H.C. Starck Tungsten Powders – empowering innovative customers
Faster, durable, superior ...
The variety and sheer diversity of cutting tools that the industry has developed over the past decades have decisively contributed to the efficiency of today’s machine tool sector. Specific markets need specific solutions that cater to their unique requirements, forcing tool manufacturers to provide an endless source of customized products to meet the market’s ever-changing demands in terms of application as well as speed, precision and durability.

Tougher, stronger, deeper ...
Resources are scarce and extracting them calls for an ever-increasing degree of resourcefulness. In the exploration of fossil and geothermal energy resources, oilfield service providers rely on the very latest technologies to reach the most remote locations and to be able to drill deeper and deeper, through increasingly harder unyielding rock formations.

Heavier, smaller, bullet proof ...
Tungsten metal and heavy alloy applications are highly diversified, catering for specialist industry sectors such as aviation, electronics, electrical and medical. Each of these sectors work with their very own tailor-made high-performance materials, which exhibit the very highest degree of stability. The size and complexity of final parts is continuously growing and changing with the manufacturers’ need to advance their own products through innovation.

Cleaner, purer, safer ...
Our understanding of the world around us and the ecological challenges we are faced with today have given rise to a sense of responsibility to think and act efficiently and in the long term, which in turn also calls for high performing chemicals. As catalysts to clean exhaust fumes or rid products of toxic compounds, tungsten chemicals offer a very safe and effective method of decontamination.

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* Courtesy of Halliburton

Today’s industries face ever increasing challenges and demands.
Let us help you meet these challenges. As your partner, we will work together with you to develop the tungsten powders and chemicals that meet your and your customers’ requirements. H.C. Starck’s outstanding quality, exceptional knowledge of technology metals and processing, our unparalleled commitment to innovation and our ability to collaborate in depth with customers globally ultimately propels our customers to success. Turn our excellence into your advantage!
The H.C. Starck Group …

Backed by nearly 100 years of experience, the H.C. Starck Group is a leading global supplier of high-performance powders and fabricated products made of technology metals and advanced ceramics.

High-performance materials at their best

As a leading developer, manufacturer and recycler of high-performance metals and ceramic powders, as well as fabricated metal and ceramic products, H.C. Starck’s unique and comprehensive product portfolio is truly unsurpassed around the world. As a technology leader in numerous fields, the company’s long-established metallurgic and process-technical expertise has been a decisive factor in its ability to meet and even surpass market requirements and to develop customer-specific product solutions.

Highest innovative force as well as our outstanding product and service quality are the pillars of H.C. Starck’s strong and longstanding relationships with its customers.

Global market presence

With 15 production facilities in Europe, America and Asia, H.C. Starck boasts a truly global market presence to serve expanding industries such as electronics, chemicals, automotive, medical, aerospace, energy and environmental technology as well as engineering companies and tool manufacturers. The proximity we foster to each individual customer and their end markets provides the highest degree of flexibility and support.

As a world technology leader and the independent provider of high-performance tungsten powders and compounds, H.C. Starck offers highest quality products, setting industry standards with its customized solutions and expert knowledge.

An independent, flexible and reliable supply chain with highest service quality

H.C. Starck clearly stands out with its excellent quality and expertise gained over the many years dedicated to the production of tungsten. State-of-the-art systems and processes as well as experienced employees who are true experts in their specific fields ensure a consistently high level of material quality. Certified quality management and the ceaseless analysis of our products’ properties ensure product performance that meets our customers’ exact needs. Our customers can therefore rely on consistent, highest quality products, enabling them to produce high-quality tools while reducing their own process costs.

H.C. Starck offers the entire range of products along the tungsten powder value chain, processing both primary and secondary raw materials and turning them into high quality, customer-specific tungsten chemicals, metal powders and carbides.

But it’s a lot more than just that; we are deeply committed to innovation and collaborate closely with customers around the world to offer truly tailor-made services, developments and solutions. Focusing on these core competencies, H.C. Starck’s position as an independent supplier is genuinely unique in the global tungsten market.

A truly global tungsten producer

H.C. Starck is a global player with a regional outreach in all major areas of the world. More recently, we have broadened our business activities in Asia. In 2011 H.C. Starck and Jiangxi Rare Metals Tungsten Holding Group Co., Ltd. entered into a joint venture to further establish the advanced tungsten products business in China, making H.C. Starck a leading supplier for the ever-growing Chinese market. Another joint venture was set up in 2013 with Nui Phao Mining in Vietnam for the production of high-performance tungsten chemicals.

H.C. Starck currently operates three tungsten powder plants in Europe and North America and is expanding its global footprint to Asia with its new joint ventures in China and Vietnam.

H.C. STARCK TUNGSTEN POWDER LOCATIONS

Goslar, Germany
Goslar is the largest of H.C. Starck’s tungsten powder sites, covering the entire Tungsten powder product range with a special focus on recycling.

Joint venture Ganzhou, China
A joint venture to strengthen the advanced tungsten business in China, with a special focus on tungsten metal and carbide powders.

Sarna, Canada
Serving mainly our Americas-based customers with tungsten metal powders & (cast) tungsten carbides.

Laufenburg, Germany
H.C. Starck’s second German-based plant, for the production of cast tungsten carbides predominantly for the oil & gas industry.

Joint venture Nui Phao, Vietnam
Joint venture with Nui Phao Mining for the production of tungsten chemicals sourced from primary raw materials.

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Application Engineering

Our customers know the true value of our application engineering services. Understanding one another and moving forward together – that’s the H.C. Starck way.

Technical Services

Our accomplished application engineers benefit from the extensive experience they have acquired in collaborating with our partners.

H.C. Starck engineers can be involved in truly every stage of production, from initial grade selection, process and quality optimization, value improvement and cost cutting projects, to the development of new powders and the evaluation of new markets. Our global network of experts provide first-class after-sales services for our customers, regardless of the project phase. H.C. Starck makes sure that each and every project is a success and that all production targets and investment goals are met.

THE CUSTOMER PROJECT – A JOINT EFFORT

Research & Innovation

Customer-driven research and innovation are the key drivers of H.C. Starck’s tungsten business.

Innovation at H.C. Starck

Long-term success is only ever possible through innovations that can keep up with the challenges of global markets and trends. Innovation and research are key strengths at H.C. Starck, which is clearly reflected in joint projects with dedicated universities and research institutes, as well as our expertise in application technology. Our devoted Research & Development (R & D) Team works on the development and improvement of our tungsten materials, products and processes. They are fully supported by H.C. Starck’s Central Laboratory in Goslar, which is one of the largest industrial laboratories for inorganic element analysis and powder characterization in Germany, and has been fully accredited as a testing laboratory according to DIN EN ISO/IEC 17025 (formerly DIN EN 45001) since 1995.

Besides the very latest in laboratory technology, as a global leader in refractory metals, H.C. Starck maintains pilot plants and a clean room zone where we are constantly in the process of refining and improving our intermediates, products and processes. H.C. Starck’s research and development activities in tungsten not only cover all kinds of pyro- and hydrometallurgical process technologies, but also the operation of a sophisticated technical thermal R & D center, providing manifold high-temperature furnaces as well as mixing, milling and classifying equipment in lab and pilot scale.

Customer-driven development

World-class R & D, application technology and laboratory services enable us to work on customer projects and offer tailor-made, customer-specific powder design, which is one of our core research areas. Our sustainable R & D programs are shaped by the ongoing dialogue with our customers. In order to ensure that all customer specifics are included in the ultimate tailor-made solution, we are involved in the entire process from the very outset of a project. By listening to customer needs and requirements, we are able to accurately adapt the chemical and physical properties of our powders to reach the precise degree of purity, functionality and appearance. Thus we help our customers to develop new and innovative products for the future. All new developments, whether product innovations or process improvements, are tested for their practical utility and modified for specific customer needs. Close cooperation is a key factor in providing high quality products.

TAILOR-MADE DESIGN OF TUNGSTEN BASED POWDERS

Ammonium Paratungstate (APT) 
(NH₄)₁₀(H₂W₁₂O₄₂)x 4H₂O

Calcination

Tungsten Oxides (isomorph to APT)

Reduction

Coarse Tungsten Metal Powder

Carburization

Coarse Tungsten Carbide Powder

Depending on customer request

Fine Tungsten Carbide Powder

Medium temperature, low humidity, high purity raw materials

Calcination

Reduction

Carburization

Coarse Tungsten Metal Powder

Depend on customer request

Ammonium Paratungstate (APT) 
(NH₄)₁₀(H₂W₁₂O₄₂)x 4H₂O

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Tungsten Oxides (isomorph to APT)

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Depend on customer request

Fine Tungsten Metal Powder
Secure & Sustainable Material Supply

Our raw material supply strategy rests on two pillars: Exclusive sourcing from well-established, conflict-free suppliers and the continuous expansion of our recycling activities.

**PRIMARY RAW MATERIALS**

**Responsible raw material sourcing**

H.C. Starck sources all raw materials exclusively from well-established, conflict-free suppliers. We work with strict purchasing policies, such as our approved Responsible Supply Chain Management (RSCM) System, that ensure that our raw materials originate from suppliers who comply with strict environmental protection requirements, observe occupational health and safety regulations and show social responsibility.

Furthermore, H.C. Starck processes only raw materials from conflict-free sources. We fully support the position of the Organization for Economic Cooperation and Development (OECD) to avoid the use of ores and metals that finance or benefit armed groups. Plus, as a founding member of the Tungsten Industry Conflict Minerals Council (TI-CMC), we contribute to implementing a tungsten-specific approach to meeting customer and statutory requirements of the Dodd-Frank Act provisions for conflict minerals.

**Our joint ventures secure long-term supply**

We have also entered into two joint ventures with established, conflict-free tungsten suppliers in Vietnam and China, that are important building blocks for the stable supply of primary raw materials. They further strengthen H.C. Starck’s position as global tungsten producer and help provide customers with long-term supply security.

**SECONDARY RAW MATERIALS**

**Conserving the environment and natural resources**

At H.C. Starck sustainability is a core element of our company strategy. As part of our commitment to sustainable economic management, we have been recycling tungsten scrap and tungsten-containing production residues since 1920. Since then, we have been working and investing continuously to improve our abilities to process all kinds of raw materials. Consequentially, recycling is one of our core competencies.

**H.C. Starck – your strategic growth partner for recycling**

The benefits of recycling for our customers are twofold: With the ever increasing demand for raw materials, recycling is a core element to secure the supply of raw materials. This is particularly true for tungsten, as its supply is limited. Plus, recycling reduces a company’s exposure to fluctuations of tungsten raw material prices. Reasons enough for our customers to have their own tungsten scrap and production residues converted to new tungsten powders and chemicals at H.C. Starck.

**Typical scraps used for recycling:**

- Inserts, tips, cutting tools
- Drills
- Drill bits / heads for oil- and gas drilling
- Morgan rolls
- Mining bits
- Wear parts
- Swarf, turnings, shavings, borings
- Grinding residues
- Spent NiW catalysts

**Recycling of valuable materials**

Recycling of tungsten scrap and tungsten-containing production residues preserves both the environment and natural resources and adds to the stability of raw material supplies for our customers.

**SECURE RAW MATERIAL POSITION**

**Nui Phao H.C. Starck Tungsten Chemicals Manufacturing**

The Nui Phao mine is one of the largest tungsten deposits outside of China. As such, our joint venture with the Vietnamese Nui Phao Mining Company will ensure the continuous supply of tungsten chemicals.

**Jiangwu H.C. Starck Tungsten Products Co., Ltd.**

Our partner JXTC is one of the largest tungsten mining companies in China. Thus, our joint venture secures raw material supply for the production of thousands of tons of high-quality tungsten products for the Asian market from early 2014.

**TUNGSTEN CLOSED-LOOP RECYCLING AT H.C. STARCK**

Based on the “closed loop” principle, almost all our products and compounds can be recycled after use. Thanks to innovative tungsten recycling processes, we can recover pure tungsten and cobalt from both hard and soft tungsten scrap. This includes for instance worn out inserts, drills, chisels, alloys, NiW catalysts and production & processing residues such as dry powders or sludges.

Thanks to the H.C. Starck “closed loop” recycling process, products can be tracked from cradle to grave. Even after the recycling process, all of our tungsten products have one thing in common: they perform just as well as they did before, a benefit with a true added value for our customers.

**Our recycling process: the closed loop principle**

The Nui Phao mine is one of the largest tungsten deposits outside of China. As such, our joint venture with the Vietnamese Nui Phao Mining Company will ensure the continuous supply of tungsten chemicals.

Our partner JXTC is one of the largest tungsten mining companies in China. Thus, our joint venture secures raw material supply for the production of thousands of tons of high-quality tungsten products for the Asian market from early 2014.
Tungsten Powders & Typical Applications

Faster, durable, superior

Tungsten Powders for Cutting Tools & Wear Parts

Today’s industrial tools and wear parts have to withstand extreme loads while offering durability and long tool life. Our exceptionally hard and resistant tungsten carbide is the material of choice for the production of cutting edge cemented carbides used in tools. In-house production of a range of titanium carbides, nitrides and various additives makes H.C. Starck a comprehensive partner of numerous cutting tool and wear part manufacturers.

H.C. STARCK – CUTS TO THE CHASE

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Short Description</th>
<th>Available Nominal Particle Size (FSSS Value) [μm] / Surface area [m²/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten Carbides WC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC DN</td>
<td>Nano to ultrafine, deagglomerated tungsten carbide grades with narrow grain size distribution Grades can be customized to include grain growth inhibitors</td>
<td>– 2.5 - 4.0 m²/g</td>
</tr>
<tr>
<td>WC DS</td>
<td>Submicron to fine, deagglomerated tungsten carbide grades with narrow grain size distribution As WC DS, but with improved pressing characteristics and adjusted shrinkage behavior (low shrinkage powder) Grades can be customized to include grain growth inhibitors</td>
<td>(0.4 µm) – 2.5 µm 2.5 m²/g –</td>
</tr>
<tr>
<td>WC DS LS</td>
<td>Deagglomerated medium to course tungsten carbide grades with minimized contents of large particles and agglomerates</td>
<td>3.0 – 5.0 µm</td>
</tr>
<tr>
<td>WC DM</td>
<td>As WC DM, but carburized at high temperature</td>
<td></td>
</tr>
<tr>
<td>WC DM HT</td>
<td>Extra coarse tungsten carbide, carburized at high temperature</td>
<td>5 – 70 µm</td>
</tr>
</tbody>
</table>

Powders for Cermets & Cutting Ceramics

<table>
<thead>
<tr>
<th>Additives for Cermets &amp; Cutting Ceramics</th>
<th>Tantalum carbide</th>
<th>Chromium carbide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium carbide</td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>Titanium nitride</td>
<td>63</td>
<td>64</td>
</tr>
<tr>
<td>Niobium carbide</td>
<td>65</td>
<td>66</td>
</tr>
<tr>
<td>Vanadium carbide</td>
<td>67</td>
<td>68</td>
</tr>
<tr>
<td>Tantalum niobium carbide</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td>Titanium-niobium carbide</td>
<td>71</td>
<td>72</td>
</tr>
</tbody>
</table>


The values in the above table are typical values and do not constitute a specification. Additional materials and grain sizes are available upon request. Product data sheets are available for download at www.hcstarck.com.
Tougher, stronger, deeper

**Tungsten Powders for Oil & Gas Exploration Tools**

Demanding deep and directional drilling through geological formations relies on tungsten matrix powders used for the drill head and tungsten metal powders for the drill bit's shoulder and shaped charges. In collaboration with our customers, we develop powders and powder mixtures that meet their very specific needs and enhance drill bit performance.

Thanks to its special physical properties, tungsten is suitable for a wide range of heavy metal and mill products employed in industries such as aviation, the electronic, electrical and medical industry. Whatever your field of applications may be, we offer the appropriate tungsten metal powder grade along with customer-specific tailor-made services.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Short Description</th>
<th>Available Nominal Particle Size (FSSS Value) [µm] / Sieving Size [µm / mesh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Tungsten Carbides CTC</td>
<td>Eutectic mixture of mono tungsten carbide (WC) and di-tungsten carbide (W₂C) with very fine internal structure (&quot;feather structure&quot;)</td>
<td>2000 &lt; 1000 µm – 45 &lt; 15 µm</td>
</tr>
<tr>
<td>MTC (Macroline)</td>
<td>Cast tungsten carbide, featuring a protective layer of tungsten carbide</td>
<td>425 &lt; 200 µm – 98 &lt; 36 µm</td>
</tr>
</tbody>
</table>

**Tungsten Metal Powders**

<table>
<thead>
<tr>
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<th>Available Nominal Particle Size (FSSS Value) [µm] / Sieving Size [µm / mesh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMP HC</td>
<td>Traditional powders with low impurity content and a broad range of available grain sizes</td>
<td>1.5 – 20 µm</td>
</tr>
<tr>
<td>WMP HC 4000</td>
<td>Standard coarse tungsten metal powders</td>
<td></td>
</tr>
<tr>
<td>WMP GG</td>
<td>Special coarse tungsten metal powder grades with very low oxygen contents and excellent infiltration characteristics</td>
<td></td>
</tr>
</tbody>
</table>

**WMP HC S**

In comparison with the HC grades, the HC S grades are deagglomerated and have very narrow grain size distributions.

**WMP D**

Softly agglomerated powders with excellent cold pressing behavior, in combination with additional components, improved mixing properties.

**WMP GG**

Special coarse tungsten metal powder grades with very low oxygen content and excellent infiltration characteristics.

**WMP HC 4000**

Standard coarse tungsten metal powders

**Hazards Identification in Advertising (Directive 67/548/EEC Article 26 and Directive 1999/45/EC Article 13):** (0) none; (4) highly flammable

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Cleaner, purer, safer
Tungsten Compounds for Chemical Applications

Tungsten chemicals widely serve as intermediates in tungsten metal and tungsten carbide production. Apart from that, they are essential components in various chemical applications, such as pigments or catalysts, e.g. in crude oil refining. H.C. Starck’s tailor-made high-quality chemicals and services are what make us a preferred supplier around the world.

H.C. STARCK – A TRUE CHEMICAL REACTION

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Short Description</th>
<th>WO₃ content in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten Chemicals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium metatungstate (AMT)</td>
<td>White crystalline powder with extraordinary high solubility in water (65 % WO₃ at 20 °C). Used for the production of catalysts</td>
<td>min. 91.0</td>
</tr>
<tr>
<td>Ammonium paratungstate (APT)</td>
<td>White crystalline finely divided powder for the production of tungsten oxides and tungsten metal powders with low solubility in water; used in lamp wires or heating wires</td>
<td>min. 88.5</td>
</tr>
<tr>
<td>Blue tungsten oxide</td>
<td>Blue crystalline powder for the production of tungsten metal powders used in hard metals, lamp wires or heating wires and for chemical applications.</td>
<td>min. 99.6</td>
</tr>
<tr>
<td>Yellow tungsten oxide</td>
<td>Yellow powder, sometimes with a touch of green for the production of tungsten metal powders used in lamp wires or heating wires</td>
<td>min. 99.6</td>
</tr>
<tr>
<td>Tungstic acid</td>
<td>Bright yellow fine powder for the production of tungsten metals and catalysts</td>
<td>min. 92.0</td>
</tr>
<tr>
<td>Sodium tungstate</td>
<td>White crystalline powder for the production of luminophors, phosphorus, pigments and catalysts</td>
<td>70.0 – 71.5</td>
</tr>
</tbody>
</table>


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