Cold-work tool steels and high-speed steels

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Supreme quality requires outstanding steel

Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen
the cold-work tool steel and high-speed steel experts

Process reliability from consultation to the final product

Precision for the tool manufacturer

Economic benefits for the user

Areas of application

Our technology and experience
your guarantee for premium quality

Custom remelting

Individually variable heat treatment

Overview of cold-work tool steels and high-speed steels

Cutting, punching and shearing

Coining, pressing and bending

Rolling

Comminuting

Guiding and folding

Machining

Tool holders

Hand and power tools

Material data sheets

Notes on processing

Overview of tool steel weights
Today tools made of cold-work and high-speed steels need to fulfill ever-increasing requirements. On the one hand this is the consequence of more modern production facilities and optimized manufacturing processes. On the other these stem from constantly increasing demands made on the quality of the products to be manufactured.

As a consequence the use of precisely the correct steel with the best performance characteristics for the tool application is decisive. Only when these considerations are borne in mind can the length of a tool’s service life be guaranteed and at the same time, ensure an economic production with reduced unit costs.

The correct alloy composition is of utmost importance in order to attain a steel’s material properties which will be most appropriate for the application required. These properties can be fine-tuned through calculating the varying quantities of the elements used in an alloy, such as chromium, molybdenum, tungsten and vanadium. Besides overseeing the optimal proportioning of the main elements, close attention is paid to keeping undesirable accompanying components to an absolute minimum.

This approach enables the supply of cold-work tool steels and high-speed steels for virtually every need and application. Cold-work tool steels are employed at operating temperatures reaching around 200 °C and are characterized by high levels of wear resistance. They also show good toughness properties depending on the intended application.

High-speed steels consist entirely of high-alloy tool steels, which retain necessary high working hardness of approximately 60 to 67 HRC at operating temperatures of nearly 600 °C. Their operational characteristics partly stem from a high carbide content resulting in very high wear resistance.

The combined Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen companies now belong to the world’s top-ranking manufacturers of cold-work tool steels and high-speed steels.

This advantageous position is based on both enterprises’ experience in steel production spanning more than 150 years, their continuous lead in casting technology and an exceptionally wide range of products and services offered, comprising several thousands of sizes and shapes.

The diversity of materials ranges from ordinary shell-hardenable steel to extremely high-alloy maraging cold-work tool steel. And for every type of application we deliver tailor-made steel grades, which excel themselves through the following properties:

- very good wear resistance
- high compression strength
- excellent toughness

So as to offer tool manufacturers and industrial users optimal conditions, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen have extended their services into customer and application-specific consultation, as well as advice on product development.

Deciding on the perfect tool steel with us starts with consulting our cold-work tool steels and high-speed steel specialists.

Together with the toolmaker, the demands on the final product and on the required steel grade are defined.

Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen’s commitments to ongoing improvements and the refining of present steels, as well as the development of new steel grades are the result of the symbiotic relationship with tool-makers and users. It is the perfect incentive to engineer and test newly developed materials, alloying concepts and production methods.

Our clients are offered the possibility to be integrated in the decision-making process from the extent to which customer-specific pre-machining should take place right through to the manufacture of components, such as cold rolls.

Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen deliver individual sizes ex-warehouse.
Process reliability from consultation to the final product

The requirements made of cold-work tool steels are exceptionally diverse. This is why appropriate adjustments of the different alloy components, as well as a relevant treatment during steel production are imperative so as to produce a steel grade which is in perfect accord with the envisaged application.

So as to ensure that the client’s demands are met, we rely on a highly experienced group of specialists in the cold-work tool steel and high-speed steel area. Together with the tool manufacturers, the specialists constitute a perfectly coordinated team to determine which steel grade and quality is most appropriate to each individual demand profile.

To complement our steel specialists’ extensive knowledge, we are in a position to rely on very modern production facilities backed up by decades of experience in every area dealing with heat treatment. In addition to this, our active and certified quality assurance system (DIN EN 14001, DIN EN ISO 9001, QS 9000, VDA 6.1 TS 16949 and KTA 1401) guarantees the production of an individually defined steel grade with continuous quality consistency.

Should problems occur in a tool’s service life, our technicians are happy to provide necessary support and advice. Through assessment and material testing, they are in the position to produce findings that lead to rapid repairs enabling long-term trouble-free operation.

Precision for the tool manufacturer

Competent advice for our clients ranges from the choice of the most suitable steel grade through to the development of specific tool steel grades. Not is there a the choice between the various forms deliverable from our extensive stock and product range, but clients also determine whether the tool is to be supplied in a pre-machined or ready-to-install state.

Edelstahl Witten-Krefeld and Edelstahlwerke Süwwestfalen then rapidly and reliably deliver the chosen steel grade, in any quantity desired – always in consistent quality. This applies to all important markets worldwide. Our global supply network ensures dependable delivery and the finest on-site quality.

We guarantee our clients customized precision from the steel production stage right through to machining – and this tool for tool.

The benefits for tool manufacturers are:

- individual material solutions
- consistently high quality
- reproducible material properties such as microstructure and purity
- good machinability
- low-distortion heat treatment
- very short delivery times
- competent consultancy
- development of new steel grades

Economic benefits for the user

Cost efficiency is achieved through three main criteria: through constantly high quality, long tool lives with reduced costs and a minimization of downtimes together with minimal tool breakage and edge roughness.

Thanks to the outstanding performance features of our cold-work tool steel and high-speed steel grades, these criteria are met and at the specified degree.

Innovative material technology coupled with decades of experience in the production of high-grade steel long products and our practice-oriented technical consultancy mean production dependability from the very start. This places us in a reliable position to produce steel grades which are precisely tailored to the respective demand profile. From the client’s perspective, this creates the chance to reduce unit cost by a more efficient control of their production processes.

The resulting benefits for the user are:

- high wear resistance
- good hardenability
- balanced toughness
- high compression strength
- dimensional stability
- profitable machinability
- long service lives
- low tool costs
- less machine downtime
- higher profitability

Areas of application

The special advantages of Edelstahl Witten-Krefeld and Edelstahlwerke Süwwestfalen’s cold-work tool steel and high-speed steel grades make them the first choice for numerous industrial tool applications, especially in the areas of:

- cutting, punching and shearing
- coining, pressing and bending (cold solid forming, cold extrusion and deep drawing)
- rolling (for cold, straightening and bending rolls)
- comminuting (granulating, chipping and shredding)
- folding and guiding
- machining (drilling, sawing and milling)
- tool holders
- hand and power tools

Saw blades
The purity and homogeneity of our cold-work tool steels and high-speed steels stem from producing them in our modern steelworks at Witten and Siegen. We fulfill our clients’ predefined demands by means of precision alloying and using process specifications for melting, shaping and heat treatment.

The tool steels produced by Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen are melted in 130-ton electric arc furnaces. A subsequent analytical fine-tuning is carried out in a ladle furnace, followed by vacuum degassing of the steel just before casting.

In order to cast the metallurgically treated molten metal, two processes can be applied depending on the required size of the final product. Usually an optimized vertical continuous casting method is used, but for large forging sizes, ingot casting is employed.

For tool steel grades having to satisfy especially high levels of toughness, homogeneity and purity standards, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen have five electroslag remelting furnaces (ESRs) and one vacuum-arc remelting furnace (VAR) at their disposal.

The decision as to which process and furnace to use is predetermined by the desired quality the remelted steel should have. Electroslag remelting (ESR) produces noticeably refined sulfidic purity in comparison to non-remelted steel. To improve oxidic purity, vacuum-arc remelting (VAR) is applied.

The integration of the previous Thyssen hardening shops into the Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen group has enabled us to build on decades of tradition in all fields of heat treatment. From a practical point of view, we are now able to manufacture products using the complete production chain – starting with steel production, via pre-machining to refining through to heat treatment. Our one-stop solution is invaluable for the world’s most important markets and facilitates fulfillment of the most discerning tool quality prerequisites.

In our hardening shops across the continents, we have vacuum-tempering furnaces, inert gas plants and plasma-nitriding plants for thermo-chemical treatments at our disposal. Thanks to computer-controlled process flows, the reproducibility of heat treatment is guaranteed at any time – from the initial inspection of incoming shipments through to the final heat-treated product.

A bonus for our clients
Through the use of a precision-hardening process – an Edelstahl Witten Krefeld development – we are in the position to reduce the deformation of thin components to a minimum (e.g. with guide strips).
Overview of cold-work tool steels and high-speed steels

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<th>Cutting shearing</th>
<th>Coining pressing bending</th>
<th>Rolling</th>
<th>Comminuting</th>
<th>Folding guiding</th>
<th>Machining Tool holders</th>
<th>Hand and power tools</th>
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<td>THYRODUR® 1520</td>
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1 also suitable for thermal stress
The cutting, punching and shearing of metallic and non-metallic materials belong to the most demanding tasks cold-work tool steel tools are subjected to. Besides cutting and shearing, there are virtually no other applications where the tool’s properties have such an influence on the process.

The design of cutting, punching or shearing tools is generally determined by three variables – the precision that will be required of it, the nature of the material to be cut and the intended batch volumes in production. Apart from the tool’s functional design, an optimal choice of steel as well as heat treatment and where necessary, surface coating will determine the tool’s service life.

Specific stresses which, for example, punches and dies are exposed to, are largely dependent on blade clearance. With decreasing clearance, the forces acting on the blades increase significantly resulting in the cutting edges chipping or blunting prematurely. So as to avoid such eventualities, the use of more highly alloyed ledeburitic cold-work tool steels and high-speed steels are recommended.

Where blade clearance increases, the material is drawn into the interstices leading to major bursting and bending stresses on the tools. To prevent this occurrence, the materials have to possess a very high toughness potential.

In addition to a wide range of globally established high-quality standard steel grades, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen provide further steels with specific qualities for cutting, punching and shearing. We have highlighted the following steel grades as most representative of our complete range.

THYRODUR® 2516, a special steel with maximum dimensional stability and outstanding wear resistance combined with a keen cutting edge, is preferred for use in high-performance cutting during thin sheet and strip processing with cutting material thicknesses of up to approximately 3 mm.

THYRODUR® 2550 is an oil-hardening, impact-resistant, tungsten-alloyed high-performance steel for cutting dies. Due to its very good toughness and high hardenability, it is employed to cut sheet of medium thicknesses.

THYRODUR® 2990 is characterized by particularly high hardness, strength and adhesive wear resistance. Through improving
High-performance steels for cutting, punching and shearing

the toughness compared to THYRODUR® 2379, enhanced fracture strength has been achieved resulting in a prolonging of service life. THYRODUR® 2990 features good EDM properties, smooth surface treatment and trouble-free inductive hardening. We recommend this grade for rotary cutters, rotary shear blades, punches, dies and progressive dies applications.

THYRAPID® 3343 is a standard high-speed steel grade with multiple applications. Its balanced alloy composition forms the basis of its high toughness, wear resistance and good cutting edge retention.

<table>
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<th>Group-specific property comparisons</th>
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<tr>
<td>Grade</td>
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<td>THYRODUR® 2516</td>
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<td>THYRODUR® 2510</td>
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<td>THYRODUR® 2516</td>
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<td>THYRODUR® 2550</td>
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<td>THYRAPID® 3343</td>
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Grades for cutting, punching and shearing

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<tr>
<th>Material to process</th>
<th>Thickness</th>
<th>Grade</th>
<th>Working hardness in HRC</th>
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<tbody>
<tr>
<td>Sheet steel, strip steel, aluminium and aluminium alloys, copper and copper alloys:</td>
<td>up to 4 mm</td>
<td>THYRODUR® 2379</td>
<td>58 – 62</td>
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<tr>
<td></td>
<td>up to 6 mm</td>
<td>THYRODUR® 2379</td>
<td>56 – 60</td>
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<td>up to 12 mm</td>
<td>THYRODUR® 2436 mod</td>
<td>58 – 60</td>
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<td>Transformer and dynamo sheet, dynamo strip</td>
<td>up to 6 mm</td>
<td>THYRODUR® 2379</td>
<td>58 – 62</td>
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<tr>
<td>Austenitic steel grades</td>
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<td>up to 6 mm</td>
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<td>over 12 mm</td>
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<tr>
<td>Metallic sheet and strip</td>
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<td>Plastic, wood, rubber, leather, textiles and paper</td>
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<td>up to 12 mm</td>
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Coining, pressing and bending

Metals take on new, specified physical qualities through cold solid forming, deep drawing, coining and cold extrusion processing methods.

During cold solid forming, materials are transformed into their final shape by cold forming or extrusion. Depending on the method employed, the forming tools can be exposed to extremely high wear resulting from pressure and abrasion.

The coining or embossing process, especially the minting of coins, creates unusually high demands on the steels used for punches and dies when it comes to purity, compression strength and wear resistance. In the mints where the coins are produced, even the slightest divergences relating to surface, dimensional or gravimetric accuracy result in the tools being taken out of service. This strongly underlines the importance of the tool steel quality employed.

The demands the deep-drawing process makes on the physical formability of the material used are very considerable. At the same time the increasing tendency to reduce material costs is nowadays accompanied by cutbacks in wall thicknesses. The tools employed in this manufacturing process are subject to exceptional attrition – in particular at the edges and on radii. With respect to production profitability, all these factors require tool properties that comply with the highest standards of dimensional stability, tolerance and surface quality.

Cold extrusion – in particular the production of cold-extruded steel components – places enormous strains on tools when it comes to toughness and wear resistance. This is due to the forces required for this type of cold forming, which lead to immense compression and tensile stresses. This scenario can lead to permanent deformation or even cracking. To reduce these two types of stress, material-related preloads are utilized in the form of reinforcement rings. Our nickel-alloyed THYRODUR® 2721 in particular is recommended for such rings.

The pelleting process, which necessitates a uniform high dimensional accuracy, more than any other characteristic, requires a fine, non-porous surface. The latter is achieved through the homogeneous microstructure of the pelletier, which enables absolutely perfect micro-engraving. So as to facilitate an uncomplicated removal of the pelletized material without sticking, pelletiers may be coated using various methods.

Besides their established high-quality standard steels featuring a diversity of alloys, Edelstahl Witten-Krefeld and Edelstahlwerke Süddeutschland supply steel grades with special qualities for coining, pressing and bending tools. The steels in question excel themselves through high toughness and wear resistance. We have chosen five steel grades representative of a larger selection.

THYRODUR® 2357 is an air-hardening cold-work tool steel with very good toughness even at high strengths. It is preferentially used for pelletiers.

THYRODUR® 2550 is an impact-resistant, tungsten-alloyed cold-work tool steel featuring very good toughness combined with high hardenability. This grade is strongly recommended for use with preforming and tablet press punches.

When it comes to coining, THYRODUR® 2550 has proven itself a good economic alternative to HSS. Where superior toughness is required, nickel-alloyed grades such as THYRODUR® 2767 are preferred.

THYRODUR® 2767 is a cold-work tool steel, the nickel content of which assures improved hardenability, toughness and polishability. Its uses include solid embossing tools, bending tools and cutlery dies.

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<th>Group-specific property comparisons</th>
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Cold rolling is a forming process which takes place below recrystallization temperature. It involves further reduction of already hot-rolled strip and a determining of the mechanical and technological properties of the same strip.

Due to specific requirements during processing, cold rolling is regarded as a speciality within the diverse application areas of cold-work tool steels.

The steels supplied by Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen for cold-working are largely employed in the classical segments of the cold-rolling industry. They nevertheless have uses in other fields such as back-up rolls, straightening and section-bending rolls.

For the cold forming of strips made from low and high-alloyed steels as well as of strips and foils made of non-ferrous metals, the combined Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen companies produce work rolls for two-high mills together with work and back-up rolls for four-high and six-high mills. We additionally equip cluster mills with work, interior and exterior intermediate rolls.

At our Krefeld works we manufacture cold rolls on-site which are supplied as ready-to-install tools. This enables us to adapt the metallurgical and technological properties of steel grades precisely and individually to our client’s specific requirements.

The use of special smelting-reduction processes, such as electroslag remelting (ESR) or vacuum arc remelting (VAR), assures compliance with demands on surface quality, purity and isotropy. Modern forging units guarantee ultimate shaping with high compression of the core area.

Our forging press and radial forging machines enable the production of forged-to-shape blanks with dimensions close to the final gauge.

The blanks are supplied annealed or in quenched and tempered condition.

For the finish-machined products, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen are equipped with hardening units for inductive surface hardening and soaking pits for through hardening of the steels.

Machining is performed on our modern machining centres.

Every roll is extensively tested as part of our guarantee for consistent premium delivery quality. For any client inquiries and specific advice on applicational use, a qualified team of engineers and steel experts is ready to be of assistance.
Comminuting

The comminuting of mineral and metallic materials, plastics and wood is a necessary and decisive economic factor for many industrial manufacturing processes.

Whether for the granulating of plastics, wood chipping or metal shredding, the tools, as well as the steels they are made from, have to cope with very considerable wear resistance, impact strength and hardness caused by a broad spectrum of very varied operational conditions.

For the comminuting of plastics, highly wear-resistant ledeburitic chromium steel grades are standard for use with granulating blades. Where exceptional demands are made on the blades, our specialty material Ferro-Titanit® guarantees ultimate wear resistance.

Specially alloyed cold-work tool steel grades have been developed for wood chippers and especially for wood processing. These grades are characterized by appropriate hardness combined with high toughness and high wear resistance.

For shredding – for example with scrap choppers – forged high nickel cold-work tool steels are used, as they best cope with the increasing demands on mechanical properties and toughness.

High-performance steels for comminuting

Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen supply a broad assortment of premium quality alloyed cold-work tool steels for granulating, chipping and shredding tools.

THYROID® 2360, a 7% chromium steel, has proven particularly successful in wood processing. Its good wear resistance and high hardness are derived from a well-balanced alloy-components ratio – namely molybdenum, vanadium and tungsten – combined with a medium carbon content.

THYROID® 2379 is a preferred choice for granulating blades to be used for comminuting. This grade offers a balanced ratio of high hardness and good wear resistance.

THYROID® 2743 is a high nickel cold-work tool steel. Its fine combination of hardness, wear resistance and toughness is particularly noteworthy. THYROID® 2743 is mainly used for shredders.

THYROID® 2746 is a high-performance high nickel cold-work tool steel. This air and oil-hardening grade featuring maximum impact resistance is utilized for cold-shear blades, which are primarily for scrap chopping.

<table>
<thead>
<tr>
<th>Group-specific property comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>THYROID® 2360</td>
</tr>
<tr>
<td>THYROID® 2379</td>
</tr>
<tr>
<td>THYROID® 2510</td>
</tr>
<tr>
<td>THYROID® 2743</td>
</tr>
<tr>
<td>THYROID® 2746</td>
</tr>
<tr>
<td>THYROID® 2842</td>
</tr>
<tr>
<td>THYRAPID® 3343</td>
</tr>
</tbody>
</table>
Ongoing improvements and continued developments in machine tool construction have resulted in increasingly complex requirements relating to the quality and profitability of tool systems. This is well illustrated by hardened guide and sliding rails for machine tools, which are now some of the most important components on the market.

There is an abundance of requirements the steels for such guide rails have to fulfil. Necessary mechanical properties are high abrasive resistance together with good fracture toughness and high dimensional stability when under permanent stress.

It is precisely these properties that distinguish Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen’s through-hardening cold-work tool steels. According to customer requirements, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen’s high-performance steel grades are delivered stress-relieved and pre-hardened or through-hardened. Alternatively they may be given induction treatment on-site at the customer.

Ultimately success depends on the degree of application specification and the efficiency of tool systems made from high-performance steels. The steel grades themselves have to ensure the following standards: high wear resistance and flexural fatigue strength, good machinability, good hardenability and virtually stress-free as-delivered condition.

The efficiency of the steel grades made by Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen is equally superior when it comes to modern folding processes.

Present-day folding technology – increasingly supported by intelligent material configurations and profitable nesting software – enables the user of press brakes to manufacture highly accurate folding products.

In the guiding and folding sector Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen supply an extensive variety of high-quality quenched and tempered cold-work tool steel grades. It is worth highlighting the following steel grades from our product range.

**THYRODUR® 2067** is characterized by a well-balanced property profile. This grade is most commonly used for guide rails.

**THYROPLAST® 2312** is a high-performance brake die steel originally designed for plastic mould construction. The grade, which features very good machinability, is delivered at a hardness of 280 to 325 HB.

**THYRODUR® 2842** is a universal cold-work tool steel for guide rails. It offers improved through hardening in comparison to the standard guide rail grade THYRODUR® 2067.

<table>
<thead>
<tr>
<th>Group-specific property comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>THYRODUR® 2067</td>
</tr>
<tr>
<td>THYROPLAST® 2312</td>
</tr>
<tr>
<td>THYRODUR® 2510</td>
</tr>
<tr>
<td>THYRODUR® 2842</td>
</tr>
</tbody>
</table>
The machining process enables the user to obtain components of a desired shape. Boring, turning and sawing are all means to this end. When selecting a material appropriate for metal-cutting tools, the machining conditions and the properties of the material to be machined need to be taken into account.

This is becoming ever more relevant with demands for higher profitability, longer service life, lighter construction, greater comfortability and product safety. The selection process also generates an increasing use of more metal and plastic-based composites as well as materials of a more tensile nature.

A diverse range of cold-work tool steels is available for machining purposes. Here though, we would primarily like to address the area of high-speed steels. The latter steels retain their indispensible high-hardness properties up to operating temperatures of 600 °C. In this way, enhanced machining requirements can be realised for longer time periods without a decrease in cutting efficiency or cutting-edge retention. The key characteristics of high-speed steels are high hardenability, fine wear resistance, good toughness and high tempering resistance combined with red hardness. Different ratios of the alloy components carbon, tungsten or molybdenum, vanadium, cobalt and chromium result in steels with very individual properties.

The ensuing diversity places us in a strong position to supply the customer with high-speed steel grades designed for every possible demand and application.

Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen have many years of experience at their disposal when it comes to high-speed steel production, with the consequence that we can guarantee higher levels of quality by applying calculated measures when smelting, casting and processing.

High tempering resistance facilitates certain surface treatments such as nitriding. This not only causes a decreased tendency to adhere and to cold lap, but also increases abrasive wear resistance.

The considerable diversity of materials and variations in products and components means that the correct choice of steel grade for metal-cutting tools becomes paramount.

Our long-term experience with material-specific chip formation and wear processes, the knowledge of our material experts as well as a coordinated cooperation with scientists are guarantors for the premium quality of our cold-work tool steels and high-speed grades – regardless for which purposes the steels are planned.

Edelstahl Witten-Krefeld’s and Edelstahlwerke Südwestfalen’s spectrum of high-performance steels for machining comprises pre-hardened as well as high alloy grades. We have highlighted the following steel grades as most representative of our range.

**THYRAPID® 3243**, which is primarily used for twist drills, is a chromium-vanadium cold-work tool steel with high wear resistance and good machinability.

**THYRAPID® 3247** is characterized by its high wear resistance, high-temperature strength and toughness. It is largely employed for tools which have to withstand abrasive wear.

**THYRAPID® 3333** is a high-speed steel with low alloy content which achieves medium-term life times. It is basically used on account of its toughness potential when parts are exposed to large impact loadings and it is frequently employed for circular and long metal saw blades.

---

**Application examples for high-speed steel grades**

<table>
<thead>
<tr>
<th>Treatment of</th>
<th>Steel or cast iron</th>
<th>Non-metallic materials</th>
<th>Wood</th>
<th>Plastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress Tool</td>
<td>slight medium intense</td>
<td>slight medium intense</td>
<td>slight medium intense</td>
<td>slight medium intense</td>
</tr>
<tr>
<td>Twist drills</td>
<td>3343 3343 3243</td>
<td>3343 3343 –</td>
<td>3343 3243 3243</td>
<td>3343 3243 3243</td>
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<td>– – –</td>
<td>– – –</td>
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<td>– – –</td>
<td>– – –</td>
</tr>
<tr>
<td>Taps</td>
<td>3343 3343 3243</td>
<td>3343 3343 3344</td>
<td>– – –</td>
<td>3343 3343 3344</td>
</tr>
<tr>
<td>Screwing dies</td>
<td>3343 3343 3243</td>
<td>3343 3343 –</td>
<td>– – –</td>
<td>3343 3343 –</td>
</tr>
<tr>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
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</tr>
<tr>
<td>Milling cutters</td>
<td>3343 3343 3202</td>
<td>3343 3343 3202</td>
<td>3343 3343 3202</td>
<td>3343 3343 3202</td>
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<tr>
<td>– – –</td>
<td>3343 –</td>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
</tr>
<tr>
<td>Reamers</td>
<td>3343 3343 3202</td>
<td>3343 3344 3202</td>
<td>– – –</td>
<td>3343 3344 3202</td>
</tr>
<tr>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
</tr>
<tr>
<td>Saws and saw segments</td>
<td>3343 3343 3243</td>
<td>3343 3343 3343</td>
<td>3343 3343 3343</td>
<td>3343 3343 –</td>
</tr>
<tr>
<td>Tool holder bits</td>
<td>3243 3243 3202</td>
<td>3202 3202 3202</td>
<td>3202 3202 3202</td>
<td>3202 3202 3202</td>
</tr>
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<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
<td>– – –</td>
</tr>
<tr>
<td>Planing tools</td>
<td>3343 3343 3243</td>
<td>3343 3343 3202</td>
<td>– – –</td>
<td>3343 3343 3202</td>
</tr>
<tr>
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<tr>
<td>Broaches</td>
<td>3343 3343 3243</td>
<td>3343 3343 –</td>
<td>– – –</td>
<td>3343 –</td>
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<td>– – –</td>
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</tr>
</tbody>
</table>
Due to growing product diversity and higher production volumes, the concepts surrounding the purpose and function of a tool have been changing in recent years. A striking technology which, to a great extent, has contributed to the development of innovative tool holders is shrink fitting. This is now made use of in all machining areas.

The more comprehensive, complex and taxing a process becomes, the larger the advantages of shrink-fit technology. This is best illustrated with long and thin tools used at high revolutions and under extreme demands on the torque transmitted.

Even with shrink-fit chucks, hydraulic chucks, shrink-fit tool holders and carbide-tipped metal-cutting tools, one constant has remained despite all other developments: in the same way that no precision tool holder can perfectly and universally fulfill every requirement simultaneously, there is no single cold-work tool steel grade predestined to suit all demands.

Correspondingly, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen have developed a broad range of high-performance steel grades for tool holders with the following characteristics: high surface hardness, good toughness, compression strength and high wear resistance.

Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen supply an extensive assortment of high-quality steel grades for tool holders, the most representative of which we have highlighted to the right.

**THYROTHERM® 2343 and THYROTHERM® 2344** are chromium-molybdenum-vanadium alloyed hot-work tool steel grades which have also proven successful as cold-work tool steels with multiple applications. The main characteristics of these steels are good wear resistance, high toughness even at elevated strengths, low dimensional variation and high resistance to thermal fatigue. 

**THYROTHERM® 2343 and THYROTHERM® 2344** are preferred for use with tool holders, especially for shrink fit chucks.

Both grades can be nitrided and are easily polishable. They also possess a very good tempering resistance and are insusceptible to hot cracking. We particularly recommend the use of **THYROTHERM® 2344** for higher demands on wear resistance.

**THYROTHERM® 2714** is a high-performance die steel and due to its good toughness and high compression strength, it is used for the main bodies of carbide-tipped tools.

**THYRODUR® 2826** is a silicon-manganese alloyed cold-work tool steel with high toughness and good resilience characteristics with the result that it is highly suitable for draw-in collets and spring collets.
In recent years, the development of hand and power tools has been characterized by the pursuit of the highest possible process reliability and correspondingly high productivity.

Especially in the area of power tools, a trend towards modular tool systems is clearly noticeable, accompanied by an ongoing development in coatings and protection from wear. For years turning and milling technologies have been combined on single machines, so it is a logical consequence that universal tools have followed suit.

So as to remain in the forefront of production, Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen deliver a very expansive range of highest quality cold-work tool steels to fulfil the needs created by ever-increasing demands. Whether drills, woodworking tools, screw-driving tools, milling cutters, tool bits for pneumatic and hydraulic hammers or hand tools, our constantly high steel quality ensures uppermost operational safety and maximum service life.

The range of high-quality steels for hand and power tools from Edelstahl Witten-Krefeld and Edelstahlwerke Südwestfalen consists of premium and special grades, the most important of which are represented here.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Strength</th>
<th>Wear resistance</th>
<th>Toughness</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>THYRDOUR® 1520</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>THYRDOUR® 2002</td>
<td>++</td>
<td>+++</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>THYRDOUR® 2008</td>
<td>++</td>
<td>+++</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>THYRDOUR® 2210</td>
<td>++</td>
<td>++</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>THYRDOUR® 2235</td>
<td>++</td>
<td>+++</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>THYRDOUR® 2242</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>THYRDOUR® 2249</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>THYRDOUR® 2381</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>THYRDOUR® 2510</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>THYRDOUR® 2766 mod</td>
<td>0</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

THYRDOUR® 2210 is a chromium-vanadium alloyed cold-work tool steel with high wear resistance as well as good machinability and metal-cutting performance. Amongst other uses, this grade is employed for sharpening steels, twist drills and ejector pins. THYRDOUR® 2210 is also supplied in silver steel quality.

THYRDOUR® 2249, a chromium-silicon-vanadium alloyed special steel, is characterized by high toughness – even when exposed to considerable impact loadings. THYRDOUR® 2249 is mainly used for pneumatic tool bits.

THYRDOUR® 2766 is a silicon-molybdenum alloyed high-tensile special steel featuring good resistance to twisting. It is preferred for bits and screwdrivers.

THYRDOUR® 2766, one of our oil and air-hardening cold-work tool steels, has the propensity to manage enormous fatigue strength and toughness in combination with tremendously high wear resistance. THYRDOUR® 2766 is also available with a modified composition resulting in even greater toughness.
Identification

Material number  Reference number  AISI
1.1520  (C70W)

Chemical composition  Typical analysis in %
C  Si  Mn
0.70  0.25  0.25

Steel properties
Shell-hardenable steel with wear-resistant surface and high core toughness.

Applications
Trimming dies, pliers, tool bits for pneumatic and hand tools.

Heat treatment

Soft annealing °C  Cooling  Hardness HB
680 – 710  Furnace, from 500 °C air  max. 180

Stress-relief annealing °C  Cooling
approx. 600 – 650  Furnace

Hardening °C  Quenching  Hardness after quenching HRC
780 – 810  Water  64
Tempering °C  HRC
100  200  64  61
300  100  56  49
500  100  54  49
700  100  54  49
900  100  54  49
1100  100  54  49
1300  100  54  49

Chemical composition  Typical analysis in %
C  Si  Mn
0.45  0.20  0.70

Steel properties
Shell-hardenable steel featuring hard surface and tough core.

Applications
Components for tools (e.g. base plates for plastic moulds and pressure casting moulds). Also suitable for hand tools, pliers and agricultural tools of all kinds.

Heat treatment

Soft annealing °C  Cooling  Hardness HB
680 – 710  Furnace  max. 207

Stress-relief annealing °C  Cooling
approx. 600 – 650  Furnace

Hardening °C  Quenching  Hardness after quenching HRC
800 – 830  Water  64
Tempering °C  HRC
100  200  300  350

Time-temperature-transformation diagram

Tempering diagram

Reference numbers in brackets are not standardized in EN ISO 4957.
**Identification**

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2002</td>
<td>(125 Cr)</td>
<td></td>
</tr>
</tbody>
</table>

**Chemical composition** Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>Si</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.30</td>
<td>0.25</td>
<td>0.25</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Steel properties**

Tool steel with high surface hardness.

**Applications**

Cutting tools, drawing dies, files and mandrels.

**Heat treatment**

**Soft annealing °C**

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>max. 200</td>
</tr>
</tbody>
</table>

**Stress-relief annealing °C**

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>approx. 650 – 680</td>
</tr>
</tbody>
</table>

**Hardening °C**

<table>
<thead>
<tr>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>770 – 800</td>
<td>c 10 mm Ø Oil</td>
</tr>
</tbody>
</table>

**Tempering °C**

<table>
<thead>
<tr>
<th>HRC</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>62</td>
<td>56</td>
<td>49</td>
<td></td>
</tr>
</tbody>
</table>

**Applications**

Water-hardening special steel.

**Heat treatment**

**Soft annealing °C**

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>max. 220</td>
</tr>
</tbody>
</table>

**Stress-relief annealing °C**

<table>
<thead>
<tr>
<th>Cooling</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>approx. 650 – 680</td>
</tr>
</tbody>
</table>

**Hardening °C**

<table>
<thead>
<tr>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>780 – 820</td>
<td>Water</td>
</tr>
</tbody>
</table>

**Tempering °C**

<table>
<thead>
<tr>
<th>HRC</th>
<th>100</th>
<th>200</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>62</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

Reference numbers in brackets are not standardized in EN ISO 4957.
Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>THYRODUR 2067</td>
<td>12067</td>
<td>1.20Cr6</td>
</tr>
<tr>
<td></td>
<td>102Cr6</td>
<td>L1/L3</td>
</tr>
</tbody>
</table>

Chemical composition

Typical analysis in %

- C: 1.00
- Si: 0.20
- Mn: 0.35
- Cr: 1.50

Steel properties

Oil-hardenable grade with low hardening depth, wear-resistant.

Physical properties

Thermal conductivity W/(m °C)

- 20 °C: 3.0
- 350 °C: 3.5
- 700 °C: 4.6

Applications

Cold pilger rolls and jaws, thread cutting tools, gauges, mandrels, wood and paper processing tools, cold extrusion and spinning tools, flanging rolls, shear and rotary shear blades.

Heat treatment

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>710 – 760</td>
<td>Furnace</td>
<td>max. 225</td>
</tr>
</tbody>
</table>

Stress-relief annealing °C

approx. 650 Furnace

Hardening °C

- Quenching
  - Oil or saltbath (180 – 220 °C): 64

Tempering °C

- HRC: 64, 61, 56, 50, 44, 36

Thermal conductivity W/(m °C)

- 20 – 100 °C: 6.7
- 200 – 300 °C: 8.0
- 300 – 400 °C: 8.6

Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>THYRODUR 2080</td>
<td>12080</td>
<td>X210Cr12</td>
</tr>
</tbody>
</table>

Chemical composition

Typical analysis in %

- C: 2.00
- Si: 0.30
- Mn: 0.30
- Cr: 12.00

Steel properties

12% ledeburitic chromium tool steel with extreme wear resistance.

Physical properties

Coefficient of thermal expansion 10⁻⁶m/(m °C)

<table>
<thead>
<tr>
<th>20 – 100 °C</th>
<th>200 – 300 °C</th>
<th>400 – 500 °C</th>
<th>600 – 700 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.8</td>
<td>11.7</td>
<td>12.2</td>
<td>12.6</td>
</tr>
</tbody>
</table>

Thermal conductivity W/(m °C)

<table>
<thead>
<tr>
<th>20 °C</th>
<th>350 °C</th>
<th>700 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.7</td>
<td>20.5</td>
<td>24.2</td>
</tr>
</tbody>
</table>

Applications

Cutting tools for sheets up to 4 mm thickness; trimming dies, blanking dies for paper and plastics, shear blades and rotary shear blades for sheet thicknesses up to 2 mm, drawing and deep-drawing tools. Woodworking tools, stone pressing tools, pressure pads and highly wear-resistant plastic moulds, profile rolls.

Heat treatment

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 – 840</td>
<td>Furnace</td>
<td>max. 250</td>
</tr>
</tbody>
</table>

Stress-relief annealing °C

approx. 650 Furnace

Hardening °C

- Quenching
  - Oil (up to 30 mm thickness): 64

Tempering °C

- HRC: 63, 62, 59, 57, 54, 46
**Identification**

Material number | Reference number | AISI
--- | --- | ---
1.2101 | (62SiMnCr4) | 

**Chemical composition**

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65</td>
<td>1.1</td>
<td>1.1</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Steel properties**

Good toughness and wear resistance.

**Physical properties**

Coefficient of thermal expansion $10^{-6} \text{m/(m \cdot K)}$

- 20 – 100°C: 11.8 ≈ 12.5
- 20 – 200°C: 

Thermal conductivity W/(m \cdot K)

- 20°C: 31.0
- 350°C: 31.5
- 700°C: 31.9

**Applications**

Spring collets, shear blades, guide rails and punching tools.

---

**Identification**

Material number | Reference number | AISI
--- | --- | ---
1.2201 | (X165CrV12) | 

**Chemical composition**

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.60</td>
<td>12.0</td>
<td>0.10</td>
</tr>
</tbody>
</table>

**Steel properties**

Dimensionally stable, oil-hardenable grade featuring extreme wear resistance combined with sufficient toughness.

**Applications**

High-performance steel for cutting, hobs, thread rolls, metal saws, wood milling machines and similar items.

---

**Heat treatment**

**Soft annealing °C**

- Cooling: Furnace max. 225

**Stress-relief annealing °C**

- Cooling: Furnace approx. 650 – 680

**Hardening °C**

- Quenching: Oil or saltbath (180 – 220 °C) 64

**Tempering °C**

- HRC: 61

---

**Time-temperature-transformation diagram**

Reference numbers in brackets are not standardized in EN ISO 4957.
### Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2210</td>
<td>(115CrV3)</td>
<td>L2</td>
</tr>
</tbody>
</table>

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.20</td>
<td>0.7</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Steel properties

Wear resistant chromium-vanadium alloyed cold-work steel.

### Physical properties

#### Coefficient of thermal expansion (10⁻⁶ m/(m • K))

- 20 – 100 °C: 10.0
- 100 – 200 °C: 12.7
- 200 – 300 °C: 13.7
- 300 – 400 °C: 14.2
- 400 – 500 °C: 14.9
- 500 – 600 °C: 15.8
- 600 – 700 °C: 16.8

#### Thermal conductivity (W/(m • K))

- 20 °C: 34.2
- 350 °C: 32.6
- 700 °C: 31.0

### Applications

Piercing dies, guide rods, twist drills, ejector pins and wood chisels.

### Heat treatment

#### Hardening °C

- 800 – 830 °C (Oil: < 15 mm Ø)
- 780 – 810 °C (Water: > 15 mm Ø)

#### Quenching

- Oil: 64
- Water: 64

#### Hardness after quenching HRC

- 800 – 830 °C: 64
- 780 – 810 °C: 64

### Tempering °C

- 100 – 200 – 300 – 400 – 500 – 600 °C
- HRC: 64, 62, 57, 51, 44, 36

### Applications

Circular and gang saws, machine knives, cutting tools for wood and non-ferrous metals, pliers and wood chisels.

### Steel properties

#### Physical properties

#### Thermal conductivity (W/(m • K))

- 20 °C: 33.5
- 350 °C: 32.0
- 700 °C: 31.0

### Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2235</td>
<td>(80CrV2)</td>
<td></td>
</tr>
</tbody>
</table>

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>0.60</td>
<td>0.20</td>
</tr>
</tbody>
</table>

### Steel properties

Special steel for woodworking, featuring a keen cutting edge.

### Applications

Wear resistant chromium-vanadium alloyed cold-work steel.
### Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2242</td>
<td>(59CrV4)</td>
<td></td>
</tr>
</tbody>
</table>

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Cr</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.19</td>
<td>0.9</td>
<td>1.0</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Steel properties

Wear resistant, high toughness.

### Applications

Special steel for hand chisels of all types, including flat, cross-cut and pointed chisels for the treatment of hard materials. Also for screwdrivers and other hand tools.

### Heat treatment

#### Soft annealing

<table>
<thead>
<tr>
<th>°C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>710</td>
<td>Furnace</td>
<td>max. 230</td>
</tr>
</tbody>
</table>

#### Stress-relief annealing

<table>
<thead>
<tr>
<th>approx. 650 – 680</th>
<th>Cooling</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Furnace</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

### Physical properties

#### Thermal conductivity W/(m · K)

- 20 °C: 30.5
- 350 °C: 32.0
- 700 °C: 31.5

### Applications

Cold heading dies, shear blades, section-cutting shear blades and trimming dies, punching tools and bolting tools.

### Time-temperature-transformation diagram

[Diagram Image]

Reference numbers in brackets are not standardized in EN ISO 4957.

---

### Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2243</td>
<td>(61CrSiV5)</td>
<td></td>
</tr>
</tbody>
</table>

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>0.9</td>
<td>0.8</td>
<td>1.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Steel properties

Wear resistant, high toughness.

### Applications

Cold heading dies, shear blades, section-cutting shear blades and trimming dies, punching tools and bolting tools.

### Heat treatment

#### Soft annealing

<table>
<thead>
<tr>
<th>°C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>700</td>
<td>Furnace</td>
<td>max. 220</td>
</tr>
</tbody>
</table>

#### Stress-relief annealing

<table>
<thead>
<tr>
<th>approx. 650 – 680</th>
<th>Cooling</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil or saltbath (180 – 220 °C)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Furnace</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

### Physical properties

#### Thermal conductivity W/(m · K)

- 20 °C: 30.5
- 350 °C: 32.0
- 700 °C: 31.5

### Applications

Cold heading dies, shear blades, section-cutting shear blades and trimming dies, punching tools and bolting tools.

### Time-temperature-transformation diagram

[Diagram Image]

Reference numbers in brackets are not standardized in EN ISO 4957.
### THYRODUR®

**Material number** 1.2249  
**Reference number** (45SiCrV6)

**Chemical composition** Typical analysis in %

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Si</th>
<th>V</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.45</td>
<td>1.35</td>
<td>0.10</td>
<td>1.35</td>
</tr>
</tbody>
</table>

**Steel properties**

Tough, impact-resistant tool steel.

**Applications**

Pneumatic chipping hammers, punching tools, riveting hammers, punches and woodworking tools.

**Heat treatment**

- **Soft annealing °C**
  - 710 – 790
  - Cooling: Furnace

- **Stress-relief annealing °C**
  - approx. 650 – 680
  - Cooling: Furnace

- **Hardening °C**
  - 860 – 890
  - Quenching: Oil

- **Tempering °C**
  - 500 – 550
  - HRC

**Time-temperature-transformation diagram**

**Tempering diagram**

**Physical properties**

- **Coefficient of thermal expansion 10^(-6) m/(m • K)**
  - 20 – 100 °C
  - 20 – 200 °C
  - 20 – 300 °C
  - Annealed: 12.5
  - Quenched and tempered: 12.3

- **Thermal conductivity W/(m • K)**
  - 100 °C
  - 150 °C
  - 200 °C
  - 250 °C
  - 300 °C

- **Coefficient of thermal expansion 10^(-6) m/(m • K)**
  - 20 – 100 °C
  - 20 – 200 °C
  - 20 – 300 °C
  - Annealed: 12.5
  - Quenched and tempered: 12.3

**Applications**

Plastic moulds, mould frames for plastic and pressure casting moulds, recipient sleeves, brake dies.

---

### THYROPLAST®

**Material number** 1.2312  
**Reference number** 40CrMnNiMo7-6-4

**Chemical composition** Typical analysis in %

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.40</td>
<td>1.35</td>
<td>1.50</td>
<td>1.90</td>
<td>0.20</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Steel properties**

Quenched and tempered plastic mould steel with a hardness in as-delivered condition of 280 to 325 HB. Improved machinability in comparison with THYROPLAST® 2311. Polishable.

**Applications**

Plastic moulds, mould frames for plastic and pressure casting moulds, recipient sleeves, brake dies.

**Heat treatment**

- **Soft annealing °C**
  - 710 – 790
  - Cooling: Furnace

- **Stress-relief annealing (annealed) °C**
  - approx. 600
  - Cooling: Furnace

- **Stress-relief annealing (quenched and tempered) °C**
  - approx. 30 – 50 under tempering temperature

- **Hardening °C**
  - 840 – 890
  - Quenching: Oil

- **Tempering °C**
  - 100 – 280
  - HRC

**Time-temperature-transformation diagram**

**Tempering diagram**

**Physical properties**

- **Coefficient of thermal expansion 10^(-6) m/(m • K)**
  - 20 – 100 °C
  - 20 – 200 °C
  - 20 – 300 °C
  - Annealed: 12.5
  - Quenched and tempered: 12.3

- **Thermal conductivity W/(m • K)**
  - 100 °C
  - 150 °C
  - 200 °C
  - 250 °C
  - 300 °C

**Applications**

Plastic moulds, mould frames for plastic and pressure casting moulds, recipient sleeves, brake dies.

---

Reference numbers in brackets are not standardized in EN ISO 4957.  
S can be raised between 0.05 and 0.1 % whereas Ni can be left out completely.
**Identification**

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>THYROLL® 12327</td>
<td>(~86CrMoV7)</td>
<td></td>
</tr>
</tbody>
</table>

**Chemical composition**  Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.83</td>
<td>0.45</td>
<td>0.40</td>
<td>1.90</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Steel properties**

Cr-Mo alloyed shell-hardenable grade with high wear resistance.

**Applications**

Standard cold-roll steel for rolls of all sizes, backup rolls and work rolls.

---

**Identification**

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>THYRODUR® 12328</td>
<td>(45CrMoV7)</td>
<td></td>
</tr>
</tbody>
</table>

**Chemical composition**  Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>0.90</td>
<td>1.8</td>
<td>0.30</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Steel properties**

Air-hardening steel of great hardness and toughness.

**Applications**

Special steel for chisels.

---

**Heat treatment**

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>790 – 790</td>
<td>Furnace</td>
<td>Max. 250</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>830 – 850</td>
<td>Water</td>
<td>64 – 85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tempering °C</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>64</td>
</tr>
<tr>
<td>200</td>
<td>68</td>
</tr>
<tr>
<td>300</td>
<td>56</td>
</tr>
<tr>
<td>400</td>
<td>53</td>
</tr>
</tbody>
</table>

---

**Heat treatment**

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>690 – 730</td>
<td>Furnace</td>
<td>Max. 248</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress-relief annealing °C</th>
<th>Cooling</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. 850</td>
<td>Furnace</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>840 – 860</td>
<td>Air</td>
<td>55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tempering °C</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>57</td>
</tr>
<tr>
<td>200</td>
<td>55</td>
</tr>
<tr>
<td>300</td>
<td>52</td>
</tr>
<tr>
<td>400</td>
<td>49</td>
</tr>
<tr>
<td>500</td>
<td>45</td>
</tr>
<tr>
<td>600</td>
<td>38</td>
</tr>
</tbody>
</table>
Besides applications typical for the area of hot-work steels, this grade is mainly used for ejector pins, tool holders and shrink fit chucks.

Steel properties
High hot-wear resistance and hot tensile strength as well as good toughness, thermal conductivity and insusceptibility to hot-cracking. Can be water-cooled to a limited extent.

Physical properties
- Coefficient of thermal expansion $10^{-6}$ m/(m $\cdot$ K)
  - 20 – 100 °C: 25.5, 27.6, 30.3
  - 20 – 200 °C: 11.5, 12.1, 12.6
  - 20 – 300 °C: 11.5, 12.1, 12.6
  - 20 – 400 °C: 11.5, 12.1, 12.6
  - 20 – 500 °C: 11.5, 12.1, 12.6
  - 20 – 600 °C: 11.5, 12.1, 12.6
  - 20 – 700 °C: 11.5, 12.1, 12.6

Heat treatment
- Soft annealing °C: 750 – 800
- Furnace max. HRC
- Stress-relief annealing °C: approx. 600 – 650
- Furnace
- Hardening °C: 1000 – 1080
- Quenching
- Air, oil or saltbath (500 – 550 °C)
- Hardness after quenching HRC
- 500 – 550 °C
- 550 – 600 °C
- 600 – 650 °C
- 700 – 750 °C
- Tempering °C: 100 – 200 °C
- Cooling
- Air, oil or saltbath (1000 – 1050 °C)
- Hardness after tempering HRC
- 100 – 200 °C
- 200 – 300 °C
- 300 – 400 °C
- 400 – 500 °C
- 500 – 600 °C
- 600 – 650 °C
- 700 – 800 °C

Chemical composition
Typical analysis in %
- C: 0.38
- Si: 1.0
- Cr: 5.3
- Mo: 1.3
- V: 0.4

Identification
Material number: 1.2343
Reference number: X3CrNiMoV5-1
AISI: H11

Steel properties
High hot tensile strength and toughness. Good thermal conductivity and insusceptibility to hot cracking. Can be water-cooled to a limited extent.

Physical properties
- Coefficient of thermal expansion $10^{-6}$ m/(m $\cdot$ K)
  - 20 – 100 °C: 10.9, 11.9, 12.3
  - 20 – 200 °C: 12.7, 13.0, 13.3
  - 20 – 300 °C: 13.0, 13.3, 13.6
  - 20 – 400 °C: 13.0, 13.3, 13.6
  - 20 – 500 °C: 13.0, 13.3, 13.6
  - 20 – 600 °C: 13.0, 13.3, 13.6
  - 20 – 700 °C: 13.0, 13.3, 13.6

Heat treatment
- Soft annealing °C: 750 – 800
- Furnace max. HRC
- Stress-relief annealing °C: approx. 600 – 650
- Furnace
- Hardening °C: 1000 – 1080
- Quenching
- Air, oil or saltbath (500 – 550 °C)
- Hardness after quenching HRC
- 500 – 550 °C
- 550 – 600 °C
- 600 – 650 °C
- 700 – 750 °C
- Tempering °C: 100 – 200 °C
- Cooling
- Air, oil or saltbath (1000 – 1050 °C)
- Hardness after tempering HRC
- 100 – 200 °C
- 200 – 300 °C
- 300 – 400 °C
- 400 – 500 °C
- 500 – 600 °C
- 600 – 650 °C
- 700 – 800 °C
**Identification**

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2357</td>
<td>(50CrMoV13-15)</td>
<td>57</td>
</tr>
</tbody>
</table>

**Chemical composition**

Typical analysis in %

<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>0.50</td>
<td>0.30</td>
<td>0.70</td>
<td>3.35</td>
<td>1.60</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Steel properties**

High toughness and wear resistance, high compression strength combined with dimensional stability and good polishability.

**Physical properties**

- **Coefficient of thermal expansion** $10^{-6}$ m/(m·K)
  - 20 – 200 °C: 12.4
  - 20 – 400 °C: 12.5
- **Thermal conductivity** W/(m·K)
  - 20 °C: 28.9
  - 200 °C: 30.9
  - 400 °C: 31.0

**Applications**

Cold-work tool steel for punching tools, moulds, scrap shear, piercing dies, hobs, coning dies, deburring tools, plastic moulds and pelletisers.

**Heat treatment**

- **Soft annealing °C**
  - 680 – 650
  - Cooling: Furnace
  - Hardness HB: approx. 220
- **Hardening °C**
  - 920 – 970
  - Quenching: Air or oil
  - Hardness after quenching HRC: 60 – 62
- **Stress-relief annealing °C**
  - approx. 600
  - Cooling: Furnace
- **Tempering °C**
  - 100 – 600
  - HRC: 50 – 44

**Steel properties**

- **Coefficient of thermal expansion** $10^{-6}$ m/(m·K)
  - 20 – 200 °C: 12.4
  - 20 – 400 °C: 12.5
- **Thermal conductivity** W/(m·K)
  - 20 °C: 28.9
  - 200 °C: 30.9
  - 400 °C: 31.0

**Applications**

THYROIDUR® 2360 is a 7% chromium steel that derives its high wear resistance from a balanced combination of the alloying elements. The medium V concentration of 0.5% generates a sufficiently high hardenability combined with high toughness, even at comparatively low operating temperatures below RT.

This grade is especially suitable for use with chipper knives, blade holders, veneer slicing blades, blade inserts, billet-shear blades and reinforcements. All require a combination of high hardness and toughness as do large cold extrusion tools of complex geometry.

**Heat treatment**

- **Soft annealing °C**
  - 830 – 860
  - Cooling: Furnace
  - Hardness HB: max. 240
- **Stress-relief annealing °C**
  - approx. 650
  - Cooling: Furnace
- **Hardening °C**
  - 1050 – 1070
  - Quenching: Air, oil or saltbath (150 °C)
  - Hardness after quenching HRC: 60 – 61
- **Tempering °C**
  - 100 – 600
  - HRC: 61 – 53

Reference numbers in brackets are not standardized in EN ISO 4957.
### THYROLL®

Intermediate rolls for cluster mills.

Cr-Mo alloyed through-hardening grade with high tempering resistance.

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>800 – 840</th>
<th>Cooling</th>
<th>max 250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardening °C</td>
<td>980 – 1020</td>
<td>Quenching</td>
<td>61 – 63</td>
</tr>
<tr>
<td>Tempering °C</td>
<td>150 200 300 400 500 550</td>
<td>HRC</td>
<td>61 59 58 57 61 58</td>
</tr>
</tbody>
</table>

**Steel properties**

High dimensional stability during heat treatment. High wear resistance and toughness.

**Applications**

Cutting tools, rolls, shear blades, cold pilger mandrels, cold stamping tools, moulds for plastics processing.

<table>
<thead>
<tr>
<th>Heat treatment</th>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>800 – 840</td>
<td>Furnace</td>
<td>max 291</td>
</tr>
<tr>
<td>Hardening °C</td>
<td>980 – 970</td>
<td>Quenching</td>
<td>63</td>
</tr>
<tr>
<td>Tempering °C</td>
<td>100 200 300 400 500 600</td>
<td>HRC</td>
<td>63 62 59 57 59 52</td>
</tr>
</tbody>
</table>

**Chemical composition**

Typical analysis in %

<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>1.00</td>
<td>0.30</td>
<td>0.50</td>
<td>5.00</td>
<td>0.95</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Steel properties**

<table>
<thead>
<tr>
<th>Thermal conductivity W/(m • K)</th>
<th>20 °C</th>
<th>350 °C</th>
<th>700 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.8</td>
<td>15.8</td>
<td>11.8</td>
</tr>
</tbody>
</table>

**Applications**

Cutting tools, rolls, shear blades, cold pilger mandrels, cold stamping tools, moulds for plastics processing.

<table>
<thead>
<tr>
<th>Heat treatment</th>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>800 – 840</td>
<td>Furnace</td>
<td>max 291</td>
</tr>
<tr>
<td>Hardening °C</td>
<td>980 – 970</td>
<td>Quenching</td>
<td>63</td>
</tr>
<tr>
<td>Stress-relief annealing °C</td>
<td>Cooling</td>
<td>approx. 610</td>
<td>Furnace</td>
</tr>
<tr>
<td>Tempering °C</td>
<td>100 200 300 400 500 600</td>
<td>HRC</td>
<td>63 62 59 57 59 52</td>
</tr>
</tbody>
</table>

**Chemical composition**

Typical analysis in %

<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>1.2362</td>
<td>(~X 63CrMoV5-1)</td>
<td>0.65</td>
<td>1.10</td>
<td>0.40</td>
<td>5.20</td>
</tr>
</tbody>
</table>

**Applications**

Intermediate rolls for cluster mills.

Cr-Mo alloyed through-hardening grade with high tempering resistance.

<table>
<thead>
<tr>
<th>Heat treatment</th>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>800 – 840</td>
<td>Furnace</td>
<td>max 250</td>
</tr>
<tr>
<td>Hardening °C</td>
<td>980 – 1020</td>
<td>Quenching</td>
<td>61 – 63</td>
</tr>
<tr>
<td>Tempering °C</td>
<td>150 200 300 400 500 550</td>
<td>HRC</td>
<td>61 59 58 57 61 58</td>
</tr>
</tbody>
</table>

**Steel properties**

High dimensional stability during heat treatment. High wear resistance and toughness.

**Applications**

Cutting tools, rolls, shear blades, cold pilger mandrels, cold stamping tools, moulds for plastics processing.
Applications

12% ledeburitic chromium steel. Combines maximum wear resistance, good toughness, outstanding cutting edge retention and tempering resistance. It can be nitrided after special heat treatment.

Physical properties

Coefficient of thermal expansion $10^{-6}$ m/(m·K)

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Coefficient of Thermal Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 – 100 °C</td>
<td>10.5</td>
</tr>
<tr>
<td>20 – 200 °C</td>
<td>11.5</td>
</tr>
<tr>
<td>20 – 300 °C</td>
<td>11.9</td>
</tr>
<tr>
<td>20 – 400 °C</td>
<td>12.2</td>
</tr>
</tbody>
</table>

Thermal conductivity W/(m·K)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Thermal Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 °C</td>
<td>16.7</td>
</tr>
<tr>
<td>350 °C</td>
<td>20.5</td>
</tr>
<tr>
<td>700 °C</td>
<td>24.2</td>
</tr>
</tbody>
</table>

Steel properties

Applications

Threading rolls and dies, cold extrusion tools, trimming, cutting and stamping tools for sheet thicknesses up to 6 mm, precision cutting tools for sheet thicknesses up to 12 mm, cold pilger mandrels, circular-shear blades, deep-drawing tools, pressure pads and highly wear-resistant plastic moulds.

Heat treatment

Soft annealing °C Cooling Hardness HB

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Cooling</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>830 – 860°C</td>
<td>Furnace</td>
<td>max. 250</td>
</tr>
</tbody>
</table>

Stress-relief annealing °C Cooling

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>650 – 700°C</td>
<td>Furnace</td>
</tr>
</tbody>
</table>

Hardening °C Quenching Hardness after quenching HRC

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 – 1050°C</td>
<td>Air, oil or salt bath (500 – 550 °C)</td>
<td>63</td>
</tr>
</tbody>
</table>

Tempering °C

<table>
<thead>
<tr>
<th>Temperature</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>63</td>
</tr>
<tr>
<td>200</td>
<td>61</td>
</tr>
<tr>
<td>300</td>
<td>58</td>
</tr>
<tr>
<td>400</td>
<td>58</td>
</tr>
<tr>
<td>500</td>
<td>58</td>
</tr>
<tr>
<td>525</td>
<td>60</td>
</tr>
<tr>
<td>550</td>
<td>56</td>
</tr>
<tr>
<td>600</td>
<td>50</td>
</tr>
</tbody>
</table>

Special heat treatment

Hardening °C Quenching Hardness after quenching HRC

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1050 – 1080°C</td>
<td>Air, oil or salt bath (500 – 550 °C)</td>
<td>63</td>
</tr>
</tbody>
</table>

Tempering °C

<table>
<thead>
<tr>
<th>Temperature</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>61</td>
</tr>
<tr>
<td>200</td>
<td>60</td>
</tr>
<tr>
<td>300</td>
<td>58</td>
</tr>
<tr>
<td>400</td>
<td>59</td>
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<tr>
<td>500</td>
<td>58</td>
</tr>
<tr>
<td>525</td>
<td>62</td>
</tr>
<tr>
<td>550</td>
<td>57</td>
</tr>
<tr>
<td>600</td>
<td>50</td>
</tr>
</tbody>
</table>

(Three times) HRC

<table>
<thead>
<tr>
<th>Temperature</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>61</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
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<tr>
<td>58</td>
<td>59</td>
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<tr>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>
IDENTIFICATION

Material number  Reference number  AISI
1.2381  (713MnV5-2)  52

CHEMICAL COMPOSITION  Typical analysis in %
C  Si  Mn  Mo  V
0.25  1.20  0.50  0.35  0.20

STEEL PROPERTIES

High tensile special steel with good resistance to twisting.

APPLICATIONS

Screwdrivers, bits, low-stressed tools for the cutting, punching and folding of sheet.

HEAT TREATMENT

Soft annealing °C  Cooling  Hardness HB
700 – 750  Furnace  max. 350

Stress-relief annealing °C  Cooling
650 – 680  Furnace

Hardening °C  Quenching  Hardness after quenching HRC
840 – 860  Oil  64

Tempering °C  HRC
100  200  300  400  500  600
64  60  56  52  48  45

APPLICATONS

CS  Mn  Mo  V
0.73  1.20  0.50  0.55  0.20

CS  Mn  Cr  W
2.10  0.35  12.00  0.70

PHYSICAL PROPERTIES

Coefficient of thermal expansion 10^-6 m/(m • K)
20 – 100 °C  10.9
20 – 200 °C  11.9
20 – 300 °C  12.3
20 – 400 °C  12.6
20 – 500 °C  12.9
20 – 600 °C  13.0
20 – 700 °C  13.2

Thermal conductivity W/(m • K)
20 °C  16.7
350 °C  20.5
700 °C  24.2

APPLICATIONS

Heavy-duty blanking dies for cutting transformer and dynamo sheets up to 2 mm thickness as well as for paper and plastics, deep-drawing tools, drawing dies and mandrels, shears, blades, stone pressing tools.

HEAT TREATMENT

Soft annealing °C  Cooling  Hardness HB
800 – 840  Furnace  max. 250

Stress-relief annealing °C  Cooling
650 – 700  Furnace

Hardening °C  Quenching  Hardness after quenching HRC
950 – 980  Air, oil or saltbath (500 – 550 °C)  64

Tempering °C  HRC
100  200  300  400  500  600
63  62  60  58  56  48

Reference numbers in brackets are not standardized in EN ISO 4957.
Identification

Material number Reference number AISI
1.2510 (100MnCrV4) 02

Chemical composition Typical analysis in %
C Si Mn Cr V W
0.95 0.20 1.10 0.60 0.10 0.60

Steel properties

Good cutting edge retention, high hardenability and dimensional stability during heat treatment.

Physical properties

Thermal conductivity W/(m·K)
20 °C 350 °C 700 °C
33.5 32.0 30.9

Applications

Blanking and stamping dies for cutting sheets up to 6 mm thickness, threading tools, drills, broaches, gauges, measuring tools, plastic moulds, shear blades, guide rails.

Heat treatment

Soft annealing °C Cooling Hardness HB
740 – 770 Furnace max. 230
Stress-relief annealing °C Cooling
approx. 650 Furnace

Hardening °C Quenching Hardness after quenching HRC
780 – 820 Oil or saltbath (880 – 920 °C) 64
Tempering °C HRC
100 200 300 400
64 62 57 51

Applications

Thread cutting tools, twist drills, dentist’s drills and metal saws.

Heat treatment

Soft annealing °C Cooling Hardness HB
700 – 720 Furnace max. 230
Stress-relief annealing °C Cooling
650 – 680 Furnace

Hardening °C Quenching Hardness after quenching HRC
780 – 820 Oil or water 66
Tempering °C HRC
100 200 300 400
65 62 57 51

Steel properties

Water-hardening steel featuring good cutting edge retention and high hardenability.

Applications

Blanking and stamping dies for cutting sheets up to 6 mm thickness, threading tools, drills, broaches, gauges, measuring tools, plastic moulds, shear blades, guide rails.

Heat treatment

Soft annealing °C Cooling Hardness HB
740 – 770 Furnace max. 230
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Stress-relief annealing °C Cooling
650 – 680 Furnace

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780 – 820 Oil or water 66
Tempering °C HRC
100 200 300 400
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Heat treatment

Soft annealing °C Cooling Hardness HB
700 – 720 Furnace max. 230
Stress-relief annealing °C Cooling
650 – 680 Furnace

Hardening °C Quenching Hardness after quenching HRC
780 – 820 Oil or water 66
Tempering °C HRC
100 200 300 400
65 62 57 51

Steel properties

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Soft annealing °C Cooling Hardness HB
740 – 770 Furnace max. 230
Stress-relief annealing °C Cooling
approx. 650 Furnace

Hardening °C Quenching Hardness after quenching HRC
780 – 820 Oil or saltbath (880 – 920 °C) 64
Tempering °C HRC
100 200 300 400
64 62 57 51

Applications

Thread cutting tools, twist drills, dentist’s drills and metal saws.
Impact-resistant oil-hardenable steel, characterized by very good toughness in combination with high hardenability.

Applications
Blanking dies for cutting sheets up to 12 mm thickness, trimming and splitting dies, cold piercing punches, preforming punches, shear blades, chipping knives, pneumatic chisels, coining tools, cold shear blades, ejectors.

Heat treatment
Soft annealing °C
710 – 710
Cooling
Furnace
Hardness HB
max. 225

Stress-relief annealing °C
approx. 650
Cooling
Furnace

Hardening °C
870 – 900
Quenching
Oil or saltbath (880 – 220 °C)

Tempering °C
100 200 300 400 500 600
HRC
60 58 56 52 48 43

Steel properties
Precipitation-hardenable grade with high yield point and tensile strength combined with good toughness.

Applications
Casings for cold extrusion tools, cutting and punching tools.

Heat treatment
Solution annealing °C
820 – 850
Cooling
Water
Hardness HB
max. 340

Precipitation temperature °C
490 / 6 h / Air
Attainable hardness HRC
approx. 55

Physical properties
Thermal conductivity W/(m • K)
20 °C
14.2
350 °C
18.5
700 °C
22.5

Chemical composition
Typical analysis in %
C 0.60
Cr 1.10
V 0.20
W 2.00

Steel properties
Precipitation-hardenable grade with high yield point and tensile strength combined with good toughness.

Physical properties
Coefficient of thermal expansion 10⁻⁶ m/(m • K)
20 – 100 °C
10.3
20 – 200 °C
11.0
20 – 300 °C
11.2
20 – 400 °C
11.5
20 – 500 °C
11.8
20 – 600 °C
11.6

Chemical composition
Typical analysis in %
C 0.02
Cr 1.10
Ni 18.00
Mo 10.00
Co 1.00

Steel properties
Precipitation-hardenable grade with high yield point and tensile strength combined with good toughness.

Applications
Casings for cold extrusion tools, cutting and punching tools.

Heat treatment
Solution annealing °C
820 – 850
Cooling
Water
Hardness HB
max. 340

Precipitation temperature °C
490 / 6 h / Air
Attainable hardness HRC
approx. 55

Physical properties
Coefficient of thermal expansion 10⁻⁶ m/(m • K)
20 – 100 °C
11.8
20 – 200 °C
12.7
20 – 300 °C
13.1
20 – 400 °C
13.5
20 – 500 °C
14.0
20 – 600 °C
14.3
20 – 700 °C
14.5
THYROTHERM®

Heat treatment

Steel properties
Tough die steel with high tempering resistance and good through-hardening properties. This grade is usually supplied in annealed condition or quenched and tempered to a working hardness of 370 to 410 HRC (round) or 355 to 400 HRC (square, flat).

Physical properties
Coefficient of thermal expansion 10^-6 m/(m·K)

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>20</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.2</td>
<td>13.0</td>
<td>13.3</td>
<td>13.7</td>
<td>14.2</td>
<td>14.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thermal conductivity W/(m·K)

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>20</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
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<tbody>
<tr>
<td></td>
<td>560</td>
<td>610</td>
<td>650</td>
<td>700</td>
<td>750</td>
<td>800</td>
<td>850</td>
<td>900</td>
</tr>
</tbody>
</table>

Chemical composition
Typical analysis in %

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.16</td>
<td>1.1</td>
<td>0.5</td>
<td>1.7</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Applications
Standard steel for forging dies of all types, press dies, extrusion dies, retainer plates, armoured trim dies, hot-shear blades and tool holders.

Heat treatment

Soft annealing °C Cooling Hardness HB
650 – 700 Furnace max. 250

Hardening °C Quenching Hardness after quenching HRC
830 – 870 Oil 58
860 – 900 Air 56

Tempering °C after quenching in oil – HRC
100 200 300 400 500 600 650
38 50 60 70 80 90 100

Tempering °C after quenching in air – HRC
55 52 50 47 45 43 40 36 32

Time-temperature-transformation diagram

Tempering diagram

Reference numbers in brackets are not standardized in EN ISO 4957.
Air or oil-hardenable steel featuring high toughness.

Applications
Special steel for cold-shears, particularly for cutting scrap. Drawing jaws, coining and bending tools.

Material number Reference number AISI
1.2746 (45NiCrMoV16-6)

Chemical composition Typical analysis in %
C   Si   Mn   Cr   Mo   Ni   V
0.45 0.25 0.70 1.50 0.80 4.00 0.50

Stress-relief annealing °C Cooling Hardness HB
approx. 600 Furnace 235

Coefficient of thermal expansion $10^{-6}$ / (m · K) in 20 – 200 °C
12.2

Heat treatment
Soft annealing °C Cooling Hardness HB
690 – 700 Furnace approx. 235

Steel properties
Nickel-alloyed cold-work steel with a good combination of wear resistance and toughness.

Physical properties
Coefficient of thermal expansion $10^{-6}$ / (m · K) in 20 – 400 °C
12.5

Tempering °C
100 200 300 400 500 550
HRC 56 54 52 50 49 48

Tempering diagram

Steel properties
Nickel-alloyed cold-work steel with a good combination of wear resistance and toughness.

Applications
Scrap-shear blades, dies and coining tools, piercing punches.

Identification
Material number Reference number AISI
1.2743 (60NiCrMoV12-4)

Chemical composition Typical analysis in %
C   Si   Mn   Cr   Mo   Ni   V
0.18 0.40 0.65 1.15 0.35 2.85 0.10

Applications
Nickel-alloyed cold-work steel with a good combination of wear resistance and toughness.

Heat treatment
Soft annealing °C Cooling Hardness HB
690 – 700 Furnace approx. 235

Steel properties
Nickel-alloyed cold-work steel with a good combination of wear resistance and toughness.

Applications
Scrap-shear blades, dies and coining tools, piercing punches.

Identification
Material number Reference number AISI
1.2743 (60NiCrMoV12-4)

Chemical composition Typical analysis in %
C   Si   Mn   Cr   Mo   Ni   V
0.18 0.40 0.65 1.15 0.35 2.85 0.10

Applications
Nickel-alloyed cold-work steel with a good combination of wear resistance and toughness.

Heat treatment
Soft annealing °C Cooling Hardness HB
690 – 700 Furnace approx. 235

Steel properties
Nickel-alloyed cold-work steel with a good combination of wear resistance and toughness.

Applications
Scrap-shear blades, dies and coining tools, piercing punches.
### THYROPLAST®

**Chemical composition**

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2764</td>
<td>(1X9NiCrMo4)</td>
<td>-P21</td>
</tr>
</tbody>
</table>

**Steel properties**

Case-hardening steel, high core strength, good polishability.

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Hardness in HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>620 – 660</td>
<td>62 - 60</td>
</tr>
</tbody>
</table>

**Applications**

Highly stressed plastic moulds, tool holders for cutter picks.

### THYRODUR®

**Chemical composition**

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2766</td>
<td>(15NiCrMo6)</td>
<td></td>
</tr>
</tbody>
</table>

**Steel properties**

Dimensionally stable air-hardening steel featuring maximum toughness, polishable.

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Hardness after quenching in HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>820 – 840</td>
<td>58</td>
</tr>
</tbody>
</table>

**Applications**

Moulds, dies with deep engravings, plastic moulds und hydraulic chisels.
Identification

Material number | Reference number  | AISI
---|---|---
1.2767            | 45NiCrMo16            | 6F3

Chemical composition

Typical analysis in %

C    Si    Mn    Cr    Mo    Ni
0.45  0.25  0.35  1.40  0.20  4.00

Steel properties

High hardenability and toughness, highly suitable for polishing, texturing and EDM machining.

We recommend the use of THYRODUR® 2767 (ESR) for extreme demands.

Physical properties

Temperature (°C) | Coefficient of thermal expansion 10^-6 m/(m · K) | Annealed | Quenched and tempered
---|---|---|---
20 – 100  | 11.7 | 12.0
20 – 200  | 12.6 | 12.5
20 – 300  | 13.1 | 13.0

Thermal conductivity W/(m · K)

Annealed | Quenched and tempered
---|---
27.7 | 28.7
28.9 | 29.7
29.7 | 30.5
30.5 | 31.0

Applications

Cutlery dies, cutting tools for thick material, billet-shear blades, drawing jaws, massive embossing and bending tools, plastic moulds, reinforcements.

Heat treatment

Soft annealing °C | Cooling | Hardness HB
---|---|---
630 – 650 | Furnace | max. 260

Stress-relief annealing °C | Cooling | approx. 650 | Furnace
---|---|---|---
840 – 870 | Air, oil or saltbath (180 – 220 °C) | 56

Tempering °C | HRC
---|---
100 | 56
200 | 54
300 | 50
400 | 46
500 | 42
600 | 38

Time-temperature-transformation diagram

Identification

Material number | Reference number  | AISI
---|---|---
1.2826            | (60Mn5Cr4)            | 54

Chemical composition

Typical analysis in %

C    Si    Mn    Cr
0.63  0.80  1.10  0.30

Steel properties

High toughness and good resilience in tempered condition.

Physical properties

Temperature (°C) | Thermal conductivity W/(m · K) | Approx. 650 | Furnace
---|---|---|---
20 – 100  | 26.2 | 20 – 100  | 28.3
20 – 200  | 32.6 | 20 – 200  | 34.2
20 – 300  | 36.5 | 20 – 300  | 39.6
20 – 400  | 40.3 | 20 – 400  | 44.7
20 – 500  | 44.7 | 20 – 500  | 47.6
20 – 600  | 47.6 | 20 – 600  | 49.5

Applications

Spring collets, shear blades and trimming dies.

Heat treatment

Soft annealing °C | Cooling | Hardness HB | Furnace | max. 220
---|---|---|---|---
880 – 910 | Oil or saltbath (180 – 220 °C) | 61

Stress-relief annealing °C | Cooling | approx. 650 | Furnace
---|---|---|---
820 – 860 | Oil or saltbath (180 – 220 °C) | 61

Hardening °C | Quenching | Hardness after quenching HRC | Furnace
---|---|---|---
820 – 910 | Oil or saltbath (180 – 220 °C) | 61

Tempering °C | HRC
---|---
100 | 61
200 | 59
300 | 57
400 | 52
500 | 46
600 | 36

Time-temperature-transformation diagram

Reference numbers in brackets are not standardized in EN ISO 4172.
### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Steel properties

Wear-resistant water-hardening steel with high insusceptibility to overheating.

### Applications

Cold heading dies, first and finish upsetting punches, cold stamps and dies for the manufacturing of screws, rivets and bolts, compression pistons.

### Heat treatment

#### Soft annealing

- **Temperature**: 730 – 760 °C
- **Cooling**: Furnace
- **Furnace max.**: 200

#### Stress-relief annealing

- **Temperature**: 650 – 680 °C
- **Cooling**: Furnace

#### Hardening

- **Temperature**: 780 – 820 °C
- **Quenching**: Water
- **Hardness after quenching HRC**: 65 – 62 – 57 – 50

### Applications

Tool steel for universal use, cutting and stamping tools for sheet up to 6 mm thickness, thread-cutting tools, reamers, gauges, measuring tools, plastic moulds, shear blades, guide strips and ejector pins.

### Heat treatment

#### Soft annealing

- **Temperature**: 680 – 720°C
- **Cooling**: Furnace
- **Furnace max.**: 220

#### Stress-relief annealing

- **Temperature**: approx. 650°C
- **Cooling**: Furnace

#### Hardening

- **Temperature**: 790 – 820°C
- **Quenching**: Oil or saltbath (180 – 220°C)
- **Hardness after quenching HRC**: 64

### Applications

Tool steel for universal use, cutting and stamping tools for sheet up to 6 mm thickness, thread-cutting tools, reamers, gauges, measuring tools, plastic moulds, shear blades, guide strips and ejector pins.

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90</td>
<td>0.20</td>
<td>2.00</td>
<td>0.40</td>
<td>0.10</td>
</tr>
</tbody>
</table>

### Steel properties

Good cutting edge retention, dimensionally stable during heat treatment.

### Applications

Tool steel for universal use, cutting and stamping tools for sheet up to 6 mm thickness, thread-cutting tools, reamers, gauges, measuring tools, plastic moulds, shear blades, guide strips and ejector pins.
Newly developed ledeburitic cold-work steel with high hardness, good toughness and high tempering resistance combined with high wear resistance.

Cutting and punching tools including precision cutting tools, threading dies and rolls, rotary shear blades, cold pilger mandrels, pressure pads and plastic moulds, cold-forming and deep-drawing dies, woodworking tools and cold rolls.

<table>
<thead>
<tr>
<th>Heat treatment</th>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>830 – 860</td>
<td>Furnace</td>
<td>max. 250</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress-relief annealing °C</th>
<th>Cooling</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>approx. 650</td>
<td>Furnace</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Hardness after quenching HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1030 – 1080°</td>
<td>Air, oil or saltbath (500 – 550 °C)</td>
<td>62 – 64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tempering °C</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>62</td>
</tr>
<tr>
<td>200</td>
<td>59</td>
</tr>
<tr>
<td>300</td>
<td>60</td>
</tr>
<tr>
<td>400</td>
<td>58</td>
</tr>
<tr>
<td>500</td>
<td>60</td>
</tr>
<tr>
<td>525</td>
<td>59</td>
</tr>
<tr>
<td>550</td>
<td>55</td>
</tr>
<tr>
<td>575</td>
<td>54</td>
</tr>
<tr>
<td>600</td>
<td>44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time-temperature-transformation diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference numbers in brackets are not standardized in EN ISO 4957.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting and punching tools including precision cutting tools, threading dies and rolls, rotary shear blades, cold pilger mandrels, pressure pads and plastic moulds, cold-forming and deep-drawing dies, woodworking tools and cold rolls.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical composition</th>
<th>Typical analysis in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.0</td>
</tr>
<tr>
<td>Si</td>
<td>0.9</td>
</tr>
<tr>
<td>Cr</td>
<td>8.0</td>
</tr>
<tr>
<td>Mo</td>
<td>1.6</td>
</tr>
<tr>
<td>V</td>
<td>1.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steel properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>New high-speed steel featuring an extremely good cutting edge retention and wear resistance due to its high vanadium content. A high cobalt content contributes to a high red hardness and tempering resistance.</td>
</tr>
</tbody>
</table>

| Machining of hard materials which wear cutting edges such as highly quenched and tempered chromium-nickel grades and non-ferrous metals, mother-of-pearl, paper, hard rubber, synthetic resins, marble, slate and the like. Ideally suited for turning and finishing tools, forming tools of all kinds, heavy-duty milling cutters and automatic lathes. |

<table>
<thead>
<tr>
<th>Heat treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft annealing °C</td>
</tr>
<tr>
<td>820 – 860</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress-relief annealing °C</th>
<th>Cooling</th>
<th>Hardness after tempering HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>830 – 650</td>
<td>Furnace</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1st pre-heating °C</th>
<th>2nd and 3rd pre-heating °C</th>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Tempering °C</th>
<th>Hardness after tempering HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>630 – 650</td>
<td>a) 850</td>
<td>1190 – 1240</td>
<td>a) Saltbath (550 °C)</td>
<td>at least three times 540 – 580</td>
<td>64 – 67</td>
</tr>
<tr>
<td></td>
<td>b) 850 and 1050</td>
<td></td>
<td>b) Oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Air</td>
<td></td>
<td>c) Air</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time-temperature-transformation diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference numbers in brackets are not standardized in EN ISO 4957.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tempering diagram/Hardening from 1080 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference numbers in brackets are not standardized in EN ISO 4957.</td>
</tr>
</tbody>
</table>
### Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3207</td>
<td>HS10-4-3-10</td>
<td>T42</td>
</tr>
</tbody>
</table>

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.23</td>
<td>4.1</td>
<td>3.5</td>
<td>3.3</td>
<td>9.5</td>
<td>10.0</td>
</tr>
</tbody>
</table>

### Steel properties

High-speed steel of superlative performance combining optimal cutting-edge retention, high-temperature strength and toughness on account of its composition.

### Applications

Universally applicable for roughing and finishing where maximum tool life is required and for automatic lathes where wear is caused by large batch production. Also for all kinds of cutting tools and milling cutters exposed to exceedingly high stresses.

### Heat treatment

#### Soft annealing

<table>
<thead>
<tr>
<th>°C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>820 – 860</td>
<td>Furnace</td>
<td>max. 102</td>
</tr>
</tbody>
</table>

#### Stress-relief annealing

<table>
<thead>
<tr>
<th>°C</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>630 – 650</td>
<td>Furnace</td>
</tr>
</tbody>
</table>

#### 1st pre-heating

<table>
<thead>
<tr>
<th>°C</th>
<th>2nd and 3rd pre-heating °C</th>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Tempering °C</th>
<th>Hardness after tempering HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to approx. 400 in an air-circulating furnace</td>
<td>a) 810</td>
<td>1190 – 1210</td>
<td>a) Saltbath (150 °C) b) Oil c) Air</td>
<td>at least three times 540 – 570</td>
<td>85 – 87</td>
</tr>
</tbody>
</table>

1. For cold-forming tools of a complex geometry, a hardening temperature at the lower end of the quoted range is recommended.

The stated hardening temperatures apply to saltbath hardening only. For vacuum hardening, we suggest a reduction of 10 to 20 °C.

### Identification

<table>
<thead>
<tr>
<th>Material number</th>
<th>Reference number</th>
<th>AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3243</td>
<td>HS6-5-2-5</td>
<td>M35</td>
</tr>
</tbody>
</table>

### Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.92</td>
<td>4.1</td>
<td>5.0</td>
<td>1.9</td>
<td>6.4</td>
<td>4.8</td>
</tr>
</tbody>
</table>

(Under the name THYRAPID® 3245, AISI M 35 + S and material number 1.3245, this steel grade is supplied with a higher sulphur content (S = 0.10 %).

### Steel properties

The cobalt content in this high-performance high-speed steel results in high red hardness and tempering resistance. As a consequence, this grade is particularly suitable for conditions involving thermal stresses and discontinuous cutting.

### Applications

Heavy-duty milling cutters of all kinds, highly stressed twist drills and taps, profile knives, machining of high-strength materials, broaches.

### Heat treatment

#### Soft annealing

<table>
<thead>
<tr>
<th>°C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>820 – 860</td>
<td>Furnace</td>
<td>max. 269</td>
</tr>
</tbody>
</table>

#### Stress-relief annealing

<table>
<thead>
<tr>
<th>°C</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>630 – 650</td>
<td>Furnace</td>
</tr>
</tbody>
</table>

#### 1st pre-heating

<table>
<thead>
<tr>
<th>°C</th>
<th>2nd and 3rd pre-heating °C</th>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Tempering °C</th>
<th>Hardness after tempering HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to approx. 400 in an air-circulating furnace</td>
<td>a) 850</td>
<td>1190 – 1230</td>
<td>a) Saltbath (150 °C) b) Oil c) Air</td>
<td>at least three times 540 – 570</td>
<td>64 – 67</td>
</tr>
</tbody>
</table>

1. For cold-forming tools of a complex geometry, a hardening temperature at the lower end of the quoted range is recommended.

The stated hardening temperatures apply to saltbath hardening only. For vacuum hardening, we suggest a reduction of 10 to 20 °C.
Steel properties

High-carbon, high-speed steel based on molybdenum. Characterized by high wear resistance, red hardness and toughness. As a result of its low vanadium content, this grade exhibits good grindability.

Applications

For tools subject to severe mechanical wear (e.g. in case of small cross-section cuts at high cutting speeds). Particularly suitable for die-sinking cutters, milling cutters and engraving machines including gravers as well as for tool bits in automatic lathes. Also suitable for non-cutting shaping (e.g. cold extrusion rams and tools employed in machining materials for the aviation industry such as titanium alloys).

Heat treatment

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>820 – 860</td>
<td>Furnace</td>
<td>max. 277</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress-relief annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>630 – 650</td>
<td>Furnace</td>
<td>max. 277</td>
</tr>
</tbody>
</table>

Chemical composition

Typical analysis in %

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>W</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.08</td>
<td>4.1</td>
<td>9.5</td>
<td>1.2</td>
<td>1.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Applications

For cold-forming tools of a complex geometry, a hardening temperature at the lower end of the quoted range is recommended. The stated hardening temperatures apply to saltbath hardening only. For vacuum hardening, we suggest a reduction of 10 to 30 °C.

Heat treatment

<table>
<thead>
<tr>
<th>Soft annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>780 – 840</td>
<td>Furnace</td>
<td>max. 265</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress-relief annealing °C</th>
<th>Cooling</th>
<th>Hardness HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>650 – 660</td>
<td>Furnace</td>
<td>max. 265</td>
</tr>
</tbody>
</table>

1st pre-heating °C

<table>
<thead>
<tr>
<th>2nd and 3rd pre-heating °C</th>
<th>Hardening °C</th>
<th>Quenching</th>
<th>Tempering °C</th>
<th>Hardness after tempering HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) 850</td>
<td>b) 850 and 1050</td>
<td>at least three times</td>
<td>550 – 560</td>
</tr>
</tbody>
</table>

Tempering °C

<table>
<thead>
<tr>
<th>HRC</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>525</th>
<th>550</th>
<th>575</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>68</td>
<td>70</td>
<td>72</td>
<td>74</td>
<td>76</td>
<td>78</td>
</tr>
<tr>
<td>b)</td>
<td>61</td>
<td>63</td>
<td>65</td>
<td>67</td>
<td>69</td>
<td>71</td>
<td>73</td>
<td>75</td>
<td>77</td>
</tr>
<tr>
<td>c)</td>
<td>60</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>68</td>
<td>70</td>
<td>72</td>
<td>74</td>
<td>76</td>
</tr>
</tbody>
</table>

1 For cold forming tools of a complex geometry, a hardened temperature at the lower end of the quoted range is recommended. For vacuum hardening, we suggest a reduction of 10 to 30 °C.
This steel is also available with an elevated S content (S = 0.12 %) under the name Thyrapid® 3341, code 5 6 5 2 3 and material number 1.3341.

Steel properties

Standard high-speed steel grade. Its well-balanced alloy composition forms the basis of its high toughness and good cutting edge retention, rendering it suitable for a large variety of applications.

Physical properties

Steel properties

Chemical composition

Typical analysis in %

C Si Mn Cr Mo V W
0.90 0.30 0.30 4.10 5.00 1.90 6.40

Steel properties

Applications

For all metal-cutting tools for roughing or finishing such as twist drills, diverse milling cutters, thread dies, broaches, reamers, countersinks, thread chasers, circular saw segments, shaping tools and woodworking tools. Also highly suitable for cold-forming tools such as cold extrusion rams and dies, as well as cutting and precision cutting tools, plastic moulds with elevated wear resistance and screws.

Heat treatment

Soft annealing °C Cooling Hardness HB
770 – 860 Furnace max. 269
Stress-relief annealing °C Cooling
610 – 650 Furnace

1st pre-heating °C 2nd and 3rd pre-heating °C Hardening °C Quenching Tempering °C Hardness after tempering HRC
up to approx. 400 a) 850 b) 850 and 1050 1190 – 1230 a) Saltbath (510 °C) b) Oil c) Air at least twice 550 – 560 64 – 66

1 For cold-forming tools of a complex geometry, a hardening temperature at the lower end of the quoted range is recommended. The stated hardening temperatures apply to saltbath hardening only. For vacuum hardening, we suggest a reduction of 10 to 20 °C.

Isothermal time-temperature-transformation diagram

Tempering diagram

Identification

Material number Reference number AISI
1.3343 HSi6-5-2C M2

Chemical composition

Typical analysis in %

C Si Mn Cr Mo V W
0.12 0.12 0.30 4.10 5.00 1.90 6.40

Steel properties

Very similar composition to THYRAPID® 3343, but with substantially higher V and C content, resulting in combined maximum wear resistance and cutting edge retention with good toughness.

Applications

Taps, reamers, heavy-duty milling cutters, dies, rotary gear shaping and shaving cutters for the processing of hard materials, hexagon socket punches and piercing dies for the nut production.

Heat treatment

Soft annealing °C Cooling Hardness HB
820 – 860 Furnace max. 269
Stress-relief annealing °C Cooling
630 – 650 Furnace

1st pre-heating °C 2nd and 3rd pre-heating °C Hardening °C Quenching Tempering °C Hardness after tempering HRC
up to approx. 400 a) 850 b) 850 and 1050 1190 – 1230 a) Saltbath (510 °C) b) Oil c) Air at least three times 540 – 570 64 – 66

1 For cold-forming tools of a complex geometry, a hardening temperature at the lower end of the quoted range is recommended. The stated hardening temperatures apply to saltbath hardening only. For vacuum hardening, we suggest a reduction of 10 to 20 °C.
It has long been known that sharp edges and large changes of cross-section should be avoided when designing tools, as peak stresses that can be several times higher than the creep limit develop at these points. Nevertheless, this old design rule is still broken surprisingly often today. The following factors can promote cracking and fracturing:
- incorrect dimensioning
- abrupt changes of cross-section
- • sharp notches (e.g. turning or grinding scores, scriber marks, punched numbers, etc.).

The notch sensitivity increases with the strength of the tools; the higher the hardness selected, the more care must be taken when machining the surfaces and the cross-section transitions. Consequently, the largest possible radii should be provided and these should also be polished if at all possible.

**Machining**

The tool-making methods and the associated influence on the material can impair the tool service life. In addition to cutting methods (milling, planing, drilling, turning, grinding), electrical discharge machining has gained increasing attention in toolmaking in recent years.

As high costs are generally incurred at a very early stage in the course of tool production (design, material, machining, etc.), errors usually entail major financial losses. Either tools of this kind are never put to use at all (production delays, contractual penalties), or the service life is seriously impaired as a result (repairs).

**Errors in operational use**
- • operating errors
- • temperature control, cooling
- • maintenance errors

**Errors during necessary repairs**
- • incorrect welding

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Notes on processing

Stress relief annealing

Stress relief annealing before hardening proves to be favourable, as this reduces any internal stresses that may have arisen during the preceding machining process. In the course of subsequent heat treatment, internal stresses can lead to distortion and, under certain circumstances, to expensive reworking.

Particularly with tools of complex shape, stress relief annealing at a temperature of 600 to 650 °C should be carried out after pre-machining. The holding time at this temperature should be a minimum of two hours, or at least one hour per 50 mm wall thickness in the case of fairly large tools. This must be followed by slow cooling in the furnace.

Heating

When heating to forming or hardening temperature, the surface and core zones reach the specified treatment temperature at different speeds. The larger the tool and the higher the heating rate, the greater the temperature difference becomes. This difference in temperature leads to tensile stresses in the core, meaning that there is a risk of cracking owing to the decrease in tensile strength that accompanies the temperature increase. Large tools of complicated shape and made of fairly high-alloy steel grades are particularly at risk due to their lower thermal conductivity.

Cracking of this kind can largely be avoided by pre-heating in several stages. The holding time at the respective temperature is 30 seconds per 50 mm wall thickness at both the first and second stage. In the case of high-alloy tool steels with a hardening temperature in excess of 900 °C, the third pre-heating stage at roughly 850 °C serves not only the above-mentioned purposes, but also to dissolve some of the carbides.

Austenitizing

Depending on the material used, every heat treatment operation requires a certain temperature and holding time during austenitization, so that the required transformations can take place. Typical errors arise if the selected hardening temperature is too high or the holding time too long. The results can be grain growth and the associated loss of toughness, as well as partial melting. Hardening temperatures that are too low and holding times that are too short result in only partial austenitization.

Stresses caused by different constituents in the microstructure can occur in this context, as can problems with setting the required hardness. The diagram provides standard values for the holding time at hardening temperature once the hardening temperature has been reached on the surface of the tool. The immersion times in the salt bath can also be determined with the help of the diagram.

Hardening behaviour

The time-temperature transformation diagrams for continuous cooling are shown in the material data sheets in order to facilitate understanding of the transformation processes taking place during hardening.

By following the various cooling curves, which begin at hardening temperature and run to room temperature, it can be seen from these diagrams which microstructure constituents (in %) are formed at a given cooling rate.

The respective cooling rate is stated on the cooling curves, either in °C/min. or, in the case of very rapid cooling, as a parameter (cooling parameter = Time to cool from 800 °C to 500 °C in s divided by 100). In order to avoid tool failures due to incorrect heat treatment whenever possible, precise heat treatment instructions are given for the individual steel grades in the material data sheets. In this context, reference must be made to the following fundamental circumstance, which applies to the heat treatment of all tool steels: given the correct heat treatment, there is no way of substantially changing the temperatures. The overall procedure must be adhered to without fail.

The hardness achieved by the individual steel grades depends not only on the carbon content, but also very much on the cross-section. The hardness values after quenching/annealing stated in the material data sheets refer to a 30 mm square cross section.
Cooling stress crack due to excessively rapid cooling

The depth of hardening for a tool of 120 mm dia. made of THYRODUR® 2379 is to be determined for a hardness of 64 HRC and oil hardening. In the top left diagram, the intersection of the vertical line for 120 mm dia. with the curve for THYRODUR® 2379 indicates a depth of hardening of 10 mm for oil hardening (to be read off the right-hand axis). The intersection of the THYRODUR® 2379 curve with the straight line at an angle of 45° yields the diameter to be through-hardened, which can be seen from the bottom axis: 100 mm dia.

The diagram above shows the depth of hardening as a function of the workpiece diameter for a minimum hardness of 64, 62, 60 and 58 HRC.

Quenching

The quenching of the tools is the most critical phase of the heat treatment process. On the one hand, quenching operations must reach the material-dependent critical cooling rates for hardening. On the other hand, however, they must proceed as slowly as possible, in order to minimize the risk of distortion and stress cracking (re-work).

As when heating, the risk is greatest when dealing with tools of complicated shape. This is particularly true if other faults are additionally present. Typical problems in this context are cracking following overheated hardening, as temperature and transformation stresses are then joined by stresses resulting from the different microstructural constituents. Cooling to room temperature is a particular disadvantage, owing to the risk of stress cracking.

The tools are expediently only cooled to approx. 80 °C before being soaked and then directly tempered. Soaking is important in order to obtain complete martensite transformation over the entire cross-section, as cracking during cooling after tempering is otherwise possible.

Step quenching is advisable in critical cases in order to avoid the risk of cracking. This extensively reduces temperature stresses and achieves almost simultaneous transformation of case and core.

Tempering

Tempering operations are necessary in order to set the correct combination of strength and toughness in tools. This both reduces the stresses in the hardening structure and eliminates the internal stresses resulting from quenching (temperature stresses). Insufficient tempering (time, temperature, frequency) can thus favour later failure. Particularly critical are steel grades which contain residual austenite after hardening that could be transformed under the effects of stress in use. In order to avoid mistakes, the information in the material data sheets concerning the correct tempering treatment for the material should be observed and no attempt made to save lost time here of all things. The holding time at tempering temperature is one hour per 20 mm wall thickness, but not less than two hours. The tools are subsequently cooled in air and their hardness is then tested.

Furnace atmospheres

In customary heat treatment operations (hardening and tempering), it is generally assumed that the furnace atmosphere is adjusted in such a way that no surface decarburization or carburation occurs. Nonetheless, practical experience shows that unintentional carburation or decarburization repeatedly occurs in the event of process malfunctions. In medium-alloy steels, surface decarburization results in a mixed microstructure. During hardening, this leads to internal stresses and frequently to cracking, owing to the different microstructure constituents. More highly alloyed steels often only display carbon depletion, resulting in impaired performance in use. In extreme cases, however, complete decarburization is also possible here. In regions close to the surface, unwanted carburation results in other microstructural states (incorrect heat treatment) and thus involves an additional risk of cracking. To avoid this, the material to be hardened should be packed for protection when using a batch furnace. In controlled-atmosphere systems, a C level must be set in the gas that corresponds to the C content of the batch to be treated. The same applies to salt baths. Only in vacuum systems do problems of this kind not occur.
Prior to nitriding, the tools are subjected to a hardness treatment, the hardness of which in tools is to afford protection against wear. The result is often spalling of the surface zone in use. Prior to nitriding, the tools must first be cleaned and degreased. Nitriding can be carried out in a salt bath, in gas or in plasma. Depending on the composition of the steel, the hardness of nitrided surfaces is up to 1000 HV. Another major mistake that can be made is that of combining tempering and nitriding in order to save time and money. This must be expected to result in dimensional changes and distortion, which is then virtually impossible to correct because of the hard surface that is subsequently present.

Repair welding

Owing to the nature of the alloys used, tool steels belong to those steel grades where welding involves a certain degree of risk. During the cooling of the weld, thermal and microstructural transformation stresses occur which can lead to cracking. However, design changes, natural wear or tool failures due to breakage or cracking often make repair by electric welding unavoidable. The following notes are intended to show how to proceed:

- clean the surfaces thoroughly, grind out the crack in U shape
- preheat thoroughly using a preheating temperature above the martensite transformation temperature (Ms line, see TTG diagram in material data sheet) to avoid microstructural transformations during welding
- high-alloy steels: heat to hardening temperature, cool to above martensite temperature
- weld (possibly with intermediate reheating)
- use electrodes corresponding to the parent material
- TIG welding offers the advantage of producing a finer microstructure, as the temperatures are lower and the cooling rate higher than when using fluxed electrodes
- in order to minimize distortion, larger areas to be built up should be welded in separate sections that are subsequently joined (the bead should be hammered in order to reduce contraction stresses)
- cooling of the tools to approx. 80 °C after the operation and welding to prevent cracking or reduce the service life

Notes on processing

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- cooling of the tools to approx. 80 °C after the operation and welding to prevent cracking or reduce the service life immediately afterwards.

Tool steel weight comparisons
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<th>Thickness in mm</th>
<th>2000 x 1000</th>
<th>2500 x 1250</th>
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## General note (liability)

All statements regarding the properties or utilization of the materials or products mentioned are for the purposes of description only. Guarantees regarding the existence of certain properties or a certain utilization are only ever valid if agreed upon in writing.
Cold-work tool steels and high-speed steels

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