Materials catalogue

Sophisticated Materials solutions
For more than 130 years, we have been producing high quality tool steel exclusively at our traditional location. Even today, Kind&Co is still a wholly-owned family company.

We stand for sophisticated material solutions, maximum quality, reliable service and competent advice – tailored to the individual purpose. We have particularly strong application expertise in the segments of extrusion, pressure die casting and die forging. Our range of services is the guarantee for economic and safe production processes of our customers.

Our company has a very special soul:
The „soul of steel“!

As the only hot work specialist worldwide, we are expanding our service and our added value chain in our home market of Europe. Through our international subsidiary companies and trading partners, we are growing successfully in the global market and thus fortify our Bielstein production site.

The experience and capabilities of our employees are our most important resource. We are working with respect for each other and with commitment to each other. New challenges are met with a willingness for change.
Sophisticated materials solutions

This materials catalogue describes and classifies the properties and applications of the materials produced by us. The various materials are manufactured by smelting, using selected scrap, by electro-slag-remelting process (ESR) in case of higher quality requirements, by forming the cast blocks on hydraulic forging presses and other mechanical processing until the product is pre-finished according to customer drawing. All process steps are accompanied by treatments, which make an important contribution to achieving the maximum material properties.

Our Service

Our broad range of services targets the individual needs of our customers.

Apart from our high performance steels, we offer you an extensive range of services as part of the tool processing and finishing. Use our relevant know-how and the experience of our specialists, paired with modern technical equipment.

With a high level of flexibility, we realise individual and tailored technologies and processes according to your requirements profile, which help your quality tools achieve maximum performance.

Talk with our experts and get qualified advice – problem-solving is our speciality.
Apart from the standardised tool steels according to DIN EN ISO 4957, we develop our own special materials for applications according to customer requirements. We see ourselves as a customer-oriented problem-solver for your applications of tool steels in numerous forming processes.

With the special steels developed in-house, we have expanded our delivery spectrum, also at the threshold between various applications, in order to be able to offer solutions.

In principle, we divide the materials in this catalogue on the basis of DIN EN ISO 4957 as follows:

- Cold-work tool steels with a surface temperature < 200 °C
- Hot-work tool steels with a surface temperature > 200 °C
- Highly heat-resistant steels with a surface temperature > 600 °C

Through competent and solution-oriented customer advice, we also want to live up to our claim going forward of being able to offer you a sophisticated material solution.
### Hot-work tool steels

<table>
<thead>
<tr>
<th>Brand name</th>
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<th>Short name</th>
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Cold-work tool steels / Plastic mould steels

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Highly heat-resistant steels / Nickel-based alloys

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Hot-work tool steel

Hot-work tool steels are used in tools that are used in general temperatures above 200 °C. As a result of the alloy elements Cr, Mo, V and W these steels have a high high-temperature strength, high tempering resistance and high-temperature toughness.

The main needs are found in the areas of pressure die casting, die forging, extrusion presses and various processes for manufacturing seamless pipes.

Specifically for these application areas we have developed several special steels in house over the last few years. Material properties such as high-temperature toughness, thermal conductivity and high-temperature strength could be increased considerably in these new materials.
CM167 (1.2323)

<table>
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<th>Mat.-no.</th>
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Material properties

CM167 is a low-alloy hot-work tool steel based on Cr-Mo-V with high high-temperature toughness and good tempering resistance. Water cooling possible.

Application

- Tools for pipe and extrusion presses in light metal processing and die holders
- Supports
- Pressure plates
- Impression dies for light and heavy metal

Physical properties

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<tr>
<th>Temperature in °C</th>
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<th>20 - 200</th>
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Heat treatment

- Soft annealing
  - Temperature: 740 - 760 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 215 HB
- Hardening
  - Temperature: 950 - 980 °C
  - Cooling: in Oil/polymer or warm bath of 300 °C, Interrupt oil or polymer cooling at 250 - 300 °C or vacuum hardening
- Tempering
  - Temperature: 500 - 700 °C
  - Hardness: see Tempering graph
- Nitriding
  - possible under some conditions
- Preheating before use
  - Temperature: 150 - 350 °C required
USN (1.2343)

<table>
<thead>
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<th>Mat.-no.</th>
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<th>Brand name</th>
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**Material properties**

USN is a Cr-Mo-V alloyed hot-work tool steel with good high temperature strength characteristics and high high-temperature toughness. USN is thermal shock resistant, water coolable, and is characterised by high hardenability.

**Application**

- Extrusion press tools for light metal processing, such as dies, chamber tools, die holders, press mandrels, press stems, container mantles, inner liners
- Press mandrels and stems for steel and heavy metal processing in extrusion presses
- Die casting tools such as moulding plates, valves, cores, ejectors, sprue bushings and filling fittings in the processing of light metals and zinc alloys
- Tools in forging machines such as pressure dies, die inserts, stamps and mandrels for steel, heavy and light metals

**Physical properties**

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<td>E module in GPa</td>
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**Heat treatment**

- **Soft annealing**
  - Temperature: 820 - 840 °C
  - Cooling: Slow furnace cooling
  - Hardness: max. 220 HB

- **Hardening**
  - Temperature: 1000 - 1020 °C
  - Cooling: Cooling in air, warm bath of approx. 540 °C, Oil/polymer;
    Interrupt oil or polymer quenching at 230 - 280 °C or vacuum hardening

- **Tempering**
  - Temperature: 520 - 700 °C
  - Hardness: see tempering diagram

- **Nitriding**
  - possible

- **Preheating before use**
  - Temperature: 150 - 350 °C essential
USD (1.2344)

Material properties
USD is a Cr-Mo-V alloyed hot-work tool steel with high-temperature strength and higher thermal shock resistance than USN. USD is thermal shock resistant, water coolable, and is characterised by high hardenability.

Application
- Extrusion press tools for light metal processing, such as dies, chamber tools, die holders, press mandrels, valves and stems, shear blades
- Press mandrels and stems for steel and heavy metal processing in extrusion presses
- Die casting tools such as moulding plates, valves, cores, ejectors, sprue bushings and filling fittings in the processing of light metals and zinc alloys
- Tools in forging machines, compression moulding dies, die inserts, punches and mandrels for steel, heavy and light metals

Physical properties

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<td>E module in GPa</td>
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Heat treatment

Soft annealing
Temperature 820 - 840 °C
Cooling Slow furnace cooling
Hardness max. 220 HB

Hardening
Temperature 1020 - 1040 °C
Cooling Air cooling, warm bath of approx. 540 °C, Oil/polymer;
Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

Tempering
Temperature 520 - 700 °C
Hardness see tempering curve

Nitriding possible

Preheating before use
Temperature 150 - 350 °C essential
USD-H (1.2345)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2345</td>
<td>X50CrMoV5-1</td>
<td>USD-H</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Si</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mn</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Cr</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>Mo</td>
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<td>V</td>
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</tr>
<tr>
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<td>0.90</td>
</tr>
</tbody>
</table>

**Material properties**

Hot-work tool steel with increased carbon content for increased resistance to wear, higher temper resistance and hardenability.

**Application**

- Cold and hot shear blades
- Forging dies
- Rollers for pipe manufacturing

**Physical properties**

<table>
<thead>
<tr>
<th>Physical property</th>
<th>Temperature in °C</th>
<th>Thermal expansion in 10⁻⁶m/m·x°K</th>
<th>Temperature in °C</th>
<th>Thermal conductivity in W/m·x°K</th>
<th>Temperature in °C</th>
<th>Density in g/cm³</th>
<th>Temperature in °C</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 - 100</td>
<td>11,5</td>
<td>20</td>
<td>25,0</td>
<td>20</td>
<td>7,73</td>
<td>20</td>
<td>215</td>
</tr>
<tr>
<td></td>
<td>20 - 400</td>
<td>12,5</td>
<td>200</td>
<td>26,7</td>
<td>400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 - 600</td>
<td>13,1</td>
<td></td>
<td>27,3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 760 - 810 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 240 HB

- **Hardening**
  - Temperature: 1010 - 1040 °C
  - Cooling: Oil or polymer cooling or vacuum hardening

- **Tempering**
  - Temperature: 520 - 620 °C
  - Hardness: see tempering curve

- **Nitriding**
  - Possible

- **Preheating before use**
  - Temperature: 150 - 350 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
RP (1.2365)

Material properties
RP is a Cr-Mo-V alloyed hot-work tool steel with very high thermal resistance and tempering resistance, water coolable due to good thermal conductivity, so not sensitive to thermal shock. RP is very good for hobbing.

Application
- Extrusion press tools for steel and heavy metal processing, such as pipe extrusion rams, die holders and inner liners
- Compression moulding dies for heavy metal processing
- Tools in forging presses such as die inserts, mandrels, forge jaws and stems for steel processing
- Piercer heads
- Piercers
- Push bench rollers in steel pipe production

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>10,3</td>
<td>11,9</td>
<td>13,0</td>
<td>13,7</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>30,0</td>
<td>30,2</td>
<td>29,3</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7,85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
- Temperature: 820 - 840 °C, 4 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 220 HB, for hobbing max. 175 HB

Hardening
- Temperature: 1020 - 1050 °C
- Cooling: Polymer, warm bath approx. 540 °C, interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

Tempering
- Temperature: 580 - 700 °C
- Hardness: see tempering curve

Nitriding
- possible

Preheating before use
- Temperature: 150 - 350 °C essential

Mat.-no. | Short name | Brand name | C | Si | Mn | Cr | Mo | V |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2365</td>
<td>32CrMoV12-28</td>
<td>RP</td>
<td>0.32</td>
<td>0.40</td>
<td>0.40</td>
<td>3.00</td>
<td>2.80</td>
<td>0.50</td>
</tr>
</tbody>
</table>
RPU (1.2367)

Material properties

RPU as a Cr-Mo alloyed hot-work tool steel is a combination of the steels USN and RP. Good high temperature toughness combined with good high temperature strength.

Application

- Extrusion press tools such as pipe extrusion mandrels, press stems, die holders and inner liners for heavy metal alloys
- Die casting tools for high shot numbers in light metal processing
- Impression dies for heavy and light metal processing
- Dies or die inserts under forging presses for steel forming

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$m/m x K</td>
<td>11.9</td>
<td>12.5</td>
<td>12.8</td>
<td>13.3</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>29.9</td>
<td>32.1</td>
<td>32.4</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
Temperature 820 - 840 °C, 4 - 6 hrs.
Cooling Slow furnace cooling
Hardness max. 220 HB

Hardening
Temperature 1030 - 1050 °C
Cooling Air, warm bath approx. 540 °C, Oil/polymer; Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

Tempering
Temperature 520 - 700 °C
Hardness see tempering curve

Nitriding possible

Preheating before use Temperature 150 - 350 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
MA (1.2581)

**Material properties**

MA is a high-W alloyed hot-work tool steel with best high temperature strength and tempering resistance with high-temperature wear resistance.

**Application**

- Thermally heavy duty tools for extrusion pressing of heavy metals such as dies, die holders and mandrels
- Partial pressure dies for heavy metal processing

Water cooling is not possible.

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m×K</td>
<td>11,2</td>
<td>11,9</td>
<td>12,5</td>
<td>13,0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m×K</td>
<td>30,6</td>
<td>30,7</td>
<td>30,8</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>8,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 240 HB

- **Hardening**
  - Temperature: 1100 - 1150 °C
  - Cooling: Oil/polymer or warm bath of approx. 540 °C, Air;
    Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

- **Tempering**
  - Temperature: 580 - 700 °C
  - Hardness: see tempering curve

- **Nitriding**
  - possible

- **Preheating before use**
  - Temperature: 300 - 400 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
**W44** (1.2603)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2603</td>
<td>45CrVMoW5-8</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>0.45</td>
</tr>
</tbody>
</table>

**Material properties**

W44 is a medium alloyed hot-work tool steel with high tempering resistance, with good high temperature wear behaviour and which is not sensitive to sudden temperature change.

**Application**

- Extrusion press tools such as pressure disks, cleaning disks, dies, die holders for light metal processing
- Impression dies for light and heavy metal processing
- Dies and stems for steel forming in the manufacture of screws, nuts and rivets under spindle presses

Water cooling is possible.

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10^-6m/m x K</td>
<td>11,7</td>
<td>12,0</td>
<td>12,5</td>
<td>13,0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20 - 100</td>
<td>20 - 200</td>
<td>20 - 400</td>
<td>20 - 600</td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>34,0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

**Soft annealing**
- Temperature: 820 - 840 °C
- Cooling: Slow furnace cooling
- Hardness: max. 220 HB

**Hardening**
- Temperature: 1000 - 1050 °C
- Cooling: Oil/polymer, for low constant thicknesses also warm bath of approx. 540 °C, oil or polymer cooling at 200 - 250 °C or vacuum hardening

**Tempering**
- Temperature: 520 - 700 °C
- Hardness: see tempering curve

**Nitriding possible**

**Preheating before use**
- Temperature: 150 - 350 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
**Material properties**

US corresponds to the steel USN with additional W content. This increases high temperature strength and high temperature wear resistance. High temperature toughness and thermal shock resistance are good. Water coolability is somewhat limited.

**Application**

- Extrusion press tools for light metal processing
- Die casting tools for light metal and zinc alloys
- Impression dies for heavy and light metal processing
- Forging tools such as small and medium full dies in forging presses
- Die inserts, mandrels, forge jaws and stamps and in steel processing

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>9.6</td>
<td>11.0</td>
<td>12.1</td>
<td>13.0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>24,2</td>
<td>25,6</td>
<td>26,8</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7,74</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

**Soft annealing**

- Temperature: 820 - 840 °C
- Cooling: Slow furnace cooling
- Hardness: max. 220 HB

**Hardening**

- Temperature: 1000 - 1050 °C
- Cooling: In air, warm bath of approx. 540 °C, Oil/polymer; Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

**Tempering**

- Temperature: 520 - 700 °C
- Hardness: see tempering curve

**Nitriding**

Possible

**Preheating before use**

- Temperature: 150 - 350 °C essential

---

### Table: Material properties

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2606</td>
<td>X37CrMoW5-1 US</td>
<td>US</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.36</td>
</tr>
</tbody>
</table>
PD (1.2622)

Material properties
PD is a high-W alloyed hot-work tool steel and combines the highest wear resistance with high tempering resistance.

Application
Hot punching and cutting tools for steel processing
Hot extrusion mandrels and shrunk dies (steel processing)
Shrunk screw dies, punching tools and shear blades
Tools for hot pressing of sintered powders
Water cooling is not possible.

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11,0</td>
<td>12,0</td>
<td>13,1</td>
<td>13,4</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>24,2</td>
<td>26,8</td>
<td>27,5</td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
- Temperature: 820 - 840 °C, 4 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 260 HB

Hardening
- Temperature: 1130 - 1180 °C
- Cooling: Air, warm bath of approx. 540 °C, Oil/polymer;
  Interrupt oil or polymer quenching at 250 - 300 °C or vacuum hardening

Tempering
- Temperature: 540 - 680 °C
- Hardness: see tempering curve

Nitriding
- possible

Preheating before use
- Temperature: 200 - 400 °C essential

Mat.-no. | Short name | Brand name | Mass.-% |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2622</td>
<td>X60WCrMoV9-4</td>
<td>PD</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C  Si  Mn  Cr  Mo  V  W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.58  0.25  0.25  4.00  0.90  0.80  9.00</td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
**Material properties**

Because of its balanced composition, HWD is a hot-work tool steel with maximum high temperature strength and tempering resistance with particularly high hot wear resistance. Compared to MA, HWD does not tend towards hot embrittlement.

**Application**

- Extrusion press dies for brass
- Die holders for heavy metal processing
- Die-casting dies for heavy metals and relatively thin-walled cast pieces, heavy duty cores, which lie in the casting stream, light metal casting
- Impression dies, especially mandrel inserts for hot pressing of heavy metals
- Small die inserts and warm extrusion dies in steel forming

Water cooling is not possible.

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11.6</td>
<td>12.0</td>
<td>12.5</td>
<td>13.0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>24.0</td>
<td>28.5</td>
<td>31.7</td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 240 HB

- **Hardening**
  - Temperature: 1130 - 1180 °C
  - Cooling: Air, warm bath of approx. 540 °C, Oil/polymer; interrupt oil or polymer cooling at 250 - 300 °C or vacuum hardening

- **Tempering**
  - Temperature: 580 - 750 °C
  - Hardness: see tempering curve

- **Nitriding**
  - possible

- **Preheating before use**
  - Temperature: 200 - 400 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph

Austenitizing temperature 1130 °C

Carbide precipitation

A + K

Ac1b

Ac1e

P

B

M

Ms

Austenitizing temperature 1130 °C

Hardness in HV

Area reduction Z in %

Test temperature in °C

Hardness in HRC

Tempering temperature in °C

0.2% proof stress and tensile strength Rm in MPa

Rt

Rm

Z

Test temperature in °C

Area reduction Z in %

Hardness in HRC

Tempering temperature in °C
UHF3 (1.2709)

Material properties

UHF3 is a high-strength and high-toughness maraging nickel steel with simple heat treatment and is suitable for tools exposed to moderate thermal loads and for cold work tools.

Application

- Die casting moulds for light metal and zinc alloys such as inserts and cores
- Impression dies for light metal processing
- Plastic moulds
- Cold impact pressing tools
- Cold punches
- Cylinders and shrink rings for cold extrusion tools or hard metal inserts
- Heavy duty cold pilger mandrels for steel and heavy metal processing in the production of thin-walled pipes

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$m/m x K</td>
<td>10.4</td>
<td>11.0</td>
<td>11.7</td>
<td>12.0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>8.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Solution annealing
- Temperature 900 °C
- Cooling Air
- Festigkeit 950 - 1100 MPa

Auslagern
- Temperature 500 °C
- Cooling 6 hrs. with cooling in calm air
  This results in a considerable increase in strength.

Nitriding possible under some conditions

Preheating before use
- UHF3 can be welded easily without preheating with equivalent filler metal.

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2709</td>
<td>X2NiCoMoTi18-9-5</td>
<td>UHF3</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
</tbody>
</table>

Mat.-no. Short name Brand name

C Si Mn Mo Ni Co Ti
High-temperature strength graph

Test temperature in °C

Area reduction Z in %

Hardness in HRC

Ageing graph
PWM (1.2714)

Material properties
PWM is the traditional high performance die steel with good toughness and high tempering and compression strength.

Application
- Forging dies for all kinds of steel forming
- Hammer and press saddles
- Jaws in cutting machines
- Tools for the extrusion industry
- Press die holder
- Linings and support tools
- Tool brackets
- Impression dies of all kinds for all light metals and their alloys
- Piercer shafts and hole pots for steel pipe bloom manufacturing

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11,0</td>
<td>12,5</td>
<td>13,3</td>
<td>14,0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>36,0</td>
<td>36,5</td>
<td>36,0</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
- Temperature 740 - 760 °C, 6 - 8 hrs.
- Cooling Slow furnace cooling
- Hardness max. 250 HB

Hardening
- Temperature 850 - 880 °C in Oil/polymer
- 880 - 900 °C in blast air
- Cooling Cooling must be interrupted at approx. 150 °C or vacuum hardening.

Tempering
- Temperature 400 - 700 °C
- Hardness see tempering curve

Nitriding
- possible under some conditions

Preheating before use
- Temperature 150 - 350 °C essential

Mat.-no. Short name Brand name Mass.-% C Si Mn Cr Mo Ni V
1.2714 55NiCrMoV7 PWM 0.55 0.30 0.80 1.10 0.45 1.70 0.10
Continuous time-temperature-transformation graph

Austenitizing temperature 850 °C

Tempering graph

High-temperature strength graph
Material properties
AWS is a high-alloy hot-work tool steel with austenitic structure.
The operational strength of approx. 1000 MPa is achieved through hammer-hard forging below the recrystallisation temperature or through a special heat treatment.

Application
• Press dies in metal extrusion presses for processing copper and its alloys in the manufacturing of rods, pipes and simple profiles

Delivery form:
Only individually forged disks, which should have the appropriate dimensions.

Physical properties
<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$m/m x K</td>
<td>16.3</td>
<td>17.4</td>
<td>17.9</td>
<td>17.7</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>13.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment
Preheating before use
Temperature 400 - 500 °C essential

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2731</td>
<td>X50NiCrWV13-13</td>
<td>AWS</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.50</td>
</tr>
</tbody>
</table>
High-temperature strength graph

Graph showing the relationship between test temperature and properties such as limit strength ($R_{p0.2}$), tensile strength ($R_m$), and area reduction ($Z$) in percent.
PWU (1.2744)

Material properties
PWU is a high performance die steel. As a result of the raised Mo content compared to PWM, there is better high-temperature wear resistance and best tempering.

Application
- Dies for all kinds of steel forming
- Jaws in cutting machines
- Tools in extrusion presses such as stamps, linings and shear blades
- Compression dies for all light metals and their alloys
- Tough shear blades for cold and hot work

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11,6</td>
<td>11,9</td>
<td>12,7</td>
<td>13,3</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>36,0</td>
<td>37,0</td>
<td>35,0</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

- Soft annealing
  - Temperature: 740 - 760 °C, 6 - 8 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 250 HB

- Hardening
  - Temperature: 850 - 880 °C in Oil/polymer
  - 870 - 900 °C blast air
  - Cooling: Cooling must be interrupted at approx. 150 °C or vacuum hardening.

- Tempering
  - Temperature: 400 - 700 °C
  - Hardness: see tempering curve

- Nitriding
  - Possible under some conditions

- Preheating before use
  - Temperature: 150 - 350 °C essential

Physical properties:

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2744</td>
<td>57NiCrMoV7-7</td>
<td>PWU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.55</td>
</tr>
</tbody>
</table>
**Material properties**

This high Cr alloyed steel has good resistance to scale and corrosion.

**Application**

- Glass moulds for household glass with high requirements in terms of glass quality, also for high-melting-point, technical, hard glass

**Delivery condition:**

- Hardened and tempered, or specially heat treated, i.e. ready to use
- Tensile strength $R_m = 950 - 1100$ MPa

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$ m/m x K</td>
<td>10.5</td>
<td>11.0</td>
<td>12.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>25.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>213</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 680 - 720 °C, 8 - 10 hrs.
  - Cooling: Slow furnace cooling

- **Hardening**
  - Temperature: 980 - 1030 °C
  - Cooling: Oil/polymer, interrupt oil or polymer cooling at 120 - 150 °C

- **Tempering**
  - Hardness: see tempering curve

- **Mould preheating in the glass industry**
  - Temperature: approx. 350 - 400 °C

---

**Mat.-no. | Short name | Brand name | Mass.-%**

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Ni</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2787</td>
<td>X23CrNi17</td>
<td>FAM</td>
<td>0.20</td>
<td>≤ 1.00</td>
<td>≤ 1.00</td>
<td>17.00</td>
<td>1.70</td>
</tr>
</tbody>
</table>
RPCo (1.2885)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2885</td>
<td>X32CrMoCoV3-3-3</td>
<td>RPCo</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.32</td>
</tr>
</tbody>
</table>

**Material properties**

RPCo corresponds to the steel RP with additional Co content. The high-temperature strength, tempering resistance and also high temperature wear resistance are increased.

**Application**

- Extrusion press tools such as pressure dies and disks, die holders
- Extrusion punch heads for copper and copper alloys
- Impression dies, especially mandrel inserts for copper and copper alloys
- Piercer heads in steel pipe production

Water cooling is possible.

**Physical properties**

- Temperature in °C 20 - 100, 20 - 400, 20 - 600
- Thermal expansion in $10^{-6}m/m x K$ 11,5, 12,0, 12,2
- Temperature in °C 20, 200, 400
- Thermal conductivity in W/m x K 30,0, 32,1, 34,1
- Temperature in °C 20
- Density in g/cm³ 7.9
- Temperature in °C 20
- E module in GPa 215

**Heat treatment**

- **Soft annealing**
  - Temperature 820 - 840 °C, 4 - 6 hrs.
  - Cooling Slow furnace cooling
  - Hardness max. 240 HB

- **Hardening**
  - Temperature 1040 - 1060 °C
  - Cooling Oil or warm bath of approx. 540 °C, Interrupt oil quenching at approx. 200 - 300 °C or vacuum hardening

- **Tempering**
  - Temperature 560 - 700 °C
  - Hardness see tempering curve

- **Nitriding**
  - possible

- **Preheating before use**
  - Temperature 150 - 350 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
RM10Co (1.2888)

Material properties
RM10Co is a high-alloy special steel with extremely high tempering resistance. RM10Co is suitable for particular requirements in respect of high-temperature wear resistance and resistance against molten metals.

Application
- Tools for extrusion presses such as press dies for steel and heavy metal processing, as well as spider tools and frame tools for processing copper and its alloys
- Mould plates for brass pressure die-casting
- Valves
- Cores and filling sets
- Filling sets in magnesium die casting in hot chamber machines
- Hot extrusion presses for dies
- Punch for steel forming

Water cooling is not possible.

Physical properties

<table>
<thead>
<tr>
<th>Physical properties</th>
<th>Temperature in °C</th>
<th>Thermal expansion in 10^-6m/m x K</th>
<th>Thermal conductivity in W/m x K</th>
<th>Density in g/cm³</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature in °C</td>
<td>20 - 100</td>
<td>11,3</td>
<td>20,5</td>
<td>8,08</td>
<td>215</td>
</tr>
<tr>
<td>20 - 200</td>
<td>12,2</td>
<td>200</td>
<td>24,2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 400</td>
<td>12,6</td>
<td>400</td>
<td>27,5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 600</td>
<td>12,6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
- Temperature: 840 - 760 °C, jeweils 4 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 320 HB

Hardening
- Temperature: 1100 - 1150 °C
- Cooling: Hot strip of approx. 540 °C, Air or oil/polymer; Interrupt oil or polymer cooling at 250 - 300 °C or vacuum hardening

Tempering
- Temperature: 600 - 750 °C
- Hardness: see tempering curve

Nitriding possible

Preheating before use
- Temperature: 150 - 350 °C essential
**HMoD (1.2889)**

### Material properties

Because of its composition, HMoD is a hot-work tool steel with maximum high-temperature strength and tempering resistance with particular high-temperature wear resistance. HMoD has the same areas of application as the steel HWD and is related in respect of the analysis. HMoD is a molybdenum alloy rather than a tungsten alloy with otherwise comparable analysis. Better toughness behaviour can be achieved as a result.

### Application

- Extrusion press dies for brass
- Die versions for heavy metal processing
- Die-casting dies for casting heavy metals and relatively thin-walled cast pieces
- Heavy duty cores in the pouring stream, when casting light metals
- Impression dies, especially mandrel inserts for hot pressing of heavy metals
- Small die inserts and warm extrusion dies in steel forming

### Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11.2</td>
<td>11.8</td>
<td>12.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20</th>
<th>200</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>24.1</td>
<td>28.8</td>
<td>32.3</td>
</tr>
</tbody>
</table>

### Heat treatment

**Soft annealing**

Temperature: 820 - 840 °C, 4 - 6 hrs.

Cooling: Slow furnace cooling

Hardness: max. 240 HB

**Hardening**

Temperature: 1120 - 1150 °C

Cooling: Air, warm bath of approx. 540 °C, Oil/polymer; Interrupt oil or polymer cooling at 250 - 300 °C or vacuum hardening

**Tempering**

Temperature: 580 - 750 °C

Hardness: see tempering curve

**Nitriding**

possible

**Preheating before use**

Temperature: 200 - 400 °C essential

### Table: Material properties

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2889</td>
<td>X45CoCrMoV5-5-3</td>
<td>HMoD</td>
<td>0.45</td>
<td>0.30</td>
<td>0.40</td>
<td>4.50</td>
<td>3.00</td>
<td>2.00</td>
<td>4.50</td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
1.4418

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4418</td>
<td>X4CrNiMo16-5-1</td>
<td>C 0.06 Si ≤ 0.70 Mn ≤ 1.50 Cr 15.00 Mo 0.90 Ni 5.00 N ≥ 0.02</td>
</tr>
</tbody>
</table>

**Material properties**

1.4418 is a low-carbon, corrosion-resistant steel. It combines high strength and good toughness.

**Application**

- Glass dies

**Physical properties**

<table>
<thead>
<tr>
<th>Physical property</th>
<th>Temperature in °C</th>
<th>Thermal expansion in 10⁻⁶ m/m x K</th>
<th>Thermal conductivity in W/m x K</th>
<th>Density in g/cm³</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 - 100</td>
<td>10,3</td>
<td>15,0</td>
<td>7,7</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>20 - 200</td>
<td>10,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 - 400</td>
<td>11,6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 600 - 650 °C
  - Cooling: Slow furnace cooling
  - Hardness: max. 320 HB
- **Hardening**
  - Temperature: 950 - 1050 °C
  - Cooling: Oil, polymer, air, water
- **Tempering**
  - Temperature: 550 - 620 °C
  - Hardness: see tempering curve
- **Nitriding**
  - possible
- **Preheating before use**
  - Temperature: 350 - 400 °C essential
High-temperature strength graph

- Test temperature in °C
- Area reduction Z in %
- 0.2 limit $R_{0.2}$ and tensile strength $R_m$ in MPa

The graph shows the variation of $R_{0.2}$, $R_m$, and area reduction $Z$ with test temperature.
CR7V-L

Material properties
This high Cr alloyed special steel with Mo and V additives is characterised, with good high-temperature strength, by particularly high wear resistance, both for cold and hot work. Thermal shock resistance is good.

Application
For cold work:
- Punches and shear blade for sheet metal thickness of approx. 6-12 mm

For hot work:
- Die inserts and mandrels
- Extrusion dies for steel forming
- Hot extrusion of copper and copper alloys
- Hot shear blades and deburring tools
- Drawing rollers for steel bottle manufacturing

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$m/m x K</td>
<td>11,4</td>
<td>11,9</td>
<td>12,5</td>
<td>13,1</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>26,7</td>
<td>29,8</td>
<td>30,8</td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment
Soft annealing
- Temperature: 820 - 840 °C, 4 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 240 HB

Hardening
- Temperature: 1030 - 1040 °C
- Cooling: Cooling in warm bath of approx. 540 °C, in air or oil/polymer; Interrupt oil or polymer cooling at 250 - 300 °C or vacuum hardening.

Tempering
- Temperature: 500 - 700 °C
- Hardness: see tempering curve

Nitriding possible

Preheating before use
- Temperature: 150 - 350 °C essential

Mat.-no. | Brand name | Mass.-% |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Special</td>
<td>CR7V-L</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.42</td>
</tr>
</tbody>
</table>
CS1

Material properties
CS1 is a Cr-Mo-V alloyed hot-work tool steel with higher C content compared to TQ1. It is characterised by particularly high strength, high-temperature strength with simultaneously very high toughness and thermal shock resistance and is only manufactured in remelted version according to the ESU process.

Application
CS1 is particularly suitable for loads above the limit of TQ1:
- Extrusion presses: For specific pressures > 1000 MPa, heavy duty press stems, press disks and inner liners
- Drop forging
- Hot forming

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$m/m x K</td>
<td>11.8</td>
<td>12.5</td>
<td>13.2</td>
<td>13.4</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>28.8</td>
<td>30.0</td>
<td>29.4</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in $g/cm^3$</td>
<td>7.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>213</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

- Soft annealing
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 230 HB

- Hardening
  - Temperature: 1010 - 1040 °C
  - Cooling: Air, warm bath of approx. 540 °C, Oil/polymer; Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

- Tempering
  - Temperature: 540 - 680 °C
  - Hardness: see tempering curve

- Nitriding: possible

- Preheating before use
  - Temperature: 150 - 350 °C according to application

Mat.-no. Brand name Mass.-% C Si Mn Cr Mo V Nb
Special CS1 0.50 0.30 0.40 5.00 1.90 0.55 +
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
FTCo

Material properties

FTCo is a special tool steel with high contents of carbide-forming elements (Cr, Mo, V, W, Nb), which guarantee particularly high temper resistance and wear resistance.

Application

- Dies and mandrels for forging applications with very high thermal and abrasive loads
- Particularly suitable for mandrels in fast cutting machines

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Thermal expansion in 10⁻⁶m/m x K</th>
<th>Thermal conductivity in W/m x K</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 100</td>
<td>11,8</td>
<td>27,2</td>
</tr>
<tr>
<td>20 - 400</td>
<td>12,1</td>
<td>28,1</td>
</tr>
<tr>
<td>20 - 600</td>
<td>13,0</td>
<td>29,3</td>
</tr>
</tbody>
</table>

Heat treatment

- Soft annealing: Temperature 820 °C, 10 hrs., Cooling slow furnace cooling, Hardness max. 300 HB
- Hardening: Temperature 1120 - 1140 °C, Cooling vacuum hardening or salt bath hardening with oil/polymer quenching
- Tempering: Temperature 560 - 600 °C, Hardness see tempering curve
- Nitriding possible
- Preheating before use: Temperature 150 - 350 °C essential

Mat.-no. Brand name Mass.-% (C Si Mn Cr Mo V Co W Nb)
Special FTCo 0.53 0.35 0.40 4.00 2.00 1.10 0.90 1.50 +
Tempering graph

Hardness in HRC

Tempering temperature in °C
GSF is a CrNiMoV alloyed high performance steel, which has been specifically developed for dies that are used under the hammer, or for large dies. GSF is the further development of the standard steel 55NiCrMoV7 (1.2714) and is characterised by a better toughness, high-temperature strength and weldability. Because of its good mechanical properties in tempered condition, GSF is the appropriate steel for various tools and heavy duty machine components. GSF is a well-suited alternative to the known tempered steels, especially for large cross-sections or diameters up to 650 mm and strengths above 1000 MPa.

**Application**
- Specially developed forging die steel with good suitability for deposition and filling welding. Because of the lower C content, the risk of crack formation in the weld transition zone is reduced.
- Can also be used without deposition and filling welding
- Tool brackets
- Heavy duty tie rods

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$m/m x K</td>
<td>11.8</td>
<td>12.0</td>
<td>13.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>31</td>
<td>34</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in $g/cm^3$</td>
<td>7.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 740 - 760 °C, 6 - 8 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 230 HB

- **Hardening**
  - Temperature: 920 - 940 °C
  - Cooling: Oil/polymer
  - Cooling must be interrupted at approx. 150 - 180 °C or vacuum hardening.

- **Tempering**
  - Temperature: 400 - 650 °C
  - Hardness: see tempering curve

- **Nitriding**
  - possible

- **Preheating before use**
  - Temperature: 150 - 350 °C necessary
Continuous time-temperature-transformation graph
Austenitizing temperature 930 °C

Tempering graph

High-temperature strength graph
**HP1**

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special</td>
<td>HP1</td>
<td>C: 0.35, Si: 0.20, Mn: 0.30, Cr: 5.20, Mo: 1.40, V: 0.55, Nb: +</td>
</tr>
</tbody>
</table>

**Material properties**

HP1 is a Cr-Mo-V alloyed hot-work tool steel with very good high-temperature strength characteristics and maximum toughness. This steel is also characterised by good thermal shock resistance. HP1 is only manufactured in remelted version according to the ESU process.

**Application**

HP1 is particularly suitable for the following applications with maximum mechanical and thermal loads:

- Pressure die casting
- Extrusion presses: Dies with high toughness requirements
- Inner liners
- Hot forming

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11.5</td>
<td>12.6</td>
<td>13.1</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>29.5</td>
<td>30.5</td>
<td>30.5</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>214</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 220 HB

- **Hardening**
  - Temperature: 1015 - 1025°C
  - Cooling: Air, warm bath of approx. 540 °C, Oil/polymer; Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

- **Tempering**
  - Temperature: 540 - 680 °C
  - Hardness: see tempering curve

- **Nitriding**
  - If die-casting dies are to be nitrided, nitriding program 99 should be selected.
  - This nitriding layer does not have a compound layer and therefore does not have a negative influence on the formation of thermal shock cracks.

- **Preheating before use**
  - Temperature: 150 - 350 °C essential
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
HS1

Material properties
Hot-work tool steel with high resistance to wear and high compression strength with balanced toughness. Suitable for secondary hardening and for use at high temperatures. Nitriding and coating possible.

Application
- Shear blades
- Cutting and punching tools
- Bending tools
- Pressing and profile rollers
- Segments for press tools

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>11,2</td>
<td>11,7</td>
<td>12,2</td>
<td>12,7</td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>25,2</td>
<td>27,3</td>
<td>29,3</td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

- **Soft annealing**
  - Temperature: 800 - 840 °C
  - Cooling: Slow furnace cooling
  - Hardness: max. 295 HB

- **Hardening**
  - Temperature: 1050 - 1080 °C
  - Cooling: Oil, polymer, gas

- **Tempering**
  - Temperature: 540 - 560 °C
  - Hardness: see tempering curve

- **Nitriding**
  - possible

---

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Special</td>
<td>HS1</td>
<td>0.50</td>
</tr>
</tbody>
</table>
HTR

Material properties
HTR is a hot-work tool steel with very good thermal shock resistance, high thermal conductivity and high-temperature strength. HTR is manufactured exclusively according to the ESU process.

Application
Areas of use with high thermal loads:
- Pressure die-casting (max. 42 HRC)
- Gravity die-casting
- Extrusion presses
- Hot/ warm forming
- Inner liners in heavy-metal extrusion presses

Delivery condition:
Annealed max. 230 HB

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10^-6 m/m x K</td>
<td>12.3</td>
<td>13.6</td>
<td>13.8</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>35.2</td>
<td>34.6</td>
<td>33.0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

<table>
<thead>
<tr>
<th>Soft annealing</th>
<th>Temperature</th>
<th>820 - 840 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>Slow furnace cooling</td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td>max. 230 HB</td>
<td></td>
</tr>
</tbody>
</table>

Hardening

<table>
<thead>
<tr>
<th>Temperature</th>
<th>1050 - 1070 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>Oil, polymer, vacuum hardening with nitrogen quenching</td>
</tr>
</tbody>
</table>

Tempering

<table>
<thead>
<tr>
<th>Temperature</th>
<th>650 - 700 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>see tempering curve</td>
</tr>
</tbody>
</table>

Preheating before use

<table>
<thead>
<tr>
<th>Temperature</th>
<th>100 - 300 °C essential</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Special</td>
<td>HTR</td>
<td>0.32</td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
PWCo

Material properties
Cobalt alloyed hot-work tool steel with good heat resistance and high hot-wear resistance.

Application
- Forging dies with high requirements for hot wear resistance and shallow cavities

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6} m/m \times K$</td>
<td>11,5</td>
<td>11,9</td>
<td>12,0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>30,0</td>
<td>32,0</td>
<td>33,6</td>
</tr>
</tbody>
</table>

Heat treatment

- Soft annealing
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 235 HB

- Hardening
  - Temperature: 1030 - 1040 °C
  - Cooling: Vacuum hardening, warm bath of 540 °C

- Tempering
  - Temperature: 520 - 600 °C
  - Hardness: see tempering curve

- Nitriding possible

- Preheating before use
  - Temperature: 250 - 350 °C essential
Tempering graph

High-temperature strength graph
Q10 is a Cr-Mo-V alloyed hot-work tool steel with very good high temperature strength characteristics and maximum toughness. This grade is also characterised by good thermal shock resistance.

**Application**
- Extrusion presses with very long lifetime with heavy duty inner linings and press stems
- Drop forging
- Hot forming

**Physical properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in (10^{-6}) m/m x K</td>
<td>10,3</td>
<td>11,3</td>
<td>12,6</td>
<td>13,0</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>29,8</td>
<td>31,0</td>
<td>31,4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7,8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>214</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Soft annealing**
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 220 HB

- **Hardening**
  - Temperature: 1010 - 1020 °C
  - Cooling: Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

- **Tempering**
  - Temperature: 540 - 680 °C
  - Hardness: see tempering curve

- **Nitriding**
  - possible

- **Preheating before use**
  - Temperature: 150 - 350 °C depending on area of application
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
S10

Material properties

S10 is a Cr-Mo-V alloyed hot-work tool steel with higher C content compared to Q10. It is characterised by particularly high strength and high-temperature strength in combination with high toughness and thermal shock resistance.

Application

- Swages
- Tools in hot forming of sheet metal

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>11.8</td>
<td>12.5</td>
<td>13.2</td>
<td>13.4</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>28.8</td>
<td>30.0</td>
<td>29.4</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>213</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

- Soft annealing
  - Temperature: 820 - 840 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 230 HB

- Hardening
  - Temperature: 1000 - 1040 °C
  - Cooling: Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

- Tempering
  - Temperature: 540 - 680 °C
  - Hardness: see tempering curve

- Nitriding: possible

- Preheating before use
  - Temperature: 150 - 350 °C depending on area of application

Mat.-no. Brand name Mass.-%  
<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>Nb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special S10</td>
<td>0.50</td>
<td>0.30</td>
<td>0.40</td>
<td>5.00</td>
<td>1.90</td>
<td>0.55</td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Tempering graph

High-temperature strength graph
TQ1

Material properties
TQ1 is a Cr-Mo-V alloyed hot-work tool steel with very good high-temperature strength characteristics and maximum toughness. This quality is also characterised by good thermal shock resistance and is only manufactured in remelted form according to the ESU process.

Application
- Pressure die casting
- Extrusion presses for heavy duty press stamps > 1100 MPa, dies
- Drop forging
- Hot forming

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>10,3</td>
<td>11,3</td>
<td>12,6</td>
<td>13,0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>29,8</td>
<td>31,0</td>
<td>31,4</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>214</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment
Soft annealing
- Temperature: 820 - 840 °C, 4 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 220 HB

Hardening
- Temperature: 1010 - 1020 °C
- Cooling: Interrupt oil or polymer cooling at 230 - 280 °C or vacuum hardening

Tempering
- Temperature: 540 - 680 °C
- Hardness: see tempering curve

Nitriding
If die-casting dies are to be nitrided, nitriding program 99 should be selected. This nitriding layer does not have a compound layer and therefore does not have a negative impact on the formation of thermal shock cracks

Preheating before use
- Temperature: 150 - 350 °C depending on area of application

Mat.-no. | Brand name | Mass.-% |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Special</td>
<td>TQ1</td>
<td>0.36</td>
</tr>
</tbody>
</table>
Cold-work tool steels / Plastic mould steels

Cold-work tool steels are used in tools whose surface temperature generally remains under 200 °C when they are being used. If cold-work tool steels are used at higher temperatures, there is a tempering effect and weakening of the steels can be expected.

While the low-alloy cold-work tool steels have a higher toughness with sufficient compression strength but lower wear resistance, high-alloy cold-work tool steels have a high resistance against wear with good compression strength. Cold-work tool steels are therefore mainly used as cutting materials or for forming tools that have a high resistance against abrasive wear.

The plastic mould steels serve plastic processing according to good polishability and corrosion resistance. They are therefore used in a variety of technologies in injection moulding such as extrusion, die-casting, press and blow moulding. The focus here is on corrosion-resistant plastic mould steels that are largely resistant to decomposition products of plastic processing.
RF (1.2083)

Material properties
RF is a high hardenable rust and acid-resistant steel. It is used in the manufacturing of smaller moulds or inserts for the plastics industry in the processing of duroplasts and thermoplasts, in which corrosive side-products can arise. RF is through-hardenable, is low in distortion, has a high wear resistance and compression strength. In tempered condition, RF is very highly polishable.

Application
- Inserts and smaller injection moulds
- Plastic pressure moulds for processing plastics

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Thermal expansion in $10^{-6}$ m/m x K</th>
<th>Thermal conductivity in W/m x K</th>
<th>Density in g/cm³</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 100</td>
<td>10,6</td>
<td>25,3</td>
<td>7,7</td>
<td>217</td>
</tr>
<tr>
<td>20 - 600</td>
<td>11,7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 400</td>
<td>12,2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

| Soft annealing | Temperature | 760 - 800 °C, 4 - 6 hrs. |
|                | Cooling     | Slow furnace cooling       |
|                | Hardness    | max. 240 HB                |

| Hardening      | Temperature | 1000 - 1030 °C |
|                | Cooling     | Interrupt oil cooling at approx. 300 °C; in blast air for thin cross-sections; in warm bath of approx. 200 °C |

| Tempering      | Temperature | 100 - 400 °C |
|                | Hardness    | see tempering curve |

Mat.-no. | Short name | Brand name | Mass.-%                  |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2083</td>
<td>X40Cr14</td>
<td>RF</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.42</td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Austenitizing temperature 1020 °C

Tempering graph
KS80 (1.2108)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2108</td>
<td>90CrSi5</td>
<td>KS80</td>
<td>C 0.90  Si 1.20 Mn 0.70 Cr 1.20</td>
</tr>
</tbody>
</table>

**Material properties**
This Cr-Si-based moderate-alloy steel is characterised by good toughness and sharpness. The hardening behaviour is moderate for large cross-sections.

**Application**
- Cutting and punching tools for sheet metal thickness of approx. 6-12 mm
- Trimming tools
- Profile shear blades
- Cold punches
- Small stamping tools
- Ejectors and similar tools

**Heat treatment**

- **Soft annealing**
  - Temperature: 720 - 750 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 230 HB

- **Hardening**
  - Temperature: 830 - 860 °C
  - Cooling: Interrupt oil cooling at approx. 150 °C

- **Tempering**
  - Temperature: 100 - 400 °C
  - Hardness: see tempering curve
Tempering graph

![Tempering graph showing the relationship between tempering temperature in °C and hardness in HRC.](image-url)
CMR (1.2316)

Material properties

CMR belongs to the group of heat-treatable corrosion-resistant steels. This resistance against corrosion is achieved through the high Cr and low C content. CMR is suitable for the processing of chemically particularly aggressive plastics such as PVC. Chrome-plating is unnecessary. CMR has a good polishability. Delivery condition: Tempered, strength as required between 800 and 1100 MPa.

Application

- Injection moulds and extrusion tools in the processing of plastics which can release corrosive materials

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Thermal expansion in ( \text{m/m x K} )</th>
<th>Thermal conductivity in W/m x K</th>
<th>Temperature in °C</th>
<th>Density in g/cm³</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 100</td>
<td>10,5</td>
<td>20,7</td>
<td>20</td>
<td>7,7</td>
<td>215</td>
</tr>
<tr>
<td>20 - 400</td>
<td>11,4</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 600</td>
<td>11,9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

- **Hardening**
  - Temperature: 1020 - 1050 °C
  - Cooling: Interrupt oil cooling at 250 °C

- **Tempering**
  - Temperature: 580 - 620 °C
    - Avoid temperature range of the secondary hardness maximum
    - Hardness: see tempering curve

- **Nitriding**
  - Possible, temper correspondingly. The corrosion resistance is reduced by such a treatment.

Mat.-no. Short name Brand name Mass.-% C Si Mn Cr Mo Ni
1.2316 X38CrMo16 CMR 0.40 ≤ 1.00 ≤ 1.00 16.00 1.20 ≤ 1.00
Continuous time-temperature-transformation graph

Austenitizing temperature 1020 °C

Tempering graph

Hardness in HRC

Tempering temperature in °C
RM189 (1.2361)

**Material properties**
RM189 belongs to the group of heat-treatable rust and acid-resistant steels. Because of the chemical composition and the associated high hardness, there is good resistance against abrasive wear.

**Application**
- Rust-resistant hand and machine blades of all kinds
- Perforated disks in meat grinders
- Needle valves and valve parts
- Ball bearings and similar parts, which are exposed to increased wear in a corrosive environment, plastic moulds

**Physical properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Temperature in °C</th>
<th>Thermal expansion in $10^{-6}$m/m x K</th>
<th>Thermal conductivity in W/m x K</th>
<th>Density in g/cm³</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in °C</td>
<td>20 - 100</td>
<td>10,4</td>
<td>15,9</td>
<td>7,7</td>
<td>215</td>
</tr>
<tr>
<td>Thermal conductivity in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**
- **Soft annealing**
  - Temperature: 780 - 840 °C
  - Cooling: Slow furnace cooling
  - Hardness: max. 265 HB
- **Hardening**
  - Temperature: 1000 - 1050 °C
  - Cooling: Oil
- **Tempering**
  - Temperature: 100 - 200 °C
  - Hardness: see tempering curve
- **Nitriding**
  - Possible

**Mat.-no. Short name Brand name Mass.-%**

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2361</td>
<td>X95CrMoV18</td>
<td>RM189</td>
<td>0.90</td>
<td>≤ 1.00</td>
<td>≤ 1.00</td>
<td>18.00</td>
<td>1.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>
**CH5M (1.2363)**

**Material properties**

CH5M is an air-hardenable cold-work tool steel with very high dimensional stability and a high cutting stability and wear resistance. The hardenability and toughness are good.

**Application**

- Cutting and punching tools
- Roller and table knives
- Threaded rolling tools
- Embossing stamps and similar

**Physical properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal expansion in 10^-6m/m x K</td>
<td>11,6</td>
<td>13,2</td>
<td>14,1</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td></td>
<td>7,7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

<table>
<thead>
<tr>
<th>Process</th>
<th>Temperature</th>
<th>Cooling</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft annealing</td>
<td>820 - 850 °C</td>
<td>Slow furnace cooling</td>
<td>max. 240 HB</td>
</tr>
<tr>
<td>Hardening</td>
<td>950 - 1000 °C</td>
<td>Blast air, thick cross-sections also in oil or warm bath of 350 - 450 °C</td>
<td></td>
</tr>
<tr>
<td>Tempering</td>
<td></td>
<td></td>
<td>see tempering curve</td>
</tr>
</tbody>
</table>
Material properties

CH16V is a high chrome alloy ledeburitic steel with Mo and V additives. These additives increase cutting stability, hardenability and the through-hardenability. Dimensional stability is good. The ledeburitic structure ensures high wear resistance. CH16V can be nitrided after special heat treatment.

Application

- High performance cutting and punching tools
- Cold extrusion tools
- Master hobs
- Thread rolling tools
- Flanging and straightening rolls

- Form rollers for continuous profile and pipe manufacturing from steel strips
- Woodworking tools
- Cutting tools for the paper and plastics industry
- Small plastic moulds or inserts for processing plastics with abrasive fillers

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Thermal expansion in (10^{-6}\text{m/m x K})</th>
<th>Thermo conductivity in (\text{W/m x K})</th>
<th>Density in (\text{g/cm}^3)</th>
<th>E module in (\text{GPa})</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 100</td>
<td>20 - 400</td>
<td>20 - 600</td>
<td>7,67</td>
<td>215</td>
</tr>
</tbody>
</table>

Heat treatment

- **Soft annealing**
  - Temperature: 820 - 850 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 250 HB

- **Hardening**
  - Temperature: 1010 - 1050 °C
  - Cooling: Vacuum hardening, oil, polymer, air or warm bath of 350 - 450 °C

- **Tempering**
  - Hardness: see tempering curve, the higher tempering temperature is preferred for the desired hardness

- **Special heat treatment for nitriding:**

  - **Hardening**
    - Temperature: 1060 - 1080 °C
    - Cooling: Vacuum hardening, oil, polymer, warm bath of 350 - 450 °C
  
  - **Tempering**
    - 520 - 580 °C
    - Triple tempering is essential

  - **Nitriding**
    - approx. 540 °C after special heat treatment

---

**Mat.-no. Short name Brand name Mass.-%**

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2379</td>
<td>X153CrMoV12</td>
<td>CH16V</td>
<td>1.50</td>
<td>0.25</td>
<td>0.25</td>
<td>11.25</td>
<td>0.80</td>
<td>0.85</td>
</tr>
</tbody>
</table>
PK (1.2542)

Material properties
PK is a tough cold-work tool steel for use under permanent hitting and impact stress.

Application
- Compressed air tools of all kinds, such as chisels, riveting heads, rivet dies, rivet blasters, etc.
- Hand chisels
- Strainers
- Deburring tools
- Cold punches
- Scrap chisels
- Profile shear blades
- Hot shear blades for medium temperature cutting material (gently preheat tools) and similar tools

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶m/m x K</td>
<td>11,0</td>
<td>13,5</td>
<td>14,5</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>25,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>8,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>210</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

<table>
<thead>
<tr>
<th>Process</th>
<th>Temperature</th>
<th>Cooling</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft annealing</td>
<td>730 - 760 °C, 4 - 6 hrs.</td>
<td>Slow furnace cooling</td>
<td>max. 225 HB</td>
</tr>
<tr>
<td>Hardening</td>
<td>880 - 920 °C</td>
<td>Interrupt oil cooling at approx. 150 °C</td>
<td></td>
</tr>
<tr>
<td>Tempering</td>
<td>100 - 350 °C</td>
<td>see tempering curve</td>
<td></td>
</tr>
</tbody>
</table>

Mat.-no. Short name Brand name Mass.-% C Si Mn Cr V W
1.2542 45WCrV7 PK 0.45 1.00 0.30 1.10 0.20 2.00
Continuous time-temperature-transformation graph

Austenitizing temperature 900 °C

Tempering graph

Hardness in HV

Temperature in °C

Time

Seconds

Minutes

Hours

Austenitizing temperature 900 °C

Testtemperatur in °C

Härte in HRC

Tempering temperature in °C

70

65

60

55

50

0 100 200 300 400 500

Tempering temperature in °C

Hardness in HRC
KL (1.2550)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2550</td>
<td>60WCrV8</td>
<td>KL</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.60</td>
</tr>
</tbody>
</table>

**Material properties**

KL is an oil-hardenable steel with very good toughness and relatively good cutting performance. The hardenability capacity is moderate for large cross-sections.

**Application**

- Cutting and punching tools for sheet metal thickness of approx. 6-12 mm
- Cold punches
- Deburring tools
- Profile shear blades
- Splicers
- Woodworking tools
- Small stamping tools
- Ejectors and similar tools
- Cutting tools for soft, medium-temperature cutting material (gently preheat tools)

**Physical properties**

- **Temperature in °C**
  - 20 - 100
  - 20 - 400
  - 20 - 600
- **Thermal expansion in 10^-6 m/m x K**
  - 11.8
  - 13.5
  - 14.3
- **Thermal conductivity in W/m x K**
  - 31.9
- **Density in g/cm³**
  - 8.0
- **E module in GPa**
  - 210

**Heat treatment**

- **Soft annealing**
  - Temperature: 750 - 780 °C, 4 - 6 hrs.
  - Cooling: Slow furnace cooling
  - Hardness: max. 225 HB
- **Hardening**
  - Temperature: 870 - 900 °C
  - Cooling: Interrupt oil cooling at approx. 150 °C
- **Tempering**
  - Temperature: for hot work 550 - 600 °C
  - Hardness: see tempering curve
Continuous time-temperature-transformation graph

Austenitizing temperature 880 °C

Tempering graph
SN (1.2721)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2721</td>
<td>50NiCr13</td>
<td>SN</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.50</td>
</tr>
</tbody>
</table>

### Material properties

SN is an air and oil hardenable steel with the best toughness and sufficient hardness, which is achieved by the high Ni content and low C content.

### Application

- Cold forming tools of all kinds
- Cutlery stamping dies
- Form dies for high pressures
- Punches
- Puller jaws and similar tools

### Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>11.5</td>
<td>12.0</td>
<td>12.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>31.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density in g/cm³</td>
<td>7.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>E module in GPa</td>
<td>210</td>
</tr>
</tbody>
</table>

### Heat treatment

**Soft annealing**
- Temperature: 720 °C, 5 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 250 HB

**Hardening**
- Temperature: 840 - 870 °C
- Cooling: Air, warm bath from 180 - 220 °C or oil, interrupt oil cooling at approx. 150 °C

**Tempering**
- Temperature: 100 - 300 °C
- Hardness: see tempering curve
N400 (1.2767)

Material properties
N400 is characterised by its high Ni content as a tough cold-work tool steel with high hardenability. As well as good polishability and texturing properties, N400 tends towards good through-hardenability.

Application
- Cutlery stamping dies, shear blades for thick but goods above 12 mm thick
- Scrap and billet shear blades
- Embossing and bending tools for heavy cold forming
- Puller jaws, large lathe punches and similar tools, which demand maximum toughness
- Shrink rings, tempered as required to a strength of 1300-1600 MPa
- Plastic moulds

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Thermal expansion in 10⁻⁶ m/m x K</th>
<th>Thermal conductivity in W/m x K</th>
<th>Density in g/cm³</th>
<th>E module in GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 100</td>
<td>12,3</td>
<td>31,0</td>
<td>7,82</td>
<td>210</td>
</tr>
<tr>
<td>20 - 200</td>
<td>13,1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 400</td>
<td>13,7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
Temperature 610 - 650 °C
Cooling Slow furnace cooling, 720 °C 6 - 8 hrs., and slow furnace cooling, annealing 620 - 640 °C 10 - 12 hrs, and slow furnace cooling
Hardness max. 260 HB

Hardening
Temperature 840 - 870 °C
Cooling Air, warm bath from 180 - 220 °C or oil, interrupt oil cooling at approx. 150 °C

Tempering
Temperature 100 - 400 °C
Hardness see tempering curve

<table>
<thead>
<tr>
<th>Material properties</th>
<th>Application</th>
<th>Physical properties</th>
<th>Heat treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>N400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mat.-no.</td>
<td>Mass.-%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2767</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short name</td>
<td>C Si Mn Cr Mo Ni</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45NiCrMo16</td>
<td>0.45 0.25 0.40 1.35 0.25 4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brand name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mat.-no.</td>
<td>Mass.-%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2767</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short name</td>
<td>C Si Mn Cr Mo Ni</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45NiCrMo16</td>
<td>0.45 0.25 0.40 1.35 0.25 4.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Austenitizing temperature 840 °C

Tempering graph

Hardness in HRC

Tempering temperature in °C
KSV (1.2838)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2838</td>
<td>145V33</td>
<td>KSV</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.45</td>
</tr>
</tbody>
</table>

**Material properties**

KSV is a water-hardenable steel (surface-hardening). The V content ensures lack of sensitivity to overheating and also a high wear resistance with a tough core. The hardness penetration depth of KSV can be increased considerably with increasing hardening temperature.

**Application**

- Cold impact tools of all kinds, such as head stamps, first and second punches, dies in screw and rivet manufacturing
- Impact seams of flat etchers and similar tools
- Cold extrusion tools
- Draw dies for drawing over a mandrel (perforation tempering)

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Thermal conductivity in W/m x K</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>25.5</td>
</tr>
<tr>
<td>200</td>
<td>26.4</td>
</tr>
<tr>
<td>400</td>
<td>27.4</td>
</tr>
</tbody>
</table>

**Heat treatment**

**Soft annealing**

- Temperature: 740 - 760 °C, 4 - 6 hrs.
- Cooling: Slow furnace cooling
- Hardness: max. 230 HB

**Hardening**

- Temperature: 800 - 950 °C
- Cooling: Water, interrupt water hardening at approx. 120 °C, further cooling in oil.

**Tempering**

- Temperature: 100 - 300 °C
- Hardness: see tempering curve
RM161a (1.4104)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2838</td>
<td>145V33</td>
<td>KSV</td>
<td>C: 0.15</td>
</tr>
</tbody>
</table>

Material properties
Martensitic, moderately corrosion resistant steel. Improved machinability through the addition of sulphur.

Application
- Hydraulic valve blocks for mining equipment
- Easily machinable, corrosion resistant steel for screws and bolts

Delivery condition: Tempered

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>10.0</td>
<td>12.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Temperature in °C 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K 25.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³ 7.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa 215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Austenitizing temperature 1010 °C

- Temperature in °C:
  - 1200
  - 1000
  - 800
  - 600
  - 400
  - 200
  - 0

- Hardness in HV:
  - 1
  - 10
  - 10²
  - 10³
  - 10⁴
  - 10⁵
  - 10⁶

- Time:
  - Seconds
  - Minutes
  - Hours

- Temperature vs. Time graph with various transformation lines and hardness values.

- Key points:
  - Ac1b
  - Ms
  - P
  - A + K

- Lines indicating temperature transformation over time and hardness values.
RM200 (1.4125)

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4125</td>
<td>X105CrMoV17</td>
<td>RM200</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.05</td>
</tr>
</tbody>
</table>

**Material properties**

Stainless, martensitic steel with high hardenability, high wear resistance, polishable.

**Application**

- Blade and cutting goods,
- Perforated disks, screw elements, spray nozzles

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>10.4</td>
<td>11.6</td>
<td>12.3</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>215</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

**Soft annealing**

Temperature 785 - 840 °C

Cooling Slow furnace cooling

Hardness max. 285 HB

**Hardening**

Temperature 1000 - 1050 °C

Cooling Oil, vacuum hardening, air or warm bath of 500 - 550 °C

**Tempering**

Temperature 100 - 600 °C

Hardness see tempering curve

**Nitriding**

possible
FSR

Material properties
FSR is a cold-work tool steel based on 12% Cr. The other alloy elements give FSR the necessary temper resistance and wear resistance. Compared to a similarly used high-speed steel such as type HS6-5-2C, FSR is characterised by better toughness with equivalent performance.

Application
∙ Cutting tools with particular wear resistance in the processing of siliconised or austenitic sheet metal or hardened strip steel, precision punching tools
∙ Cold extrusion tools
∙ Threaded rolling tools
∙ Broaches
∙ Extruder screws

Physical properties
<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in (10^{-6}) m/m x K</td>
<td>10,6</td>
<td>12,0</td>
<td>13,0</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>22,8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment
Soft annealing
Temperature | 800 - 850 °C
Cooling | Slow furnace cooling
Hardness | max. 300 HB

Hardening
Temperature | 1150 - 1180 °C
Cooling | Hot strip from 450 - 550 °C or oil, interrupt oil cooling at approx. 400 °C

Tempering
Temperature | 540 - 550 °C
Hardness | see tempering curve

Nitriding
possible, temper correspondingly

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special</td>
<td>FSR</td>
<td>1.20</td>
<td>0.30</td>
<td>0.30</td>
<td>11.50</td>
<td>1.40</td>
<td>1.70</td>
<td>2.40</td>
</tr>
</tbody>
</table>
Hardness in HRC

Tempering temperature in °C

- 1 x tempered
- 3 x tempered
PM823

Material properties
Cold-work tool steel with high vanadium content. Good tempering ability, high strength.

Application
• Shear blades
• Cutting tools
• Guide and profiled rollers with high requirements in terms of toughness and wear resistance

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in 10⁻⁶ m/m x K</td>
<td>11.3</td>
<td>12.2</td>
<td>12.7</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>24.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Soft annealing
Temperature 800 - 840 °C, 4 - 6 hrs.
Cooling Slow furnace cooling
Hardness max. 280 HB

Hardening
Temperature 1070 - 1090 °C
Cooling Oil or polymer quenching, warm bath of 540 °C

Tempering
Temperature 530 - 600 °C
Hardness see tempering curve

Mat.-no. Brand name Mass.-%  
<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.84</td>
<td>0.85</td>
<td>0.35</td>
<td>7.70</td>
<td>1.50</td>
<td>2.45</td>
</tr>
</tbody>
</table>
Tempering graph

Hardness in HRC vs Tempering temperature in °C
PW812

Material properties
Cold-work tool steel with high vanadium and tungsten content. Good secondary tempering ability, high toughness.

Application
- Shear blades
- Cutting tools
- Guide and profiled rollers with high requirements in terms of toughness and wear resistance
- Bending tools
- Punches

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $\times 10^{-6}$ m/m x K</td>
<td>11.0</td>
<td>12.2</td>
<td>12.7</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>24.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

<table>
<thead>
<tr>
<th>Process</th>
<th>Temperature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft annealing</td>
<td>800 - 840 °C, 4 - 6 hrs.</td>
<td>Cooling Slow furnace cooling Hardness max. 285 HB</td>
</tr>
<tr>
<td>Hardening</td>
<td>1100 - 1120 °C</td>
<td>Cooling Air, salt bath 500 - 550 °C oil, polymer, vacuum</td>
</tr>
<tr>
<td>Tempering</td>
<td>510 - 600 °C</td>
<td>Hardness see tempering curve</td>
</tr>
</tbody>
</table>

Mat.-no. | Brand name | Mass.-% |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PW812</td>
<td>C  1.13</td>
</tr>
</tbody>
</table>
Continuous time-temperature-transformation graph

Austenitzing temperature 1120 °C

Tempering graph

Testtemperatur in °C

Hardness in HRC

Tempering temperature in °C

Härte in HRC
Highly heat-resistant steels / Nickel-based alloys

With the traditional martensitic hot-work tool steels, adding elements such as Cr, Co, Mo and W can increase the high-temperature strength up to a certain limit. However, if the thermal stress of the tools exceeds this limit, the use of austenitic hot-work tool steels is recommended. These steels also retain their strength even under high thermal stress.

For even higher thermal stress, e.g. when forming brass and copper materials, nickel-based alloys are suitable as tool materials.
MA-Rekord (1.2758)

Material properties

MA record is a high-alloy special hot-work tool steel with austenitic structure. The operational strength of approx. 1350-1550 MPa is achieved through forging and then precipitation hardening at approx. 800 °C or through a special heat treatment.

Application

- Extrusion dies for processing hard-to-press non-ferrous metals and steel in the manufacture of wire, rods, pipes, strips and simple profiles

Delivery condition:
As disks forged on all sides with the smallest possible thickness, so that a roughly consistent temperature increase is guaranteed in extrusion press operation, in order to prevent stress cracks due to the limited thermal conductivity.

Tensile strength Rm = 1350 - 1550 MPa

Water cooling is not possible.

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$ m/m x K</td>
<td>11,3</td>
<td>11,8</td>
<td>12,2</td>
</tr>
</tbody>
</table>

Heat treatment

- Preheating before use: Temperature 400 - 600 °C essential, avoid cooling during press operation
- Cooling after use: immediately after the last pressing, slowly from 500 - 600 °C in the furnace

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>V</th>
<th>Co</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2758</td>
<td>X50WNiCrVCo12-12</td>
<td>MA-Rekord</td>
<td>0.55</td>
<td>1.40</td>
<td>0.70</td>
<td>4.00</td>
<td>0.60</td>
<td>11.50</td>
<td>1.10</td>
<td>1.50</td>
<td>12.00</td>
</tr>
</tbody>
</table>
High-temperature strength graph

- 0.2% limit $R_{p0.2}$ and tensile strength $R_m$ in MPa
- Area reduction $Z$ in %

Test temperature in °C

Graph showing the relationship between test temperature and properties such as $R_{p0.2}$, $R_m$, and area reduction $Z$. The graph illustrates how these properties change with temperature.
HWF (1.2779)

**Material properties**

HWF is an austenitic age-hardenable steel with best high-temperature strength properties. Preferred areas of use are forming work with thermal load if the temper resistance of the martensitic steels is not enough.

**Application**

- Extrusion press tools for copper and copper alloys such as inner liners, dies, spider tools
- Hot shear blades in rolling lines

**Delivery condition:**
Solution annealed or solution annealed and aged with following values:
- 0.2% yield strength $R_{p0,2}$ mind.: 650 MPa
- Tensile strength $R_m$: 950 - 1150 MPa

**Physical properties**

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$ m/m x K</td>
<td>16,5</td>
<td>16,8</td>
<td>17,2</td>
<td>17,6</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>13,0</td>
<td>16,4</td>
<td>20,3</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm$^3$</td>
<td>7,95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>208</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat treatment**

- **Solution annealing**
  - Temperature: 970 - 990 °C, 1 hr.
  - Cooling: Air
  - Festigkeit approx. 850 MPa

- **Tempering**
  - Temperature: 710 - 730 °C, 16 hrs.
  - Cooling: Air

- **Nitriding**
  - possible

### Material properties table

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2779</td>
<td>X6NiCrTi26-15</td>
<td>HWF</td>
<td>C Si Mn Cr Mo Ni Ti</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤ 0.08 ≤ 1.00 1.10</td>
</tr>
</tbody>
</table>
High-temperature strength graph

0.2% limit $R_{p0.2}$ and tensile strength $R_{m}$ in MPa

Area reduction $Z$ in %

Test temperature in °C
ZF2 (1.2782)

Material properties

This high alloyed steel with austenitic microstructure has an excellent scale and corrosion resistance and high-temperature strength.

Application

- Upper and lower sections of glass moulds, high output with best surface quality of the glass (crystal lustre), gathering irons, mouthpieces and blowing pipes in the glass industry
- Fittings for furnace construction, such as rollers, rails, axles
- Equipment for heat treating companies

Delivery condition:

- Quenched, i.e. ready for use with the following properties:
  - 0.2% yield strength $R_{p0.2} \geq 230$ MPa
  - Tensile strength $R_m = 550 - 800$ MPa
  - Tinner resistance up to approx. 1150 °C

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$ m/m x K</td>
<td>16.0</td>
<td>16.5</td>
<td>17.0</td>
<td>17.5</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>14.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>7.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E module in GPa</td>
<td>198</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

- Solution annealing
  - Temperature 1050 - 1100 °C
- Cooling Water
- Preheating before use
  - Temperature 350 - 400 °C essential

Mat.-no. Short name Brand name Mass.-%
--- --- --- --- --- --- --- ---
1.2782 X16CrNiSi25-20 ZF2 ≤ 0.08 ≤ 1.00 1.10 15.00 1.50

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Ni</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2782</td>
<td>X16CrNiSi25-20</td>
<td>ZF2</td>
<td>≤ 0.08</td>
<td>≤ 1.00</td>
<td>1.10</td>
<td>15.00</td>
<td>1.50</td>
</tr>
</tbody>
</table>
SA50Ni (2.4973)

Material properties
Age-hardenable nickel-based alloy with very high high-temperature strength. Particularly suitable as hot work material for forming work with high thermal loads, if the temper resistance of the martensitic steels is no longer sufficient.

Application
- Extrusion tools
- Forging dies
- Hot shear blades

Delivery condition:
Solution annealed and aged with following properties:
0.2% yield strength $R_{p0.2}$ = approx. 900 MPa
Tensile strength $R_m$ = approx. 1250 MPa

Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$ m/m x K</td>
<td>12.2</td>
<td>12.4</td>
<td>13.0</td>
<td>13.7</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity in W/m x K</td>
<td>11.3</td>
<td>13.4</td>
<td>15.9</td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density in g/cm³</td>
<td>8.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heat treatment

Solution annealing
Temperature 1080 °C, 4 hrs.
Cooling Air

Tempering
Temperature 760 °C, 16 hrs.
Cooling Air

<table>
<thead>
<tr>
<th>Mat.-no.</th>
<th>Short name</th>
<th>Brand name</th>
<th>Mass.-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4973</td>
<td>NiCr19CoMo</td>
<td>SA50Ni</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤ 0.12</td>
</tr>
</tbody>
</table>
### Material properties

Age-hardenable nickel-based alloy with very high high-temperature strength. Particularly suitable as hot work material for very high thermal loads, if the temper resistance of the martensitic steels is no longer sufficient.

### Application

- Dies, mandrel tips, pressure dies for extrusion presses for copper alloys
- Sinter press tools
- Hot shear blades
- Forging dies
- Inner liners
- Heavy metal extrusion presses with 1350-1450 MPa

#### Delivery condition:

Solution annealed and tempered with following properties:
- 0.2% yield strength $R_{p0.2}\approx 1100$ MPa
- Tensile strength $R_m\approx 1300$ MPa

### Physical properties

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>0 - 100</th>
<th>20 - 200</th>
<th>20 - 400</th>
<th>20 - 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal expansion in $10^{-6}$ m/m · K</td>
<td>13.0</td>
<td>14.0</td>
<td>14.5</td>
<td>15.2</td>
</tr>
<tr>
<td>Temperature in °C</td>
<td>20</td>
<td>200</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>Thermal conductivity in W/m · K</td>
<td>11.3</td>
<td>14.2</td>
<td>17.2</td>
<td>20.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density in g/cm³</td>
<td>8.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>E module in GPa</td>
<td>205</td>
</tr>
</tbody>
</table>

### Heat treatment

- **Solution annealing**
  - Temperature: 980 °C, 1 hr.
  - Cooling: Air

- **Tempering**
  - Temperature: 720 °C, 8 hrs.; Cooling to 620 °C, 8 hrs.; Cooling air
High-temperature strength graph

- 0.2% limit \( R_{p0.2} \) and tensile strength \( R_m \) in MPa
- Area reduction \( Z \) in %
- Test temperature in °C

**Graph Legend:**
- \( R_{p0.2} \)
- \( R_m \)
- \( Z \)