage en alliage de tungstène haute densité | Hochdichte Wolframlegierungsführungsring | High-density polyester alloy |
| High density tungsten alloy wear-resistant guide plate | High-Density Tungsten Alloy Wear Guide Plate | Plaque of guidance in allegiance of tungsten haute densité | Hochdichte Wolframlegierungsverschlei ß führungsplatte | High-density タングステン alloy wear-resistant ガイドプレート |
| High Density Tungsten Alloy Cutting Wire | High-Density Tungsten Alloy Cutting Wire | Fil de coupe en alliance de tungstène haute densité | Hochdichte Wolframlegieungsschneidedraht | High density タングステン alloy cutting tool |
| High density tungsten alloy wear-resistant connector | High-Density Tungsten Alloy Wear Connector | Connected with all kinds of things | Hochdichte Wolframlegierungsverschlei ß verbinder | High-density タングステン alloy wear-resistant コネクター |
| High Density Tungsten Alloy Polishing Strip | High-Density Tungsten Alloy Polishing Strip | Band of polissage en alliage de tungsten haute densité | Hochdichte Wolframlegierungspolierstreifen | High-density タングステン alloy grinding material |
| High density tungsten alloy | High-Density Tungsten Alloy | Bustage in alliance with | Hochdichte Wolframlegierungsverschlei ß dü se | High-density タングステン alloy |

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| wear-resistant nozzle | Wear Nozzle | tungsten haute densité | | wear-resistant ノズル |
| High Density Tungsten Alloy Stamping Rod | High-Density Tungsten Alloy Stamping Rod | Tage d'estampage en alliage de tungstène haute densité | Hochdichte Wolframlegieungsstanzstab | High-density polyester alloy |
| High density tungsten alloy wear-resistant valve core | High-Density Tungsten Alloy Wear Valve Core | Noyau de valved'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß ventilkern | High-density タングステン alloy wear resistant バルブコア |
| High Density Tungsten Alloy Guide Wheel | High-Density Tungsten Alloy Guiding Wheel | Rouge of guidance and alliage of tungsten haute densité | Hochdichte Wolframlegieungsführungsrad | High density タングステン alloy ガイドホイール |
| High Density Tungsten Alloy Wear-Resistant Wire Drawing Die | High-Density Tungsten Alloy Wear Drawing Die | Filière d'usure en tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß ziehmatrize | High-density タングステン alloy wear-resistant wire lead きダイ |
| High density tungsten alloy wear-resistant punch | High-Density Tungsten Alloy Wear Punch | Poin ç on d ' usure en alliage de tungst è ne haute densit é | Hochdichte Wolframlegierungsverschlei ß stanze | High-density タングステン alloy wear-resistant パンチ |
| High Density Tungsten Alloy Cutting Pad | High-Density Tungsten Alloy Cutting Pad | Cousin de coupe en alliage de tungstène haute densité | Hochdichte Wolframlegieungsschneidpolster | High-density タングステン alloy cutting materials |
| High density tungsten alloy wear-resistant bearings | High-Density Tungsten Alloy Wear Bearing | Roulement in alliance with tungsten haute densité | Hochdichte Wolframlegierungsverschlei ß lager | High-density タングステン alloy wear-resistant ベアリング |
| High Density Tungsten Alloy Wear Resistant Washers | High-Density Tungsten Alloy Wear Washer | Rondelle in alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß scheibe | High-density タングステン alloy wear-resistant ワッシャー |
| High density tungsten alloy wear-resistant sleeve | High-Density Tungsten Alloy Wear Sleeve | Manchon d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß h ü lse | High-density タングステン alloy wear-resistant スリーブ |
| High Density Tungsten Alloy | High-Density Tungsten Alloy Polishing Disc | Disques of polissage in alliage of | Hochdichte Wolframlegieungspolierscheibe | High-density タングステン alloy grinding tube |

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| Polishing Pad | | tungsten haute densité | | |
| High density tungsten alloy wear-resistant flywheel | High-Density Tungsten Alloy Wear Flywheel | Voltage in alliance with tungsten haute densité | Hochdichte Wolframlegierungsverschlei ß schwungrad | High-density タングステン alloy wear-resistant fiberglass |
| High density tungsten alloy wear-resistant guide wheel | High-Density Tungsten Alloy Wear Guide Wheel | Rouge de guidage d'usure en alliage de tungstène haute densité | Hochdichte Wolframlegierungsverschlei ß führungsrad | High-density タングステン alloy wear-resistant ガイドホイール |

**Types of Tungsten Carbide Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Carbide Rods | Tungsten Carbide Rod | Barre en carbure de tungstène | Wolframkarbidstab | Carbide Rod |
| Carbide Plate | Tungsten Carbide Plate | Plaque en carburetungstène | Wolframkarbidplatte | Carbide Plate |
| Carbide inserts | Tungsten Carbide Insert | Insert en carburetngstène | Wolframkarbideinsatz | Carbide Insulator |
| Carbide cutting tools | Tungsten Carbide Cutting Tool | Outer coupe in car | Wolframkarbid-Schneidwerkzeug | Carbide cutting tools |
| Carbide drill bits | Tungsten Carbide Drill Bit | Foret en carburetngstène | Wolframkarbidbohrer | Carbide ドリルビット |

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| Carbide mold | Tungsten Carbide Die | Moule en carburetngstène | Wolframkarbidform | Carbide Die |
| Carbide Ball | Tungsten Carbide Ball | Boule en carbure de tungstène | Wolframkarbidkugel | Carbide Ball |
| Carbide Abrasives | Tungsten Carbide Abrasive | Abrasif en carbure de tungstène | Wolframkarbidschleifmittel | Carbide Abrasives |
| Carbide Nozzle | Tungsten Carbide Nozzle | Bus in the car of tungsten | Wolframkarbiddüse | Hard alloy nozul |
| Carbide milling cutter | Tungsten Carbide Milling Cutter | Fraise in carbure de tungsten | Wolframkarbidfräser | Carbide ミリング カッター |
| Carbide Saw Blades | Tungsten Carbide Saw Blade | Lame de sci en carbure de tungstène | Wolframkarbids ä geblatt | Carbide Nokogiri Blade |
| Carbide Wire Drawing Dies | Tungsten Carbide Wire Drawing Die | Filière de tréfilage en carbure | Wolframkarbid-Ziehmatrize | Carbide wire guide |
| Carbide Punch | Tungsten Carbide Punch | Poin ç on en carbure de tungsten è ne | Wolframkarbidstanze | Carbide Pan |
| Carbide Rollers | Tungsten Carbide Roller | Rouleau en carburetungstène | Wolframkarbidrolle | Carbide Roller |
| Carbide gears | Tungsten Carbide Gear | Engagement in carburetion | Wolframkarbidzahnrad | Carbide galvanneal |
| Carbide bearings | Tungsten Carbide Bearing | Roulement en carburetungstène | Wolframkarbidlager | Cemented Carbide Bealing |
| Carbide sealing ring | Tungsten Carbide Seal Ring | Anneau d'étanchéité en carbure | Wolframkarbid-Dichtungsring | Carbide solid carbide |
| Carbide gasket | Tungsten Carbide Gasket | Joint en carburetungstène | Wolframkarbiddichtung | Carbide Gasket |
| Carbide Nuts | Tungsten Carbide Nut | É crou en carbure de tungsten è ne | Wolframkarbidmutter | Carbide Natch |
| Carbide bolts | Tungsten Carbide Bolt | Boulon en carburetungstène | Wolframkarbidschraube | Carbide Bolt |
| Carbide Tools | Tungsten Carbide Tool | Out of stock | Wolframkarbidwerkzeug | Carbide Tools |
| Carbide Bushing | Tungsten Carbide Bushing | Douille en carbure de tungstène | Wolframkarbidbushse | Carbide Brushing |
| Carbide valve core | Tungsten Carbide Valve Core | Noyau de valve en carbure | Wolframkarbidventilkern | Carbide Ball Buco |
| Carbide sandblasting nozzle | Tungsten Carbide Sandblasting Nozzle | Use of sablage in carbure | Wolframkarbid-Sandstrahldüse | Carbide solid carbide |
| Carbide grinding head | Tungsten Carbide Grinding Head | Tea of meat in carbuncle | Wolframkarbid-Schleifkopf | Carbide grinding wheel |
| Carbide pick | Tungsten Carbide Cutting Pick | Piece of coupe in car | Wolframkarbid-Schneidzahn | Carbide carbide carbide |
| Carbide Drill | Tungsten Carbide Drill | Tige of forage in | Wolframkarbid-Bohrstange | Carbide ドリル |

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| Rod | Rod | carbure | | ロッド |
| Carbide Reamers | Tungsten Carbide Reamer | Alésoir en carbure de tungstène | Wolframkarbidreamer | Hard alloy lid |
| Carbide Circular Saw | Tungsten Carbide Circular Saw | Circulation in car | Wolframkarbid - Kreissäge | Carbide Ball Noko |
| Carbide Band Saw | Tungsten Carbide Band Saw | Scissors with rubber in carbide | Wolframkarbid - Bandsäge | Carbide Band Sole |
| Carbide cutting disc | Tungsten Carbide Cutting Disc | Disque de coupe en carbure | Wolframkarbid-Schneidescheibe | Carbide cutting tool |
| Carbide Dies | Tungsten Carbide Stamping Die | Matrice d'estampage en carbure | Wolframkarbid-Stanzform | Carbide スタンピングダイ |
| Carbide drawing die | Tungsten Carbide Stretching Die | Matrice d'étirement en carbure | Wolframkarbid-Streckform | Carbide solid carbide |
| Carbide Extrusion Die | Tungsten Carbide Extrusion Die | Matrice d'extrusion en carbure | Wolframkarbid-Extrusionsform | Carbide Extrusion Machine |
| Cemented Carbide Powder | Tungsten Carbide Powder | Poudre de carbure de tungstène | Wolframkarbidpulver | Cemented Carbide Powder |
| Carbide particles | Tungsten Carbide Granule | Granule de carbure de tungstène | Wolframkarbidgranulat | Carbide particles |
| Carbide film | Tungsten Carbide Film | Film of carbuncle of tungsten | Wolframkarbidfilm | Cemented Carbide Filament |
| Carbide foil | Tungsten Carbide Foil | Feuille de carbure de tungstène | Wolframkarbidfolie | Hard alloy foil |
| Carbide wire | Tungsten Carbide Wire | Fil de carbure de tungsten | Wolframkarbiddraht | Carbide Wheel |
| Carbide Ring | Tungsten Carbide Ring | Anneau de carbure de tungstène | Wolframkarbidring | Hard alloy ring |
| Carbide welding knife | Tungsten Carbide Welding Blade | Lamb of sourdough in carb | Wolframkarbid-Schweißklinge | Carbide welding blade |
| Carbide polishing pads | Tungsten Carbide Polishing Sheet | Feuille de polissage en carbure | Wolframkarbid-Polierblech | Carbide Grinding Table |
| Carbide wear strips | Tungsten Carbide Wear Strip | Band of water in car | Wolframkarbid-Verschleißstreifen | Carbide wear-resistant alloy |
| Carbide guide rails | Tungsten Carbide Guide Rail | Rail guide in car | Wolframkarbid-Führungsschiene | Carbide ガイドレール |
| Carbide roller | Tungsten Carbide Press Roller | Rouleau de presse en carbure | Wolframkarbid-Pressrolle | Carbide alloy |
| Carbide Balls | Tungsten Carbide Roller Ball | Buy a piece of cheese | Wolframkarbid-Rollkugel | Carbide alloy |
| Carbide Connectors | Tungsten Carbide Connector | Connecteur en carburetungstène | Wolframkarbid-Verbindungsstück | Carbide Cone |
| Carbide | Tungsten Carbide Washer | Rondelle en | Wolframkarbid - | Carbide Washer |

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| washers | | carburetungstène | Unterlegscheibe | |
| Carbide Bushings | Tungsten Carbide Sleeve | Manchon en carburetungstène | Wolframkarbid-Hülse | Carbide thread |
| Carbide cutter head | Tungsten Carbide Cutter Disc | Disque de coupeur en carbure | Wolframkarbid-Schneidescheibe | Carbide carbide |
| Cemented Carbide Target | Tungsten Carbide Target | Cible en carburet tungstène | Wolframkarbid-Zielscheibe | Carbide Tips |
| Carbide spray powder | Tungsten Carbide Spray Powder | Poudre de pulvération en carbure | Wolframkarbid-Sprühpulver | Carbide スプレー powder |
| Carbide wear-resistant sheet | Tungsten Carbide Wear Plate | Plaque of water in carbure | Wolframkarbid-Verschlei ß platte | Carbide wear-resistant alloy |
| Carbide wear ring | Tungsten Carbide Wear Ring | Anne's use in carbure | Wolframkarbid-Verschlei ß ring | Carbide wear-resistant リング |
| Carbide handle | Tungsten Carbide Tool Holder | Port-out in car | Wolframkarbid-Werkzeughalter | Carbide alloy |
| Carbide burrs | Tungsten Carbide Burr | Fraise to the barber in the carb | Wolframkarbid - Frässtift | Carbide Bar |
| Carbide scraper | Tungsten Carbide Scraper | Grattoir in carburetungstène | Wolframkarbid-Schaber | Carbide スクレーパー |
| Carbide carving knife | Tungsten Carbide Engraving Tool | Outer gravity in carbure | Wolframkarbid - Gravierwerkzeug | Carbide carving knife |
| Carbide Micro Drill | Tungsten Carbide Micro Drill | Micro-foret in carbure | Wolframkarbid-Mikrobohrer | Carbide mackerel |
| Carbide End Mills | Tungsten Carbide End Mill | Fraise in the carbure | Wolframkarbid - Schaftfräser | Hard alloy endomi |
| Carbide Taper Milling Cutter | Tungsten Carbide Tapered Mill | Fold the carbide | Wolframkarbid - Kegelfräser | Carbide テーパーミル |
| Carbide ball end mills | Tungsten Carbide Ball End Mill | Fraise and bout sphérique en carbure | Wolframkarbid - Kugelkopffräser | Carbide ボールエンドミル |
| Carbide drilling and milling cutters | Tungsten Carbide Drill Mill | Fraise-foret in carbure | Wolframkarbid - Bohrfräser | Hard alloy dollil |
| Carbide Reamer Drill | Tungsten Carbide Counterbore Drill | Forage for the car | Wolframkarbid-Senkbohrer | Carbide カウンターボア |
| Carbide center drill | Tungsten Carbide Center Drill | Fortify the car | Wolframkarbid-Zentrierbohrer | Carbide carbide alloy |
| Carbide step drill | Tungsten Carbide Step Drill | Forget about eating in the car | Wolframkarbid-Stufenbohrer | Carbide solid carbide |
| Carbide countersinks | Tungsten Carbide Countersink Drill | Forage for a car | Wolframkarbid-Senkbohrer | Carbide dish |

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| Carbide milling inserts | Tungsten Carbide Milling Insert | Plaquette de fraisage en carbure | Wolframkarbid - Fräseinsatz | Carbide ミリングインサート |
| Carbide turning tools | Tungsten Carbide Turning Tool | Out of the car tour | Wolframkarbid-Drehwerkzeug | Carbide Turning Tools |
| Carbide turning inserts | Tungsten Carbide Turning Insert | Plaquette de tournage en carbure | Wolframkarbid-Dreheinsatz | Carbide turning machine |
| Carbide Grooving Tools | Tungsten Carbide Grooving Tool | External rainwater in car | Wolframkarbid-Nutwerkzeug | Carbide Grooving Tools |
| Carbide thread cutter | Tungsten Carbide Threading Tool | Out of file in car | Wolframkarbid-Gewindewerkzeug | Carbide cutting tools |
| Carbide internal hole cutter | Tungsten Carbide Boring Tool | Out of the car | Wolframkarbid-Bohrwerkzeug | Carbide ID Processing Tools |
| Carbide forming knife | Tungsten Carbide Forming Tool | Outer form in carbure | Wolframkarbid-Formwerkzeug | Carbide forming tools |
| Carbide wear pads | Tungsten Carbide Wear Pad | Cousin d'urse in carbure | Wolframkarbid-Verschlei ßpolster | Carbide wear resistant material |
| Carbide spray coating | Tungsten Carbide Coating | Revival in carbure de tungsten | Wolframkarbid-Beschichtung | Carbide carbide |
| Carbide wear-resistant lining | Tungsten Carbide Wear Liner | Double sided carbide | Wolframkarbid-Verschlei ß auskleidung | Carbide wear resistant material |
| Carbide cutting wire | Tungsten Carbide Cutting Wire | Fil de coupe en carbure | Wolframkarbid-Schneidedraht | Carbide cutting tool |
| Carbide polishing wheel | Tungsten Carbide Polishing Wheel | Routes de polissage en carbure | Wolframkarbid-Polierscheibe | Carbide grinding tool |
| Carbide grinding rod | Tungsten Carbide Grinding Rod | Tige of meat in car | Wolframkarbid-Schleifstab | Carbide grinding wheel |
| Carbide wear-resistant balls | Tungsten Carbide Wear Ball | Boule d'auré en carbure | Wolframkarbid-Verschlei ß kugel | Carbide wear resistant material |
| Carbide valve seat | Tungsten Carbide Valve Seat | Sequence of valves in carburette | Wolframkarbid-Ventilsitz | Carbide carbide |
| Carbide injection nozzle | Tungsten Carbide Jet Nozzle | Bus with jet in car | Wolframkarbid-Strahldüse | Carbide ジェットノズル |
| Carbide protective sleeve | Tungsten Carbide Protective Sleeve | Man protects car | Wolframkarbid-Schutzhülse | Carbide protection スリーブ |
| Carbide wear- | Tungsten Carbide Wear Shaft | Arbre d'use in carbure | Wolframkarbid-Verschlei ß welle | Carbide wear resistant carbide |

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| resistant shaft | | | | |
| Carbide punch head | Tungsten Carbide Stamping Head | Test of aging in carbure | Wolframkarbid-Stanzkopf | Carbide スタンプヘッド |
| Carbide Grinding Wheel | Tungsten Carbide Grinding Wheel | Meule en carbure de tungstène | Wolframkarbid-Schleifscheibe | Carbide grinding tool |
| Carbide drill bit set | Tungsten Carbide Drill Sleeve | Manchon de foret en carbure | Wolframkarbid-Bohrhülse | Carbide ドリルスリーブ |
| Carbide guide wheel | Tungsten Carbide Guide Wheel | Roue de guidage en carbure | Wolframkarbid-Führungsscheibe | Carbide ガイドホイール |
| Carbide Dies | Tungsten Carbide Press Die | Matrice of press in carbure | Wolframkarbid - Pressform | Carbide Prestige |
| Carbide cutting wheel | Tungsten Carbide Cutting Wheel | The best coupe in the car | Wolframkarbid-Schneidescheibe | Carbide cutting tool |
| Carbide wear-resistant washers | Tungsten Carbide Wear Washer | Rondelle d'use in carbure | Wolframkarbid-Verschlei ß scheibe | Carbide wear-resistant steel |
| Carbide wear-resistant roller | Tungsten Carbide Wear Roller | Rouleau d'autre in carbure | Wolframkarbid-Verschlei ß rolle | Carbide wear-resistant alloy |
| Cemented carbide particles | Tungsten Carbide Particle | Particulate matter | Wolframkarbidteilchen | Cemented Carbide Particles |
| Carbide drill bit | Tungsten Carbide Drill Needle | Aiguille of forage in carpentry | Wolframkarbid-Bohrnadel | Carbide ドリルニードル |
| Carbide cutting blades | Tungsten Carbide Cutting Strip | Carbure coupe band | Wolframkarbid-Schneidstreifen | Carbide cutting tool |
| Carbide wear blocks | Tungsten Carbide Wear Block | Block of water in car | Wolframkarbid-Verschlei ß block | Carbide wear-resistant alloy |
| Carbide polishing rod | Tungsten Carbide Polishing Rod | Tige of carpentry | Wolframkarbid-Polierstab | Carbide grinding wheel |
| Carbide spray particles | Tungsten Carbide Spray Granule | Granule of pulverization in carbure | Wolframkarbid-Sprühgranulat | Carbide Surface Plate |
| Carbide wear-resistant bushings | Tungsten Carbide Wear Bushing | How to use the car | Wolframkarbid-Verschlei ß buchse | Carbide wear resistant carbide |
| Carbide guide ring | Tungsten Carbide Guide Ring | Anne of guidance in carbure | Wolframkarbid-Führungsring | Carbide ガイドリング |
| Carbide stamping die | Tungsten Carbide Punch Die | Matrice de poinç onnage en carbure | Wolframkarbid-Stanzmatrize | Carbide Panchdai |

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| Carbide wear-resistant guide plate | Tungsten Carbide Wear Guide Plate | Plaque de guide d'usure en carbure | Wolframkarbid -Verschlei ß führungsplatte | Carbide wear resistant alloy |
| Carbide Pressed Plates | Tungsten Carbide Press Sheet | Few clicks on the car | Wolframkarbid-Pressblech | Carbide プレスシート |
| Carbide wear-resistant sleeve | Tungsten Carbide Wear Sleeve | Man with a knife in the car | Wolframkarbid-Verschlei ß h ü lse | Carbide wear resistant material |
| Carbide injection tube | Tungsten Carbide Jet Tube | Tube to jet in carbure | Wolframkarbid-Strahlrohr | Carbide carbide alloy |
| Carbide wear-resistant teeth | Tungsten Carbide Wear Tooth | Dent d'use in carbure | Wolframkarbid-Verschlei ß zahn | Carbide wear-resistant teeth |
| Carbide polishing disc | Tungsten Carbide Polishing Disc | Disque de polissage en carbure | Wolframkarbid-Polierscheibe | Carbide grinding technology |
| Carbide wear-resistant posts | Tungsten Carbide Wear Column | Colonne d'occupation en carbure | Wolframkarbid-Verschlei ß s ä ule | Carbide wear resistant carbide |
| Carbide cutting blades | Tungsten Carbide Cutting Bar | Car Coupe Car | Wolframkarbid-Schneidestange | Carbide cutting tool |
| Carbide wear-resistant bushing | Tungsten Carbide Wear Liner Bushing | Double sided carbide | Wolframkarbid-Verschlei ß buchse | Carbide wear resistant alloy |
| Carbide stamping sheet | Tungsten Carbide Stamping Sheet | Feuille d'estampage en carbure | Wolframkarbid-Stanzblech | Carbide スタンピングシート |
| Carbide wear-resistant screw | Tungsten Carbide Wear Screw | Seeing the carbure | Wolframkarbid-Verschlei ß schraube | Carbide wear resistant material |
| Carbide guide strips | Tungsten Carbide Guide Strip | Band of guidance on car | Wolframkarbid-Führungsstreifen | Carbide ガイドストリップ |
| Carbide wear-resistant disc | Tungsten Carbide Wear Disc | Disque d'use in carbure | Wolframkarbid-Verschlei ß scheibe | Carbide wear resistant material |
| Carbide spray rod | Tungsten Carbide Spray Rod | Tige de pulvération en carbure | Wolframkarbid-Sprühstab | Carbide solid carbide |
| Carbide wear- | Tungsten Carbide Wear Wheel | Roue d'usure en carbure | Wolframkarbid-Verschlei ß rad | Carbide wear resistant material |

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| resistant wheel | | | | |
| Carbide cutting needle | Tungsten Carbide Cutting Needle | A piece of coupe in car | Wolframkarbid-Schneidenadel | Carbide cutting tool |
| Carbide wear-resistant connectors | Tungsten Carbide Wear Connector | Connect your car | Wolframkarbid-Verschlei ß verbinder | Carbide wear-resistant carbide |
| Carbide polishing strips | Tungsten Carbide Polishing Strip | Band of polissage in carbure | Wolframkarbid-Polierstreifen | Carbide Grinding System |
| Carbide wear-resistant nozzle | Tungsten Carbide Wear Nozzle | Use of wood in car | Wolframkarbid-Verschlei ß d ü se | Carbide wear resistant ノズル |
| Carbide stamping rod | Tungsten Carbide Stamping Rod | Tige d'estampage en carbure | Wolframkarbid-Stanzstab | Carbide スタンピングロッド |
| Hard alloy wear-resistant valve core | Tungsten Carbide Wear Valve Core | Noyau de valve d'usure en carbure | Wolframkarbid-Verschlei ß ventilkern | Carbide wear-resistant alloy |
| Carbide guide wheel | Tungsten Carbide Guiding Wheel | Roue de guidage en carbure | Wolframkarbid-Führungsrad | Carbide ガイドホイール |
| Carbide wear-resistant wire drawing die | Tungsten Carbide Wear Drawing Die | Filière d'occupation en carbure | Wolframkarbid-Verschlei ß ziehmatrize | Carbide wear-resistant wire lead きダイ |
| Carbide spray film | Tungsten Carbide Spray Film | Film of pulverization in carbure | Wolframkarbid-Sprühfilm | Carbide スプレーフィルム |
| Carbide wear-resistant punch | Tungsten Carbide Wear Punch | Poinç on d ' usure en carbure | Wolframkarbid-Verschlei ß stanze | Carbide wear resistant material |
| Carbide cutting pads | Tungsten Carbide Cutting Pad | Cousin of coupe in car | Wolframkarbid-Schneidpolster | Carbide cutting pad |
| Hard alloy wear-resistant bearings | Tungsten Carbide Wear Bearing | Roulette d'use in carbure | Wolframkarbid-Verschlei ß lager | Carbide wear-resistant steel |

**Types of Tungsten Steel Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Steel Rod | Tungsten Steel Rod | Barre in the air | Wolframstahlstab | タングステン Steel ロッド |
| Tungsten steel plate | Tungsten Steel Plate | Plaque in the ashes | Wolframstahlplatte | タングステン Steel プレート |

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| Tungsten steel tool | Tungsten Steel Tool | Out in the heat of the night | Wolframstahlwerkzeug | Steel tools |
| Tungsten steel mold | Tungsten Steel Die | Mouth in the ashes | Wolframstahlform | Tangston steel mold |
| Tungsten jewelry | Tungsten Steel Jewelry | Bijou in the heat of the stomach | Wolframstahlschmuck | タングステン steel ジュエリー |
| Tungsten dart | Tungsten Steel Dart | Fléchette en acier de tungstène | Wolframstahlpfeil | タングステン steel ダーツ |
| Tungsten carbide drill bit | Tungsten Steel Drill Bit | Foremost in the stomach | Wolframstahlbohrer | タングステン Steel ドリルビット |

**Types of Tungsten Iron Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten iron block | Tungsten Iron Block | Block of fer-tungsten | Wolfram-Eisenblock | タングステン鉄ブロック |
| Tungsten iron powder | Tungsten Iron Powder | Poudre de fer-tungsten | Wolfram-Eisenpulver | Tangusten iron powder |
| Tungsten Iron Rod | Tungsten Iron Rod | Barre of fer-tungsten | Wolfram-Eisenstab | タングステン鉄ロッド |
| Tungsten iron particles | Tungsten Iron Granule | Granule of fer-tungsten | Wolfram-Eisengranulat | Tangston Iron Granules |
| High purity tungsten iron | High-Purity Tungsten Iron | Fer-tungstène de haute pureté | Hochreines Wolfram-Eisen | High purity polyester iron |

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**Types of Tungsten Gold & Golden Plated Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Bar | Tungsten Gold Bar | Barre d'or de tungstène | Wolfram-Goldbarren | Tangusten Gold Ball |
| Tungsten Jewelry | Tungsten Gold Jewelry | Bijoux in or de tungstène | Wolfram-Goldschmuck | タングステン金ジュエリー |
| Tungsten Ring | Tungsten Gold Ring | Anne in or out of bed | Wolfram-Goldring | タングステン金リング |
| Tungsten Necklace | Tungsten Gold Necklace | Collier in or out of tungstène | Wolfram-Goldkette | タングステン金ネックレス |
| Tungsten Bracelet | Tungsten Gold Bracelet | Bracelet in or out of thong | Wolfram-Goldarmband | タングステン金ブレスレット |
| Tungsten Earrings | Tungsten Gold Earring | Boucle d'oreille en or de tungstène | Wolfram-Goldohrring | タングステン金イヤリング |
| Tungsten Pendant | Tungsten Gold Pendant | Pendentif en or de tungstène | Wolfram - Goldanhänger | タングステン金ペンダント |
| Tungsten Brooch | Tungsten Gold Brooch | Brochure or tungstène | Wolfram-Goldbrosche | タングステン金ブローチ |
| Tungsten Cufflinks | Tungsten Gold Cufflink | Bouton de manchette en or de tungstène | Wolfram-Goldmanschettenknopf | タングステン金カフスボタン |
| Tungsten gold commemorative coins | Tungsten Gold Commemorative Coin | Piece commemorative en or de tungsten | Wolfram-Goldgedenkmünze | タングステン金 commemorative コイン |
| Tungsten decorative plate | Tungsten Gold Decorative Plate | Plaque décorative en or de tungsten | Wolfram-Golddekorplatte | タングステン Gold |

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| | | | | Decoration プレート |
| Tungsten gold conductive sheet | Tungsten Gold Conductive Sheet | Feuille conductrice in or de tungstène | Wolfram-Goldleitblech | タングステン gold conductive シート |
| Tungsten gold contacts | Tungsten Gold Contact | Contact us or send us a message | Wolfram-Goldkontakt | タングステン金コンタクト |
| Tungsten gold electrode | Tungsten Gold Electrode | Électrode en or de tungsten è ne | Wolfram-Goldelektrode | Tangston Gold Electrode |
| Tungsten Foil | Tungsten Gold Foil | Few tungstène | Wolfram-Goldfolie | タングステン金フォイル |
| Tungsten Wire | Tungsten Gold Wire | Fil d'or de tungstène | Wolfram-Golddraht | タングステン金ワイヤー |
| Tungsten gold film | Tungsten Gold Film | Film of tungstène | Wolfram-Goldfilm | タングステン金フィルム |
| Tungsten gold shielding | Tungsten Gold Shielding | Blindness in or out of bed | Wolfram-Goldabschirmung | タングステン金シールド |

**Types of Tungsten Copper Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Tungsten Copper Rod | Tungsten Copper Rod | Barre of tungstène | Wolfram-Kupferstab | タングステン copper ロッド |
| Tungsten Copper Plate | Tungsten Copper Plate | Plate of tungstène | Wolfram-Kupferplatte | タングステン copper プレート |
| Tungsten Copper Block | Tungsten Copper Block | Bloc of tungstène | Wolfram-Kupferblock | タングステン copper ブロック |
| Tungsten Copper Electrode | Tungsten Copper Electrode | Électrode de cuivre - tungstène | Wolfram-Kupferelektrode | Tangusten copper electrode |
| Tungsten Copper Heat Sink | Tungsten Copper Heat Sink | Dissipateur thermique en cuivre-tungstène | Wolfram -Kupfer-Wärmesenke | タングステン copper ヒートシンク |
| Tungsten Copper Tube | Tungsten Copper Tube | Tube of tungstène | Wolfram-Kupferrohr | タングステン copper チューブ |
| Tungsten copper package | Tungsten Copper Encapsulation Sheet | Feuille d'encapsulation cuivre-tungstène | Wolfram-Kupfer-Kapselungsblech | タングステン copper カプセルシート |
| Tungsten Copper Foil | Tungsten Copper Foil | Few dishes of tungstène | Wolfram-Kupferfolie | タングステン copper フォイル |
| Tungsten Copper Wire | Tungsten Copper Wire | Fil de cuivre-tungsten | Wolfram-Kupferdraht | タングステン copper ワイヤー |
| Tungsten Copper Ring | Tungsten Copper Ring | Anne of tungstène | Wolfram-Kupferring | タングステン copper リング |
| Tungsten | Tungsten Copper | Boule de cuivre- | Wolfram-Kupferkugel | タングステン |

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| Copper Ball | Ball | tungstène | | copper ボール |
| Tungsten copper film | Tungsten Copper Film | Film of tungstène | Wolfram-Kupferfilm | タングステン copper フィルム |
| Tungsten copper heat sink | Tungsten Copper Heat Dissipator | Dissipateur de cuivre-tungstène | Wolfram -Kupfer-Wärmeableiter | タングステン copper heat sink |
| Tungsten copper contacts | Tungsten Copper Contact | Contact us | Wolfram-Kupferkontakt | タングステン copper コンタクト |
| Tungsten copper conductive sheet | Tungsten Copper Conductive Sheet | Feuille conductrice cuivre-tungstène | Wolfram-Kupfer-Leitblech | タングステン copper conductive シート |
| Tungsten copper welding joint | Tungsten Copper Weld Joint | Joint de soudure cuivre-tungstène | Wolfram-Kupfer-Schwei ß verbindung | タングステン copper welding ジョイント |
| Tungsten Copper Nozzle | Tungsten Copper Nozzle | Cooking Cuisine | Wolfram-Kupferdüse | タングステン copper ノズル |
| Tungsten Copper Shim | Tungsten Copper Gasket | Joint of tungstène | Wolfram-Kupferdichtung | タングステン copper ガスケット |
| Tungsten Copper Nut | Tungsten Copper Nut | É crou de cuivre-tungsten è ne | Wolfram-Kupfermutter | タングステン copper ナット |
| Tungsten Copper Bolt | Tungsten Copper Bolt | Bouquet of tungstène | Wolfram-Kupferschraube | タングステン copper ボルト |
| Tungsten copper bearings | Tungsten Copper Bearing | Roulement de cuivre-tungstène | Wolfram-Kupferlager | タングステン copper ベアリング |
| Tungsten Copper Gear | Tungsten Copper Gear | Engagement de cuivre-tungstène | Wolfram-Kupferzahnrad | Tangusten Copper Gear |
| Tungsten Copper Connector | Tungsten Copper Connector | Connecteur de cuivre-tungstène | Wolfram-Kupferverbinder | タングステン copper コネクター |
| Tungsten copper guide rail | Tungsten Copper Guide Rail | Rail de guide cuivre-tungstène | Wolfram-Kupferführungsschiene | タングステン copper ガイドレール |
| Tungsten copper sealing ring | Tungsten Copper Seal Ring | Anneau d'étanchéité cuivre-tungstène | Wolfram-Kupferdichtungsring | タングステン copper シールリング |
| Tungsten Copper Target | Tungsten Copper Target | Cible de cuivre-tungstène | Wolfram-Kupferscheibe | タングステン copper ターゲット |
| Tungsten Copper Evaporation Boat | Tungsten Copper Evaporation Boat | Bateau d'évaporation cuivre-tungstène | Wolfram-Kupferverdampfungsboot | タングステン copper steamed 発ボート |

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| Tungsten Copper Thermocouple | Tungsten Copper Thermocouple | Thermocouple de cuivre-tungstène | Wolfram-Kupfer-Thermoelement | タングステン copper thermoelectric |
| Tungsten Copper Fiber | Tungsten Copper Fiber | Fiber of tungstène | Wolfram-Kupferfaser | タングステン copper ファイバー |
| Tungsten Copper Particles | Tungsten Copper Granule | Granule of tungstène | Wolfram-Kupfergranulat | Tangston copper granules |
| Tungsten copper shield | Tungsten Copper Shielding | Blindness of tucked away food | Wolfram-Kupferabschirmung | タングステン copper シールド |
| Tungsten Copper Bushing | Tungsten Copper Bushing | Cup of tungstène | Wolfram-Kupferbuchse | タングステン copper ブッシング |
| Tungsten copper valve core | Tungsten Copper Valve Core | Noyau de valve cuivre-tungstène | Wolfram-Kupferventilkern | タングステン copper バルブコア |
| Tungsten copper probe | Tungsten Copper Probe | Son of tungstène | Wolfram-Kupfersonde | タングステン copper プローブ |
| Tungsten Copper Capillary | Tungsten Copper Capillary Tube | Tube capillary cuivre-tungstène | Wolfram-Kupferkapillarrohr | タングステン copper キャピラリーチューブ |
| Tungsten copper reflector | Tungsten Copper Reflector Plate | Plaque réfléchissante cuivre-tungstène | Wolfram-Kupferreflektorplatte | タングステン copper reflective plate |
| Tungsten Copper Diffuser | Tungsten Copper Diffusion Disc | Disque de diffusion cuivre-tungstène | Wolfram-Kupferdiffusionsscheibe | タングステン copper loose powder |
| Tungsten copper support rod | Tungsten Copper Support Rod | Tige de support cuivre-tungstène | Wolfram-Kupferstützstange | タングステン copper サポートロッド |
| Tungsten copper adjustment piece | Tungsten Copper Adjustment Sheet | Feuille d'ajustement cuivre-tungstène | Wolfram-Kupferinstellblech | タングステン copper adjustment tool |
| Tungsten Copper Filter | Tungsten Copper Filter Sheet | Feuille de filtre cuivre-tungstène | Wolfram-Kupferfilterblech | タングステン copper フィルターシート |

**Metallic Tungsten Products**

| Product Name | English (EN) | French (FR) | German (DE) | Japanese (JP) |
|---|---|---|---|---|
| Pure Tungsten | Pure Tungsten | Tungsten pur | Reines Wolfram | Pure Tangsten |
| Tungsten Rod | Tungsten Rod | Tungstène Bar | Wolframstab | Tangusten Lock |
| Tungsten Wire | Tungsten Wire | Fil de tungstène | Wolframdraht | タングステンワイヤー |
| Tungsten Plate | Tungsten Plate | Tungstène plaque | Wolframplatte | タングステンプレ |

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| | | | | ート |
| Tungsten tube | Tungsten Tube | Tube of tungsten | Wolframrohr | タングステンチューブ |
| Tungsten Foil | Tungsten Foil | Few words | Wolframfolie | タングステンフォイル |
| Tungsten powder | Tungsten Powder | Poudre de tungstène | Wolframpulver | Tangusten powder |
| Tungsten Sputtering Target | Tungsten Target | Cable de tungstène | Wolframscheibe | タングステンターゲット |
| Tungsten Crucible | Tungsten Crucible | Creuset of tungstène | Wolframtiegel | Tangustenrutsubo |
| Tungsten Boat | Tungsten Boat | Tungstène Bateau | Wolframboot | Tangustenbottle |
| Tungsten Ring | Tungsten Ring | Anne of tungstène | Wolframring | Tangusting line |
| Tungsten Sheet | Tungsten Sheet | Few words | Wolframblech | Tangustenshi |
| Tungsten Ball | Tungsten Ball | Boule de tungstène | Wolframkugel | Tangustenball |
| Tungsten needle | Tungsten Needle | Aiguille of tungstène | Wolframnadel | タングステンニードル |
| Tungsten Screws | Tungsten Screw | See the tungstène | Wolframschraube | Tangustenneji |
| Tungsten divertor | Tungsten Divertor | Divertisseur in tungstène | Wolframdivertor | タングステンダイバータ |
| Tungsten Nozzle | Tungsten Nozzle | Bus of tungstène | Wolframdüse | Tangustennozul |
| Tungsten Evaporation Boat | Tungsten Evaporation Boat | Bateau d'évaporation tungsten | Wolframverdampfungsboot | タングステン発ボート |
| Tungsten hot wire | Tungsten Heating Wire | Fil chauffeur de tungstène | Wolframheizdraht | タングステン heating tube |
| Tungsten filament | Tungsten Filament | Tungsten Filament | Wolframglühfaden | タングステンフィラメント |
| Tungsten welding rod | Tungsten Welding Rod | Baguette de soudage tungsten | Wolframschweißstab | Tangusten welding rod |
| Tungsten-based catalyst | Tungsten-Based Catalyst | Catalyseur à base de tungstène | Wolfram-Baser Katalysator | Tangusten-based catalyst |
| Tungsten Thermocouple | Tungsten Thermocouple | Thermocouple in tungsten | Wolfram-Thermoelement | Tangusten Thermoelectric |
| Tungsten evaporation coil | Tungsten Evaporation Coil | Bobine d'évaporation tungsten | Wolframverdampfungsspule | タングステン発発イル |
| Tungsten Fiber | Tungsten Fiber | Fiber of tungsten | Wolframfaser | タングステンファイバー |

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| Tungsten particles | Tungsten Granule | Granule of tungstène | Wolframgranulat | Tangsten grains |
| Tungsten Cylinder | Tungsten Cylinder | Cylindre of tungstène | Wolframzylinder | タングステンシリンダー |
| Tungsten Strip | Tungsten Strip | Band of tungstène | Wolframstreifen | タングステンストリップ |
| Tungsten particles | Tungsten Particle | Participate in tungstène | Wolframteilchen | Tangusten particles |
| Tungsten thin film | Tungsten Film | Film of tungstène | Wolframfilm | タングステンフィルム |
| Tungsten Heat Sink | Tungsten Heat Sink | Dissipate of tungstène | Wolfram - Wärmesenke | タングステンヒートシンク |
| Tungsten capacitors | Tungsten Capacitor | Condensate of tungsten | Wolframkondensator | タングステンコンデンサー |
| Tungsten air nozzle | Tungsten Jet Nozzle | Bus with a jet of tungsten | Wolframstrahldüse | タングステンジェットノズル |
| Tungsten balance weight | Tungsten Balance Weight | Poids d'équilibre en tungstène | Wolfram-Ausgleichsgewicht | タングステンバランスウェイト |
| Tungsten Drill Rod | Tungsten Drill Rod | Tige of forage in tungstène | Wolfram-Bohrstange | タングステンドリルロッド |
| Tungsten pick | Tungsten Cutting Pick | Piece of coupe in tungsten | Wolfram-Schneidzahn | タングステンカッティングピック |
| Tungsten sandblasting nozzle | Tungsten Sandblasting Nozzle | Use of massage in tummy | Wolfram-Sandstrahldüse | タングステンサンドブラストノズル |
| Tungsten grinding head | Tungsten Grinding Head | Têtes de meulage en tungstène | Wolfram-Schleifkopf | タングステン grinding ヘッド |
| Tungsten sputtering target | Tungsten Sputtering Target | Cable de pulvération tungsten | Wolfram-Sputtertarget | タングステンスパッタリングターゲット |
| Tungsten Wafer Chuck | Tungsten Wafer Clamp | Pince to wafer in tungstène | Wolfram-Waferklemme | タングステンウェハクランプ |
| Tungsten battery electrode | Tungsten Battery Electrode | Électrode de batterie tungsten è ne | Wolfram-Batterieelektrode | タングステン battery electrode |
| Tungsten conductive film | Tungsten Conductive Film | Film conductor of tungstène | Wolfram-Leitfilm | Tangusten conductive film |
| Tungsten armor plate | Tungsten Armor Plate | Plaque of arm in tungstène | Wolfram-Panzerplatte | Tangusten armor plate |
| Tungsten core | Tungsten Bullet Core | Noy the ball in tungstène | Wolfram-Geschoss Kern | Tangusten Bullet |
| Tungsten X-ray Shielding | Tungsten X-Ray Shield | Bouclier à rayons X en tungstène | Wolfram - Röntgenschild | タングステン X-ray シールド |
| Tungsten | Tungsten | Aiguille | Wolfram-Chirurgienadel | Tangusten surgical |

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| | | | | |
|---|---|---|---|---|
| surgical needle | Surgical Needle | chirurgicale tungstène | | needle |
| Recycled tungsten powder | Recycled Tungsten Powder | Poudre de tungstène recycling | Recycling-Wolframpulver | Recycled タングステン powder |
| Recycled tungsten rod | Recycled Tungsten Rod | Tungstène recovery system | Recycling - Wolframstab | Renewal technology |
| Tungsten crankshaft | Tungsten Crankshaft | Vilebrequin in tungstène | Wolfram-Kurbelwelle | タングステンクランクシャフト |
| Tungsten piston | Tungsten Piston | Piston in tungstène | Wolfram-Kolben | タングステンピストン |
| Tungsten bearings | Tungsten Bearing | Roulement in tungstène | Wolfram-Lager | タングステンベアリング |
| Tungsten gear | Tungsten Gear | Engagement in tungsten | Wolfram-Zahnrad | Tangustengia |
| Tungsten connector | Tungsten Connector | Connect in tungstène | Wolfram-Verbindungsstück | タングステンコネクター |
| Tungsten valve core | Tungsten Valve Core | Noy the valve in tungsten | Wolfram-Ventilkern | タングステンバルブコア |
| Tungsten Shims | Tungsten Gasket | Joint in tungstène | Wolfram-Dichtung | タングステンガスケット |
| Tungsten sealing ring | Tungsten Seal Ring | Anneau d'étanchéité tungstène | Wolfram-Dichtungsring | タングステンシールリング |
| Tungsten guide rail | Tungsten Guide Rail | Rail guide in tungsten | Wolfram-Führungsschiene | タングステンガイドレール |
| Tungsten Bushing | Tungsten Bushing | Douille in tungstène | Wolfram-Buchse | タングステンブッシング |
| Tungsten Ball | Tungsten Roller Ball | A simple way to eat | Wolfram-Rollkugel | タングステンローラーボール |
| Tungsten Washers | Tungsten Washer | Rondelle in tungstène | Wolfram-Unterlegscheibe | タングステンワッシャー |
| Tungsten compact | Tungsten Press Block | Block of press in tungsten | Wolfram-Pressblock | タングステンプレスブロック |
| Tungsten pull rod | Tungsten Tie Rod | Tige de traction in tungsten | Wolfram-Zugstange | タングステンタイロッド |
| Tungsten Rivets | Tungsten Rivet | Rivet in tungstène | Wolfram-Niet | タングステンリベット |
| Tungsten Pins | Tungsten Pin | Couple in bed | Wolfram-Stift | Tangustenpin |
| Tungsten Nuts | Tungsten Nut | I 'm tired | Wolfram-Mutter | Tangustennet |
| Tungsten backing plate | Tungsten Backing Plate | Plaque de support en tungstène | Wolfram - Trägerplatte | タングステンバッキングプレート |
| Tungsten fixture | Tungsten Fixture | Fixation in | Wolfram-Vorrichtung | タングステンフィ |

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| | | | | |
|---|---|---|---|---|
| | | tungstène | | クスチャー |
| Tungsten probe | Tungsten Probe | Son in tungstène | Wolfram-Sonde | タングステンプローブ |
| Tungsten capillary | Tungsten Capillary Tube | Tube cap in tungsten | Wolfram-Kapillarrohr | タングステンキャピラリーチューブ |
| Tungsten electrode | Tungsten Electrode Sheet | Feuille d'électrode tungstène | Wolfram-Elektrodenblech | タングステン electrode sensor |
| Tungsten wire | Tungsten Conductor Wire | Conduct yourself in tungsten | Wolfram-Leitdraht | Tangusten wire |
| Tungsten separator | Tungsten Partition | Cloison in tungstène | Wolfram-Trennwand | タングステンパーティション |
| Tungsten protective sleeve | Tungsten Protective Sleeve | Manchon protects against tungstène | Wolfram-Schutz | タングステン protection スリーブ |
| Tungsten reflector | Tungsten Reflector Plate | Plaque réfléchissante tungstène | Wolfram-Reflektorplatte | Tangusten reflector |
| Tungsten Diffuser Plate | Tungsten Diffusion Disc | Disque de diffusion tungsten | Wolfram-Diffusionsscheibe | タングステン拡 san ディスク |
| Tungsten support rod | Tungsten Support Rod | Tige of support in tungstène | Wolfram-Stützstange | タングステンサポートロッド |
| Tungsten adjustment piece | Tungsten Adjustment Sheet | Feuille d'ajustement tungstène | Wolfram-Einstellblech | タングステン Adjustment シート |
| Tungsten Filter | Tungsten Filter Sheet | Feuille de filtre en tungstène | Wolfram-Filterblech | タングステンフィルターシート |
| Tungsten thermal pad | Tungsten Thermal Conductive Sheet | Few conduction thermique | Wolfram - Wärmeleitblech | タングステン heater guide |
| Tungsten heat sink | Tungsten Heat Absorption Sheet | Feuille d'absorption thermique | Wolfram - Wärmeabsorptionsblech | タングステン Endothermic Thermos |

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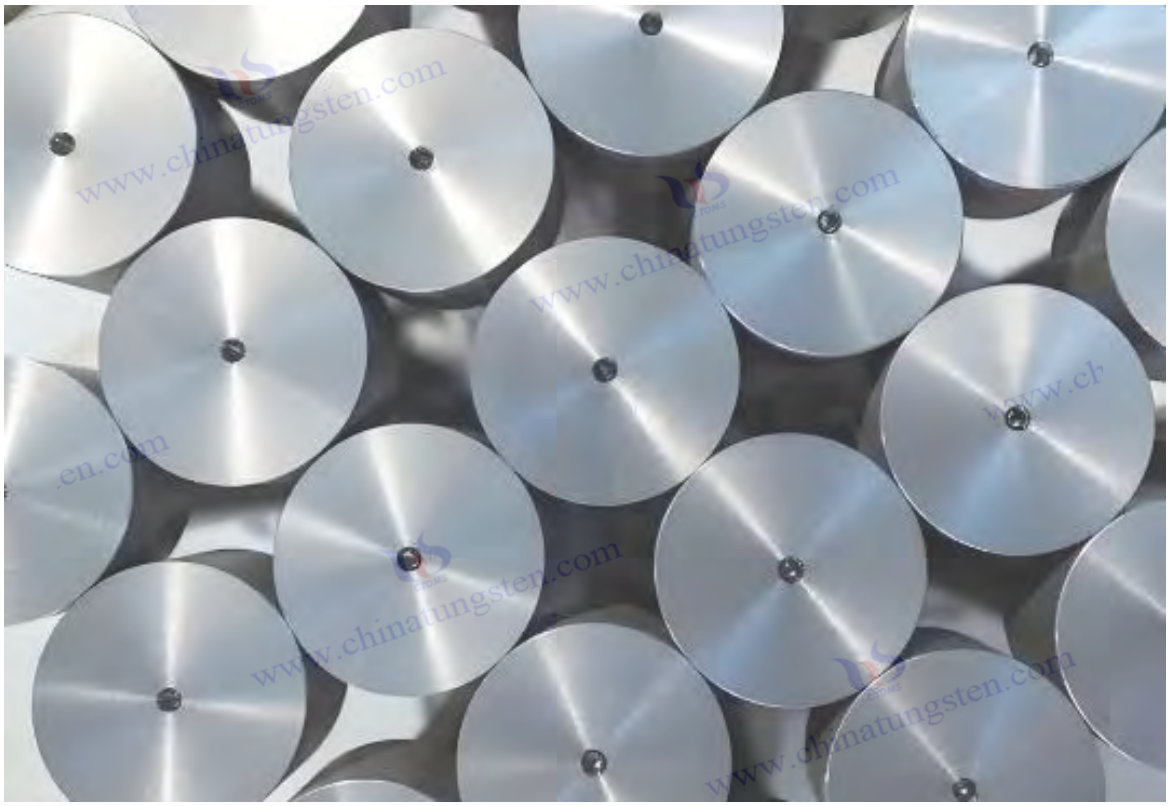

**Tungsten Industry Chain Glossary**
A global multilingual terminology comparison of all relevant information on the performance, characteristics, composition, production, processing, manufacturing, technology, equipment, inspection and testing, packaging, etc. of tungsten-related products.

**Tungsten Ore Mining Machinery , Equipment and Instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Primary crushing of tungsten ore to 10-20 cm |
| Cone Crusher | Cone Crusher | Conn Club | High efficiency, adjustable discharging size | Secondary crushing of tungsten ore to 1-5 cm |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening of crushed tungsten ore particles |
| Ore washing machine | Ore Washing Machine | Mineral washing machine | Water washing and separation, energy saving and environmental protection | Washing tungsten ore to remove dirt and impurities |
| Rock Drill | Rock Drill | Rock chipper | High impact, portable | Drilling holes for blasting in tungsten mining |
| Roadheader | Roadheader | Tunnel boring machine | Automation, high excavation efficiency | Excavation of tunnels in underground tungsten mining |

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| | | | | |
|---|---|---|---|---|
| Loader | Loader | RODAL | Large capacity, flexible and maneuverable | Loading mined tungsten ore onto transport equipment |
| Dump Truck | Dump Truck | Dump Track | Heavy-duty and durable | Transport tungsten ore to crushing station or stockpile yard |
| Drilling Rig | Drilling Rig | DRILINGRIG | High precision, deep hole drilling capability | Exploration for tungsten deposits or blasting drilling |
| Explosive Device | Blasting Equipment | Explosive Device | Safety control, adjustable power | Using explosives to blast tungsten ore |
| Mine hoist | Mine Hoist | Mining winch | High load-bearing capacity and high safety | Lifting ore and personnel in underground tungsten mines |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Providing ventilation for underground tungsten mining |
| Mining pump | Mine Pump | Mineral Pump | Corrosion resistance, high lift | Draining groundwater from tungsten mining |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transporting tungsten ore from mining sites to processing areas |
| Impact crusher | Impact Crusher | インパクトクラッシャー | High impact energy, good finished product shape | Crushing tungsten ore to medium particle size |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed tungsten ore evenly into the crusher |
| Mining shovel | Mine Shovel | Mineral products | High digging force and flexible operation | Excavating and loading tungsten ore |
| Mining excavator | Mining Excavator | Mining excavator | High power, multi-function | Excavation operations in open pit tungsten mining |
| bulldozer | Bulldozer | Bulldog | Large thrust and strong adaptability | Leveling tungsten mining sites or pushing ore |
| Mining screening machine | Mining Screening Machine | Mineral Screening Machine | High screening efficiency, wear resistance | Preliminary screening of tungsten ore to remove large impurities |
| Hydrocyclone | Hydrocyclone | High Speed Clone | High separation efficiency and small size | Separation of fine particles from tungsten ore |
| Mining winch | Mine Winch | Mineral Wein | Strong traction, safe and reliable | Traction mine car or lifting equipment |
| Mining drilling machine | Mine Drilling Machine | Mineral punching machine | High drilling speed and good stability | Drilling holes in tungsten ore to install blasting devices |
| Mining Breaker | Hydraulic | Oil pressure | High impact, portable | Breaking up hard |

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| | | | | |
|---|---|---|---|---|
| | Breaker | brake | | tungsten ore layers |
| Mining shotcrete machine | Shotcrete Machine | Pulping Machine | Uniform spraying and high efficiency | Shotcrete reinforcement in underground tungsten mine tunnels |
| Mining Drilling Machine | Rock Drilling Jumbo | Rock Cutting | Multifunctional, automated operation | Efficient drilling and blasting in underground tungsten mines |
| Minecart | Mine Car | Mining Vehicle | Strong carrying capacity, rail transportation | Transport tungsten ore to the elevator or stockpile |
| Mining rock loader | Mucking Machine | Mining rock loader | Fast loading, durable | Loading underground tungsten ore onto transport vehicles |
| Mining bolter | Roof Bolting Machine | Ankabolt machine | High stability, quick installation | Installation of bolt reinforcement in underground tungsten mine tunnels |
| Mining scraper conveyor | Scraper Conveyor | スクレーパーコンベア | Wear-resistant, continuous transportation | Transporting tungsten ore from underground mining |
| Mining bucket elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lifting tungsten ore to the surface |
| Mining pneumatic pick | Pneumatic Pick | Wind Pick | Lightweight, high impact | Manual crushing of small tungsten ore blocks |
| Mining bolter | Bolter Miner | Anchor Digger | Integrated excavation and support, high efficiency | Tunneling and reinforcement of underground tungsten mines |
| Mining shuttle car | Shuttle Car | Seatka | Flexible transportation, large capacity | Transporting ore in underground tungsten mines over short distances |
| Mining crushing station | Mobile Crushing Station | Mobile breaking system | Strong mobility and integration | Crushing tungsten ore directly at the mining site |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of element content in tungsten ore (such as $WO_3$) |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring particle size distribution of crushed tungsten ore |
| Geological radar | Ground Penetrating Radar (GPR) | Underground Ladder | Deep detection, non-destructive | Detecting the distribution and depth of tungsten deposits |
| Ore sampling | Ore Sampler | Mineral Sand | Automatic sampling, strong | Extract samples from |

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| | | | | |
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| machine | | | representativeness | tungsten ore for analysis |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of tungsten ore |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungsten ore composition |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten ore |
| Magnetometer | Magnetometer | Magnetometer | High sensitivity, portable | Detection of magnetic minerals associated with tungsten deposits |
| Radiation detector | Radiation Detector | Radiation detector | High precision, portable | Detection of possible radioactive elements in tungsten ores |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multiple test modes | Testing the hardness of tungsten ore |

**Tungsten Ore Beneficiation**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Fine Crushing and Grinding Equipment | | | | |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind the tungsten ore to 200 mesh |
| Rod Mill | Rod Mill | Lockdomir | Uniform grinding, less over-grinding | Grinding tungsten ore into coarse particles |
| Hammer Crusher | Hammer Crusher | ハンマークラッシャー | Strong impact force and high crushing efficiency | Crush tungsten ore to 5-10 mm |
| Cone Crusher | Cone Crusher | Conn Club | High efficiency, adjustable discharging size | Further crush the tungsten ore to 1-5 cm |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening of tungsten ore particles after grinding |
| Spiral Classifier | Spiral Classifier | SPIRAL SORTING MACHINE | High grading accuracy and simple operation | Tungsten ore particles after graded grinding |
| Reselection equipment | | | | |
| Jigging Machine | Jig Machine | Gigmachin | High sorting efficiency and energy saving | Separation of tungsten ores by gravity |
| Shaker | Shaking Table | Vibration Table | High sorting accuracy and strong adaptability | Separation of fine tungsten ore and gangue |
| Centrifugal | Centrifugal | Centrifugal | High recovery rate, | Enrichment of fine- |

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| | | | | |
|---|---|---|---|---|
| concentrator | Concentrator | Mining Machine | automation | grained tungsten ore |
| Hydrocyclone | Hydrocyclone | High Speed Clone | High separation efficiency and small size | Separation of fine particles from tungsten ore |
| Flotation equipment | | | | |
| Flotation Machine | Flotation Machine | Flotation Machine | High recovery rate, adjustable foam thickness | Separation of useful components from tungsten ore by flotation |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mixing flotation reagents and tungsten ore slurry |
| Thickener | Thickener | Concentrator | Large capacity, automatic control | Tungsten concentrate slurry after flotation |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filter tungsten concentrate slurry to prepare dry filter cake |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated tungsten concentrate or tailings |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten ore or concentrate to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten concentrate or tailings to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten ore into the ore dressing equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for the ore dressing workshop |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of element content in tungsten concentrate (such as $WO_3$) |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of tungsten ore after grinding |
| Hydrometer | Specific Gravity | Density meter | High precision, | Measuring the specific |

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| | | | | |
|---|---|---|---|---|
| | Meter | | portable | gravity of tungsten concentrate |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | $WO_3$ content in tungsten concentrate |
| Flotation recovery tester | Flotation Recovery Tester | Flotation recovery rate test device | Real-time and automated data | Testing the recovery of flotation processes |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detect moisture content of tungsten concentrate or tailings |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungsten concentrate composition |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten concentrate |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check particle morphology and mineral structure of tungsten concentrate |
| Turbidimeter | Turbidimeter | Turbidity meter | High precision, portable | Measuring turbidity of tungsten ore slurries |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of the flotation solution |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring density of tungsten concentrate or slurry |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure particle size distribution of tungsten concentrate |

**Tungsten Ore Metallurgy**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Roasting and pretreatment equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Preparation of Tungsten Trioxide by Roasting Tungsten Concentrate |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Roasting tungsten concentrate to remove impurities such as sulfur and arsenic |
| Multi-chamber | Multiple Hearth | Multi-layer furnace | Multi-layer | Roasted tungsten |

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| furnace | Furnace | | heating, high heat utilization rate | concentrate, suitable for mass production |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Tungsten concentrate before drying and roasting |
| Leaching and chemical treatment equipment | | | | |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable reaction conditions | Acid or alkali leaching of tungsten concentrate to prepare tungstic acid or tungstate |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mix tungsten concentrate with leaching agent (such as NaOH or HCl) |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filter the leached tungstate or tungstate solution |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated leachate or residue |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated tungstate solution |
| Crystallizer | Crystallizer | Crystallizer | Precise control of crystal growth | Crystallization of tungstates (such as sodium tungstate) from solution |
| Purification and reduction equipment | | | | |
| Ion exchange column | Ion Exchange Column | Ion Exchange Karam | High selectivity, simple operation | Purify tungstate solution and remove impurities |
| Extraction equipment | Extraction Equipment | Extraction device | High separation efficiency and continuous operation | Extraction of tungsten compounds from tungsten solution |
| Hydrogen reduction furnace | Hydrogen Reduction Furnace | Hydrogen reduction furnace | High purity reduction, adjustable temperature | Reducing tungsten trioxide to tungsten powder |
| Electric Arc Furnace | Electric Arc Furnace | Electric arc stove | High temperature smelting, high efficiency | Smelting tungsten concentrate to produce crude |

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| | | | | |
|---|---|---|---|---|
| | | | | tungsten |
| Distillation tower | Distillation Tower | Distillation tower | High separation efficiency, corrosion resistance | Purification of tungsten hexafluoride ( $WF_6$ ) |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray drying of tungstate solution into powder |
| Calcination furnace | Calcination Furnace | Calcining furnace | High temperature control, uniform heating | Preparation of high purity tungsten trioxide by calcining tungstic acid |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or intermediate products to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder or chemicals to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten concentrate into smelting equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry or leachate |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for smelting workshop |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detect the element content in tungsten concentrate or tungsten powder |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring particle size distribution of tungsten powder |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of tungsten content in tungsten solution |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten |

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| | | | | |
|---|---|---|---|---|
| | | | | compounds |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the microstructure of tungsten powder or intermediate products |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detect moisture content of tungsten concentrate or tungsten powder |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungsten intermediate product composition |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of the leachate or extract |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten powder or solution |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze mass changes during roasting or reduction |
| Gas Chromatograph | Gas Chromatograph (GC) | Gas Croma Graf | High separation ability and high sensitivity | Analysis of Volatile Impurities in Tungsten Hexafluoride |

**Ferrotungsten Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and crushing equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate or waste into 10-20 cm |
| Cone Crusher | Cone Crusher | Conn Club | High efficiency, adjustable discharging size | Further crush the tungsten raw material into 1-5 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind the tungsten raw material into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening and crushing of tungsten raw material particles |
| Mixer | Mixer | Mikisa | Even mixing, | Mixing tungsten |

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| | | | multifunctional | concentrate with iron raw materials (such as iron powder or scrap steel) |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten iron raw material mixture |
| Melting and alloying equipment | | | | |
| Electric Arc Furnace | Electric Arc Furnace | Electric arc stove | High temperature smelting, high efficiency | Smelting tungsten concentrate and iron to produce tungsten iron |
| Induction furnace | Induction Furnace | Induction furnace | Fast heating, temperature controllable | Smelting ferrotungsten raw materials, suitable for small batch production |
| Medium frequency furnace | Medium Frequency Furnace | Medium frequency oven | Energy saving, uniform melting | Melting tungsten iron alloy |
| Vacuum melting furnace | Vacuum Melting Furnace | Vacuum melting furnace | Low oxygen environment, high purity | Melting high purity ferrotungsten under vacuum |
| Stirring device | Stirring Device | Stirring device | Even mixing, high temperature resistance | Stirring the molten tungsten iron to ensure uniform composition |
| Deoxidizer Doser | Deoxidizer Feeder | Deacidifier supply device | Precise dosing, automation | Adding deoxidizers (such as aluminum or silicon) to molten ferrotungsten |
| Casting and molding equipment | | | | |
| Casting Machine | Casting Machine | Casting Machine | Precise control, continuous operation | Casting molten ferrotungsten into ingots or blocks |
| Mould | Mold | Casting | High temperature resistant, customizable shapes | Formed tungsten iron ingot |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Tungsten iron ingot after cooling casting |
| Crusher | Crusher | Club | High impact force, adjustable particle size | The cooled tungsten iron ingot is crushed into specified particle size |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening and crushing of tungsten iron particles |
| Refining and post-processing equipment | | | | |
| Refining furnace | Refining Furnace | Refining furnace | High temperature refining, impurity removal | Remove impurities from ferrotungsten and improve purity |
| Oxygen blowing | Oxygen Blowing | Acid blowing | Efficient oxidation, | Removal of carbon and |

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| | | | | |
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| device | Device | device | precise control | sulfur from ferrotungsten by oxygen blowing |
| Vacuum degassing furnace | Vacuum Degassing Furnace | Vacuum degassing furnace | Low air pressure, good degassing effect | Removal of gas impurities from ferrotungsten |
| Shot blasting machine | Shot Blasting Machine | Seat Brass Machine | Clean surface, efficient | Clean the oxide scale and impurities on the surface of tungsten iron ingot |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport ferrotungsten raw materials or finished products to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten iron particles or powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed ferrotungsten raw materials evenly into the smelting equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Providing ventilation for the melting shop |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten and iron content in tungsten iron |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of ferrotungsten particles after crushing |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten Content in Ferrotungsten |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten iron |
| microscope | Microscope | Microscope | High resolution, magnified observation | Examining the microstructure and phase distribution of tungsten iron |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multiple test modes | Test the hardness of tungsten iron (such as Brinell or Rockwell) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten iron |

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| | | | | |
|---|---|---|---|---|
| Spectrometer | Spectrometer | Spectrometer | Multi-wavelength analysis, high resolution | Analysis of the chemical composition of tungsten iron |
| Oxygen Analyzer | Oxygen Analyzer | Oxygen analysis device | High sensitivity, real-time monitoring | Detection of oxygen content in tungsten iron |

**Tungsten Oxide Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten concentrate into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Tungsten concentrate particles after screening and crushing |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten concentrate to remove moisture |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mixing tungsten concentrate with additives (such as sodium carbonate) |
| Roasting and oxidation equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Preparation of crude tungsten trioxide by roasting tungsten concentrate |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Roasting tungsten concentrate to remove impurities and oxidize |
| Multi-chamber furnace | Multiple Hearth Furnace | Multi-layer furnace | Multi-layer heating, high heat utilization rate | Roasted tungsten concentrate, suitable for mass production |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust the waste gas generated during the roasting |

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|---|---|---|---|---|
| | | | | process |
| Leaching and solution treatment equipment | | | | |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable reaction conditions | Acid or alkali leaching of roasted products to extract tungstic acid or tungstate |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mixed leaching agent and roasting product |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filter the leached tungstate or tungstate solution |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated leachate or residue |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated tungstate solution |
| Crystallizer | Crystallizer | Crystallizer | Precise control of crystal growth | Crystallization of tungstates (such as ammonium tungstate) from solution |
| Purification and drying equipment | | | | |
| Ion exchange column | Ion Exchange Column | Ion Exchange Karam | High selectivity, simple operation | Purify tungstate solution and remove impurities |
| Extraction equipment | Extraction Equipment | Extraction device | High separation efficiency and continuous operation | Extraction of high purity tungsten compounds from tungsten solution |
| Calcination furnace | Calcination Furnace | Calcining furnace | High temperature control, uniform heating | Preparation of high purity tungsten trioxide by calcining tungstic acid or tungstate |
| Spray Dryer | Spray Dryer | Spread Line | Fast drying, uniform particles | Spray drying of tungstate solution into tungsten oxide powder |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry tungsten oxide to avoid oxidation or decomposition |

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| Grinding Machine | Grinding Machine | Grinding Machine | High precision, adjustable particle size | Grind tungsten oxide to specified particle size |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or tungsten oxide to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten oxide powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten concentrate into roasting or leaching equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry or leachate |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten content and impurities in tungsten oxide |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of tungsten oxide powder |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | content in tungsten oxide raw materials or intermediates |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten oxide |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the particle morphology of tungsten oxide powder |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of tungsten oxide powder |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungsten oxide composition |

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| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of the leachate |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze mass changes during roasting or calcination |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of tungsten oxide powder |

**Sodium Tungstate Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten concentrate into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Tungsten concentrate particles after screening and crushing |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten concentrate to remove moisture |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mix tungsten concentrate with sodium carbonate or sodium hydroxide |
| Roasting and leaching equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Roasting tungsten concentrate with alkaline substances to produce sodium tungstate |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Roasted tungsten concentrate, suitable for mass production |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable | Use hot water or alkali solution to leach the roasted |

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| | | | reaction conditions | product and extract sodium tungstate |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Stir the leaching solution to promote the dissolution of sodium tungstate |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filter the sodium tungstate solution after leaching |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated leachate or residue |
| Purification and crystallization equipment | | | | |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated sodium tungstate solution |
| Crystallizer | Crystallizer | Crystallizer | Precise control of crystal growth | Crystallization of sodium tungstate crystals from concentrated solution |
| Ion exchange column | Ion Exchange Column | Ion Exchange Karam | High selectivity, simple operation | Purify sodium tungstate solution and remove impurities |
| Extraction equipment | Extraction Equipment | Extraction device | High separation efficiency and continuous operation | Extraction of high purity tungsten compounds from sodium tungstate solution |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of sodium tungstate crystals and mother liquor |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Drying Sodium Tungstate Crystals |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or sodium tungstate to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベー | Vertical | Lift sodium |

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| | | ター | transportation, high efficiency | tungstate crystals or powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten concentrate into roasting or leaching equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry or leachate |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten and impurity content in sodium tungstate |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten Content in Sodium Tungstate |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in sodium tungstate |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of sodium tungstate crystals |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of sodium tungstate |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of sodium tungstate composition |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitor the pH of the leachate or crystallization solution |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of sodium tungstate solution or crystal |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of sodium tungstate |

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| | | | | |
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| | | | | crystals |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of mass changes during drying of sodium tungstate |

**Tungstate Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten concentrate into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Tungsten concentrate particles after screening and crushing |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten concentrate to remove moisture |
| Leaching and solution preparation equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Preparation of tungsten oxide by roasting tungsten concentrate |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable reaction conditions | Leach the roasted product with an acid (such as HCl) to prepare tungstic acid |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mix tungstic acid and ammonia to generate ammonium tungstate solution |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filter the ammonium tungstate solution or residue |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration | Dehydrated |

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| | | | speed and low energy consumption | ammonium tungstate solution |
| Purification and crystallization equipment | | | | |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated ammonium tungstate solution |
| Crystallizer | Crystallizer | Crystallizer | Precise control of crystal growth | Crystallization of ammonium tungstate (such as APT) from solution |
| Ion exchange column | Ion Exchange Column | Ion Exchange Karam | High selectivity, simple operation | Purify ammonium tungstate solution and remove impurities |
| Extraction equipment | Extraction Equipment | Extraction device | High separation efficiency, continuous operation | Extraction of high purity tungsten compounds from ammonium tungstate solution |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of ammonium tungstate crystals and mother liquor |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray drying of ammonium tungstate solution into powder |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Drying Ammonium Tungstate Crystals |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or ammonium tungstate to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift ammonium tungstate crystals or powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Send tungsten concentrate uniformly to roasting or leaching |

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| | | | | equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear and corrosion resistant | Transporting tungsten slurry or leachate |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of tungsten and impurities in ammonium tungstate |
| Chemical titration apparatus | Titration Apparatus | Titration device | Simple and accurate operation | Analysis of Tungsten Content in Ammonium Tungstate |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in ammonium tungstate |
| Microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of ammonium tungstate crystals |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of ammonium tungstate |
| Portable Spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of ammonium tungstate components |
| pH meter | pH Meter | pH meter | Fast response, high precision | Monitor the pH of the leachate or crystallization solution |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of ammonium tungstate solution or crystal |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of ammonium tungstate crystals |

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| Thermogravimetric analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature test, accurate data | Analysis of mass changes during the drying process of ammonium tungstate |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of ammonium tungstate powder |

**Tungstic Acid Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten concentrate into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Tungsten concentrate particles after screening and crushing |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten concentrate to remove moisture |
| Roasting and leaching equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Preparation of tungsten oxide by roasting tungsten concentrate |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable reaction conditions | The roasted product is leached with hydrochloric acid (HCl) to precipitate tungstic acid |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mix the calcined product with acid to promote the precipitation of tungstic acid |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and | Filtration of tungstate precipitate |

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| | | | good filter cake quality | |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated tungstate precipitate or residue |
| Washing equipment | Washing Equipment | Washing device | Efficient cleaning, saving water resources | Washing tungstic acid to remove residual acid and impurities |
| Purification and drying equipment | | | | |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of solid and liquid tungstate |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry tungstic acid to low moisture state |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry the tungstic acid under vacuum to avoid decomposition |
| Grinding Machine | Grinding Machine | Grinding Machine | High precision, adjustable particle size | Grind tungstic acid to specified particle size |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated leachate, assisted tungstic acid precipitation |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or tungstic acid to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungstic acid powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten concentrate into roasting or leaching equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry or leachate |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |

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| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of tungsten content and impurities in tungstic acid |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of tungsten content in tungstic acid |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungstic acid |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of tungstate particles |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of tungstic acid |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungstic acid composition |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of the leachate |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungstic acid |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of tungstic acid powder |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of mass changes during drying of tungstic acid |

**Ammonium Metatungstate Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy | Grind tungsten concentrate into fine powder |

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| | | | consumption | |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Tungsten concentrate particles after screening and crushing |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten concentrate to remove moisture |
| Leaching and solution preparation equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Preparation of tungsten oxide by roasting tungsten concentrate |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable reaction conditions | Use acid to leach the roasted product to prepare tungstic acid solution |
| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mix tungstic acid solution with ammonia water to generate ammonium metatungstate |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filtration of tungstic acid or intermediates |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated tungstic acid solution or residue |
| Purification and crystallization equipment | | | | |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated ammonium metatungstate solution |
| Crystallizer | Crystallizer | Crystallizer | Precise control of crystal growth | Crystallization of ammonium metatungstate (AMT) from solution |
| Ion exchange column | Ion Exchange Column | Ion Exchange Karam | High selectivity, simple operation | Purify ammonium metatungstate solution and remove |

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| | | | | impurities |
| Extraction equipment | Extraction Equipment | Extraction device | High separation efficiency and continuous operation | Extraction of high purity tungsten compounds from ammonium metatungstate solution |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of ammonium metatungstate crystals and mother liquor |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray drying of ammonium metatungstate solution into powder |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Drying Ammonium Metatungstate Crystals |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or ammonium metatungstate to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift ammonium metatungstate crystals or powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten concentrate into roasting or leaching equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry or leachate |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten content and impurities in ammonium metatungstate |

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| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten Content in Ammonium Metatungstate |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in ammonium metatungstate |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of ammonium metatungstate crystals |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of ammonium metatungstate |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of ammonium metatungstate composition |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitor the pH of the leachate or crystallization solution |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of ammonium metatungstate solution or crystals |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of ammonium metatungstate powder |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of the mass change of ammonium metatungstate during drying |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of ammonium metatungstate powder |

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**Ammonium Paratungstate Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten concentrate into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Tungsten concentrate particles after screening and crushing |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying tungsten concentrate to remove moisture |
| Roasting and leaching equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Preparation of tungsten oxide by roasting tungsten concentrate |
| Reactor | Reactor | Reactor | Corrosion resistance, controllable reaction conditions | Leach the roasted product with an acid (such as HCl) to prepare a tungstic acid solution |

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| Mixing tank | Agitation Tank | Mixing tank | Even mixing, corrosion resistance | Mix tungstic acid solution and ammonia water to generate ammonium paratungstate solution |
| Filter Press | Filter Press | Pressure filter | High dehydration efficiency and good filter cake quality | Filtration of tungstic acid or intermediate product solutions |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Dehydrated tungstic acid solution or residue |
| Washing equipment | Washing Equipment | Washing device | Efficient cleaning, saving water resources | Wash tungstate precipitate to remove impurities |
| Purification and crystallization equipment | | | | |
| Evaporator | Evaporator | Steamer | High efficiency concentration, high temperature resistance | Concentrated ammonium paratungstate solution |
| Crystallizer | Crystallizer | Crystallizer | Precise control of crystal growth | Crystallization of ammonium paratungstate (APT) from solution |
| Ion exchange column | Ion Exchange Column | Ion Exchange Karam | High selectivity, simple operation | Purify ammonium paratungstate solution to remove impurities |
| Extraction equipment | Extraction Equipment | Extraction device | High separation efficiency and continuous operation | Extraction of high purity tungsten compounds from ammonium paratungstate solution |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of ammonium paratungstate crystals and mother liquor |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray drying of ammonium paratungstate solution into powder |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Drying ammonium paratungstate crystals |

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| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry ammonium paratungstate under vacuum to avoid decomposition |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten concentrate or ammonium paratungstate to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift ammonium paratungstate crystals or powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Evenly feed tungsten concentrate into roasting or leaching equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten ore slurry or leachate |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Inspection and testing equipment and instruments | | | | |
| X- ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten content and impurities in ammonium paratungstate |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten Content in Ammonium Paratungstate |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in ammonium paratungstate |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of ammonium paratungstate crystals |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detection of moisture content of ammonium |

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| | | | | paratungstate |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of ammonium paratungstate components |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitor the pH of the leachate or crystallization solution |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of ammonium paratungstate solution or crystals |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of ammonium paratungstate powder |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of the mass change of ammonium paratungstate during drying process |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of ammonium paratungstate powder |
| illustrate | The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email . | | | |

**Tungsten Oxide Production Equipment and Instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate or ammonium paratungstate (APT) to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding | Grind the raw |

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| | | | | |
|---|---|---|---|---|
| | | | precision, low energy consumption | materials into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening and crushing of raw material particles |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying raw materials (such as APT) to remove moisture |
| Roasting and reduction equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Calcination of APT or tungsten trioxide to prepare blue tungsten precursor |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Roasting raw materials, suitable for mass production |
| Hydrogen reduction furnace | Hydrogen Reduction Furnace | Hydrogen reduction furnace | Precise temperature control, strong reduction | Use hydrogen to slightly reduce APT or $WO_3$ to generate blue tungsten oxide |
| Four-tube furnace | Four-Tube Furnace | Four-tube furnace | Multi-tube design, high output | Reducing APT in hydrogen atmosphere to produce blue tungsten |
| Eleven-tube furnace | Eleven-Tube Furnace | Eleven-tube furnace | High capacity, uniform heating | Large-scale reduction production of blue tungsten oxide |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust the waste gas generated during roasting or reduction |
| Purification and post-processing equipment | | | | |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of blue tungsten powder and residual liquid |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry Blue Tungsten Oxide Powder |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry blue tungsten under vacuum to avoid oxidation |
| Grinding Machine | Grinding Machine | Grinding Machine | High precision, | Grind blue tungsten |

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| | | | | |
|---|---|---|---|---|
| | | | adjustable particle size | to a specified particle size (e.g. 12-19 microns) |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, high precision | Sieve blue tungsten powder to ensure uniform particle size |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport raw materials or blue tungsten to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift blue tungsten powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed the raw materials evenly into the roasting or reduction equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten slurry in wet preparation |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provides hydrogen for reduction |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten content and impurities in blue tungsten (such as $WO_{2.90}$ content) |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten Content in Blue Tungsten |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in blue tungsten |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the particle morphology of blue tungsten powder |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of blue tungsten |

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| | | | | |
|---|---|---|---|---|
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of blue tungsten composition |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measure the particle size distribution of blue tungsten powder (e.g. 12-19 microns) |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of blue tungsten powder |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measure the density of blue tungsten powder (about 7.15 g/ $cm^3$ ) |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the quality changes of blue tungsten during roasting or drying |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analysis of the crystal phase of blue tungsten (such as $WO_{2.90}$ or ammonium tungsten bronze) |
| Surface Area Analyzer | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of blue tungsten |

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**Tungsten Oxide Production Equipment and Instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten concentrate or ammonium paratungstate (APT) to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind the raw materials into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening and crushing of raw material particles |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying raw materials (such as APT) to remove moisture |
| Roasting and reduction equipment | | | | |
| roaster | Roasting Furnace | Baking furnace | High temperature uniformity, energy saving | Calcination of APT or tungsten trioxide to prepare purple tungsten precursor |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high | Roasting raw materials, suitable |

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| | | | thermal efficiency | for mass production |
| Hydrogen reduction furnace | Hydrogen Reduction Furnace | Hydrogen reduction furnace | Precise temperature control, strong reduction | Use hydrogen to slightly reduce APT or $WO_3$ to generate purple tungsten oxide |
| Four-tube furnace | Four-Tube Furnace | Four-tube furnace | Multi-tube design, high output | Reduction of APT in hydrogen atmosphere to produce purple tungsten |
| Eleven-tube furnace | Eleven-Tube Furnace | Eleven-tube furnace | High capacity, uniform heating | Large-scale reduction production of purple tungsten oxide |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust the waste gas generated during roasting or reduction |
| Atmosphere control device | Atmosphere Control Device | Air control device | Precise atmosphere adjustment, high stability | Control the ratio of hydrogen and oxygen in the reduction furnace to generate $WO_{2.72}$ |
| Purification and post-processing equipment | | | | |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of violet tungsten powder and residual liquid |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry Purple Tungsten Oxide Powder |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry the tungsten under vacuum to avoid oxidation |
| Grinding Machine | Grinding Machine | Grinding Machine | High precision, adjustable particle size | Grind the purple tungsten to a specified particle size (e.g. 10-20 microns) |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, high precision | Screening of tungsten powder to ensure uniform particle size |
| Assistive and transport equipment | | | | |

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| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport raw materials or purple tungsten to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift the purple tungsten powder to the specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed raw materials evenly into roasting or reduction equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten slurry in wet preparation |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provides hydrogen for reduction |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten content and impurities in purple tungsten (such as $WO_{2.72}$ content) |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten Content in Purple Tungsten |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in violet tungsten |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the particle morphology of purple tungsten powder (such as needle-like structure) |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of purple tungsten |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of violet tungsten components |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measure the particle size distribution of |

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| | | | | purple tungsten powder (e.g. 10-20 microns) |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of violet tungsten powder |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measure the density of tungsten powder (about 7.3 g/ $cm^3$ ) |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the quality changes of purple tungsten during roasting or drying |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analysis of the crystal phase of purple tungsten (such as $W_{18}O_{49}$ ) |
| Surface Area Analyzer | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of violet tungsten |

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**Tungsten Metal Powder Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and pretreatment equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing tungsten trioxide or APT to 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind the raw materials into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening and crushing of raw material particles |
| Dryer | Dryer | Dryer | High thermal efficiency and | Dry the raw material (such as |

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| | | | uniform drying | APT or $WO_3$ ) to remove moisture |
| Reduction and milling equipment | | | | |
| Hydrogen reduction furnace | Hydrogen Reduction Furnace | Hydrogen reduction furnace | Precise temperature control, strong reduction | Use hydrogen to reduce $WO_3$ or APT to generate metal tungsten powder |
| Four-tube furnace | Four-Tube Furnace | Four-tube furnace | Multi-tube design, high output | Reducing raw materials in a hydrogen atmosphere to produce tungsten powder |
| Eleven-tube furnace | Eleven-Tube Furnace | Eleven-tube furnace | High capacity, uniform heating | Large-scale reduction production of tungsten metal powder |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Reduction of $WO_3$ , suitable for mass production of tungsten powder |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust water vapor and waste gas generated during the reduction process |
| Atmosphere control device | Atmosphere Control Device | Air pressure control device | Precise atmosphere adjustment, high stability | Control the hydrogen concentration in the reduction furnace to ensure the purity of tungsten powder |
| Post-processing and refining equipment | | | | |
| Grinding Machine | Grinding Machine | Grinding Machine | High precision, adjustable particle size | Grind tungsten powder to a specified particle size (e.g. 0.5-50 microns) |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, high precision | Sieving tungsten powder to ensure uniform particle size |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of tungsten powder and residual liquid (such as in wet preparation) |

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|---|---|---|---|---|
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry tungsten metal powder to remove residual moisture |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry the tungsten powder under vacuum to avoid oxidation |
| Powder Mixer | Powder Mixer | Powder Mikisa | Even mixing, multifunctional | Mix different batches of tungsten powder to ensure consistency |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport raw materials or tungsten powder to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed the raw materials evenly into the reduction equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten slurry in wet preparation |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provide high-purity hydrogen required for reduction |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detect tungsten content and impurities in tungsten powder (such as W ≥ 99.9%) |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of tungsten content in tungsten powder |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten powder |
| microscope | Microscope | Microscope | High resolution, | Check the particle |

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| | | | magnified observation | morphology of tungsten powder (e.g. spherical or polyhedral) |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of tungsten powder |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungsten powder composition |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measure the particle size distribution of tungsten powder (e.g. 0.5-50 microns) |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the particle size distribution of tungsten powder |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the apparent density and tap density of tungsten powder |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the mass change of tungsten powder during drying or reduction |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analyze the crystal phase of tungsten powder (such as pure W phase) |
| Surface Area Analyzer | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of tungsten powder |

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**Cesium Tungsten Bronze Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and mixing equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing cesium tungstate or tungsten oxide raw materials into 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind the raw materials into fine powder (e.g. micron grade) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening of ground raw material particles |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mixing tungsten source (such as $WO_3$) and cesium source (such as $Cs_2CO_3$) |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry mixed raw materials to remove moisture |
| Calcination and reduction | | | | |

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| | | | | |
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| equipment | | | | |
| Calcination furnace | Calcination Furnace | Calcining furnace | High temperature control, uniform heating | Calcinate the mixture to generate cesium tungstate precursor |
| Hydrogen reduction furnace | Hydrogen Reduction Furnace | Hydrogen reduction furnace | Precise temperature control, strong reduction | Use hydrogen to reduce $WO_3$ and Cs compounds to generate cesium tungsten bronze |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Continuous calcination and reduction of raw materials, suitable for large-scale production |
| Four-tube furnace | Four-Tube Furnace | Four-tube furnace | Multi-tube design, high output | Production of cesium tungsten bronze by reduction in hydrogen atmosphere |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust gas from calcination or reduction process |
| Atmosphere control device | Atmosphere Control Device | Air pressure control device | Precise atmosphere adjustment, high stability | Control the ratio of hydrogen and oxygen in the furnace to ensure the $Cs_xWO_3$ structure |
| Post-processing and refining equipment | | | | |
| Grinding Machine | Grinding Machine | Grinding Machine | High precision, adjustable particle size | Grind cesium tungsten bronze to nanometer particle size (e.g. 20-100 nm) |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, high precision | Sieving cesium tungsten bronze powder to ensure uniform particle size |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of Cesium Tungsten Bronze and Solution in Wet Preparation |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Drying of cesium tungsten bronze powder to remove residual moisture |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry the Cesium Tungsten Bronze under vacuum to avoid oxidation |
| Ultrasonic disperser | Ultrasonic Disperser | Ultrasonic disperser | High frequency vibration, uniform dispersion | Disperse cesium tungsten bronze particles to prevent agglomeration |
| Assistive and transport | | | | |

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| equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport raw materials or cesium tungsten bronze to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift cesium tungsten bronze powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed raw materials evenly into calcination or reduction equipment |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten slurry in wet preparation |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provide high-purity hydrogen required for reduction |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of Cs and W content and impurities in cesium tungsten bronze |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of Tungsten and Cesium Content in Cesium Tungsten Bronze |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in cesium tungsten bronze |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of the cesium tungsten bronze particles (e.g. rod or cube) |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of cesium tungsten bronze |
| UV-Vis Spectrophotometer | UV-Vis Spectrophotometer | UV-Vis Spectrophotometer | High precision, spectral analysis | Measuring the Near-Infrared Absorption Properties of Cesium Tungsten Bronze |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measure the particle size distribution of cesium tungsten bronze (e.g. 20-100 nm) |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure the nanoparticle size distribution of cesium tungsten bronze |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the Density of Cesium Tungsten Bronze Powder |

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| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the mass change of cesium tungsten bronze during calcination or drying |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analysis of the crystal phase of cesium tungsten bronze (such as $Cs_{0.32}WO_3$) |
| Surface Area Analyzer | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of cesium tungsten bronze |

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**Tungsten Carbide Powder Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and mixing equipment | | | | |
| Jaw Crusher | Jaw Crusher | Jockey Club | Simple structure, durable, high crushing ratio | Crushing metal tungsten powder or tungsten trioxide into 10-20 cm |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten powder and carbon source (such as carbon black) into fine powder |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Screening of ground raw material particles |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mix tungsten powder with carbon source (such as carbon black or graphite) and proportion it according to the ratio |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry the mixed raw materials to remove moisture |
| Carbonization and reaction equipment | | | | |
| Carbonization furnace | Carburizing Furnace | Carbonization furnace | High temperature control, corrosion resistance | Tungsten carbide powder is oxidized at high temperature (1400-2000°C) to produce WC |
| Vacuum Carbonization Furnace | Vacuum Carburizing Furnace | Vacuum carbonization furnace | Low oxygen environment, high purity | Tungsten carbide powder is processed under vacuum to avoid oxidation |
| Hydrogen | Hydrogen | Hydrogen | Precise | Reduction of $WO_3$ and |

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| reduction furnace | Reduction Furnace | reduction furnace | temperature control, strong reduction | carbonization to prepare tungsten carbide |
| Rotary kiln | Rotary Kiln | Lottery Kirun | Continuous operation, high thermal efficiency | Continuous carbonization of raw materials, suitable for mass production |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust waste gas (such as CO) generated during carbonization |
| Atmosphere control device | Atmosphere Control Device | Air pressure control device | Precise atmosphere adjustment, high stability | Control the atmosphere in the carbonization furnace (such as $H_2$ or Ar) to ensure the purity of WC |
| Post-processing and refining equipment | | | | |
| Grinding Machine | Grinding Machine | Grinding Machine | High precision, adjustable particle size | Grind tungsten carbide to a specified particle size (e.g. 0.2-10 microns) |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, high precision | Sieving tungsten carbide powder to ensure uniform particle size |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of tungsten carbide from solution in wet preparation |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry tungsten carbide powder to remove residual moisture |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry the tungsten carbide under vacuum to avoid oxidation |
| Powder Mixer | Powder Mixer | Powder Mikisa | Even mixing, multifunctional | Mix different batches of tungsten carbide powder to ensure consistency |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport raw materials or tungsten carbide to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten carbide powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable | Feed the raw materials evenly into the carbonization furnace |

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| | | | speed | |
| Slurry pump | Slurry Pump | Slalom Pop | Wear-resistant and corrosion-resistant | Transporting tungsten slurry in wet preparation |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Inert gas generator | Inert Gas Generator | Inactive gas generating device | High purity, stable supply | $N_2$ ) required for carbonization |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of W and C content and impurities in tungsten carbide |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analyzing Carbon Content in Tungsten Carbide |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten carbide |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the morphology of tungsten carbide particles (e.g. polyhedron) |
| Moisture meter | Moisture Analyzer | Moisture Tester | Fast measurement, high sensitivity | Detecting the moisture content of tungsten carbide |
| Portable spectrometer | Portable Spectrometer | Portable spectrometer | Portable, real-time analysis | On-site analysis of tungsten carbide composition |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measure the particle size distribution of tungsten carbide (e.g. 0.2-10 microns) |
| Laser particle size analyzer | Laser Particle Size Analyzer | Reser Particle Size Analyzer | Non-contact, high resolution | Accurately measure particle size distribution of tungsten carbide |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the apparent density and tap density of tungsten carbide powder |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of mass changes during the carburization process of tungsten carbide |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analysis of the crystal phase of tungsten carbide (such as WC single phase) |

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| | | | | |
|---|---|---|---|---|
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Testing the hardness of tungsten carbide (such as Vickers hardness) |

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**Tungsten Metal Products Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and forming equipment | | | | |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mix tungsten powder with binder (such as PVA) to prepare uniform raw material |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten powder to a specified particle size (e.g. 1-5 microns) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieving tungsten powder to ensure uniform particle size |
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Pressing tungsten powder into billets (such as rods, slabs) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of tungsten billets to increase billet density |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry the pressed tungsten blank to remove moisture or binder |
| Sintering and heat treatment equipment | | | | |
| Hydrogen sintering furnace | Hydrogen Sintering Furnace | Hydrogen sintering furnace | High temperature control, strong reducing ability | Sintering tungsten blanks (1600-2200°C) in a hydrogen atmosphere to produce tungsten products |
| Vacuum sintering furnace | Vacuum Sintering Furnace | Vacuum sintering furnace | Low oxygen environment, high purity | Sintering of tungsten blanks under vacuum to avoid oxidation |
| Medium frequency induction furnace | Medium Frequency Induction Furnace | Medium frequency induction furnace | Fast heating and uniform temperature | Melting or sintering tungsten billets to produce high-density products |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust the waste gas generated during sintering |

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| | | | | |
|---|---|---|---|---|
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Tungsten products after cooling and sintering |
| Processing and finishing equipment | | | | |
| lathe | Lathe | Rotary Disk | High precision and multifunctional | Turning tungsten blanks into tungsten rods or tungsten parts |
| grinder | Grinding Machine | Grinding Machine | High precision, smooth surface | Grind the surface of tungsten products to the specified size and finish |
| Wire cutting machine | Wire Cutting Machine | Wai Yakto Machine | High precision, non-contact | Cutting tungsten blanks to prepare tungsten wire or sheets |
| Rolling Mill | Rolling Mill | Calendering Machine | High pressure, continuous processing | Rolling tungsten billets to produce tungsten plates or foils |
| Polishing Machine | Polishing Machine | Grinding Machine | High finish, automation | Polishing the surface of tungsten products to improve appearance and performance |
| Wire drawing machine | Wire Drawing Machine | Wire drawing machine | High precision, continuous stretching | Draw tungsten wire to a specified diameter (e.g. 0.01-1 mm) |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten blanks or products to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder or billet to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed tungsten powder evenly into pressing or sintering equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provide hydrogen required for sintering |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of W content and impurities in tungsten products |

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|---|---|---|---|---|
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of tungsten content in tungsten products |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten products |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the microstructure and surface defects of tungsten products |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of tungsten products (such as Vickers or Rockwell hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten products (approximately 19.25 g/cm³ ) |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect cracks or defects inside tungsten products |
| Coordinate Measuring Machine | Coordinate Measuring Machine (CMM) | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring the dimensional accuracy of tungsten products (such as tungsten rod diameter) |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the surface roughness of tungsten products |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the quality changes of tungsten products during sintering |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analyze the crystal phase of tungsten products (such as pure W phase) |
| Metallographic microscope | Metallographic Microscope | Metallographic microscope | High resolution, material analysis | Check the metallographic structure of tungsten products |

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**Alloy Production Machinery and Equipment**

Tungsten-copper alloy (W-Cu) is a composite material composed of tungsten and copper, combining the high melting point of tungsten and the high conductivity of copper. It is widely used in electrical contact materials, heat sinks and electrodes.

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| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and mixing equipment | | | | |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten powder and copper powder to micron level (e.g. 1-5 microns) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieve tungsten powder and copper powder to ensure uniform particle size |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mix tungsten powder and copper powder in proportion (such as W70Cu30) |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry the mixed powder to remove moisture |
| Granulator | Granulator | Granulator | Uniform particles, easy to compress | Make mixed powder into granules to improve fluidity |
| Pressing and forming equipment | | | | |
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Pressing W-Cu mixed powder into billets (such as discs, bars) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of W-Cu billets to increase density |
| Mould | Mold | Casting | High temperature resistant, customizable shapes | Forming W-Cu billets to ensure consistent dimensions |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry the pressed W-Cu billet to remove moisture |
| Sintering and Infiltration Equipment | | | | |
| Hydrogen sintering furnace | Hydrogen Sintering Furnace | Hydrogen sintering furnace | High temperature control, strong reducing ability | Pre-sintering of W-Cu billets in hydrogen atmosphere (1000-1200°C) |
| Vacuum sintering furnace | Vacuum Sintering Furnace | Vacuum sintering furnace | Low oxygen environment, high purity | Sintering of W-Cu billets under vacuum to avoid oxidation |

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| Infiltration furnace | Infiltration Furnace | Leaching furnace | High temperature uniformity and good permeability | Infiltrate copper into the tungsten skeleton (1300-1500°C) to form a W-Cu alloy |
| Medium frequency induction furnace | Medium Frequency Induction Furnace | Medium frequency induction furnace | Fast heating and uniform temperature | Melt copper and infiltrate it to produce a high-density alloy |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust gas from sintering or infiltration process |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Cooling of W-Cu alloy after sintering or infiltration |
| Processing and finishing equipment | | | | |
| lathe | Lathe | Rotary Disk | High precision and multifunctional | Turning W-Cu blanks into specified shapes (such as electrodes) |
| grinder | Grinding Machine | Grinding Machine | High precision, smooth surface | Grind the surface of W-Cu alloy to achieve the specified finish |
| Wire cutting machine | Wire Cutting Machine | Wai Yakto Machine | High precision, non-contact | Cutting W-Cu billets to produce thin sheets or complex shapes |
| Polishing Machine | Polishing Machine | Grinding Machine | High finish, automation | Polishing W-Cu alloy surface to improve appearance and performance |
| Cleaning Machine | Cleaning Machine | Washing Machine | Efficient cleaning, no residue | Clean W-Cu products to remove surface oil and impurities |
| Assistive and transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport W-Cu powder, billet or product to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift W-Cu powder or billet to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed the W-Cu mixed powder evenly into the pressing or sintering equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen | High purity, | Provide high-purity |

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| | | Generating Device | stable supply | hydrogen required for sintering |
| Inspection and testing equipment and instruments | | | | |
| X- ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detection of W and Cu content and impurities in W-Cu alloy |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of copper content in W-Cu alloy |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in W-Cu alloy |
| microscope | Microscope | Microscope | High resolution, magnified observation | Examining the microstructure and phase distribution of W-Cu alloys |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of W-Cu alloys (such as Brinell or Vickers hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of W-Cu alloy (e.g. W70Cu30 is about 14.5 g/cm³ ) |
| Conductivity Tester | Conductivity Tester | Conductivity Tester | High sensitivity, real-time measurement | Testing the electrical conductivity of W-Cu alloy |
| Thermal conductivity tester | Thermal Conductivity Tester | Thermal conductivity tester | High-precision, fast testing | Measuring the thermal conductivity of W-Cu alloy |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect cracks or defects inside W-Cu alloy |
| Coordinate Measuring Machine | Coordinate Measuring Machine (CMM) | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring the dimensional accuracy of W-Cu products |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the surface roughness of W-Cu products |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the quality changes of W-Cu during sintering or infiltration |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analysis of crystal phase and phase ratio of W-Cu alloy |
| Metallographic | Metallographic | Metallographic | High resolution, | Check the metallographic |

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| microscope | Microscope | microscope | material analysis | structure and interface bonding of W-Cu alloy |

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**Tungsten Wire Production Machinery and Equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Raw material preparation and doping equipment | | | | |
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten powder to micron level (e.g. 1-5 microns) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieving tungsten powder to ensure uniform particle size |
| Doping mixer | Doping Mixer | Doppinmg Mikiss | High uniformity, corrosion resistance | tungsten powder and dopant ($K_2SiO_3$ , $Al(NO_3)_3$ ) uniformly |
| Solution preparation tank | Solution Preparation Tank | Solution preparation tank | Corrosion-resistant and precise metering | Preparation of dopant solution (e.g. potassium silicate aqueous solution) |
| Spray Dryer | Spray Dryer | Spread Line | Fast drying, uniform particles | The doped tungsten slurry is spray dried into powder |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying doped tungsten powder to remove moisture |
| Pressing and forming equipment | | | | |
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Press doped tungsten powder into tungsten bars (e.g. 10-20 mm diameter) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of tungsten bars to improve density and uniformity |
| Mould | Mold | Casting | High temperature resistant, customizable shapes | Forming tungsten bar blanks to ensure consistent dimensions |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry the pressed tungsten blank to remove residual moisture |

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|---|---|---|---|---|
| Sintering and heat treatment equipment | | | | |
| Hydrogen sintering furnace | Hydrogen Sintering Furnace | Hydrogen sintering furnace | High temperature control, strong reducing ability | Pre-sintering of tungsten blanks in hydrogen atmosphere (1300-1500°C) |
| Vacuum sintering furnace | Vacuum Sintering Furnace | Vacuum sintering furnace | Low oxygen environment, high purity | Sintering of tungsten blanks under vacuum (2000-2200°C) to produce tungsten bars |
| Medium frequency induction furnace | Medium Frequency Induction Furnace | Medium frequency induction furnace | Fast heating and uniform temperature | High temperature sintered tungsten bars ensure high density |
| Annealing furnace | Annealing Furnace | Anil furnace | Precise temperature control and adjustable atmosphere | Annealing tungsten bar or wire to eliminate internal stress |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust waste gas (such as water vapor) during sintering process |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Cooling and sintering of tungsten bar |
| Wire drawing and processing equipment | | | | |
| Rotary forging machine | Swaging Machine | スウェージングマシン | High precision, continuous processing | Forging tungsten rod into thick tungsten wire (e.g. 1-3 mm diameter) |
| Wire drawing machine | Wire Drawing Machine | Wire drawing machine | High precision, continuous stretching | Drawing tungsten wire to a fine diameter (e.g. 0.01-1 mm) |
| Wire drawing die | Drawing Die | Wire drawing | Wear-resistant, high hardness | Controlling diameter and surface quality during tungsten wire drawing |
| Lubrication device | Lubrication Device | Lubrication device | Reduce friction and extend mold life | Provide lubrication during the wire drawing process (such as graphite emulsion) |
| Winding Machine | Winding Machine | Winding machine | Adjustable speed, automatic | Wind the drawn tungsten wire into a coil |
| Polishing Machine | Polishing Machine | Grinding Machine | High finish, automation | Polished tungsten wire surface for improved finish and consistency |
| Cleaning Machine | Cleaning Machine | Washing Machine | Efficient cleaning, no residue | Clean the tungsten wire to remove surface oil and impurities |
| Assistive and | | | | |

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| transport equipment | | | | |
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten powder, tungsten billet or tungsten wire to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder or tungsten blank to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed the doped tungsten powder evenly into the pressing or sintering equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provides high purity hydrogen required for sintering and annealing |
| Inspection and testing equipment and instruments | | | | |
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detect the W content and doping elements (such as K, Al, Si) in tungsten wire |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analyzing dopant content in tungsten wire |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten wire |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the surface morphology and microstructure of tungsten wire |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of tungsten wire (such as Vickers hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten wire (approximately 19.25 g/ $cm^3$ ) |
| Tensile testing machine | Tensile Testing Machine | Tension testing machine | High precision and multifunctional | Testing the tensile strength and elongation of tungsten wire |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect cracks or defects inside tungsten wire |
| Coordinate | Coordinate | Three-dimensional | High-precision, | Measuring the diameter and |

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| Measuring Machine | Measuring Machine (CMM) | measuring machine | three-dimensional measurement | roundness of tungsten wire (e.g. 0.01-1 mm) |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the roughness of tungsten wire surface |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the quality changes of tungsten wire during sintering or annealing |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analyzing the crystal phase and doping distribution of tungsten wire |
| Metallographic microscope | Metallographic Microscope | Metallographic microscope | High resolution, material analysis | Check the metallographic structure and grain size of tungsten wire |

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**Instruments and equipment for the production of contemporary tungsten wire in China**
**Instruments and Equipment for Tungsten Wire Processing**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten powder to micron level (e.g. 1-5 microns) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieving tungsten powder to ensure uniform particle size |
| Doping mixer | Doping Mixer | Doppinmg Mikiss | High uniformity, corrosion resistance | tungsten powder and dopant (such as $K_2SiO_3$ , Al ( $NO_3$ ) $_3$ ) uniformly |
| Solution preparation tank | Solution Preparation Tank | Solution preparation tank | Corrosion-resistant and precise metering | Preparation of dopant solution (e.g. potassium silicate aqueous solution) |
| Spray Dryer | Spray Dryer | Spread Line | Fast drying, uniform particles | The doped tungsten slurry is spray dried into powder |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Drying doped tungsten powder to remove moisture |
| Planetary ball mill | Planetary Ball Mill | プラネタリーボールミル | High efficiency and various grinding | Finely ground tungsten powder and dopant mixture |
| Ultrasonic cleaning machine | Ultrasonic Cleaner | Ultrasonic cleaning machine | High frequency cleaning, no damage | Clean grinding equipment (e.g. ball mills) to remove residues |
| Metering Pumps | Metering Pump | Metering Pump | Precise metering, corrosion resistance | Precise delivery of dopant solution to mixing equipment |

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| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Filter the wet powder after doping to remove excess liquid |
| New Equipment | | | | |
| Air jet mill | Air Jet Mill | EagerToMil | Non-contact, high fineness | Grind tungsten powder into ultra-fine particles (e.g. less than 1 micron) |
| Blender | Agitator | Blender | Efficient mixing, high temperature resistance | Mix dry powder or wet method to prepare dopant |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring pH of doping solutions |
| Centrifuge | Centrifugal Separator | Telecentric Separation Machine | High speed separation, high efficiency | Separate the doped slurry and extract the solid powder |
| Powder Classifier | Powder Classifier | Powder Classifier | High precision, multi-level grading | Classify tungsten powder to ensure consistent particle size distribution |

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**Pressing and forming equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Press doped tungsten powder into tungsten bars (e.g. 10-20 mm diameter) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of tungsten bars to improve density and uniformity |
| Mould | Mold | Casting | High temperature resistant, customizable shapes | Forming tungsten bar blanks to ensure consistent dimensions |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry the pressed tungsten blank to remove residual moisture |
| Cold isostatic press | Cold Isostatic Press (CIP) | Cold room isostatic pressure press | No thermal deformation, high uniformity | Pressing tungsten billets at room temperature to improve billet strength |
| Demoulding machine | Demolding Machine | Demolding machine | Automation and high efficiency | Remove the pressed tungsten blank from the mold |
| Weighing Machine | Weighing Machine | Measuring machine | High-precision and fast weighing | Accurately weigh tungsten powder to ensure consistent amount each time you press it |
| New Equipment | | | | |
| Hot Isostatic Press (HIP) | Hot Isostatic Press | Hot Isostatic Pressure Press | High temperature, high pressure, high density | Pressing the tungsten blank at high temperature further increases the density |

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| Vacuum degreasing furnace | Vacuum Degreasing Furnace | Vacuum degreasing furnace | Low oxygen environment, high efficiency | Removal of binder (such as PVA) from tungsten blanks |
| Mould cleaning machine | Mold Cleaning Machine | Casting washing machine | Efficient cleaning and durable | Cleaning the pressing die to maintain precision |
| Press dressing machine | Billet Trimming Machine | Pressing and trimming machine | High precision and automation | Trimming the edge of the pressed tungsten blank |
| Powder filling machine | Powder Filling Machine | Powder filling machine | Automatic and uniform filling | Automatically load doped tungsten powder into the mold |

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**Sintering and heat treatment equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydrogen sintering furnace | Hydrogen Sintering Furnace | Hydrogen sintering furnace | High temperature control, strong reducing ability | Pre-sintering of tungsten blanks in hydrogen atmosphere (1300-1500°C) |
| Vacuum sintering furnace | Vacuum Sintering Furnace | Vacuum sintering furnace | Low oxygen environment, high purity | Sintering of tungsten blanks under vacuum (2000-2200°C) to produce tungsten bars |
| Medium frequency induction furnace | Medium Frequency Induction Furnace | Medium frequency induction furnace | Fast heating and uniform temperature | High temperature sintered tungsten bars ensure high density |
| Annealing furnace | Annealing Furnace | Anil furnace | Precise temperature control and adjustable atmosphere | Annealing tungsten bar or wire to eliminate internal stress |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust waste gas (such as water vapor) during sintering process |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Cooling and sintering of tungsten rod |
| Atmosphere sintering furnace | Atmosphere Sintering Furnace | Fen gas sintering furnace | Multiple atmospheres available, high stability | Sintering in a specific atmosphere (such as $H_2$ + $N_2$ ) to optimize the doping effect |
| Temperature recorder | Temperature Recorder | Temperature recording device | Real-time monitoring, high precision | Record the temperature curve during sintering |
| Thermocouple | Thermocouple | Thermoelectric | High temperature tolerance, fast response | Measuring the temperature in the sintering furnace to ensure process stability |
| New Equipment | | | | |

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| High temperature sintering furnace | High-Temperature Sintering Furnace | High temperature sintering furnace | Ultra-high temperature (>2200°C), durable | High temperature sintered tungsten bars for special specifications |
| Atmosphere circulation device | Atmosphere Circulation Device | Ventilation device | Uniform atmosphere, energy saving | Circulate the gas in the sintering furnace to improve efficiency |
| Sintering Boat | Sintering Boat | Yakibutsu | High temperature and corrosion resistance | Carrying tungsten billet into sintering furnace |
| Heat treatment fixture | Heat Treatment Fixture | Heat treatment fixture | High stability, high temperature resistance | Fixing tungsten bar or wire for annealing |
| Vacuum sealing device | Vacuum Sealing Device | Vacuum silo device | High sealing and pressure resistance | Ensure the airtightness of the vacuum sintering furnace |
| Water cooling system | Water Cooling System | Water Cooling System | Efficient cooling, energy saving | Provide cooling water for sintering furnaces or coolers |

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**Wire drawing and processing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Rotary forging machine | Swaging Machine | スウェージングマシン | High precision, continuous processing | Forging tungsten rod into thick tungsten wire (e.g. 1-3 mm diameter) |
| Wire drawing machine | Wire Drawing Machine | Wire drawing machine | High precision, continuous stretching | Drawing tungsten wire to a fine diameter (e.g. 0.01-1 mm) |
| Wire drawing die | Drawing Die | Wire drawing | Wear-resistant, high hardness | Controlling diameter and surface quality during tungsten wire drawing |
| Lubrication device | Lubrication Device | Lubrication device | Reduce friction and extend mold life | Provide lubrication during the wire drawing process (such as graphite emulsion) |
| Winding Machine | Winding Machine | Winding machine | Adjustable speed, automatic | Wind the drawn tungsten wire into a coil |
| Polishing Machine | Polishing Machine | Grinding Machine | High finish, automation | Polished tungsten wire surface for improved finish and consistency |
| Cleaning Machine | Cleaning Machine | Washing Machine | Efficient cleaning, no residue | Clean the tungsten wire to remove surface oil and impurities |
| Multi-stage wire drawing machine | Multi-Stage Wire Drawing Machine | Multi-stage wire drawing machine | Multi-stage stretching, high efficiency | The diameter of the tungsten wire is gradually reduced by multiple drawing passes |
| Straightening | Straightening | Correction | High precision, no | Straighten the drawn |

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|---|---|---|---|---|
| Machine | Machine | Machine | damage | tungsten wire to ensure straightness |
| Cutting Machine | Cutting Machine | Cutting Machine | Precision cutting, automation | Cut tungsten wire into specified lengths |
| Grinding machine | Grinding Wheel Machine | Sharpening Machine | High hardness, wear resistance | Repair the surface of wire drawing die or tungsten wire |
| Tension controller | Tension Controller | Tension control device | Precise control and high stability | Control the tension during wire drawing to prevent wire breakage |
| Microscope inspection table | Microscope Inspection Station | Microscope inspection station | High resolution, portable | Check the surface quality of tungsten wire after drawing |
| New equipment and tools | | | | |
| Electrolytic polishing machine | Electrolytic Polishing Machine | Electrolytic grinding machine | No mechanical damage, high finish | Improve quality by electrolytically polishing the tungsten wire surface |
| Hot wire drawing machine | Hot Wire Drawing Machine | Hot Wire Drawing Machine | High temperature stretching, good ductility | Drawing tungsten wire at high temperature, suitable for ultra-fine wire |
| Mould finishing machine | Die Repair Machine | Dai trimmer | High precision and automation | Repair the wire drawing die to extend its service life |
| Tungsten wire winding frame | Wire Winding Frame | ワイヤー廻取フレーム | Stable and adjustable structure | Support and fix the tungsten wire disc |
| Ultrasonic cleaning tank | Ultrasonic Cleaning Tank | Ultrasonic cleaning tank | Deep cleaning, high efficiency | Deep cleaning of tungsten wire to remove tiny particles |
| Surface treatment machine | Surface Treatment Machine | Surface treatment machine | Multifunctional and automated | Surface coating or treatment of tungsten wire |
| Wire drawing speed monitor | Drawing Speed Monitor | Wire drawing speed monitor | Real-time monitoring, high precision | Monitor wire drawing speed to ensure process stability |
| pliers | Pliers | Planiya | High strength, precision operation | Manual adjustment or trimming of tungsten wire |

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**Assistive and transport equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten powder, tungsten billet or tungsten wire to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder or tungsten blank to a specified height |

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|---|---|---|---|---|
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed the doped tungsten powder evenly into the pressing or sintering equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provides high purity hydrogen required for sintering and annealing |
| Vacuum Pump | Vacuum Pump | Vacuum Pump | High vacuum, low noise | Provide vacuum environment for vacuum sintering furnace |
| Nitrogen Generator | Nitrogen Generator | Antagonist Generating Device | High purity, stable supply | Provide inert gas protection (such as annealing or storage) |
| Air compressor | Air Compressor | Eacon Press | High pressure, stable output | Provide compressed air for pneumatic equipment (such as wire drawing machines) |
| Storage tank | Storage Tank | Storage Tank | Good sealing and large capacity | Storage of doped tungsten powder or intermediate products |
| Transporter | Forklift | FO CLIFFT | Flexible transport, high load capacity | Handling tungsten blanks or tungsten wire coils |
| New Equipment | | | | |
| dust collector | Dust Collector | Dust Collector | Efficient dust removal, environmental protection | Collect dust generated during production |
| Temperature and humidity controller | Temperature and Humidity Controller | Temperature and humidity control device | Precise control and high stability | Control the temperature and humidity in the workshop to protect the quality of tungsten wire |
| Static Eliminator | Static Eliminator | Static Electricity Removal Device | Rapid elimination of static electricity, high safety | Prevent tungsten powder or tungsten wire from adhering due to static electricity |
| Protective cover | Protective Cover | Protection card | High temperature resistance and high safety | Protect equipment or operators (such as sintering furnace protection) |
| Tool Cart | Tool Cart | Tool Card | Portable and versatile | Storage and transport of small tools or parts |

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**Inspection and testing equipment and instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray analysis device | Non-destructive testing, high precision | Detect the W content and doping elements (such as K, Al, Si) in tungsten wire |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analyzing dopant content in tungsten wire |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten wire |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the surface morphology and microstructure of tungsten wire |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of tungsten wire (such as Vickers hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten wire (approximately 19.25 g/ $cm^3$ ) |
| Tensile testing machine | Tensile Testing Machine | Tension testing machine | High precision and multifunctional | Testing the tensile strength and elongation of tungsten wire |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect cracks or defects inside tungsten wire |
| Coordinate Measuring Machine | Coordinate Measuring Machine (CMM) | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring the diameter and roundness of tungsten wire (e.g. 0.01-1 mm) |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the roughness of tungsten wire surface |
| Thermogravimetric Analyzer | Thermogravimetric Analyzer (TGA) | Thermogravimetric analysis device | High temperature testing, accurate data | Analyze the quality changes of tungsten wire during sintering or annealing |
| X-ray diffractometer | X-Ray Diffractometer (XRD) | X-ray folding device | High resolution, structural analysis | Analyzing the crystal phase and doping distribution of tungsten wire |

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| Metallographic microscope | Metallographic Microscope | Metallographic microscope | High resolution, material analysis | Check the metallographic structure and grain size of tungsten wire |
| Resistance Tester | Resistance Tester | Resistance Tester | High-precision, fast measurement | Test the resistivity of tungsten wire to ensure conductivity |
| Fatigue testing machine | Fatigue Testing Machine | Fatigue test machine | Multi-cycle, high reliability | Testing the fatigue life of tungsten wire at high temperature |
| Scanning electron microscopy (SEM) | Scanning Electron Microscope | Scanning electron microscope | High resolution, surface analysis | Observe the microscopic morphology of the tungsten wire surface and fracture |
| Energy dispersive spectrometer (EDS) | Energy Dispersive Spectrometer | エネルギー dispersion beam splitter | Elemental analysis, high sensitivity | Analyzing the distribution of doping elements in tungsten wire |
| Thermal dilatometer | Thermal Expansion Analyzer | Thermal expansion meter | High precision and wide temperature range | Measuring the thermal expansion coefficient of tungsten wire |
| Laser diameter gauge | Laser Diameter Gauge | Reser diameter measuring device | Non-contact, high precision | Online measurement of tungsten wire diameter to ensure consistency |
| New Instruments | | | | |
| Surface Area Analyzer | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of doped tungsten powder |
| Infrared thermometer | Infrared Thermometer | Infrared thermometer | Non-contact, fast response | Measuring the temperature of tungsten wire or sintering process |
| Torsion testing machine | Torsion Testing Machine | Nejiri test machine | High precision and multifunctional | Testing the torsional strength of tungsten wire |
| Optical projector | Optical Projector | Optical projector | High magnification, precise measurement | Checking the geometry and dimensions of tungsten wire |
| Conductivity Meter | Conductivity Meter | Conductivity meter | High sensitivity, portable | Measuring the conductivity of tungsten wire |
| Dynamic Mechanical Analyzer | Dynamic Mechanical Analyzer | Dynamic Thermomechanical | Multi-parameter, high precision | Analysis of the mechanical |

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| (DMA) | | Analysis Device | | properties of tungsten wire as a function of temperature |
| High temperature creep testing machine | High-Temperature Creep Tester | High temperature crystal test machine | High temperature testing, long term stability | Testing the creep properties of tungsten wire at high temperatures |
| Trace oxygen analyzer | Trace Oxygen Analyzer | Trace oxygen analysis device | High sensitivity, fast response | Detect oxygen content in sintering environment to ensure low oxygen environment |

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**Raw and auxiliary materials**

| Material Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| High purity tungsten powder | High-Purity Tungsten Powder | High purity polyester powder | High purity (≥99.95%), adjustable particle size | Main raw materials for preparing doped tungsten wire |
| Potassium silicate ($K_2SiO_3$) | Potassium Silicate | Kalimum | Water soluble, high doping efficiency | Dopant, providing K and Si elements |
| Aluminum nitrate ($Al(NO_3)_3$) | Aluminum Nitrate | Alminium nitrate | Easy to dissolve, good decomposition | Dopant, providing Al element |
| Carbon Black | Carbon Black | Carbon Brack | High purity, fine particles | Auxiliary reducing agent for carbonization during sintering |
| Polyvinyl alcohol (PVA) | Polyvinyl Alcohol | ポリビニルアルコール | Strong adhesion, easy to decompose | Binder for compression molding |
| Graphite emulsion | Graphite Emulsion | Gravure Emulsion | High lubricity, high temperature resistance | Lubricants in wire drawing |
| Hydrogen ( $H_2$ ) | Hydrogen | Hydrogen | High purity, strong reducing ability | Protective and reducing gases during sintering and annealing |
| Nitrogen ( $N_2$ ) | Nitrogen | chlorine | Inertness, high stability | Auxiliary protective gas to prevent oxidation |
| Deionized water | Deionized Water | Deionized water | High purity, no impurities | Prepare dopant solution or clean tungsten wire |

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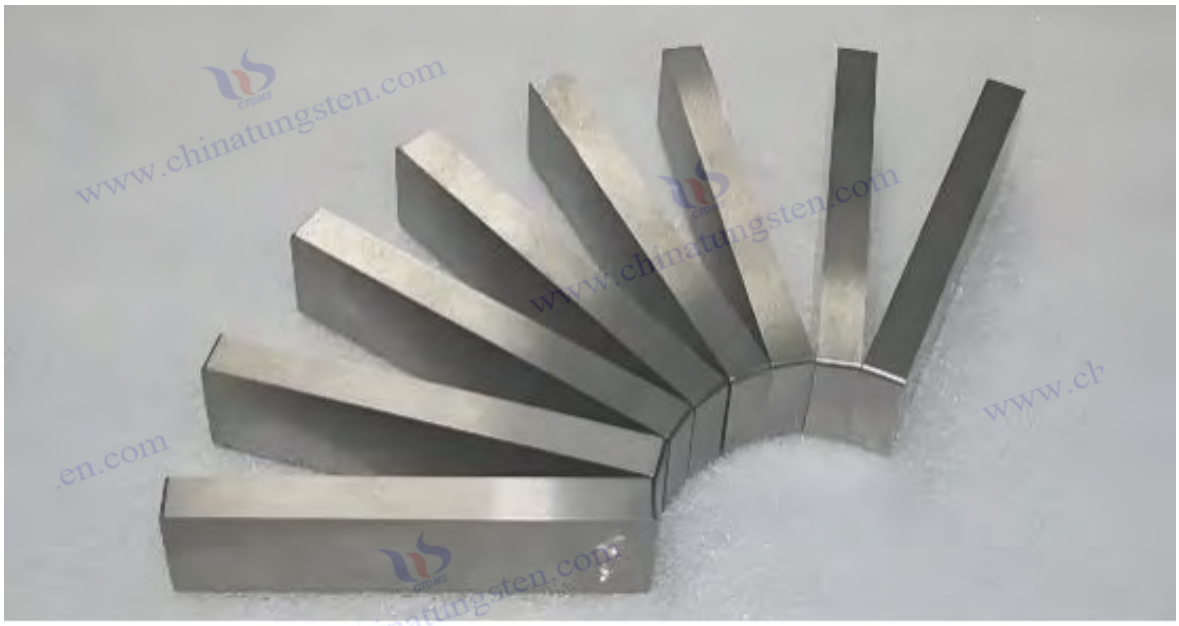

**High-density tungsten alloy production inspection equipment and raw and auxiliary materials**
**High-density タングステン alloy production inspection equipment and raw materials**
**High-Density Tungsten Alloy Production and Inspection Equipment and Raw Materials**

**1. Raw material preparation and mixing equipment**

| Equipment Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grinding tungsten powder, nickel powder, iron powder to micron level (such as 1-10 microns) |
| Planetary ball mill | Planetary Ball Mill | プラネタリーボールミル | High efficiency and various grinding | Finely ground tungsten alloy mixed powder |
| Air jet mill | Air Jet Mill | EagerToMil | Non-contact, high fineness | Grind tungsten powder into ultra-fine particles (e.g. less than 1 micron) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieve the ground powder to ensure uniform particle size |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mix tungsten powder with nickel, iron or copper powder in proportion |
| V-type mixer | V-Type Mixer | V-type Mikisa | High uniformity, low shear | Dry Mixed Tungsten Alloy Powder |
| Double cone mixer | Double Cone Mixer | Double cone mikisara | Large capacity, even mixing | Bulk Mixed Tungsten Alloy Powder |
| Blender | Agitator | Blender | Efficient mixing, high temperature resistance | Wet mixing of tungsten alloy powder and binder |
| Solution | Solution | Solution | Corrosion-resistant | Preparation of adhesive or |

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| preparation tank | Preparation Tank | preparation tank | and precise metering | lubricant solution (such as PVA solution) |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray drying wet mixed powder into uniform particles |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry the mixed powder to remove moisture |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Filter wet mixed powder to remove excess liquid |
| Powder Classifier | Powder Classifier | Powder Classifier | High precision, multi-level grading | Grading tungsten alloy powder to ensure consistent particle size distribution |
| Ultrasonic cleaning machine | Ultrasonic Cleaner | Ultrasonic cleaning machine | High frequency cleaning, no damage | Cleaning of grinding and mixing equipment to remove residues |
| High Energy Ball Mill | High-Energy Ball Mill | 高エネルギー・ボールミル | High impact, ultra-fine grinding | Ultra-fine tungsten alloy powder to improve uniformity |
| Turbine grinder | Turbo Mill | Tabomir | High-speed crushing, multi-function | Quickly crush tungsten powder or other metal powders |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, automation | Fine Screening Tungsten Alloy Powder |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of solid and liquid components in wet mixed powders |
| Metering Pumps | Metering Pump | Metering Pump | Precise metering, corrosion resistance | Precise delivery of adhesive or lubricant solutions |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of wet mix solutions |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry tungsten alloy powder under vacuum to avoid oxidation |
| Powder Dispersing Machine | Powder Disperser | Powder Dispersing Machine | High dispersibility and good uniformity | Disperse tungsten alloy powder to prevent agglomeration |
| Weighing batching machine | Weighing and Batching Machine | Measuring and batching machine | High precision and automation | Weigh tungsten, nickel and iron powders according to the proportion |
| Powder conveyor | Powder Conveyor | Powder Conbe | Sealed transportation, dustproof | Conveying tungsten alloy powder to mixing or pressing equipment |
| Mixing cooler | Mixing Cooler | Hybrid Cooler | Rapid cooling and uniform cooling | Cooling the mixed tungsten alloy powder |
| Hammer mill | Hammer Mill | Hanmar | High impact, high capacity | Preliminary crushing of tungsten powder or other |

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| | | | | |
|---|---|---|---|---|
| | | | | metal powder |
| Powder granulator | Powder Granulator | Powder Granulator | Uniform particles and good fluidity | Make tungsten alloy powder into granules to improve pressing performance |
| Wet mixer | Wet Mixer | Wet Mikisa | High uniformity, corrosion resistance | Mixing tungsten alloy powder in liquid medium |
| High pressure homogenizer | High-Pressure Homogenizer | High pressure homogenizer | High pressure dispersion, good uniformity | Homogenized wet mixed tungsten alloy powder |
| Powder grinding jar | Powder Grinding Jar | Powder grinding jar | Wear-resistant, high sealing performance | Loading tungsten alloy powder for ball milling |
| Screening vibrator | Screening Vibrator | Screening vibrating machine | High frequency vibration, high efficiency | Auxiliary screening of tungsten alloy powder |
| Powder drying tower | Powder Drying Tower | Powder drying tower | Large capacity, efficient drying | Large Scale Drying of Tungsten Alloy Powder |
| Powder mixing tank | Powder Mixing Tank | Powder mixing tank | Large capacity, corrosion resistant | Bulk wet mixed tungsten alloy powder |
| Powder screening conveyor | Powder Screening Conveyor | Powder Screening Conveyor | Screening and conveying integrated, high efficiency | Sieving and conveying tungsten alloy powder |
| Powder storage silo | Powder Storage Silo | Powder storage silo | Large capacity, moisture-proof | Store tungsten alloy powder and keep it dry |

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**2. Pressing and molding equipment**

| Equipment Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Pressing tungsten alloy powder into billets (such as rods and plates) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of tungsten alloy billets to increase density |
| Cold Isostatic Press (CIP) | Cold Isostatic Press | Cold room isostatic pressure press | No thermal deformation, high uniformity | Pressing tungsten alloy billets at room temperature to increase strength |
| Hot Isostatic Press (HIP) | Hot Isostatic Press | Hot Isostatic Pressure Press | High temperature, high pressure, high density | Press tungsten alloy billets under high temperature and high pressure to eliminate pores |
| Mould | Mold | Casting | High temperature resistant, customizable shapes | Forming tungsten alloy billets to ensure consistent dimensions |
| Demoulding | Demolding | Demolding | Automation and high | Take the pressed tungsten |

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|---|---|---|---|---|
| machine | Machine | machine | efficiency | alloy billet out of the mold |
| Weighing Machine | Weighing Machine | Measuring machine | High-precision and fast weighing | Precisely weigh the powder to ensure consistent amount every time you press it |
| Powder filling machine | Powder Filling Machine | Powder filling machine | Automatic and uniform filling | Automatically load tungsten alloy powder into the mold |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry the pressed tungsten alloy billet to remove moisture |
| Vacuum degreasing furnace | Vacuum Degreasing Furnace | Vacuum degreasing furnace | Low oxygen environment, high efficiency | Removal of binder (such as PVA) from tungsten alloy billets |
| Press dressing machine | Billet Trimming Machine | Pressing and trimming machine | High precision and automation | Trimming the edge of the pressed tungsten alloy billet |
| Mould cleaning machine | Mold Cleaning Machine | Casting washing machine | Efficient cleaning and durable | Cleaning the pressing die to maintain precision |
| Powder compactor | Powder Compactor | Powder Compressor | High efficiency and uniform compaction | Initial compaction of tungsten alloy powder for subsequent molding |
| Automatic feeding machine | Automatic Feeder | Automatic feeder | Automatic and continuous feeding | Automatic feeding of powder into the pressing equipment |
| Green sheet cutting machine | Billet Cutting Machine | Billet cutting machine | Precise cutting without damage | Cut the pressed billet into specified size |
| Double-action hydraulic press | Double-Action Hydraulic Press | Double action hydraulic press | Bidirectional pressure, good uniformity | Bidirectional pressing of tungsten alloy billets to increase density |
| Mold preheater | Mold Preheater | Casting preheater | Temperature controllable, fast heating | Preheat the mold to reduce pressing stress |
| Greenhouse shaping machine | Billet Shaping Machine | Blank shaping machine | High precision and multifunctional | Tungsten alloy billet after shaping and pressing |
| Vacuum packaging machine | Vacuum Packing Machine | Vacuum packaging machine | Good sealing and anti-oxidation | Packaging pressed blanks to prevent oxidation |
| Powder Vibrator | Powder Vibrator | Powder vibrating machine | Even distribution, low energy consumption | Vibrate the powder to distribute it evenly in the mold |
| Mould polishing machine | Mold Polishing Machine | Casting grinding machine | High finish, durable | Polish the inner surface of the mold to improve the quality of the blank |
| Green compact weighing instrument | Billet Weighing Instrument | Pressing gauge | High-precision, fast measurement | Weighing pressed billets to ensure consistent quality |
| Die lubrication device | Mold Lubrication Device | Casting lubrication | Apply evenly and reduce friction | Apply lubricant inside the mold to facilitate |

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|---|---|---|---|---|
| | | device | | demoulding |
| Powder sieving and filling machine | Powder Screening and Filling Machine | Powder Screening Filling Machine | Screening and filling in one, high efficiency | Sieve and fill tungsten alloy powder into mold |
| Pressed billet transport rack | Billet Transport Rack | Pressed billet transport | Stable structure, easy to carry | Handling the pressed tungsten alloy billet |
| Rotary press | Rotary Press | Return to the pres | Continuous pressing, high efficiency | Continuous pressing of tungsten alloy billets |
| Mold heating furnace | Mold Heating Furnace | Casting heating furnace | High temperature, uniform and rapid heating | Heating the mold to improve pressing quality |
| Green compact surface cleaning machine | Billet Surface Cleaner | Pressed blank surface cleaning machine | Efficient cleaning, no damage | Clean impurities on the surface of pressed billets |
| Powder pre-pressing machine | Powder Pre-Press Machine | Powder pre-pressing machine | Low pressure preforming, energy saving | Pre-press tungsten alloy powder to facilitate subsequent high pressure forming |
| Mold detector | Mold Inspection Instrument | Casting tester | High precision, lossless | Check the mold for wear or deformation |
| Pressed green sheet drying rack | Billet Drying Rack | Pressed Bread Drying Ruck | Good ventilation and large capacity | Place the pressed blank for natural drying |
| Powder Flow Tester | Powder Flow Tester | Powder Flow Tester | High-precision, fast measurement | Testing the fluidity of tungsten alloy powder |
| Mould sandblasting machine | Mold Sandblasting Machine | 鋳 type サンドブラスト machine | Efficient cleaning and surface roughening | Sand blasting to clean the mold surface |
| Green compact stacker | Billet Stacking Machine | Pressing and stacking machine | Automation and space saving | Stacking the pressed tungsten alloy billets |
| Mould storage cabinet | Mold Storage Cabinet | 鋳 -shaped storage tube | Dust and moisture proof | Store pressing dies and keep them clean |

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### 3. Sintering and heat treatment equipment

| Equipment Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydrogen sintering furnace | Hydrogen Sintering Furnace | Hydrogen sintering furnace | High temperature control, strong reducing ability | Sintering of tungsten alloy billets in hydrogen atmosphere (1300-1500°C) |
| Vacuum sintering furnace | Vacuum Sintering Furnace | Vacuum sintering furnace | Low oxygen environment, high purity | Sintering tungsten alloy billets under vacuum to avoid oxidation |

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| Medium frequency induction furnace | Medium Frequency Induction Furnace | Medium frequency induction furnace | Fast heating and uniform temperature | High temperature sintered tungsten alloy billet to ensure high density |
| Liquid Phase Sintering Furnace | Liquid Phase Sintering Furnace | Liquid Phase Sintering Furnace | High temperature liquid phase, densification | Sintering tungsten alloy in liquid phase (e.g. above 1500°C) |
| Annealing furnace | Annealing Furnace | Anil furnace | Precise temperature control and adjustable atmosphere | Annealed tungsten alloy products to eliminate internal stress |
| High temperature sintering furnace | High-Temperature Sintering Furnace | High temperature sintering furnace | Ultra-high temperature (>2000°C), durable | High temperature sintered tungsten alloy, suitable for special requirements |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Exhaust waste gas (such as water vapor, CO) during sintering process |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Tungsten alloy products after cooling and sintering |
| Atmosphere sintering furnace | Atmosphere Sintering Furnace | Fen gas sintering furnace | Multiple atmospheres available, high stability | Sintering in a specific atmosphere (such as $H_2$ + $N_2$ ) to optimize performance |
| Atmosphere circulation device | Atmosphere Circulation Device | Ventilation circulation device | Uniform atmosphere, energy saving | Circulate the gas in the sintering furnace to improve efficiency |
| Sintering Boat | Sintering Boat | Yakibutsu | High temperature and corrosion resistance | Carrying tungsten alloy billet into sintering furnace |
| Thermocouple | Thermocouple | Thermoelectric | High temperature tolerance, fast response | Measuring the temperature in the sintering furnace to ensure process stability |
| Temperature recorder | Temperature Recorder | Temperature recording device | Real-time monitoring, high precision | Record the temperature curve during sintering |
| Vacuum sealing device | Vacuum Sealing Device | Vacuum silo device | High sealing and pressure resistance | Ensure the airtightness of the vacuum sintering furnace |
| Water Cooling System | Water Cooling System | Water Cooling System | Efficient cooling, energy saving | Provide cooling water for sintering furnaces or coolers |
| Vacuum pressure sintering furnace | Vacuum Pressure Sintering Furnace | Vacuum pressure sintering furnace | High pressure, dense, low oxygen environment | Sintering tungsten alloy under vacuum and pressure to increase density |
| Sintering furnace | Sintering Furnace | Sintering grate gas | Efficient exhaust, | Collect and treat |

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| exhaust system | Exhaust System | system | environmentally friendly | sintering furnace waste gas |
| Sintering fixture | Sintering Fixture | Sintering jig | High stability, high temperature resistance | Fixing tungsten alloy billet for sintering |
| Atmosphere Analyzer | Atmosphere Analyzer | Air gas analysis device | High sensitivity, real-time monitoring | Analysis of gas composition in sintering furnace (such as $H_2$ and $O_2$ content ) |
| Sintering boat cleaning machine | Sintering Boat Cleaner | Baking Bottom Washing Machine | Efficient cleaning, corrosion resistance | Cleaning of sintering boats to remove residues |
| High pressure cooler | High-Pressure Cooler | High pressure cooler | Rapid cooling, high efficiency | Tungsten alloy products after accelerated cooling and sintering |
| Sintering temperature calibrator | Sintering Temperature Calibrator | Sintering Temperature Calibrator | High precision and good stability | Calibrate sintering furnace temperature to ensure consistent process |
| Heat treatment transport vehicle | Heat Treatment Transport Cart | Hot handling transport truck | High temperature resistance, high load | Handling sintered tungsten alloy products |
| Sintering furnace maintenance tools | Sintering Furnace Maintenance Tool | Sintering furnace maintenance | Versatile and durable | Maintenance and repair of sintering furnaces |
| Atmosphere purification device | Atmosphere Purifier | Air purification device | High purification, energy saving | Purify the gas in the sintering furnace and reduce impurities |
| Sintering pressure controller | Sintering Pressure Controller | Sintering pressure control device | Precise control, high stability | Controlling the pressure of vacuum pressure sintering furnace |
| Resistance sintering furnace | Resistance Sintering Furnace | Resistance to sintering furnace | Fast heating, energy saving | Sintering Tungsten Alloy by Resistance Heating |
| Plasma Sintering Furnace (SPS) | Spark Plasma Sintering Furnace | スパークプラズマ焼 furnace | Ultra-fast, high densification | Fast sintering of tungsten alloy to increase density |
| Sintering furnace insulation layer | Sintering Furnace Insulation | Sintering furnace insulation layer | High heat resistance, low thermal conductivity | Improving the thermal insulation performance of sintering furnaces |
| Heat treatment quenching furnace | Heat Treatment Quenching Furnace | Heat treatment furnace | Rapid cooling, high hardness | Quenching tungsten alloy products to enhance performance |
| Sintered billet shaping machine | Sintered Billet Shaping Machine | Sintered agglomeration shaping machine | High precision and multifunctional | Tungsten alloy billet after shaping and sintering |
| Sintering cooling rack | Sintering Cooling Rack | Sintering cooling rack | Good ventilation and large capacity | Place the sintered blank for natural |

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| | | | | |
|---|---|---|---|---|
| | | | | cooling |
| Heat treatment cleaning machine | Heat Treatment Cleaner | Thermal treatment washing machine | Efficient cleaning, no residue | Cleaning of tungsten alloy products after heat treatment |
| Sintering boat transporter | Sintering Boat Transport Cart | Yarn vehicle transport truck | High temperature resistance, high load | Transporting sintering boat |
| Atmosphere preheater | Atmosphere Preheater | Insulated air heater | Rapid heating, energy saving | Preheating the gas in the sintering furnace |
| Sintering furnace vacuum pump | Sintering Furnace Vacuum Pump | Sintering furnace vacuum pump | High vacuum, low noise | Additional vacuum support for sintering furnaces |
| Sintering waste collector | Sintering Scrap Collector | Sintering Chip Collector | Efficient collection and environmental protection | Collecting waste from the sintering process |
| Heat treatment temperature monitor | Heat Treatment Temperature Monitor | Thermal treatment temperature | Real-time monitoring, high precision | Monitoring temperature during heat treatment |
| Sintering furnace seal tester | Sintering Furnace Seal Tester | Sintering furnace cell tester | High sensitivity, rapid detection | Check the sealing performance of the sintering furnace |
| Sintered billet stacker | Sintered Billet Stacking Machine | Sintered agglomerate stacking machine | Automation and space saving | Stacking sintered tungsten alloy billets |

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## 4. Forging and forging equipment

| Equipment Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Forging Machine | Forging Machine | Forging Machine | High impact, densification | Forging tungsten alloy billets to increase density and strength |
| Hydraulic forging machine | Hydraulic Forging Machine | Hydraulic forging machine | High pressure, precise control | Hydraulic forging of tungsten alloy billets for large parts |
| Hammer forging machine | Hammer Forging Machine | Hanmar forging machine | High impact, high efficiency | Forging tungsten alloy billet by hammering |
| Hot forging machine | Hot Forging Machine | Hot forging machine | High temperature forging, good ductility | Forging tungsten alloy billets at high temperatures |
| Cold Forging Machine | Cold Forging Machine | Cold forging machine | No thermal deformation, high precision | Forging tungsten alloy billets at room temperature |
| Rotary forging machine | Rotary Forging Machine | Rotary Forging Machine | Continuous forging, high efficiency | Rotary Forged Tungsten Alloy Rod or Tube |
| Forging heating | Forging Heating | Forging heating | High temperature, | Heat the tungsten alloy |

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| | | | | |
|---|---|---|---|---|
| furnace | Furnace | furnace | uniform and rapid heating | billet to forging temperature (e.g. 1000-1300°C) |
| Forging fixture | Forging Fixture | Forging jig | High stability, high temperature resistance | Fixing tungsten alloy billet for forging |
| Forging finishing machine | Forging Trimming Machine | Forging finishing machine | High precision and automation | Trimming the edge of tungsten alloy billet after forging |
| Hot rolling mill | Hot Rolling Mill | Hot rolling machine | High temperature rolling, densification | Hot rolled tungsten alloy billets to produce plates or bars |
| Cold rolling mill | Cold Rolling Mill | Cold calendering machine | High precision, no thermal deformation | Cold rolling tungsten alloy billet to improve surface quality |
| Four-high rolling mill | Four-High Rolling Mill | Four roll rolling machine | High pressure, high flatness | Precision rolled tungsten alloy plate |
| Rolling heating furnace | Rolling Heating Furnace | Rolling heating furnace | High temperature, uniform and rapid heating | Heat the tungsten alloy billet to rolling temperature |
| Rolling straightening machine | Rolling Straightener | Roll Forming Machine | High precision, no damage | Tungsten alloy plates or bars after straightening and rolling |
| Forging cooler | Forging and Rolling Cooler | Forging pressure cooler | Rapid cooling and uniform cooling | Tungsten alloy products after cooling forging |
| Forging Die | Forging Die | Forging Dai | High temperature resistance, high hardness | Controlling the Shape of Forged Tungsten Alloy |
| Forging table | Forging Table | Workout Table | High stability, impact resistance | Supporting tungsten alloy billets for manual forging |
| Forging Truck | Forging Transport Cart | Forging transport truck | High temperature resistance, high load | Handling of forged tungsten alloy billets |
| Rolling tension controller | Rolling Tension Controller | Compression tension control device | Precise control and high stability | Controlling the tension during rolling |
| Forging scrap collector | Forging and Rolling Scrap Collector | Forging Chip Collector | Efficient collection and environmental protection | Collecting scrap from forging and rolling processes |

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**5. Processing and finishing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| lathe | Lathe | Rotary Disk | High precision and multifunctional | Turning tungsten alloy billets into rods or parts |
| grinder | Grinding Machine | Grinding Machine | High precision, smooth surface | Grinding tungsten alloy surface to specified size |

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| | | | | |
|---|---|---|---|---|
| | | | | and finish |
| Milling Machine | Milling Machine | Freeze Plate | Multifunctional and efficient | Milling tungsten alloy billets and processing complex shapes |
| Drill Press | Drilling Machine | Drill Plate | High precision and good stability | Drilling holes in tungsten alloy |
| Wire cutting machine | Wire Cutting Machine | Wai Yakto Machine | High precision, non-contact | Cutting tungsten alloy blanks to produce thin sheets or complex parts |
| Electrical discharge machining (EDM) | Electrical Discharge Machine | Discharge processing machine | High precision, hard-resistant materials | Machining high hardness tungsten alloy parts |
| Rolling Mill | Rolling Mill | Calendering Machine | High pressure, continuous processing | Rolling tungsten alloy billets to produce tungsten alloy plates or foils |
| Polishing Machine | Polishing Machine | Grinding Machine | High finish, automation | Polishing tungsten alloy surface to improve appearance and performance |
| Electrolytic polishing machine | Electrolytic Polishing Machine | Electrolytic grinding machine | No mechanical damage, high finish | Tungsten alloy surface polishing |
| Cutting Machine | Cutting Machine | Cutting Machine | Precision cutting, automation | Cut tungsten alloy into specified lengths |
| Grinding machine | Grinding Wheel Machine | Sharpening Machine | High hardness, wear resistance | Repair tungsten alloy surface or tool |
| Ultrasonic cleaning machine | Ultrasonic Cleaning Machine | Ultrasonic cleaning machine | Deep cleaning, high efficiency | Clean tungsten alloy products and remove processing residues |
| Straightening Machine | Straightening Machine | Correction Machine | High precision, no damage | Straightening tungsten alloy rods or plates to ensure straightness |
| Surface treatment machine | Surface Treatment Machine | Surface treatment machine | Multifunctional and automated | Surface coating or treatment of tungsten alloy |
| CNC machine tools | CNC Machine | CNC machine tools | High precision and automation | Precision machining of tungsten alloy parts |
| Tapping machine | Tapping Machine | Taping Maschinen | High efficiency, precise thread | Threading in Tungsten Alloy |
| Heat treatment fixture | Heat Treatment Fixture | Heat treatment fixture | High stability, high temperature resistance | Fixing tungsten alloy products for heat treatment |
| Dressing tools | Trimming Tool | Trimming Tull | High hardness, precision operation | Hand-finished tungsten alloy edges |
| Sandblasting Machine | Sandblasting Machine | Sandblaster | Efficient cleaning and surface roughening | Sandblasting of tungsten alloy surface to improve adhesion |

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| | | | | |
|---|---|---|---|---|
| Laser marking machine | Laser Marking Machine | レーザーマーキング machine | High precision, non-contact | Marking or numbering on tungsten alloy products |
| Precision grinding machine | Precision Grinding Machine | Precision grinding machine | Ultra-high precision, high finish | Precision Grinding Tungsten Alloy Parts |
| Broaching Machine | Broaching Machine | Blog | High efficiency, complex processing | Machining complex grooves or holes inside tungsten alloy |
| planer | Planing Machine | Kanana Plate | High flatness, large-scale processing | Planing tungsten alloy plates or large parts |
| punch | Punching Machine | Panching Mashin | High efficiency and precise punching | Punching holes in tungsten alloy plate |
| Water jet cutting machine | Water Jet Cutting Machine | ウォータージェット cutting machine | No thermal damage, high precision | Waterjet cutting of tungsten alloy for complex shapes |
| Ultrasonic processing machine | Ultrasonic Machining Machine | Ultrasonic processing machine | High precision, stress-free | Ultrasonic machining of tungsten alloy small parts |
| Heat straightening machine | Hot Straightening Machine | Heat correction machine | High temperature correction, no damage | Straightening tungsten alloy products at high temperatures |
| Shot blasting machine | Shot Blasting Machine | Seat Brass Machine | Surface enhancement, high efficiency | Shot peening of tungsten alloy surface |
| Electroplating equipment | Electroplating Equipment | Electroplating device | Uniform coating, corrosion resistance | Electroplating on the surface of tungsten alloy (such as nickel plating) |
| Processing fixture | Machining Fixture | Processing fixture | High stability, customization | Fixing tungsten alloy parts for processing |
| Tool grinding machine | Tool Grinder | Tool grinder | High precision and durable | Grinding of tungsten alloy tools |
| Parts handling rack | Parts Transport Rack | Parts transport luggage | Stable structure, easy to carry | Handling processed tungsten alloy parts |
| Surface roughening machine | Surface Roughening Machine | Surface roughening machine | Controllable roughness, high efficiency | Roughen the surface of tungsten alloy and enhance the adhesion of coating |
| Laser welding machine | Laser Welding Machine | Lazer welding machine | High precision, no damage | Welding tungsten alloy parts |
| Processing waste collector | Machining Scrap Collector | Chip Collector | Efficient collection and environmental protection | Collect tungsten alloy waste during processing |
| Rolling machine | Rolling Press Machine | Roller Press | High pressure, smooth surface | Rolling tungsten alloy surface to improve density and smoothness |
| Plasma cutting machine | Plasma Cutting Machine | Plasma cutting machine | High temperature cutting, high efficiency | Plasma cutting of tungsten alloy plates or parts |

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| Polishing liquid preparation tank | Polishing Liquid Preparation Tank | Grinding liquid preparation tank | Corrosion-resistant and precise metering | Prepare polishing fluid for tungsten alloy polishing |
| Parts cleaning tank | Parts Cleaning Tank | Parts cleaning tank | Large capacity, corrosion resistant | Cleaning of tungsten alloy parts after processing |
| Surface hardening furnace | Surface Hardening Furnace | Surface hardening furnace | High temperature treatment, high hardness | Hardened tungsten alloy surface to improve wear resistance |
| Precision turning machine | Precision Turning Machine | Precision turning machine | Ultra-high precision, multi-function | Precision Turning Tungsten Alloy Parts |
| Parts polishing rack | Parts Polishing Rack | Parts grinding rack | Good ventilation and large capacity | Place tungsten alloy parts for polishing |
| Process cooling system | Machining Cooling System | Processing cooling system | Efficient cooling, energy saving | Provide coolant for processing equipment |
| Parts stacker | Parts Stacking Machine | Parts storage machine | Automation and space saving | Stacking processed tungsten alloy parts |
| Surface spraying machine | Surface Coating Machine | Surface coating machine | Uniform coating, durable | Spraying protective layer on tungsten alloy surface |
| Processing vibrator | Machining Vibrator | Processing vibration machine | High frequency vibration, high efficiency | Auxiliary processing of tungsten alloy parts |
| Parts testing bench | Parts Inspection Station | Parts Inspection Station | High precision, portable | Check the quality of processed tungsten alloy parts |
| Tool cleaning machine | Tool Cleaning Machine | Tool Washing Machine | Efficient cleaning, no residue | Cleaning tools for machining tungsten alloy |
| Parts packaging machine | Parts Packing Machine | Parts Packaging Machine | Automation, anti-oxidation | Packaging of processed tungsten alloy parts |
| Processing exhaust gas processor | Machining Exhaust Gas Processor | Processing exhaust treatment device | Efficient purification and environmental protection | Treatment of waste gas generated during processing |

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**6. Auxiliary and transportation equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten alloy powder, billet or products to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten alloy powder or billet to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, | Feed tungsten alloy powder |

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| | | | adjustable speed | evenly into pressing or sintering equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provide high-purity hydrogen required for sintering |
| Nitrogen Generator | Nitrogen Generator | Antagonist Generating Device | High purity, stable supply | Provide inert gas protection (such as annealing or storage) |
| Vacuum Pump | Vacuum Pump | Vacuum Pump | High vacuum, low noise | Provide vacuum environment for vacuum sintering furnace |
| Air compressor | Air Compressor | Eacon Press | High pressure, stable output | Provide compressed air for pneumatic equipment |
| Storage tank | Storage Tank | Storage Tank | Good sealing and large capacity | Storage of tungsten alloy powder or intermediate products |
| Transporter | Forklift | FO CLIFFT | Flexible transport, high load capacity | Handling tungsten alloy billets or products |
| dust collector | Dust Collector | Dust Collector | Efficient dust removal, environmental protection | Collect dust generated during production |
| Temperature and humidity controller | Temperature and Humidity Controller | Temperature and humidity control device | Precise control and high stability | Control the temperature and humidity in the workshop to protect the quality of tungsten alloy |
| Static Eliminator | Static Eliminator | Static Electricity Removal Device | Rapid elimination of static electricity, high safety | Prevent tungsten powder from sticking due to static electricity |
| Protective cover | Protective Cover | Protection card | High temperature resistance and high safety | Protect equipment or operators (such as sintering furnace protection) |
| Tool Cart | Tool Cart | Tool Card | Portable and versatile | Storage and transport of small tools or parts |
| Gas Pressure Regulator | Gas Pressure Regulator | Gas pressure regulator | Precise control and high stability | Regulate the pressure of hydrogen or nitrogen |
| Exhaust gas treatment device | Exhaust Gas Treatment Device | Exhaust treatment device | Efficient purification and environmental protection | Treatment of waste gas from sintering or processing |
| Dust monitor | Dust Monitor | Dust Monitor | Real-time monitoring, high sensitivity | Monitor dust concentration in the workshop to ensure safety |
| Explosion proof lights | Explosion-Proof Lamp | Explosion-proof lamp | High safety and durability | Provide lighting for powder handling areas |
| Material sorting machine | Material Sorting Machine | Material sorting machine | Automation and high efficiency | Sorting different batches of tungsten alloy powder |

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| | | | | |
|---|---|---|---|---|
| Automatic stacker | Automatic Stacker | Automatic stacking machine | Automation and space saving | Stacking tungsten alloy billets or products |
| Pneumatic handling device | Pneumatic Transport Device | Air pressure transport device | Fast shipping, dust-free | Tungsten Alloy Powder by Pneumatic Conveying |
| Anti-vibration pads | Anti-Vibration Pad | Vibration-proof pad | High shock absorption, durable | Reduce equipment vibration and protect precision instruments |
| Safety fence | Safety Guardrail | Security Fence | High strength, easy to install | Isolate dangerous areas to ensure safe operation |
| Equipment lubrication system | Equipment Lubrication System | Equipment Lubrication System | Automatic lubrication, extended service life | Provide lubricants for processing equipment |
| Gas storage tank | Gas Storage Tank | Gas Storage Tank | High sealing performance and large capacity | Storage of hydrogen or nitrogen |
| Workshop monitoring system | Workshop Monitoring System | Factory Monitoring System | Real-time monitoring, multi-function | Monitor workshop operation status |
| Transport Robot | Transport Robot | Transport robot | Automation and high efficiency | Automatic handling of tungsten alloy blanks or products |
| Powder sealing box | Powder Sealing Box | Powder seal box | High sealing, moisture-proof | Sealed storage of tungsten alloy powder |
| Waste Compactor | Scrap Compressor | Chip Compressor | High compression ratio, space saving | Compressing waste from production processes |
| Air Purifier | Air Purifier | Air Purifier | High efficiency purification, low noise | Purify workshop air and keep it clean |
| Transport rail car | Transport Rail Car | Transport | Large load, high stability | Transporting tungsten alloy products within the workshop |
| Emergency lighting | Emergency Lighting | Emergency lighting lamp | High brightness, long life | Providing lighting in emergency situations |
| Equipment Calibration Tools | Equipment Calibration Tool | Equipment Calibration Tutorial | High precision and multifunctional | Calibrate production equipment to ensure accuracy |
| Dust curtain | Dust Curtain | Dustproof Door | High sealing, easy to install | Isolate dust areas to reduce pollution |

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**7. Inspection and testing equipment and instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detect the content and impurities of W, Ni, Fe and other |

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| | | | | |
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| | | | | elements in tungsten alloy |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analyzing the Metal Content in Tungsten Alloy |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten alloy |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the surface morphology and microstructure of tungsten alloy |
| Metallographic microscope | Metallographic Microscope | Metallographic microscope | High resolution, material analysis | Check the metallographic structure and grain size of tungsten alloy |
| Scanning electron microscopy (SEM) | Scanning Electron Microscope | Scanning electron microscope | High resolution, surface analysis | Observe the microscopic morphology of the surface and fracture of tungsten alloy |
| Energy dispersive spectrometer (EDS) | Energy Dispersive Spectrometer | エネルギー dispersion beam splitter | Elemental analysis, high sensitivity | Analyze the distribution of elements in tungsten alloy |
| X- ray diffractometer (XRD) | X-Ray Diffractometer | X-ray folding device | High resolution, structural analysis | Analyze the crystal structure of tungsten alloy |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of tungsten alloy (such as Brinell or Vickers hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten alloy (17-19 g/ $cm^3$ ) |
| Tensile testing machine | Tensile Testing Machine | Tension testing machine | High precision and multifunctional | Testing the tensile strength and elongation of tungsten alloy |
| Fatigue testing machine | Fatigue Testing Machine | Fatigue test machine | Multi-cycle, high reliability | Testing the Fatigue Life of Tungsten Alloy |
| Torsion testing machine | Torsion Testing Machine | Nejiri test machine | High precision and multifunctional | Testing the Torsional Strength of Tungsten Alloy |
| High temperature creep testing machine | High-Temperature Creep Tester | High temperature crystal test machine | High temperature testing, long term stability | Testing the creep properties of tungsten alloy at |

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| | | | | high temperatures |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect cracks or defects inside tungsten alloy |
| Coordinate Measuring Machine (CMM) | Coordinate Measuring Machine | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring the dimensional accuracy of tungsten alloy products |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the roughness of tungsten alloy surfaces |
| Thermogravimetric Analyzer (TGA) | Thermogravimetric Analyzer | Thermogravimetric analysis device | High temperature testing, accurate data | Analyzing the quality changes of tungsten alloy during sintering |
| Thermal dilatometer | Thermal Expansion Analyzer | Thermal expansion meter | High precision and wide temperature range | Measuring the Thermal Expansion Coefficient of Tungsten Alloy |
| Dynamic Mechanical Analyzer (DMA) | Dynamic Mechanical Analyzer | Dynamic Thermomechanical Analysis Device | Multi-parameter, high precision | Analysis of the mechanical properties of tungsten alloys as a function of temperature |
| Specific surface area analyzer (BET) | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the Specific Surface Area of Tungsten Alloy Powder |
| Laser diameter gauge | Laser Diameter Gauge | Reser diameter measuring device | Non-contact, high precision | Measuring the diameter of tungsten alloy rods or parts |
| Infrared thermometer | Infrared Thermometer | Infrared thermometer | Non-contact, fast response | Measuring temperature during sintering or machining |
| Trace oxygen analyzer | Trace Oxygen Analyzer | Trace oxygen analysis device | High sensitivity, fast response | Detect oxygen content in sintering environment to ensure low oxygen environment |
| Optical projector | Optical Projector | Optical projector | High magnification, precise measurement | Check the geometry and dimensions of tungsten alloy products |
| Impact testing machine | Impact Testing Machine | Impact test machine | High precision and | Testing the Impact Toughness of |

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| | | | | |
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| | | | multifunctional | Tungsten Alloy |
| Compression testing machine | Compression Testing Machine | Compression test machine | High load, good stability | Testing the Compressive Strength of Tungsten Alloy |
| Wear testing machine | Wear Testing Machine | Wear testing machine | High simulation, durable | Testing the Wear Resistance of Tungsten Alloy |
| Corrosion testing machine | Corrosion Testing Machine | Corrosion testing machine | Multiple environments, high precision | Testing the Corrosion Resistance of Tungsten Alloy |
| Acoustic Emission Detector | Acoustic Emission Detector | Audio output detector | Nondestructive testing, high sensitivity | Detection of micro cracks inside tungsten alloy |
| Conductivity Meter | Conductivity Meter | Conductivity meter | High sensitivity, portable | Measuring the conductivity of tungsten alloys |
| Residual Stress Analyzer | Residual Stress Analyzer | Residual stress analysis device | High precision, lossless | Analyzing Residual Stress in Tungsten Alloys |
| Porosity Tester | Porosity Tester | Porosity Tester | High-precision, fast measurement | Measuring Porosity of Tungsten Alloys |
| Microhardness tester | Microhardness Tester | Micro Hardness Tester | High resolution, micro-area testing | Testing the hardness of a small area of tungsten alloy |
| Thermal conductivity meter | Thermal Conductivity Meter | Thermal Conductivity Meter | High precision and fast response | Measuring Thermal Conductivity of Tungsten Alloys |
| Magnetic Tester | Magnetic Tester | Magnetic Tester | High sensitivity, multifunctional | Testing the magnetic properties of tungsten alloys (such as tungsten nickel iron alloy) |
| Laser interferometer | Laser Interferometer | Lesa Intervention Plan | Ultra-high precision, non-contact | Measuring the flatness of tungsten alloy surfaces |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring particle size distribution of tungsten alloy powder |
| Environmental Simulation Test Chamber | Environmental Simulation Chamber | Environmental Simulation Test Chamber | Multi-condition simulation, high reliability | Simulating the performance of tungsten alloy in different environments |

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## 8. Raw and auxiliary materials

| Material Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| High purity tungsten powder | High-Purity Tungsten Powder | High purity polyester powder | High purity (≥99.95%), adjustable particle size | The main raw materials of high-density tungsten alloy (accounting for 85-97%) |
| Nickel powder | Nickel Powder | Nikka powder | High purity, easy to sinter | Binder phase, providing toughness and strength (2-10%) |
| Iron Fan | Iron Powder | Iron powder | High purity, good economy | Binder phase, enhancing the performance of tungsten alloy (accounting for 1-5%) |
| Copper powder | Copper Powder | Copper powder | High conductivity, easy to process | Replace iron for tungsten-nickel-copper alloy (accounting for 1-5%) |
| **Molybdenum powder** | **Molybdenum Powder** | **Moldy powder** | High melting point, corrosion resistance | Enhance the high temperature performance of tungsten alloy and partially replace tungsten (accounting for 1-5%) |
| Polyvinyl alcohol (PVA) | Polyvinyl Alcohol | ポリビニルアルコール | Strong adhesion, easy to decompose | Binder for compression molding |
| Stearic acid | Stearic Acid | Sterilin | Good lubricity, easy to evaporate | Lubricants during pressing |
| **paraffin** | **Paraffin Wax** | **Paraffin Works** | Strong lubricity, low melting point | Binder or lubricant for compression molding |
| Hydrogen ( $H_2$ ) | Hydrogen | Hydrogen | High purity, strong reducing ability | Protective and reducing gases during sintering |
| Nitrogen ( $N_2$ ) | Nitrogen | chlorine | Inertness, high stability | Auxiliary protective gas to prevent oxidation |
| Deionized water | Deionized Water | Deionized water | High purity, no impurities | Prepare binder solution or clean tungsten alloy |
| Ethanol | Ethanol | Etanol | Highly volatile, no residue | Solvent for wet mixing of powders or cleaning |

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**Cemented carbide production inspection equipment and raw and auxiliary materials**
**Carbide production inspection equipment and raw materials**
**Hard Alloy Production and Inspection Equipment and Raw Materials**

**1. Raw material preparation and mixing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind WC powder and Co powder to submicron level (e.g. 0.1-1 micron) |
| Planetary ball mill | Planetary Ball Mill | プラネタリーボールミル | High efficiency and various grinding | Finely ground cemented carbide mixed powder |
| Air jet mill | Air Jet Mill | EagerToMil | Non-contact, high fineness | Grind WC powder into ultra-fine particles (e.g. below 0.5 microns) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieve the ground powder to ensure uniform particle size |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mix WC powder and Co powder according to the proportion |
| V-type mixer | V-Type Mixer | V-type Mikisa | High uniformity, low shear | Dry Mixed Carbide Powder |
| Double cone mixer | Double Cone Mixer | Double cone mikisara | Large capacity, even mixing | Bulk Mixing of Carbide Powders |

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| | | | | |
|---|---|---|---|---|
| Blender | Agitator | Blender | Efficient mixing, high temperature resistance | Wet mixing of cemented carbide powder and binder |
| Solution preparation tank | Solution Preparation Tank | Solution preparation tank | Corrosion-resistant and precise metering | Preparation of adhesive or lubricant solutions (such as paraffin solutions) |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray drying wet mixed powder into uniform particles |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry the mixed powder to remove moisture |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Filter wet mixed powder to remove excess liquid |
| Powder Classifier | Powder Classifier | Powder Classifier | High precision, multi-level grading | Grading carbide powder to ensure consistent particle size distribution |
| Ultrasonic cleaning machine | Ultrasonic Cleaner | Ultrasonic cleaning machine | High frequency cleaning, no damage | Cleaning of grinding and mixing equipment to remove residues |
| High Energy Ball Mill | High-Energy Ball Mill | 高エネルギー・ボールミル | High impact, ultra-fine grinding | Ultra-fine WC-Co powder to improve uniformity |
| Turbine grinder | Turbo Mill | Tabomir | High-speed crushing, multi-function | Rapid crushing of WC or other hard phase powders |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, automation | Finely sieved cemented carbide powder |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of solid and liquid components in wet mixed powders |
| Metering Pumps | Metering Pump | Metering Pump | Precise metering, corrosion resistance | Precise delivery of adhesive or lubricant solutions |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of wet mix solutions |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Drying of cemented carbide powder under vacuum to avoid oxidation |
| Powder Dispersing Machine | Powder Disperser | Powder Dispersing Machine | High dispersibility and good uniformity | Disperse cemented carbide powder to prevent agglomeration |
| Weighing batching machine | Weighing and Batching Machine | Measuring and batching machine | High precision and automation | Weigh WC, Co and other powders according to the proportion |
| Powder conveyor | Powder Conveyor | Powder Conbe | Sealed transportation, dustproof | Conveying cemented carbide powder to mixing or pressing equipment |
| Mixing cooler | Mixing Cooler | Hybrid Cooler | Rapid cooling and | Cooling the mixed |

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|---|---|---|---|---|
| | | | uniform cooling | cemented carbide powder |
| Hammer mill | Hammer Mill | Hanmar | High impact, high capacity | Preliminary crushing of WC powder or other hard phase materials |
| Powder granulator | Powder Granulator | Powder Granulator | Uniform particles and good fluidity | Make cemented carbide powder into granules to improve pressing performance |
| Wet mixer | Wet Mixer | Wet Mikisa | High uniformity, corrosion resistance | Mixing carbide powder in liquid medium |
| High pressure homogenizer | High-Pressure Homogenizer | High pressure homogenizer | High pressure dispersion, good uniformity | Homogenized wet mixed cemented carbide powder |
| Powder grinding jar | Powder Grinding Jar | Powder grinding jar | Wear-resistant, high sealing performance | Loading carbide powder for ball milling |
| Screening vibrator | Screening Vibrator | Screening vibrating machine | High frequency vibration, high efficiency | Auxiliary screening of cemented carbide powder |
| Powder drying tower | Powder Drying Tower | Powder drying tower | Large capacity, efficient drying | Large-scale drying of cemented carbide powders |
| Powder mixing tank | Powder Mixing Tank | Powder mixing tank | Large capacity, corrosion resistant | Bulk wet mixing of cemented carbide powders |
| Powder screening conveyor | Powder Screening Conveyor | Powder Screening Conveyor | Screening and conveying integrated, high efficiency | Sieving and conveying cemented carbide powder |
| Powder storage silo | Powder Storage Silo | Powder storage silo | Large capacity, moisture-proof | Store carbide powder dry |

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**2. Pressing and molding equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Pressing carbide powder into blanks (such as tools, molds) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of carbide billets to improve uniformity |
| Cold Isostatic Press (CIP) | Cold Isostatic Press | Cold room isostatic pressure press | No thermal deformation, high uniformity | Pressing of cemented carbide billets at room temperature |
| Hot Isostatic Press (HIP) | Hot Isostatic Press | Hot Isostatic Pressure Press | High temperature, high pressure, high density | Pressing carbide blanks under high temperature and high pressure to eliminate porosity |
| Mould | Mold | Casting | High temperature | Forming carbide billets to |

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| | | | resistant, customizable shapes | ensure consistent dimensions |
| Demoulding machine | Demolding Machine | Demolding machine | Automation and high efficiency | Remove the pressed carbide blank from the die |
| Weighing Machine | Weighing Machine | Measuring machine | High-precision and fast weighing | Precisely weigh the powder to ensure consistent amount every time you press it |
| Powder filling machine | Powder Filling Machine | Powder filling machine | Automatic and uniform filling | Automatically load carbide powder into the mold |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Dry the pressed cemented carbide blank to remove moisture |
| Vacuum degreasing furnace | Vacuum Degreasing Furnace | Vacuum degreasing furnace | Low oxygen environment, high efficiency | Removal of paraffin or PVA from carbide blanks |
| Press dressing machine | Billet Trimming Machine | Pressing and trimming machine | High precision and automation | Trimming the edge of the pressed cemented carbide billet |
| Mould cleaning machine | Mold Cleaning Machine | Casting washing machine | Efficient cleaning and durable | Cleaning the pressing die to maintain precision |
| Powder compactor | Powder Compactor | Powder Compressor | High efficiency and uniform compaction | Initial compaction of carbide powder to facilitate subsequent molding |
| Automatic feeding machine | Automatic Feeder | Automatic feeder | Automatic and continuous feeding | Automatic feeding of powder into the pressing equipment |
| Green sheet cutting machine | Billet Cutting Machine | Billet cutting machine | Precise cutting without damage | Cut the pressed billet into specified size |
| Double-action hydraulic press | Double-Action Hydraulic Press | Double action hydraulic press | Bidirectional pressure, good uniformity | Double-direction pressing of carbide billets to increase density |
| Mold preheater | Mold Preheater | Casting preheater | Temperature controllable, fast heating | Preheat the mold to reduce pressing stress |
| Greenhouse shaping machine | Billet Shaping Machine | Blank shaping machine | High precision and multifunctional | Cemented carbide billet after shaping and pressing |
| Vacuum packaging machine | Vacuum Packing Machine | Vacuum packaging machine | Good sealing and anti-oxidation | Packaging pressed blanks to prevent oxidation |
| Powder Vibrator | Powder Vibrator | Powder vibrating machine | Even distribution, low energy consumption | Vibrate the powder to distribute it evenly in the mold |
| Mould polishing machine | Mold Polishing Machine | Casting grinding machine | High finish, durable | Polish the inner surface of the mold to improve the quality of the blank |
| Green compact weighing instrument | Billet Weighing Instrument | Pressing gauge | High-precision, fast measurement | Weighing pressed billets to ensure consistent quality |

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| Die lubrication device | Mold Lubrication Device | Casting lubrication device | Apply evenly and reduce friction | Apply lubricant inside the mold to facilitate demoulding |
| Powder sieving and filling machine | Powder Screening and Filling Machine | Powder Screening Filling Machine | Screening and filling in one, high efficiency | Sieving and filling carbide powder into molds |
| Pressed billet transport rack | Billet Transport Rack | Pressed billet transport | Stable structure, easy to carry | Handling of pressed carbide billets |
| Rotary press | Rotary Press | Return to the pres | Continuous pressing, high efficiency | Continuous pressing of cemented carbide billets |
| Mold heating furnace | Mold Heating Furnace | Casting heating furnace | High temperature, uniform and rapid heating | Heating the mold to improve pressing quality |
| Green compact surface cleaning machine | Billet Surface Cleaner | Pressed blank surface cleaning machine | Efficient cleaning, no damage | Clean impurities on the surface of pressed billets |
| Powder pre-pressing machine | Powder Pre-Press Machine | Powder pre-pressing machine | Low pressure preforming, energy saving | Pre-press carbide powder to facilitate subsequent high pressure forming |
| Mold detector | Mold Inspection Instrument | Casting tester | High precision, lossless | Check the mold for wear or deformation |
| Pressed green sheet drying rack | Billet Drying Rack | Pressed Bread Drying Ruck | Good ventilation and large capacity | Place the pressed blank for natural drying |
| Powder Flow Tester | Powder Flow Tester | Powder Flow Tester | High-precision, fast measurement | Testing the fluidity of cemented carbide powder |
| Mould sandblasting machine | Mold Sandblasting Machine | 鋳 type サンドブラスト machine | Efficient cleaning and surface roughening | Sand blasting to clean the mold surface |
| Green compact stacker | Billet Stacking Machine | Pressing and stacking machine | Automation and space saving | Stacking pressed carbide billets |
| Mould storage cabinet | Mold Storage Cabinet | 鋳 -shaped storage tube | Dust and moisture proof | Store the pressing dies and keep them clean |

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### 3. Sintering and heat treatment equipment

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydrogen sintering furnace | Hydrogen Sintering Furnace | Hydrogen sintering furnace | High temperature control, strong reducing ability | Sintering of cemented carbide blanks in hydrogen atmosphere (1300-1500°C) |
| Vacuum sintering furnace | Vacuum Sintering Furnace | Vacuum sintering furnace | Low oxygen environment, high purity | Sintering of cemented carbide blanks under vacuum to avoid oxidation |

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| Medium frequency induction furnace | Medium Frequency Induction Furnace | Medium frequency induction furnace | Fast heating and uniform temperature | High temperature sintered carbide blank to ensure high hardness |
| Liquid Phase Sintering Furnace | Liquid Phase Sintering Furnace | Liquid Phase Sintering Furnace | High temperature liquid phase, densification | Sintering WC-Co in liquid phase (e.g. 1400-1500°C) |
| Annealing furnace | Annealing Furnace | Anil furnace | Precise temperature control and adjustable atmosphere | Annealing carbide products to eliminate internal stress |
| High temperature sintering furnace | High-Temperature Sintering Furnace | High temperature sintering furnace | Ultra-high temperature (>2000°C), durable | High temperature sintered carbide, suitable for special performance requirements |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | $CO_2$ ) during sintering process |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Cemented carbide products after cooling and sintering |
| Atmosphere sintering furnace | Atmosphere Sintering Furnace | Fen gas sintering furnace | Multiple atmospheres available, high stability | Sintering in a specific atmosphere (such as $H_2$ + $N_2$ ) to optimize performance |
| Atmosphere circulation device | Atmosphere Circulation Device | Ventilation circulation device | Uniform atmosphere, energy saving | Circulate the gas in the sintering furnace to improve efficiency |
| Sintering Boat | Sintering Boat | Yakibutsu | High temperature and corrosion resistance | Carrying carbide billets into the sintering furnace |
| Thermocouple | Thermocouple | Thermoelectric | High temperature tolerance, fast response | Measuring the temperature in the sintering furnace to ensure process stability |
| Temperature recorder | Temperature Recorder | Temperature recording device | Real-time monitoring, high precision | Record the temperature curve during sintering |
| Vacuum sealing device | Vacuum Sealing Device | Vacuum silo device | High sealing and pressure resistance | Ensure the airtightness of the vacuum sintering furnace |
| Water Cooling System | Water Cooling System | Water Cooling System | Efficient cooling, energy saving | Provide cooling water for sintering furnaces or coolers |
| Vacuum pressure sintering furnace | Vacuum Pressure Sintering Furnace | Vacuum pressure sintering furnace | High pressure, dense, low oxygen environment | Sintering cemented carbide under vacuum and pressure to increase hardness |
| Sintering furnace exhaust system | Sintering Furnace Exhaust System | Sintering grate gas system | Efficient exhaust, environmentally friendly | Collect and treat sintering furnace waste gas |

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| Sintering fixture | Sintering Fixture | Sintering jig | High stability, high temperature resistance | Fixing carbide billets for sintering |
| Atmosphere Analyzer | Atmosphere Analyzer | Air gas analysis device | High sensitivity, real-time monitoring | Analysis of gas composition in sintering furnace (such as $H_2$ and $O_2$ content ) |
| Sintering boat cleaning machine | Sintering Boat Cleaner | Baking Bottom Washing Machine | Efficient cleaning, corrosion resistance | Cleaning of sintering boats to remove residues |
| High pressure cooler | High-Pressure Cooler | High pressure cooler | Rapid cooling, high efficiency | Cemented carbide products after accelerated cooling and sintering |
| Sintering temperature calibrator | Sintering Temperature Calibrator | Sintering Temperature Calibrator | High precision and good stability | Calibrate sintering furnace temperature to ensure consistent process |
| Heat treatment transport vehicle | Heat Treatment Transport Cart | Hot handling transport truck | High temperature resistance, high load | Handling sintered cemented carbide products |
| Sintering furnace maintenance tools | Sintering Furnace Maintenance Tool | Sintering furnace maintenance | Versatile and durable | Maintenance and repair of sintering furnaces |
| Atmosphere purification device | Atmosphere Purifier | Air purification device | High purification, energy saving | Purify the gas in the sintering furnace and reduce impurities |
| Sintering pressure controller | Sintering Pressure Controller | Sintering pressure control device | Precise control, high stability | Controlling the pressure of vacuum pressure sintering furnace |
| Resistance sintering furnace | Resistance Sintering Furnace | Resistance to sintering furnace | Fast heating, energy saving | Sintering of cemented carbide by resistance heating |
| Plasma Sintering Furnace (SPS) | Spark Plasma Sintering Furnace | スパークプラズマ焼 furnace | Ultra-fast, high densification | Rapid sintering of cemented carbide to improve hardness and strength |
| Sintering furnace insulation layer | Sintering Furnace Insulation | Sintering furnace insulation layer | High heat resistance, low thermal conductivity | Improving the thermal insulation performance of sintering furnaces |
| Heat treatment quenching furnace | Heat Treatment Quenching Furnace | Heat treatment furnace | Rapid cooling, high hardness | Hardened carbide products to enhance performance |
| Sintered billet shaping machine | Sintered Billet Shaping Machine | Sintered agglomeration shaping machine | High precision and multifunctional | Cemented carbide blank after shaping and sintering |
| Sintering cooling rack | Sintering Cooling Rack | Sintering cooling rack | Good ventilation and large capacity | Place the sintered blank for natural cooling |
| Heat treatment | Heat Treatment | Thermal treatment | Efficient cleaning, no | Cleaning of heat treated |

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| cleaning machine | Cleaner | washing machine | residue | cemented carbide products |
| Sintering boat transporter | Sintering Boat Transport Cart | Yarn vehicle transport truck | High temperature resistance, high load | Transporting sintering boat |
| Atmosphere preheater | Atmosphere Preheater | Indoor air heater | Rapid heating, energy saving | Preheating the gas in the sintering furnace |
| Sintering furnace vacuum pump | Sintering Furnace Vacuum Pump | Sintering furnace vacuum pump | High vacuum, low noise | Additional vacuum support for sintering furnaces |
| Sintering waste collector | Sintering Scrap Collector | Sintering Chip Collector | Efficient collection and environmental protection | Collecting waste from the sintering process |
| Heat treatment temperature monitor | Heat Treatment Temperature Monitor | Thermal treatment temperature | Real-time monitoring, high precision | Monitoring temperature during heat treatment |
| Sintering furnace seal tester | Sintering Furnace Seal Tester | Sintering furnace cell tester | High sensitivity, rapid detection | Check the sealing performance of the sintering furnace |
| Sintered billet stacker | Sintered Billet Stacking Machine | Sintered agglomerate stacking machine | Automation and space saving | Stacking sintered cemented carbide billets |

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**4. Forging and forging equipment (20 types)**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Forging Machine | Forging Machine | Forging Machine | High impact, densification | Forged carbide billet for increased strength |
| Hydraulic forging machine | Hydraulic Forging Machine | Hydraulic forging machine | High pressure, precise control | Hydraulic forging of carbide billets for large parts |
| Hammer forging machine | Hammer Forging Machine | Hanmar forging machine | High impact, high efficiency | Forging carbide billets by hammering |
| Hot forging machine | Hot Forging Machine | Hot forging machine | High temperature forging, good ductility | Forging carbide billets at high temperatures |
| Cold Forging Machine | Cold Forging Machine | Cold Forging Machine | No thermal deformation, high precision | Forging carbide billets at room temperature |
| Rotary forging machine | Rotary Forging Machine | Rotary Forging Machine | Continuous forging, high efficiency | Rotary forged carbide rod or tube |
| Forging heating furnace | Forging Heating Furnace | Forging heating furnace | High temperature, uniform and rapid heating | Heat the carbide blank to forging temperature (e.g. 1000-1300°C) |
| Forging fixture | Forging Fixture | Forging jig | High stability, high temperature resistance | Fixing carbide billets for forging |
| Forging finishing | Forging | Forging finishing | High precision and | Trimming the edge of |

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| machine | Trimming Machine | machine | automation | forged carbide billet |
| Hot rolling mill | Hot Rolling Mill | Hot rolling machine | High temperature rolling, densification | Hot rolling of cemented carbide billets to produce plates |
| Cold rolling mill | Cold Rolling Mill | Cold calendering machine | High precision, no thermal deformation | Cold rolling of cemented carbide billets to improve surface quality |
| Four-high rolling mill | Four-High Rolling Mill | Four roll rolling machine | High pressure, high flatness | Precision rolled carbide plates |
| Rolling heating furnace | Rolling Heating Furnace | Rolling heating furnace | High temperature, uniform and rapid heating | Heat the carbide billet to rolling temperature |
| Rolling straightening machine | Rolling Straightener | Roll Forming Machine | High precision, no damage | Straightening and rolling of cemented carbide plates or bars |
| Forging cooler | Forging and Rolling Cooler | Forging pressure cooler | Rapid cooling and uniform cooling | Cemented carbide products after cooling and forging |
| Forging Die | Forging Die | Forging Dai | High temperature resistance, high hardness | Controlling the shape of forged carbide |
| Forging table | Forging Table | Workout Table | High stability, impact resistance | Supporting carbide billets for manual forging |
| Forging Truck | Forging Transport Cart | Forging transport truck | High temperature resistance, high load | Handling of forged cemented carbide billets |
| Rolling tension controller | Rolling Tension Controller | Compression tension control device | Precise control and high stability | Controlling the tension during rolling |
| Forging scrap collector | Forging and Rolling Scrap Collector | Forging Chip Collector | Efficient collection and environmental protection | Collecting scrap from forging and rolling processes |

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**5. Processing and finishing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| lathe | Lathe | Rotary Disk | High precision and multifunctional | Turning carbide blanks into tools or parts |
| grinder | Grinding Machine | Grinding Machine | High precision, smooth surface | Grinding carbide surfaces to achieve high precision and finish |
| Milling Machine | Milling Machine | Freeze Plate | Multifunctional and efficient | Milling of carbide blanks and complex shapes |
| Drill Press | Drilling Machine | Drill Plate | High precision and | Drilling holes in carbide |

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| | | | good stability | |
| Wire cutting machine | Wire Cutting Machine | Wai Yakto Machine | High precision, non-contact | Cutting carbide blanks to produce thin sections or complex parts |
| Electrical discharge machining (EDM) | Electrical Discharge Machine | Discharge processing machine | High precision, hard-resistant materials | Machining high hardness carbide parts |
| Rolling Mill | Rolling Mill | Calendering Machine | High pressure, continuous processing | Rolling carbide billets to produce thin plates |
| Polishing Machine | Polishing Machine | Grinding Machine | High finish, automation | Polished carbide surface to improve appearance and wear resistance |
| Electrolytic polishing machine | Electrolytic Polishing Machine | Electrolytic grinding machine | No mechanical damage, high finish | Electrolytic polishing of carbide surfaces |
| Cutting Machine | Cutting Machine | Cutting Machine | Precision cutting, automation | Cut carbide into specified lengths |
| Grinding machine | Grinding Wheel Machine | Sharpening Machine | High hardness, wear resistance | Dressing carbide surfaces or tools |
| Ultrasonic cleaning machine | Ultrasonic Cleaning Machine | Ultrasonic cleaning machine | Deep cleaning, high efficiency | Cleaning carbide products and removing processing residues |
| Straightening Machine | Straightening Machine | Correction Machine | High precision, no damage | Straightening carbide bars or plates to ensure straightness |
| Surface treatment machine | Surface Treatment Machine | Surface treatment machine | Multifunctional and automated | Surface coating of cemented carbide (such as TiN coating) |
| CNC machine tools | CNC Machine | CNC machine tools | High precision and automation | Precision machining of carbide tools or parts |
| Tapping machine | Tapping Machine | Taping Maschinen | High efficiency, precise thread | Threading in carbide |
| Heat treatment fixture | Heat Treatment Fixture | Heat treatment fixture | High stability, high temperature resistance | Fixing carbide products for heat treatment |
| Dressing tools | Trimming Tool | Trimming Tull | High hardness, precision operation | Hand-finished carbide edges |
| Sandblasting Machine | Sandblasting Machine | Sandblaster | Efficient cleaning and surface roughening | Sandblasting of cemented carbide surface to improve coating adhesion |
| Laser marking machine | Laser Marking Machine | レーザーマーキング machine | High precision, non-contact | Marking or numbering on cemented carbide products |
| Precision grinding machine | Precision Grinding Machine | Precision grinding machine | Ultra-high precision, high finish | Precision ground carbide tools |
| Broaching Machine | Broaching Machine | Blog | High efficiency, complex processing | Machining complex grooves or holes inside cemented carbide |

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| planer | Planing Machine | Kanana Plate | High flatness, large-scale processing | Planing carbide plates or large parts |
| punch | Punching Machine | Panching Mashin | High efficiency and precise punching | Punching holes in carbide plates |
| Water jet cutting machine | Water Jet Cutting Machine | ウォータージェット cutting machine | No thermal damage, high precision | Waterjet cutting of carbide for complex shapes |
| Ultrasonic processing machine | Ultrasonic Machining Machine | Ultrasonic processing machine | High precision, stress-free | Ultrasonic machining of small carbide parts |
| Heat straightening machine | Hot Straightening Machine | Heat correction machine | High temperature correction, no damage | Straightening of cemented carbide products at high temperatures |
| Shot blasting machine | Shot Blasting Machine | Seat Brass Machine | Surface enhancement, high efficiency | Shot peening hard alloy surface |
| Electroplating equipment | Electroplating Equipment | Electroplating device | Uniform coating, corrosion resistance | Electroplating on the surface of cemented carbide (such as Cr plating) |
| Processing fixture | Machining Fixture | Processing fixture | High stability, customization | Fixing carbide parts for machining |
| Tool grinding machine | Tool Grinder | Tool grinder | High precision and durable | Grinding of carbide tools |
| Parts handling rack | Parts Transport Rack | Parts transport luggage | Stable structure, easy to carry | Handling processed carbide parts |
| Surface roughening machine | Surface Roughening Machine | Surface roughening machine | Controllable roughness, high efficiency | Roughen the carbide surface and enhance the coating adhesion |
| Laser welding machine | Laser Welding Machine | Lazer welding machine | High precision, no damage | Welding carbide parts |
| Processing waste collector | Machining Scrap Collector | Chip Collector | Efficient collection and environmental protection | Collecting carbide scrap during machining |
| Rolling machine | Rolling Press Machine | Roller Press | High pressure, smooth surface | Rolling carbide surface to improve finish |
| Plasma cutting machine | Plasma Cutting Machine | Plasma cutting machine | High temperature cutting, high efficiency | Plasma cutting of carbide plates or parts |
| Polishing liquid preparation tank | Polishing Liquid Preparation Tank | Grinding liquid preparation tank | Corrosion-resistant and precise metering | Prepare polishing fluid for hard alloy polishing |
| Parts cleaning tank | Parts Cleaning Tank | Parts cleaning tank | Large capacity, corrosion resistant | Cleaning of processed cemented carbide parts |
| Surface hardening furnace | Surface Hardening Furnace | Surface hardening furnace | High temperature treatment, high hardness | Hardened carbide surface to improve wear resistance |
| Precision turning | Precision Turning | Precision turning | Ultra-high precision, | Precision turning |

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| machine | Machine | machine | multi-function | carbide parts |
| Parts polishing rack | Parts Polishing Rack | Parts grinding rack | Good ventilation and large capacity | Placing carbide parts for polishing |
| Process cooling system | Machining Cooling System | Processing cooling system | Efficient cooling, energy saving | Provide coolant for processing equipment |
| Parts stacker | Parts Stacking Machine | Parts storage machine | Automation and space saving | Stacking processed carbide parts |
| Surface spraying machine | Surface Coating Machine | Surface coating machine | Uniform coating, durable | Spraying wear-resistant coating on cemented carbide surface |
| Processing vibrator | Machining Vibrator | Processing vibration machine | High frequency vibration, high efficiency | Auxiliary machining of carbide parts |
| Parts testing bench | Parts Inspection Station | Parts Inspection Station | High precision, portable | Check the quality of processed carbide parts |
| Tool cleaning machine | Tool Cleaning Machine | Tool Washing Machine | Efficient cleaning, no residue | Cleaning tools for machining carbide |
| Parts packaging machine | Parts Packing Machine | Parts packaging machine | Automation, anti-oxidation | Packaging of processed carbide parts |
| Processing exhaust gas processor | Machining Exhaust Gas Processor | Processing exhaust treatment device | Efficient purification and environmental protection | Treatment of waste gas generated during processing |

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**6. Auxiliary and transportation equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport carbide powder, billet or product to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift carbide powder or blank to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed cemented carbide powder evenly into pressing or sintering equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Hydrogen Generator | Hydrogen Generator | Hydrogen Generating Device | High purity, stable supply | Provide high-purity hydrogen required for sintering |
| Nitrogen Generator | Nitrogen Generator | Antagonist Generating Device | High purity, stable supply | Provide inert gas protection (such as annealing or storage) |
| Vacuum Pump | Vacuum Pump | Vacuum Pump | High vacuum, low noise | Provide vacuum environment for vacuum sintering furnace |

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| Air compressor | Air Compressor | Eacon Press | High pressure, stable output | Provide compressed air for pneumatic equipment |
| Storage tank | Storage Tank | Storage Tank | Good sealing and large capacity | Storage of cemented carbide powder or intermediate products |
| Transporter | Forklift | FO CLIFFT | Flexible transport, high load capacity | Handling carbide blanks or products |
| dust collector | Dust Collector | Dust Collector | Efficient dust removal, environmental protection | Collect dust generated during production |
| Temperature and humidity controller | Temperature and Humidity Controller | Temperature and humidity control device | Precise control and high stability | Control the temperature and humidity in the workshop to protect the quality of cemented carbide |
| Static Eliminator | Static Eliminator | Static Electricity Removal Device | Rapid elimination of static electricity, high safety | Prevent WC powder from adhering due to static electricity |
| Protective cover | Protective Cover | Protection card | High temperature resistance and high safety | Protect equipment or operators (such as sintering furnace protection) |
| Tool Cart | Tool Cart | Tool Card | Portable and versatile | Storage and transport of small tools or parts |
| Gas Pressure Regulator | Gas Pressure Regulator | Gas pressure regulator | Precise control and high stability | Regulate the pressure of hydrogen or nitrogen |
| Exhaust gas treatment device | Exhaust Gas Treatment Device | Exhaust treatment device | Efficient purification and environmental protection | Treatment of waste gas from sintering or processing |
| Dust monitor | Dust Monitor | Dust Monitor | Real-time monitoring, high sensitivity | Monitor dust concentration in the workshop to ensure safety |
| Explosion proof lights | Explosion-Proof Lamp | Explosion-proof lamp | High safety and durability | Provide lighting for powder handling areas |
| Material sorting machine | Material Sorting Machine | Material sorting machine | Automation and high efficiency | Sorting different batches of cemented carbide powder |
| Automatic stacker | Automatic Stacker | Automatic stacking machine | Automation and space saving | Stacking of cemented carbide blanks or products |
| Pneumatic handling device | Pneumatic Transport Device | Air pressure transport device | Fast shipping, dust-free | Pneumatic conveying of cemented carbide powder |
| Anti-vibration pads | Anti-Vibration Pad | Vibration-proof pad | High shock absorption, durable | Reduce equipment vibration and protect precision instruments |
| Safety fence | Safety Guardrail | Security Fence | High strength, easy to install | Isolate dangerous areas to ensure safe operation |
| Equipment lubrication system | Equipment Lubrication System | Equipment Lubrication System | Automatic lubrication, extended service life | Provide lubricants for processing equipment |
| Gas storage tank | Gas Storage Tank | Gas Storage Tank | High sealing | Storage of hydrogen or |

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| | | | performance and large capacity | nitrogen |
| Workshop monitoring system | Workshop Monitoring System | Factory Monitoring System | Real-time monitoring, multi-function | Monitor workshop operation status |
| Transport Robot | Transport Robot | Transport robot | Automation and high efficiency | Automatic handling of carbide blanks or products |
| Powder sealing box | Powder Sealing Box | Powder seal box | High sealing, moisture-proof | Sealed storage of cemented carbide powder |
| Waste Compactor | Scrap Compressor | Chip Compressor | High compression ratio, space saving | Compressing waste from production processes |
| Air Purifier | Air Purifier | Air Purifier | High efficiency purification, low noise | Purify workshop air and keep it clean |
| Transport rail car | Transport Rail Car | Transport | Large load, high stability | Transporting carbide products within the workshop |
| Emergency lighting | Emergency Lighting | Emergency lighting lamp | High brightness, long life | Providing lighting in emergency situations |
| Equipment Calibration Tools | Equipment Calibration Tool | Equipment Calibration Tutorial | High precision and multifunctional | Calibrate production equipment to ensure accuracy |
| Dust curtain | Dust Curtain | Dustproof Door | High sealing, easy to install | Isolate dust areas to reduce pollution |

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**7. Inspection and testing equipment and instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detect the content and impurities of W, C, Co and other elements in cemented carbide |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analyzing Cobalt Content in Cemented Carbide |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in cemented carbide |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the surface morphology and microstructure of cemented carbide |
| Metallographic microscope | Metallographic Microscope | Metallographic microscope | High resolution, material analysis | Check the metallographic structure and WC |

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| | | | | grain size of cemented carbide |
| Scanning electron microscopy (SEM) | Scanning Electron Microscope | Scanning electron microscope | High resolution, surface analysis | Observe the microscopic morphology of the cemented carbide surface and fracture |
| Energy dispersive spectrometer (EDS) | Energy Dispersive Spectrometer | エネルギー dispersion beam splitter | Elemental analysis, high sensitivity | Analysis of the distribution of WC and Co in cemented carbide |
| X-ray diffractometer (XRD) | X-Ray Diffractometer | X-ray folding device | High resolution, structural analysis | Analysis of the crystal phase structure of cemented carbide (such as WC phase) |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of cemented carbide (such as Rockwell HRA or Vickers hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of cemented carbide (14-15 g/cm³ ) |
| Tensile testing machine | Tensile Testing Machine | Tension testing machine | High precision and multifunctional | Testing the tensile strength of cemented carbide |
| Fatigue testing machine | Fatigue Testing Machine | Fatigue test machine | Multi-cycle, high reliability | Testing the fatigue life of cemented carbide |
| Torsion testing machine | Torsion Testing Machine | Nejiri test machine | High precision and multifunctional | Testing the Torsional Strength of Cemented Carbide |
| High temperature creep testing machine | High-Temperature Creep Tester | High temperature crystal test machine | High temperature testing, long term stability | Testing the creep properties of cemented carbide at high temperatures |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect cracks or defects inside cemented carbide |
| Coordinate Measuring Machine (CMM) | Coordinate Measuring Machine | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring the dimensional accuracy of cemented carbide products |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the roughness of |

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| | | | | |
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| | | | | cemented carbide surfaces |
| Thermogravimetric Analyzer (TGA) | Thermogravimetric Analyzer | Thermogravimetric analysis device | High temperature testing, accurate data | Analyzing the quality changes during cemented carbide sintering |
| Thermal dilatometer | Thermal Expansion Analyzer | Thermal expansion meter | High precision and wide temperature range | Measuring the thermal expansion coefficient of cemented carbide |
| Dynamic Mechanical Analyzer (DMA) | Dynamic Mechanical Analyzer | Dynamic Thermomechanical Analysis Device | Multi-parameter, high precision | Analysis of the mechanical properties of cemented carbide as a function of temperature |
| Specific surface area analyzer (BET) | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of cemented carbide powder |
| Laser diameter gauge | Laser Diameter Gauge | Reser diameter measuring device | Non-contact, high precision | Measuring the diameter of carbide rods or parts |
| Infrared thermometer | Infrared Thermometer | Infrared thermometer | Non-contact, fast response | Measuring temperature during sintering or machining |
| Trace oxygen analyzer | Trace Oxygen Analyzer | Trace oxygen analysis device | High sensitivity, fast response | Detect oxygen content in sintering environment to ensure low oxygen environment |
| Optical projector | Optical Projector | Optical projector | High magnification, precise measurement | Checking the geometry and dimensions of cemented carbide products |
| Impact testing machine | Impact Testing Machine | Impact test machine | High precision and multifunctional | Testing the impact toughness of cemented carbide |
| Compression testing machine | Compression Testing Machine | Compression test machine | High load, good stability | Testing the compressive strength of cemented carbide |
| Wear testing machine | Wear Testing Machine | Wear testing machine | High simulation, durable | Testing the wear resistance of cemented carbide |
| Corrosion testing machine | Corrosion Testing Machine | Corrosion testing machine | Multiple environments, | Testing the corrosion resistance |

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| | | | | |
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| | | | high precision | of cemented carbide |
| Acoustic Emission Detector | Acoustic Emission Detector | Audio output detector | Nondestructive testing, high sensitivity | Detection of micro cracks inside cemented carbide |
| Conductivity Meter | Conductivity Meter | Conductivity meter | High sensitivity, portable | Measuring the electrical conductivity of cemented carbide |
| Residual Stress Analyzer | Residual Stress Analyzer | Residual stress analysis device | High precision, lossless | Analyzing Residual Stress in Cemented Carbide |
| Porosity Tester | Porosity Tester | Porosity Tester | High-precision, fast measurement | Measuring the porosity of cemented carbide |
| Microhardness tester | Microhardness Tester | Micro Hardness Tester | High resolution, micro-area testing | Testing the hardness of a small area of cemented carbide |
| Thermal conductivity meter | Thermal Conductivity Meter | Thermal Conductivity Meter | High precision and fast response | Measuring the thermal conductivity of cemented carbide |
| Magnetic Tester | Magnetic Tester | Magnetic Tester | High sensitivity, multifunctional | Testing the magnetic properties of cemented carbide (such as the influence of Co content) |
| Laser interferometer | Laser Interferometer | Lesa Intervention Plan | Ultra-high precision, non-contact | Measuring the flatness of cemented carbide surfaces |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring the particle size distribution of cemented carbide powders |
| Environmental Simulation Test Chamber | Environmental Simulation Chamber | Environmental Simulation Test Chamber | Multi-condition simulation, high reliability | Simulating the performance of cemented carbide in different environments |

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## 8. Raw and auxiliary materials

| Material Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Tungsten Carbide Powder(WC) | Tungsten Carbide Powder | Carbonized タングステン powder | High hardness, high melting point | The main hard phase of cemented carbide (accounting for 70-95%) |

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|---|---|---|---|---|
| Cobalt powder (Co) | Cobalt Powder | Compal powder | High toughness, easy to sinter | Binder phase, providing toughness and strength (5-30%) |
| Toner | Carbon Powder | Kabon powder | High purity, fine particle size | Adjust the carbon content in cemented carbide to prevent decarburization or carburization |
| Titanium Carbide (TiC) | Titanium Carbide Powder | Carbonized chitan powder | High hardness, high temperature resistance | Enhance the wear resistance and high temperature performance of cemented carbide (optional addition, 1-5%) |
| Molybdenum powder | Molybdenum Powder | Moldy powder | High melting point, corrosion resistance | Enhance high temperature performance of cemented carbide (optional addition, 1-5%) |
| Polyvinyl alcohol (PVA) | Polyvinyl Alcohol | ポリビニルアルコール | Strong adhesion, easy to decompose | Binder for compression molding |
| Stearic acid | Stearic Acid | Sterilin | Good lubricity, easy to evaporate | Lubricants during pressing |
| paraffin | Paraffin Wax | Paraffin Works | Strong lubricity, low melting point | Binder or lubricant for compression molding |
| Hydrogen ( $H_2$ ) | Hydrogen | Hydrogen | High purity, strong reducing ability | Protective and reducing gases during sintering |
| Nitrogen ( $N_2$ ) | Nitrogen | chlorine | Inertness, high stability | Auxiliary protective gas to prevent oxidation |
| Deionized water | Deionized Water | Deionized water | High purity, no impurities | Preparation of binder solution or cleaning of cemented carbide |
| Ethanol | Ethanol | Etanol | Highly volatile, no residue | Solvent for wet mixing of powders or cleaning |

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**Tungsten plastic and tungsten mud production inspection equipment and raw and auxiliary materials**
**タングステンプラスチックとタングステンパテ production inspection equipment and raw materials**
**Tungsten Plastic & Tungsten Putty Production , Inspection Equipment & Raw Materials**

**1. Raw material preparation and mixing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grind tungsten powder to micron level (e.g. 5-20 microns) |
| Planetary ball mill | Planetary Ball Mill | プラネタリーボールミル | High efficiency and various grinding | Finely grind tungsten powder to ensure uniform particle size |
| Air jet mill | Air Jet Mill | EagerToMil | Non-contact, high fineness | Grind the tungsten powder into fine particles (e.g. 1-10 microns) |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Sieve the ground tungsten powder to ensure consistent particle size |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mixing tungsten powder with polymer or adhesive matrix |
| V-type mixer | V-Type Mixer | V-type Mikisa | High uniformity, low shear | Dry mixing of tungsten powder and solid matrix |
| Double cone mixer | Double Cone Mixer | Double cone mikisara | Large capacity, even mixing | Bulk mixing of tungsten plastic or tungsten clay materials |
| Blender | Agitator | Blender | Efficient mixing, high | Wet mixing of tungsten |

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| | | | temperature resistance | powder and liquid matrix (such as grease) |
| Solution preparation tank | Solution Preparation Tank | Solution preparation tank | Corrosion-resistant and precise metering | Formulating liquid polymers or viscous matrices |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Spray dry the wet mixed tungsten powder into uniform particles |
| Dryer | Dryer | Dryer | High thermal efficiency and uniform drying | Dry the mixed tungsten plastic material to remove moisture |
| Vacuum filter | Vacuum Filter | Vacuum filter | Fast filtration speed and low energy consumption | Filter wet mixed tungsten mud material to remove excess liquid |
| Powder Classifier | Powder Classifier | Powder Classifier | High precision, multi-level grading | Classify tungsten powder to ensure consistent particle size distribution |
| Ultrasonic cleaning machine | Ultrasonic Cleaner | Ultrasonic cleaning machine | High frequency cleaning, no damage | Clean mixing equipment and remove residues |
| High Energy Ball Mill | High-Energy Ball Mill | 高エネルギー・ボールミル | High impact, ultra-fine grinding | Ultra-fine tungsten powder to improve mixing uniformity |
| Turbine grinder | Turbo Mill | Tabomir | High-speed crushing, multi-function | Rapidly crush tungsten powder to produce fine particles |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, automation | Fine Screened Tungsten Powder |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of solid and liquid components in wet mixed tungsten mud |
| Metering Pumps | Metering Pump | Metering Pump | Precise metering, corrosion resistance | Precise delivery of liquid bases or additives |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring the pH of wet mix solutions |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Dry the tungsten plastic material under vacuum to avoid oxidation |
| Powder Dispersing Machine | Powder Disperser | Powder Dispersing Machine | High dispersibility and good uniformity | Disperse tungsten powder to prevent agglomeration |
| Weighing batching machine | Weighing and Batching Machine | Measuring and batching machine | High precision and automation | Weigh tungsten powder and matrix materials according to the proportion |
| Powder conveyor | Powder Conveyor | Powder Conbe | Sealed transportation, dustproof | Convey tungsten powder to mixing or forming equipment |
| Mixing cooler | Mixing Cooler | Hybrid Cooler | Rapid cooling and | Cooling the mixed |

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| | | | uniform cooling | tungsten plastic or tungsten mud material |
| Hammer mill | Hammer Mill | Hanmar | High impact, high capacity | Preliminary crushing of tungsten powder or other solid matrix |
| Powder granulator | Powder Granulator | Powder Granulator | Uniform particles and good fluidity | Make tungsten plastic material into granules to improve molding performance |
| Wet mixer | Wet Mixer | Wet Mikisa | High uniformity, corrosion resistance | Mix tungsten powder and matrix in liquid medium |
| High pressure homogenizer | High-Pressure Homogenizer | High pressure homogenizer | High pressure dispersion, good uniformity | Homogenized wet mixed tungsten mud material |
| Powder grinding jar | Powder Grinding Jar | Powder grinding jar | Wear-resistant, high sealing performance | Loading tungsten powder for ball milling |
| Screening vibrator | Screening Vibrator | Screening vibrating machine | High frequency vibration, high efficiency | Auxiliary screening of tungsten powder |
| Powder drying tower | Powder Drying Tower | Powder drying tower | Large capacity, efficient drying | Large-scale drying of tungsten plastic materials |
| Powder mixing tank | Powder Mixing Tank | Powder mixing tank | Large capacity, corrosion resistant | Large batch wet mixed tungsten mud materials |
| Powder screening conveyor | Powder Screening Conveyor | Powder Screening Conveyor | Screening and conveying integrated, high efficiency | Screening and conveying of tungsten powder |
| Powder storage silo | Powder Storage Silo | Powder storage silo | Large capacity, moisture-proof | Store tungsten powder dry |

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**2. Pressing and molding equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Hydraulic Press | Hydraulic Press | Oil pressure press | High pressure, precise molding | Pressing tungsten plastic materials into shapes (such as plates and rods) |
| Isostatic Press | Isostatic Press | Isostatic Pressure Press | Uniform pressure, high density | Isostatic pressing of tungsten plastic blanks to increase density |
| Cold Isostatic Press (CIP) | Cold Isostatic Press | Cold room isostatic pressure press | No thermal deformation, high uniformity | Pressing tungsten plastic blanks at room temperature |
| Extrusion Machine | Extruder | Extruder | Continuous molding, high efficiency | Extruding tungsten plastic or tungsten clay into strips or tubes |
| Mould | Mold | Casting | Customizable shapes, durable | Molding tungsten plastic or tungsten clay to ensure |

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| | | | | consistent size |
| Demoulding machine | Demolding Machine | Demolding machine | Automation and high efficiency | Remove the pressed tungsten plastic blank from the mold |
| Weighing Machine | Weighing Machine | Measuring machine | High-precision and fast weighing | Precisely weigh the mixed materials to ensure consistent amounts for each pressing |
| Powder filling machine | Powder Filling Machine | Powder filling machine | Automatic and uniform filling | Automatically load tungsten plastic material into the mold |
| Oven | Oven | Ouban | Adjustable temperature, uniform drying | Low temperature curing of tungsten plastic (50-150°C) to remove moisture |
| Vacuum Degasser | Vacuum Degassing Machine | Vacuum degassing machine | Low oxygen environment, high efficiency | Remove bubbles from tungsten plastic blanks |
| Press dressing machine | Billet Trimming Machine | Pressing and trimming machine | High precision and automation | Trimming the edges of pressed tungsten plastic blanks |
| Mould cleaning machine | Mold Cleaning Machine | Casting washing machine | Efficient cleaning and durable | Cleaning the pressing die to maintain precision |
| Powder compactor | Powder Compactor | Powder Compressor | High efficiency and uniform compaction | Initially compact the tungsten plastic material to facilitate subsequent molding |
| Automatic feeding machine | Automatic Feeder | Automatic feeder | Automatic and continuous feeding | Automatically feed tungsten plastic materials into pressing or extrusion equipment |
| Green sheet cutting machine | Billet Cutting Machine | Billet cutting machine | Precise cutting without damage | Cut pressed or extruded billets into specified sizes |
| Double-action hydraulic press | Double-Action Hydraulic Press | Double action hydraulic press | Bidirectional pressure, good uniformity | Double-direction pressing of tungsten plastic blank to increase density |
| Mold preheater | Mold Preheater | Casting preheater | Temperature controllable, fast heating | Preheat the mold to improve the fluidity of tungsten plastic |
| Greenhouse shaping machine | Billet Shaping Machine | Blank shaping machine | High precision and multifunctional | Tungsten plastic or tungsten clay after shaping and pressing |
| Vacuum packaging machine | Vacuum Packing Machine | Vacuum packaging machine | Good sealing and anti-oxidation | Packaging tungsten plastic products to prevent oxidation |
| Powder Vibrator | Powder Vibrator | Powder vibrating machine | Even distribution, low energy consumption | Vibrate the material to distribute it evenly in the mold |
| Mould polishing | Mold Polishing | Casting grinding | High finish, durable | Polish the inner surface of |

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| machine | Machine | machine | | the mold to improve the quality of the blank |
| Green compact weighing instrument | Billet Weighing Instrument | Pressing gauge | High-precision, fast measurement | Weighing pressed billets to ensure consistent quality |
| Die lubrication device | Mold Lubrication Device | Casting lubrication device | Apply evenly and reduce friction | Apply lubricant inside the mold to facilitate demoulding |
| Powder sieving and filling machine | Powder Screening and Filling Machine | Powder Screening Filling Machine | Screening and filling in one, high efficiency | Screening and filling tungsten plastic material into the mold |
| Pressed billet transport rack | Billet Transport Rack | Pressed billet transport | Stable structure, easy to carry | Handling the pressed tungsten plastic blanks |
| Rotary press | Rotary Press | Return to the pres | Continuous pressing, high efficiency | Continuous pressing of tungsten plastic blanks |
| Mold heating furnace | Mold Heating Furnace | Casting heating furnace | High temperature, uniform and rapid heating | Heating the mold to improve the quality of tungsten plastic molding |
| Green compact surface cleaning machine | Billet Surface Cleaner | Pressed blank surface cleaning machine | Efficient cleaning, no damage | Clean impurities on the surface of pressed billets |
| Powder pre-pressing machine | Powder Pre-Press Machine | Powder pre-pressing machine | Low pressure preforming, energy saving | Pre-press tungsten plastic material to facilitate subsequent molding |
| Mold detector | Mold Inspection Instrument | Casting tester | High precision, lossless | Check the mold for wear or deformation |
| Pressed green sheet drying rack | Billet Drying Rack | Pressed Bread Drying Ruck | Good ventilation and large capacity | Place the pressed blank for natural drying |
| Powder Flow Tester | Powder Flow Tester | Powder Flow Tester | High-precision, fast measurement | Test the fluidity of tungsten plastic materials |
| Mould sandblasting machine | Mold Sandblasting Machine | 鋳 type サンドブラスト machine | Efficient cleaning and surface roughening | Sand blasting to clean the mold surface |
| Green compact stacker | Billet Stacking Machine | Pressing and stacking machine | Automation and space saving | Stacking the pressed tungsten plastic blanks |
| Mould storage cabinet | Mold Storage Cabinet | 鋳 -shaped storage tube | Dust and moisture proof | Store the pressing dies and keep them clean |

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**3. Curing and heat treatment equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Low temperature curing oven | Low-Temperature Curing Furnace | Low temperature hardening furnace | Precise temperature control, low energy consumption | Solidify tungsten plastic or tungsten mud (50-200°C) |
| Vacuum curing | Vacuum Curing | Vacuum hardening | Low oxygen | Curing tungsten plastic |

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| oven | Furnace | furnace | environment, high purity | under vacuum to avoid oxidation |
| Medium frequency induction heater | Medium Frequency Induction Heater | Medium frequency induction heater | Fast heating and uniform temperature | Local heating of tungsten plastic preform to assist solidification |
| Hot air circulation furnace | Hot Air Circulation Furnace | Hot air circulation furnace | Uniform heating and high efficiency | Curing tungsten plastic or tungsten clay by hot air |
| Annealing furnace | Annealing Furnace | Anil furnace | Precise temperature control and adjustable atmosphere | Annealing tungsten plastic products to eliminate internal stress |
| Constant temperature box | Constant Temperature Chamber | Constant temperature bottle | Stable temperature, low fluctuation | Constant temperature curing tungsten plastic or tungsten mud |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Remove volatile substances (such as solvents) during the curing process |
| Cooling machine | Cooling Machine | Cooling machine | Rapid cooling and uniform cooling | Tungsten plastic products after cooling and solidification |
| Atmosphere curing furnace | Atmosphere Curing Furnace | Induction hardening furnace | Multiple atmospheres available, high stability | Solidify the tungsten plastic in an inert atmosphere (such as $N_2$ ) |
| Atmosphere circulation device | Atmosphere Circulation Device | Ventilation circulation device | Uniform atmosphere, energy saving | Circulate the gas in the curing furnace to improve efficiency |
| Curing tray | Curing Tray | Hardened Toray | Heat and corrosion resistance | Carrying tungsten plastic blanks for curing |
| Thermocouple | Thermocouple | Thermoelectric | High temperature tolerance, fast response | Measure the temperature in the curing oven to ensure a stable process |
| Temperature recorder | Temperature Recorder | Temperature recording device | Real-time monitoring, high precision | Recording of temperature profile during curing |
| Vacuum sealing device | Vacuum Sealing Device | Vacuum silo device | High sealing and pressure resistance | Ensure the airtightness of the vacuum curing oven |
| Water Cooling System | Water Cooling System | Water Cooling System | Efficient cooling, energy saving | Provide cooling water for curing equipment |
| Vacuum pressure curing oven | Vacuum Pressure Curing Furnace | Vacuum pressure hardening furnace | High pressure, dense, low oxygen environment | Solidify tungsten plastic under vacuum and pressure to increase density |
| Curing oven exhaust system | Curing Furnace Exhaust System | Hardened grate air system | Efficient exhaust, environmentally | Collect and treat curing oven exhaust gas |

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| | | | friendly | |
| Curing fixture | Curing Fixture | Hardening jig | High stability, heat resistance | Fixing tungsten preform for curing |
| Atmosphere Analyzer | Atmosphere Analyzer | Air gas analysis device | High sensitivity, real-time monitoring | Analysis of gas composition in the curing furnace (such as $O_2$ content ) |
| Curing tray cleaning machine | Curing Tray Cleaner | Hardened Tray Washer | Efficient cleaning, corrosion resistance | Clean the curing tray to remove any residue |
| High pressure cooler | High-Pressure Cooler | High pressure cooler | Rapid cooling, high efficiency | Tungsten plastic products after accelerated cooling and solidification |
| Curing Temperature Calibrator | Curing Temperature Calibrator | Hardening Temperature Calibrator | High precision and good stability | Calibrate curing oven temperature to ensure consistent process |
| Heat treatment transport vehicle | Heat Treatment Transport Cart | Hot handling transport truck | Heat resistance, high load | Handling of solidified tungsten plastic products |
| Curing Oven Maintenance Tools | Curing Furnace Maintenance Tool | Hardening furnace maintenance | Versatile and durable | Maintaining and repairing curing ovens |
| Atmosphere purification device | Atmosphere Purifier | Air purification device | High purification, energy saving | Purify the gas in the curing furnace and reduce impurities |
| Curing pressure controller | Curing Pressure Controller | Hardening pressure control device | Precise control, high stability | Controlling the pressure of the vacuum pressure curing oven |
| Resistance Heating Furnace | Resistance Heating Furnace | Resistance to heating furnace | Fast heating, energy saving | Curing Tungsten Plastics by Resistance Heating |
| UV curing machine | UV Curing Machine | UV Curing Machine | Fast curing, energy saving | Tungsten plastic containing photosensitive polymer is cured using UV light |
| Curing furnace insulation layer | Curing Furnace Insulation | Hardening furnace insulation layer | High heat resistance, low thermal conductivity | Improving the thermal insulation performance of the curing oven |
| Heat treatment cooling furnace | Heat Treatment Cooling Furnace | Heat treatment cooling furnace | Rapid cooling, good uniformity | Controlled cooling of tungsten plastics to enhance performance |
| Solidification blank shaping machine | Cured Billet Shaping Machine | Hardened billet shaping machine | High precision and multifunctional | Tungsten plastic or tungsten clay after shaping and solidification |
| Curing cooling rack | Curing Cooling Rack | Hardening Cooling Ruck | Good ventilation and large capacity | Place the solidified blank for natural cooling |

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| Heat treatment cleaning machine | Heat Treatment Cleaner | Thermal treatment washing machine | Efficient cleaning, no residue | Cleaning of cured tungsten plastic products |
| Curing Pallet Trucks | Curing Tray Transport Cart | Hardened Truck | Heat resistance, high load | Handling curing pallets |
| Atmosphere preheater | Atmosphere Preheater | Insulated air heater | Rapid heating, energy saving | Preheating the gas in the curing oven |
| Curing oven vacuum pump | Curing Furnace Vacuum Pump | Hardening furnace vacuum pump | High vacuum, low noise | Provides additional vacuum support for curing ovens |
| Solid waste collector | Curing Scrap Collector | Hardened chip collection machine | Efficient collection and environmental protection | Collecting waste from the curing process |
| Heat treatment temperature monitor | Heat Treatment Temperature Monitor | Thermal treatment temperature | Real-time monitoring, high precision | Monitoring temperature during curing |
| Curing oven seal tester | Curing Furnace Seal Tester | Hardening furnace tester | High sensitivity, rapid detection | Check the sealing performance of the curing oven |
| Solidified billet stacker | Cured Billet Stacking Machine | Hardened billet weighing machine | Automation and space saving | Stacking the solidified tungsten plastic blanks |

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**4. Processing and finishing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| lathe | Lathe | Rotary Disk | High precision and multifunctional | Turning tungsten plastic blanks into counterweights or parts |
| grinder | Grinding Machine | Grinding Machine | High precision, smooth surface | Grind the tungsten plastic surface to the specified size |
| Milling Machine | Milling Machine | Freeze Plate | Multifunctional and efficient | Milling of tungsten plastic blanks and processing of complex shapes |
| Drill Press | Drilling Machine | Drill Plate | High precision and good stability | Drilling holes in tungsten plastic |
| Wire cutting machine | Wire Cutting Machine | Wai Yakto Machine | High precision, non-contact | Cutting tungsten plastic blanks to prepare thin sheets or complex parts |
| Electrical discharge machining (EDM) | Electrical Discharge Machine | Discharge processing machine | High precision, hard-resistant materials | Processing tungsten plastic parts to ensure precision |
| Rolling Mill | Rolling Mill | Calendering Machine | High pressure, continuous processing | Rolling tungsten plastic billets to produce thin sheets |
| Polishing | Polishing | Grinding | High finish, | Polished tungsten surface |

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| Machine | Machine | Machine | automation | to enhance appearance |
| Cutting Machine | Cutting Machine | Cutting Machine | Precision cutting, automation | Cut tungsten plastic or tungsten clay into specified lengths |
| Grinding machine | Grinding Wheel Machine | Sharpening Machine | High hardness, wear resistance | Tungsten plastic surface finishing |
| Ultrasonic cleaning machine | Ultrasonic Cleaning Machine | Ultrasonic cleaning machine | Deep cleaning, high efficiency | Clean tungsten plastic products and remove processing residues |
| Straightening Machine | Straightening Machine | Correction Machine | High precision, no damage | Straightening tungsten plastic rods or plates to ensure straightness |
| Surface treatment machine | Surface Treatment Machine | Surface treatment machine | Multifunctional and automated | Surface coating or treatment of tungsten plastic |
| CNC machine tools | CNC Machine | CNC machine tools | High precision and automation | Precision machining of tungsten plastic parts |
| Tapping machine | Tapping Machine | Taping Maschinen | High efficiency, precise thread | Processing threads on tungsten plastic |
| Dressing tools | Trimming Tool | Trimming Tull | High hardness, precision operation | Hand-finished tungsten plastic or tungsten clay edges |
| Sandblasting Machine | Sandblasting Machine | Sandblaster | Efficient cleaning and surface roughening | Sandblasting of tungsten plastic surface to improve adhesion |
| Laser marking machine | Laser Marking Machine | レーザーマーキング machine | High precision, non-contact | Marking or numbering on tungsten plastic products |
| Precision grinding machine | Precision Grinding Machine | Precision grinding machine | Ultra-high precision, high finish | Precision Grinding Tungsten Plastic Parts |
| Broaching Machine | Broaching Machine | Blog | High efficiency, complex processing | Processing complex grooves or holes inside tungsten plastic |
| planer | Planing Machine | Kanana Plate | High flatness, large-scale processing | Planing tungsten plastic plates or large parts |
| punch | Punching Machine | Panching Mashin | High efficiency and precise punching | Punching holes in tungsten plastic sheet |
| Water jet cutting machine | Water Jet Cutting Machine | ウォータージェット cutting machine | No thermal damage, high precision | Waterjet cutting of tungsten plastic, suitable for complex shapes |
| Ultrasonic processing machine | Ultrasonic Machining Machine | Ultrasonic processing machine | High precision, stress-free | Ultrasonic machining of tungsten plastic small parts |
| Shot blasting machine | Shot Blasting Machine | Seat Brass Machine | Surface enhancement, high efficiency | Shot peening strengthened tungsten plastic surface |
| Processing fixture | Machining Fixture | Processing fixture | High stability, customization | Fixing tungsten plastic parts for processing |

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| | | | | |
|---|---|---|---|---|
| Tool grinding machine | Tool Grinder | Tool grinder | High precision and durable | Grinding and processing tungsten plastic cutting tools |
| Parts handling rack | Parts Transport Rack | Parts transport luggage | Stable structure, easy to carry | Transporting processed tungsten plastic parts |
| Surface roughening machine | Surface Roughening Machine | Surface roughening machine | Controllable roughness, high efficiency | Roughen the surface of tungsten plastic and enhance the adhesion of coating |
| Laser welding machine | Laser Welding Machine | Lazer welding machine | High precision, no damage | Welding tungsten plastic parts |
| Processing waste collector | Machining Scrap Collector | Chip Collector | Efficient collection and environmental protection | Collect tungsten plastic waste during processing |
| Rolling machine | Rolling Press Machine | Roller Press | High pressure, smooth surface | Rolled tungsten plastic surface to improve density and smoothness |
| Plasma cutting machine | Plasma Cutting Machine | Plasma cutting machine | High temperature cutting, high efficiency | Plasma cutting of tungsten plastic plates or parts |
| Polishing liquid preparation tank | Polishing Liquid Preparation Tank | Grinding liquid preparation tank | Corrosion-resistant and precise metering | Prepare polishing liquid for tungsten plastic polishing |
| Parts cleaning tank | Parts Cleaning Tank | Parts cleaning tank | Large capacity, corrosion resistant | Cleaning of processed tungsten plastic parts |
| Precision turning machine | Precision Turning Machine | Precision turning machine | Ultra-high precision, multi-function | Precision turning tungsten plastic parts |
| Parts polishing rack | Parts Polishing Rack | Parts grinding rack | Good ventilation and large capacity | Place tungsten plastic parts for polishing |
| Process cooling system | Machining Cooling System | Processing cooling system | Efficient cooling, energy saving | Provide coolant for processing equipment |
| Parts stacker | Parts Stacking Machine | Parts storage machine | Automation and space saving | Stacking processed tungsten plastic parts |
| Surface spraying machine | Surface Coating Machine | Surface coating machine | Uniform coating, durable | Spraying protective layer on the surface of tungsten plastic |
| Processing vibrator | Machining Vibrator | Processing vibration machine | High frequency vibration, high efficiency | Auxiliary processing of tungsten plastic parts |
| Parts testing bench | Parts Inspection Station | Parts Inspection Station | High precision, portable | Check the quality of processed tungsten plastic parts |
| Tool cleaning machine | Tool Cleaning Machine | Tool Washing Machine | Efficient cleaning, no residue | Cleaning tools for machining tungsten plastic |
| Parts packaging machine | Parts Packing Machine | Parts packaging machine | Automation, anti-oxidation | Packaging of processed tungsten plastic parts |
| Processing exhaust gas | Machining Exhaust Gas | Processing exhaust treatment | Efficient purification and environmental | Treatment of waste gas generated during |

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| processor | Processor | device | protection | processing |
| Manual dressing table | Manual Trimming Station | Manual trimming table | Simple operation and high flexibility | Manual shaping of tungsten clay |
| Extrusion cutting machine | Extrusion Cutting Machine | Extrusion cutting machine | Precise cutting, high efficiency | Cutting extruded tungsten strips |
| Parts molding mold | Parts Forming Mold | Parts forming casting | Customizable and durable | Molding tungsten plastic or tungsten clay parts |
| Surface grinding machine | Surface Buffing Machine | Surface Baffle Machine | High finish, low damage | Polish the tungsten plastic surface to improve the appearance |
| Flexible processing fixture | Flexible Machining Fixture | Soft processing jig | Strong adjustability and good adaptability | Fix flexible tungsten plastic or tungsten clay for processing |

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**5. Auxiliary and transportation equipment**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transport tungsten powder, tungsten plastic blanks or products to the next process |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder or tungsten plastic material to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, adjustable speed | Feed the tungsten plastic material evenly into the pressing or extrusion equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Provide ventilation for production workshops |
| Nitrogen Generator | Nitrogen Generator | Antagonist Generating Device | High purity, stable supply | Provide inert gas protection (such as curing or storage) |
| Vacuum Pump | Vacuum Pump | Vacuum Pump | High vacuum, low noise | Provide vacuum environment for vacuum curing furnace |
| Air compressor | Air Compressor | Eacon Press | High pressure, stable output | Provide compressed air for pneumatic equipment |
| Storage tank | Storage Tank | Storage Tank | Good sealing and large capacity | Storage of tungsten powder or liquid matrix |
| Transporter | Forklift | FO CLIFFT | Flexible transport, high load capacity | Handling tungsten plastic blanks or products |
| dust collector | Dust Collector | Dust Collector | Efficient dust removal, environmental protection | Collect dust generated during production |
| Temperature and | Temperature and | Temperature and | Precise control and | Control the temperature and |

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| humidity controller | Humidity Controller | humidity control device | high stability | humidity in the workshop to protect the quality of tungsten plastic |
| Static Eliminator | Static Eliminator | Static Electricity Removal Device | Rapid elimination of static electricity, high safety | Prevent tungsten powder from sticking due to static electricity |
| Protective cover | Protective Cover | Protection card | Heat resistant and highly safe | Protect equipment or operators (such as extruder protection) |
| Tool Cart | Tool Cart | Tool Card | Portable and versatile | Storage and transport of small tools or parts |
| Gas Pressure Regulator | Gas Pressure Regulator | Gas pressure regulator | Precise control and high stability | Adjusting nitrogen pressure |
| Exhaust gas treatment device | Exhaust Gas Treatment Device | Exhaust treatment device | Efficient purification and environmental protection | Treatment of waste gases from curing or processing |
| Dust monitor | Dust Monitor | Dust Monitor | Real-time monitoring, high sensitivity | Monitor dust concentration in the workshop to ensure safety |
| Explosion proof lights | Explosion-Proof Lamp | Explosion-proof lamp | High safety and durability | Provide lighting for powder handling areas |
| Material sorting machine | Material Sorting Machine | Material sorting machine | Automation and high efficiency | Sorting different batches of tungsten powder or tungsten plastic materials |
| Automatic stacker | Automatic Stacker | Automatic stacking machine | Automation and space saving | Stacking tungsten plastic blanks or products |
| Pneumatic handling device | Pneumatic Transport Device | Air pressure transport device | Fast shipping, dust-free | Tungsten powder conveying by pneumatic conveying |
| Anti-vibration pads | Anti-Vibration Pad | Vibration-proof pad | High shock absorption, durable | Reduce equipment vibration and protect precision instruments |
| Safety fence | Safety Guardrail | Security Fence | High strength, easy to install | Isolate dangerous areas to ensure safe operation |
| Equipment lubrication system | Equipment Lubrication System | Equipment Lubrication System | Automatic lubrication, extended service life | Provide lubricants for processing equipment |
| Gas storage tank | Gas Storage Tank | Gas Storage Tank | High sealing performance and large capacity | Nitrogen storage |
| Workshop monitoring system | Workshop Monitoring System | Factory Monitoring System | Real-time monitoring, multi-function | Monitor workshop operation status |
| Transport Robot | Transport Robot | Transport robot | Automation and high efficiency | Automatically transport tungsten plastic blanks or products |
| Powder sealing box | Powder Sealing Box | Powder seal box | High sealing, moisture-proof | Sealed storage of tungsten powder |
| Waste | Scrap | Chip Compressor | High compression | Compressing waste from |

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| Compactor | Compressor | | ratio, space saving | production processes |
| Air Purifier | Air Purifier | Air Purifier | High efficiency purification, low noise | Purify workshop air and keep it clean |
| Transport rail car | Transport Rail Car | Transport | Large load, high stability | Transporting tungsten plastic products in the workshop |
| Emergency lighting | Emergency Lighting | Emergency lighting lamp | High brightness, long life | Providing lighting in emergency situations |
| Equipment Calibration Tools | Equipment Calibration Tool | Equipment Calibration Tutorial | High precision and multifunctional | Calibrate production equipment to ensure accuracy |
| Dust curtain | Dust Curtain | Dustproof Door | High sealing, easy to install | Isolate dust areas to reduce pollution |
| Flexible conveyor belt | Flexible Conveyor Belt | Soft Convex Armor | Strong adjustability and good adaptability | Transporting flexible tungsten plastic or tungsten clay products |

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**6. Inspection and testing equipment and instruments**

| Device Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| X-ray fluorescence analyzer | X-Ray Fluorescence Analyzer (XRF) | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten content and impurities in tungsten plastic |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of polymer or additive content in tungsten plastics |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten plastic |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the surface morphology and microstructure of tungsten plastic |
| Metallographic microscope | Metallographic Microscope | Metallographic microscope | High resolution, material analysis | Check the distribution of tungsten powder in the matrix |
| Scanning electron microscopy (SEM) | Scanning Electron Microscope | Scanning electron microscope | High resolution, surface analysis | Observe the microscopic morphology of the tungsten plastic surface and fracture |
| Energy dispersive | Energy Dispersive | エネルギー | Elemental | Analysis of the |

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| spectrometer (EDS) | Spectrometer | dispersion beam splitter | analysis, high sensitivity | distribution of tungsten and matrix in tungsten plastics |
| X-ray diffractometer (XRD) | X-Ray Diffractometer | X-ray folding device | High resolution, structural analysis | Analysis of the crystal structure in tungsten plastic |
| Hardness Tester | Hardness Tester | Hardness Tester | Simple operation, multi-mode | Test the hardness of tungsten plastic (such as Shore hardness) |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the density of tungsten plastic (10-17 g/cm³ ) |
| Tensile testing machine | Tensile Testing Machine | Tension testing machine | High precision and multifunctional | Test the tensile strength and elongation of tungsten plastic |
| Fatigue testing machine | Fatigue Testing Machine | Fatigue test machine | Multi-cycle, high reliability | Testing the fatigue life of tungsten plastic |
| Torsion testing machine | Torsion Testing Machine | Nejiri test machine | High precision and multifunctional | Testing the torsional strength of tungsten plastic |
| High temperature creep testing machine | High-Temperature Creep Tester | High temperature crystal test machine | High temperature testing, long term stability | Test the creep properties of tungsten plastic at high temperature |
| Ultrasonic flaw detector | Ultrasonic Flaw Detector | Ultrasonic flaw detection device | Nondestructive testing, high sensitivity | Detect bubbles or defects inside tungsten plastic |
| Coordinate Measuring Machine (CMM) | Coordinate Measuring Machine | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring the dimensional accuracy of tungsten plastic products |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the roughness of tungsten plastic surface |
| Thermogravimetric Analyzer (TGA) | Thermogravimetric Analyzer | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of mass changes during the solidification process of tungsten plastic |
| Thermal dilatometer | Thermal Expansion Analyzer | Thermal expansion meter | High precision and wide temperature range | Measuring the thermal expansion coefficient of tungsten plastic |

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| Dynamic Mechanical Analyzer (DMA) | Dynamic Mechanical Analyzer | Dynamic Thermomechanical Analysis Device | Multi-parameter, high precision | Analysis of the mechanical properties of tungsten plastics changing with temperature |
| Specific surface area analyzer (BET) | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of tungsten powder |
| Laser diameter gauge | Laser Diameter Gauge | Reser diameter measuring device | Non-contact, high precision | Measuring the diameter of tungsten plastic rods or parts |
| Infrared thermometer | Infrared Thermometer | Infrared thermometer | Non-contact, fast response | Measuring temperature during curing or processing |
| Trace oxygen analyzer | Trace Oxygen Analyzer | Trace oxygen analysis device | High sensitivity, fast response | Detect oxygen content in the curing environment to ensure a low oxygen environment |
| Optical projector | Optical Projector | Optical projector | High magnification, precise measurement | Check the geometry and size of tungsten plastic products |
| Impact testing machine | Impact Testing Machine | Impact test machine | High precision and multifunctional | Testing the impact toughness of tungsten plastic |
| Compression testing machine | Compression Testing Machine | Compression test machine | High load, good stability | Testing the compressive strength of tungsten plastic |
| Flexibility Tester | Flexibility Tester | Flexibility Tester | High precision and multifunctional | Test the flexibility and ductility of tungsten plastic or tungsten clay |
| Viscometer | Viscometer | Viscometer | High-precision, fast measurement | Measuring the viscosity of tungsten sludge |
| Acoustic Emission Detector | Acoustic Emission Detector | Audio output detector | Nondestructive testing, high sensitivity | Detection of micro cracks inside tungsten plastic |
| Conductivity Meter | Conductivity Meter | Conductivity meter | High sensitivity, portable | Measuring the conductivity of tungsten plastic |
| Residual Stress | Residual Stress | Residual stress | High precision, | Analysis of residual |

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| Analyzer | Analyzer | analysis device | lossless | stress in tungsten plastics |
| Porosity Tester | Porosity Tester | Porosity Tester | High-precision, fast measurement | Measuring the porosity of tungsten plastic |
| Thermal conductivity meter | Thermal Conductivity Meter | Thermal Conductivity Meter | High precision and fast response | Measuring the thermal conductivity of tungsten plastic |
| Radiation Shielding Tester | Radiation Shielding Tester | Radiation shielding tester | High sensitivity, multifunctional | Testing the Radiation Shielding Performance of Tungsten Plastic |
| Laser interferometer | Laser Interferometer | Lesa Intervention Plan | Ultra-high precision, non-contact | Measuring the flatness of tungsten plastic surface |
| Particle size analyzer | Particle Size Analyzer | Particle size analysis device | Fast analysis, accurate data | Measuring particle size distribution of tungsten powder |
| Environmental Simulation Test Chamber | Environmental Simulation Chamber | Environmental Simulation Test Chamber | Multi-condition simulation, high reliability | Simulate the performance of tungsten plastic in different environments |
| Plasticity Tester | Plasticity Tester | Plasticity Tester | High precision and multifunctional | Testing the plasticity and deformation ability of tungsten mud |

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**7. Raw and auxiliary materials**

| Material Name | English (EN) | Japanese (JP) | Features | Uses |
|---|---|---|---|---|
| High purity tungsten powder | High-Purity Tungsten Powder | High purity polyester powder | High purity (≥99.9%), adjustable particle size | The main high-density components of tungsten plastic and tungsten mud (accounting for 70-95%) |
| Polyethylene (PE) | Polyethylene | PolyEtriren | High flexibility, chemical resistance | The main polymer matrix of tungsten plastic (accounting for 5-20%) |
| Polypropylene (PP) | Polypropylene | Polypro Piren | High strength, good temperature resistance | Auxiliary polymer matrix for tungsten plastic (optional addition, 5-10%) |
| Rubber powder | Rubber Powder | Gomu powder | High elasticity and strong plasticity | Enhance the flexibility of tungsten plastic (optional addition, 5-15%) |
| Molybdenum powder | Molybdenum Powder | Moldy powder | High melting point, corrosion | Enhance the density and strength of tungsten plastic |

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| | | | resistance | (optional addition, 1-5%) |
| paraffin | Paraffin Wax | Paraffin Works | Strong lubricity, low melting point | The main viscous matrix or molding aid of tungsten mud (accounting for 5-20%) |
| Mineral oil | Mineral Oil | Mineral Oil | High viscosity, good stability | Viscous matrix of tungsten mud (accounting for 5-15%) |
| Stearic acid | Stearic Acid | Sterilin | Good lubricity, easy to evaporate | Lubricants in mixing and forming processes |
| Nitrogen ( $N_2$ ) | Nitrogen | chlorine | Inertness, high stability | Protective gas during curing |
| Plasticizers | Plasticizer | Plasticizer | Enhanced flexibility and easy processing | Improve the plasticity of tungsten plastic or tungsten mud (such as DOP, 1-5%) |
| Deionized water | Deionized Water | Deionized water | High purity, no impurities | Prepare liquid matrix or clean tungsten plastic |
| Ethanol | Ethanol | Etanol | Highly volatile, no residue | Solvent for wet mixing of tungsten powder or cleaning |

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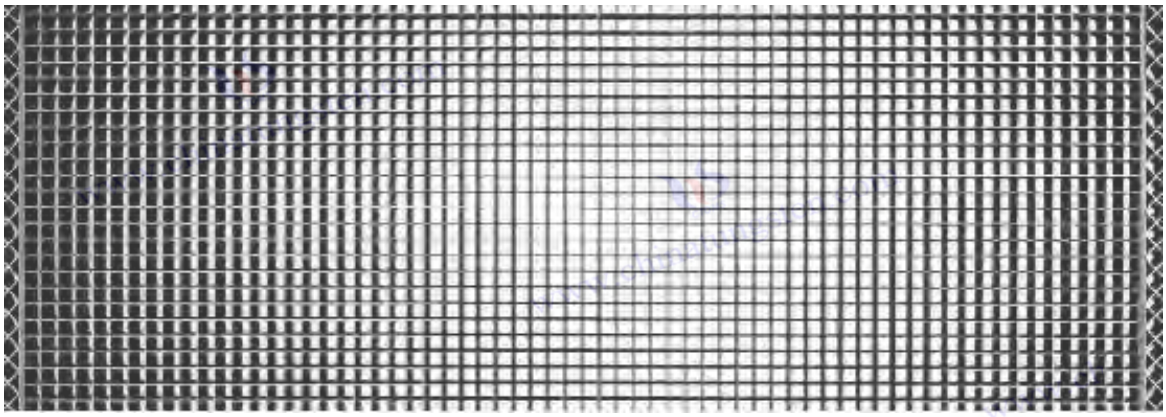

**Tungsten ball production and inspection equipment and raw and auxiliary materials for 3D printing**
**3D プリント uses タングステン ball production inspection equipment and raw materials**
**Tungsten Spheres for 3D Printing Production and Inspection Equipment and Raw Material**

**1. Raw material preparation and mixing equipment**

| Device Name | English (EN) | Japanese (JP) | Features | use |
|---|---|---|---|---|
| Ball mill | Ball Mill | Ballumil | High grinding precision, low energy consumption | Grinding tungsten raw materials to micron level |
| Planetary ball mill | Planetary Ball Mill | プラネタリーボールミル | High efficiency and various grinding | Finely ground tungsten powder |
| Air jet mill | Air Jet Mill | EagerToMil | Non-contact, high fineness | Crushing tungsten powder into ultra-fine particles |
| Vibrating screen | Vibrating Screen | Vibration Scale | Multi-layer screening, high efficiency | Preliminary screening of tungsten powder |
| Mixer | Mixer | Mikisa | Even mixing, multifunctional | Mixed tungsten powder with antioxidant |
| V-type mixer | V-Type Mixer | V-type Mikisa | High uniformity, low shear | Dry Mixed Tungsten Powder |
| Double cone mixer | Double Cone Mixer | Double cone mikisara | Large capacity, even mixing | Bulk Mixed Tungsten Powder |
| Blender | Agitator | Blender | Efficient mixing, high temperature resistance | Wet mixing of tungsten powder and deionized water |
| Solution preparation tank | Solution Preparation Tank | Solution preparation tank | Corrosion-resistant and precise metering | Preparing cleaning or grinding solutions |
| Spray Dryer | Spray Dryer | Spread Livery | Fast drying, uniform particles | Dry wet mixed tungsten powder |
| Vacuum Dryer | Vacuum Dryer | Vacuum Dryer | Low temperature, dry and oxygen-free environment | Vacuum dry tungsten powder to avoid oxidation |
| High Energy Ball | High-Energy | 高エネルギー・ボ | High impact, ultra- | Ultrafine tungsten |

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|---|---|---|---|---|
| Mill | Ball Mill | ール ミル | fine grinding | powder |
| Turbine grinder | Turbo Mill | Tabomir | High-speed crushing, multi-function | Rapid crushing of tungsten raw materials |
| Screening Machine | Screening Machine | Screening Machine | Multi-layer screening, automation | Fine Screened Tungsten Powder |
| Centrifuge | Centrifuge | Telecentric | High speed separation, high efficiency | Separation of solid and liquid in wet mixed tungsten powder |
| Metering Pumps | Metering Pump | Metering Pump | Precise metering, corrosion resistance | Transporting liquid media |
| pH Meter | pH Meter | pH meter | Fast response, high precision | Monitoring wet mix pH |
| Powder Dispersing Machine | Powder Disperser | Powder Dispersing Machine | High dispersibility and good uniformity | Disperse tungsten powder to prevent agglomeration |
| Weighing batching machine | Weighing and Batching Machine | Measuring and batching machine | High precision and automation | Weighing tungsten powder in proportion |
| Powder conveyor | Powder Conveyor | Powder Conbe | Sealed transportation, dustproof | Transporting tungsten powder to the spheroidizing equipment |
| Mixing cooler | Mixing Cooler | Hybrid Cooler | Rapid cooling and uniform cooling | Cooling the mixed tungsten powder |
| Hammer mill | Hammer Mill | Hanmar | High impact, high capacity | Initial crushing of tungsten raw materials |
| Wet mixer | Wet Mixer | Wet Mikisa | High uniformity, corrosion resistance | Wet Mixed Tungsten Powder |
| High pressure homogenizer | High-Pressure Homogenizer | High pressure homogenizer | High pressure dispersion, good uniformity | Homogenized wet mixed tungsten powder |
| Powder grinding jar | Powder Grinding Jar | Powder grinding jar | Wear-resistant, high sealing performance | Loading tungsten powder for ball milling |
| Screening vibrator | Screening Vibrator | Screening vibrating machine | High frequency vibration, high efficiency | Auxiliary screening of tungsten powder |
| Powder drying tower | Powder Drying Tower | Powder drying tower | Large capacity, efficient drying | Large-scale drying of tungsten powder |
| Powder mixing tank | Powder Mixing Tank | Powder mixing tank | Large capacity, corrosion resistant | Wet Mixed Tungsten Powder |
| Powder screening conveyor | Powder Screening Conveyor | Powder Screening Conveyor | Screening and conveying integrated, high efficiency | Sieving and conveying tungsten powder |
| Powder storage silo | Powder Storage | Powder storage silo | Large capacity, | Storage of tungsten |

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| | Silo | | moisture-proof | powder |
| Powder cleaning tank | Powder Cleaning Tank | Powder washing tank | Large capacity, corrosion resistant | Clean tungsten powder and remove impurities |
| Powder preheater | Powder Preheater | Powder preheater | Temperature controllable, fast heating | Preheat tungsten powder to improve fluidity |
| Powder Cooler | Powder Cooler | Powder Cooler | Rapid cooling and uniform cooling | Cooling of ground tungsten powder |
| Powder demagnetization device | Powder Demagnetizer | Powder demagnetization device | Highly efficient demagnetization, no damage | Removing magnetism from tungsten powder |
| Powder Homogenizer | Powder Homogenizer | Powder Homogenizer | High uniformity, low energy consumption | Homogenized tungsten powder |
| Powder grinding filter | Powder Grinding Filter | Powder grinding powder | High efficiency filtration, durable | Filter grinding impurities |
| Powder delivery pump | Powder Transfer Pump | Powder transfer pump | Sealed conveying, high efficiency | Pumping tungsten powder |
| Powder particle size pre-screening machine | Powder Pre-Screening Machine | Powder Pre-screening Machine | Fast screening, high precision | Pre-screen tungsten powder to remove oversized particles |
| Powder dust cover | Powder Dust Cover | Powder dustproof cap | High sealing, dustproof | Cover grinding equipment to reduce dust |
| Powder grinding cooling system | Powder Grinding Cooling System | Powder grinding cooling システム | Efficient cooling, energy saving | Provide cooling for grinding equipment |
| Powder storage tank | Powder Storage Tank | Powder Storage Tank | High sealing, moisture-proof | Storage of tungsten powder to be spheroidized |
| Powder weighing conveyor | Powder Weighing Conveyor | Powder dosing machine | Accurate weighing, automation | Weighing and conveying tungsten powder |
| Powder grinding waste collector | Powder Grinding Scrap Collector | Powder Grinding Dust Collector | Efficient collection and environmental protection | Collecting grinding waste |
| Powder Moisture Tester | Powder Moisture Tester | Powder Moisture Tester | High-precision, fast measurement | Testing the moisture content of tungsten powder |
| Powder Grinding Maintenance Tools | Powder Grinding Maintenance Tool | Powder grinding conservative | Versatile and durable | Maintaining grinding equipment |
| Tungsten wire drawing machine | Tungsten Wire Drawing Machine | タングステンワイヤー Induction machine | High precision, high temperature resistance | Drawn tungsten wire for subsequent processes |
| Tungsten wire cutting machine | Tungsten Wire Cutting Machine | タングステンワイヤー cutting machine | Precise cutting without damage | Cut tungsten wire to desired length |

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| Tungsten filament heater | Tungsten Wire Heater | タングステンワイヤー heater | High temperature stable and durable | Heating tungsten powder or equipment with tungsten wire |
| Tungsten wire cleaning machine | Tungsten Wire Cleaner | タングステンワイヤー washing machine | Efficient cleaning, no residue | Clean the tungsten wire and remove surface impurities |
| Tungsten wire storage rack | Tungsten Wire Storage Rack | タングステンワイヤー custody ラック | Good ventilation and large capacity | Storage of tungsten wire |

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**2. Powder spheroidization equipment**

| Device Name | English (EN) | Japanese (JP) | Features | use |
|---|---|---|---|---|
| Plasma spheroidization equipment | Plasma Spheroidization Equipment | Plasma spheroidizing device | High temperature melting, high sphericity | Melt and spheroidize tungsten powder |
| Radio frequency plasma generator | RF Plasma Generator | RF Plug Generator | High energy, good stability | Provide plasma spheroidization high temperature |
| Aerosol equipment | Gas Atomization Equipment | Gas atomization device | High pressure airflow, rapid cooling | Atomizing molten tungsten with high pressure gas |
| Rotating electrode atomization equipment | Plasma Rotating Electrode Equipment | Rotating electrode atomization device | High purity, low impurities | Preparation of spherical tungsten powder by rotating tungsten rod |
| Powder feeding system | Powder Feeding System | Powder supply system | Continuous feeding, precise metering | Feed tungsten powder into the spheroidizing equipment |
| Spheroidizing cooler | Spheroidization Cooler | Spheroidizing cooler | Rapid cooling and uniform cooling | Tungsten powder after cooling and spheroidization |
| Vacuum Spheroidizing Furnace | Vacuum Spheroidization Furnace | Vacuum Spheroidizing Furnace | Low oxygen environment, high purity | Vacuum spheroidized tungsten powder |
| High temperature nozzle | High-Temperature Nozzle | High temperature | High temperature resistance, precise spraying | Control the flow of tungsten powder or molten tungsten |
| Spheroidizing gas circulation system | Spheroidization Gas Circulation System | Sphericalized ガス cyclic システム | Gas recovery, energy saving | Circulating inert gas |
| Powder collector | Powder Collector | Powder Collector | Efficient collection and dust prevention | Collect the spheroidized tungsten powder |
| Spheroidization Chamber | Spheroidization Chamber | Spherical Chianbar | High sealing, high temperature | Provide spheroidization |

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| | | | resistance | reaction space |
| Gas Pressure Controller | Gas Pressure Controller | Gas pressure control device | Precise control, high stability | Control spheroidizing gas pressure |
| Spheroidizing waste gas processor | Spheroidization Exhaust Gas Processor | Spheroidizing exhaust treatment device | Efficient purification and environmental protection | Treatment of spheroidization waste gas |
| Powder preheater | Powder Preheater | Powder preheater | Temperature controllable, fast heating | Preheating tungsten powder |
| Spheroidization temperature monitor | Spheroidization Temperature Monitor | Spheroidization temperature | Real-time monitoring, high precision | Monitoring spheroidization temperature |
| Spheroidizing chamber sealing tester | Spheroidization Chamber Seal Tester | Spheroidizing tester | High sensitivity, rapid detection | Check the spheroidizing chamber seal |
| Powder flow meter | Powder Flow Meter | Powder flow meter | High-precision, real-time measurement | Measuring tungsten powder flow |
| Spheroidizing cooling water system | Spheroidization Cooling Water System | Spheroidizing cooling water system | Efficient cooling, energy saving | Provide cooling water |
| Spheroidizing powder conveyor | Spheroidized Powder Conveyor | Spheroidized powder compa | Sealed transportation, dustproof | Conveying spheroidized tungsten powder |
| Spheroidizing waste collector | Spheroidization Scrap Collector | Spherical Chip Collector | Efficient collection and environmental protection | Collection of spheroidized waste |
| Spheroidizing gas purifier | Spheroidization Gas Purifier | Spheroidizing gas purification device | High purification, energy saving | Purification of inert gas |
| Spheroidizing chamber ventilation system | Spheroidization Chamber Ventilation System | Sphericalization of チャンバー for 気 システム | Large air volume, low noise | Exhaust gas from spheroidization chamber |
| Spheroidizing powder dryer | Spheroidized Powder Dryer | Spheroidizing powder dryer | High thermal efficiency and uniform drying | Dry spheroidized tungsten powder |
| Spheroidization parameter recorder | Spheroidization Parameter Recorder | Spherical recording device | Real-time recording, high precision | Recording of spheroidization parameters |
| Spheroidizing equipment maintenance tools | Spheroidization Equipment Maintenance Tool | Spheroidizing machine maintenance | Versatile and durable | Maintenance of spheroidizing equipment |
| Spheroidizing powder vibrator | Spheroidized Powder Vibrator | Spheroidizing powder vibrating machine | Even distribution, low energy consumption | Vibrate tungsten powder to prevent agglomeration |
| Spheroidizing Chamber Pressure Controller | Spheroidization Chamber Pressure Controller | Spherical pressure control device | Precise control, high stability | Controlling the pressure of the spheroidizing |

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| | | | | |
|---|---|---|---|---|
| | | | | chamber |
| Spheroidized gas storage tank | Spheroidization Gas Storage Tank | Spheroidized Gas Storage Tank | High sealing performance and large capacity | Storage of inert gases |
| Spheroidizing powder recycling machine | Spheroidized Powder Recovery Machine | Spheroidizing powder recycling machine | Efficient recycling and environmental protection | Recycling of unspheroidized tungsten powder |
| Spheroidizing nozzle cleaning machine | Spheroidization Nozzle Cleaner | Spheroidizing Nozzle Washing Machine | Efficient cleaning, no damage | Cleaning the spheroidizing nozzle |
| Vacuum Induction Melting Furnace | Vacuum Induction Melting Furnace | Vacuum Induction Melting Furnace | High temperature melting, high purity | Smelting tungsten raw materials (for gas atomization) |
| Atomization tower | Atomization Tower | Atomization Tower | Large capacity, fast cooling | Cooling atomized tungsten powder |
| Rotating electrode device | Rotating Electrode Device | Rotating electrode device | High speed rotation, high stability | Rotating tungsten rod for atomization |
| Tungsten Rod Sintering Furnace | Tungsten Rod Sintering Furnace | タングステンロッド焼 furnace | High temperature control, uniform heating | Sintered tungsten rod (for PREP) |
| Tungsten wire electrode processing machine | Tungsten Wire Electrode Machine | Electrode processing machine | High precision, high temperature resistance | Processing tungsten wire electrodes |
| Spheroidizing tank heater | Spheroidization Chamber Heater | Spheroidizing heater | High temperature, uniform and rapid heating | Preheating spheroidizing chamber |
| Spheroidized powder storage tank | Spheroidized Powder Storage Tank | Spheroidized powder storage tank | High sealing, moisture-proof | Storage of spheroidized tungsten powder |
| Spheroidizing gas flow meter | Spheroidization Gas Flow Meter | Spheroidizing Gas Flow Meter | High-precision, real-time measurement | Measuring inert gas flow |
| Spheroidizing powder delivery pump | Spheroidized Powder Transfer Pump | Spheroidized powder transfer pump | Sealed conveying, high efficiency | Pumping spheroidized tungsten powder |
| Spheroidizing chamber dust cover | Spheroidization Chamber Dust Cover | Sphericalized チャンバーdustproof カバー | High sealing, dustproof | Covering spheroidizing equipment |
| Spheroidizing cooling tower | Spheroidization Cooling Tower | Spheroidizing cooling tower | Large capacity, efficient cooling | Large-scale cooling of spheroidized tungsten powder |
| Spheroidizing powder sieving machine | Spheroidized Powder Screening Machine | Spheroidizing powder sieving machine | Multi-layer screening, automation | Preliminary screening of spheroidized tungsten powder |
| Spheroidized powder weighing instrument | Spheroidized Powder Weighing Instrument | Spheroidizing powder meter | High-precision, fast measurement | Weighing spheroidized tungsten powder |

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| Spheroidizing gas preheater | Spheroidization Gas Preheater | Spheroidizing Gas Preheater | Rapid heating, energy saving | Preheating inert gas |
| Spheroidizing powder anti-oxidation device | Spheroidized Powder Anti-Oxidation Device | Spheroidized powder anti-acidification device | High sealing, oxygen-free environment | Prevent tungsten powder from oxidation |
| Spheroidizing chamber maintenance rack | Spheroidization Chamber Maintenance Rack | Globularized チャンバーConservative Raku | Stable structure, easy to operate | Support spheroidization chamber maintenance |
| Spheroidizing powder conveyor belt | Spheroidized Powder Conveyor Belt | Spheroidized powder コンベアベルト | Continuous transportation, high efficiency | Transport of spheroidized tungsten powder |
| Spheroidized powder drying rack | Spheroidized Powder Drying Rack | Spheroidized powder dry ruck | Good ventilation and large capacity | Natural drying spheroidized tungsten powder |
| Spheroidizing gas filter | Spheroidization Gas Filter | Spheroidized Gas Field | High efficiency filtration, durable | Filtering inert gas impurities |
| Spheroidizing equipment monitoring system | Spheroidization Equipment Monitoring System | Spheroidizing Machine Monitoring System | Real-time monitoring, multi-function | Monitor the operation of spheroidizing equipment |

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**3. Powder screening and packaging equipment**

| Device Name | English (EN) | Japanese (JP) | Features | use |
|---|---|---|---|---|
| Multi-layer vibrating screen | Multi-Layer Vibrating Screen | Multi-layer vibration screen | Multi-stage screening, high efficiency | Tungsten powder classification by particle size |
| Air classifier | Air Classifier | AEARCHLASHIFIA | Non-contact, high precision | Tungsten powder classification by air flow |
| Ultrasonic screening machine | Ultrasonic Screening Machine | Ultrasonic screening machine | High frequency vibration, high precision | Ultrafine Screened Tungsten Powder |
| Screening conveyor | Screening Conveyor | Screening Conveyor | Screening and conveying integrated, high efficiency | Screening and conveying of tungsten powder |
| Powder Classification Collector | Powder Classification Collector | Powder Classification and Collection Machine | Multi-level collection, environmental protection | Collect tungsten powder of different particle sizes |
| Vacuum packaging machine | Vacuum Packing Machine | Vacuum packaging machine | Good sealing and anti-oxidation | Vacuum Packed Tungsten Powder |
| Automatic weighing machine | Automatic Weighing Machine | Automatic measuring machine | High precision and automation | Weighing Tungsten Powder |

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|---|---|---|---|---|
| Powder bagging machine | Powder Bagging Machine | Powder Bag Making Machine | Automation and high efficiency | Put tungsten powder into packaging bags |
| Sealing Machine | Sealing Machine | Sail Machine | High sealing, fast operation | Sealed Tungsten Powder Packaging |
| Powder stacker | Powder Stacking Machine | Powder Accumulation Machine | Automation and space saving | Stacking packaged tungsten powder |
| Screening vibrator | Screening Vibrator | Screening vibrating machine | High frequency vibration, high efficiency | Auxiliary screening of tungsten powder |
| Powder conveyor belt | Powder Conveyor Belt | Powder Convex | Continuous transportation, high efficiency | Transporting sieved tungsten powder |
| Powder storage tank | Powder Storage Tank | Powder Storage Tank | High sealing, moisture-proof | Storage of sieved tungsten powder |
| Powder Dryer | Powder Dryer | Powder Dryer | High thermal efficiency and uniform drying | Tungsten powder after drying and sieving |
| Powder dust cover | Powder Dust Cover | Powder dustproof cap | High sealing, dustproof | Covering screening equipment |
| Powder weighing conveyor | Powder Weighing Conveyor | Powder dosing machine | Accurate weighing, automation | Weighing and conveying tungsten powder |
| Powder Screening Waste Collector | Powder Screening Scrap Collector | Powder Screening and Chip Collecting Machine | Efficient collection and environmental protection | Collecting screening waste |
| Powder Packaging Detector | Powder Packaging Inspector | Powder Packaging Inspector | High precision, lossless | Check packaging integrity |
| Powder sieving cooler | Powder Screening Cooler | Powder Screen Cooler | Rapid cooling and uniform cooling | Tungsten powder after cooling and screening |
| Powder Classification Pump | Powder Classification Transfer Pump | Powder graded transfer pump | Sealed conveying, high efficiency | Pumping and Classifying Tungsten Powder |
| Powder Sieving Maintenance Tools | Powder Screening Maintenance Tool | Powder Screening Conservative Ture | Versatile and durable | Maintaining screening equipment |
| Powder packaging truck | Powder Packaging Transport Cart | Powder packaging truck | High load capacity, easy to carry | Handling packaged tungsten powder |
| Powder Sieving Monitoring System | Powder Screening Monitoring System | Powder screening monitoring システム | Real-time monitoring, multi-function | Monitoring the sieving process |
| Powder classification storage silo | Powder Classification Storage Silo | Powder graded storage | Large capacity, moisture-proof | Storage and classification of tungsten powder |

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| Powder sieving vibration table | Powder Screening Vibration Table | Powder Screening Vibration Table | High frequency vibration, uniform screening | Auxiliary screening of tungsten powder |
| Powder packaging seal detector | Powder Packaging Seal Tester | Powder packaging tester | High sensitivity, rapid detection | Check the sealing of the packaging |
| Powder Screening Dust Collector | Powder Screening Dust Collector | Powder Screening Dust Collector | Efficient dust removal, environmental protection | Collecting sieving dust |
| Powder grading weighing instrument | Powder Classification Weighing Instrument | Powder grader | High-precision, fast measurement | Weighing and grading tungsten powder |
| Powder packaging stacking rack | Powder Packaging Stacking Rack | Powder packaging volume | Stable structure and large capacity | Storage and packaging of tungsten powder |
| Powder screening conveyor | Powder Screening Conveyor Rack | Powder screening コンベアラック | Easy to carry and efficient | Support screening and conveying equipment |
| Powder grading drying rack | Powder Classification Drying Rack | Powder graded drying ruck | Good ventilation and large capacity | Natural drying graded tungsten powder |
| Powder packaging cleaning machine | Powder Packaging Cleaner | Powder packaging washing machine | Efficient cleaning, no residue | Cleaning and packaging equipment |
| Powder Sieving Parameter Recorder | Powder Screening Parameter Recorder | Powder screening パラメータ recording device | Real-time recording, high precision | Recording of screening parameters |
| Powder classification and anti-oxidation device | Powder Classification Anti-Oxidation Device | Powder grading and acidification prevention device | High sealing, oxygen-free environment | Prevent tungsten powder from oxidation |
| Powder packaging conveyor belt | Powder Packaging Transport Belt | Powder packaging and transportation | Continuous transportation, high efficiency | Transport packaging of tungsten powder |
| Powder screening cooling system | Powder Screening Cooling System | Powder screening cooling system | Efficient cooling, energy saving | Provide cooling for screening equipment |
| Powder classification storage tank | Powder Classification Storage Tank | Powder Grading Storage Tank | High sealing, moisture-proof | Storage and classification of tungsten powder |
| Powder packaging labeling machine | Powder Packaging Labeling Machine | Powder packaging machine | Automation, high precision | Labeling Tungsten Powder Packages |
| Powder sieving ventilation system | Powder Screening Ventilation System | Powder screening | Large air volume, low noise | Exhaust screening dust |

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| Powder grading conveyor belt | Powder Classification Conveyor Belt | Powder classification コンベアベルト | Continuous transportation, high efficiency | Transporting graded tungsten powder |
| Powder packaging dust cover | Powder Packaging Dust Cover | Powder packaging dustproof card | High sealing, dustproof | Covering packaging equipment |
| Powder Screening Exhaust Gas Processor | Powder Screening Exhaust Gas Processor | Powder screening and exhaust treatment device | Efficient purification and environmental protection | Treatment of screening waste gas |
| Powder Classification Stacker | Powder Classification Stacking Machine | Powder grading and accumulating machine | Automation and space saving | Stacking and grading tungsten powder |
| Powder packaging weighing detector | Powder Packaging Weight Inspector | Powder packaging metering tester | High precision, lossless | Check the package weight |
| Powder sieving maintenance rack | Powder Screening Maintenance Rack | Powder Screening Conservative Rack | Stable structure, easy to operate | Support screening equipment maintenance |
| Powder Classification Dust Collector | Powder Classification Dust Collector | Powder Classification Dust Collector | Efficient dust removal, environmental protection | Collecting classified dust |
| Powder packaging transport rack | Powder Packaging Transport Rack | Powder packaging and transportation | Stable structure, easy to carry | Handling and packaging of tungsten powder |
| Powder screening weighing conveyor | Powder Screening Weighing Conveyor | Powder screening and measuring system | Accurate weighing, automation | Weighing and conveying sieved tungsten powder |
| Powder packaging storage cabinet | Powder Packaging Storage Cabinet | Powder packaging storage キャビネット | Dust and moisture proof | Storage and packaging of tungsten powder |
| Powder Classification Parameter Tester | Powder Classification Parameter Tester | Powder classification パラメータ tester | High precision and multifunctional | Test and grade tungsten powder characteristics |

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**4. Auxiliary and transportation equipment**

| Device Name | English (EN) | Japanese (JP) | Features | use |
|---|---|---|---|---|
| Belt conveyor | Belt Conveyor | Beltoconbe | Continuous transportation, high efficiency | Transporting tungsten powder |
| Bucket Elevator | Bucket Elevator | バケットエレベーター | Vertical transportation, high efficiency | Lift tungsten powder to a specified height |
| Feeder | Feeder | FIDAL | Uniform feeding, | Feed tungsten |

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| | | | adjustable speed | powder into the spheroidizing equipment |
| Ventilator | Ventilation Fan | Air conditioning fan | Large air volume, low noise | Workshop ventilation |
| Nitrogen Generator | Nitrogen Generator | Antagonist Generating Device | High purity, stable supply | Provide inert gas protection |
| Argon generator | Argon Generator | Algon Generator | High purity, inert | Provide inert gas for spheroidization |
| Vacuum Pump | Vacuum Pump | Vacuum Pump | High vacuum, low noise | Provide vacuum environment |
| Air compressor | Air Compressor | Eacon Press | High pressure, stable output | Provide compressed air for pneumatic equipment |
| Storage tank | Storage Tank | Storage Tank | Good sealing and large capacity | Storage of tungsten powder |
| Transporter | Forklift | FO CLIFFT | Flexible transport, high load capacity | Handling tungsten powder or packaging |
| dust collector | Dust Collector | Dust Collector | Efficient dust removal, environmental protection | Collect dust |
| Temperature and humidity controller | Temperature and Humidity Controller | Temperature and humidity control device | Precise control and high stability | Control workshop temperature and humidity |
| Static Eliminator | Static Eliminator | Static Electricity Removal Device | Rapid elimination of static electricity, high safety | Prevent tungsten powder from sticking |
| Protective cover | Protective Cover | Protection card | Heat resistant and highly safe | Protecting equipment or personnel |
| Tool Cart | Tool Cart | Tool Card | Portable and versatile | Storage and transportation tools |
| Gas Pressure Regulator | Gas Pressure Regulator | Gas pressure regulator | Precise control and high stability | Regulating inert gas pressure |
| Exhaust gas treatment device | Exhaust Gas Treatment Device | Exhaust treatment device | Efficient purification and environmental protection | Treatment of spheroidization waste gas |
| Dust monitor | Dust Monitor | Dust Monitor | Real-time monitoring, high sensitivity | Monitor dust concentration in the workshop |
| Explosion proof lights | Explosion-Proof Lamp | Explosion-proof lamp | High safety and durability | Provide lighting for dusty areas |
| Material sorting machine | Material Sorting Machine | Material sorting machine | Automation and high efficiency | Sorting different batches of tungsten powder |

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| Automatic stacker | Automatic Stacker | Automatic stacking machine | Automation and space saving | Stacking tungsten powder packaging |
| Pneumatic handling device | Pneumatic Transport Device | Air pressure transport device | Fast shipping, dust-free | Pneumatic conveying of tungsten powder |
| Anti-vibration pads | Anti-Vibration Pad | Vibration-proof pad | High shock absorption, durable | Reduce equipment vibration |
| Safety fence | Safety Guardrail | Security Fence | High strength, easy to install | Isolate the danger zone |
| Equipment lubrication system | Equipment Lubrication System | Equipment Lubrication System | Automatic lubrication, extended service life | Provide lubricating oil for equipment |
| Gas storage tank | Gas Storage Tank | Gas Storage Tank | High sealing performance and large capacity | Storage of inert gases |
| Workshop monitoring system | Workshop Monitoring System | Factory Monitoring System | Real-time monitoring, multi-function | Monitor workshop operation |
| Transport Robot | Transport Robot | Transport robot | Automation and high efficiency | Automatic handling of tungsten powder |
| Powder sealing box | Powder Sealing Box | Powder seal box | High sealing, moisture-proof | Sealed storage of tungsten powder |
| Waste Compactor | Scrap Compressor | Chip Compressor | High compression ratio, space saving | Compressed waste |
| Air Purifier | Air Purifier | Air Purifier | High efficiency purification, low noise | Purify workshop air |
| Transport rail car | Transport Rail Car | Transport | Large load, high stability | Transporting tungsten powder within the workshop |
| Emergency lighting | Emergency Lighting | Emergency lighting lamp | High brightness, long life | Emergency lighting |
| Equipment Calibration Tools | Equipment Calibration Tool | Equipment Calibration Tutorial | High precision and multifunctional | Calibration of production equipment |
| Dust curtain | Dust Curtain | Dustproof Door | High sealing, easy to install | Isolate dust area |
| Powder conveyor belt | Powder Transport Belt | Powder transport bell | Continuous transportation, high efficiency | Transporting tungsten powder |
| Powder handling rack | Powder Transport Rack | Powder transport luggage | Stable structure, easy to carry | Transporting tungsten powder |
| Gas flow meter | Gas Flow Meter | Gas flow meter | High-precision, real-time measurement | Measuring inert gas flow |
| Powder storage | Powder Storage | Powder storage | Dust and moisture | Storage of tungsten |

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| cabinet | Cabinet | technology | proof | powder |
| Powder transport pump | Powder Transport Pump | Powder transport pump | Sealed conveying, high efficiency | Pumping tungsten powder |
| Workshop ventilation system | Workshop Ventilation System | Factory Air Conditioning System | Large air volume, low noise | Keep the air circulating in the workshop |
| Powder anti-oxidation device | Powder Anti-Oxidation Device | Powder acidification prevention device | High sealing, oxygen-free environment | Prevent tungsten powder from oxidation |
| Powder transport vehicle | Powder Transport Cart | Powder transport cabinet | High load capacity, easy to operate | Transporting tungsten powder |
| Gas Purifier | Gas Purifier | Gas purification device | High purification, energy saving | Purification of inert gas |
| Powder dust collector | Powder Dust Collector | Powder dust collector | Efficient dust removal, environmental protection | Collecting and transporting dust |
| Powder storage rack | Powder Storage Rack | Powder storage luggage | Good ventilation and large capacity | Storing tungsten powder |
| Powder transport sealed box | Powder Transport Sealing Box | Powder handling seal ボックス | High sealing, moisture-proof | Sealed transportation of tungsten powder |
| Powder handling robot | Powder Handling Robot | Powder ハンドリングロボット | Automation and high precision | Automatic handling of tungsten powder |
| Powder transport cooler | Powder Transport Cooler | Powder handling cooler | Rapid cooling and uniform cooling | Cooling of tungsten powder during transportation |
| Powder storage monitoring system | Powder Storage Monitoring System | Powder Storage Monitoring System | Real-time monitoring, multi-function | Monitoring the storage environment |
| Powder transport dust cover | Powder Transport Dust Cover | Powder handling dust control cabinet | High sealing, dustproof | Covering transportation equipment |
| Powder handling stacker | Powder Handling Stacking Machine | Powder printing machine | Automation and space saving | Stacking tungsten powder |
| Powder transport weighing instrument | Powder Transport Weighing Instrument | Powder transport meter | High-precision, fast measurement | Weighing and transporting tungsten powder |
| Powder storage sealed jar | Powder Storage Sealing Tank | Powder Storage Sealing Tank | High sealing, moisture-proof | Sealed storage of tungsten powder |
| Powder transport ventilation system | Powder Transport Ventilation System | Powder handling equipment | Large air volume, low noise | Exhaust of transport dust |
| Powder Handling | Powder | Powder ハンドリン | Versatile and | Maintaining |

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| Maintenance Tools | Handling Maintenance Tool | グ Conservative ツール | durable | transportation equipment |
| Powder transport monitoring system | Powder Transport Monitoring System | Powder transportation monitoring system | Real-time monitoring, multi-function | Monitor the transportation process |
| Powder storage dust cover | Powder Storage Dust Cover | Powder storage dustproof card | High sealing, dustproof | Overwrite storage device |
| Powder transport stacking rack | Powder Transport Stacking Rack | Powder handling equipment | Stable structure and large capacity | Storage and transportation of tungsten powder |
| Powder handling cooling system | Powder Handling Cooling System | Powder ハンドリング cooling システム | Efficient cooling, energy saving | Providing cooling for transport equipment |
| Powder transport seal tester | Powder Transport Seal Tester | Powder handling tester | High sensitivity, rapid detection | Check shipping container seals |
| Powder Storage Thermohygrometer | Powder Storage Temperature and Humidity Meter | Powder Storage Thermohygrometer | High-precision, real-time measurement | Monitor storage temperature and humidity |
| Powder transport exhaust gas processor | Powder Transport Exhaust Gas Processor | Powder transportation exhaust treatment device | Efficient purification and environmental protection | Treating transport exhaust |
| Powder handling parameter recorder | Powder Handling Parameter Recorder | Powder ハンドリング パラメータ recording device | Real-time recording, high precision | Recording of transport parameters |

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**5. Inspection and testing equipment and instruments**

| Device Name | English (EN) | Japanese (JP) | Features | use |
|---|---|---|---|---|
| X-ray Fluorescence Analyzer (XRF) | X-Ray Fluorescence Analyzer | X-ray spectroscopy device | Non-destructive testing, high precision | Detection of tungsten powder purity and impurities |
| Chemical titration device | Titration Apparatus | Titration device | Simple and precise operation | Analysis of trace elements in tungsten powder |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometer | ICP mass analysis device | High sensitivity, multi-element analysis | Detection of trace impurities in tungsten powder |
| microscope | Microscope | Microscope | High resolution, magnified observation | Check the surface morphology of tungsten powder |
| Scanning electron | Scanning Electron | Scanning electron | High resolution, | Observe the |

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| microscopy (SEM) | Microscope | microscope | surface analysis | sphericity of tungsten powder |
| Energy dispersive spectrometer (EDS) | Energy Dispersive Spectrometer | エネルギー dispersion beam splitter | Elemental analysis, high sensitivity | Analyze the element distribution of tungsten powder |
| X-ray diffractometer (XRD) | X-Ray Diffractometer | X-ray folding device | High resolution, structural analysis | Analyze the crystal structure of tungsten powder |
| Density meter | Densitometer | Density meter | High precision, non-contact | Measuring the apparent density of tungsten powder |
| Laser Particle Size Analyzer | Laser Particle Size Analyzer | レーザー Particle size analysis device | Fast analysis, accurate data | Measuring tungsten powder particle size distribution |
| Specific surface area analyzer (BET) | BET Surface Area Analyzer | BET specific surface area analyzer | High-precision, fast testing | Measuring the specific surface area of tungsten powder |
| Flow Tester | Flowability Tester | Flow tester | High-precision, fast measurement | Testing the fluidity of tungsten powder |
| Sphericity measuring instrument | Sphericity Measuring Instrument | Sphericity Tester | High precision, non-contact | Measuring the sphericity of tungsten powder |
| Powder Moisture Tester | Powder Moisture Tester | Powder Moisture Tester | High-precision, fast measurement | Testing the moisture content of tungsten powder |
| Trace oxygen analyzer | Trace Oxygen Analyzer | Trace oxygen analysis device | High sensitivity, fast response | Detecting oxygen content of tungsten powder |
| Coordinate Measuring Machine (CMM) | Coordinate Measuring Machine | Three-dimensional measuring machine | High-precision, three-dimensional measurement | Measuring Tungsten Powder Size Consistency |
| Surface Roughness Tester | Surface Roughness Tester | Surface Roughness Tester | High precision, portable | Measuring the surface roughness of tungsten powder |
| Thermogravimetric Analyzer (TGA) | Thermogravimetric Analyzer | Thermogravimetric analysis device | High temperature testing, accurate data | Analysis of high temperature quality changes of tungsten powder |
| Thermal dilatometer | Thermal Expansion Analyzer | Thermal expansion meter | High precision and wide temperature range | Measuring the thermal expansion coefficient of tungsten powder |
| Dynamic Mechanical Analyzer (DMA) | Dynamic Mechanical Analyzer | Dynamic Thermomechanical Analysis Device | Multi-parameter, high precision | Analysis of the thermomechanical properties of tungsten powder |
| Laser diameter gauge | Laser Diameter | Reser diameter | Non-contact, | Measure the average |

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| | Gauge | measuring device | high precision | diameter of tungsten powder |
| Infrared thermometer | Infrared Thermometer | Infrared thermometer | Non-contact, fast response | Measuring spheroidization or sieving temperature |
| Optical projector | Optical Projector | Optical projector | High magnification, precise measurement | Checking Tungsten Powder Geometry |
| Powder Bulk Density Tester | Powder Tap Density Tester | Powder tap density meter | High-precision, fast measurement | Measuring Tungsten Powder Bulk Density |
| Powder Flow Meter | Powder Flow Meter | Powder Flow Meter | High-precision, real-time measurement | Measuring tungsten powder flow time |
| Powder Sieving Analyzer | Powder Sieve Analyzer | Powder sieving and analysis device | Multi-level analysis, high efficiency | Analyze tungsten powder particle size distribution |
| Powder Antioxidant Tester | Powder Oxidation Resistance Tester | Powder Acid Resistance Tester | High sensitivity, multifunctional | Testing the Anti-Oxidation Performance of Tungsten Powder |
| Powder Magnetic Tester | Powder Magnetic Tester | Powder Magnetic Tester | High sensitivity, fast measurement | Testing the magnetic properties of tungsten powder |
| Powder conductivity meter | Powder Conductivity Meter | Powder conductivity meter | High precision, portable | Measuring the conductivity of tungsten powder |
| Powder Porosity Tester | Powder Porosity Tester | Powder Porosity Tester | High-precision, fast measurement | Measuring the porosity of tungsten powder |
| Powder Surface Energy Analyzer | Powder Surface Energy Analyzer | Powder surface analysis device | High precision and multifunctional | Analysis of tungsten powder surface energy |
| Powder shape analyzer | Powder Particle Shape Analyzer | Powder shape analysis device | High resolution, fast analysis | Analyze the shape characteristics of tungsten powder |
| Powder Residual Stress Analyzer | Powder Residual Stress Analyzer | Powder residual stress analysis device | High precision, lossless | Analysis of residual stress in tungsten powder |
| Powder Thermal Conductivity Tester | Powder Thermal Conductivity Meter | Powder Thermal Conductivity Meter | High precision and fast response | Measuring thermal conductivity of tungsten powder |
| Powder environment simulation test chamber | Powder Environmental Simulation Chamber | Powder environment simulation test chamber | Multi-condition simulation, high reliability | Simulated tungsten powder environmental performance |
| Powder Microhardness | Powder Microhardness Tester | Powder Micro Hardness Tester | High resolution, micro-area | Testing the microhardness of |

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| Tester | | | testing | tungsten powder |
| Powder Flow Simulator | Powder Flowability Simulator | Powder flowability シミュレーター | High simulation, accurate data | Simulating the fluidity of tungsten powder in 3D printing |
| Powder Particle Size Distribution Analyzer | Powder Particle Size Distribution Analyzer | Powder particle size distribution analysis device | High precision and multifunctional | Accurately analyze the particle size distribution of tungsten powder |
| Powder surface defect detector | Powder Surface Defect Detector | Powder surface defect detector | High sensitivity, lossless | Detection of tungsten powder surface defects |
| Powder Quality Consistency Tester | Powder Quality Consistency Tester | Powder quality consistency tester | High precision, multi-parameter | Testing Tungsten Powder Batch Consistency |

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## 6. Raw and auxiliary materials

| Material Name | English (EN) | Japanese (JP) | Features | use |
|---|---|---|---|---|
| High purity tungsten powder | High-Purity Tungsten Powder | High purity polyester powder | High purity (≥99.95%), adjustable particle size | Main raw materials |
| Tungsten Wire | Tungsten Wire | タングステンワイヤー | High melting point, high temperature resistance | Used as heating element or electrode |
| Nitrogen ( $N_2$ ) | Nitrogen | chlorine | Inertness, high stability | Protective gas to prevent oxidation |
| Argon (Ar) | Argon | Algon | High purity, inert | Inert gas for spheroidization |
| Deionized water | Deionized Water | Deionized water | High purity, no impurities | Wet grinding or cleaning media |
| Ethanol | Ethanol | Etanol | Highly volatile, no residue | Cleaning tungsten powder or preparing solution |
| Polyvinyl alcohol (PVA) | Polyvinyl Alcohol | ポリビニルアルコール | Strong adhesion, easy to decompose | Temporary adhesive |
| Stearic acid | Stearic Acid | Sterilin | Good lubricity, easy to evaporate | Grinding or mixing lubricants |
| Zirconia grinding balls | Zirconia Grinding Balls | ジルコニア grinding ボール | High hardness, wear resistance | Ball mill grinding media |
| Silicone oil | Silicone Oil | Celicon Oil | High stability, low volatility | Improve the fluidity of tungsten powder |
| Antioxidants | Antioxidant | Antioxidants | Highly effective anti-oxidation and high temperature resistance | Prevent tungsten powder from oxidation |
| Powder sieve | Powder Sieve | Powder sieve | High precision and | Tungsten powder |

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durable screening tools

The relevant contents are all written based on the production practice and research experiments of CTIA GROUP LTD, and are for reference only, not as actual investment and production guidance workbooks. For more information or actual product requirements, production and experimental guidance, please visit its website ( www.ctia.com.cn ) or contact by email .

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**Tungsten ball (powder) production process for 3D printing**

"Tungsten balls (powders) for 3D printing" refers to spherical tungsten powders designed for additive manufacturing technologies (such as selective laser melting SLM, electron beam melting EBM, Binder Jetting, etc.). Typical requirements include: purity ≥ 99.95%, sphericity > 0.9, particle size range 10-50 microns, fluidity < 25 seconds/50g (Hall flow rate, according to ASTM B213 standard). The mainstream processes for producing such tungsten powders in China include plasma spheroidization, gas atomization, and plasma rotating electrode plasma atomization (Plasma Rotating Electrode Process, PREP). These processes have their own characteristics and are suitable for different production scales and quality requirements. The following describes in detail the process, equipment, raw and auxiliary materials, and technical points of each process, with verifiable data attached, and finally summarizes the characteristics and advantages and disadvantages through a comparison table.

## 1. Plasma Spheroidization of Tungsten Balls (Powder) for 3D Printing

**Process Overview**

Plasma spheroidization uses radio frequency plasma to generate ultra-high temperature (6000-10000°C) to melt irregular tungsten powder into droplets, which solidify into spherical particles under the action of surface tension. This process is suitable for preparing high-sphericity powder from existing tungsten powder and is widely used in small and medium-sized batch production. It is favored because of its mature process and strong adaptability to raw materials.

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**Process**

**Raw material preparation**
**Steps** : Select high-purity tungsten powder (purity ≥ 99.95%, initial particle size 10-100 microns, source such as Xiamen Tungsten Industry), remove oversized particles through a vibrating screen (mesh size 50-100 microns), and use an ultrasonic cleaner (frequency 40kHz, power 200W) to clean with deionized water and ethanol to remove surface oxides and organic impurities.
**Equipment** :
Vibrating screen (such as Xinxiang Pioneer XZS-800, screening capacity 500kg/h)
Ultrasonic cleaning machine (such as Kunshan KSD-200, volume 20L)
Powder storage silo (stainless steel, capacity 1-5 tons, tightness <0.1Pa)
**Raw and auxiliary materials** : high-purity tungsten powder, deionized water (resistivity ≥ 18MΩ·cm), ethanol (analytical grade, 99.5%).
**Purpose** : To ensure the purity of raw materials (oxygen content <500ppm) and particle size consistency, laying the foundation for subsequent processing.

**Ultrafine grinding and homogenization**
**Steps** : Place tungsten powder in a planetary ball mill (speed 300-500rpm, grinding time 4-8 hours), use zirconium oxide balls (diameter 5-10mm, ball-to-material ratio 10:1) to grind to 10-50 microns, add 0.1-0.5wt% stearic acid (lubricant) and antioxidant (such as vitamin E), and homogenize through a V-type mixer (speed 20rpm, mixing for 2 hours).
**Equipment** :
Planetary ball mill (such as Nanjing Nanda QM-3SP4, volume 4L, power 1.5kW)
Airflow pulverizer (such as Kunshan Miyou QYF-150, output 50-100kg/h, air pressure 0.8MPa)
V-type mixer (such as Changzhou One-Step V-500, volume 500L)
**Raw and auxiliary materials** : zirconium oxide grinding balls ($ZrO_2$, hardness> 9 Mohs), stearic acid, antioxidants.
**Purpose** : To obtain fine and uniform tungsten powder (D50≈20 microns), improve spheroidization efficiency and prevent agglomeration.

**Plasma spheroidization**
**Steps** : The tungsten powder is uniformly fed into the plasma spheroidization equipment through the powder feeding system (feeding rate 5-20g/min). The radio frequency plasma generator (power 20-50kW, frequency 13.56MHz) generates high-temperature plasma in an argon (purity 99.999%, flow rate 20-50L/min) atmosphere. The tungsten powder melts instantly (melting point 3422°C) and forms spherical droplets. Tungsten wire (diameter 0.5-1mm) can be used as a heating element to assist in heating.
**Equipment** :
Plasma spheroidization equipment (such as Canadian Tekna PS-50, output 10-50kg/h)
Radio frequency plasma generator (such as domestic PL-50, power 50kW)
Spheroidizing chamber (temperature resistance > 2000°C, volume 50L)
**Raw and auxiliary materials** : argon, nitrogen, tungsten wire (purity 99.95%, optional).
**Purpose** : To convert irregular particles into spherical powders with a sphericity of more than 0.95 (according to ISO 9276-6 standard).

**Cooling and collection**
**Steps** : The molten droplets are rapidly cooled in an inert gas (cooling rate $10^3$ -$10^4$ °C/s), and the spheroidized tungsten powder is recovered through a powder collector (cyclone separation efficiency >95%).
**Equipment** :
Spheroidizing cooler (water cooling, flow rate 10L/min)
Powder collector (such as Shanghai Deke DC-3000, collection rate 98%)
Spheroidizing gas circulation system (recovery rate>90%)

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**Raw and auxiliary materials** : argon and nitrogen.
**Purpose** : To solidify spherical particles, with a collection rate of more than 90%, and avoid oxidation (oxygen content <200ppm).

**Screening and grading**
**Steps** : Use a multi-layer vibrating screen (sieve hole 10-50 microns, vibration frequency 3000 times/min) and an airflow classifier (classification accuracy ±2 microns) to classify the tungsten powder into specifications such as 10-20 microns and 20-50 microns to ensure that the particle size distribution meets the SLM requirements (D10/D50/D90=10/20/40 microns).
**Equipment** :
Multi-layer vibrating screen (such as Xinxiang Dahan DH-1000, screening efficiency 200kg/h)
Airflow classifier (such as Weifang Zhengyuan LHB-10, output 50kg/h)
Ultrasonic screening machine (such as Shanghai Navector SW-1000, frequency 35kHz)
**Raw and auxiliary materials** : powder screen (stainless steel, pore size 10-50 microns).
**Purpose** : To precisely control particle size and meet the uniformity requirements of 3D printing.

**Inspection and packaging**
**Steps** : Use a laser particle size analyzer (measuring range 0.1-1000 microns, accuracy ±1%), a scanning electron microscope (magnification 5000x), and a flowability tester (Hall funnel method) to test particle size, sphericity, and flowability (target <25 seconds/50g). If qualified, use a vacuum packaging machine (vacuum degree <10Pa) to seal and package.
**Equipment** :
Laser particle size analyzer (such as Malvern Mastersizer 3000)
Scanning electron microscope (such as Japan JEOL JSM-6700F)
Vacuum packaging machine (such as Shanghai Yatai VP-800, packaging speed 20 bags/min)
**Raw and auxiliary materials** : None.
**Purpose** : To verify product quality and ensure storage stability (moisture content < 0.02%).

**Key technical features**
Using existing tungsten powder as raw material, the process is simple and suitable for small batch production.
High temperature plasma ensures high sphericity (>0.95) and controllable particle size distribution.
The feed rate (deviation < 5%) and gas purity (impurities < 10 ppm) must be strictly controlled to avoid oxidation or agglomeration.

## 2. Gas Atomization

**Process Overview**
The gas atomization process uses high-pressure inert gas (pressure 5-10MPa) to atomize the molten tungsten liquid into tiny droplets, which are then cooled to form spherical tungsten powder. This process is directly prepared from tungsten blocks or tungsten powder raw materials, suitable for large-scale industrial production, and is widely used due to its high yield and cost advantages.

**Process**
**Raw material preparation**
**Steps** : Select high-purity tungsten blocks or tungsten powder (purity ≥ 99.95%, such as products of Zhongnan Tungsten Industry), clean them with deionized water and ethanol using an ultrasonic cleaner (frequency 40kHz, power 500W), and place them in a vacuum dryer (temperature 80°C, vacuum degree <10Pa) to dry.
**Equipment** :
Ultrasonic cleaning machine (such as Kunshan KSD-500, volume 50L)
Vacuum dryer (such as Shanghai Yiheng ZK-50, volume 50L)
Powder storage tank (stainless steel, capacity 2-10 tons)

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**Raw and auxiliary materials** : high-purity tungsten block, deionized water (resistivity ≥ 18MΩ·cm), ethanol (analytical grade, 99.5%).
**Purpose** : To remove surface impurities (oxygen content < 300ppm) and prepare pure raw materials for smelting.

**Smelting**
**Steps** : Place the tungsten block in a vacuum induction melting furnace (power 100-200kW, vacuum degree <$10^{-3}$ Pa ), heat it to above 3422°C to melt it into tungsten liquid. Tungsten wire (diameter 1-2mm, resistivity 5.5μΩ·cm) can be used as a heating element to assist in heating.
**Equipment** :
Vacuum induction melting furnace (such as Zhuzhou Nanfang VIM-50, melting capacity 50kg)
Tungsten filament heater (domestic, temperature resistance>3000°C)
**Raw and auxiliary materials** : tungsten wire (purity 99.95%).
**Purpose** : To convert solid tungsten into a uniform molten state and ensure fluidity.

**Aerosolization**
**Steps** : The molten tungsten liquid is sprayed out through a high-temperature nozzle (temperature resistance >3500°C, aperture 0.5-1mm), and the high-pressure argon gas (pressure 5-10MPa, flow rate 100-200L/min) breaks the liquid flow into tiny droplets, which are cooled and solidified in the atomization tower (cooling rate $10^{4}$ °C/s).
**Equipment** :
Gas atomization equipment (such as German ALD VIGA-25, output 50-100kg/h)
Atomization tower (height 5-10m, volume 100$m^{3}$ )
High pressure nozzle (made of tungsten alloy, life span>500h)
**Raw and auxiliary materials** : argon (purity 99.999%).
**Purpose** : To form spherical tungsten powder with a particle size of 10-50 microns and a sphericity of 0.9-0.95.

**Cooling and collection**
**Steps** : The droplets are rapidly cooled in the atomization tower, and the spheroidized tungsten powder is recovered through a powder collector (collection efficiency > 95%).

**Equipment** :
Atomization tower (built-in water cooling system, flow rate 20L/min)
Powder collector (such as Jiangsu Tianrui DC-5000, collection rate 97%)
**Raw and auxiliary materials** : argon.
**Purpose** : To solidify and recycle tungsten powder, with a collection rate of more than 92%.

**Screening and grading**
**Steps** : Use a multi-layer vibrating screen (sieve opening 10-50 microns, vibration frequency 3000 times/min) and an air flow classifier (classification accuracy ±2 microns) to classify into specifications such as 10-20 microns, 20-50 microns, etc.
**Equipment** :
Multi-layer vibrating screen (such as Xinxiang Dahan DH-1200, screening efficiency 300kg/h)
Airflow classifier (such as Weifang Zhengyuan LHB-20, output 80kg/h)
**Raw and auxiliary materials** : powder screen (stainless steel, pore size 10-50 microns).
**Purpose** : To control particle size distribution and meet SLM/EBM requirements.

**Inspection and packaging**
**Steps** : Use a laser particle size analyzer (accuracy ±1%), a sphericity measuring instrument (resolution 0.01), and a fluidity tester to test the indicators. If qualified, use a vacuum packaging machine (vacuum degree <10Pa) to seal.
**Equipment** :

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Laser particle size analyzer (such as Beckman LS 13 320)
Sphericity measuring instrument (such as Japan HORIBA LA-960)
Vacuum packaging machine (such as Shanghai Yatai VP-1000)
**Raw and auxiliary materials** : None.
**Purpose** : To ensure quality (flowability <25 seconds/50g) and prevent oxidation.

**Key technical features**
Prepared directly from molten tungsten, suitable for mass production (daily output up to 500kg).
Wide particle size range (5-100 microns) and adjustable by gas pressure.
It has high requirements for smelting and nozzle design (nozzle life <1000h) and is easily contaminated by oxygen (oxygen content may reach 300ppm).

**3. Plasma Rotating Electrode Process (PREP)**

**Process Overview**
PREP uses a high-speed rotating tungsten rod electrode (5000-15000 rpm) to melt and scatter into droplets under the action of a plasma arc (temperature > 6000°C), and then forms high-purity spherical tungsten powder after cooling. This process is particularly suitable for high-end 3D printing applications such as aerospace due to its high purity and low impurities.

**Process**
**Raw material preparation**
**Steps** : Select high-purity tungsten blocks (purity ≥ 99.95%) and sinter them into tungsten rods (diameter 10-50mm) through a tungsten rod sintering furnace (temperature 2800°C, hydrogen reducing atmosphere). Tungsten wires (diameter 0.5-2mm) can be used for sintering or electrode preparation, and then cleaned and dried .
**Equipment** :
Tungsten rod sintering furnace (such as Zhuzhou Cemented Carbide S-50, output 50kg/batch)
Tungsten wire drawing machine (such as Xi'an Taijin TJ-300, drawing speed 10m/min)
Ultrasonic cleaning machine (such as Kunshan KSD-300, volume 30L)
**Raw and auxiliary materials** : high purity tungsten block, tungsten wire, deionized water.
**Purpose** : To prepare high-density tungsten rods (density>19g/cm³ ) to ensure electrode quality.

**Rotating electrode preparation**
**Steps** : Install the tungsten rod on the rotating electrode device, adjust the speed to 5000-15000 rpm, and check the electrode concentricity (deviation <0.1mm).
**Equipment** :
Rotating electrode device (such as domestic PREP-50, speed range 0-20000rpm)
Tungsten wire electrode processing machine (processing accuracy ±0.01mm)
**Raw and auxiliary materials** : tungsten wire (optional, used as auxiliary electrode).
**Purpose** : To ensure stable rotation of the electrode and uniform melting.

**Plasma atomization**
**Steps** : The plasma generator (power 30-60kW) generates a high-temperature plasma arc in a helium or argon (flow rate 30-60L/min) atmosphere, melts the end of the tungsten rod, and rotates at high speed to scatter the molten droplets into spherical particles (scattering speed>50m/s).
**equipment** :
Rotating electrode atomization equipment (such as American Carpenter PREP-100, output 5-20kg/h)
Plasma generator (such as domestic PL-60, power 60kW)
Vacuum atomization chamber (vacuum degree <10 $^{-2}$ Pa )
**Raw and auxiliary materials** : helium (purity 99.999%), argon.
**Purpose** : To prepare high-purity spherical tungsten powder with sphericity > 0.98.

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**Cooling and collection**
**Procedure** : The droplets are cooled in a vacuum atomization chamber (cooling rate $10^4$ °C/s) and recovered via a powder collector.
**Equipment** :
Vacuum atomization chamber (volume 50m³ )
Powder collector (such as Jiangsu Tianrui DC-3000, collection rate 98%)
**Raw and auxiliary materials** : helium and argon.
**Purpose** : To solidify and recycle tungsten powder, with a collection rate of more than 95%.

**Screening and grading**
**Steps** : Use a multi-layer vibrating screen (mesh size 10-50 microns) and an ultrasonic sieving machine to classify into 10-20 microns and 20-50 microns.
**Equipment** :
Multi-layer vibrating screen (such as Xinxiang Dahan DH-800, screening efficiency 150kg/h)
Ultrasonic screening machine (such as Shanghai Navector SW-1200)
**Raw and auxiliary materials** : powder screen.
**Purpose** : To meet the particle size requirements of high-end 3D printing.

**Inspection and packaging**
**Steps** : Use X-ray fluorescence analyzer (detection limit 0.01%) and fluidity tester to detect purity and fluidity, and vacuum pack after passing the test.
**Equipment** :
X-ray fluorescence analyzer (such as German Bruker S8 TIGER)
Vacuum packaging machine (such as Shanghai Yatai VP-600)
**Raw and auxiliary materials** : None.
**Purpose** : To ensure purity >99.98% and fluidity <20 seconds/50g.

**Key technical features**
Prepared directly from tungsten rods, with extremely high purity (oxygen content <100ppm) and few impurities.
Excellent sphericity and consistency (standard deviation <5%) for high-end applications.
The production efficiency is low (single batch <20kg) and the equipment is complicated.

**Comparison of the characteristics, advantages and disadvantages of the three processes**

| Technology | Features | advantage | shortcoming |
|---|---|---|---|
| **Plasma spheroidization** | Use existing tungsten powder raw materials , high temperature plasma melting (6000-10000°C) Sphericity>0.95 | Mature technology, simple operation , high sphericity (0.95-0.98) , output 10-50kg/h, suitable for small batches , strong adaptability to raw materials | High energy consumption (20-50kW/h) , limited output (daily output <100kg) , need to control feed rate (deviation <5%) and gas purity (impurities <10ppm) |
| **Aerosolization** | Prepared from molten tungsten liquid , atomized by high pressure gas (5-10MPa) , particle size range 5-100 microns | Large output (50-500kg/h) , adjustable particle size (D50=10-50 microns) , low cost (about 500 yuan/kg) , suitable for industrial production | The equipment is complex (investment > 5 million) , susceptible to oxygen contamination (oxygen content 200-300ppm) , and the sphericity is slightly low (0.9-0.95) |
| **Rotating Electrode Plasma** | Directly prepared from tungsten rod , plasma arc | High purity (oxygen content <100ppm) , | Low production efficiency (5-20kg/h) , complex equipment |

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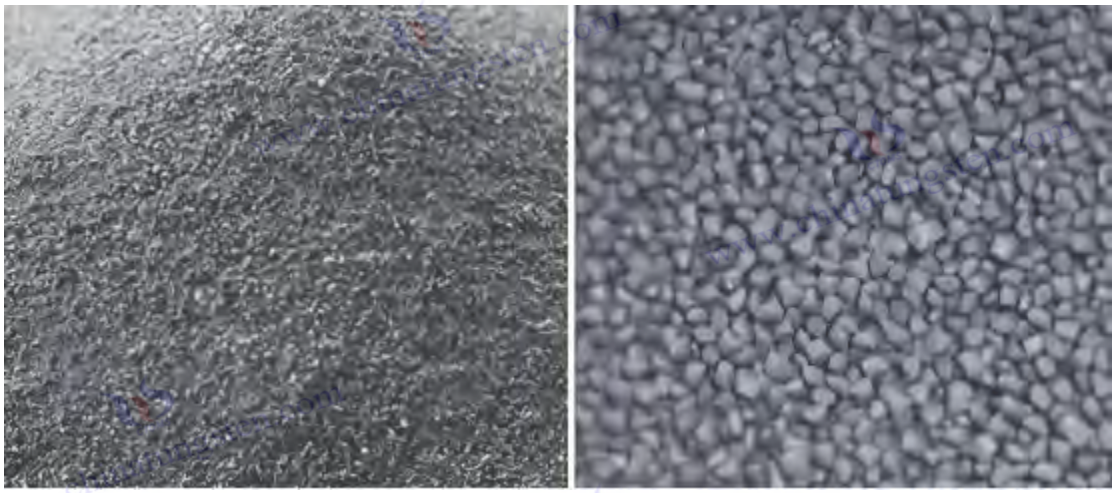
| | | | |
|---|---|---|---|
| **Atomization (PREP)** | melting and scattering (speed 5000-15000rpm) , purity>99.98% | excellent sphericity (>0.98) , good consistency (particle size deviation <5%) , suitable for high-end applications | (high maintenance cost) , high raw material preparation cost (tungsten rod is about 1000 yuan/kg) |

**References**

**Plasma spheroidization** is suitable for small and medium-scale scenarios with high sphericity requirements. The process is simple but the energy consumption is high. Typical applications can be found in the literature (such as "Materials Science and Engineering A", 2020).

**Aerosol atomization** is suitable for large-scale production, with high output and controllable costs, and is widely used in industrial-grade 3D printing powders (data reference report of China Nonferrous Metals Society, 2022).

**PREP** is the first choice for high-purity, high-quality tungsten powder, suitable for high-end fields such as aerospace, although its efficiency is lower (see "Powder Metallurgy", 2021).



**Appendix:**

**Tungsten related standards and specifications (international compilation)**

**Comparison between Chinese standards and ISO and DIN**

**Tungsten-related standards and specifications (international compilation)**

Tungsten (element symbol W) is a rare metal with a high melting point (3422°C) and high density (19.25 g/cm³ ) , which is widely used in metallurgy, chemical industry, electronics, aerospace and additive manufacturing. Its relevant standards cover the entire industry chain from mineral raw materials (such as black tungsten concentrate and scheelite concentrate) to intermediate compounds (such as tungstic acid, tungstate, blue tungsten, yellow tungsten, and purple tungsten), powders (such as tungsten powder and tungsten carbide powder), metal products (such as tungsten wire and tungsten boat) and alloys (such as cemented carbide and tungsten copper). This article compiles the tungsten-related standards of major international standardization organizations and countries, and compares the Chinese standard (GB) with ISO and DIN. For substances such as purple tungsten that do not have independent standards, refer to the information of CTIA GROUP LTD (CTIA) for supplementary information.

**1. International Organization for Standardization (ISO) standards**

ISO standards are universal global specifications. The standards related to tungsten mainly involve powder

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metallurgy, cemented carbide and additive manufacturing:
**ISO 4499-2:2020** - *Hardmetals — Metallographic determination of microstructure — Part 2: Measurement of WC grain size*
**Content** : Method for determination of microstructure of cemented carbide (tungsten carbide, WC).
**Scope of application** : tungsten carbide powder, cemented carbide.

**ISO 3252:2019** - *Powder metallurgy — Vocabulary*
**Contents** : Define the terms used for tungsten powder and tungsten carbide powder (e.g. sphericity, particle size distribution).
**Scope of application** : tungsten powder, tungsten carbide powder, tungsten compounds.

**ISO/ASTM 52900:2021** - *Additive manufacturing — General principles — Fundamentals and vocabulary*
**Content** : Additive manufacturing terminology, involving the requirements of tungsten powder as a raw material for 3D printing.
**Application** : tungsten powder.
**ISO 17296-3:2014** - *Additive manufacturing — General principles — Part 3: Main characteristics and factors affecting the process*
**Content** : Specifies the sphericity (>0.9) and fluidity (<25 seconds/50g) of tungsten powder.
**Application** : tungsten powder.

**ISO 9276-6:2008** - *Representation of results of particle size analysis — Part 6: Descriptive and quantitative representation of particle shape and morphology*
**Content** : Quantitative analysis method for particle shape and sphericity of tungsten powder.
**Scope of application** : tungsten powder, tungsten carbide powder.

**2. German Institute for Standardization (DIN) Standards**
DIN standards are of great importance in Europe and cover the processing and application of tungsten products:

**DIN 8570:2008** - *General tolerances for welded structures*
**Content** : Welding structure tolerances, applicable to tungsten wire and tungsten electrode in TIG welding.
**Scope of application** : tungsten wire, tungsten electrode.

**DIN ISO 2768:1991** - *General tolerances*
**Content** : Linear dimensional tolerances, applicable to tungsten rods, tungsten pellets, and tungsten boats.
**Scope of application** : tungsten metal products, tungsten alloys.

**DIN 50981:1982** - *Determination of tungsten content in ores*
**Contents** : Method for determination of tungsten content in ores.
**Scope of application** : black tungsten concentrate and scheelite concentrate.

**3. American Society for Testing and Materials (ASTM) Standards**
ASTM standards are widely used in North America and around the world, covering the entire tungsten industry chain:

**ASTM B777-20** - *Standard Specification for Tungsten Base, High-Density Metal*
**Content** : High-density tungsten-based material, W≥90%, density 17-19.3 g/ $cm^3$ .
**Scope of application** : tungsten metal products, tungsten alloys.

**ASTM B760-07(2019)** - *Standard Specification for Tungsten Plate, Sheet, and Foil*
**Contents** : Tungsten plate, tungsten sheet, tungsten foil, purity ≥99.95%.
**Scope of application** : metal tungsten products (such as tungsten boats).

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**ASTM B702-93(2019)** - *Standard Specification for Copper-Tungsten Electrical Contact Material*
**Contents** : Tungsten copper electrical contact material.
**Application** : tungsten copper.

**ASTM B631-93(2016)** - *Standard Specification for Silver-Tungsten Electrical Contact Materials*
**Contents** : Tungsten silver electrical contact material.
**Application** : Tungsten silver.

**ASTM B213-20** - *Standard Test Methods for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel*
**Content** : Tungsten powder fluidity test, target value <25 seconds/50g.
**Application** : tungsten powder.

**ASTM F288-96(2019)** - *Standard Specification for Tungsten Wire for Electron Devices and Lamps*
**Content** : Tungsten wire for electronic devices and lamps, purity ≥99.9%, diameter 0.01-2mm.
**Application** : tungsten wire.

**4. Chinese National Standard (GB)**
Chinese standards are divided into mandatory (GB) and recommended (GB/T), covering the entire tungsten industry chain:

**GB/T 6156-2008** - *Wolframite Concentrate*
**Content** : Wolframite concentrate, $WO_3$ content ≥50%.
**Scope of application** : wolframite concentrate.

**GB/T 6157-2008** - *Scheelite Concentrate*
**Content** : Scheelite concentrate, $WO_3$ content ≥ 55%.
**Scope of application** : scheelite concentrate.

**GB/T 10116-2007** - *Sodium tungstate*
**Content** : Sodium tungstate ($Na_2WO_4$), purity ≥ 98%.
**Scope of application** : sodium tungstate.

**GB/T 26038-2010** - *Tungstic acid*
**Content :** Tungstic acid ($H_2WO_4$) , $WO_3$ content ≥99 %.
**Scope of application** : tungstic acid.

**GB/T 23365-2009** -Ammonium *metatungstate*
**Content** : Ammonium metatungstate (AMT), $WO_3$ content ≥ 88%.
**Scope of application** : ammonium metatungstate.

**GB/T 26037-2010** - *Ammonium paratungstate*
**Content** : Ammonium paratungstate (APT), $WO_3$ content ≥ 88.5%.
**Scope of application** : ammonium paratungstate.

**GB/T 3467-2010** - *Tungsten Trioxide*
**Content** : Yellow tungsten ($WO_3$), $WO_3$ content ≥ 99.9%.
**Scope of application** : yellow tungsten.

**GB/T 4197-2011** - *Tungsten powder and tungsten carbide powder*
**Contents** : Tungsten powder (purity ≥99.8%), tungsten carbide powder (WC ≥99%), particle size 0.1-100 microns.
**Scope of application** : tungsten powder, tungsten carbide powder.

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**GB/T 3458-2006** - *Tungsten powder*
**Content** : Tungsten powder classification and particle size requirements.
**Application** : tungsten powder.

**GB/T 4295-2013** - *Cemented Carbide*
**Contents** : Composition and properties of cemented carbide.
**Scope of application** : cemented carbide.

**GB/T 3649-2008** -Tungsten *Ferro*
**Content** : Ferrotungsten, W content 50-80%.
**Scope of application** : tungsten iron.

**GB/T 3489-2016** - *Tungsten Wire*
**Content** : Tungsten wire, purity ≥99.9%.
**Scope of application** : tungsten wire, tungsten electrode.

**5. Japanese Industrial Standards (JIS)**
JIS has influence in Asia:

**JIS H 1402:2001** - *Tungsten powder and tungsten carbide powder*
**Contents** : Tungsten powder (purity ≥99.8%), tungsten carbide powder.
**Scope of application** : tungsten powder, tungsten carbide powder.

**JIS H 5761:1998** - *Tungsten wires for lighting and electronic equipment*
**Contents** : Tungsten filaments for lamps and electronic equipment.
**Application** : tungsten wire.

**6. Other national standards**
**Russia GOST 213-83** - *Tungsten concentrate*
**Content** : Tungsten concentrate, $WO_3$ content ≥ 60%.
**Scope of application** : black tungsten concentrate and scheelite concentrate.

**MIL-T-13827** (U.S. Military Standard) - *Tungsten Powder*
**Content** : Military tungsten powder, purity ≥99.9%, particle size 10-50 microns.
**Application** : tungsten powder.

**7. Tungsten compounds and chemicals standards (including blue tungsten, yellow tungsten and purple tungsten)**

**Blue Tungsten Oxide ($W_{20}O_{58}$)**
There is no independent international standard. Refer to CTIA data (www.ctia.com.cn): $WO_3$ content ≥ 99.5%, blue-purple color, particle size 1-20 microns, used for tungsten powder preparation.
**Yellow Tungsten Oxide, $WO_3$**
GB/T 3467-2010, $WO_3$ content ≥99.9%, yellow powder.
**Violet Tungsten Oxide ($W_{18}O_{49}$)**
There is no independent international standard, refer to CTIA data ( www.ctia.com.cn ): $WO_3$ content ≥99.5% , purple powder, oxidation state +3.7 , particle size 1-10 microns, used for the production of high-purity tungsten powder.

**8. Tungsten Metal Products and Alloy Standards**

**Tungsten Pellets**
ASTM B777-20, density 17-19.3 g/ $cm^3$ .

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**Tungsten Needles, Tungsten Boats**
ASTM B760-07(2019), purity ≥99.95%.

**Tungsten Copper**
ASTM B702-93(2019), such as W85Cu15.

**Tungsten Silver**
ASTM B631-93(2016), such as W70Ag30.

**Tungsten Gold (Tungsten-based gold-plated products)**
No independent standard, refer to ASTM B777.

**Tungsten Alloys**
ASTM B777-20, GB/T 4295-2013, such as W-Ni-Fe.

**Comparison between Chinese Standard (GB) and ISO and DIN**

**Comparison between Chinese standards and SO**

| category | Chinese Standard (GB) | ISO Standards | Comparative Analysis |
|---|---|---|---|
| **Mineral Raw Materials** | GB/T 6156, GB/T 6157 | No direct standard | GB specifies the $WO_3$ content , but ISO lacks mineral standards. |
| **Compound** | GB/T 10116 (sodium tungstate), GB/T 3467 (yellow tungsten) | No direct compound standards | GB has a wide coverage, while ISO does not involve tungsten chemicals. |
| **Tungsten powder** | GB/T 4197, GB/T 3458 | ISO 3252 (terminology), ISO 9276-6 (particle shape) | GB is more detailed (particle size 0.1-100 microns), ISO is more theoretical. |
| **Additive Manufacturing** | No special standard, refer to GB/T 4197 | ISO/ASTM 52900, ISO 17296-3 | ISO is more advanced, GB needs to improve 3D printing standards. |
| **Cemented Carbide** | GB/T 4295 | ISO 4499-2 | GB is more comprehensive, while ISO only shows microstructure. |

**Comparison between Chinese Standard (GB) and DIN**

| category | Chinese Standard (GB) | DIN Standards | Comparative Analysis |
|---|---|---|---|
| **Mineral Raw Materials** | GB/T 6156, GB/T 6157 | DIN 50981 | GB is more detailed, while DIN only has detection methods. |
| **Tungsten wire/electrode** | GB/T 3489 | DIN 8570 | GB is for performance, DIN is for welding application. |
| **Processed products** | GB/T 4295 (hard alloy) | DIN ISO 2768 | DIN systematizes tolerances, GB focuses on material properties. |
| **Compound** | GB/T 23365 (AMT), CTIA violet tungsten specification | No direct standard | GB and CTIA are more comprehensive, while DIN relies on ISO. |

**International Collection**
ISO, ASTM, DIN, GB, JIS and other standards cover the entire tungsten industry chain. ASTM and GB are the most comprehensive, ISO is more additive manufacturing, and DIN is stronger in processing. When there

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is no independent standard for purple tungsten, CTIA provides supplementary standards (such as $WO_3$ ≥99.5%, purple).

**Chinese Standards**

GB has a wide coverage, but it needs to learn from ISO and DIN in the field of 3D printing and processing tolerances.

**Data Source**

Standard text, CTIA official website ( www.ctia.com.cn ), and corporate specifications.

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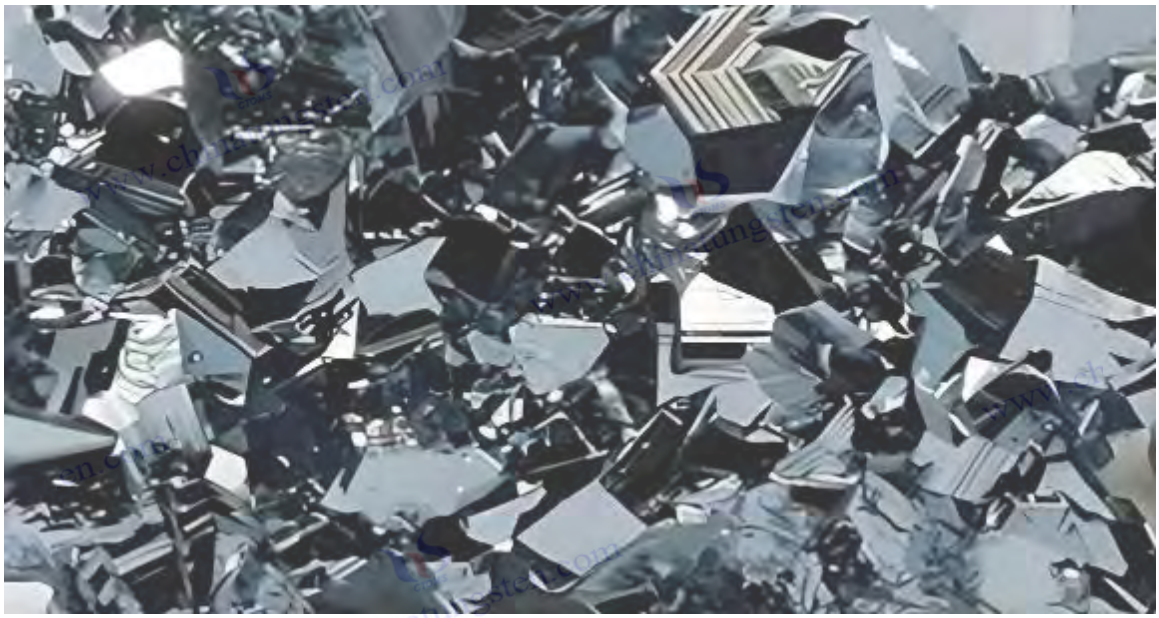

**Toxicity, safety and environmental protection of tungsten**

Tungsten (W), as a rare metal with a high melting point (3422°C) and high density (19.25 g/cm³ ) , has an irreplaceable position in the fields of industry, military and high-tech. However, tungsten and its compounds may have potential impacts on human health and the ecological environment during mining, processing and use. This article systematically analyzes the toxicity characteristics of tungsten (including pure tungsten, compounds and alloys), safety protection measures and environmental protection requirements, and brings together the latest toxicological research in Europe and the United States, China's development and environmental protection practices, as well as global regulations and cases, aiming to provide a comprehensive reference for tungsten-related research and industry.

**1. Toxicity of Tungsten**

**1. Toxicity of pure tungsten**

**Toxicity level**
Pure tungsten metal is considered a low-toxic substance. The 2022 report of the National Toxicology Program (NTP) of the United States confirmed that the acute oral toxicity LD50>5000 mg/kg (rat), and the skin and eye irritation tests were negative. The International Agency for Research on Cancer (IARC) did not list it as a carcinogen, and occupational exposure studies did not find significant chronic effects.

**Exposure routes**
**Inhalation**
Tungsten dust (particle size <10 μm) may cause mild upper respiratory tract irritation, but lung deposition is low (<10%) and there is no evidence of fibrosis (NIOSH, 2010).
**Ingestion**
The solubility of tungsten in the gastrointestinal tract is less than 1%, and it is mainly excreted in its original form.
**Skin contact**
Non-allergenic or corrosive.
**metabolism**
Human studies (ATSDR, 2005) showed that tungsten is excreted in urine with a half-life of approximately 5

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hours and does not significantly bioaccumulate.

**2. Toxicity of tungsten compounds**

**Tungsten powder (W Powder):**
**toxicity**
Inhalation of ultrafine particles (<1 micron) may cause alveolar inflammation, but there is no evidence of chronic toxicity. A 2024 study in Environmental Health Perspectives showed that IL-6 levels in the lung tissue of rats exposed to a concentration of 10 mg/m³ ( 28 days) increased by 20%.
**risk**
The smaller the particle size, the higher the lung deposition rate (PM2.5 deposition rate can reach 50%).

**Tungsten Carbide (WC)**
**toxicity**
WC alone has low toxicity (LD50>2000 mg/kg), but it is often combined with cobalt (Co). In 2023, "Toxicology Letters" reported that WC-Co mixed dust (Co content 5%) induced pulmonary fibrosis in mice, with a lesion rate of 60%.
**mechanism**
Cobalt dissolution release induces oxidative stress, and WC acts as a carrier to enhance toxicity.

**Tungstate (such as sodium tungstate $Na_2WO_4$ , ammonium metatungstate AMT)**
**Acute toxicity**
Sodium tungstate LD50=1450 mg/kg (rat), moderately toxic; AMT LD50≈2000 mg/kg.
**Chronic toxicity**
A 2022 study published in the Journal of Applied Toxicology showed that after mice drank $Na_2WO_4$-containing water (100 mg/L, 90 days) for a long time , the rate of renal tubular necrosis increased by 15% and sperm motility decreased by 10%.
**Water Solubility**
Tungstate ($WO_4^{2-}$) has a solubility of up to 57 g/L at pH 7 and can easily enter water bodies and the food chain.

**Tungsten trioxide ( $WO_3$ , yellow tungsten )**
**toxicity**
LD50>2000 mg/kg, inhalation of dust (5 mg/m³ , 90 days) only causes mild pulmonary edema (Inhalation Toxicology, 2021).

**Blue tungsten ( $W_{20}O_{58}$ ) , purple tungsten ( $W_{18}O_{49}$ )**
**toxicity**
The data is limited. CTIA data states that $WO_3$ content ≥ 99.5% is considered to be of low toxicity, but nanoparticles may increase cytotoxicity (Nanotoxicology, 2023).

**Tungsten alloys (such as W-Ni-Fe, W-Ni-Co)**
**toxicity**
A 2024 study in Environmental Research showed that after mice were exposed to W-Ni-Co alloy dust (Ni 5%, Co 2%) (10 mg/m³ , 180 days), the rate of pre-lung cancer lesions reached 30%, which was attributed to the carcinogenicity of Ni and Co (IARC Class 1 and 2B).
**mechanism**
Tungsten enhances the dissolution of heavy metals and induces the generation of ROS (reactive oxygen species).

**3. Progress of toxicity research in Europe and the United States**

**USA**

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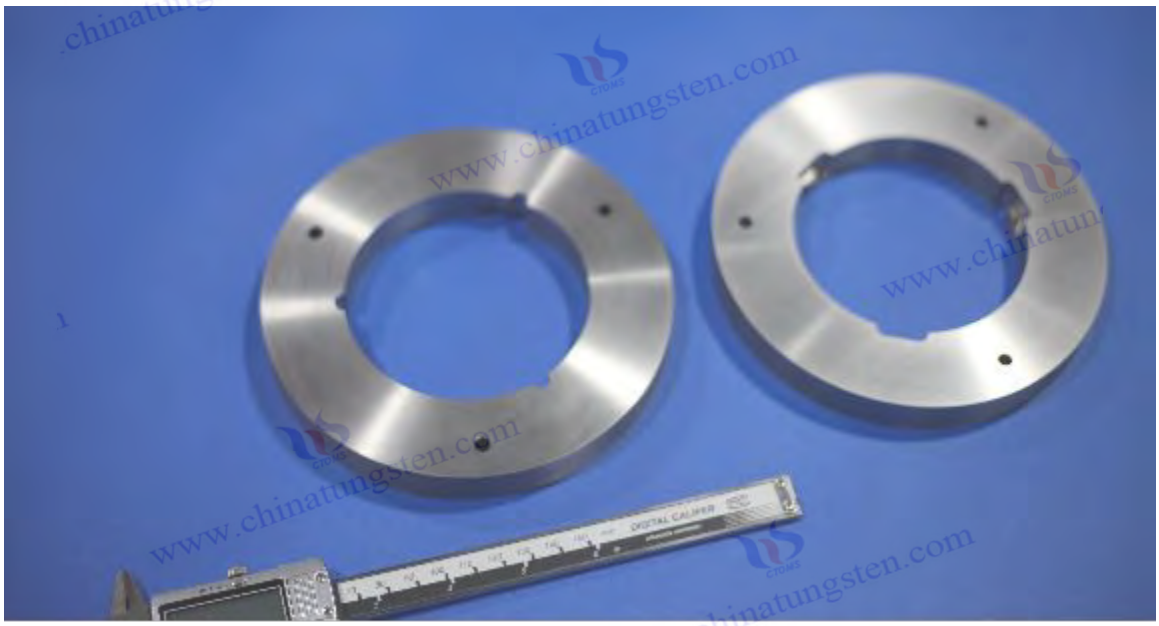
**NTP (2022)**
exposure to tungsten dust (15 mg/m³ , 14 days), the serum tungsten concentration of rats increased to 0.02 mg/L and liver enzyme (AST) increased by 15%, indicating potential hepatotoxicity.
**EPA (2023)**
Tungsten is converted into an insoluble form in acidic soils (pH < 6), but its solubility increases 10 times in alkaline environments (pH > 8), increasing the risk of groundwater contamination.

**Military Research (2024)**
Tungsten alloy ammunition residues (W-Ni-Fe) release Ni (0.5-1 mg/L) into the soil, and the tumor incidence rate in mice is as high as 80% (Toxicological Sciences).

**Europe**
**ECHA (2023)**
After sodium tungstate exposure (50 mg/kg/day, 90 days), the kidney weight of mice increased by 10% and urine protein increased by 30%, indicating renal toxicity.
**Ecological Effects (2022, Germany**
When soil tungsten concentration is >1000 mg/kg, earthworm survival rate decreases by 40% and plant root DNA damage increases by 25% (Ecotoxicology).
**Occupational exposure (2024, Sweden)**
Tungsten processing workers (exposed to 5 mg/m³ for 15 years) experienced a 10% decrease in lung function, but no association with cancer (Occupational & Environmental Medicine).

**4. Toxicity controversy and data gaps**

**Carcinogenicity**
IARC has not classified tungsten, but the carcinogenic risk of W-Ni-Co alloys has attracted much attention.
**Nanotoxicity**
Nanotungsten particles (<100 nm) may penetrate cell membranes, but toxicity studies are insufficient (Nanotechnology Reviews, 2023).
**Low dose effect**
long-term low-level exposure (<1 mg/m³ ) remain inconclusive.



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## 2. Safety protection measures

### 1. Global safety standards

**USA**
**OSHA (2023)**
The PEL for insoluble tungsten compounds is 5 mg/m³ , the PEL for soluble compounds is 1 mg/ m³ , and the new PM2.5 limit is 2.5 mg/ m³ .
NIOSH (2024)
The REL has been reduced to 3 mg/ m³ and the STEL remains at 10 mg/ m³ . It is recommended to monitor air concentrations weekly.

**European Union**
**OEL (2022, Directive 2019/983)**
The insoluble tungsten is 5 mg/ m³ and the soluble tungsten is 1 mg/ m³ . It is planned to be reduced to 3 mg/ m³ and 0.5 mg/ m³ by 2025 .
COSHH (UK, 2023)
Tungsten powder WEL (Workplace Exposure Limit) = 5 mg/m³ , emphasizing ultrafine particle control.

**China**
**GBZ 2.1-2019**
The limit for tungsten and its compounds is 5 mg/ m³ , and the PC-TWA (time-weighted average permissible concentration) is consistent with OSHA.

### 2. Protective measures

**Personal protection**
**breathe**
NIOSH N100 or EU EN149 FFP3 mask (filtration efficiency >99%), positive pressure respirator for high concentration scenarios.
**Skin/Eyes**
Nitrile gloves (thickness > 0.4 mm), chemical protective clothing, dust goggles.
**Engineering Controls**
**ventilation**
Local exhaust system (wind speed>0.5 m/s), HEPA filter (capture rate>99.97%).
**equipment**
Closed grinding machine, wet dust collector (dust removal rate>95%).

**Emergency treatment**
**Inhalation**
Move to a ventilated place, provide oxygen support, and monitor lung function in severe cases.
**touch**
The patients were rinsed with water for 15 minutes, and renal function was tested after exposure to tungstate.

### 3. Case Analysis

**Tungsten Processing Plant in the United States (2023)**
A factory in Pennsylvania was fined $100,000 by OSHA for exceeding the dust limit (8 mg/ m³ ). After that, a dust collection system was installed and the concentration was reduced to 2 mg/ m³ .

**Welding accidents in Europe (2022)**
A German welder inhaled tungsten electrode dust because he did not use a fume hood. A lung CT scan showed mild inflammation and he strengthened protective measures after recovery.

### 3. Environmental Protection

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**1. European and American environmental regulations and research**

**USA**

**EPA (2023)**

Soil Screening Limit (RSL): 930 mg/kg for industrial use and 63 mg/kg for residential use. There is no federal limit for groundwater, but California recommends 0.05 mg/L.

**CERCLA (2024)**

Tungsten is not listed as a priority pollutant, but tungsten mine tailings that contain arsenic (As) must be cleaned up under superfund.

**Research (2024, MIT)**

In the tungsten tailings plant remediation test, the sunflower absorption rate was 0.02 mg/g and the remediation cost was about $50/ton.

**European Union**

**IED (revised in 2023)**

Dust emission is <3 mg/ $m^3$ , tungsten limit in wastewater is 0.5 mg/L, and mine waste requires zero leakage design.

**REACH (2023)**

Registration of tungsten compounds requires companies with an annual production of >1,000 tons to submit ecotoxicity data.

**Research ( 2023, Netherlands)**

In soils with tungsten concentrations >500 mg/kg, bacterial abundance decreased by 30%, and fixation with biochar was recommended (adsorption rate >80%).

**2. Tungsten development and environmental protection in China**

**Policies and Regulations**

**"Standardized Conditions for Tungsten Industry" (revised in 2023)**

Mine recovery rate>90%, tailings utilization rate>85%, wastewater recycling rate>95%, dust emission<5 mg/ $m^3$ .

**Regulations on the Administration of Rare Metals (Draft) (2024)**

The total amount of tungsten mining is controlled at 100,000 tons/year ($WO_3$ ) , the export tax rate is 25%, and violators will be fined 5-10 million yuan.

**Measures for the Administration of Pollutant Discharge Permits (2022)**

Tungsten smelting enterprises need to apply for a pollution discharge permit, and the tungsten concentration in wastewater must be less than 1 mg/L.

**Practical Cases**

**Jiangxi Dayu (2024)**

The abandoned tungsten mine restoration project, with an investment of 1.5 billion yuan, planted alfalfa + applied lime, and the soil tungsten concentration was reduced to 30 mg/kg, with a compliance rate of 90%.

**Zhuzhou, Hunan (2023)**

Zhuzhou Cemented Carbide Plant adopts a closed-loop circulation process, with a wastewater tungsten recovery rate of 98% and an annual emission reduction of 200 tons.

**Chongzuo, Guangxi (2022)**

In the tailings pond leakage incident, the tungsten concentration exceeded the standard by 10 times (10 mg/L), resulting in a fine of 3 million yuan and repair costs of 120 million yuan.

**Research progress**

**Chinese Academy of Sciences (2024)**

Bioleaching technology recovers tungsten from tungsten slag (efficiency 85%) and removes As (90%) at the same time, with a cost of about RMB 800/ton.

**Tsinghua University (2023)**

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The new technology for treating tungstate wastewater (membrane separation + electrocoagulation) has a removal rate of >99% and has been put into industrial pilot.

**2. Comparison of global regulations**

| Area | Dust emission (mg/m³) | Tungsten limit in wastewater (mg/l) | Soil limit (mg/kg) | Recycling requirements |
|---|---|---|---|---|
| Usa | 5 | 0.05-7.3 (state differences) | 930 (industry) | No mandatory |
| European union | 3 | 0.5 | 500 (recommended) | >80% |
| China | 5 | 1 | 150 (agricultural land) | >85% |

**4. Environmental impact cases**

**Nevada, USA (2023)**
The tungsten concentration in the soil of the tungsten mining area reached 2000 mg/kg, and the groundwater pollution range expanded to 5 kilometers. The restoration budget was $2 billion.
Panasqueira Mine, Portugal (2022)
The tailings leakage caused a 50% mortality rate of aquatic life in the river and a peak tungsten concentration of 15 mg/L.

**4. Future Research Directions**

**toxicity**
Cytotoxicity and genotoxicity of nanotungsten.
Metabolomics study of low-dose chronic exposure (<1 mg/m³ ) .
**Safety**
Develop low-cost, highly effective dust prevention technologies (such as electrostatic adsorption).
Establish synergistic toxicity limits of Ni and Co in tungsten alloys.
**Environmental friendly**
The migration and transformation mechanism of tungsten in the ecosystem.
High-value utilization technology of low-grade tailings.

**V. Conclusion**

**toxicity**
Pure tungsten has low toxicity, while the toxicity of its compounds and alloys varies significantly due to their chemical forms and synergistic effects. European and American research focuses on lung, kidney and ecological risks.
**Safety**
Global standards are becoming stricter (limit value 3-5 mg/m³ ) , and protection must start with dust control.
**Environmental friendly**
China emphasizes resource protection and pollution control, Europe and the United States focus on soil and water restoration, and green technology is the future trend.

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**Appendix**

**Tungsten related unit conversion table**

**Tungsten related mass unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| kilogram | kg | 1 kg = 1000 g |
| gram | g | 1 g = 0.001 kg = 1000 mg |
| mg | mg | 1 mg = 0.001 g |
| pound | lb | 1 lb = 0.453592 kg |
| ounce | oz | 1 oz = 0.0283495 kg |

**Tungsten-related density unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| g/cm3 | g/ $cm^3$ | 1 g/$cm^3$ = 1000 kg/ $m^3$ |
| kg/m3 | kg/ $m^3$ | 1 kg/ $m^3$ = 0.001 g/ $cm^3$ |
| Pounds/cubic inch | lb/ $in^3$ | 1 lb/$in^3$ = 27.6799 g/ $cm^3$ |
| | | |

**Tungsten related particle size unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| Micrometer | μ m | 1 μm = 0.001 mm = 1000 nm |
| Millimeters | mm | 1 mm = 1000 μm |
| inch | in | 1 in = 25.4 mm = 25400 μm |

**Tungsten-related temperature unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| Celsius | °C | °C = (°F - 32) × 5/9 |

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| | | |
|---|---|---|
| Fahrenheit | °F | °F = (°C × 9/5) + 32 |
| Kelvin | K | K = °C + 273.15 |

**Tungsten-related pressure unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| Pascal | Pa | 1 Pa = 0.00001 bar |
| -bar | bar | 1 bar = 100000 Pa = 0.986923 atm |
| Atmospheric pressure | atm | 1 atm = 101325 Pa |
| MPa | MPa | 1 MPa = 1000000 Pa = 10 bar |

**Tungsten-related liquidity unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| sec/50g | s/50g | Hall flow rate standard unit, no conversion required |
| | | |

**Tungsten related length unit conversion**

| unit | symbol | Conversion relationship |
|---|---|---|
| Millimeters | mm | 1 mm = 0.0393701 in |
| inch | in | 1 in = 25.4 mm |
| Micrometer | μ m | 1 μm = 0.001 mm |

**Tungsten product hardness unit conversion table**

| HB | HRB | HRC | HRA | HV | HK | Comparison of application scope |
|---|---|---|---|---|---|---|
| 200 | 95 | 14 | 65 | 210 | 225 | HB: <650, suitable for low hardness tungsten alloys (such as pure tungsten annealed state), not suitable for tungsten carbide. |
| 300 | - | 31 | 71 | 318 | 340 | HRB: 20-100, suitable for softer tungsten alloys (such as annealed pure tungsten), ineffective when the hardness is too high. |
| 400 | - | 42 | 76 | 429 | 460 | HRC: 20-70, suitable for high hardness tungsten steel, not applicable to super hard tungsten carbide (>HRC 70). |
| 500 | - | 50 | 81 | 540 | 580 | HRA: 20-88, medium to high hardness tungsten products , tungsten steel HRA 70-85, cemented carbide HRA 80-90) |
| 600 | - | 57 | 84 | 655 | 700 | HV: 50-3000, covering the full hardness range of tungsten products (such as pure tungsten HV 300, tungsten carbide HV 1800). |
| - | - | 65 | 87 | 900 | 960 | HK: 50-2000, suitable for brittle tungsten products (such as WC ceramic composites). |
| - | - | 70 | 88 | 1200 | 1280 | Note: HB > 650, HRB > 100, HRC > 70 are not applicable to tungsten products.<br>HRA 88 is the upper limit, and super-hard tungsten carbide requires HV or HK.<br>MADE BY: CTIA GROUP |
| - | - | - | - | 1500 | 1600 | |
| - | - | - | - | 1800 | 1920 | |

**Appendix:**
**Expression and conversion relationship of hardness of tungsten products**

The hardness of tungsten products is a key indicator of their ability to resist external forces (such as indentation, scratches or wear). Due to their high hardness (from HV 300 for pure tungsten to HV 1800 for tungsten carbide), high melting point and excellent wear resistance, they are widely used in cemented carbide, tungsten steel products and high-performance materials. The expression of the hardness of tungsten products varies depending on the test method. Commonly used methods include Brinell hardness (HB), Rockwell

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hardness (HRC, HRB, HRA), Vickers hardness (HV) and Knoop hardness (HK). Each method has its specific test principle, scope of application and expression method. Due to the large hardness span of tungsten products, the conversion between hardness values depends on empirical comparison tables (such as ASTM E140, ISO 18265) rather than simple formulas. The following details the expression of the hardness of tungsten products and their conversion relationship.

**1. Expression method of hardness of tungsten products**

1. Brinell Hardness (HB)

Expression: Indicated by "HB", the unit is kgf/mm² ( now mostly MPa), and the test conditions are often marked, such as "HB 10/3000" (10mm diameter indenter, 3000kgf load).
Test principle: Use a carbide ball (usually a tungsten carbide ball, because tungsten products have high hardness) to press into the surface of the tungsten product under a specified load, measure the indentation diameter and calculate the hardness.
formula: $HB = \frac{2F}{\pi D(D - \sqrt{D^2 - d^2})}$
Where: FFF is the load (kgf), DDD is the indenter diameter (mm), and ddd is the indentation diameter (mm).
Scope of application: Suitable for softer tungsten products, such as pure tungsten or low-hardness tungsten alloys (hardness <650 HB). Since most tungsten products are made of high-hardness materials, the application of HB is limited.
Example: Annealed pure tungsten HB is about 200-300.

**2. Rockwell Hardness (HR)**

Expression: "HR" plus scale, such as "HRC" (C scale), "HRB" (B scale), "HRA" (A scale), without unit.
Test principle: Use a diamond cone or steel ball indenter to apply an initial load of 10kgf, then apply the main load, measure the indentation depth difference and calculate the hardness.
Scale and applicability:
HRC: Diamond indenter, total load 150kgf, suitable for high hardness tungsten steel.
HRB: 1/16 inch steel ball, total load 100kgf, suitable for softer tungsten alloy.
HRA: Diamond indenter, total load 60kgf, suitable for thin hard tungsten products.
formula:
HRC/HRA = 100 - h/0.002h / 0.002h/0.002 (hhh is the depth difference, mm).
HRB = 130 - h/0.002h / 0.002h/0.002.
Scope of application: HRC and HRA are widely used in tungsten steel and cemented carbide, while HRB is limited to low-hardness tungsten products. HRA is particularly suitable for thin parts or surface hardened layers due to its light load.
Examples: Tungsten carbide based cemented carbide HRA 80-90, tungsten steel HRC 50-60, pure tungsten annealed HRB 60-95.

**3. Vickers Hardness (HV)**

Expression: Indicated by "HV", the unit is kgf/mm² or MPa, often marked with load, such as "HV 1" (1kgf load).
Test principle: Use a 136° diamond quadrangular pyramid indenter to press into the tungsten product, measure the diagonal length of the indentation and calculate the hardness.
formula: $HV = \frac{1.8544F}{d^2}$
Where: FFF is the load (kgf), ddd is the average diagonal length of the indentation (mm).
Scope of application: Covers the entire hardness range of tungsten products and is the most commonly used method.
Examples: Sintered tungsten carbide (WC-Co) HV 1500-1800, pure tungsten HV 350.

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**4. Knoop Hardness (HK)**

Expression: Indicated by "HK", the unit is kgf/mm² , and the load is often marked, such as "HK 0.5".
Test principle: Use a diamond pyramid indenter with a major-minor axis ratio of 7:1 to press into the tungsten product and measure the major axis length of the indentation.

formula: $HK = \frac{14.229F}{L^2}$

Where: FFF is the load (kgf), LLL is the major axis length of the indentation (mm).
Scope of application: Suitable for testing brittle phase or surface coating in tungsten products.
Example: Tungsten carbide coating HK 1600-2000.

**2. Conversion relationship of hardness of tungsten products**

Due to different testing principles, there is no strict mathematical conversion between the hardness values of tungsten products. It is necessary to rely on empirical comparison tables or standards (such as ASTM E140, ISO 18265). The following provides a conversion relationship for the hardness range of tungsten products (pure tungsten, tungsten steel, tungsten carbide), and adds a comparison of the applicable range.

**1. Tungsten product hardness conversion table (including comparison of applicable scope)**

| HB | HRB | HRC | HRA | HV | HK | Comparison of application scope |
|---|---|---|---|---|---|---|
| 200 | 95 | 14 | 65 | 210 | 225 | HB: <650, suitable for low hardness tungsten alloys (such as pure tungsten annealed state), not suitable for tungsten carbide. |
| 300 | - | 31 | 71 | 318 | 340 | HRB: 20-100, suitable for softer tungsten alloys (such as annealed pure tungsten), ineffective when the hardness is too high. |
| 400 | - | 42 | 76 | 429 | 460 | HRC: 20-70, suitable for high hardness tungsten steel, but not for super hard tungsten carbide (>HRC 70). |
| 500 | - | 50 | 81 | 540 | 580 | HRA: 20-88, suitable for medium and high hardness tungsten products (such as tungsten steel HRA 70-85, cemented carbide HRA 80-90). |
| 600 | - | 57 | 84 | 655 | 700 | HV: 50-3000, covering the full hardness range of tungsten products (such as pure tungsten HV 300, tungsten carbide HV 1800). |
| - | - | 65 | 87 | 900 | 960 | HK: 50-2000, suitable for brittle tungsten products (such as WC ceramic composites). |
| - | - | 70 | 88 | 1200 | 1280 | |
| - | - | - | - | 1500 | 1600 | |
| - | - | - | - | 1800 | 1920 | |

Note:
HB > 650, HRB > 100, HRC > 70 are not applicable to tungsten products.
HRA 88 is the upper limit, and super-hard tungsten carbide requires HV or HK.

**2. Characteristics of conversion relationship**

HB and HV: Low hardness tungsten alloys (such as pure tungsten) are close to linear, HV ≈ 1.05-1.1 × HB; high hardness (such as tungsten carbide) has no HB data.
HRC and HV: nonlinear, HV 540 ≈ HRC 50, HV 1200 ≈ HRC 70, HRC failure in the super-hard range.
HRA and HRC: HRA value is higher than HRC, such as HRA 80 ≈ HRC 59, HRA 88 ≈ HRC 70.
HRA and HV: HRA 70 ≈ HV 400, HRA 88 ≈ HV 1500, non-linear relationship.
HK and HV: HK is slightly higher than HV, HK ≈ 1.05-1.1 × HV, suitable for brittle tungsten products.

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**3. Approximate conversion formula (applicable to tungsten steel)**

HB → HV:

$$HV \approx 1.05 \times HB \quad (HB < 400)$$

HRC → HV:

$$HV = 100 + 10 \times (HRC - 10) \quad (HRC < 10)$$

$$HV \approx 150 + 15 \times (HRC - 10) \quad (HRC > 10)$$

HRA → HV:

$$HV = 10 \times (HRA - 30) \quad (HRA < 80)$$

$$HV = 50 \times (HRA - 80) + 675 \quad (HRA > 80)$$

High hardness range (tungsten carbide): HV 900-1800, need to look up the table, no simple formula.

**4. Notes**

Material properties: The hardness of tungsten products varies depending on the composition (such as pure tungsten, tungsten steel, WC-Co) and process (such as sintering, heat treatment), and the conversion needs to be adjusted for the specific type.

Test limitation: High hardness tungsten products (such as tungsten carbide HV > 1000) are not suitable for HB, HRB or HRC, and HV, HRA or HK are preferred.

Standard reference: ASTM E140 (metal hardness conversion) and ISO 18265 (hard alloy conversion) provide authoritative data.

Expression method: The hardness of tungsten products is usually expressed by Vickers (HV), Rockwell (HRC, HRA), and Knoop (HK). HV covers the entire hardness range (pure tungsten HV 300-400, tungsten carbide HV 1200-1800), and is the preferred method; HRA (20-88) is suitable for thin hard tungsten products; HRC (20-70) is used for tungsten steel; HB (<650) and HRB (20-100) are limited to low hardness tungsten alloys.

Conversion relationship: The hardness conversion of tungsten products depends on the comparison table. HRA overlaps with HRC and HV in the high hardness range, HB and HRB are only applicable to low hardness, HK is close to HV but higher. The superhard range (such as tungsten carbide) is mainly HV or HK.

Applicability: HV has the widest applicability, HRA is suitable for rapid detection of thin hard tungsten products, HRC is used for tungsten steel tools, HK is for brittle materials, HB and HRB are limited to soft tungsten products.

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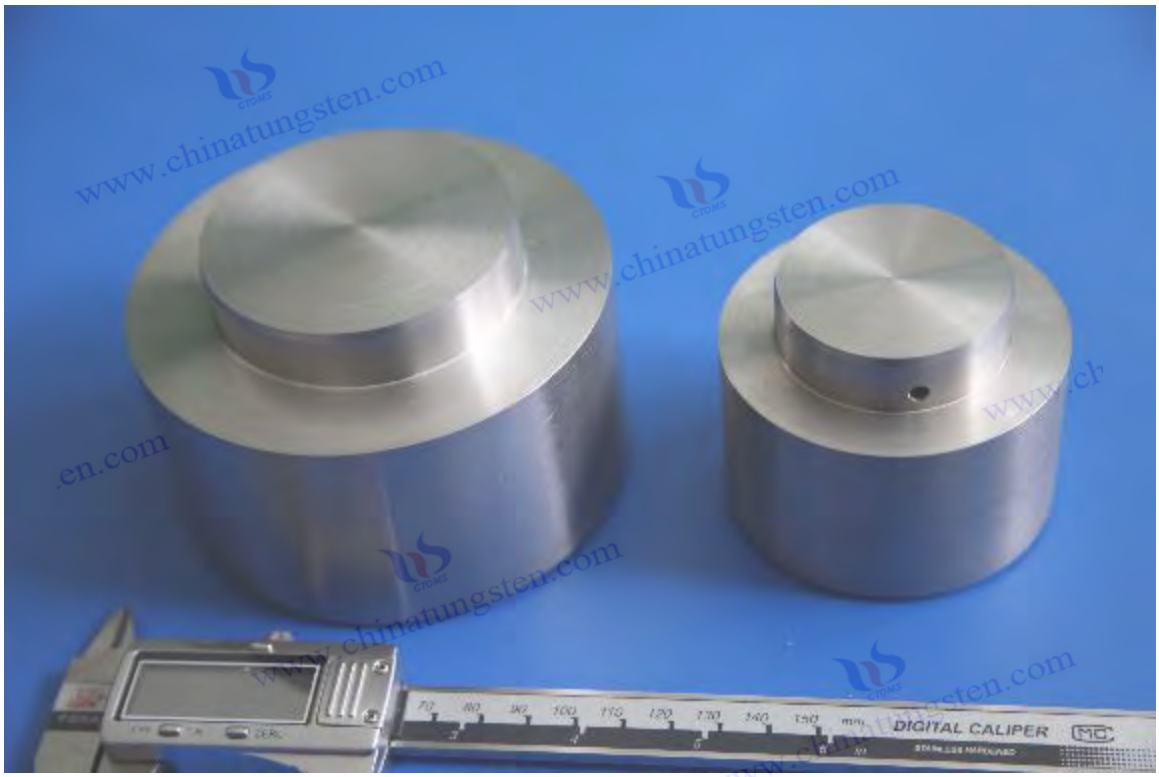


**Multilingual Glossary of Terms for Tungsten and Related Products**

Basic terminology of tungsten, mineral raw materials, compounds, powder products, and some metal products and alloys. The terminology is based on international standards (such as ISO 3252, ASTM B777, GB/T 4197) and information from CTIA GROUP LTD (CTIA ) ( www.ctia.com.cn), and the product names are expanded to cover various forms and applications of the tungsten industry chain.

| Chinese | English | French | German | Japanese |
|---|---|---|---|---|
| Tungsten | Tungsten | Tungstène | Wolfram | Tangusten |
| Tungsten | Tungsten Element | I 'm tired of it | Wolfram-Element | Tangusten element |
| Tungsten Atom | Tungsten Atom | Atome de tungstène | Wolfram-Atom | Tangusten Atom |
| Tungsten Isotopes | Tungsten Isotope | Isotope de tungstène | Wolfram-Isotop | Tangusten isotope |
| Wolframite Concentrate | Wolframite Concentrate | Wolframite Concentrate | Wolframit-Konzentrat | 黑タングステン Concentrate |
| Scheelite Concentrate | Scheelite Concentrate | Concentré de scheelite | Scheelit-Konzentrat | White タングステン concentrate |
| Tungsten Ore | Tungsten Ore | Tungsten Mineral | Wolfram-Erz | Tangusten Mineral |
| High-grade | High-Grade | Concentration | Hochgradiges Wolframit- | High-grade |

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| | | | | | |
|---|---|---|---|---|---|
| wolframite concentrate | Wolframite Concentrate | wolframite haute qualité | of | Konzentrat | black cathode concentrate |
| Low-grade wolframite concentrate | Low-Grade Wolframite Concentrate | Concentration of wolframite basse quality | of | Niedriggradiges Wolframit-Konzentrat | Low grade black sulfate concentrate |
| High-grade scheelite concentrate | High-Grade Scheelite Concentrate | Concentration of scheelite and quality | | Hochgradiges Scheelit-Konzentrat | High-grade white タングステン concentrate |
| Low-grade scheelite concentrate | Low-Grade Scheelite Concentrate | Concentration of Scheelite of Basse Qualité | | Niedriggradiges Scheelit-Konzentrat | Low-grade white terpene concentrate |
| Tungsten Oxide | Tungsten Sand | Sable de tungstène | of | Wolfram-Sand | Tangusten sand |
| Tungsten ore powder | Tungsten Ore Powder | Poudre de minerai de tungstène | | Wolfram-Erzpulver | Tangusten Mineral Powder |
| Coarse tungsten ore powder | Coarse Tungsten Ore Powder | Poudre grossière de minerai de tungstène | | Grobes Wolfram-Erzpulver | Crude Tangusten Mineral Powder |
| Fine tungsten ore powder | Fine Tungsten Ore Powder | Poudre fine de minerai de tungstène | | Feines Wolfram-Erzpulver | Fine tannin mineral powder |
| Sodium Tungstate | Sodium Tungstate | Tungstate de sodium | | Natrium wolframat | タングステンナトリウム |
| Tungstic acid | Tungstic Acid | Acide tungstique | | Wolframsäure | Tangustenic acid |
| Ammonium Metatungstate | Ammonium Metatungstate | Metatungstate d'ammonium | | Ammoniummetawolframat | メタタングステンアンモニウム |
| Ammonium paratungstate | Ammonium Paratungstate | Paratungstate d'ammonium | | Ammoniumparawolframat | パラタングステンアンモニウム |
| Blue Tungsten | Blue Tungsten Oxide | Oxyde tungstène bleu | of | Blaues Wolframoxid | Aoconic acid compound |
| Yellow Tungsten | Yellow Tungsten Oxide | Oxyde tungsten jaune | of | Gelbes Wolframoxid | Yellow sulfate acid compound |
| Purple Tungsten | Violet Tungsten Oxide | Oxyde tungstène violet | of | Violettes Wolframoxid | Purple polysaccharide |
| Tungsten Trioxide | Tungsten Trioxide | Trioxygen tungstène | of | Wolframtrioxid | Triacidification Tangusten |
| Calcium Tungstate | Calcium Tungstate | Tungstate de calcium | | Calcium wolframat | タングステン acid カルシウム |
| Magnesium | Magnesium | Tungstate | of | Magnesium wolframat | タングステン |

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| | | | | |
|---|---|---|---|---|
| Tungstate | Tungstate | magnésium | | マグネシウム |
| Potassium Tungstate | Potassium Tungstate | Tungstate de potassium | Kalium wolframat | タングステン acid カリウム |
| Lithium Tungstate | Lithium Tungstate | Tungstate de lithium | Lithium wolframat | タングステン acid リチウム |
| Zinc Tungstate | Zinc Tungstate | Tungstate de zinc | Zinkwolframat | Sub-lead tannate |
| Iron Tungstate | Iron Tungstate | Tungstate de fer | Eisenwolfframat | Iron tannate |
| Cobalt Tungstate | Cobalt Tungsten | Tungstate de cobalt | Kobaltwolframat | タングステン acid コバルト |
| Cerium Tungstate | Cerium Tungstate | Tungstate de cerium | Cerwolframat | タングステン acid セリウム |
| High purity blue tungsten | High-Purity Blue Tungsten Oxide | Oxyde de tungsten bleu haute pureté | Hochreines Blaues Wolframoxid | High-purity Aoconic acid compound |
| High purity yellow tungsten | High-Purity Yellow Tungsten Oxide | Oxyde de tungsten jaune haute pureté | Hochreines Gelbes Wolframoxid | High-purity yellow polysaccharide |
| High purity violet tungsten | High-Purity Violet Tungsten Oxide | Oxyde de tungsten violet haute pureté | Hochreines Violettes Wolframoxid | High Purity Purple Acidic Acid |
| Tungstate | Tungstate | Tungstate | Wolframat | Tangustenic acid |
| Tungsten powder | Tungsten Powder | Poudre de tungstène | Wolframpulver | タングステン パウダー |
| Tungsten Carbide Powder | Tungsten Carbide Powder | Poudre de carbure de tungstène | Wolframcarbidpulver | Carbonized carbon dioxide |
| Spherical tungsten powder | Spherical Tungsten Powder | Poudre sphérique de tungsten | Sphärisches Wolframpulver | Spherical タングステンパウダー |
| Ultrafine tungsten powder | Ultrafine Tungsten Powder | Poudre ultrafine de tungstène | Ultrafeines Wolframpulver | Ultra-fine fiberglass |
| Nano tungsten powder | Nano Tungsten Powder | Poudre nano de tungstène | Nano-Wolframpulver | ナノタングステンパウダー |
| High purity tungsten powder | High-Purity Tungsten Powder | Poudre de tungstène haute pureté | Hochreines Wolframpulver | High purity polyester |
| Medium particle size tungsten powder | Medium-Grain Tungsten Powder | Poudre de tungstène à grain moyen | Mittelk ö rniges Wolframpulver | Medium particle size powder |
| Coarse grain tungsten powder | Coarse-Grain Tungsten Powder | Poudre de tungstène à gros grains | Grobkörniges Wolframpulver | Coarse-grained filter |

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| | | | | |
|---|---|---|---|---|
| Fine grain tungsten powder | Fine-Grain Tungsten Powder | Poudre de tungstène à grains fins | Feinkörniges Wolframpulver | Fine-grained particle size |
| Tungsten powder 10-20 microns | Tungsten Powder 10-20 μm | Poudre de tungstène 10-20 μm | Wolframpulver 10-20 μm | タングステンパウダー10-20ミクロン |
| Tungsten powder 20-50 microns | Tungsten Powder 20-50 μm | Poudre de tungstène 20-50 μm | Wolframpulver 20-50 μm | タングステンパウダー20-50ミクロン |
| Tungsten powder 50-100 microns | Tungsten Powder 50-100 μm | Poudre de tungsten 50-100 μm | Wolframpulver 50-100 μm | タングステンパウダー50-100ミクロン |
| High fluidity tungsten powder | High-Flowability Tungsten Powder | Poudre de tungstène and haute fluidity | Hochflie ß f ä higes Wolframpulver | High Liquidity Stock |
| Low oxygen tungsten powder | Low-Oxygen Tungsten Powder | Poudre de tungstène à faible teneur en oxygène | Sauerstoffarmes Wolframpulver | Low acid content |
| Tungsten Carbide Ultrafine Powder | Ultrafine Tungsten Carbide Powder | Poudre ultrafine de carbure de tungstène | Ultrafeines Wolframcarbidpulver | Ultra-fine carbonized carbon dioxide |
| Tungsten Carbide Nanopowder | Nano Tungsten Carbide Powder | Poudre nano de carbure de tungstène | Nano-Wolframcarbidpulver | ナノCarbonizedタングステンパウダー |
| Tungsten Titanium Carbide Powder | Tungsten Titanium Carbide Powder | Poudre de carbure de tungstène-titane | Wolfram-Titancarbidpulver | タングステンチタンカーバイドパウダー |
| Tungsten Cobalt Carbide Powder | Tungsten Cobalt Carbide Powder | Poudre de carbure de tungstène-cobalt | Wolfram-Kobaltcarbidpulver | タングステンコバルトカーバイドパウダー |
| Tungsten chromium carbide powder | Tungsten Chromium Carbide Powder | Poudre de carbure de tungstène-chrome | Wolfram-Chromcarbidpulver | タングステンクロムカーバイドパウダー |
| Tungsten particles | Tungsten Pellets | Granules of tungstène | Wolframgranulat | タングステンペレット |
| Tungsten needle | Tungsten Needles | Aiguilles of tungstène | Wolframnadeln | タングステンニードル |
| Tungsten Boat | Tungsten Boats | Nacelles of tungstène | Wolfram-Schiffchen | Tangustenbottle |
| Tungsten Wire | Tungsten Wire | Fil de tungstène | Wolfram-Draht | タングステン |

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| | | | | |
|---|---|---|---|---|
| | | | | ワイヤー |
| Tungsten Electrode | Tungsten Electrode | The electric current of tungst | Wolframelektrode | Tangusten electrode |
| Tungsten Rod | Tungsten Rod | Tige of tungstène | Wolfram-Stab | Tangusten Lock |
| Tungsten Plate | Tungsten Plate | Tungstène plaque | Wolfram-Platte | タングステンプレート |
| Tungsten Foil | Tungsten Foil | Few words | Wolfram-Folie | タングステンフォイル |
| Tungsten tube | Tungsten Tube | Tube of tungsten | Wolfram-Rohr | タングステンチューブ |
| Tungsten Crucible | Tungsten Crucible | Creuset of tungstène | Wolfram-Tiegel | Tangston Crucible |
| Tungsten Sputtering Target | Tungsten Sputtering Target | Cable de pulvération en tungstène | Wolfram-Sputtertarget | タングステンスパッタリングターゲット |
| Tungsten Ring | Tungsten Ring | Anne of tungstène | Wolfram-Ring | Tangusting line |
| Tungsten Sheet | Tungsten Sheet | Few words | Wolfram-Blech | Tangustenshi |
| Tungsten Bar | Tungsten Bar | Tungstène Bar | Wolfram-Stange | Tangustenba |
| Tungsten Block | Tungsten Block | Tungstène Block | Wolfram-Block | タングステンブロック |
| Tungsten Ball | Tungsten Ball | Bill of tungstène | Wolfram-Kugel | Tangustenball |
| Tungsten disc | Tungsten Disc | Disque de tungstène | Wolfram-Scheibe | タングステンディスク |
| Tungsten Screws | Tungsten Screw | See the tungstène | Wolfram-Schraube | Tangustenneji |
| Tungsten Shims | Tungsten Washer | Rondelle of tungstène | Wolfram-Unterlegscheibe | タングステンワッシャー |
| Tungsten Nuts | Tungsten Nut | I 'm so tired | Wolfram-Mutter | Tangustennet |
| Tungsten Rivets | Tungsten Rivet | Rivet of tungstène | Wolfram-Niet | タングステンリベット |
| Tungsten Pins | Tungsten Pin | Tungstène | Wolfram-Stift | Tangustenpin |
| Tungsten wire mesh | Tungsten Wire Mesh | Grilling of tungstène | Wolfram-Drahtgewebe | タングステンワイヤーメッシュ |
| Tungsten foil tape | Tungsten Foil Strip | bande de feuille de tungstène | Wolfram-Folienstreifen | タングステンフォイルストリップ |
| Tungsten thin film | Tungsten Thin Film | Film mince of tungstène | Wolfram-Dünnfilm | Tangusten film |
| Tungsten Nozzle | Tungsten Nozzle | Bus of tungstène | Wolfram-Düse | Tangustennozul |
| Tungsten | Tungsten | Tungsten tea | Wolfram - Heizgerät | タングステン |

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|---|---|---|---|---|
| Heater | Heater | | | ヒーター |
| Tungsten Evaporation Boat | Tungsten Evaporation Boat | Nacelle d'évaporation de tungstène | Wolfram-Verdampfungsschiffchen | タングステン発ボート |
| Tungsten Electrode | Tungsten Electrode Rod | Tige d'électrode de tungstène | Wolframelektrodenstab | タングステン electrode ロッド |
| Tungsten electrode | Tungsten Electrode Plate | Plaque d'électrode de tungstène | Wolframelektrodenplatte | タングステン electrode sensor |
| Tungsten Electrode Ring | Tungsten Electrode Ring | Anneau d'électrode de tungstène | Wolframelektrodenring | タングステン electrode リング |
| Tungsten Copper | Tungsten Copper | Cuivre-tungstène | Wolfram-Kupfer | Tangusten copper |
| Tungsten Copper Alloy | Tungsten Copper Alloy | All kinds of food | Wolfram-Kupferlegierung | Tangston copper alloy |
| Tungsten Copper Rod | Tungsten Copper Rod | Tige cuivre-tungstène | Wolfram-Kupferstab | タングステン copper ロッド |
| Tungsten Copper Plate | Tungsten Copper Plate | Place of cooking | Wolfram-Kupferplatte | タングステン copper プレート |
| Tungsten Copper Foil | Tungsten Copper Foil | Few cuivre-tungstène | Wolfram-Kupferfolie | タングステン copper フォイル |
| Tungsten Copper Tube | Tungsten Copper Tube | Tube cuivre-tungsten | Wolfram-Kupferrohr | タングステン copper チューブ |
| Tungsten Copper Block | Tungsten Copper Block | Bloc cuivre-tungstène | Wolfram-Kupferblock | タングステン copper ブロック |
| Tungsten Copper Ring | Tungsten Copper Ring | Anne's cuivre-tungsten | Wolfram-Kupferring | タングステン copper リング |
| Tungsten Copper Bar | Tungsten Copper Bar | Barre cuivre-tungstène | Wolfram-Kupferstange | Tangusten copper bus |
| Tungsten Copper Sheet | Tungsten Copper Sheet | Few dishes-tungstène | Wolfram-Kupferblech | タングステン copper シート |
| Tungsten Silver | Tungsten Silver | Argent-tungstène | Wolfram-Silber | Tangusten silver |
| Tungsten Silver Alloy | Tungsten Silver Alloy | Alliage argent-tungstène | Wolfram-Silberlegierung | Tangusten silver alloy |
| Tungsten Silver Rod | Tungsten Silver Rod | Tiger argent-tungstène | Wolfram-Silberstab | タングステン金ロッド |
| Tungsten Silver | Tungsten Silver | Argent-tungstène | Wolfram-Silberplatte | タングステン |

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|---|---|---|---|---|
| Plate | Plate | | | silver プレート |
| Tungsten Silver Foil | Tungsten Silver Foil | Few argent-tungstène | Wolfram-Silberfolie | タングステン金フォイル |
| Tungsten silver tube | Tungsten Silver Tube | Tube argent-tungstène | Wolfram-Silberrohr | タングステン金チューブ |
| Tungsten Silver Block | Tungsten Silver Block | Block argent-tungstène | Wolfram-Silberblock | タングステン silver ブロック |
| Tungsten Gold | Tungsten Gold | Or-tungstène | Wolfram-Gold | Tangusten gold |
| Tungsten gold alloy | Tungsten Gold Alloy | Alliage or tungstène | Wolfram-Goldlegierung | Tangusten gold alloy |
| Tungsten Rod | Tungsten Gold Rod | Tige or tungstène | Wolfram-Goldstab | タングステン金ロッド |
| Tungsten gold plate | Tungsten Gold Plate | Plaque or tungstène | Wolfram-Goldplatte | タングステン金プレート |
| Tungsten Alloy | Tungsten Alloy | Alliage of tungstène | Wolframlegierung | Tangusten alloy |
| Cemented Carbide | Cemented Carbide | Carbure cut | Hartmetall | Super Hard Alloy |
| Tungsten Iron Rod | Ferro-Tungsten Rod | Tige ferro-tungsten | Ferro-Wolframstab | フェロタングステンロッド |
| Tungsten iron plate | Ferro-Tungsten Plate | Plaque ferro-tungstène | Ferro-Wolframplatte | フェロタングステンプレート |
| Tungsten Nickel Iron | Tungsten-Nickel-Iron | Tungstène-nickel-fer | Wolfram-Nickel-Eisen | タングステンニッケル鄄 |
| Tungsten Nickel Iron Rod | Tungsten-Nickel-Iron Rod | Tige tungstène-nickel-fer | Wolfram-Nickel-Eisenstab | タングステンニッケル鉄ロッド |
| Tungsten Nickel Iron Plate | Tungsten-Nickel-Iron Plate | Plaque tungstène-nickel-fer | Wolfram-Nickel-Eisenplatte | タングステンニッケル鉄プレート |
| Tungsten Nickel Iron Block | Tungsten-Nickel-Iron Block | Bloc tungstène-nickel-fer | Wolfram-Nickel-Eisenblock | タングステンニッケル鉄ブロック |
| Tungsten-Molybdenum Alloy | Tungsten-Molybdenum Alloy | Alliage tungstène-molybdenum | Wolfram - Molybdenumänlegierung | タングステンモリブデン alloy |
| Tungsten molybdenum rod | Tungsten-Molybdenum Rod | Tige tungstène-molybden | Wolfram - Molybdänstab | タングステンモリブデンロッド |
| Tungsten | Tungsten- | Tungstène- | Wolfram - Molybdänplatte | タングステン |

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|---|---|---|---|---|
| molybdenum plate | Molybdenum Plate | molybdenum plaque | | モリブデンプレート |
| Tungsten Cobalt Alloy | Tungsten-Cobalt Alloy | Alliage tungstène-cobalt | Wolfram-Kobaltlegierung | タングステンコバルトAlloy |
| Tungsten Cobalt Rod | Tungsten-Cobalt Rod | Tige tungstène-cobalt | Wolfram-Kobaltstab | タングステンコバルトロッド |
| Tungsten Cobalt Plate | Tungsten-Cobalt Plate | Plaque tungstène-cobalt | Wolfram-Kobaltplatte | タングステンコバルトプレート |
| Tungsten-Rhenium Alloy | Tungsten-Rhenium Alloy | Alliage tungstène-rhénium | Wolfram-Rheniumlegierung | タングステンレニウムalloy |
| Tungsten Iron | Ferro-Tungsten | Ferro-tungstène | Ferro-Wolfram | Feloton Stein |
| Tungsten Rhenium Rod | Tungsten-Rhenium Rod | Tige tungstène-rhénium | Wolfram-Rheniumstab | タングステンレニウムロッド |
| Tungsten Rhenium Wire | Tungsten-Rhenium Wire | Fil tungstène-rhénium | Wolfram-Rheniumdraht | タングステンレニウムワイヤー |
| Tungsten Cylinder | Tungsten Cylinder | Cylindre of tungstène | Wolfram-Zylinder | タングステンシリンダー |
| Tungsten cone | Tungsten Cone | I 'm tired | Wolfram-Kegel | Tangustencon |
| Tungsten Cube | Tungsten Cube | Cube of tungstène | Wolfram-Würfel | タングステンキューブ |
| Tungsten Column | Tungsten Column | Colonne of tungstène | Wolfram - Säule | Tangustencom |
| Tungsten Rod | Tungsten Bar Stock | Tungstène Bar | Wolfram-Stangenmaterial | Tangusten rod |
| Tungsten Plate | Tungsten Plate Stock | Tungstène plaque | Wolfram-Plattenmaterial | Tangston sheet |
| Tungsten Foil Roll | Tungsten Foil Roll | Rouleau de feuille de tungstène | Wolfram-Folienrolle | タングステンフォイルロール |
| Tungsten wire coil | Tungsten Wire Coil | Bobine of tungstène | Wolfram-Drahtspule | タングステンワイヤーコイル |
| Tungsten electrode wire | Tungsten Electrode Wire | Fil d'électrode de tungstène | Wolframelektrodendraht | タングステンelectrode sensor |
| Tungsten heating wire | Tungsten Heating Wire | Fil chauffeur de tungstène | Wolfram-Heizdraht | タングステンheating tube |
| Tungsten | Tungsten | Fil d'alumage de | Wolfram-Zünddraht | タングステン |

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| ignition wire | Ignition Wire | tungsten | | | 火狐ワイヤー |
| Tungsten wire drawing die | Tungsten Drawing Die | Matrice tréfilage tungstène | de en | Wolfram-Ziehmatrize | タングステン抜ダイ |
| Tungsten stamping die | Tungsten Stamping Die | Matrice d'estampage tungstène | en | Wolfram-Stanzmatrize | タングステンスタンプダイ |
| Tungsten extrusion die | Tungsten Extrusion Die | Matrice d'extrusion tungstène | en | Wolfram-Extrusionsmatrize | タングステン出ダイ |
| Tungsten mold | Tungsten Mold | Mouth tungstène | of | Wolfram-Form | Tangusten type |
| Tungsten Spray Target | Tungsten Spray Target | Cable pulvération tungstène | de en | Wolfram-Sprühziel | タングステンスプレーターゲット |
| Tungsten Ion Implantation Target | Tungsten Ion Implantation Target | Cable d'implantation ionique tungstène | en | Wolfram-Ionenimplantationstarget | タングステンイオン inject ターゲット |
| Tungsten Evaporation Target | Tungsten Evaporation Target | Cible vaporization tungsten | in | Wolfram-Verdampfungsziel | Steamed タングステンターゲット |
| Tungsten round target | Tungsten Circular Target | Cable circulation en tungsten | | Wolfram-Kreisziel | タングステン円 shaped ターゲット |
| Tungsten rectangular target | Tungsten Rectangular Target | Cable rectangulaire tungsten | en | Wolfram-Rechteckziel | タングステン rectangular ターゲット |
| Tungsten Rotating Target | Tungsten Rotary Target | Cible rotation tungstène | in | Wolfram-Rotationstarget | タングステン回転ターゲット |
| Tungsten high purity target | High-Purity Tungsten Target | Cible detungsten haute pureté | | Hochreines Wolfram-Ziel | High purity polyester |
| Tungsten crucible cover | Tungsten Crucible Lid | Couvercle creuset tungstene | de en | Wolfram-Tiegeldeckel | Tangston crucible cover |
| Tungsten crucible liner | Tungsten Crucible Liner | Doublure creuset tungstène | de en | Wolfram-Tiegelauskleidung | タングステン crucible ライナー |
| Tungsten Heating Crucible | Tungsten Heating Crucible | Creuset chauffant in tungsten | | Wolfram-Heiztiegel | タングステン heating crucible |
| Tungsten Melting Crucible | Tungsten Melting Crucible | Creuset de fusion en tungstène | | Wolfram-Schmelztiegel | タングステン dissolving crucible |

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|---|---|---|---|---|---|
| Tungsten evaporation crucible | Tungsten Evaporation Crucible | Creuset d'évaporation en tungstène | | Wolfram-Verdampfungstiegel | タングステン steaming crucible |
| Tungsten Sintered Crucible | Tungsten Sintering Crucible | Creuset de frittage en tungstène | | Wolfram-Sintertiegel | タングステン焼 crucible |
| Tungsten Ring | Tungsten Circular Ring | Anneau circulaire en tungstène | | Wolfram-Rundring | Tangston ring |
| Tungsten Square Ring | Tungsten Square Ring | Anne's car in bed | | Wolfram-Quadratring | タングステン square リング |
| Tungsten sealing ring | Tungsten Sealing Ring | Anneau d'étanchéité en tungstène | | Wolfram-Dichtring | タングステンシールリング |
| Tungsten Washers | Tungsten Gasket | Joint of tungstène | | Wolfram-Dichtung | タングステンガスケット |
| Tungsten Bushing | Tungsten Bushing | Bague de tungstène | | Wolfram-Buchse | タングステンブッシング |
| Tungsten bearings | Tungsten Bearing | Tungsten tummy | | Wolfram-Lager | タングステンベアリング |
| Tungsten Ball | Tungsten Roller Ball | A large piece of tungstène | | Wolfram-Rollkugel | タングステンローラーボール |
| Tungsten Spherical Particles | Tungsten Spherical Particle | Particulate splendor tungsten | of | Sphärisches Wolfram -Partikel | タングステン spherical particles |
| Tungsten particles | Tungsten Microparticle | Microstructure of tungstène | | Wolfram-Mikropartikel | タングステンマイクロ particles |
| Tungsten needle | Tungsten Needle Tip | Pointe d'aiguille en tungstène | | Wolfram-Nadelspitze | タングステンニードルチップ |
| Tungsten probe | Tungsten Probe | Son of tungstène | | Wolfram-Sonde | タングステンプローブ |
| Tungsten Tip | Tungsten Tip | Point of tungstène | | Wolfram-Spitze | Tangusten Tip |
| Tungsten Nozzle Tip | Tungsten Nozzle Tip | Point of bus in the city | | Wolfram-Düsenspitze | タングステンノズルチップ |
| Tungsten injection tube | Tungsten Jet Tube | Tube of jet in tungsten | | Wolfram-Strahlrohr | タングステンジェットチューブ |
| Tungsten catheter | Tungsten Conduit | Conduit of tungsten | | Wolfram-Leitung | Tangusten catheter |
| Tungsten capillary | Tungsten Capillary Tube | Tube cap in tungsten | | Wolfram- Kapillarr öhre | タングステンキャピラリーチューブ |

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| Tungsten Heat Pipe | Tungsten Heat Pipe | Tuyau therapy in tungstène | Wolfram - Wärmerohr | タングステンヒートパイプ |
| Tungsten evaporation tray | Tungsten Evaporation Dish | Platt d'évaporation en tungstène | Wolfram-Verdampfungsschale | タングステン発ディッシュ |
| Tungsten sintering disk | Tungsten Sintering Dish | Platt de frittage en tungstène | Wolfram-Sinterschale | タングステン焼懇ィッシュ |
| Tungsten melting plate | Tungsten Melting Dish | Plate of fusion in tungstène | Wolfram-Schmelzschale | タングステンsoluble ディッシュ |
| Tungsten filter | Tungsten Filter Mesh | Grilled filtration in tungsten | Wolfram-Filternetz | タングステンフィルターメッシュ |
| Tungsten Screen | Tungsten Sieve Mesh | Tamis in tungstène | Wolfram-Siebnetz | タングステンsieve filter |
| Tungsten Heater | Tungsten Heating Plate | Plaque chauffante en tungstène | Wolfram-Heizplatte | タングステンHeating プレート |
| Tungsten Heat Shield | Tungsten Insulation Plate | Plaque isolated in tungstène | Wolfram-Isolierplatte | タングステン极缘プレート |
| Tungsten reflector | Tungsten Reflector Plate | Plaque refléchissante en tungstène | Wolfram-Reflektorplatte | タングステンReflection プレート |
| Tungsten shielding plate | Tungsten Shielding Plate | Plaque of blindage in tungsten | Wolfram-Abstractplatte | タングステンシールドプレート |
| Tungsten conductive plate | Tungsten Conductive Plate | Plaque conductrice en tungstène | Wolfram-Leitplatte | タングステンconductive プレート |
| Tungsten wear plate | Tungsten Wear-Resistant Plate | Plaque résistante and l'usure en tungstène | Wolfram - Verschleißplatte | タングステンanti-wear wear-resisting material |
| Tungsten heat resistant plate | Tungsten Heat-Resistant Plate | Plaque résistante à la chaleur en tungstène | Wolfram-Hitzbest ä ndigplatte | タングステンheat-resistant プレート |
| Tungsten electrode needle | Tungsten Electrode Needle | Aiguille d'électrode en tungstène | Wolframelektrodennadel | タングステンelectrode sensor |
| Tungsten welding needle | Tungsten Welding Needle | Aiguille de soudage en tungstène | Wolfram - Schweißnadel | タングステンwelding ニードル |
| Tungsten cutting needle | Tungsten Cutting Needle | Aiguille de coupe en tungstène | Wolfram-Schneidenadel | タングステンcut off ニード |

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| Tungsten Micro Needle | Tungsten Micro Needle | Micro-aiguille en tungstène | Wolfram-Mikronadel | タングステンマイクロニードル |
| Tungsten precision needle | Tungsten Precision Needle | Aiguille de précision en tungstène | Wolfram - Präzisionsnadel | タングステン Precision Instrument |
| Tungsten Cerium Alloy | Cerium-Tungsten Alloy | Allure cérium-tungsten | Cer-Wolframlegierung | セリウムタングステン alloy |
| Tungsten Cerium Rod | Cerium-Tungsten Rod | Tige cérium-tungsten | Cer-Wolframstab | セリウムタングステンロッド |
| Tungsten Cerium Plate | Cerium-Tungsten Plate | Plaque cerium-tungstène | Cer-Wolframplatte | セリウムタングステンプレート |
| Tungsten Cerium Wire | Cerium-Tungsten Wire | Fil cérium-tungsten | Cer-Wolframdraht | セリウムタングステンワイヤー |
| Cerium Tungsten Electrode | Cerium-Tungsten Electrode | Électrode cérium - tungstène | Cer-Wolframelektrode | セリウムタングステン electrode |
| Tungsten Thorium Alloy | Thorium-Tungsten Alloy | Alliage thorium-tungsten | Thorium-Wolframlegierung | トリウムタングステン alloy |
| Tungsten Thorium Rod | Thorium-Tungsten Rod | Tige thorium-tungsten | Thorium-Wolframstab | トリウムタングステンロッド |
| Tungsten Thorium Plate | Thorium-Tungsten Plate | Plaque thorium-tungsten | Thorium-Wolframplatte | トリウムタングステンプレート |
| Tungsten Thorium Wire | Thorium-Tungsten Wire | Fil thorium-tungstène | Thorium-Wolframdraht | トリウムタングステンワイヤー |
| Thorium Tungsten Electrode | Thorium-Tungsten Electrode | Électrode thorium - tungstène | Thorium-Wolframelektrode | Torotron Electrode |
| Tungsten Lanthanum Alloy | Lanthanum-Tungsten Alloy | Alliage lanthane-tungstène | Lanthan-Wolframlegierung | ランタンタングステン alloy |
| Tungsten Lanthanum Rod | Lanthanum-Tungsten Rod | Tige lanthane-tungstène | Lanthan-Wolframstab | ランタンタングステンロッド |
| Tungsten | Lanthanum- | Plaque lanthane- | Lanthan-Wolframplatte | ランタンタン |

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| Lanthanum Plate | Tungsten Plate | tungstène | | グステンプレート |
| Tungsten Lanthanum Wire | Lanthanum-Tungsten Wire | Fil lanthane-tungstène | Lanthan-Wolframdraht | ランタンタングステンワイヤー |
| Tungsten lanthanum electrode | Lanthanum-Tungsten Electrode | Électrode lanthane - tungstène | Lanthan-Wolframelektrode | ランタンタングステン electrode |
| Tungsten Zirconium Alloy | Zirconium-Tungsten Alloy | Allium tungstène | Zirkonium-Wolframlegierung | ジルコニウムタングステン alloy |
| Tungsten Zirconium Rod | Zirconium-Tungsten Rod | Tige zirconium-tungsten | Zirkonium-Wolframstab | ジルコニウムタングステンロッド |
| Tungsten Zirconium Plate | Zirconium-Tungsten Plate | Plaque zirconium-tungstène | Zirkonium-Wolframplatte | ジルコニウムタングステンプレート |
| Tungsten Zirconium Wire | Zirconium-Tungsten Wire | Zirconia-tungstène | Zirkonium-Wolframdraht | ジルコニウムタングステンワイヤー |
| Tungsten-zirconium electrode | Zirconium-Tungsten Electrode | Électrode zirconium-tungsten è ne | Zirkonium-Wolframelektrode | ジルコニウムタングステン electrode |
| Tungsten Yttrium Alloy | Yttrium-Tungsten Alloy | Alliage yttrium-tungstène | Yttrium-Wolframlegierung | イットリウムタングステン alloy |
| Tungsten Yttrium Rod | Yttrium-Tungsten Rod | Tige yttrium-tungstène | Yttrium-Wolframstab | イットリウムタングステンロッド |
| Tungsten Yttrium Plate | Yttrium-Tungsten Plate | Plaque yttrium-tungstène | Yttrium-Wolframplatte | イットリウムタングステンプレート |
| Tungsten Yttrium Wire | Yttrium-Tungsten Wire | Fil yttrium-tungstène | Yttrium-Wolframdraht | イットリウムタングステンワイヤー |
| Tungsten Yttrium Electrode | Yttrium-Tungsten Electrode | Électrode yttrium - tungstène | Yttrium-Wolframelektrode | イットリウムタングステン electrode |
| Tungsten Nickel Copper Alloy | Tungsten-Nickel-Copper Alloy | Alliage tungstène-nickel-cuivre | Wolfram-Nickel-Kupferlegierung | タングステンニッケル copper alloy |
| Tungsten Nickel Copper Rod | Tungsten-Nickel-Copper Rod | Tige tungstène nickel-cuisine | Wolfram-Nickel-Kupferstab | タングステンニッケル Cu ロッド |

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| Tungsten Nickel Copper Plate | Tungsten-Nickel-Copper Plate | Plaque tungstène-nickel-cuivre | Wolfram-Nickel-Kupferplatte | タングステンニッケルcopperプレート |
| Tungsten Nickel Copper Block | Tungsten-Nickel-Copper Block | Tungsten nickel-cuisine block | Wolfram-Nickel-Kupferblock | タングステンニッケルcopperブロック |
| Tungsten Titanium Alloy | Tungsten-Titanium Alloy | Alliage tungstène-titane | Wolfram-Titanlegierung | タングステンチタンalloy |
| Tungsten Titanium Rod | Tungsten-Titanium Rod | Tige tungstène-titane | Wolfram-Titanstab | タングステンチタンロッド |
| Tungsten Titanium Plate | Tungsten-Titanium Plate | Plaque tungstène-titane | Wolfram-Titanplatte | タングステンチタンプレート |
| Tungsten Titanium Wire | Tungsten-Titanium Wire | Tungstène-titane | Wolfram-Titandraht | タングステンチタンワイヤー |
| Tungsten Vanadium Alloy | Tungsten-Vanadium Alloy | Alliage tungstène-vanadium | Wolfram-Vanadiumlegierung | タングステンバナジウムalloy |
| Tungsten Vanadium Rod | Tungsten-Vanadium Rod | Tige tungstène-vanadium | Wolfram-Vanadiumstab | タングステンバナジウムロッド |
| Tungsten Vanadium Plate | Tungsten-Vanadium Plate | Plaque tungstène-vanadium | Wolfram-Vanadiumplatte | タングステンバナジウムプレート |
| Tungsten Vanadium Wire | Tungsten-Vanadium Wire | Fil tungstène-vanadium | Wolfram-Vanadiumdraht | タングステンバナジウムワイヤー |
| Tungsten Chrome Alloy | Tungsten-Chromium Alloy | Alliage tungstène-chrome | Wolfram-Chromlegierung | タングステンクロムalloy |
| Tungsten chromium rod | Tungsten-Chromium Rod | Tige tungstène-chrome | Wolfram-Chromstab | タングステンクロムロッド |
| Tungsten chromium plate | Tungsten-Chromium Plate | Plaque tungstène-chrome | Wolfram-Chromplatte | タングステンクロムプレート |
| Tungsten chromium wire | Tungsten-Chromium Wire | Fil tungstène-chrome | Wolfram-Chromdraht | タングステンクロムワイヤー |
| Tungsten Manganese Alloy | Tungsten-Manganese Alloy | Allure tungstène-manganese | Wolfram-Manganlegierung | タングステンマンガンalloy |

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| Tungsten Manganese Rod | Tungsten-Manganese Rod | Tige tungstène-manganese | Wolfram-Manganstab | タングステンマンガンロッド |
| Tungsten manganese plate | Tungsten-Manganese Plate | Tungstène-manganese plate | Wolfram-Manganplatte | タングステンマンガンプレート |
| Tungsten manganese wire | Tungsten-Manganese Wire | Fil tungstène-manganese | Wolfram-Mangandraht | タングステンマンガンワイヤー |
| Tungsten Copper 50/50 Alloy | Tungsten Copper 50/50 Alloy | Alliage cuivre-tungstène 50/50 | Wolfram-Kupfer 50/50 Legierung | タングステン copper 50/50 alloy |
| Tungsten Copper 70/30 Alloy | Tungsten Copper 70/30 Alloy | Alliage cuivre-tungstène 70/30 | Wolfram-Kupfer 70/30 Legierung | タングステン copper 70/30 alloy |
| Tungsten Copper 80/20 Alloy | Tungsten Copper 80/20 Alloy | Alliage cuivre-tungstène 80/20 | Wolfram-Kupfer 80/20 Legierung | タングステン copper 80/20 alloy |
| Tungsten Copper 90/10 Alloy | Tungsten Copper 90/10 Alloy | Alliage cuivre-tungstène 90/10 | Wolfram-Kupfer 90/10 Legierung | タングステン copper 90/10 alloy |
| Tungsten Silver 50/50 Alloy | Tungsten Silver 50/50 Alloy | Alliage argent-tungstène 50/50 | Wolfram-Silber 50/50 Legierung | タングステン silver 50/50 alloy |
| Tungsten silver 70/30 alloy | Tungsten Silver 70/30 Alloy | Alliage argent-tungstène 70/30 | Wolfram-Silber 70/30 Legierung | タングステン silver 70/30 alloy |
| Tungsten silver 80/20 alloy | Tungsten Silver 80/20 Alloy | Alliage argent-tungstène 80/20 | Wolfram-Silber 80/20 Legierung | タングステン silver 80/20 alloy |
| Tungsten Nickel Iron 90/5/5 Alloy | Tungsten-Nickel-Iron 90/5/5 Alloy | Alliage tungstène-nickel-fer 90/5/5 | Wolfram-Nickel-Eisen 90/5/5 Legierung | タングステンニッケル鄄 90/5/5 alloy |
| Plasma spheroidization | Plasma Spheroidization | Spray plasma | Plasma - Spheroidisierung | Plasma spheroidization |
| Aerosolization | Gas Atomization | Atomisation gazeuse | Gas station | Gasato Mystery |
| Rotating electrode atomization | Plasma Rotating Electrode Process (PREP) | Procédé d'électrode rotative plasma | Plasma-Rotierende-Elektroden-Verfahren | Return electrode プラズマプロセス |
| sintering | Sintering | Frittage | Sintern | Sintering |
| Hot Pressing | Hot Pressing | Pressage à chaud | Heiß pressen | Thermal compression |
| forging | Forging | Forgeage | Schmieden | Forging |
| Rolling | Rolling | Laminage | Walzen | Pressure |

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| | | | | extension |
| extrusion | Extrusion | Extrusion | Extruder | Push out |
| Brushed | Wire Drawing | Tréfilage | Drahtziehen | Wire drawing |
| Cold Forging | Cold Forging | Forgeage à froid | Kaltschmieden | Cold Forging |
| Hot Forging | Hot Forging | Forgeage at the end | Warmschmieden | Hot forging |
| Isostatic Pressing | Isostatic Pressing | Pressing isostatique | Isostatisches Pressen | Isostatic Pressure Press |
| Vacuum sintering | Vacuum Sintering | Sous vide frittata | Vakuumsintern | Vacuum sintering |
| Hydrogen reduction | Hydrogen Reduction | Réduction of hydrogene | Wasserstoffreduktion | Hydrogen reduction |
| Arc Melting | Arc Melting | Fusion to the arc | Lichtbogenschmelzen | Ark Dissolution |
| Electron beam melting | Electron Beam Melting | Fusion par faisceau d'électrons | Electrical installation | Electronic Bim Dissolution |
| Powder Metallurgy | Powder Metallurgy | Metallurgy of poultry | Pulvermetallurgie | Powder Metallurgy |
| Chemical Vapor Deposition | Chemical Vapor Deposition (CVD) | Dépôt chimique en phase vapeur | Chemische Gasphasenabscheidung | Chemical vapor deposition |
| Physical Vapor Deposition | Physical Vapor Deposition (PVD) | Dépôt physique en phase vapeur | Physikalische Gasphasenabscheidung | Physical gas phase evaporation |
| Spraying | Spraying | Development | Sprühen | Spray |
| Thermal Spraying | Thermal Spraying | Treatment | Thermisches Sprühen | Thermal Spray |
| Plasma spraying | Plasma Spraying | Plasma purification | Plasma prühen | Plasma spray |
| plating | Electroplating | Galvanoplastie | Galvanisieren | Denki Metki |
| Mechanical grinding | Mechanical Grinding | Meulage mécanique | Mechanisches Schleifen | Mechanical grinding |
| polishing | Polishing | Polissage | Polier | Grinding |
| Cutting | Cutting | Decoupe | Schneiden | Cutting |
| Turning | Turning | Tournage | Drehen | Turning |
| Milling | Milling | Fraisage | Fräsen | Frying Processing |
| drilling | Drilling | Per ç age | Bohren | Anaake |
| welding | Welding | Soudage | Schweißen | Welding |
| Brazing | Brazing | Brasage | Löten | Roufuke |
| Heat Treatment | Heat Treatment | Traitement therapy | Wärmebehandlung | Heat treatment |
| annealing | Annealing | Recuit | Glühen | Aniling |
| Quenching | Quenching | Trempe | Abschrecken | Burning |

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| Tempering | Tempering | Revenu | Anlassen | Burning |
| carburization | Carburizing | Cémentation | Aufköhlen | Carbonization |
| Surface hardening | Surface Hardening | Duration of surface | Oberflächenhärtung | Surface hardening |
| Shot Peening | Shot Peening | Grenaillage of pre-construction | Kugelstrahlen | Switch Pinning |
| Particle size distribution | Particle Size Distribution | Distribution granulometry | Part Ignition | Particle size distribution |
| Sphericity | Sphericity | Sphéricity | This is a good idea | Sphericity |
| Liquidity | Flowability | Fluidity | Fly high | Liquidity |
| density | Density | Densité | Dichte | density |
| Apparent density | Apparent Density | Density apparent | Scheindichte | See hanging density |
| Tap density | Tap Density | Densité tasting | Stampfdichte | Tap density |
| purity | Purity | Pureté | Reinheit | Purity |
| Oxygen content | Oxygen Content | Teneur in oxygen | Sauerstoffgehalt | Acid content |
| Carbon content | Carbon Content | Carbon dioxide | Kohlenstoffgehalt | Carbon content |
| hardness | Hardness | Dureté | Harte | hardness |
| Microhardness | Microhardness | Microdureté | Mikrohärte | Micro hardness |
| tensile strength | Tensile Strength | Rest and traction | Zugfestigkeit | Tensile strength |
| Yield Strength | Yield Strength | Limit of elasticity | Streckgrenze | Yield strength |
| Fracture toughness | Fracture Toughness | Restoration of power | Bruch 's height | Destruction resistance |
| Wear resistance | Wear Resistance | Restoration of the environment | Verschleißfestigkeit | Wear resistance |
| Corrosion resistance | Corrosion Resistance | Resistance to corrosion | Best selection of products | Corrosion resistance |
| Thermal conductivity | Thermal Conductivity | Conductive therapy | What is the best way to deal with it? | Thermal conductivity |
| Conductivity | Electrical Conductivity | Conductive electrification | Electric Leitfähigkeit | Electrical conductivity |
| Specific surface area | Specific Surface Area | Surface design | Spend the day | Specific surface area |
| Grain size | Grain Size | Taille des grains | Korngröße | Crystalline particle size |
| Microstructure | Microstructure | Microstructure | Mikrogefüge | Microstructure |
| Chemical composition analysis | Chemical Composition Analysis | Analyze de composition chimique | Chemische Zusamensetzungsanalyse | Chemical composition analysis |
| X-ray diffraction analysis | X-Ray Diffraction Analysis | Analyze par diffraction des rayons X | Röntgenbeugungsanalyse | X-ray reflection analysis |
| Scanning electron microscopy | Scanning Electron Microscopy | Microscopy électronique à balayage | Rasterelektronenmikroskopie | Scanning electron microscope |

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| analysis | (SEM) | | | analysis |
| Transmission electron microscopy analysis | Transmission Electron Microscopy (TEM) | Microscopie électronique en transmission | Transmissionselektronenmikroskopie | Analysis by electron microscope |
| Energy spectrum analysis | Energy Dispersive Spectroscopy (EDS) | Spectroscopie à dispersion d'énergie | Energiedispersive Spektroskopie | Eryna dispersion spectroscopic analysis |
| Spectral analysis | Spectral Analysis | Analyse spectra | Spektralanalyse | Spectrum Analysis |
| Coefficient of thermal expansion | Coefficient of Thermal Expansion | Coefficient of dilation thermique | Wärmeausdehnungskoeffizient | Thermal expansion coefficient |
| Melting point test | Melting Point Test | Test point of fusion | Schmelzpunkttest | Melting point test |
| Fatigue testing | Fatigue Test | Test of fatigue | Ermüdungstest | Fatigue test |
| Shock Test | Impact Test | Test d'impact | Schlagtest | Impact test |
| Tungsten 3D printing powder | Tungsten 3D Printing Powder | Poudre de tungstène pour impression 3D | Wolfram-3D-Druckpulver | タングステン 3D プリントパウダー |
| Tungsten Aerospace Parts | Tungsten Aerospace Component | Composant aerospace en tungsten | Wolfram-Luftfahrtbauteil | タングステン Aerospace Parts |
| Tungsten Aviation Weights | Tungsten Aerospace Counterweight | Contrepoids aerospace en tungsten | Wolfram-Luftfahrtgegenegewicht | タングステン Aviation Company |
| Tungsten Rocket Nozzle | Tungsten Rocket Nozzle | Use the fusée in tungsten | Wolfram-Raketendüse | タングステン ロケットノズル |
| Tungsten Missile Components | Tungsten Missile Component | Composition of missiles in tungsten | Wolfram-Raketenbauteil | タングステン ミサイル parts |
| Tungsten Satellite Shielding | Tungsten Satellite Shielding | Blindness in satellite en tungsten | Wolfram-Satellitenabschirmung | タングステン SATELLITE |
| Tungsten Electronic Packaging Substrates | Tungsten Electronic Packaging Substrate | Substratum d'encapsulation électronique en tungstène | Wolfram-Elektronikverpackungssubstrat | タングステン electronics board |
| Tungsten PCB Heat Sink | Tungsten Circuit Board Heat Sink | Dissipateur thermique pour carte de circuit en tungstène | Wolfram -Leiterplatten-Wärmesenke | タングステン circuit substrate circuit board |
| Tungsten chip substrate | Tungsten Chip Substrate | Substratum de puce en tungstène | Wolfram-Chipsubstrat | タングステン チップ substrate |

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| Tungsten semiconductor target | Tungsten Semiconductor Target | Cible semi-conductrice en tungstène | Wolfram-Halbleiterziel | タングステン Semiconductor Technology |
| Tungsten electrode welding needle | Tungsten Electrode Welding Needle | Aiguille de soudage à électrode en tungstène | Wolframelektroden-Schwei ß nadel | タングステン electrode welding device |
| Tungsten TIG welding electrode | Tungsten TIG Welding Electrode | Électrode de soudage TIG en tungsten è ne | Wolfram-WIG-Schwei ß elektrode | タングステン TIG welding electrode |
| Tungsten plasma welding electrodes | Tungsten Plasma Welding Electrode | Électrode de soudage plasma en tungsten ène | Wolfram-Plasmaschwei ß elektrode | タングステン プラズマ welding electrode |
| Tungsten Resistance Welding Electrode | Tungsten Resistance Welding Electrode | Électrode de soudage par ésistance en tungstè ne | Wolfram-Widerstandsschwei ß elektrode | タングステン resistance welding electrode |
| Tungsten spot welding electrode | Tungsten Spot Welding Electrode | Électrode de soudage par point en tungsten è ne | Wolfram-Punktschwei ß elektrode | タングステン スポット welding electrode |
| Tungsten Medical Radiation Shielding | Tungsten Medical Radiation Shield | Blindage radiologique medical en tungsten | Wolfram-Medizinische Strahlenschutz | タングステン medical radiation therapy |
| Tungsten X-ray shield | Tungsten X-Ray Shielding Plate | Plaques of protection contre les rayons X en tungsten | Wolfram - Röntgenabschirmplatte | タングステン X-ray protection プレート |
| Tungsten Gamma Ray Shielding | Tungsten Gamma Ray Shielding | Blind age contre les rayons gamma en tungstène | Wolfram-Gammastrahlenabschirmung | タングステン ガンマ线シールド |
| Tungsten Syringe Shield | Tungsten Syringe Shield | Blind age in seringue en tungsten | Wolfram-Spritzenschutz | タングステン syringe シールド |
| Tungsten Nuclear Medicine Protective Container | Tungsten Nuclear Medicine Shielding Container | Protect your health | Wolfram-Kernmedizin-Abschirmbeh ä lter | タングステン nuclear medicine protective container |
| Tungsten high temperature furnace heating element | Tungsten High-Temperature Furnace Heating Element | Élément chauffant de four haute température en tungsten è ne | Wolfram-Hochtemperaturofen-Heizelement | タングステン high temperature furnace heating elements |
| Tungsten | Tungsten | Plaque isolante | Wolfram-Vakuumofen-Isolierplatte | タングステン |

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| vacuum furnace insulation board | Vacuum Furnace Insulation Plate | four and one vide en tungsten | | vacuum furnace absolute vacuum furnace |
| Tungsten sintering furnace crucible | Tungsten Sintering Furnace Crucible | Creuset four de frittage en tungstène | Wolfram-Sinterofen-Tiegel | タングステン crucible |
| Tungsten Evaporation Boat Assemblies | Tungsten Evaporation Boat Assembly | Ensemble de nacelle d'évaporation en tungstène | Wolfram-Verdampfungsschiffchen-Baugruppe | タングステン発ボートアセンブリ |
| Tungsten Thermocouple Protection Sheath | Tungsten Thermocouple Protection Sleeve | Gain protection in thermocouples | Wolfram-Thermoelement-Schutzhülse | タングステン Thermoelectric protection system |
| Tungsten wear-resistant cutting tools | Tungsten Wear-Resistant Tool | Out of stock | Wolfram-Verschlei ß festivals Werkzeug | タングステン anti-wear tools |
| Tungsten Carbide Blades | Tungsten Carbide Cutting Insert | Plaquette de coupe en carburetngstène | Wolframcarbid-Schneideinsatz | タングステン super hard cutting tool |
| Tungsten drill bit | Tungsten Drill Bit | Forget about eating | Wolfram-Bohrer | タングステンドリルビット |
| Tungsten milling cutter | Tungsten Milling Cutter | Fraise in tungstène | Wolfram - Fräser | タングステンフライスカッター |
| Tungsten turning tool | Tungsten Turning Tool | Out of sight tour en tungsten | Wolfram-Drehwerkzeug | タングステン turning tools |
| Tungsten cutting tools | Tungsten Cutting Tool | Outer coupe in tungsten | Wolfram-Schneidwerkzeug | タングステン cutting tools |
| Tungsten Abrasives | Tungsten Grinding Tool | Out of stock in tungsten | Wolfram-Schleifwerkzeug | タングステン grinding tools |
| Tungsten Polishing Tools | Tungsten Polishing Tool | Out of stock in tungsten | Wolfram-Polierwerkzeug | タングステン grinding tools |
| Tungsten wear resistant lining | Tungsten Wear-Resistant Liner | Doublure résistante and l'usure en tungstène | Wolfram-Verschlei ß auskleidung | タングステン resistant wear resistance ライナー |
| Tungsten heat resistant lining | Tungsten Heat-Resistant Liner | Doublure résistante and la chaleur in tungsten | Wolfram-Hitzbest ä ndige Auskleidung | タングステン heat-resistant ライナー |
| Tungsten corrosion resistant | Tungsten Corrosion-Resistant | Revival of corrosion in tungsten | Wolfram- Korrosionsbeständige Beschichtung | タングステン corrosion-resistant food |

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| coating | Coating | | | |
| Tungsten Nuclear Reactor Shielding | Tungsten Nuclear Reactor Shielding | Blind age in tungsten | Wolfram-Kernreaktorabschirmung | タングステン atomic furnace シールド |
| Tungsten Radiation Shielding Container | Tungsten Radiation Protection Container | Conteneur de protection radiologique en tungstène | Wolfram - Strahlenschutzbehälter | タングステン radiation protection container |
| Tungsten Neutron Shielding | Tungsten Neutron Shielding Plate | Plaque de blindage contre neutrons en tungstène | Wolfram-Neutronenabschirmplatte | タングステン neutral child シールドプレート |
| Tungsten Nuclear Fuel Container | Tungsten Nuclear Fuel Container | Conteneur de combustible nucléaire en tungstène | Wolfram-Kernbrennstoffbeh ä lter | タングステン nuclear fuel container |
| Tungsten Thermonuclear Fusion Components | Tungsten Thermonuclear Fusion Component | Composant fusion thermonucléaire en tungsten | Wolfram-Thermonuklearfusionsbauteil | Thermonuclear fusion parts |
| Tungsten plasma facing material | Tungsten Plasma-Facing Material | Matériau face au plasma en tungsten | Wolfram-Plasmafrontmaterial | タングステン プラズマ custom material |
| Tungsten fusion reactor wall | Tungsten Fusion Reactor Wall | Parody of the fusion in tungsten | Wolfram-Fusionsreaktorwand | タングステン fusion furnace wall |
| Tungsten Energy Storage Electrode | Tungsten Energy Storage Electrode | Électrode de stockage d' énergie en tungsten è ne | Wolfram-Energiespeicherelektrode | タングステン エネルギー storage electrode |
| Tungsten battery separator | Tungsten Battery Separator | Séparateur de batterie en tungstène | Wolfram-Batterieseparator | タングステン バッテリーセパレーター |
| Tungsten Fuel Cell Components | Tungsten Fuel Cell Component | Composable piles in tungsten | Wolfram-Brennstoffzellenbauteil | タングステン fuel cell parts |
| Tungsten Solar Reflectors | Tungsten Solar Reflector Plate | Plaque refléchissante solaire en tungstène | Wolfram-Solar Reflektorplatte | タングステン solar reflection light |
| Tungsten Photovoltaic Substrate | Tungsten Photovoltaic Substrate | Substratum photovoltaic | Wolfram-Photovoltaiksubstrat | タングステン photovoltaic power substrate |
| Tungsten Wind Turbine | Tungsten Wind Turbine | Composant d'éolienne en | Wolfram-Windkraftanlagenbauteil | タングステン wind power |

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| Components | Component | tungstène | | motor parts |
| Tungsten weight wheel | Tungsten Counterweight Wheel | Rouge de contrepoids en tungstène | Wolfram-Gegengewichtsrad | タングステンカウンターウェイトホイール |
| Tungsten military armor-piercing core | Tungsten Armor-Piercing Core | Noyau perforant in tungstène | Wolfram-Panzerdurchschlagskern | タングステン armor penetration core |
| Tungsten tank shell parts | Tungsten Tank Shell Component | Composant d'obus de char en tungstène | Wolfram-Panzergeschossbauteil | タングステンタンク cannon parts |
| Tungsten Missile Weights | Tungsten Missile Counterweight | Contrepoids de missile en tungsten | Wolfram-Raketengegengewicht | タングステンミサイルカウンターウェイト |
| Tungsten Military Shielding | Tungsten Military Shielding | Blind age militancy en tungsten | Wolfram- Militä rabschirmung | タングステン military シールド |
| Tungsten bulletproof plate | Tungsten Bulletproof Plate | Plaque pare-balles en tungstène | Wolfram-Kugelsichere Platte | タングステン anti-bouncer |
| Tungsten armor plate | Tungsten Armor Plate | Plaque of arm in tungstène | Wolfram-Panzerplatte | タングステン armor プレート |
| Tungsten explosively formed core | Tungsten Explosively Formed Penetrator Core | Noyau de pénétrateur form par explosion en tungstène | Wolfram-Explosivgeformter Penetratorkern | タングステン blast molded through core |
| Tungsten Military Radiation Protection Parts | Tungsten Military Radiation Protection | Protection radiologique militaire en tungsten | Wolfram-Milit ä rstrahlenschutz | タングステン military radiation protection parts |
| Tungsten Submarine Counterweight | Tungsten Submarine Counterweight | Contrepoids de sous-marin en tungstène | Wolfram-U-Boot-Gegengewicht | タングステン submarine カウンターウェイト |
| Tungsten aircraft engine blades | Tungsten Aircraft Engine Blade | Pale de moteur d'avion en tungstène | Wolfram-Flugzeugmotorblatt | タングステン Aviation Airlines |
| Tungsten turbine blades | Tungsten Turbine Blade | Pale of turbines in tungsten | Wolfram-Turbinenschaufel | タングステンタービンブレード |
| Tungsten Gas Turbine Components | Tungsten Gas Turbine Component | Composant turbines and turbines | Wolfram-Gasturbinenbauteil | タングステンガスタービン |

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| | | | | parts |
| Tungsten Jet Engine Nozzles | Tungsten Jet Engine Nozzle | Busy de moteurs and actions in tungsten | Wolfram-Strahltriebwerksdüse | タングステンジェットエンジンノズル |
| Tungsten high temperature combustion chamber lining | Tungsten High-Temperature Combustion Chamber Liner | Doubling down on the combustion process in tungsten | Wolfram-Hochtemperatur-Brennkammerauskleidung | タングステン high temperature combustion chamber ライナー |
| Tungsten Rocket Thruster Components | Tungsten Rocket Thruster Component | Composers of propulsions in tungsten | Wolfram-Raketenantriebbauteil | タングステンロケットスラスター parts |
| Tungsten heat resistant nozzle | Tungsten Heat-Resistant Nozzle | Bust the challenge | Wolfram - HitzbeständigeDüse | タングステン heat-resistant ノズル |
| Tungsten high temperature heat shield | Tungsten High-Temperature Insulation Screen | É cran isolant haute temp é rature en tungsten è ne | Wolfram-Hochtemperatur-Isolierschirm | タングステン High Temperature Absolute Water |
| Tungsten Vacuum Deposition Boat | Tungsten Vacuum Evaporation Boat | Nacelle vaporization sous vide en tungstène | Wolfram-Vakuumverdampfungsschiffchen | タングステン vacuum steamed ボート |
| Tungsten Ion Source Parts | Tungsten Ion Source Component | Composers of sources in tungsten | Wolfram-Ion Enquellenbauteil | タングステンイオン source parts |
| Tungsten Electron Beam Evaporation Boat | Tungsten Electron Beam Evaporation Boat | Nacelle d'évaporation par faisceau d'électrons en tungstène | Wolfram-Elektronenstrahl-Verdampfungsschiffchen | タングステン ELECTRONIC STEEL |
| Tungsten mass spectrometer electrodes | Tungsten Mass Spectrometer Electrode | Électrode de spectromè tre de masse en tungsten è ne | Wolfram-Massenspektrometerelektrode | タングステン mass analyzer electrode |
| Tungsten scanning probe | Tungsten Scanning Probe | Sonde de balayage en tungstène | Wolfram-Scanning-Sonde | タングステンスキャニングプローブ |
| Tungsten AFM Needle | Tungsten Atomic Force Microscope Needle | Aiguille de microscope à force atomique en tungstène | Wolfram-Atomkraftmikroskopnadel | タングステン Atomic Force Microscope |
| Tungsten Electron Microscope | Tungsten Electron Microscope | Plateau d'échantillon de microscope | Wolfram-Elektronenmikroskop-Probenbühne | タングステン Electronic Microscope |

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| Stage | Sample Stage | électronique en tungstène | | Microscope |
| Tungsten X-ray Tube Target | Tungsten X-Ray Tube Target | Cable de tube à rayon X en tungstène | Wolfram-R ö ntgenr ö hrenziel | タングステン X-ray tube ターゲット |
| Tungsten CT machine shielding | Tungsten CT Scanner Shielding | Blind age scanner CT en tungsten | Wolfram-CT-Scanner-Abschirmung | タングステン CT スキャナーシールド |
| Tungsten radiation therapy shield | Tungsten Radiotherapy Shielding Hood | Capot de protection pour radiothérapie en tungstène | Wolfram-Strahlentherapie-Abschirmhaube | タングステン radiation therapy |
| Tungsten medical forceps | Tungsten Medical Forceps | Pince médicale in tungsten | Wolfram-Medizinische Zange | タングステン ピンセット for medical use |
| Tungsten surgical blades | Tungsten Surgical Blade | Lame chirurgicale en tungsten | Wolfram-Chirurgisches Messer | タングステン ブレード for surgery |
| Tungsten Orthopedic Implants | Tungsten Orthopedic Implant | Implant orthopedic en tungsten | Wolfram-Orthop ä dishes Implantat | タングステン Plastic Surgery Clinic |
| Tungsten dental drill | Tungsten Dental Drill Bit | Former dentist in tungsten | Wolfram-Zahnbohrer | タングステン 歯科ドリルビット |
| Tungsten dental polishing needle | Tungsten Dental Polishing Needle | Aiguille de polissage dentaire en tungstène | Wolfram-Zahnpoliernadel | タングステン 歯科综合ニードル |
| Tungsten Mining Drill Bits | Tungsten Mining Drill Bit | Forget about eating | Wolfram-Bergbaubohrer | Depositphotos |
| Tungsten Oil Drilling Tools | Tungsten Oil Drilling Tool | Outil de forage pétrolier en tungstène | Wolfram - Ölbohrwerkzeug | タングステン oil digging tools |
| Tungsten geological exploration core tube | Tungsten Geological Exploration Core Tube | Tube de carrotage géologique en tungstène | Wolfram-Geologische Erkundungskernrohr | タングステン Geological Exploration Service |
| Tungsten wear-resistant bearings | Tungsten Wear-Resistant Bearing | Roulement résistant à l'usure en tungstène | Wolfram-Verschlei ß festivals Lager | タングステン resistant wear-resistant ベアリング |
| Tungsten high temperature valve | Tungsten High-Temperature Valve | Vanne haute température in tungsten | Wolfram-Hochtemperaturventil | タングステン High Temperature |
| Tungsten | Tungsten | Tuyau résistant | Wolfram-Korrosionsbest ä ndiges | タングステン |

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| Corrosion Resistant Pipe | Corrosion-Resistant Pipe | and corrosion in tungsten | Rohr | corrosion-resistant パイプ |
| Tungsten pump body sealing ring | Tungsten Pump Body Sealing Ring | Anneau d'étanchéité de corps de pompe en tungstène | Wolfram-Pumpenkörper - Dichtring | タングステンポンプボディシールリング |
| Tungsten Mechanical Seals | Tungsten Mechanical Seal | Joint mécanique en tungsten | Wolfram-Mechanische Dichtung | タングステン Mechanical Equipment |
| Tungsten Industrial Nozzles | Tungsten Industrial Nozzle | Buse industrielle en tungstène | Wolfram-Industriedüse | タングステン INDUSTRIAL ノズル |
| Tungsten wear resistant sandblasting nozzle | Tungsten Wear-Resistant Sandblasting Nozzle | Bust the sablage résistante à l'usure en tungsten | Wolfram-Verschlei ß feste Sandstrahld ü se | タングステン resistant wear and tear wear resistant |
| Tungsten Cutting Wheel | Tungsten Cutting Wheel | The coupe in the tungsten | Wolfram-Schneidrad | タングステン cut off ホイール |
| Tungsten grinding wheel | Tungsten Grinding Wheel | Roule de ulture en tungsten | Wolfram-Schleifscheibe | タングステン grinding ホイール |
| Tungsten polishing disc | Tungsten Polishing Disc | Disques of polissage in tungsten | Wolfram-Polierscheibe | タングステンディスク |
| Tungsten high temperature resistant gasket | Tungsten High-Temperature Gasket | Joint haute température en tungsten | Wolfram-Hochtemperaturdichtung | タングステン High temperature ガスケット |
| Tungsten Industrial Filters | Tungsten Industrial Filter | Filtre industriel en tungstène | Wolfram-Industriefilter | タングステン INDUSTRIAL FIRST |
| Tungsten wear-resistant roller | Tungsten Wear-Resistant Roller | Rouleau résistant and l'usure en tungstène | Wolfram-Verschlei ß feste Walze | タングステン resistant wear-resistant ローラー |
| Tungsten High Temperature Reactor Lining | Tungsten High-Temperature Reactor Liner | Doublure de réacteur haute température en tungstène | Wolfram-Hochtemperaturreaktor-Auskleidung | タングステン high temperature reactor ライナー |
| Tungsten Chemical Reactor | Tungsten Chemical Reaction Vessel | Recipe for your action Chimique en Tungstène | Wolfram-Chemischer Reaktionsbehälter | タングステン chemical reaction container |

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| Tungsten Experimental Crucible | Tungsten Experimental Crucible | Creuset expérimental en tungsten | Wolfram-Experimenteller Tiegel | タングステン実験 crucible |
| Tungsten high temperature test boat | Tungsten High-Temperature Experimental Boat | Nacelle expérimentale haute température en tungsten | Wolfram-Hochtemperatur-Experimentalschiffchen | タングステン High temperature 実験ボート |
| Tungsten Scientific Analysis Target | Tungsten Scientific Analysis Target | Cible d'analyze scientifique en tungsten | Wolfram-Wissenschaftliches Analysenziel | タングステン scientific analysis ターゲット |
| Tungsten Optical Lens Substrate | Tungsten Optical Lens Substrate | Substratum de lentille optique en tungstène | Wolfram-Optisches Linsensubstrat | タングステン optical レンズ substrate |
| Tungsten Laser Reflector | Tungsten Laser Reflector | Réflecteur laser en tungsten | Wolfram-Laserreflektor | タングステンレーザーリフレクター |
| Tungsten infrared reflective sheet | Tungsten Infrared Reflector Plate | Plaque réfléchissante infrarouge en tungstène | Wolfram-Infrarotreflektorplatte | タングステン infrared reflection beam |
| Tungsten UV Shielding | Tungsten UV Shielding | Blindage UV in tungstène | Wolfram-UV-Abstract | タングステン UV UV light |
| Tungsten Spectrometer Parts | Tungsten Spectrometer Component | Composant of spectromètres | Wolfram-Spektrometerbauteil | タングステン spectrometer parts |
| Tungsten high temperature filament | Tungsten High-Temperature Filament | Filament haute température en tungsten | Wolfram-Hochtemperaturfaden | タングステン High temperature filter |
| Tungsten incandescent filament | Tungsten Incandescent Lamp Filament | Filament de lampe à incandescence en tungsten | Wolfram-Glühlampenfaden | タングステン白熱ランプフィラメント |
| Tungsten halogen lamp filament | Tungsten Halogen Lamp Filament | Filament de lamp halogène en tungsten | Wolfram-Halogenlampenfaden | タングステンハロゲンランプフィラメント |
| Tungsten LED heat dissipation substrate | Tungsten LED Heat Dissipation Substrate | Substratum dissipation thermique pour LED en tungstène | Wolfram-LED-Wärmeableitungssubstrat | タングステン LED heat radiation substrate |
| Tungsten Laser Heat Sink | Tungsten Laser Heat Sink | Dissipateur thermique pour laser en tungsten | Wolfram -Laser- Wärmesenke | タングステンレーザーヒートシンク |
| Tungsten Fiber | Tungsten Fiber | Composer of | Wolfram-Glasfaserverbinderbauteil | タングステン |

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| Optic Connector Components | Optic Connector Component | connective tissue fiber optique en tungsten | | 光ファイバーコネクター parts |
| Tungsten Optical Coating Target | Tungsten Optical Coating Target | Cable de revêtement optique en tungstène | Wolfram-Optische Beschichtungsziel | タングステン optical optics |
| Tungsten high temperature resistant lens | Tungsten High-Temperature Lens | Lentille haute temperament in tungsten | Wolfram-Hochtemperaturlinse | タングステン High temperature レンズ |
| Tungsten infrared detector substrate | Tungsten Infrared Detector Substrate | Substratum destructor infrarouge en tungsten | Wolfram-Infrarotdetektorsubstrat | タングステン infrared ray detector substrate |
| Tungsten Copper 60/40 Rod | Tungsten Copper 60/40 Rod | Tige cuivre-tungsten 60/40 | Wolfram-Kupfer 60/40 Stab | タングステン copper 60/40 ロッド |
| Tungsten Copper 75/25 Plate | Tungsten Copper 75/25 Plate | Plaque cuivre-tungstène 75/25 | Wolfram-Kupfer 75/25 Plate | タングステン copper 75/25 プレート |
| Tungsten Copper 85/15 Block | Tungsten Copper 85/15 Block | Bulk cuivre-tungsten 85/15 | Wolfram-Kupfer 85/15 Block | タングステン copper 85/15 ブロック |
| Tungsten Silver 60/40 Rod | Tungsten Silver 60/40 Rod | Tige thick-tungsten 60/40 | Wolfram-Silber 60/40 Stab | タングステン silver 60/40 ロッド |
| Tungsten silver 75/25 plate | Tungsten Silver 75/25 Plate | Plaque argent-tungstène 75/25 | Wolfram-Silber 75/25 Plate | タングステン Silver 75/25 プレート |
| Tungsten silver 85/15 pieces | Tungsten Silver 85/15 Block | Block argent-tungsten 85/15 | Wolfram-Silber 85/15 Block | タングステン silver 85/15 ブロック |
| Tungsten Nickel Iron 85/10/5 Rod | Tungsten-Nickel-Iron 85/10/5 Rod | Tige tungstène-nickel-fer 85/10/5 | Wolfram-Nickel-Eisen 85/10/5 Stab | タングステン ニッケル鄄 85/10/5 ロッド |
| Tungsten Nickel Iron 95/3/2 Plate | Tungsten-Nickel-Iron 95/3/2 Plate | Plaque tungstène-nickel-fer 95/3/2 | Wolfram-Nickel-Eisen 95/3/2 Platte | タングステン ニッケル鄄 95/3/2 プレート |
| Tungsten Molybdenum 70/30 Rod | Tungsten-Molybdenum 70/30 Rod | Tige tungsten-molybdene 70/30 | Wolfram-Molybdä n 70/30 Stab | タングステン モリブデン 70/30 ロッド |
| Tungsten-Molybdenum | Tungsten-Molybdenum | Plaque tungsten-molybdene 50/50 | Wolfram-Molybdä n 50/50 Platte | タングステン モリブデン |

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| 50/50 Plate | 50/50 Plate | | | 50/50 プレート |
| Tungsten cobalt 80/20 blade | Tungsten-Cobalt 80/20 Blade | Laminate tungstène-cobalt 80/20 | Wolfram-Kobalt 80/20 Klinge | タングステンコバルト 80/20 ブレード |
| Tungsten Cobalt 90/10 Drill Bit | Tungsten-Cobalt 90/10 Drill Bit | Foret tungstène-cobalt 90/10 | Wolfram-Kobalt 90/10 Bohrer | タングステンコバルト 90/10 ドリルビット |
| Tungsten Rhenium 95/5 Wire | Tungsten-Rhenium 95/5 Wire | Fil tungstène-rhénium 95/5 | Wolfram-Rhenium 95/5 Draht | タングステンレニウム 95/5 ワイヤー |
| Tungsten Rhenium 75/25 Rod | Tungsten-Rhenium 75/25 Rod | Tige tungsten-rhénium 75/25 | Wolfram-Rhenium 75/25 Stab | タングステンレニウム 75/25 ロッド |
| Tungsten Titanium 90/10 Knife | Tungsten-Titanium 90/10 Tool | Outil tungstène-titane 90/10 | Wolfram-Titan 90/10 Werkzeug | タングステンチタン 90/10 tools |
| Tungsten Vanadium 85/15 Plate | Tungsten-Vanadium 85/15 Plate | Plaque tungsten-vanadium 85/15 | Wolfram-Vanadium 85/15 Plate | タングステンバナジウム 85/15 プレート |
| Tungsten Chrome 80/20 Rod | Tungsten-Chromium 80/20 Rod | Tige tungsten-chrome 80/20 | Wolfram-Chrom 80/20 Stab | タングステンクロム 80/20 ロッド |
| Tungsten manganese 70/30 block | Tungsten-Manganese 70/30 Block | Bloc tungsten-manganese 70/30 | Wolfram-Mangan 70/30 Block | タングステンマンガン 70/30 ブロック |
| Tungsten lanthanum 98/2 electrode | Lanthanum-Tungsten 98/2 Electrode | Électrode lanthane-tungstène 98/2 | Lanthan-Wolfram 98/2 Elektrode | ランタンタングステン 98/2 electrode |
| Cerium Tungsten 98/2 Electrode | Cerium-Tungsten 98/2 Electrode | Électrode c érium -tungsten è ne 98/2 | Cer-Wolfram 98/2 Elektrode | セリウムタングステン 98/2 electrode |
| Tungsten Copper 55/45 Rod | Tungsten Copper 55/45 Rod | Tige cuivre-tungsten 55/45 | Wolfram-Kupfer 55/45 Stab | タングステン copper 55/45 ロッド |
| Tungsten Copper 65/35 Plate | Tungsten Copper 65/35 Plate | Plaque cuivre-tungstène 65/35 | Wolfram-Kupfer 65/35 Plate | タングステン copper 65/35 プレート |
| Tungsten Copper 95/5 | Tungsten Copper 95/5 | Bulk cuivre-tungsten 95/5 | Wolfram-Kupfer 95/5 Block | タングステン copper 95/5 ブ |

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| Block | Block | | | ロック |
| Tungsten Silver 55/45 Rod | Tungsten Silver 55/45 Rod | Tige high-rise 55/45 | Wolfram-Silber 55/45 Stab | タングステン silver 55/45 ロッド |
| Tungsten silver 65/35 plate | Tungsten Silver 65/35 Plate | Plaque argent-tungstene 65/35 | Wolfram-Silber 65/35 Plate | タングステン silver 65/35 プレート |
| Tungsten Silver 95/5 Block | Tungsten Silver 95/5 Block | Block argent-tungsten 95/5 | Wolfram-Silber 95/5 Block | タングステン silver 95/5 ブロック |
| Tungsten Nickel Iron 80/15/5 Rod | Tungsten-Nickel-Iron 80/15/5 Rod | Tige tungstène-nickel-fer 80/15/5 | Wolfram-Nickel-Eisen 80/15/5 Stab | タングステンニッケル鄄 80/15/5 ロッド |
| Tungsten Nickel Iron 90/7/3 Plate | Tungsten-Nickel-Iron 90/7/3 Plate | Plaque tungstène-nickel-fer 90/7/3 | Wolfram-Nickel-Eisen 90/7/3 Platte | タングステンニッケル鄄 90/7/3 プレート |
| Tungsten Nickel Iron 93/5/2 Block | Tungsten-Nickel-Iron 93/5/2 Block | Bloc tungstène-nickel-fer 93/5/2 | Wolfram-Nickel-Eisen 93/5/2 Block | タングステンニッケル鄄 93/5/2 ブロック |
| Tungsten Molybdenum 60/40 Rod | Tungsten-Molybdenum 60/40 Rod | Tige tungsten-molybdene 60/40 | Wolfram-Molybd ä n 60/40 Stab | タングステンモリブデン 60/40 ロッド |
| Tungsten-molybdenum 80/20 plate | Tungsten-Molybdenum 80/20 Plate | Plaque tungsten-molybdene 80/20 | Wolfram-Molybd ä n 80/20 Platte | タングステンモリブデン 80/20 プレート |
| Tungsten Molybdenum 90/10 Block | Tungsten-Molybdenum 90/10 Block | Bloc tungsten-molybdene 90/10 | Wolfram-Molybdän 90/10 Block | タングステンモリブデン 90/10 ブロック |
| Tungsten cobalt 70/30 blade | Tungsten-Cobalt 70/30 Blade | Laminate tungstène-cobalt 70/30 | Wolfram-Kobalt 70/30 Klinge | タングステンコバルト 70/30 ブレード |
| Tungsten cobalt 85/15 drill bit | Tungsten-Cobalt 85/15 Drill Bit | Foret tungstène-cobalt 85/15 | Wolfram-Kobalt 85/15 Bohrer | タングステンコバルト 85/15 ドリルビット |
| Tungsten Cobalt 95/5 Cutting Tools | Tungsten-Cobalt 95/5 Tool | Outil tungstène-cobalt 95/5 | Wolfram-Kobalt 95/5 Werkzeug | タングステンコバルト 95/5 tool |

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| Tungsten Rhenium 90/10 Wire | Tungsten-Rhenium 90/10 Wire | Thickened rhinoideae 90/10 | Wolfram-Rhenium 90/10 Draht | タングステンレニウム 90/10 ワイヤー |
| Tungsten Rhenium 85/15 Rod | Tungsten-Rhenium 85/15 Rod | Tige tungsten-rhénium 85/15 | Wolfram-Rhenium 85/15 Stab | タングステンレニウム 85/15 ロッド |
| Tungsten Rhenium 50/50 Plate | Tungsten-Rhenium 50/50 Plate | Plaque tungsten-rhénium 50/50 | Wolfram-Rhenium 50/50 Plate | タングステンレニウム 50/50 プレート |
| Tungsten Titanium 80/20 Knife | Tungsten-Titanium 80/20 Tool | Outil tungstène-titane 80/20 | Wolfram-Titan 80/20 Werkzeug | タングステンチタン 80/20 tools |
| Tungsten Titanium 95/5 Rod | Tungsten-Titanium 95/5 Rod | Tige tungstène-titane 95/5 | Wolfram-Titan 95/5 Stab | タングステンチタン 95/5 ロッド |
| Tungsten Vanadium 90/10 Plate | Tungsten-Vanadium 90/10 Plate | Plaque tungsten-vanadium 90/10 | Wolfram-Vanadium 90/10 Plate | タングステンバナジウム 90/10 プレート |
| Tungsten Chrome 90/10 Rod | Tungsten-Chromium 90/10 Rod | Tige tungsten-chrome 90/10 | Wolfram-Chrom 90/10 Stab | タングステンクロム 90/10 ロッド |
| Tungsten chromium 70/30 plate | Tungsten-Chromium 70/30 Plate | Plaque tungsten-chrome 70/30 | Wolfram-Chrom 70/30 Plate | タングステンクロム 70/30 プレート |
| Tungsten manganese 80/20 pieces | Tungsten-Manganese 80/20 Block | Bloc tungsten-manganèse 80/20 | Wolfram-Mangan 80/20 Block | タングステンマンガン 80/20 ブロック |
| Tungsten Manganese 90/10 Rod | Tungsten-Manganese 90/10 Rod | Tige tungsten-manganèse 90/10 | Wolfram-Mangan 90/10 Stab | タングステンマンガン 90/10 ロッド |
| Tungsten lanthanum 95/5 electrode | Lanthanum-Tungsten 95/5 Electrode | Électrode lanthane-tungstène 95/5 | Lanthan-Wolfram 95/5 Elektrode | ランタンタングステン 95/5 electrode |
| Cerium Tungsten 95/5 Electrode | Cerium-Tungsten 95/5 Electrode | Électrode c érium -tungsten è ne 95/5 | Cer-Wolfram 95/5 Elektrode | セリウムタングステン 95/5 electrode |
| Thorium Tungsten 95/5 Electrode | Thorium-Tungsten 95/5 Electrode | Électrode thorium-tungstène 95/5 | Thorium-Wolfram 95/5 Elektrode | Torotron 95/5 electrode |
| Tungsten- | Zirconium- | Électrode | Zirkonium-Wolfram 95/5 Elektrode | ジルコニウム |

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| zirconium 95/5 electrode | Tungsten 95/5 Electrode | zirconium-tungsten è ne 95/5 | | タングステン 95/5 electrode |
| Tungsten Yttrium 95/5 Electrode | Yttrium-Tungsten 95/5 Electrode | Électrode yttrium-tungstène 95/5 | Yttrium-Wolfram 95/5 Elektrode | イットリウムタングステン 95/5 electrode |
| Tungsten high temperature thermocouple | Tungsten High-Temperature Thermocouple | Thermocouple haute température in tungsten | Wolfram-Hochtemperatur-Thermoelement | タングステン high temperature thermoelectric |
| Tungsten Heat Resistant Sensor | Tungsten Heat-Resistant Sensor | Capteur résistant à la chaleur en tungstène | Wolfram- Hitzbeständiger Sensor | タングステン heat-resistant センサー |
| Tungsten Pressure Sensor Components | Tungsten Pressure Sensor Component | Composition of capteurs in tungsten | Wolfram-Drucksensorbauteil | タングステン センサー parts |
| Tungsten temperature probe | Tungsten Temperature Probe | Sonde de température en tungstène | Wolfram-Temperatursonde | タングステン Temperature プローブ |
| Tungsten Flow Meter Components | Tungsten Flowmeter Component | Composant deeds in tungsten | Wolfram-Durchflussmesserbauteil | タングステン flowmeter parts |
| Tungsten level gauge electrode | Tungsten Level Gauge Electrode | Électrode de jauge de niveau en tungsten è ne | Wolfram-Füllstandsmesserelektrode | タングステン level gauge electrode |
| Tungsten Industrial Heat Sink | Tungsten Industrial Heat Sink | Dissipateur thermique industriel en tungstène | Wolfram -Industrie- Wärmesenke | タングステン industrial ヒートシンク |
| Tungsten Motor Rotor Weight | Tungsten Motor Rotor Counterweight | Contrepoids de rotor de moteur en tungstène | Wolfram-Motorrotor-Gegengewicht | タングステン モーターローターカウンターウェイト |
| Tungsten generator weight | Tungsten Generator Counterweight | Contrepoids de générateur en tungsten | Wolfram-Generator-Gegengewicht | Electric motor |
| Tungsten compressor blades | Tungsten Compressor Blade | Pale de compresseur en tungsten | Wolfram-Kompressorschaufel | タングステン コンプレッサーブレード |
| Tungsten pump impeller | Tungsten Pump Impeller | Pompe in tungstène | Wolfram-Pumpenlaufrad | タングステン ポンプインペラー |
| Tungsten valve seals | Tungsten Valve Sealing Gasket | Joint d'étanchéité de vanne en tungstène | Wolfram-Ventil-Dichtung | タングステン バルブシールガスケット |
| Tungsten wear-resistant piston | Tungsten Wear-Resistant Piston | Anneau de piston résistant à l'usure | Wolfram-Verschlei ß fester Kolbenring | タングステン |

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| ring | Ring | en tungstène | | anti-wear wear-resistance |
| Tungsten high temperature bolts | Tungsten High-Temperature Bolt | Boulon haute température en tungsten | Wolfram-Hochtemperaturschraube | タングステン high temperature ボルト |
| Tungsten Corrosion Resistant Nuts | Tungsten Corrosion-Resistant Nut | Errors in corrosion and corrosion | Wolfram-Korrosionsbest ä ndige Mutter | タングステン corrosion-resistant ナット |
| Tungsten Mechanical Drive Shaft | Tungsten Mechanical Drive Shaft | Arbre de transmission mécanique en tungstène | Wolfram-Mechanische Antriebswelle | タングステン Mechanical motion control system |
| Tungsten gear weights | Tungsten Gear Counterweight | Contrepoids d'engrenage en tungstène | Wolfram-Zahnrad-Gegenwicht | タングステン ギアカウンターウェイト |
| Tungsten wear-resistant gear | Tungsten Wear-Resistant Gear | Engagement in the environment | Wolfram-Verschlei ß festivals Zahnrad | タングステン anti-wear wear ギア |
| Tungsten Industrial Chain Components | Tungsten Industrial Chain Component | Composable in the industry | Wolfram-Industriekettenbauteil | タングステン industrial parts |
| Tungsten high temperature sprocket | Tungsten High-Temperature Sprocket | Pignon haute temperament in tungsten | Wolfram-Hochtemperaturkettenrad | High-temperature heat treatment |
| Tungsten Mining Crusher Hammer | Tungsten Mining Crusher Hammer | Marteau de concasses minier en tungstène | Wolfram-Bergbau-Brecherhammer | タングステン 犅クラッシャーハンマー |
| Tungsten Tunnel Boring Machine Tools | Tungsten Tunneling Machine Tool | Out of stock machine forage en tungsten | Wolfram-Tunnelbaumaschinenwerkzeug | タングステン boring machine tools |
| Tungsten rock drill bits | Tungsten Rock Drill Bit | Foretold perceuse and roches en tungsten | Wolfram-Felsbohrer | Gemstone |
| Wear-resistant lining for tungsten mine | Tungsten Mining Wear-Resistant Liner | Doublure résistante à l'usure pour mines en tungstène | Wolfram-Bergbau-Verschlei ß auskleidung | タングステン 鉱 industry wear resistant ライナー |
| Tungsten oil pipeline valve | Tungsten Oil Pipeline Valve | Vanne de pipeline pétrolier en tungstène | Wolfram - Ölpipelineventil | タングステン Petroleum Pipeline |
| Tungsten drilling fluid nozzle | Tungsten Drilling Fluid Nozzle | Buse of fluids in forage | Wolfram-Bohrflüssigkeitsdüse | タングステン excavating fluid ノズル |

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| Tungsten Oilfield Seal Ring | Tungsten Oilfield Sealing Ring | Anneau d'étanchéité pour champ petrolifere en tungstène | Wolfram- Ölfeld -Dichtring | タングステン oilfield sewage |
| Tungsten Natural Gas Pipeline Lining | Tungsten Natural Gas Pipeline Liner | Doublure of pipelines of nature in tungsten | Wolfram-Erdgaspipeline-Auskleidung | タングステン natural ガスパイプライナー |
| Tungsten deep sea drilling tools | Tungsten Deep-Sea Drilling Tool | Out of stock in haute mer in tungsten | Wolfram-Tiefseebohrwerkzeug | タングステン deep sea drilling tools |
| Tungsten Offshore Counterweight | Tungsten Marine Engineering Counterweight | Contrepoids pour ingénierie marine en tungstène | Wolfram-Marinebau-Gegengewicht | タングステン Marine Engineering Technology |
| Tungsten Ship Propeller Parts | Tungsten Ship Propeller Component | COMPOSANT D'hélice de navire en tungstène | Wolfram-Schiffspropellerbauteil | タングステン shipbuilding parts |
| Tungsten Submarine Pressure Hull Components | Tungsten Submarine Pressure Hull Component | Composant coque sous pression de sous-marin en tungstène | Wolfram-U-Boot - Druckkörperbauteil | タングステン submarine pressure-resistant hull parts |
| Tungsten Submarine Cable Shielding | Tungsten Subsea Cable Shielding | Blind age in tungsten è ne | Wolfram-Unterseekabel-Abschirmung | タングステン Undersea ケーブルシールド |
| Tungsten Ocean Sensor Components | Tungsten Marine Sensor Component | Composant capteur marin en tungstène | Wolfram-Marinesensorbauteil | タングステン 海センサー parts |
| Tungsten Automobile Engine Counterweight | Tungsten Car Engine Counterweight | Contradictions of moteurs in tungsten | Wolfram-Automotor-Gegengewicht | Electric car |
| Tungsten brake pad wear layer | Tungsten Brake Pad Wear Layer | Couple of things to do in the future | Wolfram-Bremsbelag-Verschleischicht | タングステン ブレーキパッド anti- wear layer |
| Tungsten Crankshaft Weights | Tungsten Crankshaft Counterweight | Contrepoids de vilebrequin en tungstène | Wolfram-Kurbelwellen-Gegengewicht | タングステン クランクシャフトカウンターウェイト |
| Tungsten turbocharger parts | Tungsten Turbocharger Component | Composant de turbocompresseur en tungstène | Wolfram-Turboladerbauteil | タングステン ターボチャージャー parts |
| Tungsten Automobile Exhaust Pipe | Tungsten Car Exhaust Pipe Liner | Doubly troubling and tungsten | Wolfram-Autoauspuffrohr-Auskleidung | タングステン automatic car exhaust pipe |

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| Lining | | | | ライナー |
| Tungsten Racing Wheel Weights | Tungsten Racing Wheel Counterweight | Contradictions of course in tungsten | Wolfram-Rennrad-Gegengewicht | タングステンレースホイールカウンターウェイト |
| Tungsten high-speed rail brake disc parts | Tungsten High-Speed Train Brake Disc Component | Composing the difference between trains and trains | Wolfram-Hochgeschwindigkeitszug-Bremsscheibenbauteil | タングステン Highway Railway Railroad Parts |
| Tungsten Railway Track Wear Parts | Tungsten Railway Track Wear Part | Piece of cake | Wolfram-Eisenbahnschienen-Verschlei ß teil | タングステン rail track wear-resistant parts |
| Tungsten Train Wheel Weights | Tungsten Train Wheel Counterweight | Contrepoids in trains in tungsten | Wolfram-Zugrad-Gegenwicht | タングステン train wheel カウンターウェイト |
| Tungsten Aircraft Tire Weights | Tungsten Aircraft Tire Counterweight | Contrepoids de pneumatic d'avion en tungstène | Wolfram-Flugzeugreifen-Gegengewicht | タングステン AIR AIRLINES |
| Tungsten Drone Motor Parts | Tungsten Drone Motor Component | Composer of moteurs and drones | Wolfram-Drohnenmotorbauteil | タングステンドローンモーター parts |
| Tungsten spacecraft heat shield | Tungsten Spacecraft Thermal Protection Plate | Plaque of protection thermique of vacuum space in tungsten | Wolfram -Raumschiff-Wärmeschutzplatte | タングステン spaceship thermal protection プレート |
| Tungsten Satellite Dish Base | Tungsten Satellite Antenna Base | Base d'antenne de satellite en tungstène | Wolfram - Satellitenantennenbasis | タングステン SATELLITE アンテナベース |
| Tungsten Aerospace Gyroscope Components | Tungsten Aerospace Gyroscope Component | Composant de gyroscope aerospatial en tungsten | Wolfram-Luftfahrt-Gyroskopbauteil | タングステン aerospace equipment parts |
| Tungsten Space Station Shielding | Tungsten Space Station Shielding | Blind age in station spatiale en tungsten | Wolfram-Raumstationsabschirmung | タングステン universe space ションシールド |
| Tungsten Planetary Probe Components | Tungsten Planetary Probe Component | Composant sonde planétaire en tungsten | Wolfram-Planetenforschungssondenbauteil | タングステン planet exploration machine parts |
| Tungsten Lunar Rover | Tungsten Lunar Rover | Contrepoids de rover lunaire en | Wolfram-Mondrover-Gegengewicht | タングステン lunar vehicle |

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| Counterweight | Counterweight | tungstène | | カウンターウェイト |
| Tungsten Mars Exploration Wear-Resistant Parts | Tungsten Mars Exploration Wear Part | Continuous exploration of Mars in tungsten | Wolfram-Marsforschung-Verschleiß teil | タングステン Mars Exploration Wear-resistant Parts |
| Tungsten Space Telescope Substrates | Tungsten Space Telescope Substrate | Substratum of telescopic space in tungsten | Wolfram-Weltraumteleskopsubstrat | タングステン space telescope substrate |
| Tungsten Microsatellite Components | Tungsten Microsatellite Component | Composition of microsatellites in tungsten | Wolfram-Mikrosatellitenbauteil | タングステン マイクロサテライト parts |
| Tungsten Aerospace Thruster Nozzles | Tungsten Aerospace Thruster Nozzle | Buse de propulseur aérospatial en tungsten | Wolfram-Luftfahrt-Antriebsdüse | タングステン aerospace space science |
| Tungsten interstellar detection shielding | Tungsten Interstellar Probe Shielding | Blind age in sonde interstellaire en tungstène | Wolfram-Interstellar-Sondenabschirmung | Star Exploration System |
| Tungsten Rocket Heat Shield | Tungsten Rocket Insulation Plate | Plaque isolation in fusée en tungsten | Wolfram-Raketen-Isolierplatte | タングステン ロケット縁プレート |
| Tungsten Spacecraft Wear Lining | Tungsten Spacecraft Wear-Resistant Liner | Doublure résistante à l'usure de vaisseau spatial en tungstène | Wolfram-Raumschiff-Verschleiß auskleidung | タングステン spaceship wear-resistant ライナー |
| Tungsten Microwave Transmitter Components | Tungsten Microwave Emitter Component | Composant d'émetteur micro-ondes en tungsten | Wolfram-Mikrowellenstrahlerbauteil | タングステン マイクロ波エミッター parts |
| Tungsten Radar Antenna Substrate | Tungsten Radar Antenna Substrate | Substrata d'antenne radar en tungstène | Wolfram-Radarantennensubstrat | タングステン レーダーアンテナ substrate |
| Tungsten Communication n Equipment Heat Sink | Tungsten Communication Device Heat Sink | Dissipate thermique pour communication in tungsten | Wolfram-Kommunikationsgerät Wärmesenke | Telecom communication equipment |
| Tungsten Radio Transmitter Parts | Tungsten Radio Transmitter Component | Composant d'émetteur radio en tungstène | Wolfram-Radiosenderbauteil | タングステン wireless transmitter parts |
| Tungsten Antenna Support | Tungsten Antenna Support | Support d'antenne en tungstène | Wolfram-Antennenstütze | タングステン アンテナサポート |

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| Tungsten signal amplifier substrate | Tungsten Signal Amplifier Substrate | Substratum d'amplificateur de signal en tungstène | Wolfram - Signalverstärkersubstrat | タングステン signal amplifier board |
| Tungsten electronic countermeasure components | Tungsten Electronic Countermeasure Component | Composer of contre-mesure in tungsten | Wolfram-Elektronische Gegenma ß nahmenbauteil | タングステン electronic resistive parts |
| Tungsten radar reflector | Tungsten Radar Reflector | Réflecteur radar in tungsten | Wolfram-Radarreflektor | タングステンレーダーリフレクター |
| Tungsten navigation equipment weight | Tungsten Navigation Device Counterweight | Contrary to navigation in tungsten | Wolfram-Navigationsgerät - Gegengewicht | タングステンナビゲーション machine カウンターウェイト |
| Tungsten gyroscope rotor | Tungsten Gyroscope Rotor | Rotor de gyroscope in tungsten | Wolfram-Gyroskoprotor | タングステンジャイロスコープローター |
| Tungsten Inertial Navigation Unit | Tungsten Inertial Navigation Component | Composant navigation inertielle en tungstène | Wolfram-Inertialnavigationsbauteil | タングステン inertial navigation parts |
| Tungsten precision instrument shielding | Tungsten Precision Instrument Shielding | Blind age and instrumentation in tungsten | Wolfram-Pr ä zisionsinstrument-Abschirmung | タングステン precision machine tool |
| Tungsten Laboratory Heating Plate | Tungsten Laboratory Heating Plate | Plaque chauffante de laboratoire en tungstène | Wolfram-Laboratory Platform | タングステン実験 Chamber Heating Room |
| Tungsten Analytical Instrument Probes | Tungsten Analytical Instrument Probe | Sonde d'instrument analysis in tungsten | Wolfram-Analyseinstrument-Sonde | タングステン analytical machine プローブ |
| Tungsten Experimental Reactor Components | Tungsten Experimental Reactor Component | Composant experience in tungsten | Wolfram-Experimenteller Reaktorbauteil | タングステン実験 reactor parts |
| Tungsten High Temperature Test Fixture | Tungsten High-Temperature Test Fixture | Fixation of test conditions in tungsten | Wolfram-Hochtemperatur-Testvorrichtung | High-temperature thermometer |
| Tungsten scientific research weight | Tungsten Research Counterweight | Contrepoids de recherche en tungstène | Wolfram-Forschungs-Gegengewicht | タングステンカウンターウェイト for research |
| Tungsten wear plate for | Tungsten Experimental | Plaque résistante à l'usure | Wolfram-Experimentelle Verschlei ß platte | タングステン |

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| experiment | Wear-Resistant Plate | expérimentale en tungstène | | 実験 use wear-resistant プレート |
| Tungsten powder 0.1-0.5 micron | Tungsten Powder 0.1-0.5 µm | Poudre de tungsten 0,1-0,5 µm | Wolframpulver 0.1-0.5 µm | タングステンパウダー0.1-0.5 ミクロン |
| Tungsten powder 0.5-1 micron | Tungsten Powder 0.5-1 µm | Poudre de tungsten 0,5-1 µm | Wolframpulver 0,5-1 µm | タングステンパウダー0.5-1 ミクロン |
| Tungsten powder 1-5 microns | Tungsten Powder 1-5 µm | Tungstène volume 1-5 µm | Wolframpulver 1-5 µm | タングステンパウダー1-5 ミクロン |
| Tungsten powder 5-10 microns | Tungsten Powder 5-10 µm | Poudre de tungstene 5-10 µm | Wolframpulver 5-10 µm | タングステンパウダー5-10 ミクロン |
| Tungsten powder 100-200 microns | Tungsten Powder 100-200 µm | Poudre de tungsten 100-200 µm | Wolframpulver 100-200 µm | タングステンパウダー100-200 ミクロン |
| Tungsten powder 200-500 microns | Tungsten Powder 200-500 µm | Poudre de tungsten 200-500 µm | Wolframpulver 200-500 µm | タングステンパウダー200-500 ミクロン |
| Tungsten carbide powder 0.1-0.5 micron | Tungsten Carbide Powder 0.1-0.5 µ m | Poudre de carbure tungstène 0,1-0,5 µ m | Wolframcarbidpulver 0,1-0,5 µ m | Carbonized carbon fiber 0.1-0.5 ミクロン |
| Tungsten carbide powder 1-5 microns | Carbide Powder 1-5 µm | Poudre de carburetungstène 1-5 µm | Wolframcarbidpulver 1-5 µm | Carbonized タングステンパウダー1-5 ミクロン |
| Tungsten carbide powder 10-20 microns | Tungsten Carbide Powder 10-20 µm | Poudre de carburetungstène 10-20 µ m | Wolframcarbidpulver 10-20 µ m | Carbonized タングステンパウダー10-20 ミクロン |
| Tungsten carbide powder 50-100 microns | Tungsten Carbide Powder 50-100 µ m | Poudre de carburetungstène 50-100 µ m | Wolframcarbidpulver 50-100 µ m | Carbonized タングステンパウダー50-100 ミクロン |
| High purity tungsten powder 0.5-1 micron | High-Purity Tungsten Powder 0.5-1 µm | Poudre de tungsten haute pureté 0,5-1 µ m | Hochreines Wolframpulver 0,5-1 µ m | High purity polyester 0.5-1 ミクロン |
| High purity tungsten powder 5-10 microns | High -Purity Tungsten Powder 5-10 µm | Poudre de tungsten haute pureté 5-10 µ m | Wolframpulver 5-10 µm | High purity polyester 5-10 ミクロン |

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| Spherical tungsten powder 1-5 microns | Tungsten Powder 1-5 μm | tungsten 1-5 μm | Sphä risches Wolframpulver 1-5 μ m | Spherical タングステンパウダー1-5 ミクロン |
| Spherical tungsten powder 10-20 microns | Tungsten Powder 10-20 μm | Poudre sphérique de tungsten 10-20 μm | Sph ä risches Wolframpulver 10-20 μ m | Spherical タングステンパウダー10-20 ミクロン |
| Nano tungsten powder 50-100 nanometers | Nano Tungsten Powder 50-100 nm | Poudre nano detungsten 50-100 nm | Nano-Wolframpulver 50-100 nm | ナノタングステンパウダー50-100 ナノメートル |
| Nano tungsten powder 100-200 nanometers | Nano Tungsten Powder 100-200 nm | Poudre nano detungsten 100-200 nm | Nano-Wolframpulver 100-200 nm | ナノタングステンパウダー100-200 ナノメートル |
| Ultrafine tungsten powder 0.5-2 microns | Ultrafine Tungsten Powder 0.5-2 μ m | Poudre ultrafine detungsten 0,5-2 μ m | Ultrafeines Wolframpulver 0,5-2 μ m | Ultra-fine micrometer 0.5-2 micron |
| Ultrafine tungsten powder 2-5 microns | Ultrafine Tungsten Powder 2-5 μm | Poudre ultrafine detungsten 2-5 μm | Ultrafeines Wolframpulver 2-5 μ m | Ultra-fine fiberglass 2-5 micrometer |
| Tungsten AI Processor Heat Sink | Tungsten AI Processor Heat Sink | Dissipateur thermique pour processeur AI en tungstène | Wolfram -KI-Prozessor-Wärmesenke | タングステン AI プロセッサヒートシンク |
| Tungsten AI chip heat dissipation substrate | Tungsten AI Chip Heat Dissipation Substrate | Substrate the dissipation thermique pour puce AI en tungstène | Wolfram-KI-Chip-W ä rmeableitungssubstrat | タングステン AI チップ heat-radiating substrate |
| Tungsten AI Server Shield | Tungsten AI Server Shielding | Blind age of server AI en tungsten | Wolfram-KI-Server-Abstract | タングステン AI サーバーシールド |
| Tungsten AI Computing Module Counterweight | Tungsten AI Computing Module Counterweight | Contrepoids de module de calculus AI en tungstène | Wolfram-KI-Rechenmodul-Gegengewicht | タングステン AI calculation モジュールカウンターウェイト |
| Tungsten AI sensor wear-resistant shell | Tungsten AI Sensor Wear-Resistant Shell | Coque résistante à l'usure pour capteur AI en tungstène | Wolfram-KI-Sensor-Verschlei ß scale | タングステン AI センサー abrasion-resistant シェル |

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| Tungsten AI Robot Joint Parts | Tungsten AI Robot Joint Component | Composer of robot AI in tungsten | Wolfram-KI-Roboter-Gelenkbauteil | タングステン AI ロボット joint parts |
| Tungsten AI Robot Arm Wear Parts | Tungsten AI Robot Arm Wear Part | Pieces of work in tungsten | Wolfram-KI-Roboterarm-Verschleiß teil | タングステン AI ロボットアーム wear-resistant parts |
| Tungsten AI Vision System Substrate | Tungsten AI Vision System Substrate | Substratum de système de vision AI en tungstène | Wolfram-KI-Visionssystemsubstrat | タングステン AI ビジョンシステム substrate |
| Tungsten AI Data Center Heat Pipe | Tungsten AI Data Center Heat Pipe | Tuyau thermique de center de données AI en tungstène | KI -Rechenzentrum- Wärmerohr | タングステン AI データセンターヒートパイプ |
| Tungsten AI Control Unit Shield | Tungsten AI Control Unit Shielding | Blind age in controversies | Wolfram-KI-Steuergerät - Abschirmung | タングステン AI controlled ユニットシールド |
| Tungsten drone weight | Tungsten Drone Counterweight | Contrepoids in drones | Wolfram-Drohnen-Gegengewicht | タングステンドローンカウンターウェイト |
| Tungsten UAV Motor Rotor | Tungsten Drone Motor Rotor | Rotor de moteur de drone en tungstène | Wolfram-Drohnenmotorrotor | タングステンドローンモーターローター |
| Tungsten drone propeller parts | Tungsten Drone Propeller Component | Composant d'hélice de drone en tungstène | Wolfram-Drohnenpropellerbauteil | タングステンドローンプロペラ parts |
| Tungsten UAV wear-resistant bearings | Tungsten Drone Wear-Resistant Bearing | Roulement résistant à l'usure de drone en tungstène | Wolfram-Drohnen-Verschleiß lager | タングステンドローン resistant wear and tear wear resistant |
| Tungsten UAV Navigation Substrate | Tungsten Drone Navigation Substrate | Substratum of navigation in drones | Wolfram-Drohnen-Navigationssubstrat | タングステンドローンナビゲーション substrate |
| Tungsten Drone Transmission Gear | Tungsten Drone Transmission Gear | Engage in transmission of drones in tungsten | Wolfram-Drohnen-Getriebezahnrad | タングステンドローン伝動ギア |
| Tungsten UAV Hydraulic Valves | Tungsten Drone Hydraulic Valve | Vanne hydraulique de drone en tungstène | Wolfram-Drohnen-Hydraulikventil | タングステンドローン oil 弁バルブ |

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| Tungsten UAV Heat Sink | Tungsten Drone Heat Sink | Dissipateur thermique of drone en tungsten | Wolfram -Drohnen- Wärmesenke | タングステンドローンヒートシンク |
| Tungsten UAV fuselage shielding | Tungsten Drone Fuselage Shielding | Blindness of fuselage in tungsten | Wolfram-Drohnen-Rumpfabschirmung | タングステンドローンBody シールド |
| Tungsten Drone Camera Mount | Tungsten Drone Camera Base | Base of caméra in tungsten | Wolfram-Drohnen-Kamerabasis | タングステンドローンカメラベース |
| Tungsten counterweight for unmanned vehicles | Tungsten Unmanned Vehicle Counterweight | Contradictions in véhicule sans pilote en tungsten | Wolfram-Fahrerloses Fahrzeug-Gegengewicht | Autonomous vehicle Autonomous vehicle |
| Tungsten unmanned vehicle motor rotor | Tungsten Unmanned Vehicle Motor Rotor | Rotor de moteur de véhicule sans pilote en tungstène | Wolfram-Fahrerloser Fahrzeugmotorrotor | Autonomous vehicle driverless car |
| Tungsten unmanned vehicle wheel hub parts | Tungsten Unmanned Vehicle Wheel Hub Component | Composer of moyeu and route of véhicule sans pilote en tungsten | Wolfram-Fahrerloses Fahrzeugradnabenbauteil | タングステンunmanned vehicle ホイールハブparts |
| Tungsten wear-resistant gear for unmanned vehicles | Tungsten Unmanned Vehicle Wear-Resistant Gear | Engaging in a new way of life | Wolfram-Fahrerloses Fahrzeug-Verschlei ß zahnrad | タングステンunmanned vehicle wear-resistant ギア |
| Tungsten Autonomous Vehicle Navigation Sensor | Tungsten Unmanned Vehicle Navigation Sensor | Capturing navigation in tungsten | Wolfram-Fahrerloser Fahrzeug-Navigationssensor | Autonomous vehicle driverless car |
| Tungsten unmanned vehicle drive shaft | Tungsten Unmanned Vehicle Drive Shaft | Arbre de transmission de véhicule sans pilote en tungstène | Wolfram-Fahrerloser Fahrzeug-Antriebswelle | タングステンUnmanned vehicle 伝动シャフト |
| Tungsten unmanned vehicle hydraulic piston | Tungsten Unmanned Vehicle Hydraulic Piston | Piston hydraulique de véhicule sans pilote en tungsten | Wolfram-Fahrerloser Fahrzeug-Hydraulikkolben | タングステンUnmanned vehicle oil pressure meter |
| Tungsten unmanned vehicle brake disc parts | Tungsten Unmanned Vehicle Brake Disc Component | Composers of different kinds of things | Wolfram-Fahrerloses Fahrzeug-Bremsscheibenbauteil | タングステンunmanned vehicle ブレーキディスクparts |

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| Tungsten unmanned vehicle suspension weight | Tungsten Unmanned Vehicle Suspension Counterweight | Contradictory suspensions in véhicule sans pilote en tungsten | Wolfram-Fahrerloses Federungs-Gegengewicht | Fahrzeug- | Autonomous vehicle driverless vehicle |
| Tungsten unmanned vehicle wear resistant lining | Tungsten Unmanned Vehicle Wear-Resistant Liner | Doublure résistante à l'usure de véhicule sans pilote en tungstène | Wolfram-Fahrerloses Verschlei ß auskleidung | Fahrzeug- | タングステン unmanned vehicle wear-resistant ライナー |
| Tungsten counterweight for unmanned ship | Tungsten Unmanned Vessel Counterweight | Contradictions in navigation | Wolfram-Fahrerloses Gegengewicht | Schiff- | タングステン unmanned ship カウンターウェイト |
| Tungsten unmanned boat propeller parts | Tungsten Unmanned Vessel Propeller Component | Composant work in navire sans pilote en tungsten | Wolfram-Fahrerloses Propellerbauteil | Schiff- | タングステン unmanned ship プロペラ parts |
| Tungsten unmanned boat steering gear parts | Tungsten Unmanned Vessel Rudder Component | Composant gouvernail navire sans pilote en tungsten | Wolfram-Fahrerloses Ruderbauteil | Schiff- | タングステン unmanned ship steering gear parts |
| Tungsten wear-resistant bearings for unmanned ships | Tungsten Unmanned Vessel Wear-Resistant Bearing | Roulement résistant à l'usure de navire sans pilote en tungstène | Wolfram-Fahrerloses Verschlei ß lager | Schiff- | タングステン unmanned ship wear-resistant ベアリング |
| Tungsten unmanned ship navigation substrate | Tungsten Unmanned Vessel Navigation Substrate | Substratum navigation in navigation | Wolfram-Fahrerloses Navigationssubstrat | Schiff- | タングステン unmanned ship ナビゲーション substrate |
| Tungsten unmanned ship drive sprocket | Tungsten Unmanned Vessel Transmission Sprocket | Transmission in navigation | Wolfram-Fahrerloses Getriebekettenrad | Schiff- | タングステン Unmanned ship スプロケット |
| Tungsten Drone Hydraulic Valve | Tungsten Unmanned Vessel Hydraulic Valve | Vanne hydraulique de navire sans pilote en tungstène | Wolfram-Fahrerloses Hydraulikventil | Schiff- | タングステン unmanned ship oil pressure sensor |
| Tungsten corrosion resistant lining for unmanned ships | Tungsten Unmanned Vessel Corrosion-Resistant Liner | Doubling down on corrosion and corrosion | Wolfram-Fahrerloses Korrosionsbest ä ndige Auskleidung | Schiff- | タングステン Unmanned Ship Scavenger-resistant Rana |
| Tungsten drone propulsion | Tungsten Unmanned | Composant propulsion of | Wolfram-Fahrerloses Antriebsbauteil | Schiff- | タングステン unmanned ship |

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| components | Vessel Thruster Component | navire sans pilote en tungsten | | | propeller parts |
| Tungsten underwater sensor for unmanned vessels | Tungsten Unmanned Vessel Underwater Sensor | Capteur sous-marin de navire sans pilote en tungstène | Wolfram-Fahrerloses Unterwassersensor | Schiff- | タングステン Unmanned ship underwater センサー |
| Tungsten drone navigation gyroscope | Tungsten Autonomous Navigation Gyroscope | Gyroscope de navigation autonome en tungsten | Wolfram-Autonome Navigationsgyroskop | | タングステン Unmanned Transport 転ナビゲーションジャイロスコープ |
| Tungsten Unmanned Drone Radar Substrate | Tungsten Autonomous Radar Substrate | Substrata de radar autonome en tungstène | Wolfram-Autonomes | Radarsubstrat | タングステン unmanned transport robot substrate |
| Tungsten unmanned laser ranging components | Tungsten Autonomous Lidar Component | Composant lidar autonome en tungstène | Wolfram-Autonomes | Lidarbauteil | タングステン unmanned aerial vehicle range measuring parts |
| Tungsten Unmanned Driving Inertial Sensor | Tungsten Autonomous Inertial Sensor | Capteur inertiel autonome en tungstène | Wolfram-Autonomer | Inertialsensor | タングステン Unmanned Transport Inertial System |
| Tungsten drone navigation weight | Tungsten Autonomous Navigation Counterweight | Contrepoids de navigation autonome en tungstène | Wolfram-Autonome Gegengewicht | Navigations- | Unmanned transport system |
| Tungsten unmanned driving positioning substrate | Tungsten Autonomous Positioning Substrate | Substrate positioning autonome en tungstène | Wolfram-Autonomes Positionierungssubstrat | | タングステン Unmanned Vehicle Position Decision Board |
| Tungsten Drone Antenna Components | Tungsten Autonomous Antenna Component | Composant d'antenne autonome en tungstène | Wolfram-Autonome Antennenbauteil | | タングステン unmanned transport アンテナ parts |
| Tungsten Drone Signal Amplifier | Tungsten Autonomous Signal Amplifier | Amplificateur signal autonome en tungstène | Wolfram-Signalverstärker | Autonomer | タングステン unmanned transport signal amplifier |
| Tungsten heat sink for unmanned navigation | Tungsten Autonomous Navigation Heat Sink | Dissipateur thermique de navigation autonome en tungstène | Wolfram -Autonome Wärmesenke | Navigations- | タングステン Unmanned Transport 転ナビゲーションヒートシン |

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| Tungsten Drone Shield | Tungsten Autonomous Shielding Cover | Capot de blindage autonome en tungstène | Wolfram-Autonome Abschirmhaube | | タングステン Unmanned Transport System |
| Tungsten Drone Mechanical Gear | Tungsten Autonomous Machinery Gear | Engagement of machineries in tungsten | Wolfram-Autonome Maschinenzahnrad | | タングステン unmanned transport machinery ギア |
| Tungsten driverless machinery chain | Tungsten Autonomous Machinery Chain | Cha îne de machinerie autonome en tungsten è ne | Wolfram-Autonome Maschinenkette | | タングステン Unmanned Transport Machinery チェーン |
| Tungsten bearings for autonomous machines | Tungsten Autonomous Machinery Bearing | Roulement de machinerie autonome en tungstène | Wolfram-Autonome Maschinenlager | | タングステン unmanned transport machinery ベアリング |
| Tungsten driverless mechanical shaft | Tungsten Autonomous Machinery Shaft | Arbre de machinerie autonome en tungstène | Wolfram-Autonome Maschinenwelle | | タングステン unmanned transport machinery シャフト |
| Tungsten unmanned machinery lining | Tungsten Autonomous Machinery Liner | Doublure de machinerie autonome en tungstène | Wolfram-Autonome Maschinenauskleidung | | タングステン Unmanned Transport Machinery ライナー |
| Tungsten driverless mechanical roller | Tungsten Autonomous Machinery Roller | Rouleau de machinerie autonome en tungstène | Wolfram-Autonome Maschinenwalze | | タングステン Unmanned Transport Machinery ローラー |
| Tungsten unmanned machine tool | Tungsten Autonomous Machinery Tool | Outil de machinerie autonome en tungstène | Wolfram-Autonome Maschinenwerkzeug | | タングステン unmanned transport machinery tools |
| Tungsten counterweight for unmanned machinery | Tungsten Autonomous Machinery Counterweight | Contrepoids de machinerie autonome en tungstène | Wolfram-Autonome Gegengewicht | Maschinen- | タングステン Unmanned transport machinery カウンターウェイト |

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| Tungsten Unmanned Machinery Gasket | Tungsten Autonomous Machinery Gasket | Joint machinerie autonome tungstène | de en | Wolfram-Autonome Maschinendichtung | | タングステン unmanned transport machine ガスケット |
| Tungsten Drone Machine Bolts | Tungsten Autonomous Machinery Bolt | Boulon machinerie autonome tungstène | de en | Wolfram-Autonome Maschinenschraube | | タングステン unmanned transport machinery ボルト |
| Tungsten driverless transmission gear | Tungsten Autonomous Transmission Gear | Engagement transmission autonome tungsten | in de en | Wolfram-Autonome Getriebezahnrad | | タングステン unmanned transport |
| Tungsten driverless transmission sprocket | Tungsten Autonomous Transmission Sprocket | Pignon transmission autonome tungstène | de en | Wolfram-Autonome Getriebekettenrad | | Unmanned transport system |
| Tungsten driverless drive shaft | Tungsten Autonomous Transmission Shaft | Arbre transmission autonome tungstène | de en | Wolfram-Autonome Getriebewelle | | タングステン unmanned transport vehicle |
| Tungsten driverless transmission chain | Tungsten Autonomous Transmission Chain | Cha îne transmission autonome tungsten è ne | de en | Wolfram-Autonome Getriebekette | | タングステン Unmanned transport vehicle |
| Tungsten driverless transmission bearings | Tungsten Autonomous Transmission Bearing | Route transmission autonome tungsten | of in | Wolfram-Autonome Getriebelager | | タングステン Unmanned transport vehicle |
| Tungsten Drone Drive Pulley | Tungsten Autonomous Transmission Pulley | Poulie transmission autonome tungstène | de en | Wolfram-Autonome Getrieberiemenscheibe | | タングステン Unmanned transport vehicle |
| Tungsten driverless transmission clutch | Tungsten Autonomous Transmission Clutch | Embroidery transmission autonomes tungsten | of in | Wolfram-Autonome Getriebekupplung | | Unmanned transport system |
| Tungsten unmanned transport transmission weight | Tungsten Autonomous Transmission Counterweight | Contrepoids transmission autonome tungstène | de en | Wolfram-Autonome Gegengewicht | Getriebe- | Unmanned transport system |
| Tungsten unmanned transmission wear parts | Tungsten Autonomous Transmission Wear Part | Pieces transmission tungsten | of in | Wolfram-Autonome Verschlei ß teil | Getriebe- | タングステン Unmanned aerial vehicle wear-resistant parts |

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| Tungsten driverless transmission seals | Tungsten Autonomous Transmission Seal | Joint transmission autonome tungstène | de en | Wolfram-Autonome Getriebedichtung | | タングステン unmanned transport vehicle |
| Tungsten driverless hydraulic valve | Tungsten Autonomous Hydraulic Valve | Vanne hydraulique autonome tungstène | en | Wolfram-Autonome Hydraulikventil | | タングステン unmanned transport oil pressure gauge |
| Tungsten Drone Hydraulic Piston | Tungsten Autonomous Hydraulic Piston | Piston hydraulique autonome tungstène | en | Wolfram-Autonome Hydraulikkolben | | タングステン Unmanned transportation oil pressure ストン |
| Tungsten unmanned hydraulic cylinder lining | Tungsten Autonomous Hydraulic Cylinder Liner | Double cylindrical hyaluronic acid in tungsten | | Wolfram-Autonome Hydraulikzylinder-Auskleidung | | タングステン Unmanned transportation oil pressure シリンダーライナー |
| Tungsten Drone Hydraulic Pipe | Tungsten Autonomous Hydraulic Pipe | Tuyau hydraulique autonome tungstène | en | Wolfram-Autonome | Hydraulikrohr | タングステン Unmanned transportation oil pressure pump |
| Tungsten Drone Hydraulic Sealing Ring | Tungsten Autonomous Hydraulic Sealing Ring | Anneau d'étanchéité hydraulique autonome tungstène | en | Wolfram-Autonome Dichtring | Hydraulik- | タングステン Unmanned transportation oil pressure シールリング |
| Tungsten Drone Hydraulic Pump Components | Tungsten Autonomous Hydraulic Pump Component | Composant depompe hydraulique autonome tungstène | en | Wolfram-Autonome Hydraulikpumpenbauteil | | タングステン unmanned transport oil pressure gauge parts |
| Tungsten unmanned transport hydraulic counterweight | Tungsten Autonomous Hydraulic Counterweight | Contrepoids hydraulique autonome tungstène | en | Wolfram-Autonome Gegengewicht | Hydraulik- | タングステン Unmanned transportation oil pressure カウンターウェイト |
| Tungsten unmanned transport hydraulic wear parts | Tungsten Autonomous Hydraulic Wear Part | Piece résistante à l'usure hydraulique autonome tungstène | en | Wolfram-Autonome Verschlei ß teil | Hydraulik- | タングステン unmanned transport oil pressure and wear-resistant parts |
| Tungsten unmanned | Tungsten Autonomous | Buse hydraulique autonome | en | Wolfram-Autonome | Hydraulikdüse | タングステン |

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| transport hydraulic nozzle | Hydraulic Nozzle | tungstène | | | Unmanned transportation oil pressure gauge |
| Tungsten unmanned transport hydraulic gasket | Tungsten Autonomous Hydraulic Gasket | Joint hydraulique autonome en tungstène | Wolfram-Autonome Hydraulikdichtung | | タングステン Unmanned transportation oil pressure ガスケット |
| Tungsten Copper 45/55 Rod | Tungsten Copper 45/55 Rod | Tige cuivre-tungsten 45/55 | Wolfram-Kupfer 45/55 Stab | | タングステン copper 45/55 ロッド |
| Tungsten Copper 40/60 Plate | Tungsten Copper 40/60 Plate | Plaque cuivre-tungstène 40/60 | Wolfram-Kupfer 40/60 Plate | | タングステン copper 40/60 プレート |
| Tungsten Copper 30/70 Block | Tungsten Copper 30/70 Block | Block cuivre-tungsten 30/70 | Wolfram-Kupfer 30/70 Block | | タングステン copper 30/70 ブロック |
| Tungsten Silver 45/55 Rod | Tungsten Silver 45/55 Rod | Tige high-rise 45/55 | Wolfram-Silber 45/55 Stab | | タングステン silver 45/55 ロッド |
| Tungsten silver 40/60 plate | Tungsten Silver 40/60 Plate | Plaque argent-tungstène 40/60 | Wolfram-Silber 40/60 Plate | | タングステン silver 40/60 プレート |
| Tungsten silver 30/70 pieces | Tungsten Silver 30/70 Block | Block argent-tungsten 30/70 | Wolfram-Silber 30/70 Block | | タングステン silver 30/70 ブロック |
| Tungsten Nickel Iron 70/20/10 Rod | Tungsten-Nickel-Iron 70/20/10 Rod | Tige tungstène-nickel-fer 70/20/10 | Wolfram-Nickel-Eisen Stab | 70/20/10 | タングステンニッケル鄄 70/20/10 ロッド |
| Tungsten Nickel Iron 75/15/10 Plate | Tungsten-Nickel-Iron 75/15/10 Plate | Plaque tungstène-nickel-fer 75/15/10 | Wolfram-Nickel-Eisen Platte | 75/15/10 | タングステンニッケル鄄 75/15/10 プレート |
| Tungsten Nickel Iron 80/10/10 Block | Tungsten-Nickel-Iron 80/10/10 Block | Bloc tungstène-nickel-fer 80/10/10 | Wolfram-Nickel-Eisen Block | 80/10/10 | タングステンニッケル鄄 80/10/10 ブロック |
| Tungsten Molybdenum 40/60 Rod | Tungsten-Molybdenum 40/60 Rod | Tige tungsten-molybdene 40/60 | Wolfram-Molybd ä n 40/60 Stab | | タングステンモリブデン 40/60 ロッド |
| Tungsten-molybdenum 30/70 plate | Tungsten-Molybdenum 30/70 Plate | Plaque tungsten-molybdene 30/70 | Wolfram-Molybdän 30/70 Platte | | タングステンモリブデン 30/70 プレー |

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| Tungsten molybdenum 20/80 blocks | Tungsten-Molybdenum 20/80 Block | Bloc tungsten-molybdene 20/80 | Wolfram-Molybdän 20/80 Block | タングステンモリブデン 20/80 ブロック |
| Tungsten cobalt 60/40 blade | Tungsten-Cobalt 60/40 Blade | Laminate tungstène-cobalt 60/40 | Wolfram-Kobalt 60/40 Klinge | タングステンコバルト 60/40 ブレード |
| Tungsten Cobalt 50/50 Drill Bit | Tungsten-Cobalt 50/50 Drill Bit | Foret tungstène-cobalt 50/50 | Wolfram-Kobalt 50/50 Bohrer | タングステンコバルト 50/50 ドリルビット |
| Tungsten Cobalt 40/60 Cutting Tools | Tungsten-Cobalt 40/60 Tool | Outil tungstène-cobalt 40/60 | Wolfram-Kobalt 40/60 Werkzeug | タングステンコバルト 40/60 tools |
| Tungsten Rhenium 80/20 Wire | Tungsten-Rhenium 80/20 Wire | Fil tungstène-rhénium 80/20 | Wolfram-Rhenium 80/20 Draht | タングステンレニウム 80/20 ワイヤー |
| Tungsten Rhenium 70/30 Rod | Tungsten-Rhenium 70/30 Rod | Tige tungsten-rhénium 70/30 | Wolfram-Rhenium 70/30 Stab | タングステンレニウム 70/30 ロッド |
| Tungsten Rhenium 60/40 Plate | Tungsten-Rhenium 60/40 Plate | Plaque tungsten-rhénium 60/40 | Wolfram-Rhenium 60/40 Plate | タングステンレニウム 60/40 プレート |
| Tungsten Titanium 70/30 Knife | Tungsten-Titanium 70/30 Tool | Outil tungstène-titane 70/30 | Wolfram-Titan 70/30 Werkzeug | タングステンチタン 70/30 tools |
| Tungsten Titanium 60/40 Rod | Tungsten-Titanium 60/40 Rod | Tige tungstène-titane 60/40 | Wolfram-Titan 60/40 Stab | タングステンチタン 60/40 ロッド |
| Tungsten Vanadium 70/30 Plate | Tungsten-Vanadium 70/30 Plate | Plaque tungsten-vanadium 70/30 | Wolfram-Vanadium 70/30 Plate | タングステンバナジウム 70/30 プレート |
| Tungsten Chrome 60/40 Rod | Tungsten-Chromium 60/40 Rod | Tige tungsten-chrome 60/40 | Wolfram-Chrom 60/40 Stab | タングステンクロム 60/40 ロッド |
| Tungsten manganese 60/40 block | Tungsten-Manganese 60/40 Block | Bloc tungsten-manganèse 60/40 | Wolfram-Mangan 60/40 Block | タングステンマンガン 60/40 ブロック |

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| Tungsten microporous membrane | Tungsten Microporous Filter Membrane | Membrane filtration micropore use en tungsten | Wolfram-Mikropor ö se Filtermembran | タングステンマイクロポアフィルターメンブレン |
| Tungsten Nano-Coated Target | Tungsten Nano-Coated Target | Cable and revamp nano en tungsten | Wolfram-Nanobeschichtetes Ziel | タングステンナノコーティングターゲット |
| Tungsten Ultra-Thin Foil | Tungsten Ultra-Thin Foil | Feuille ultra-fine en tungstène | Wolfram-Ultradünne Folie | タングステン ultra-thin フォイル |
| Tungsten high density particles | Tungsten High-Density Particle | Particulate and haute densité in tungsten | Wolfram-Hochdichtepartikel | タングステン high density particles |
| Tungsten porous sintered block | Tungsten Porous Sintered Block | Bloc fritté poreux en tungstène | Wolfram-Por ö ser Sinterblock | タングステン porous yaki knotted ブロック |
| Tungsten composite fiber | Tungsten Composite Fiber | Fibre composite in tungsten | Wolfram-Verbundfaser | タングステン composite filter |
| Tungsten Micro Helical Tube | Tungsten Micro Helical Tube | Tube hélico dal micro en tungst è ne | Wolfram-Microspiralschlauch | タングステンマイクロヘリカルチューブ |
| Tungsten interstellar spacecraft heat shield | Tungsten Interstellar Spacecraft Thermal Shield | Bouclier thermique de vaisseau interstellaire en tungsten | Wolfram-Interstellar-Raumschiff - Wärmeschutz | タングステン interstellar spaceship heat wave |
| Tungsten Space Station Wear Lining | Tungsten Space Station Wear-Resistant Liner | Doublure résistante à l'usure de station spatiale en tungstène | Wolfram-Raumstation-Verschlei ß auskleidung | タングステン Cosmos System |
| Tungsten Astronaut Protective Shield | Tungsten Astronaut Radiation Shielding | Blindage radiologique pour astronaute en tungstène | Wolfram-Astronauten-Strahlenschutz | タングステン space pilot radioactive ray |
| Tungsten Space Telescope Mirrors | Tungsten Space Telescope Reflector | Réflecteur de telescope spatial en tungstène | Wolfram-Weltraumteleskopreflektor | タングステン Space Telescope リフレクター |
| Tungsten Planetary Lander Weights | Tungsten Planetary Lander Counterweight | Contrary to the public | Wolfram-Planetenlander-Gegengewicht | Terrestrial Lander |
| Tungsten Space Probe Nozzles | Tungsten Space Probe Nozzle | Buse de sonde spatiale en | Wolfram-Weltraumsonden-Düse | タングステン |

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| | | tungstène | | Space Exploration Machine ノズル |
| Tungsten interstellar thruster components | Tungsten Interstellar Thruster Component | Composant de propulsions interstellaire en tungstène | Wolfram-Interstellar-Antriebsbauteil | タングステン interstellar thruster parts |
| Tungsten Space Mining Drill | Tungsten Space Mining Drill Bit | Foreground space en tungsten | Wolfram-Weltraumbergbau-Bohrer | タングステン Cosmos Collection 鉱ドリルビット |
| Tungsten Moon Base Shielding | Tungsten Lunar Base Shielding | Blind age in lunaire en tungsten | Wolfram-Mondbasis-Abstract | タングステン lunar base シールド |
| Tungsten Mars Base Heat Sink | Tungsten Mars Base Heat Sink | Dissipateur thermique de base martienne en tungstène | Wolfram -Marsbasis- Wärmesenke | タングステン Mars Base ヒートシンク |
| Tungsten quantum chip substrate | Tungsten Quantum Chip Substrate | Substratum de puce quantique en tungstène | Wolfram-Quanten-Chipsubstrat | タングステン quantum チップ substrate |
| Tungsten Quantum Computing Heat Sink | Tungsten Quantum Computing Heat Sink | Dissipateur thermique pour calculus quantique en tungstène | Wolfram-Quantencomputing - Wärmesenke | タングステン quantum computing technology |
| Tungsten Quantum Sensor Components | Tungsten Quantum Sensor Component | Composant capteur quantique en tungsten | Wolfram-QuantensorButeil | タングステン quantum センサー parts |
| Tungsten quantum entanglement experimental target | Tungsten Quantum Entanglement Experiment Target | Cable and expérience of intricacy and quantity | Wolfram-Quantenverschränkungs - Experimentziel | タングステン quantum もつれ実験ターゲット |
| Tungsten Qubit Shielding | Tungsten Qubit Shielding | Blind age in tungsten | Wolfram-Qubit-Abstract | タングステン quantum ビットシールド |
| Tungsten cooling tubes for quantum computing | Tungsten Quantum Computing Cooling Tube | Tube de refroidissement pour calculus quantique en tungstène | Wolfram-Quantencomputing-Kühlrohr | タングステン quantum computing cooling system |
| Tungsten Quantum Processor Counterweight | Tungsten Quantum Processor Counterweight | Contrast the process in tungsten | Wolfram-Quantenprozessor-Gegengewicht | タングステン quantum プロセッサカウン |

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| Tungsten quantum communication substrate | Tungsten Quantum Communication Substrate | Substratum of communication in tungsten | Wolfram-Quantenkommunikationssubstrat | タングステン quantum communication substrate |
| Tungsten Quantum Experiment Crucible | Tungsten Quantum Experiment Crucible | Creuset d'expérience quantity en tungstène | Wolfram-Quantenexperiment-Tiegel | タングステン quantum crucible |
| Tungsten Quantum Detector Components | Tungsten Quantum Detector Component | Composer of quality in tungsten | Wolfram-Quantendetektorbauteil | タングステン quantum extractor parts |
| Tungsten Medical Robotic Joints | Tungsten Medical Robot Joint | Articulation of robots in tungsten | Wolfram-Medizinroboter-Gelenk | タングステン Medical Radiology Joint |
| Tungsten Medical Robot Knife | Tungsten Medical Robot Tool | Out of robot medicine en tungsten | Wolfram-Medizinroboter-Werkzeug | タングステン Medical Tools |
| Tungsten Medical Robot Bearings | Tungsten Medical Robot Bearing | Routing of robots in tungsten | Wolfram-Medizinroboter-Lager | タングステン Medical Treatment |
| Tungsten medical robot drive shaft | Tungsten Medical Robot Drive Shaft | Transmission of robots in tungsten | Wolfram-Medizinroboter-Antriebswelle | タングステン Medical Treatment |
| Tungsten Medical Robot Counterweight | Tungsten Medical Robot Counterweight | Contrepoids of robots in tungsten | Wolfram-Medizinroboter-Gegengewicht | タングステン Medical Treatment |
| Tungsten Medical Robot Shielding | Tungsten Medical Robot Shielding | Blind age of robots in tungsten | Wolfram-Medizinroboter-Abschirmung | タングステン Medical Treatment |
| Tungsten Medical Robot Heat Sink | Tungsten Medical Robot Heat Sink | Dissipate thermique of robot medicine in tungsten | Wolfram-Medizinroboter Wärmesenke - | タングステン Medical Treatment |
| Tungsten Medical Robot Probe | Tungsten Medical Robot Probe | Sonde robot medical en tungsten | Wolfram-Medizinroboter-Sonde | タングステン Medical Treatment |
| Tungsten Medical Robot Hydraulic Components | Tungsten Medical Robot Hydraulic Component | Composant hydration of robots in tungsten | Wolfram-Medizinroboter-Hydraulikbauteil | Deton Medical Medical Oil Pressure Parts |
| Tungsten medical robot wear parts | Tungsten Medical Robot Wear Part | The most beautiful thing about robots | Wolfram-Medizinroboter-Verschleiß teil | タングステン Medical ロボット wear-resistant parts |
| Tungsten | Tungsten | Électrode de | Wolfram-Lithiumbatterie-Elektrode | タングステン |

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| lithium battery electrode | Lithium Battery Electrode | batterie au lithium en tungsten è ne | | リチウム battery electrode |
| Tungsten supercapacitor substrate | Tungsten Supercapacitor Substrate | Substratum de supercondensateur en tungstène | Wolfram-Superkondensatorsubstrat | タングステンスーパーキャパシタ substrate |
| Tungsten Energy Storage System Heat Sink | Tungsten Energy Storage System Heat Sink | Dissipateur thermique de système de stockage d'énergie en tungstène | Wolfram -Energiespeichersystem-Wärmesenke | タングステンエネルギー蔵システムヒートシンク |
| Sodium Tungsten Battery Separator | Tungsten Sodium Battery Separator | Separatist batterie au sodium en tungstène | Wolfram-Natriumbatterie-Separator | タングステンナトリウム battery セパレーター |
| Tungsten solid-state battery electrodes | Tungsten Solid-State Battery Electrode | The sound of the batter This is a solid thing . | Wolfram- Festkörperbatterie -Elektrode | タングステン solid battery electrode |
| Tungsten fuel cell heat pipe | Tungsten Fuel Cell Heat Pipe | Tuyau thermique de pile à combustible en tungsten | Wolfram -Brennstoffzellen-Wärmerohr | タングステン fuel cell battery |
| Tungsten energy storage module counterweight | Tungsten Energy Storage Module Counterweight | Contrepoids de module de stockage en tungsten | Wolfram-Energiespeichermodul-Gegengewicht | タングステンエネルギー store 蔵モジュールカウンターウェイト |
| Tungsten Battery Shield | Tungsten Battery Shielding | Blind age in tungsten | Wolfram-Batterie-Abschirmung | タングステン battery シールド |
| Tungsten energy storage system wear parts | Tungsten Energy Storage System Wear Part | The perfect time to stay in stock | Wolfram-Energiespeichersystem-Verschlei ß teil | タングステンエネルギー蔵システム wear-resistant parts |
| Tungsten Electrochemical Reactor Components | Tungsten Electrochemical Reactor Component | Composers of different styles | Wolfram-Elektrochemischer Reaktorbauteil | タングステン Electric chemical reactor parts |
| Tungsten wear-resistant wheel for unmanned mining car | Tungsten Unmanned Mining Vehicle Wear-Resistant Wheel | Rouge résistante à l'usure de véhicule minier sans pilote tungsten | Wolfram-Fahrerloses Bergbaufahrzeug-Verschlei ß rad | タングステン unmanned vehicle wear-resistant ホイール |

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| Tungsten unmanned excavator tool | Tungsten Unmanned Excavator Tool | Outil d'excavatrice sans pilote en tungsten | Wolfram-Fahrerloser Bagger-Werkzeug | タングステン unmanned digging machine tools |
| Tungsten counterweight for unmanned transport vehicles | Tungsten Unmanned Transport Vehicle Counterweight | Contradictory transport of transport sans pilots in tungsten | Wolfram-Fahrerloses Transportfahrzeug-Gegengewicht | タングステン unmanned conveyor vehicle カウンターウェイト |
| Tungsten unmanned agricultural machinery wear parts | Tungsten Unmanned Agricultural Machine Wear Part | The perfect machine for your work | Wolfram-Fahrerlose Landmaschine-Verschlei ß teil | タングステン unmanned agricultural machinery wear-resistant parts |
| Tungsten unmanned tractor gear | Tungsten Unmanned Tractor Gear | Engagement in tracteur sans pilote in tungsten | Wolfram-Fahrerloser Traktor-Zahnrad | タングステン无人トラクターギア |
| Tungsten unmanned harvester blade | Tungsten Unmanned Harvester Blade | Lame de moissonneuse sans pilote en tungstène | Wolfram-Fahrerlose Erntemaschine-Klinge | タングステン unmanned harvester ブレード |
| Tungsten Unmanned Patrol Boat Thruster | Tungsten Unmanned Patrol Boat Thruster | Propulsion of bateau de patrouille sans pilote en tungstène | Wolfram-Fahrerloses Patrouillenboot-Antrieb | タングステン unmanned patrol boat propeller |
| Tungsten counterweight for unmanned cargo ship | Tungsten Unmanned Cargo Ship Counterweight | Contrepoids de navire cargo sans pilote en tungsten | Wolfram-Fahrerloses Frachtschiff-Gegengewicht | タングステン unmanned cargo ship カウンターウェイト |
| Tungsten unmanned submarine pressure resistant parts | Tungsten Unmanned Submarine Pressure Component | Composant sous expression de sous-marin sans pilote en tungstène | Wolfram-Fahrerloses U-Boot-Druckbauteil | タングステン unmanned submarine pressure-resistant parts |
| Tungsten UAV Heat Sink | Tungsten Unmanned Aircraft Heat Sink | Dissipateur thermique d'aéronef sans pilote en tungsten | Wolfram -Fahrerloses Flugzeug-Wärmesenke | タングステン UAV ヒートシンク |
| Tungsten Flexible Electronic Substrates | Tungsten Flexible Electronics Substrate | Substratum d'électronique flexible en tungsten | Wolfram-Flexibles Elektroniksubstrat | タングステン フレキシブル エレクトロニクス substrate |
| Tungsten | Tungsten | Contrepoids | Wolfram-Tragbares Gerät - | タングステン |

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| Wearable Weights | Wearable Device Counterweight | d'appareil portable en tungsten | Gegengewicht | ウェアラブルデバスカウンターウェイト |
| Tungsten Smart Glasses Heat Sink | Tungsten Smart Glasses Heat Sink | Dissipateur thermique de lunette intelligentes en tungstène | Wolfram -Smart-Brille-Wärmesenke | タングステンスマートグラスヒートシンク |
| Tungsten Neural Interface Electrodes | Tungsten Neural Interface Electrode | Électrode d' interface neuronale en tungsten è ne | Wolfram-Neurales Interface-Elektrode | Electrode |
| Tungsten Biosensor Components | Tungsten Biosensor Component | Composant biocapteur en tungsten | Wolfram-Biosensorbauteil | タングステンバイオセンサー parts |
| Tungsten implantable medical weight | Tungsten Implantable Medical Counterweight | Contrepoids médical implantable en tungsten | Wolfram-Implantierbares Medizin-Gegengewicht | タングステン bury the medical treatment |
| Tungsten Nanorobot Components | Tungsten Nanorobot Component | Composant nanorobot en tungsten | Wolfram-Nanoroboterbauteil | タングステンナノロボット parts |
| Tungsten Virtual Reality Device Substrate | Tungsten VR Device Substrate | Substratum d'appareil de realité virtuelle en tungstène | Wolfram-VR-Ge ä tesubstrat | タングステン VR デバイス substrate |
| Tungsten Augmented Reality Heat Sink | Tungsten AR Heat Sink | Dissipate thermique and augmentation in tungsten | AR - Wärmesenke | タングステン AR ヒートシンク |
| Tungsten Smart Home Sensors | Tungsten Smart Home Sensor | Capteur de maison intelligente en tungstène | Wolfram-Smarthome-Sensor | タングステンスマートホームセンサー |
| **Chinese** | **English** | **French** | **German** | **Japanese** |
| Tungsten black box housing | Tungsten Black Box Shell | Coque de boi te noire en tungsten è ne | Wolfram-Schwarzkasten- Gehä use | タングステンブラックボックスシェル |
| Tungsten flight recorder heat resistant case | Tungsten Flight Recorder Heat-Resistant Shell | Coque résistante à la chaleur pour enregistreur de vol en tungstène | Wolfram-Flugschreiber-Hitzbest ä ndiges Geh ä use | Heat-resistant シェル |
| Tungsten waverider protection plate | Tungsten Hypersonic Waverider Shield | Bouclier de waverider hypersonique en tungstène | Wolfram-Hyperschall-Waverider-Schutz | タングステン Wave Rider Protection System |
| Tungsten high | Tungsten High- | Pale turbines and | Wolfram-Hochtemperatur- | タングステン |

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| temperature gas turbine blades | Temperature Gas Turbine Blade | haute tempests in tungsten | Gasturbinenschaufel | High temperature ガスタービンブレード |
| Tungsten Rocket Engine Combustion Chamber | Tungsten Rocket Engine Combustion Chamber | Chambre de combustion de moteur-fusée en tungstène | Wolfram-Raketenmotor-Brennkammer | タングステンロケットエンジン焼 Chamber |
| Tungsten high temperature jet engine nozzle | Tungsten High-Temperature Jet Engine Nozzle | Busy and moteur à réaction haute température in tungsten | Wolfram-Hochtemperatur-Strahltriebwerksdüse | High-temperature heat treatment |
| Tungsten Spacecraft Reentry Shield | Tungsten Spacecraft Reentry Shield | Bouclier de rentrée de vaisseau spatial en tungstène | Wolfram-Raumschiff-Wiedereintrittsschutz | Terrestrial spacecraft re-intrusion protection system |
| Tungsten high temperature furnace lining | Tungsten High-Temperature Furnace Lining | Revival of four haute temperaments in tungsten | Wolfram-Hochtemperaturofen-Auskleidung | タングステン high temperature furnace Zhang |
| Tungsten high temperature test chamber shell | Tungsten High-Temperature Test Chamber Shell | Coque de chambre de test haute température en tungstène | Wolfram-Hochtemperatur-Testkammer- Gehä use | タングステン High temperature 実験キャビンシェル |
| Tungsten high temperature reactor heat shield | Tungsten High-Temperature Reactor Insulation Plate | Plaque isolante de réacteur haute température en tungsten | Wolfram-Hochtemperaturreaktor-Isolierplatte | タングステン high temperature reaction furnace absolute furnace |
| Tungsten Corrosion Resistant Chemical Reactors | Tungsten Corrosion-Resistant Chemical Reactor | Reduced corrosion resistance | Wolfram-Korrosionsbeständiger Chemischer Reaktor | タングステン corrosion-resistant chemical reactor |
| Tungsten acid resistant pipe | Tungsten Acid-Resistant Pipe | Tuyau résistant aux acides en tungstène | Wolfram-S ä urebest ä ndiges Rohr | タングステン acid-resistant パイプ |
| Tungsten alkali resistant tank lining | Tungsten Alkali-Resistant Tank Lining | Revival of réservoir résistant aux alcalis en tungsten | Wolfram-Alkalibest ä ndige Tankauskleidung | タングステン resistant アルカリタンク uchi Zhang |
| Tungsten Marine | Tungsten Marine | Plaque de protection contre | Wolfram-Meereskorrosionsschutzplatte | タングステン Marine |

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| Corrosion Protection Plate | Corrosion Protection Plate | la corrosion marine en tungstène | | Scavenging Protection System |
| Tungsten corrosion resistant pump and valve components | Tungsten Corrosion-Resistant Pump Valve Component | Composing the environment and reducing corrosion | Wolfram-Korrosionsbest ä ndiges Pumpenventilbauteil | タングステン corrosion-resistant ポンプバルブ parts |
| Tungsten corrosion resistant deep sea housing | Tungsten Corrosion-Resistant Deep-Sea Shell | Corrosion-free corrosion protection | Wolfram-Korrosionsbest ä ndiges Tiefsee-Geh ä use | タングステン corrosion-resistant deep sea water |
| Tungsten corrosion resistant electrolytic cell electrodes | Tungsten Corrosion-Resistant Electrolytic Cell Electrode | Électrode de cellule lectrolyte sistante à la corrosion en tungsten è ne | Wolfram-Korrosionsbeständige Elektrolysezellen -Elektrode | タングステン corrosion-resistant electrolytic cell electrode |
| Tungsten Corrosion Resistant Test Container | Tungsten Corrosion-Resistant Experimental Vessel | Reduced risk of corrosion in tungsten | Wolfram - Korrosionsbeständiger Experimenteller Behälter | タングステン corrosion-resistant food container |
| Tungsten Corrosion Resistant Filter | Tungsten Corrosion-Resistant Filter | Filtresistant and corrosion-resistant | Wolfram- Korrosionsbeständiger Filter | タングステン corrosion-resistant food |
| Tungsten corrosion resistant industrial nozzles | Tungsten Corrosion-Resistant Industrial Nozzle | Busy industrielle résistante and corrosion in tungsten | Wolfram-Korrosionsbest ä ndige Industried ü se | タングステン corrosion-resistant industrial ノズル |
| Tungsten wear-resistant black box protective layer | Tungsten Wear-Resistant Black Box Protective Layer | Couche protector résistante à l'usure pour bo îte noire en tungsten è ne | Wolfram-Verschlei ß feste Schwarzkasten-Schutzschicht | タングステン abrasion resistant ブラックボックス protective layer |
| Tungsten wear-resistant waverider housing | Tungsten Wear-Resistant Waverider Shell | Coque résistante à l'usure de waverider en tungstène | Wolfram-Verschlei ß festes Waverider-Geh ä use | タングステン anti-wear wave rider body シェル |
| Tungsten wear-resistant mining hammer | Tungsten Wear-Resistant Mining Crusher Hammer | Martial arts and craftsmanship | Wolfram-Verschlei ß fester Bergbau-Brecherhammer | タングステン resistant wear and tear industry クラッシャーハンマー |
| Tungsten wear-resistant oil | Tungsten Wear-Resistant Oil | Foretold pétrolier résistant and | Wolfram-Verschlei ß fester Ö lbohrer | タングステン anti-wear oil |

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| drill bit | Drill Bit | l'usure en tungsten | | | ドリルビット |
| Tungsten wear-resistant mechanical seals | Tungsten Wear-Resistant Mechanical Seal | Joint taste buds | Wolfram-Verschlei ß feste Mechanische Dichtung | | タングステン anti-wear machinery シール |
| Tungsten wear-resistant deep sea drilling tools | Tungsten Wear-Resistant Deep-Sea Drilling Tool | Unforgettable experience in the environment | Wolfram-Verschlei ß festes Tiefseebohrwerkzeug | | タングステン wear-resistant deep sea drilling tools |
| Tungsten wear-resistant aviation bearings | Tungsten Wear-Resistant Aerospace Bearing | Roulement aerospace résistant à l'usure en tungstène | Wolfram-Verschlei ß festes Luftfahrtlager | | タングステン aerospace aviation |
| Tungsten wear-resistant industrial gears | Tungsten Wear-Resistant Industrial Gear | Engage industriel résistant à l'usure en tungstène | Wolfram-Verschlei ß festes Industriezahnrad | | タングステン anti-wear industry |
| Tungsten wear-resistant cutting wheel | Tungsten Wear-Resistant Cutting Wheel | Rouge de coupe résistante à l'usure en tungstène | Wolfram-Verschlei ß festes Schneidrad | | タングステン anti-wear cutting tool |
| Tungsten wear-resistant polishing disc | Tungsten Wear-Resistant Polishing Disc | Disques from the polissage résistant | Wolfram-Verschlei ß feste Polierscheibe | | タングステン anti-wear grinding ディスク |
| Tungsten Wedding Rings | Tungsten Wedding Ring | Anneau de mariage en tungstène | Wolfram-Hochzeitsring | | タングステン wedding ring |
| Tungsten Engagement Rings | Tungsten Engagement Ring | Bague de fian ç ailles en tungsten è ne | Wolfram-Verlobungsring | | タングステン engagement ring |
| Tungsten Memorial Rings | Tungsten Commemorative Ring | Anneau commemoration en tungsten | Wolfram-Gedenkring | | タングステン commemorative thumb wheel |
| Tungsten Soldier Name Tag | Tungsten Soldier Nameplate | Plaque de nom de soldat en tungstène | Wolfram-Soldaten-Namensschild | | Soldiers |
| Tungsten Military ID Card | Tungsten Military ID Tag | Étiquette d ' identification militaire en tungsten è ne | Wolfram-Militär - ID-Marke | | タングステン Military ID タグ |
| Tungsten luggage identification card | Tungsten Luggage Tag | Étiquette de bagage en tungsten è ne | Wolfram - Gepen | | タングステン 重物タグ |
| Tungsten Pet ID Tags | Tungsten Pet ID Tag | Étiquette d ' identification pour animal en tungsten è ne | Wolfram-Haustier-ID-Marke | | タングステン ペット ID タグ |

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| Tungsten Memorial Necklace Pendant | Tungsten Commemorative Necklace Pendant | Pendentif de collier commemorative en tungsten | Wolfram -Gedenkhalskette-Anhänger | タングステン Memory of ネックレスペンダント |
| Tungsten family crest | Tungsten Family Crest | Blason family in tungstène | Wolfram-Familienwappen | The coat of arms of the Sensun family |
| Tungsten Eternal Life Memorial Plaque | Tungsten Eternal Memorial Plaque | Plaque commemorative éternelle en tungstène | Wolfram-Ewige Gedenkplakette | タングステン forever commemorative plaque |
| Tungsten submersible housing | Tungsten Deep Submersible Shell | Coque de submersible profond en tungstène | Wolfram-Tiefsee-Tauchger ä t-Geh ä use | タングステン deep submersible submersible |
| Tungsten Deep Sea Detector Counterweight | Tungsten Deep-Sea Probe Counterweight | Contradictions in sonde and profondes in tungsten | Wolfram-Tiefsee-Sonden-Gegengewicht | タングステン deep sea exploration aircraft カウンターウェイト |
| Tungsten deep sea pressure chamber parts | Tungsten Deep-Sea Pressure Chamber Component | Composer of chambre sous pression and professed in tungsten | Wolfram-Tiefsee-Druckkammerbauteil | タングステン deep sea pressure resistant parts |
| Tungsten Deep Sea Mining Drill | Tungsten Deep-Sea Mining Drill Bit | Forage minier and profondes en tungstène | Wolfram-Tiefsee-Bergbau-Bohrer | タングステン deep sea mining 鉱ドリルビット |
| Tungsten deep sea pipeline corrosion resistant lining | Tungsten Deep-Sea Pipeline Corrosion-Resistant Lining | Improved corrosion resistance in pipelines and pipelines | Wolfram-Tiefsee-Rohrleitung-Korrosionsbest ä ndige Auskleidung | Delicate deep sea water |
| Tungsten submersible thruster parts | Tungsten Deep Submersible Thruster Component | Composable propulsion and submersible profond en tungsten | Wolfram-Tiefsee-Tauchgerät - Antriebsbauteil | Teton submersible thruster parts |
| Tungsten deep sea sensor wear shell | Tungsten Deep-Sea Sensor Wear-Resistant Shell | Coque résistante à l'usure de capteur en aux profondes en tungstène | Wolfram-Tiefsee-Sensor-Verschlei ß schale | タングステン deep sea センサー abrasion-resistant rubber |
| Tungsten deep sea cable fixings | Tungsten Deep-Sea Cable Anchor | Anonymous | Wolfram-Tiefsee-Kabelverankerung | タングステン deep sea ケーブル fixed |

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| Tungsten submersible high temperature resistant nozzle | Tungsten Deep Submersible High-Temperature Nozzle | Busy haute temperament de submersible profond en tungsten | Wolfram-Tiefsee-Tauchger ä t-Hochtemperatur-D ü se | タングステン deep submersible high temperature ノズル |
| Tungsten deep sea geological sampling tool | Tungsten Deep-Sea Geological Sampling Tool | Out of stock in tungsten products | Wolfram-Tiefsee-Geologie-Probenahmewerkzeug | タングステン deep sea geology tool |
| Tungsten plasma confinement components | Tungsten Plasma Confinement Component | Composition of confinement in plasma en tungsten | Wolfram-Plasmaeinschlussbauteil | タングステン プラズマ closed parts |
| Tungsten fusion reactor wall | Tungsten Fusion Reactor Wall | Parody of the fusion in tungsten | Wolfram-Fusionsreaktorwand | タングステン nuclear fusion furnace wall |
| Tungsten nuclear fusion high temperature resistant lining | Tungsten Fusion High-Temperature Lining | Revival haute température pour fusion into tungsten | Wolfram-Fusion-Hochtemperaturauskleidung | タングステン nuclear fusion high temperature ライナー |
| Tungsten plasma jet shield | Tungsten Plasma Jet Shield | Bouclier de jet de plasma en tungstène | Wolfram-Plasmastrahl-Schutzplatte | タングステン プラズマジェット protection プレート |
| Tungsten Nuclear Fusion Experiment Target | Tungsten Fusion Experiment Target | Impossible fusion in tungsten | Wolfram-Fusionsexperiment-Ziel | タングステン nuclear fusion 実験ターゲット |
| Tungsten Fusion Heat Sink | Tungsten Fusion Heat Sink | Dissipateur thermique pour fusion into tungsten | Wolfram-Fusion - Wärmesenke | タングステン nuclear fusion technology |
| Tungsten plasma deflector | Tungsten Plasma Diverter Plate | Plaque de déviation de plasma en tungstène | Wolfram-Plasmaumleitungsplatte | タングステン プラズマダイバータープレート |
| Tungsten Nuclear Fusion Wear-Resistant Parts | Tungsten Fusion Wear-Resistant Component | Composant résistant and l'usure pour fusion in tungsten | Wolfram-Fusion-Verschlei ß bauteil | Eton Nuclear Fusion Wear-Resistant Parts |
| Tungsten Fusion Shielding | Tungsten Fusion Shielding | blindage pour fusion en tungsten | Wolfram-Fusion-Abstract | タングステン nuclear fusion system |
| Tungsten Nuclear Fusion | Tungsten Fusion High- | Creuset haute température pour | Wolfram-Fusion-Hochtemperatur-Tiegel | タングステン nuclear fusion |

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| High Temperature Crucible | Temperature Crucible | fusion into tungsten | | high temperature crucible |
| Tungsten high temperature aviation turbine blades | Tungsten High-Temperature Aerospace Turbine Blade | Pale de turbine aerospace haute temperature en tungsten | Wolfram-Hochtemperatur-Luftfahrt-Turbinenschaufel | タングステン High Temperature Aviation タービンブレード |
| Tungsten corrosion resistant submarine hull | Tungsten Corrosion-Resistant Submarine Shell | Coque de sous-marin résistante à la corrosion en tungstène | Wolfram-Korrosionsbest ä ndiges U-Boot-Geh ä use | The scavenger-resistant submersible Submarine |
| Tungsten wear-resistant unmanned vehicle wheel hub | Tungsten Wear-Resistant Unmanned Vehicle Wheel Hub | The most beautiful thing in the world | Wolfram-Verschlei ß festes Fahrerloses Fahrzeugradnabe | タングステン abrasion-resistant unmanned vehicle ホイールハブ |
| Tungsten high temperature rocket heat shield | Tungsten High-Temperature Rocket Thermal Shield | Bouclier thermique de fusée haute température en tungsten | Wolfram-Hochtemperatur-Raketen-W ä rmeschutz | タングステン High temperature ロケット縁フード |
| Tungsten corrosion resistant unmanned ship hull | Tungsten Corrosion-Resistant Unmanned Vessel Shell | Coque de navire sans pilote résistante à la corrosion en tungstène | Wolfram-Korrosionsbest ä ndiges Fahrerloses Schiff-Geh ä use | タングステン Scavenger, a rot-resistant unmanned ship |
| Tungsten wear-resistant submersible propeller | Tungsten Wear-Resistant Deep Submersible Thruster | Submersible provocations | Wolfram-Verschlei ß festes Tiefsee-Tauchger ä t-Antrieb | タングステン wear-resistant deep submersible thruster |
| Tungsten high temperature nuclear reactor casing | Tungsten High-Temperature Nuclear Reactor Shell | Coque de réacteur nucléaire haute température en tungsten | Wolfram-Hochtemperatur-Kernreaktor-Geh ä use | タングステン high temperature atomic furnace シェル |
| Tungsten Corrosion Resistant Aviation Fuel Tube | Tungsten Corrosion-Resistant Aerospace Fuel Pipe | Tuyau de carburant aerosol résistant à la corrosion en tungstène | Wolfram-Korrosionsbest ä ndiges Luftfahrt-Brennstoffrohr | タングステン corrosion-resistant aviation fuel パイプ |
| Tungsten wear-resistant drone propeller | Tungsten Wear-Resistant Drone Propeller | Hélice de drone résistante à l'usure en tungstène | Wolfram-Verschlei ß fester Drohnen-Propeller | タングステン resistant wear and tear wear resistant |

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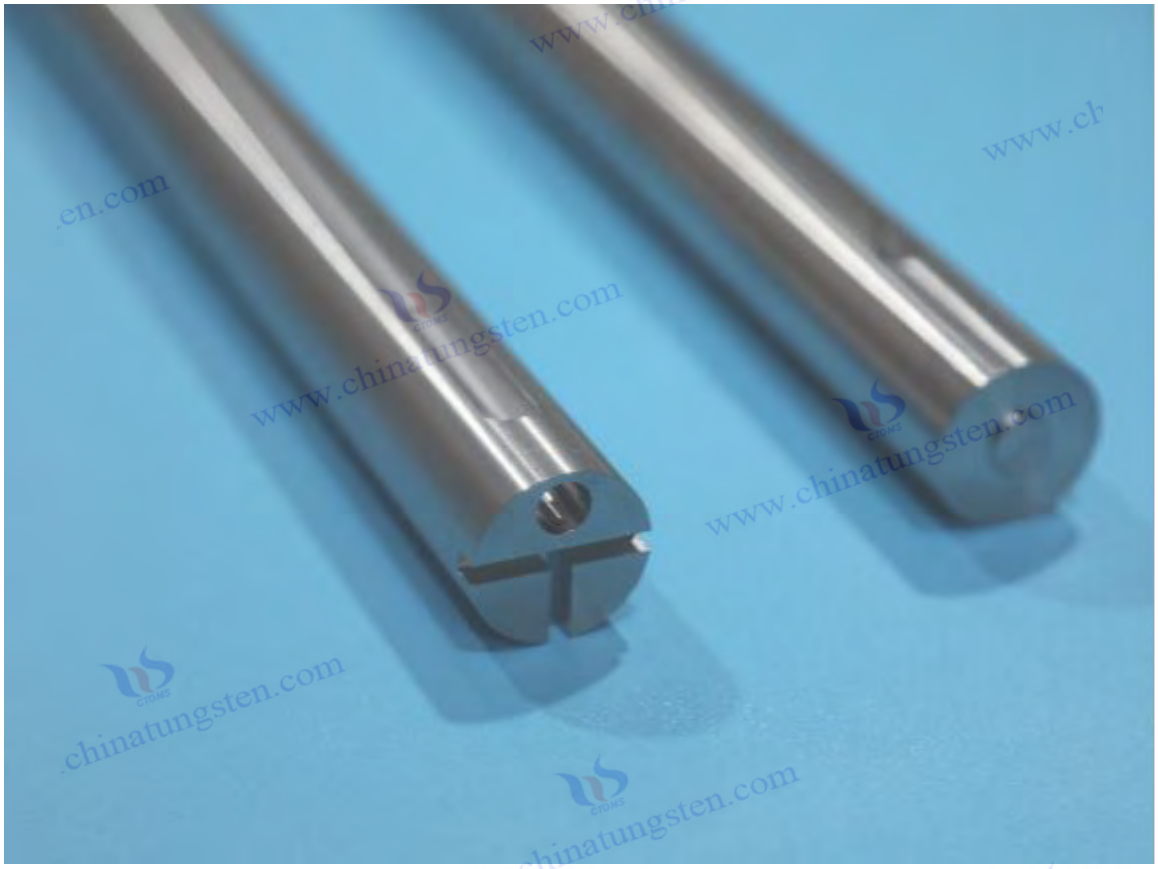
| Tungsten high temperature satellite heat shield | Tungsten High-Temperature Satellite Insulation Plate | Plaque isolation of satellite haute temperature tungsten | タングステン High Temperature Satellite Absolute Heater<br>Wolfram-Hochtemperatur-in Satelliten-Isolierplatte |



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