Steel for plastic moulding

Deutsche Edelstahlwerke

Member of Swiss Steel Group

Plastics – an ever growing market

Although plastics have only been in existence for about 100 years, their contemporary uses reach into virtually every area of our lives.

Applications span from bulk commodities such as packaging and reusable bottles, to high-quality articles and accessories manufactured for the consumer goods, leisure, automotive and construction industries. High-tech applications have found their way into the aerospace industry too – life today has become unimaginable without plastics.

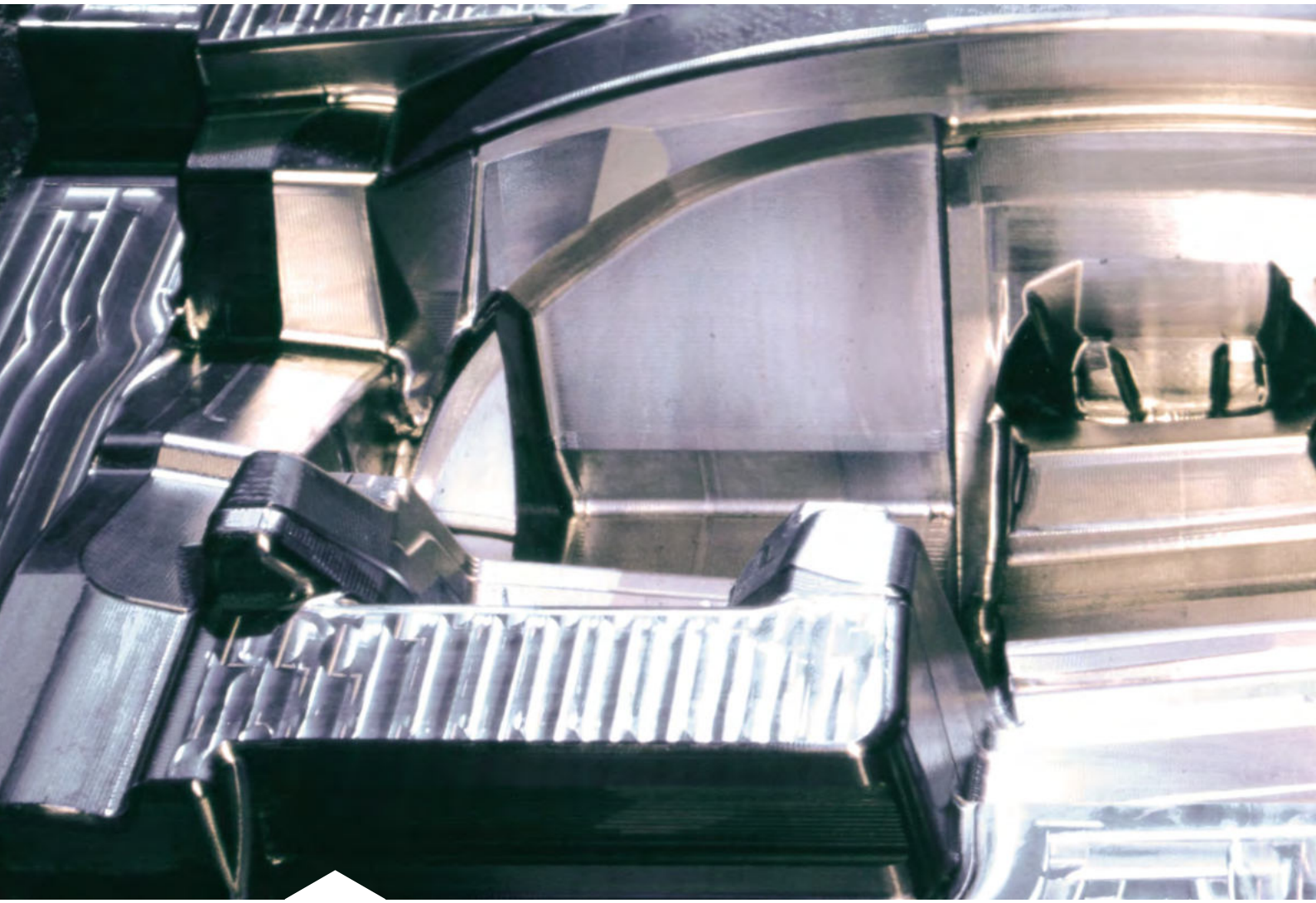
In 2003 global plastics production exceeded the 200 million-ton threshold. The steadily increasing use of plastics requires ever more efficient and reliable processing to trim production costs. This also applies to the optimization of tool steel.

When considering the entire plastic-manufacturing process chain, it becomes evident that mould design and engineering are of outstanding importance.

For this reason plastic mould steel is of key importance, as they serve as a basis for the ultimate quality of the ready-to-use plastic product.

Each plastic product has to fulfil completely individual requirements when it comes to quality, optical and tactile appearance, surface finish and strain limits. To ensure these demands are met, high-quality and special steel is essential for the construction of a mould.

The valency of a plastic surface – whether perfectly textured, photo-etched or immaculately mirror-finished – can only be as good as the finish of the mould the plastic product has been moulded with. The better a tool steel is matched to the demands of the plastic product, the better the final product quality.

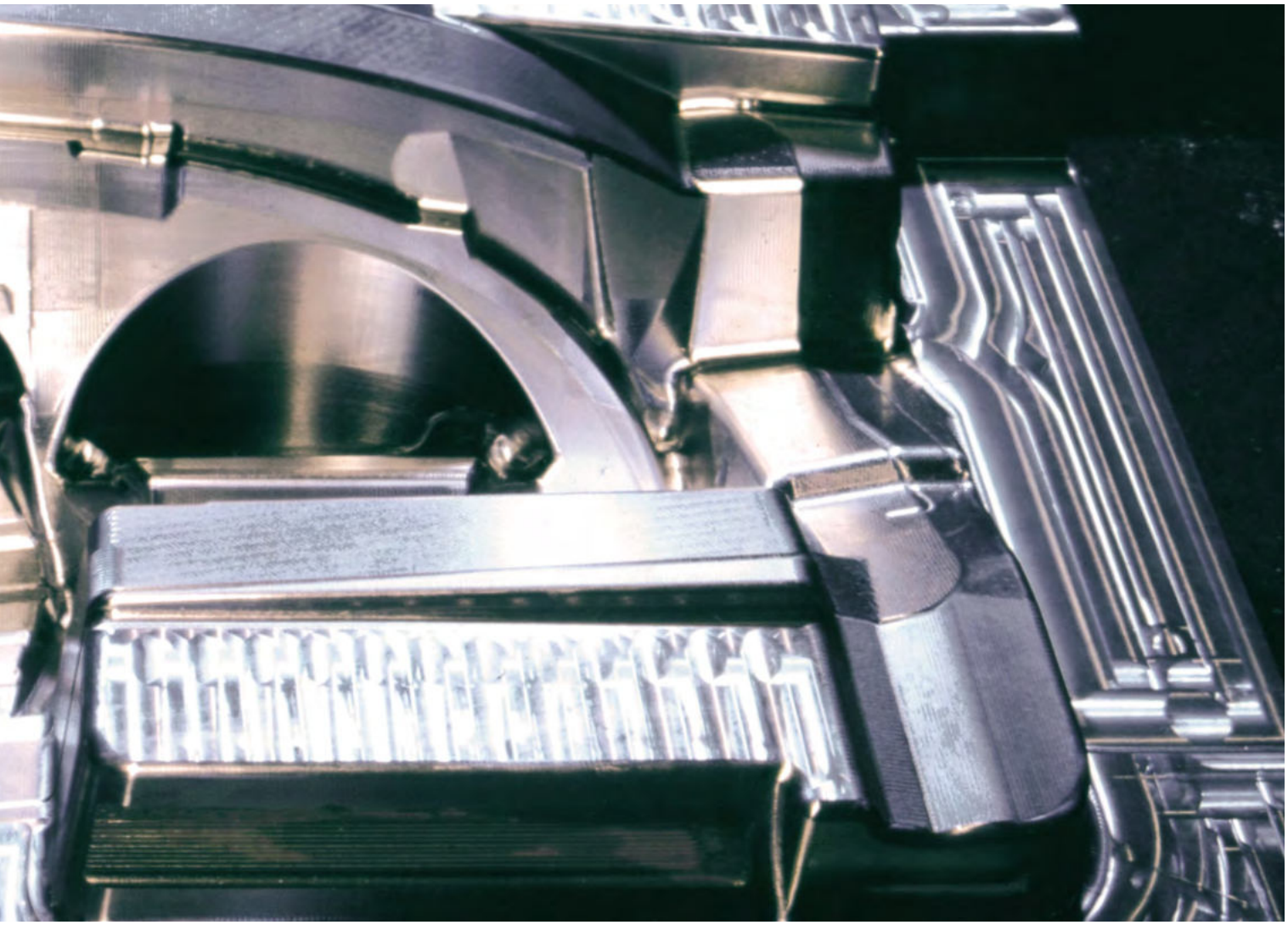


Deutsche Edelstahlwerke – the experts in steel for plastic moulding

The Deutsche Edelstahlwerke steel for plastic moulding is characterized by two factors. On the one hand the use of the highest steel quality and on the other hand the steel's properties which in each individual case can be ideally adjusted to the most diverse requirements of different dies or to those of the plastic product itself.

The use of the most modern technology for Deutsche Edelstahlwerke's plastic mould steel meet the most rigorous demands regarding:

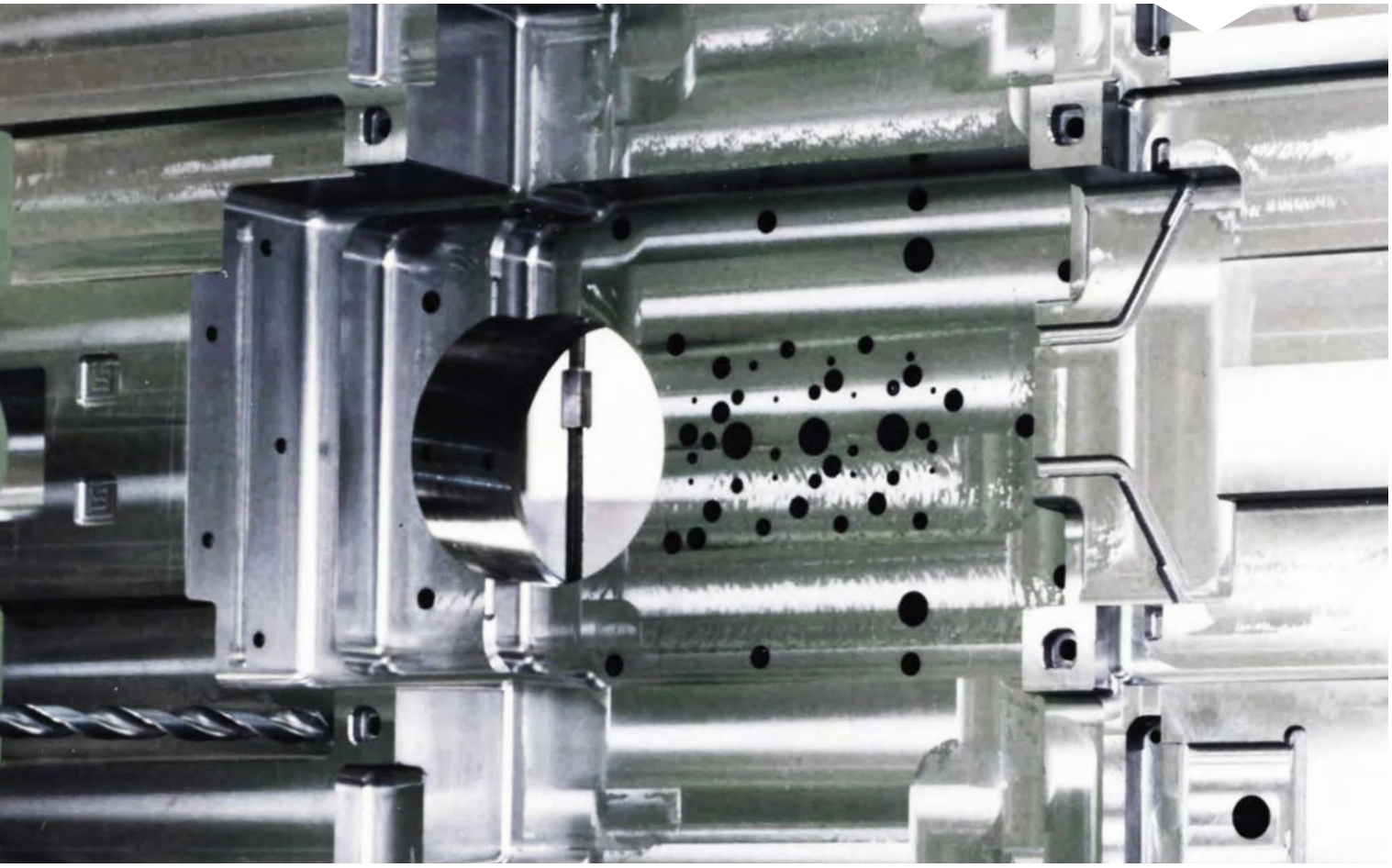
» purity
» polishability
» consistent hardness and microstructure
» wear resistance
» temperature resistance
» machinability
» toughness and degree of hardness
» thermal conductivity



So as to offer optimal conditions to mould manufacturers, the plastic-processing industry and other industrial users, Deutsche Edelstahlwerke extends their services into customer and application-specific consultation as well as advice on product development.

Deciding on the perfect tool steel at Deutsche Edelstahlwerke begins by consulting our plastic mould steel specialists. The demands on the final product are defined by the plasticmould strain and the demands on the required steel grade.

Deutsche Edelstahlwerke delivers individual sizes ex-warehouse. Our clients are given the chance to be integrated in decision making from the extent to which pre-machining should take place, via the manufacture of components right through to the perfectly fitting moulded article.
In addition to a broad spectrum of conventional steel, Deutsche Edelstahlwerke also supplies specialty materials such as Ferro-Titanit®.



Process reliabilty from consultation through to the final product

The moulds used for plastic processing are very diverse in their functionality and the demands made on them. The correct choice and treatment of the steel grade are decisively influential on the quality and resulting profitability of plastic production.

So as to ensure the client's demands are met, we rely on a highly experienced group of specialists in the steel-for-plastic-moulding area. Together with the mould manufacturers, they constitute a perfectly coordinated team to determine which steel grade and quality are most appropriate to the individual profile demands as characterized by the final plastic product.

To complement the know-how of our steel specialists, we are able to rely on the most modern production facilities backed up by decades of experience in every area dealing with heat treatment. Furthermore, our active and certified quality assurance system (DIN EN 14001, DIN EN ISO 9001, QS 9000, VDA 6.1 TS 16949 and KTA 1401) warrants the production of an individually defined steel grade with continuous quality consistence.

Precision for mould manufacturers

Our competence begins with advice on the choice of the most suitable steel and extends to the development of new specific tool-steel grades. Not only do you have the choice between the various forms delivered from our extensive stock and product range, but you also determine whether the mould is to be delivered in a pre-machined or ready-to-install state.

Deutsche Edelstahlwerke then reliably delivers the chosen steel grade fast and in any quantity desired – and always with consistent quality. This applies to all important markets worldwide via the distribution network of the Swiss Steel Group
.

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

Benefits for the mould manufacturers are:
» high degree of purity
» excellent polishability
» exceptional texturing properties
» consistent microstructure
» optimal machinability
» reproducible heat treatment
» very short delivery times
» competent advisors
» development of new steel grades

Profitability for the plastic-processing industry

Long exposure times and high-quality continuity for every plastic product are generelly expected from the mould in plastic processing.

In order to achieve this, the dies have to be exceptionally finely tuned to the specific properties of the plastic used and to the demands of the final plastic product.

Many years of experience, coupled with innovative material technology in production together with treatment of long products – made of quality steel – have placed us in a position to deliver tailor-made steel grades to satisfy mechanical, thermal and chemical demands of the plastic products.

Our technicians provide advice and support even when problems with the exposure time for the moulds occur. They are able to produce findings for rapid and long-term damage repair through assessment and material testing.

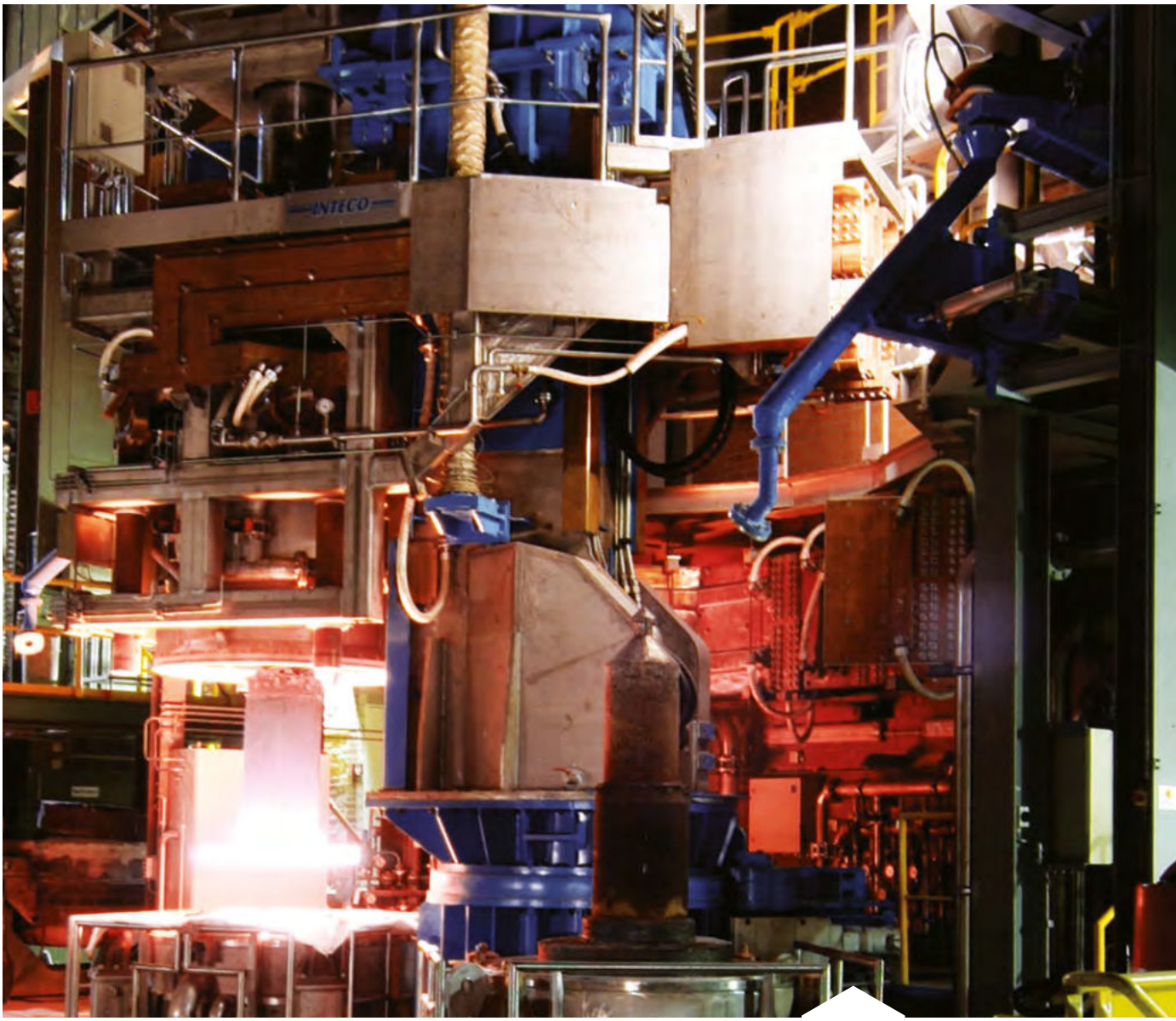
The ensuing benefits for the plastic mould manufacturer are:
» excellent thermal conductivity
» optimal wear resistance
» unique compression strength,
» hardness and toughness
» corrosion resistance
» low-maintenance costs
» minimum mould maintenance
» extraordinary dimensional stability
» good repair weldability

Dependability for the plastic user

Because the quality of the steel used for plastic moulding is crucial for the processing quality of the final plastic product, it is highly recommended to consult with Deutsche Edelstahlwerke's specialists at an early stage – optimally at the planning stage. Our know-how and technical advice mean production security right from the start. The advantage of fine tuning at preliminary stages results in minimization of production costs.

Deutsche Edelstahlwerke supplies the chosen steel grade or the pre-machined moulds to mould manufacturers throughout the world. They then produce the mould. Our global supply network of the Swiss Steel Group concurrently guarantees dependable delivery and highest quality on site.

The resulting benefits for the plastic user are:
» technical consultation
» shorter delivery times
» long-term know-how
» plastic surfaces reproducable at any time
» consistent quality



Our technology and experience – your guarantee for premium quality

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

The tool steel produced by Deutsche Edelstahlwerke is 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.

Custom remelting

For tool steel grades having to satisfy especially high levels of toughness, homogeneity and purity standards, Deutsche Edelstahlwerke has several electroslag remelting furnaces (ESRs) as well vacuum-arc remelting furnaces (VAR) at its diposal.

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.

Individually variable heat treatment

The integration of the previous Thyssen hardening shops into the Deutsche Edelstahlwerke 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 presmachining to refining through to heat treatment. Our one-stop solution is invaluable for the world's most important markets and facilitates fulfilment of the most discerning tool quality prerequisites.
In our hardening shops of the Swiss Steel Group across the continents, we have vacuum-tempering furnaces, inert gas plants and plasma-nitriding plants for thermochemical 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 heattreated product.

A bonus for our clients

Through the use of a precision-hardening process – a Deutsche Edelstahlwerke development – we are in the position to reduce the deformation of thin components to a minimum (e.g. with guide strips).

Processes and steel for plastics processing

As the processing methods for plastics vary to a great extent, the demand profile of the steel moulds for plastic moulding may show very considerable differences. Consequently, different steel grades are inevitable to attain a perfect final plastic product.

Deutsche Edelstahlwerke supplies superlative tool steel for each type of application and every stage related to plastic processing.

The most important Deutsche Edelstahlwerke steel grades for moulds used in different processing methods are referred to in detail on the following pages.

Steel for plastic moulding is used for:

» injection moulding
» compression moulding
» plastic extrusion
» blow moulding
» large moulds
» mould frames
» extruders

Overview of plastic mould steel

Steel for plastic moulding	Injection moulding	Com-pression	Extrusion	Blow moulding	Large moulds	Mould frames	Extruders
Formadur® 2083	●	●	●				
Formadur® 2083 Superclean	●	●	●				
Formadur® 2085	●	●				●	
Formadur® 2162	●	●					
Formadur® 2190 Superclean	●	●					
Formadur® 2311	●	●		●	●		
Formadur® 2312	●	●			●	●	
Formadur® 2316	●	●	●	●	●		●
Formadur® 2316 Superclean	●	●	●	●	●		●
Thermodur® 2343 EFS	●	●					●
Thermodur® 2343 EFS Superclean	●	●					●
Thermodur® 2344 EFS	●	●					●
Thermodur® 2344 EFS Superclean	●	●					●
Cryodur® 2357	●	●					
Formadur® 2361	●	●					●
Cryodur® 2363	●	●					
Cryodur® 2379	●	●					●
Cryodur® 2709	●	●					
Formadur® 2711	●	●			●		
Formadur® 2738	●	●		●	●		
Formadur® 2764	●	●					
Cryodur® 2767	●	●					
Cryodur® 2842	●	●					
Formadur® 2891							●
Cryodur® 2990	●	●					●
Rapidur® 3343	●	●					
Formadur® PH X Superclean	●	●	●	●			●
Formadur® PH 42 Superclean	●	●	●	●			
Formadur® 320	●	●		●	●	●	
Corroplast®	●	●		●		●	

Injection moulding

Injection moulding is the most significant method employed to produce moulded parts for thermoplastics. It is also used for the processing of thermosetting plastics and elastomers. Injection moulding is ideal for the plastics manufacturer producing such products as cogwheels for watches, or bumpers and mudguards for automobiles.

During the moulding process the smelted plastic is injected into a die which then forms the mould cavity. Here the plastic develops the desired shape and cools. The finish of the final product is characterized by three factors: the type of plastic used, the processing parameters and the injection mould itself.

The basic tasks of an injection mould are to intake the melt, distribute and form it and to cool it rendering a solid state object. Finally the finished product is ejected. For this reason an appropriate steel grade is of paramount importance for the thermal design of a mould, since differences in the die's surface temperature or wall thickness bring about varying cooling conditions and thereby influence the properties of the moulded part.

High-performance steel for injection moulds

Additionally to a broad range of globally established high-quality standard steel grades, Deutsche Edelstahlwerke provides further steel with specific qualities for injection moulds. Please see the product table below for property comparisons. We have highlighted the following steel grades as most representative of our complete range.

Formadur® PH X Superclean is an extremely corrosion-resistant, precipitation-hardenable and remelted steel grade exhibiting outstanding polishability. Typical operational applications of this very pure steel include spectacles lenses, headlight moulds for the automobile industry and components for the aeronautics and chemical industries.

Formadur® PH 42 Superclean is a precipitation-hardenable remelted steel for plastic moulding, exhibiting excellent polishability and weldability as well as outstanding toughness and texturing properties. This steel grade is ideal for extensively used injection moulds.
Corroplast® is a low-carbon stainless steel which machines more easily than any other stainless steel for plastic moulding known to date. Since Corroplast® is supplied at an approximate hardness of 320 HB, this steel grade does not necessitate any additional heat treatment. Corroplast® is suitable for mould frames and plastic moulds with standard demands on polishability and resistance to condensation and cooling water.

Cryodur® 2709 is characterized by the following properties – extreme toughness, polishability, good texturing properties and weldability. The martensitic hardenable coldwork steel is employed for moulds and mould cores with complex geometry used under extreme flexural stress.

Cryodur® 2357 is a steel with good toughness also at an elevated hardness. The chemical composition makes Cryodur® 2357 suitable for air hardening for tools with medium wall thicknesses, bigger cross sections must be quenched in oil. Good polishability in combination with high wear resistance and high compressive strength makes Cryodur® 2357 universally useable in mould manufacturing.

Compression moulding

For compression moulding, a compression moulding material, usually pre-heated and in the form of powder, grain or pellets, is poured into the mould. The moulding material is plastified using pressure and heat and formed in such a way that the plastic to be manufactured completely fills the mould cavity.

Decisive process parameters for a mould are pressure and temperature.

When manufacturing the mould plates and all shaping elements of the mould it is important that the temperature of the mould during working should not exceed the tempering temperature and thereby the retention of hardness of the steel. Wear resistance is a further but important criterium made on the tool steel, since the fillers contained in the compression-moulding material have the capacity to create extreme wear and tear. This is the case, for example, with fibreglass containing plastics.

High-performance steel for compression moulds

When it comes to moulds, Deutsche Edelstahlwerke does not only supply an extensive range of high-quality quenched and tempered, annealed and solution-annealed steel grades, but other steel with special properties.

We have chosen two steel grades to represent a larger selection.

Formadur® 320 is a pre-hardened high-performance steel for the production of very large-sized moulds and dies. This steel grade is supplied at a hardness of 280 – 325 HB and of 310 – 355 HB achieved by quenching and tempering. It exhibits very good texturing properties, machinability, weldability and nitridability. In comparison to steel grades used to date, Formadur® 320 features increased thermal conductivity as well as enhanced quenching and tempering properties. Due to its improved toughness and a hardness symmetrically distributed over the entire cross section, this high-tech steel grade is recommended for the construction of more complicated moulds, such as those needed for bumpers, sinks and cladding for automobile and plane interiors.

Cryodur® 2990 is a newly developed, ledeburitic cold work tool steel with high hardness, good toughness and high tempering strength which simultaneously displays a high wear resistance. Its excellent compression strength, high abrasion and adhesion resistance create a property profile ideal for pressure pads and plastic moulds.

Plastic extrusion

Extrusion is a shaping process, the result of which are strand-like plastic semi-finished or continuous products. Product examples include plastic profiles or continuous-strand pipes. In this process, the plastified plastic to be processed is pressed by means of an extruder from a pressure chamber through a mould orifice. The profiles of the female mould have to be purpose shaped to enable the extrusion of complicated cross sections of the strand.

Decisive factors for the success of an extrusion process are shape retention and dimensional stability of the female mould, which ensure the manufacture of precise profiles and the ensuing products necessitating standardized high quality. Resistance to mechanical wear and corrosion are prerequisites the steel used to produce the mould also has to meet.

High-performance steel for plastic extruders

Besides its established high-quality standard steel (quenched and tempered or annealed), Deutsche Edelstahlwerke supplies steel grades with special qualities for extruders.

We would like to highlight the following steel grades from our complete product range. Please see the product table below for a comparison of properties.

Formadur® 2316 is a standard steel grade, which is supplied quenched and tempered at a working hardness of approximately 300 HB. Due to its increased chromium content, this grade is endowed with greater corrosion resistance. The steel shows an appropriate polishability, weldability and machinability. Formadur® 2316 is mainly used for moulds to process corrosive plastics as well as for mould inserts, slot dies, profile moulds and sizing dies.

Formadur® PH X Superclean is an extremely corrosion-resistant, precipitation-hardenable and remelted steel grade exhibiting outstanding polishability. A derivative of Formadur® 2316, this exceptionally pure premium steel grade features better wear resistance and high dimensional stability after machining. Formadur® PH X Superclean is, amongst other purposes, used for heavily strained female moulds and for continuous or hollow profiles such as window frames.

The blow-moulding process

Blow moulding is the usual production process for hollow plastic objects such as bottles, canisters and similar containers. This process is also used for the making of flat and tubular films. A blow mould is constructed from several parts.

In the production of hollow articles such as bottles, a preform is moulded by means of a blowing mandrel and compressed air. The manufacture of flat films using this method is carried out by means of slot dies. Tubular films are produced with blow heads.

Blow moulds are particularly subjected to increased wear and tear at the parting lines. These mechanically heavily stressed parts should, therefore, be replaceable and made from high tensile steel.

In PET processing for example, cooling is important for the quality and performance of a blow mould. For this reason steel grades with particularly good thermal conductivity should be taken into consideration when choosing materials.

High-performance steel for blow-moulding moulds

For blow moulding Deutsche Edelstahlwerke supplies a broad assortment of high-quality quenched and tempered steel grades with highly minimized distortion.

Regardless whether intended for use as a slot mould, blow head or for a hollow article mould (for products such as bottles or canisters), every listed steel grade is perfectly designed for different blow moulds.

The blow mould product range consists of the following steel grades. Please refer to the product table for property comparisons.

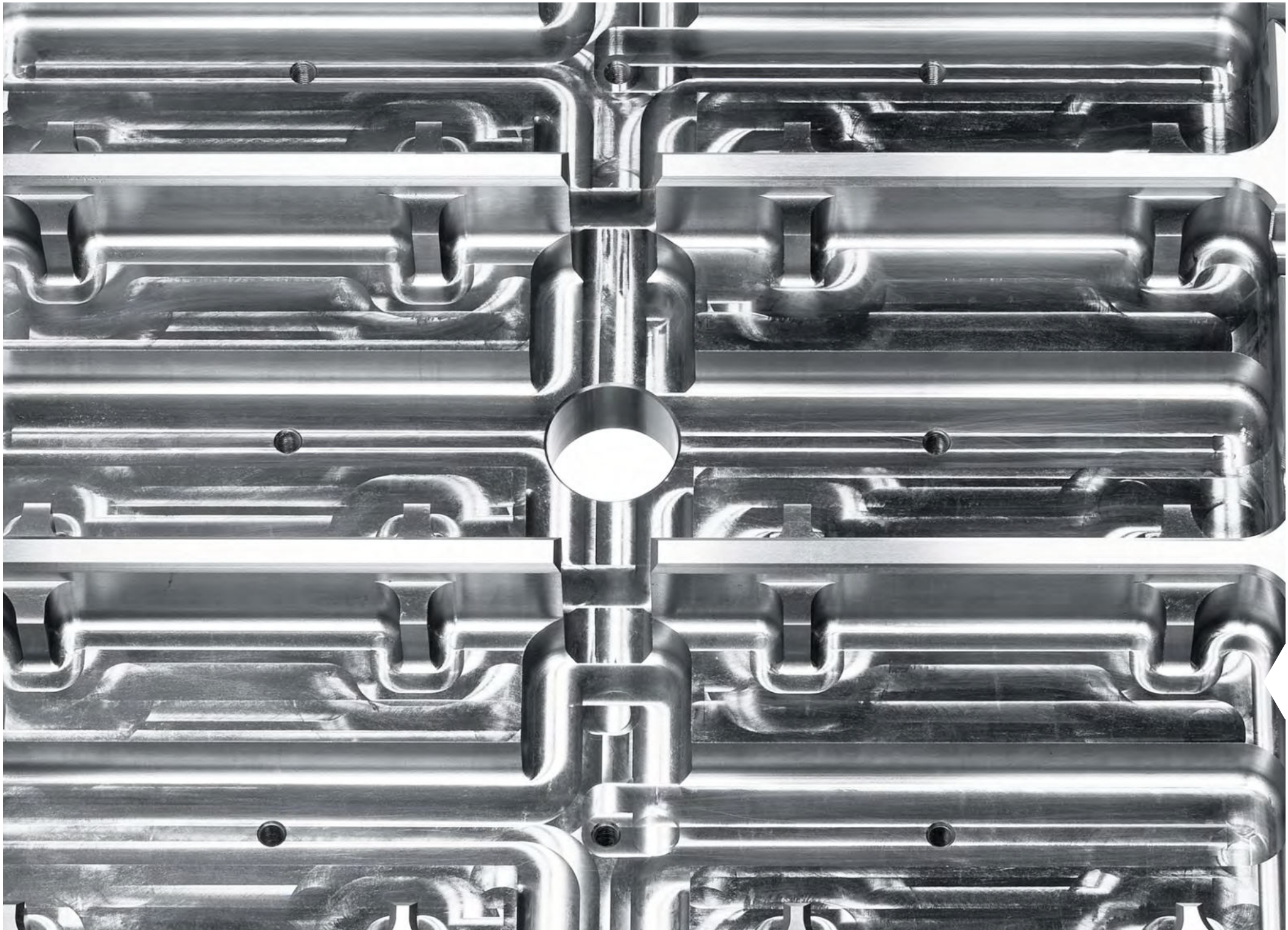
Corroplast® is a low-carbon stainless tool steel which is more easily machined than any other stainless steel for plastic moulding known to-date. Since Corroplast® is supplied at an approximate hardness of 320 HB, this steel grade does not necessitate any additional heat treatment. Corroplast® is suitable for mould frames and plastic moulds, meeting standard demands on polishability and resistance to condensation and cooling water.

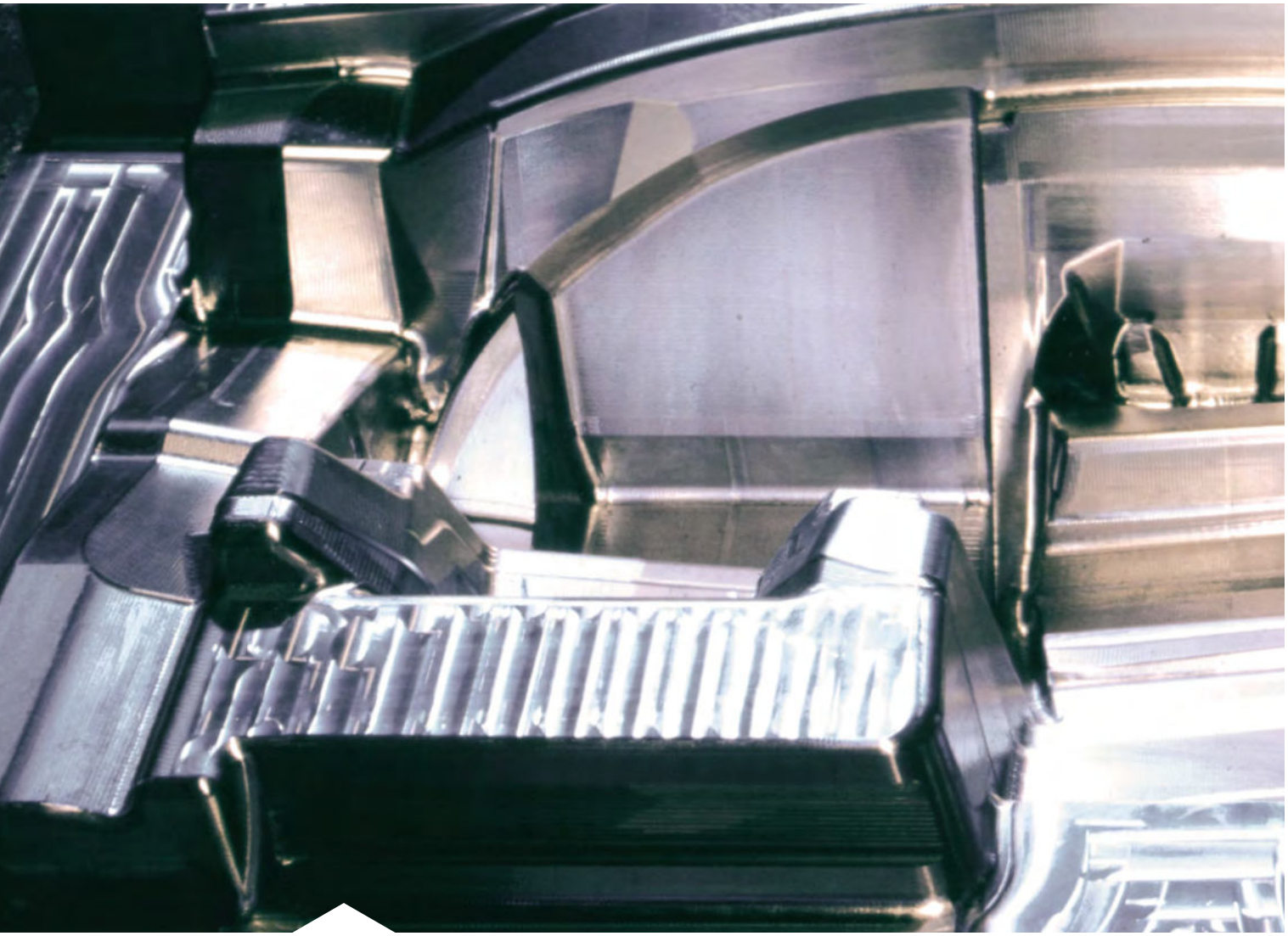
Formadur® 2311 is a quenched and tempered standard steel grade, supplied at a hardness of 280 to 325 HB. It comes with a minimal sulphur content and is characterized by its good machinability, weldability and suitability for nitriding. It displays sufficiently high robustness for standard applications. Quenching and tempering is limited to a thickness of approximately 400 mm.

Formadur® 2738 is a quenched and tempered steel for plastic moulding and comes at a hardness of 280 to 325 HB. This steel grade is a derivative of Formadur® 2311 and is characterized by good machinability and polishability. In comparison to Formadur® 2311 it is quenched and tempered more easily when thicker than 400 mm.

Formadur® 2316 and **Formadur® 2316 Superclean** are standard steel grades and are supplied quenched and tempered at a working hardness of approximately 300 HB. Due to their increased chromium content these grades display a higher corrosion resistance. The steels' polishability and weldability properties are good – likewise their machinability. These corrosion-resistant steel grades are mainly used for the processing of chemically aggressive plastics like PVC.

Formadur® PH X Superclean is an extremely corrosion-resistant, precipitation-hardenable and remelted steel grade with outstanding polishability. This exceptionally pure premium steel grade is a derivative of Formadur® 2316, featuring better wear resistance and greater dimensional stability after machining.





Plastic moulding for large moulds

The percentage of plastic parts used in the construction of automobiles and other vehicles is steadily rising. The size of the required moulds is likewise increasing, to the extent that the steel ingots now need to have cross sections up to 2 metres and can weigh up to 100 tons. The demands made on the moulds used to produce the pre-machined plastic moulds are determined on the one hand by the large plastic product dimensions and on the other hand by the required surface quality of the parts (e.g. bumpers, mudguards or bonnets) which have to be supplied ready-to-install.

The moulds used in the manufacturing of large plastic parts have to have good machinability and high dimensional stability to be able to guarantee distortion-minimized finishes.

Another client extra

As a special service Deutsche Edelstahlwerke offers its clients the pre-machining of large moulds. The electronic transfer of CAD data enables us to manufacture large moulds with very short delivery times.

High-performance steel for large moulds

The range of high-quality steel grades for plastic moulding designed for large moulds at Deutsche Edelstahlwerke covers quenched and tempered steel grades, which are characterized by high hardenability and machinability as well as by excellent polishability and texturing properties.

The product range consists of the following steel grades. Please see the product table below for property comparisons.

Formadur® 2311 is a quenched and tempered standard steel grade supplied at a hardness of 280 to 325 HB. The grade is produced with minimum sulphur content and is characterized by its good machinability, weldability and nitriding suitability. It is wear resistant and displays sufficiently high robustness. Quenching and tempering is limited to a thickness of around 400 mm.

Formadur® 2312 is a pre-hardened plastic-moulding steel grade supplied at a hardness of 280 to 325 HB. With an increased sulphur content this grade shows very good machinabilty and is well suited for nitriding. However, polishability and texturing properties are limited.

Formadur® 2711 is a tough quenched and tempered steel grade for plastic moulding with a high degree of purity. This grade is supplied at a hardness of 355 to 400 HB (square, flat) and 370 to 410 HB (diameter). It has excellent texturing properties, is well suited to mirror polishing and can be hard chromium plated. It has a higher compression strength than Formadur® 2738. Formadur® 2711 is preferential for plastic moulds with increased demands on compression strength and wear resistance.

Formadur® 2738 is a quenched and tempered steel for plastic moulding, is supplied at a hardness of 280 to 325 HB, appropriate for texturing and is a derivative of Formadur® 2311. It exhibits high machinability and polishability and is more easily quenched and tempered than Formadur® 2311. Formadur® 2738 is used for large plastic moulds with deep engraving where there is intensive impact on the core.

Formadur® 320 is a pre-hardened steel for plastic moulding, being supplied at a hardness of 280 – 325 HB and of 310 – 355 HB. It is extremely easily textured and machined as well as being unproblematic when polished and welded. In comparison to Formadur® 2738 the quenching and tempering properties have been further improved. Formadur® 320 is recommended for dies and moulds of very large dimensions for products such as bumpers, plastic containers, TV cases and dashboards.

Mould frames

Following the two-piece construction principle, these dies consist of a mould frame and respective mould inserts. Depending on the size of the plastic product to be manufactured, up to 192 mould inserts (so-called cavities) can be integrated into a single mould frame.

Typical end products for this technology include screw caps for beverage bottles and PET preforms.

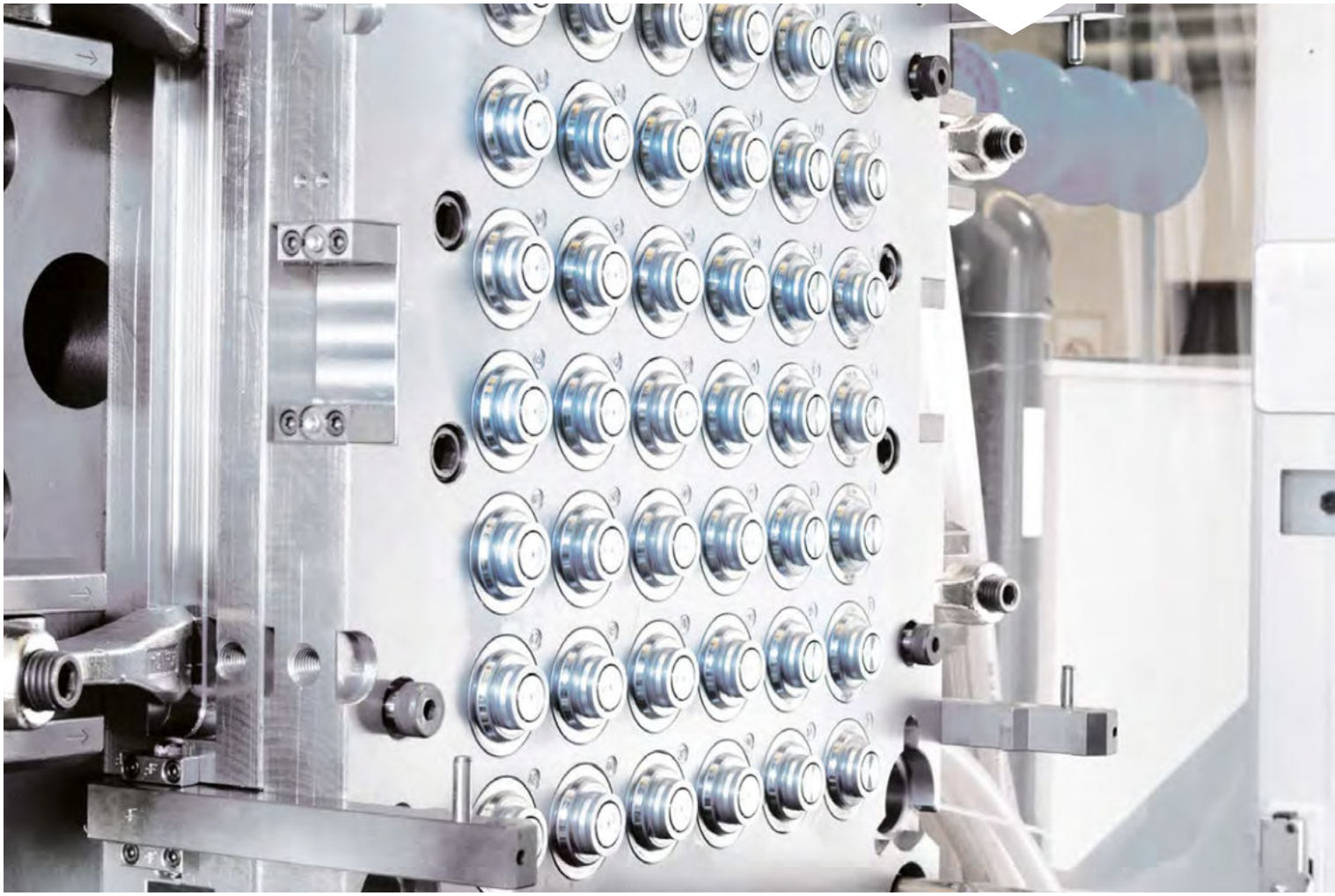
High-performance steel for mould frames

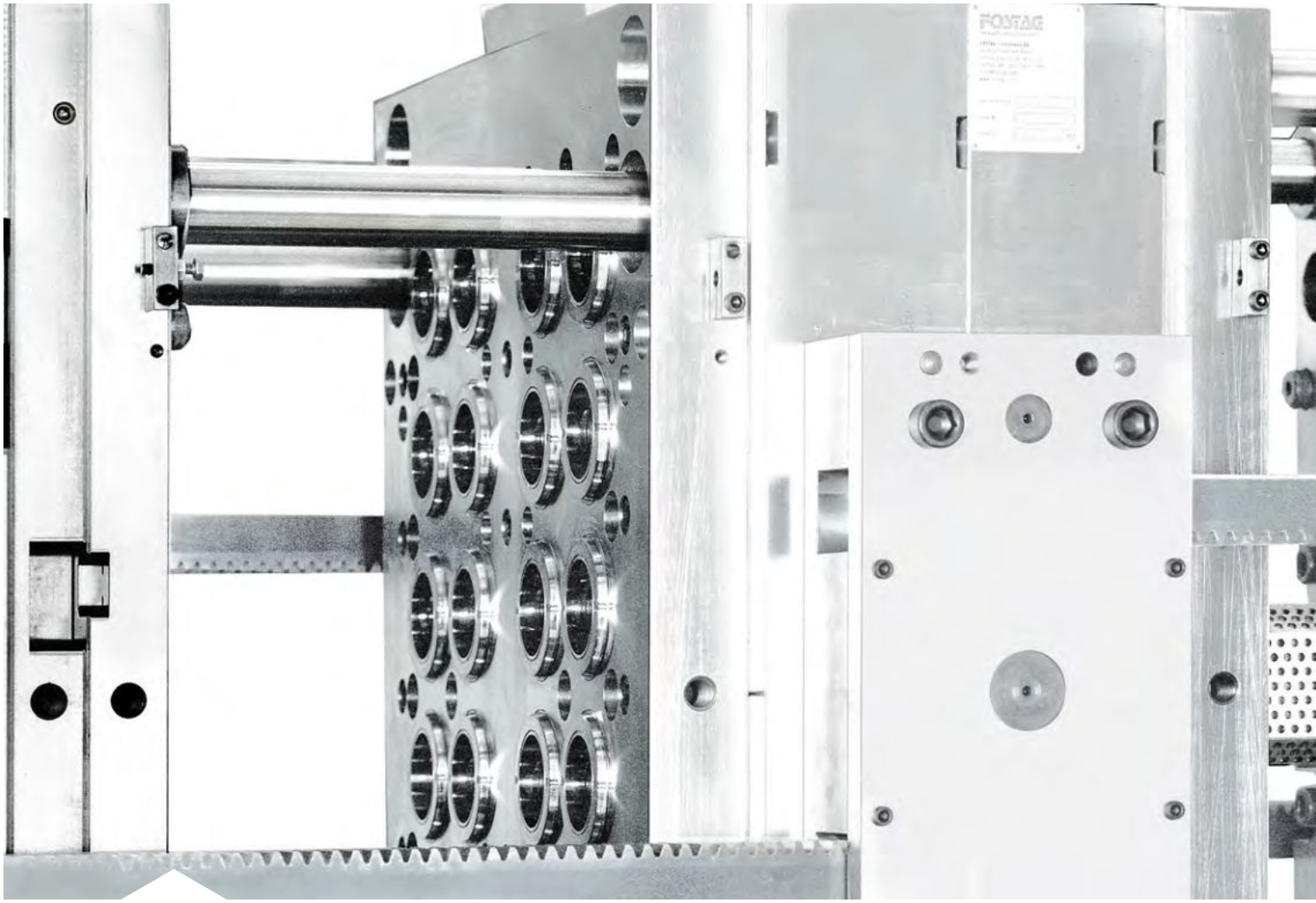
The range of high-quality steel grades for mould frames at Deutsche Edelstahlwerke include pre-hardened steel grades with excellent machinability. Other grades are available which are corrosion resistant with particularly low compression strength. Please see the product table for property comparisons.

Formadur® 2085 combines excellent corrosion resistance with economical machinability for sulphurized plastic moulding steel. This is why this quenched and tempered steel grade is the perfect fit for mould frames. Formadur 2085® is supplied at a hardness of 280 to 325 HB.

Formadur® 2312 is a pre-hardened steel grade for plastic moulding supplied at a hardness of 280 to 325 HB. This grade shows very good machinabilty and is well suited for nitriding. Texturing properties and polishability are restricted by its high sulphur content.

Corroplast® is a low-carbon stainless steel which machines more easily than any other stainless steel for plastic moulding known to date. Since Corroplast® is supplied at an approximate hardness of 320 HB, this steel grade does not necessitate any additional heat treatment. Corroplast® is particularly suitable where there is a high corrosion potential. Further advantages are exceptional toughness, particularly low stress and good weldability.




FONTAG

Moulds for plastic-extrusion lines

The plastification, transport and compression of the melted plastic necessitate an extrusion line.

The different elements of the extrusion line include cylinders, screws, screw tips, retaining valve and other components.

Deutsche Edelstahlwerke supplies a product range especially adapted to these needs, consisting of either distortion-minimized, quenched and tempered steel grades with a high wear resistance, or steel grades which are to be hardened at a later stage.

High-performance steel grades for plastic extruders

In addition to steel grades such as Formadur® 2891, which are supplied for normal applications and usually in a quenched and tempered condition, Deutsche Edelstahlwerke produces other high-performance steel that meet special demands. These include excellent wear resistance accompanied by exceptional toughness as well as torsion resistance. All of the grades listed meet these requirements. Please see the product table for property comparisons.

Cryodur® 2990 is a newly developed, ledeburitic cold-tool steel with great hardness, good toughness and a high tempering strength. At the same time it also exhibits very high wear resistance. Its high compression strength and resistance to abrasive and adhesive wear lend this special steel an ideal property profile for use with pressure pads and plastic moulds.

Formadur® 2891 is an aluminium-alloyed nitriding steel specially designed for extruders. It is used for plasticising devices, screw cylinders and extruder screws.

Thermodur® 2343 EFS and **Thermodur® 2343 EFS Superclean** are the first choice when it comes to torsion resistance and toughness. Surface-treated screws made of these highperformance steel grades are ideal even for the most demanding purposes.

Steel for plastic moulding and their properties

Brand	Wear resistance	Corrosion resistance	Toughness	Polishability
Formadur® 2083	● ●	● ●	●	● ●
Formadur® 2083 Superclean	● ●	● ●	● ●	● ●
Formadur® 2085	●	● ●	●	○
Formadur® 2162	● ●	●	●	● ● ●
Formadur® 2190 Superclean	● ●	● ●	●	● ● ●
Formadur® 2311	●	●	●	●
Formadur® 2312	●	●	●	○
Formadur® 2316	●	● ●	●	● ●
Formadur® 2316 Superclean	●	● ●	●	● ●
Thermodur® 2343 EFS	● ●	●	● ●	● ●
Thermodur® 2343 EFS Superclean	● ●	●	● ● ●	● ● ●
Thermodur® 2344 EFS	● ●	●	● ●	●
Thermodur® 2344 EFS Superclean	● ●	●	● ●	● ●
Cryodur® 2357	● ●	●	● ●	● ●
Formadur® 2361	● ● ●	● ●	●	●
Cryodur® 2363	● ●	●	●	●
Cryodur® 2379	● ● ●	●	○	○
Cryodur® 2709	● ●	●	● ● ●	● ● ●
Formadur® 2711	●	●	●	●
Formadur® 2738	●	●	●	●
Formadur® 2764	● ●	●	● ●	● ● ●
Cryodur® 2767	● ●	●	● ●	● ●
Cryodur® 2842	● ●	●	●	● ●
Formadur® 2891	● ● ●	●	● ●	○
Cryodur® 2990	● ● ●	●	●	●
Rapidur® 3343	● ● ●	●	●	○
Formadur® PH X Superclean	●	● ● ● ●	● ● ●	● ● ● ●
Formadur® PH 42 Superclean	●	●	● ●	● ● ● ●
Formadur® 320	●	●	●	● ●
Corroplast®	●	● ●	● ●	●

Texturing properties	Weldability	Machinability	Nitridability
● ●	●	● ●	●
● ●	●	● ●	●
○	●	● ● ●	●
● ● ●	● ●	● ● ●	●
● ●	●	● ●	● ●
● ●	● ●	● ●	● ●
○	●	● ● ●	● ●
● ●	● ●	● ●	●
● ●	● ●	● ●	●
● ●	● ●	● ●	● ●
● ●	● ●	● ●	● ●
● ●	● ●	● ●	● ●
● ●	● ●	● ●	● ●
● ●	●	● ●	–
○	○	●	● ● ●
●	○	● ●	●
○	○	●	●
● ● ●	● ● ●	● ●	● ●
● ●	● ●	● ●	● ●
● ●	● ●	● ●	● ●
● ● ●	● ●	● ●	–
● ●	● ●	● ●	–
● ●	○	● ●	–
○	○	● ●	● ● ●
○	○	● ●	●
●	○	●	●
● ● ●	● ● ● ●	● ●	● ●
● ● ●	● ● ● ●	● ●	● ●
● ● ●	● ● ●	● ● ●	● ●
●	● ● ● ●	● ● ● ●	● ●

Material Data Sheets

Consecutively the most important materials in the area of plastic mould steel with its steel properties, standards, physical properties, applications and heat treatment.

Formadur® 2083/2083 Superclean

Formadur® 2085

Formadur® 2162

Formadur® 2190 Superclean

Formadur® 2311

Formadur® 2312

Formadur® 2316/ 2316 Superclean

Thermodur® 2343 EFS/2343 EFS Superclean

Thermodur® 2344 EFS/ 2344 EFS Superclean

Cryodur® 2357

Formadur® 2361

Cryodur® 2363

Cryodur® 2379

Cryodur® 2709

Formadur® 2711

Formadur® 2738

Formadur® 2764

Cryodur® 2767

Cryodur® 2842

Formadur® 2891

Cryodur® 2990

Rapidur® 3343

Formadur® PH X Superclean

Formadur® PH 42 Superclean

Formadur® 320/320 Superclean

Corroplast®

Formadur® 2083/2083 Superclean

X40Cr14	C 0.40 Cr 13.00
Steel properties	Corrosion-resistant, good polishability. We recommend the use of Formadur® 2083 Superclean for the highest demands on polishability.
Standards	**AISI** 420 **AFNOR** Z40C14
Standards	**Coefficient of thermal expansion**

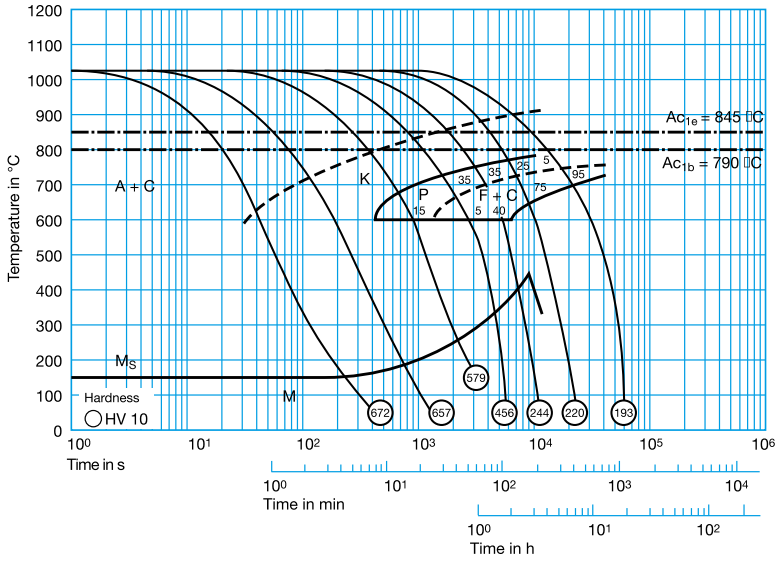
bei °C	20 - 100	20 - 150	20 - 200	20 - 250	20 - 300	20 - 350	20 - 400	20 - 450	20 - 500
10^{-6} m/(m • K)	11.1	11.3	11.6	11.8	12.0	12.3	12.4	12.5	12.6
Quenched and tempered									

Thermal conductivity at °C	23	150	300	350	400	500
W/(m • K)	22.6	24.0	24.6	24.9	24.4	23.7
Quenched and tempered						

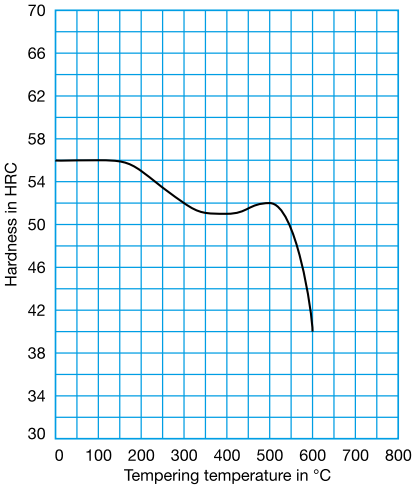
Applications	Moulds for processing plastics with corrosive reactions.		
Heat treatment	**Soft annealing °C** 760 – 800	**Cooling** Furnace	**Hardness HB** max. 230
	Hardening °C 1000 – 1050	**Quenching** Oil or saltbath, 500 – 550 °C	**Hardness after quenching HRC** 56

Tempering °C	100	200	300	400	500	600
HRC	56	55	52	51	52	40

Time-temperature-transformation diagram



Tempering diagram

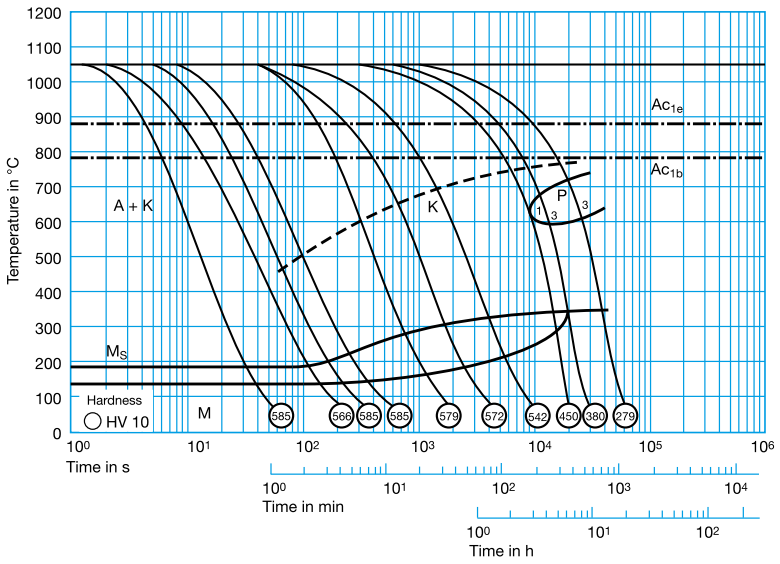


Formadur® 2085

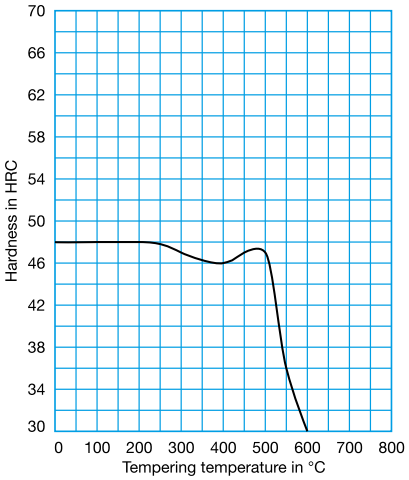
X33CrS16	C 0.33 Cr 16.00 S 0.05 Ni 0.50
Steel properties	Pre-hardened corrosion-resistant mould frame steel, hardness in as-delivered condition of 280 to 325 HB. Improved machinability in comparison to Formadur® 2316.
Standards	**AISI** ~420FM
Applications	Mould frames, components, plastic moulds.
Heat treatment	**Soft annealing °C** 850 – 880 / **Cooling** Furnace / **Hardness HB** max. 230 **Hardening °C** 1000 – 1050 / **Quenching** Oil / **Hardness after quenching HRC** 48

Hardness after quenching HRC	100	200	300	400	450	500	550	600
HRC	48	48	47	46	47	47	36	30

Time-temperature-transformation diagram



Tempering diagram



Formadur® 2162

21MnCr5	C 0.21 Mn 1.30 Cr 1.20
Steel properties	Case hardening steel, good polishability, suitable for cold hobbing.
Standards	**AISI** ~P2
Physical properties	**Coefficient of thermal expansion**

bei °C	20 - 100	20 - 200	20 - 300	20 - 400	20 - 500	20 - 600	20 - 700
10^{-6} m/(m • K)	12.2	12.9	13.5	13.9	14.2	14.5	14.8

Thermal conductivity at °C	20	350	700
W/(m • K)	39.5	36.5	33.5

Applications: Mirror-finished plastic moulds and guide pins.

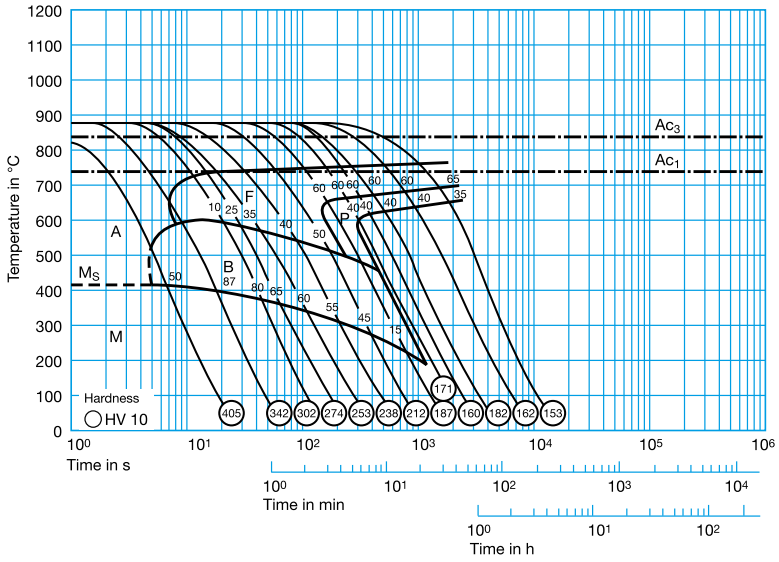
Heat treatment

Soft annealing °C	**Cooling**	**Hardness HB**
670 – 710	Furnace	max. 210

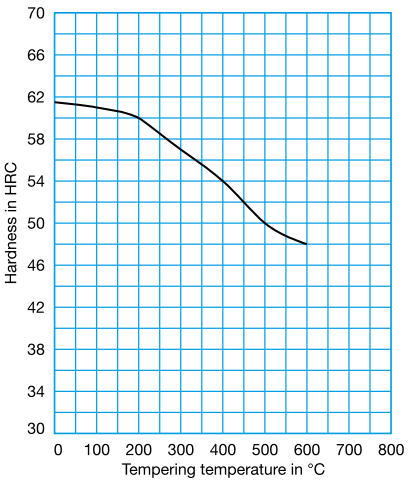
Carburizing °C	**Intermediate annealing °C**	**Hardening °C**	**Quenching**	**Surface hardness after quenching HRC**
870 – 900	620 – 650	810 – 840	Oil or saltbath, 180 – 220 °C	62

Tempering °C	100	200	300	400	500	600
HRC	61	60	57	54	50	48

Time-temperature-transformation diagram



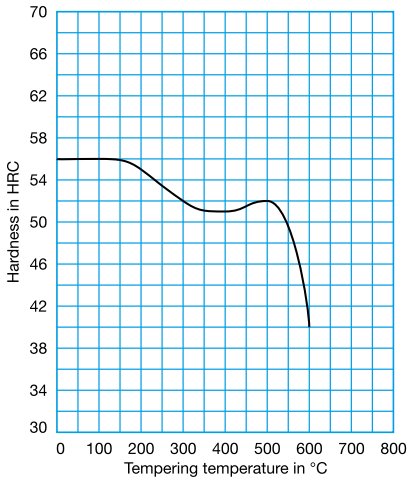
Tempering diagram



Formadur® 2190 Superclean

(X37Cr13)	C 0.37 Si 0.90 Mn 0.50 Cr 13.60 V 0.30
Steel properties	Corrosion-resistant, very good polishability.
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 100	20 - 150	20 - 200	20 - 250	20 - 300	20 - 350	20 - 400	20 - 450	20 - 500 **10^{-6} m/(m • K)** 10.7	11.0	11.2	11.5	11.7	11.9	12.1	12.3	12.4 **Quenched and tempered** **Thermal conductivity at °C** 23	150	300	350	400	500 **W/(m • K)** 21.5	23.2	23.9	24.3	24.2	24.0 **Quenched and tempered**
Applications	Moulds for processing of corrosive plastics.
Heat treatment	**Soft annealing °C** 760 – 800 — **Cooling** Furnace — **Hardness HB** max. 230 **Hardening °C** 1000 – 1050 — **Quenching** Oil or saltbath, 500 – 550 °C — **Hardness after quenching HRC** 56 **Tempering °C** 100	200	300	400	500	600 **HRC** 56	55	52	51	52	40

Tempering diagram

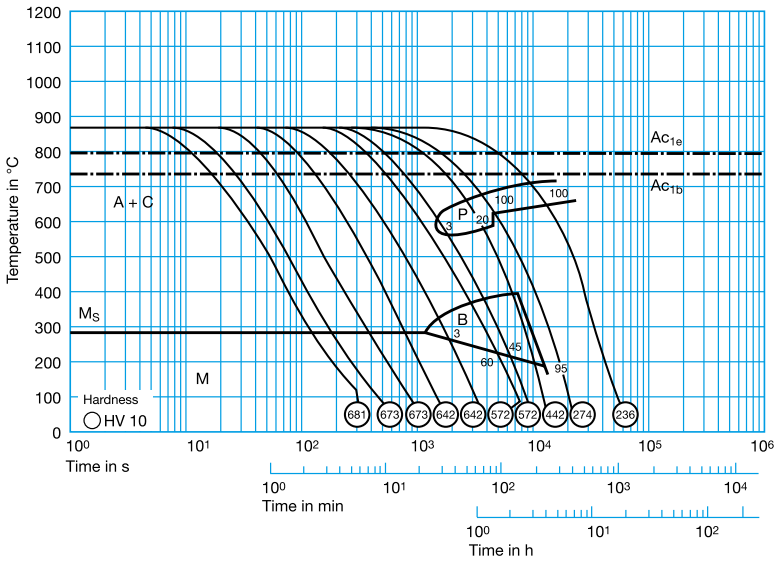


Reference numbers in brackets are not standardized in EN ISO4957.

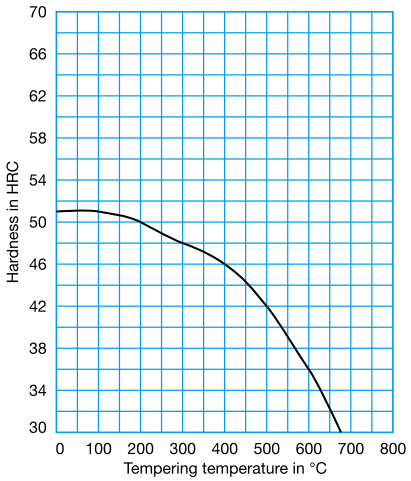
Formadur® 2311

40CrMnMo7	C 0.40 Mn 1.50 Cr 1.90 Mo 0.20
Steel properties	Pre-hardened plastic mould steel, hardness in as-delivered condition 280 to 325 HB. Good machinability, suitable for texturing, better polishability than Formadur® 2312.
Standards	**AISI** P20
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 100 20 - 150 20 - 200 20 - 250 20 - 300 20 - 350 20 - 400 20 - 450 20 - 500 **10^{-6} m/(m • K)** 12.6 12.8 13.0 13.3 13.5 13.7 13.9 14.1 14.3 **Quenched and tempered** **Thermal conductivity at °C** 23 150 300 350 400 500 **W/(m • K)** 32.5 32.9 31.3 30.2 29.5 27.4 **Quenched and tempered**
Applications	Plastic moulds, mould frames for plastic moulds and pressure casting moulds and recipient sleeves.
Heat treatment	**Soft annealing °C** 710 – 740 — **Cooling** Furnace — **Hardness HB** max. 235 **Hardening °C** 840 – 840 – 870 — **Quenching** Oil or saltbath, 180 – 220 °C — **Hardness after quenching HRC** 51 **Tempering °C** 100 200 300 400 500 600 700 **HRC** 51 50 48 46 42 36 28

Time-temperature-transformation diagram



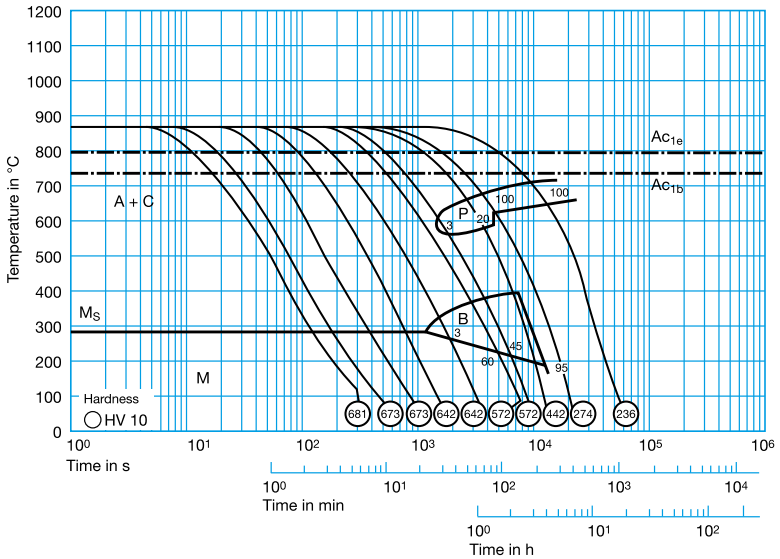
Tempering diagram



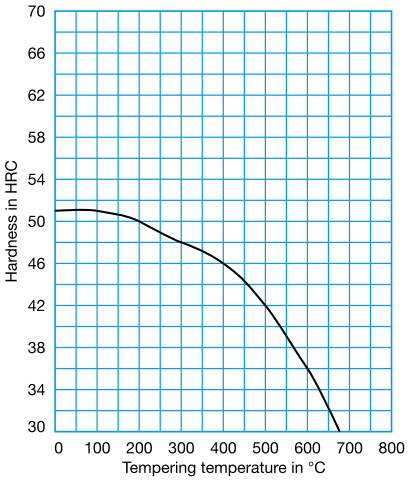
Formadur® 2312

40CrMnMoS8-6[1)]	C 0.40 Si 0.35 Mn 1.50 Cr 1.90 Mo 0.20 S 0.05
Steel properties	Quenched and tempered plastic mould steel with a hardness of 280 to 325 HB in as-delivered condition. Improved machinability in comparison with Formadur® 2311. Polishable.
Standards	**AISI** P20+S
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 100 20 - 200 20 - 300 **10^{-6} m/(m • K) Annealed** 12.5 13.4 13.9 **10^{-6} m/(m • K) Quenched and tempered** 12.3 13.0 13.7 **Thermal conductivity at °C** 100 150 200 250 300 **W/(m • K) Annealed** 40.2 40.9 40.3 40.0 39.0 **W/(m • K) Quenched and tempered** 39.8 40.4 40.4 39.9 39.0
Applications	Plastic moulds, mould frames for plastic and pressure casting moulds, recipient sleeves, brake dies.
Heat treatment	**Soft annealing °C** 710 – 740 — **Cooling** Furnace — **Hardness HB** max. 235 **Stress-relief annealing °C** (Annealed) approx. 600 — **Stress-relief annealing °C** (Quenched and tempered) approx. 30 – 50 under tempering temperature — **Cooling** Furnace **Hardening °C** 840 – 870 — **Quenching** Oil or saltbath, 180 – 220 °C — **Hardness after quenching HRC** 51 **Tempering °C** 100 200 300 400 500 600 700 **HRC** 51 50 48 46 42 36 28

Time-temperature-transformation diagram



Tempering diagram



[1)] *S can be raised between 0.05 and 0.1 % whereas Ni can be left out completely.*

Formadur® 2316/2316 Superclean

X38CrMo16	C 0.36 Cr 16.00 Mo 1.20
Steel properties	Increased corrosion resistance in comparison to Formadur® 2083, good polishability. Usually this steel grade is supplied in a quenched and tempered condition with a working hardness of approx. 300 HB.
Standards	**AISI** 420mod
Physical properties	**Coefficient of thermal expansion**

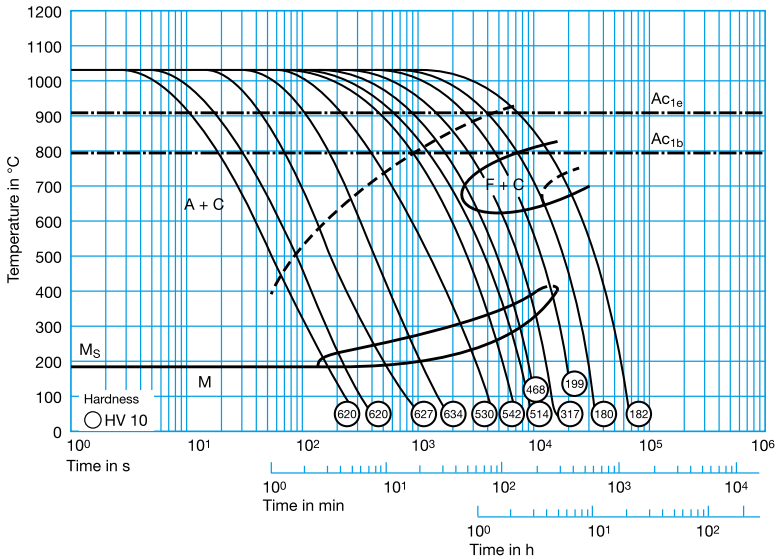
at °C	20 - 100	20 - 150	20 - 200	20 - 250	20 - 300	20 - 350	20 - 400	20 - 450	20 - 500
10^{-6} m/(m • K)	10.5	10.7	10.8	10.9	11.1	11.3	11.5	11.6	11.7
Quenched and tempered									

Thermal conductivity at °C	23	150	300	350	400	500
W/(m • K)	23.5	24.2	24.3	24.4	24.1	23.2
Quenched and tempered						

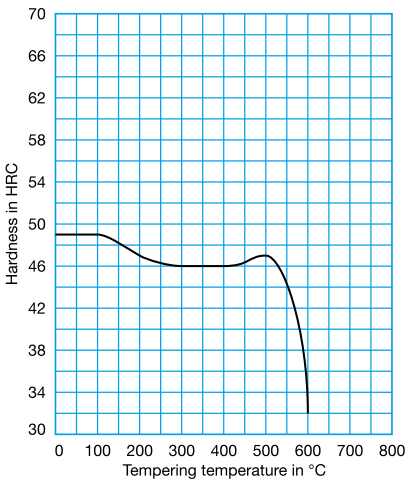
Applications	Moulds for processing plastics with corrosive reactions.		
Heat treatment	**Soft annealing °C** 760 – 800	**Cooling** Furnace	**Hardness HB** max. 230
	Hardening °C 1020 – 1050	**Quenching** Oil or saltbath, 500 – 550 °C	**Hardness after quenching HRC** 49

Tempering °C	100	200	300	400	500	600
HRC	49	47	46	46	47	32

Time-temperature-transformation diagram



Tempering diagram



Thermodur® 2343 EFS/2343 EFS Superclean

X37CrMoV5-1	C 0.38 Si 1.00 Cr 5.30 Mo 1.30 V 0.40
Steel properties	High hot tensile strength and toughness. Good thermal conductivity and insusceptibility to hot cracking. Can be water-cooled to a limited extent.
Standards	**AISI** H11 **AFNOR** Z38CDV5

Physical properties

Coefficient of thermal expansion

at °C	20 - 100	20 - 150	20 - 200	20 - 250	20 - 300	20 - 350	20 - 400	20 - 450	20 - 500
10^{-6} m/(m • K)	11.7	11.9	12.2	12.4	12.6	12.8	13.0	13.1	13.3
Quenched and tempered									

Thermal conductivity at °C	23	300	400	500
W/(m • K)	24.4	28.2	28.9	28.8
Quenched and tempered				

Applications

Hot-work steel for universal use. Pressure casting moulds, metal extrusion tools for processing light metals, forging dies, moulds, screws and barrels for plastic processing, shrink rings and hot-shear blades.
We recommend the use of Thermodur® 2343 EFS Superclean (ESR) for the highest demands.

Heat treatment

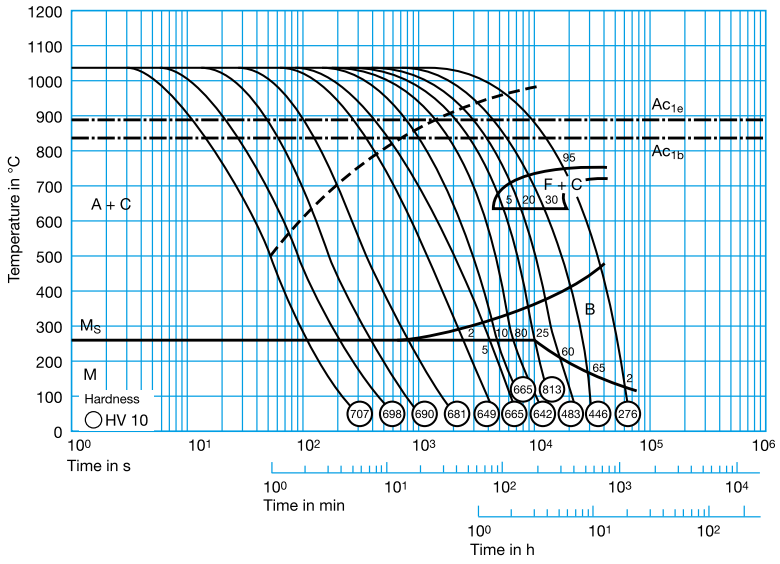
Soft annealing °C	**Cooling**	**Hardness HB**
750 – 800	Furnace	max. 230

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

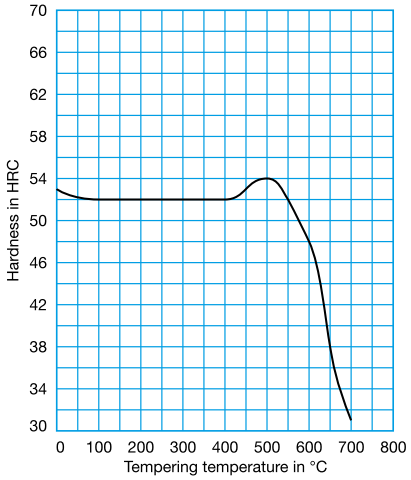
Hardening °C	**Quenching**	**Hardness after quenching HRC**
1000 – 1030	Oil or saltbath, 500 – 550 °C	54

Tempering °C	100	200	300	400	500	550	600	650	700
HRC	52	52	52	52	54	52	48	38	31

Time-temperature-transformation diagram



Tempering diagram



Thermodur® 2344 EFS/2344 EFS Superclean

X40CrMoV5-1	C 0.40 Si 1.00 Cr 5.30 Mo 1.40 V 1.00
Steel properties	High hot-wear resistance, high hot tensile strength and toughness. Good thermal conductivity and insusceptibility to hot cracking. Can be water-cooled to a limited extent.
Standards	**AISI** H13 **AFNOR** Z40CDV5
Physical properties	**Coefficient of thermal expansion**

at °C	20 - 100	20 - 200	20 - 300	20 - 400	20 - 500	20 - 600	20 - 700
10^{-6} m/(m • K)	10.9	11.9	12.3	12.7	13.0	13.3	13.5

Thermal conductivity at °C	23	350	700
W/(m • K) Annealed	27.2	30.5	33.4
W/(m • K) Quenched and tempered	25.5	27.6	30.3

Applications	Hot-work steel for universal use. Pressure casting moulds and metal extrusion tools for processing light metals, forging moulds, moulds, screws and barrels for plastic processing, nitrided ejectors and hot-shear blades. **We recommend the use of Thermodur® 2344 EFS Superclean (ESR) for the highest demands.**

Heat treatment

Soft annealing °C
750 - 800

Cooling
Furnace

Hardness HB
max. 230

Hardening °C
1010 – 1030

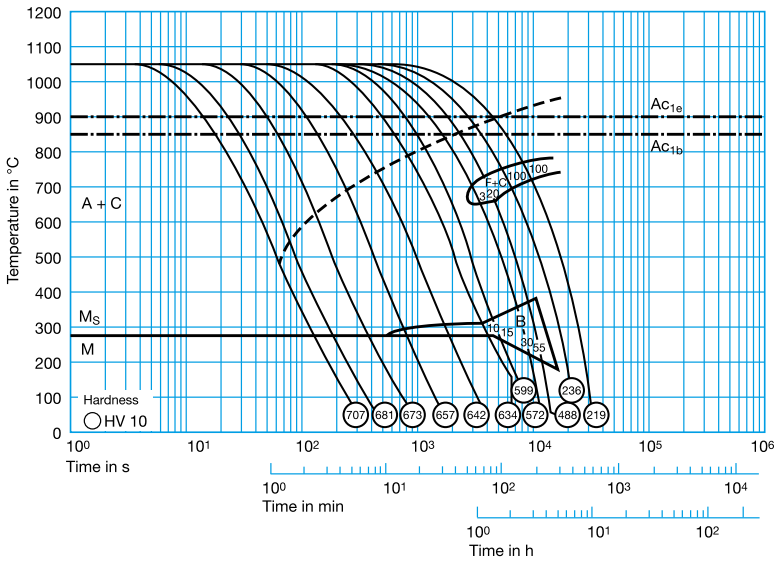
Quenching
Air, oil or
saltbath, 500 – 550 °C

Hardness after quenching HRC
54

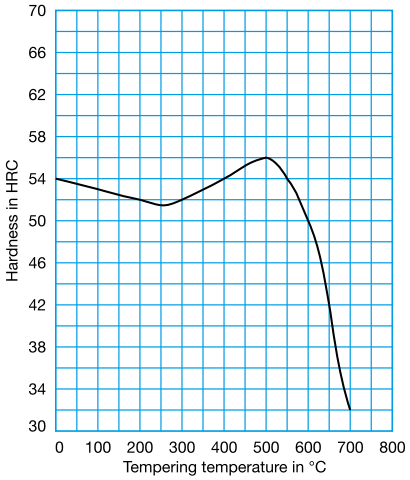
Tempering °C

HRC	100	200	300	400	500	550	600	650	700
	53	52	52	54	56	54	50	42	32

Time-temperature-transformation diagram



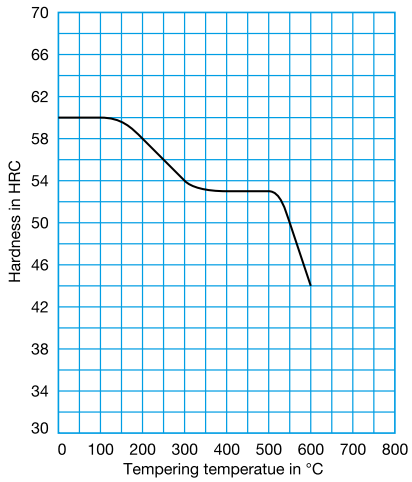
Tempering diagram



Cryodur® 2357

(50CrMoV1315)	C 0.50 Si 0.30 Mn 0.70 Cr 3.35 Mo 1.60 V 0.25
Steel properties	High toughness and wear resistance, high compression strength combined with dimensional stability and good polishability.
Standards	**AISI** S7
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 200 20 - 400 **10^{-6} m/(m • K)** 12.2 12.5 **Thermal conductivity at °C** 20 200 400 **W/(m • K)** 28.9 30.0 31.0
Applications	Cold-work tool steel for punching tools, moulds, scrap shears, piercing dies, hobbers, coining dies, deburring tools, plastic moulds and pelleters.
Heat treatment	**Soft annealing °C** **Cooling** **Hardness HB** 810 - 850 Furnace approx. 220 **Stress-relief annealing °C** **Cooling** approx. 600 Furnace **Hardening °C** **Quenching** **Hardness after quenching HRC** 920 – 970 Air or oil 60 – 62 **Tempering °C** 100 200 300 400 500 550 600 **HRC** 60 58 54 53 53 50 44

Tempering diagram

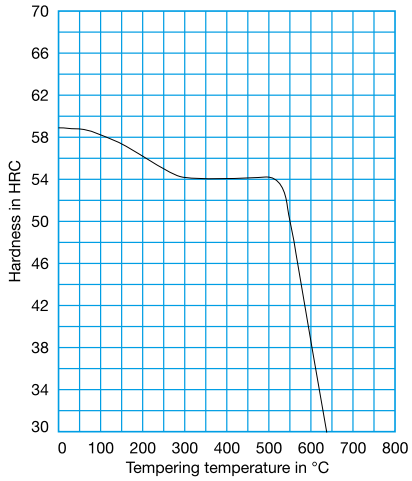


Reference numbers in brackets are not standardized in EN ISO 4957.

Formadur® 2361

X91CrMoV18	C 0.90 Si < 1.00 Cr 18.00 Mo 1.00 V 0.10						
Steel properties	Corrosion-resistant steel for plastic moulding characterized by a very good wear resistance.						
Physical properties	**Coefficient of thermal expansion**						
	at °C	20 - 200	20 - 200	20 - 300	20 - 400		
	10^{-6} m/(m • K)	10.5	11.0	11.0	12.0		
	Thermal conductivity at °C	20					
	W/(m • K)	29					
Applications	Plastic moulds, injection nozzles, valve components and ball bearings.						
Heat treatment	**Soft annealing °C**	**Cooling**			**Hardness HB**		
	800 – 850	Slow, e.g. furnace			max. 265		
	Hardening °C	**Quenching**			**Hardness after quenching HRC**		
	1000 – 1050	Oil			59		
	Tempering °C	100	200	300	400	500	550	600
	HRC	58	56	54	54	54	50	40

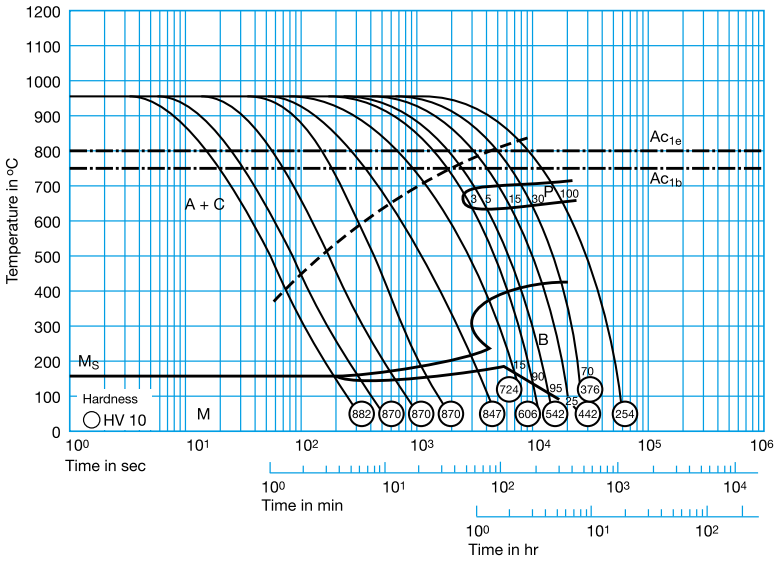
Tempering diagram



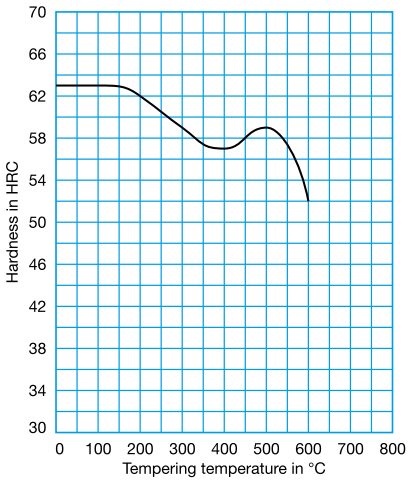
Cryodur® 2363

X100CrMoV5	C 1.00 Si 0.30 Mn 0.50 Cr 5.00 Mo 0.95 V 0.20						
Steel properties	High dimensional stability during heat treatment. High wear resistance and toughness.						
Standards	**AISI** A2	**AFNOR** Z100CDV5					
Physical properties	**Thermal conductivity at °C**	20	350	700			
	W/(m • K)	15.8	26.7	29.1			
Applications	Cutting tools, rolls, shear blades, cold pilger mandrels, cold stamping tools and moulds for processing plastics.						
Heat treatment	**Soft annealing °C**	**Cooling**		**Hardness HB**			
	800 – 840	Furnace		max. 231			
	Stress-relief annealing °C	**Cooling**					
	approx. 650	Furnace					
	Hardening °C	**Quenching**		**Hardness after quenching HRC**			
	930 – 970	Air, oil or saltbath, 500 – 550 °C		63			
	Tempering °C	100	200	300	400	500	600
	HRC	63	62	59	57	59	52

Time-temperature transformation diagram



Tempering diagram

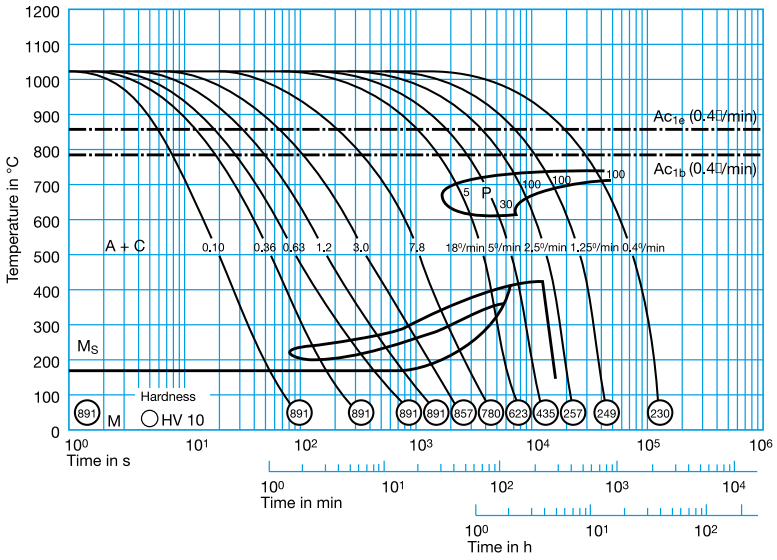


Cryodur® 2379

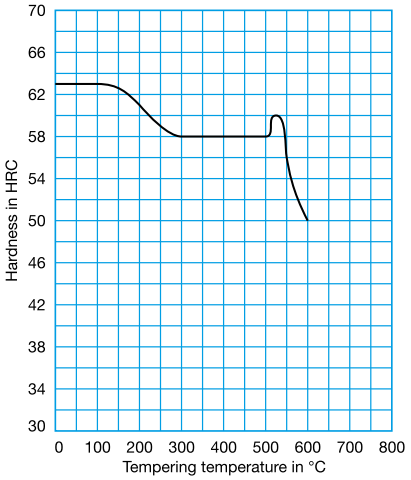
X153CrMoV12	C 1.55 Si 0.30 Mn 0.35 Cr 12.00 Mo 0.75 V 0.90							
Steel properties	12% ledeburitic chromium steel. Maximum wear resistance, sufficient toughness. Best cutting-edge endurance and resistance to tempering, can be nitrided after special heat treatment.							
Standards	**AISI** D2	**AFNOR** Z160CDV12						
Physical properties	**Coefficient of thermal expansion**							
	at °C	20 - 100	20 - 200	20 - 300	20 - 400			
	10^{-6} m/(m • K)	10.5	11.5	11.9	12.2			
	Thermal conductivity at °C	20	350	700				
	W/(m • K)	16.7	20.5	24.2				
Applications	Thread rolling rolls and thread rolling dies, cold extrusion tools, cutting and stamping tools for sheet thicknesses up to 6 mm, precision cutting tools 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**				
	830 – 860	Furnace		max. 250				
	Stress-relief annealing °C	**Cooling**						
	650 –700	Furnace						
	Hardening °C	**Quenching**		**Hardness after quenching HRC**				
	1000 – 1050	Air, oil or saltbath, 500 – 550 °C		63				
	Tempering °C	100	200	300	400	500	525	550	600
	HRC	63	61	58	58	58	60	56	50
Special heat treatment	**Hardening °C**	**Quenching**		**Hardness after quenching HRC**				
	1050 – 1080	Air, oill or saltbath, 500 – 550 °C		61				
	Tempering °C (three times)	100	200	300	400	500	525	550	600
	HRC	61	60	58	59	62	62	57	50

Cryodur® 2379

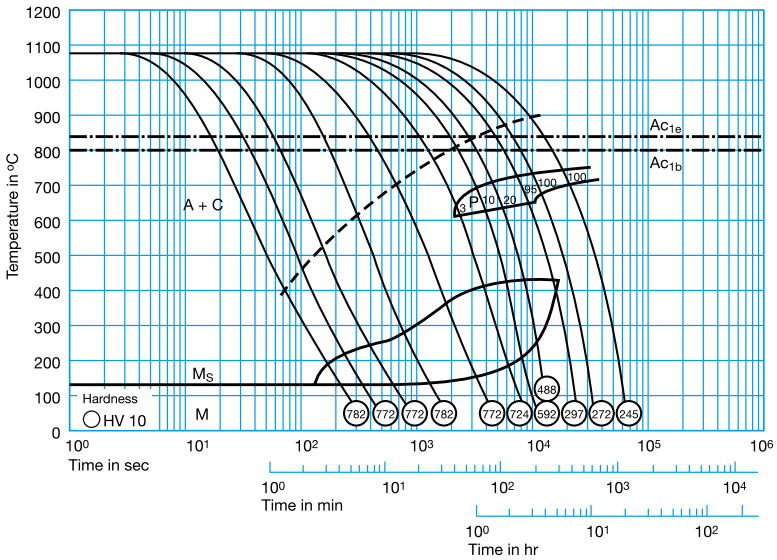
Time-temperature-transformation diagram Hardening temperature: 1030 °C



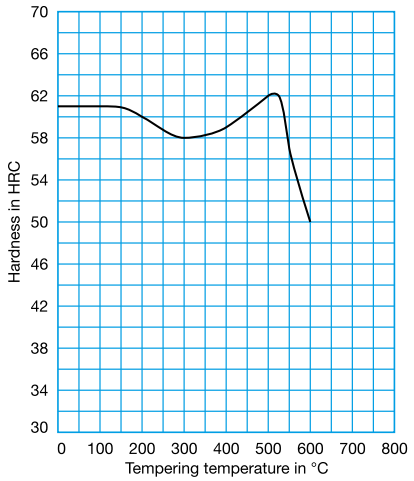
Tempering diagram



Time-temperature-transformation diagram Hardening temperature: 1080 °C



Tempering diagram



Cryodur® 2709

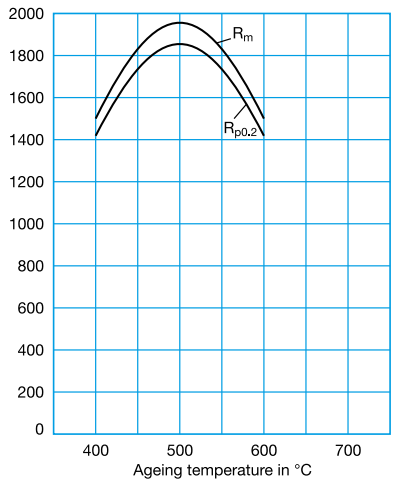
(X3NiCoMoTi18-9-5)	C ≤ 0.02 Mo 5.00 Ni 18.00 Co 10.00 Ti 1.00
Steel properties	Low susceptibility to distortion, precipitation hardening, high yield point and tensile strength combined with good toughness.
Standards	**AISI** 18MAR300
Physical properties	**Coefficient of thermal expansion**

at °C	20 - 100	20 - 150	20 - 200	20 - 250	20 - 300	20 - 350	20 - 400	20 - 450	20 - 500
10^{-6} m/(m • K)	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.8
Precipitation hardened									

Thermal conductivity at °C	23	150	300	350	400	500
W/(m • K)	18.4	20.4	22.7	23.2	23.5	24.0
Precipitation hardened						

Applications	Casings for cold extrusion tools, pressure casting moulds for light metals and plastic moulds of intricate design.		
Heat treatment	**Soft annealing °C** 820 – 850	**Cooling** Water	**Hardness HB** max. 340
	Ausscheidungshärte °C 490 / 6 hr / (Air)	**Attainable hardness HRC** approx. 55	

Precipitation diagram

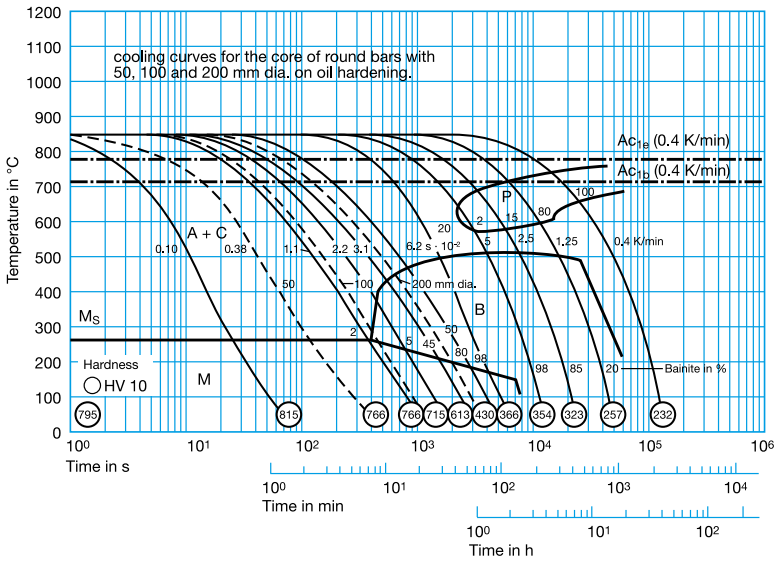


Reference numbers in brackets are not standardized in EN ISO4957.

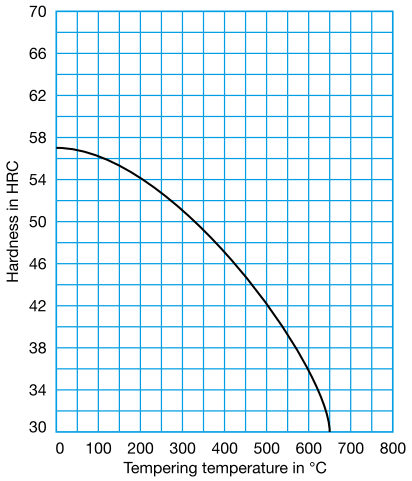
Formadur® 2711

54NiCrMoV6	C 0.55 Cr 1.10 Ni 1.70 Mo 0.50 V 0.10
Steel properties	Pre-hardened plastic mould steel, hardness in as-delivered condition 355 to 400 HB (square, flat) and 370 – 410 HB (round). Increased compressive strength in comparison to Formadur® 2738, good polishability.
Standards	**AISI** ~L6
Physical properties	**Coefficient of thermal expansion** **at °C** 20 – 100 / 20 – 150 / 20 – 200 / 20 – 250 / 20 – 300 / 20 – 350 / 20 – 400 / 20 – 450 / 20 – 500 **10^{-6} m/(m • K)** 12.2 / 12.5 / 12.7 / 13.0 / 13.3 / 13.5 / 13.8 / 13.9 / 14.1 **Quenched and tempered** **Thermal conductivity at °C** 23 / 150 / 300 / 350 / 400 / 500 **W/(m • K)** 30.5 / 32.1 / 30.8 / 29.6 / 28.7 / 26.5 **Quenched and tempered**
Applications	Plastic moulds with increased demands on compression strength and wear resistance.
Heat treatment	**Soft annealing °C** 650 – 700 — **Cooling** Furnace — **Hardness HB** max. 240 **Hardening °C** 830 – 830 — **Quenching** Air or oil — **Hardness after quenching HRC** 57 **Tempering °C** 100 / 200 / 300 / 400 / 450 / 500 / 550 / 600 / 650 **HRC** 56 / 54 / 51 / 47 / 44 / 42 / 39 / 36 / 30

Time-temperature-transformation diagram



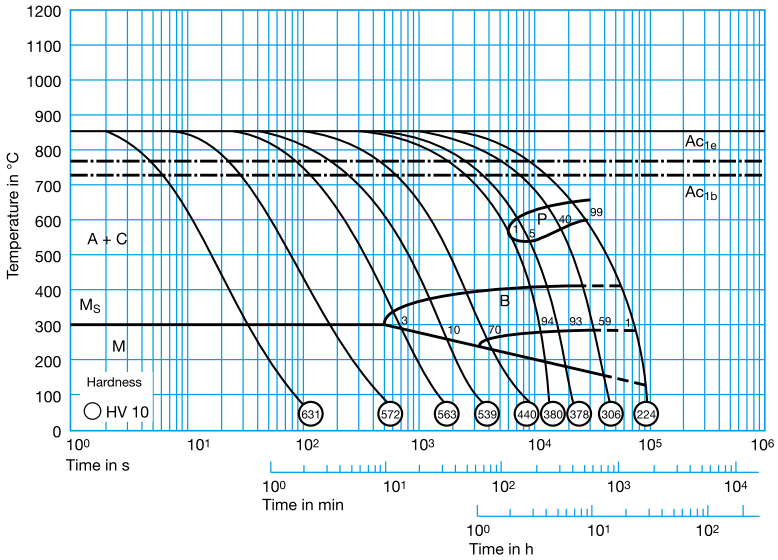
Tempering diagram



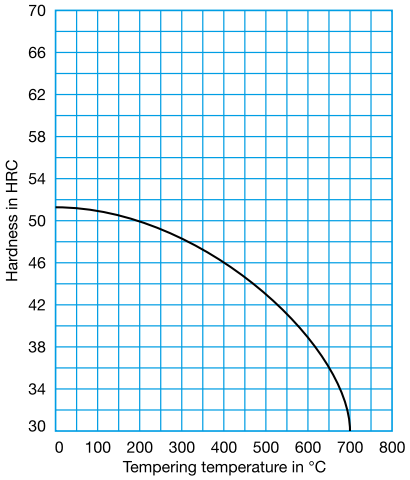
Formadur® 2738

40CrMnNiMo8-6-4	C 0.40 Mn 1.50 Cr 1.90 Ni 1.00 Mo 0.20
Steel properties	Pre-hardened plastic mould steel, hardness in as-delivered condition 280 to 325 HB. Good machinability, suitable for texturing, improved through hardening in comparison to Formadur® 2711, good polishability.
Standards	**AISI** P20+Ni
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 100 | 20 - 200 | 20 - 300 | 20 - 400 | 20 - 500 | 20 - 600 | 20 - 700 **10^{-6} m/(m • K)** 11.1 | 12.9 | 13.4 | 13.8 | 14.2 | 14.6 | 14.9 **Thermal conductivity at °C** 20 | 350 | 700 **W/(m • K)** 34.5 | 33.5 | 32.0
Applications	Large plastic moulds with deep engravings and intensive impacts on the core. Formadur® 2738 is the logical development of Formadur® 2311, a pre-hardened plastic mould steel for use in large moulds, which also have to display high core strength. The additional nickel content of 1 % increases through hardening. Formadur® 2738 ia a micro-alloyed, vacuum-degassed steel with the following excellent features: good machinability, outstanding polishability, good texturing properties.
Heat treatment	**Soft annealing °C** 710 – 740 | **Cooling** Furnace | **Hardness HB** max. 235 **Hardening °C** 840 – 870 | **Quenching** Polymer or oil | **Hardness after quenching HRC** 51 **Tempering °C** 100 | 200 | 300 | 400 | 500 | 600 | 700 **HRC** 51 | 50 | 48 | 46 | 42 | 39 | 28

Time-temperature-transformation diagram



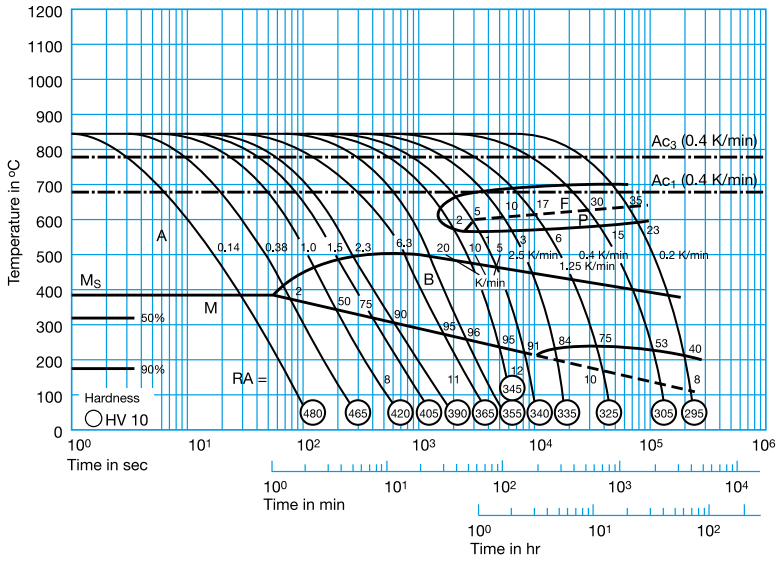
Tempering diagram



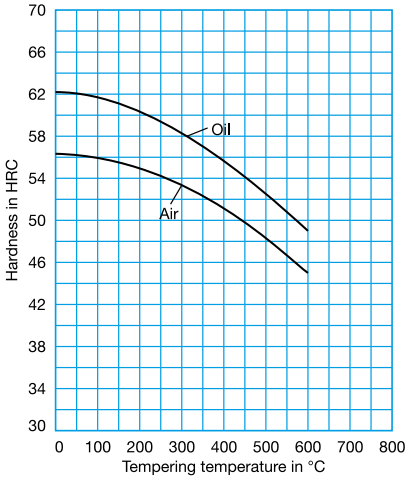
Formadur® 2764

(X19NiCrMo4)	C 0.19 Cr 1.30 Mo 0.20 Ni 4.10
Steel properties	Case-hardening steel, high core strength, good polishability.
Standards	**AISI** ~P21
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 100 20 - 200 20 - 300 20 - 400 **10^{-6} m/(m • K)** 12.1 13.0 13.1 13.5 **Thermal conductivity at °C** 20 350 700 **W/(m • K)** 33.5 32.5 32.0
Applications	Highly stressed plastic moulds.
Heat treatment	**Soft annealing °C** 620 – 660 — **Cooling** Furnace — **Hardness HB** max. 250 **Stress-relief annealing °C** 600 — **Cooling** Furnace **Carburizing °C** / **Intermediate annealing °C** — **Hardening °C** — **Quenching** — **Hardness after quenching HRC** 860 – 890 / 600 – 630 — 780 – 810 — Oil or saltbath, 180 – 220 °C — 62 860 – 890 / 600 – 630 — 800 – 830 — Air — 56 **Tempering °C** 100 200 300 400 500 600 **after oil hardening HRC** 62 60 58 56 52 49 **after air hardening HRC** 56 55 53 51 48 45

Time-temperature-transformation diagram



Tempering diagram



Reference numbers in brackets are not standardized in EN ISO4957.

Cryodur® 2767

45NiCrMo16	C 0.45 Si 0.25 Mn 0.35 Cr 1.40 Mo 0.20 Ni 4.00
Steel properties	High hardenability and toughness, highly suitable for polishing, texturing and EDM machining.
Standards	**AISI** 6F3
Physical properties	**Coefficient of thermal expansion**

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	11.3	11.7	11.9	12.2	12.5	12.2	12.0	12.1	12.4

Quenched and tempered

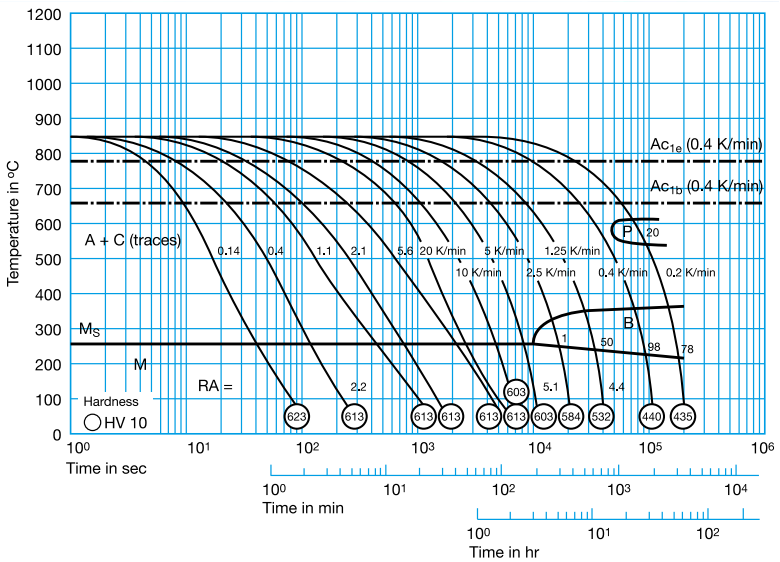
Thermal conductivity at °C	23	150	300	350	400	500
W/(m • K)	31.0	34.0	33.9	34.1	33.2	31.2

Quenched and tempered

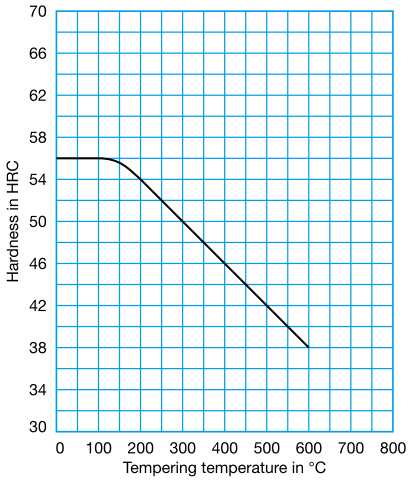
Applications	Cutlery moulds, cutting tools for thick material, billet-shear blades, drawing jaws, solid embossing and bending tools, plastic moulds, casings.		
Heat treatment	**Soft annealing °C** 610 – 650	**Cooling** Furnace	**Hardness HB** max. 260
	Stress-relief annealing °C approx. 600 – 650	**Cooling** Furnace	
	Hardening °C 840 – 870	**Quenching** Air, oil or saltbath, 180 – 220 °C	**Hardness after quenching HRC** 56

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

Time-temperature-transformation diagram



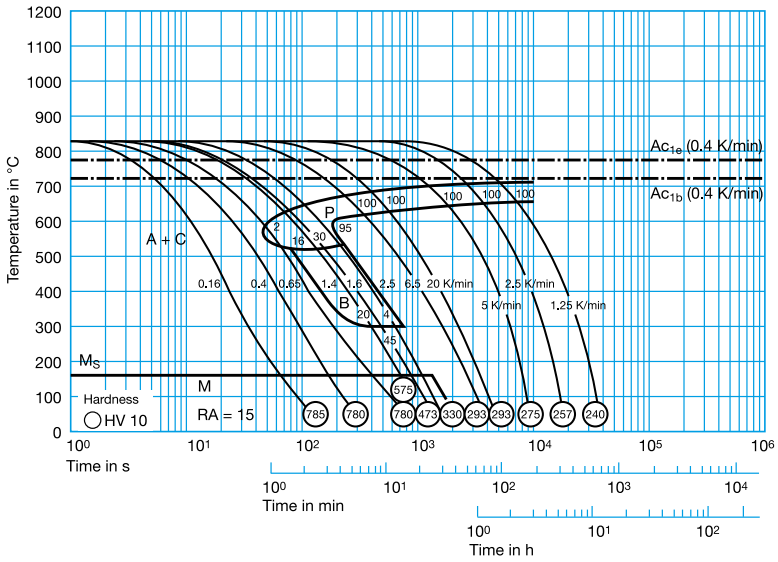
Tempering diagram



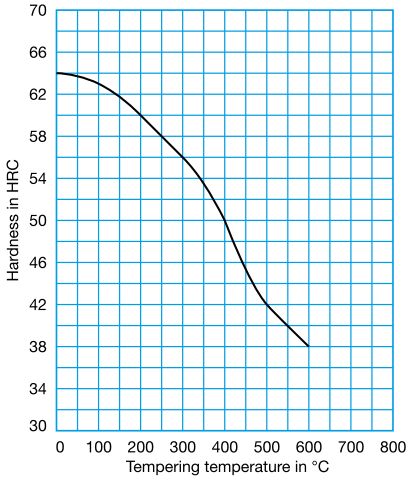
Cryodur® 2842

90MnCrV8	C 0.90 Si 0.20 Mn 2.00 Cr 0.40 V 0.10						
Steel properties	Good cutting-edge endurance, high hardenability, dimensionally stable during heat treatment.						
Standards	**AISI** O2 **AFNOR** 90MV8						
Physical properties	**Coefficient of thermal expansion**						
	at °C	20 - 100	20 - 200	20 - 300	20 - 400	20 - 500	20 - 600	20 - 700
	10^{-6} m/(m • K)	12.2	13.2	13.8	14.3	14.7	15.0	15.3
	Thermal conductivity at °C	20	350	700				
	W/(m • K)	33.0	32.0	31.3				
Applications	Tool steel for universal use, cutting and stamping tools for sheet metal up to 6 mm thick, thread-cutting tools, drills, reamers, gauges, measuring tools, plastic moulds, shear blades, guide strips.						
Heat treatment	**Soft annealing °C**	**Cooling**			**Hardness HB**		
	680 – 720	Furnace			max. 220		
	Stress-relief annealing °C	**Cooling**					
	approx. 650	Furnace					
	Hardening °C	**Quenching**			**Hardness after quenching HRC**		
	790 – 820	Oil or saltbath, 180 – 220 °C			64		
	Tempering °C	100	200	300	400	500	600
	HRC	63	60	56	50	42	38

Time-temperature-transformation diagram



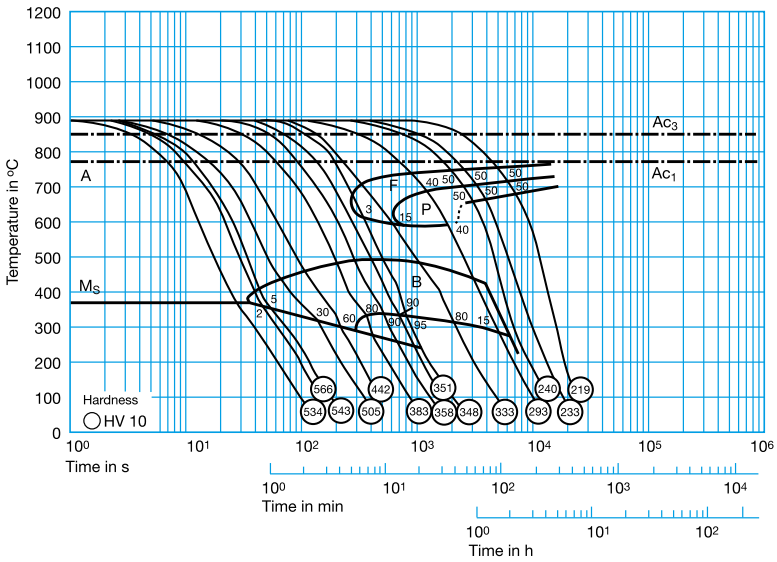
Tempering diagram



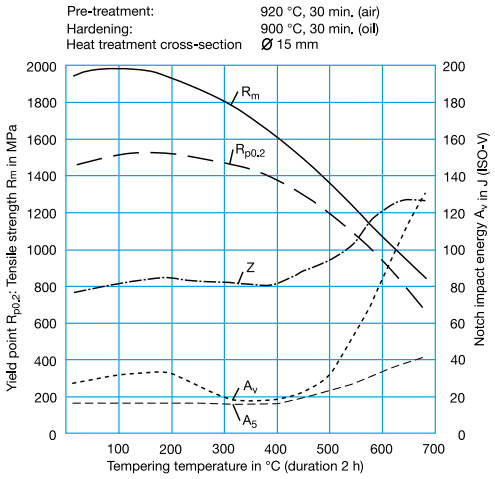
Formadur® 2891

34CrAlNi7	C 0.35 Si 0.40 Al 1.00 Cr 1.70 Mo 0.20 Ni 1.00					
Physical properties	Quenched and tempered QT					
	Heat treatment diameter in mm Ø	**Yield stress in MPa, $R_{p0,2}$ min.**	**Tensile strength in MPa, R_m**	**Elongation at fracture in % A min.**	**Reduction of area at fracture in % Z min.**	**Notched impact energy (ISO-V) in J Av min.**
	16 – 40	680	900 – 1100	10	–	30
	> 40 – 100	650	850 – 1050	12	–	30
	> 100 – 160	600	800 – 1000	13	–	35
	> 160 – 250	600	800 – 1000	13	–	35
Applications	Aluminium-alloyed nitriding steel for large cross sections, suitable for piston rods, extruders, cylinders.					
Hardness at different treatment stages	**Soft-annealed HB** max. 248		**Nitrided surface hardness HV1** approx. 950			
Heat treatment	**Soft annealing °C** 680 – 720	**Hardening °C** Furnace	**Quenching** Polymer or oil	**Tempering °C** 580 – 700	**Nitriding °C** 480 – 570	
Thermal expansion	**Tempering °C**	-191 – +16	20 – 100	20 – 200	20 – 300	20 – 400	20 – 500
	Linear coefficient of thermal expansion α 10^{-6} K^{-1}	9.1	11.1	12.1	12.9	13.5	13.9

Time-temperature-transformation diagram



Tempering diagram



Cryodur® 2990

(~X100CrMoV8-1-1)	C 1.00 Si 0.90 Cr 8.00 Mo 1.60 V 1.60
Steel properties	Newly developed ledeburitic cold-work steel with high hardness, good toughness and high tempering resistance combined with high wear resistance.
Physical properties	**Coefficient of thermal expansion**

at °C	20 - 100	20 - 150	20 - 200	20 - 250	20 - 300	20 - 350	20 - 400	20 - 450	20 - 500
10^{-6} m/(m • K)	11.4	11.6	11.7	11.9	12.0	12.1	12.3	12.4	12.6

Thermal conductivity at °C	RT	100	150	200	300	400	500
W/(m • K)	24.0	25.9	26.8	27.1	27.4	27.2	26.8

Applications	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.

Heat treatment

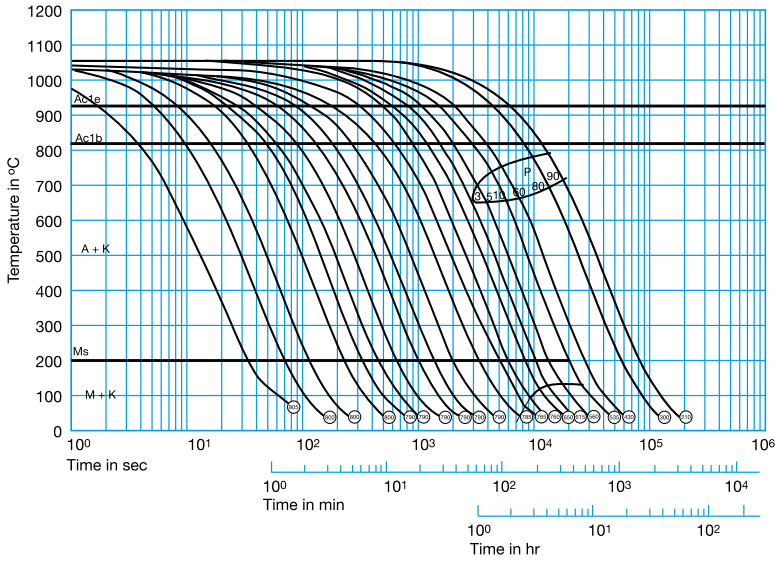
Soft annealing °C	**Cooling**	**Hardness HB**
830 – 860	Furnace	max. 250

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

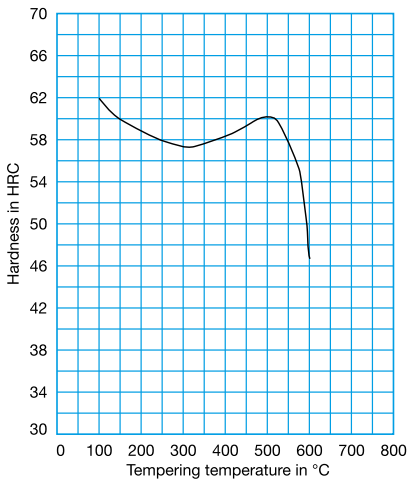
Hardening °C	**Quenching**	**Hardness after quenching HRC**
1030[1] – 1080[2]	Air, oil or saltbath, 500 – 550 °C	62 – 64

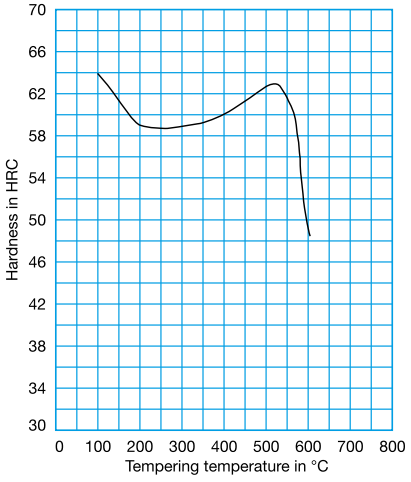
Tempering °C	100	200	300	400	500	525	550	575	600
[1] HRC	62	59	57	58	60	60	59	55	46
[2] HRC	64	59	59	60	63	63	61	57	48

Time-temperature-transformation diagram



Tempering diagram
Above: Hardening 1030 °C
Below: Hardening 1080 °C





Reference numbers in brackets are not standardized in EN ISO4957.

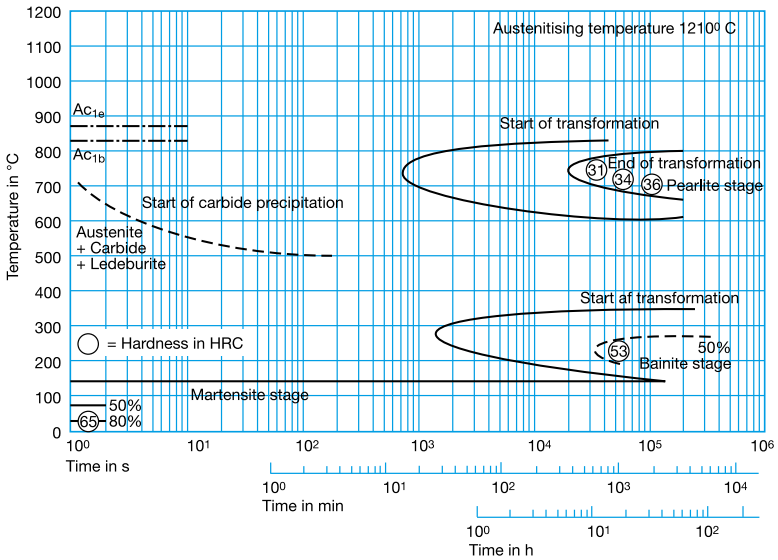
Rapidur® 3343

HS6-5-2C	C 0.90 Si 0.30 Mn 0.30 Cr 4.10 Mo 5.00 V 1.90 W 6.40
Steel properties	Standard high-speed steel grade. High toughness and good cutting power owing to its well-balanced alloy composition. Therefore suitable for a wide variety of applications.
Standards	**AISI** M2 — **AFNOR** Z85WDCV06-05-04-02
Physical properties	**Coefficient of thermal expansion at °C** 20 350 700 **W/(m • K)** 32.8 23.5 25.5
Applications	Plastic moulds with increased wear resistance, screws.
Heat treatment	**Soft annealing °C** 770 - 860 — **Cooling** Furnace — **Hardness HB** max. 269 **Stress-relief annealing °C** 630 – 650 — **Cooling** Furnace

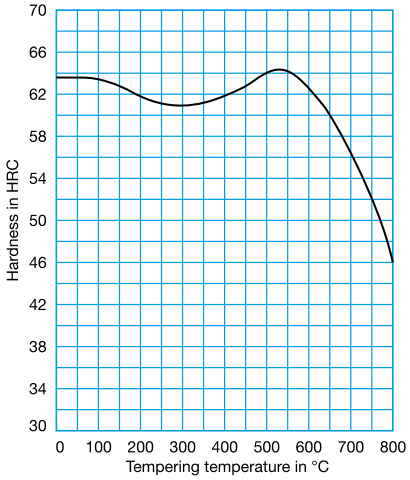
1st pre-heating °C	2nd and 3rd pre-heating °C	Hardening °C	Quenching	Tempering °C	Hardness after tempering HRC
up to approx. 400 in an air-circulating furnace	a) 850 b) 850 and 1050	1190 - 1230	a) Saltbath, 550 °C b) Oil c) Air	at least twice 530 - 560	64 - 66

[1] For cold-forming tools with 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 °C to 30 °C.

Isothermal time-temperature-transformation diagram



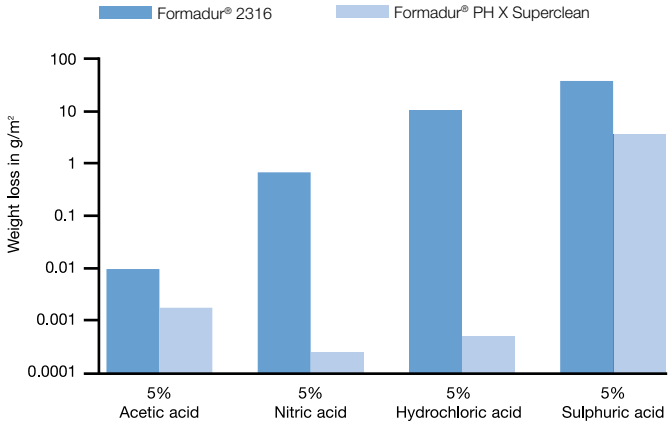
Tempering diagram



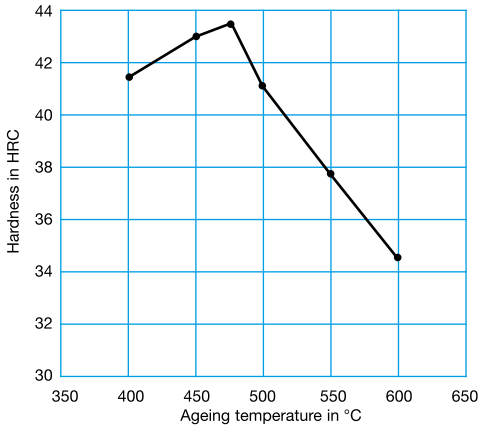
Formadur® PH X Superclean

(X5CrNiCuNb15-5)	C 0.05 Cr 15.00 Ni 4.50 Cu 3.50 Nb +
Steel properties	Formadur® PH X Superclean is a corrosion-resistant, precipitation hardened steel with high strength. It shows excellent polishability due to the applied remelting process. Compared to Formadur® 2316, hardness in as-delivered condition and corrosion resistance are improved.
Physical properties	**Coefficient of thermal expansion** **at °C** 20 - 100 20 - 150 20 - 200 20 - 250 20 - 300 20 - 350 20 - 400 20 - 450 20 - 500 **10^{-6} m/(m • K)** 10.4 10.6 10.9 11.1 11.4 11.5 11.7 11.9 12.0 **Precipitation hardened** **Thermal conductivity at °C** 23 150 300 350 400 500 **W/(m • K)** 16.8 20.1 22.1 22.8 23.3 24.1 **Precipitation hardened**
Applications	Formadur® PH X Superclean is recommended for tools used in the processing of corrosive plastics. Further applications for components in aircraft and chemical industries.
Heat treatment	Formadur® PH X Superclean usually is supplied in precipitation-hardened condition with a hardness of 40 HRC.

Weight loss diagram



Ageing diagram

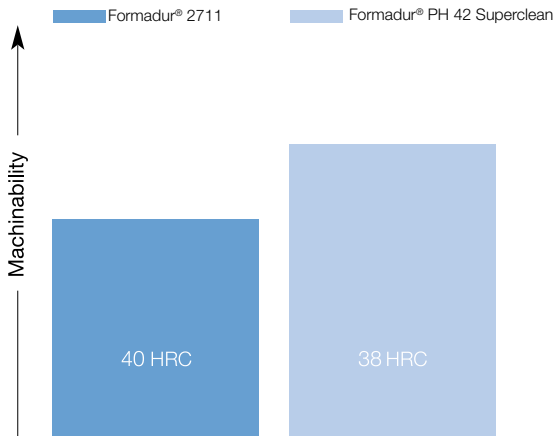


Reference numbers in brackets are not standardized in EN ISO 4957.

Formadur® PH 42 Superclean

(15NiCuAl12-10-10)	C 0.15 Mn 1.50 Ni 3.00 Cu 1.00 Al 1.00
Steel properties	As-delivered hardness approx. 38 HRC (approx. 1200 MPa). Precipitation hardened, remelted plastic mould steel with exellent polishability and suitability for texturing. Good electrical discharge machinability, machinability and weldability, suitable for nitriding. Improved compressive strength due to higher hardness compared to conventional plastic mould steel.
Physical properties	**Coefficient of thermal expansion** **at °C** 20 – 100 20 – 150 20 – 200 20 – 250 20 – 300 20 – 350 20 – 400 20 – 450 20 – 500 **10^{-6} m/(m • K)** 12.6 12.8 13.0 13.3 13.5 13.7 13.9 14.0 14.2 **Precipitation hardened** **Thermal conductivity at °C** 23 150 300 350 400 500 **W/(m • K)** 25.7 29.4 29.8 29.6 29.2 28.2 **Precipitation hardened** **Modulus of elasticity at °C** 20 **MPa** 206000
Applications	Formadur® PH 42 Superclean is suitable for all kinds of tools in plastic processing with high demands on strength, such as highly stressed plastic injection moulds, compression moulds and hot-runner systems.
Heat treatment	Formadur® PH 42 Superclean is supplied in precipitation hardened condition with a hardness of approx. 38 HRC. No additional heat treatment is necessary. After repair welding an ageing at 520 °C/1 hr is recommended.
Special information	Due to its well-balanced composition and its high homogeneity, Formadur® PH42 Superclean has a comparable machinability to Formadur® 2311 and 2738 even at a higher as-delivered hardness approx. 38 HRC. Compared to Formadur® 2711, machinability is significantly improved with a similar hardness level.

Machinability



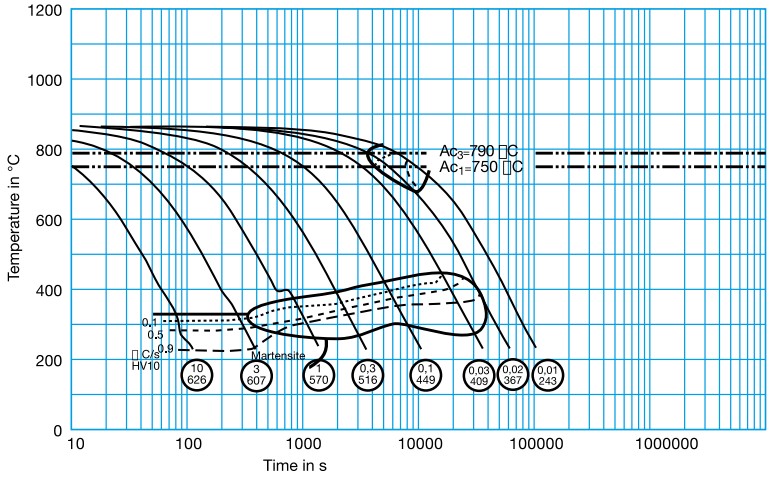
Comparison of machinability of conventional plastic mould steel Formadur® 2711 with Formadur® PH 42 Superclean.

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

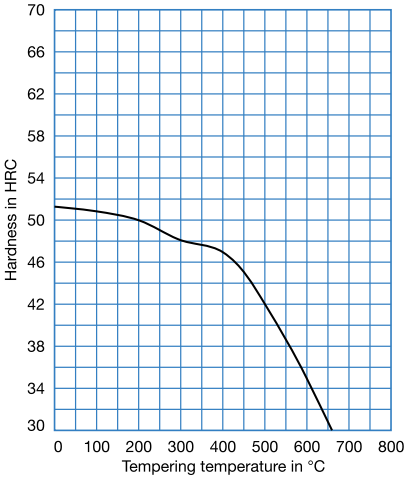
Formadur® 320/320 Superclean

	C 0.34 Mn 0.80 Cr 1.70 Ni 0.50 Mo 0.40						
Steel properties	Heat-treated mould steel with improved quenching and tempering properties in comparison to 1.2738. Good machinability, polishable, weldable and can easily be textured. Formadur® 320 is either available at a hardness of 280 – 325 HB or 310 – 355 HB. This grade offers substantial improvements, especially for building larger and complex moulds. Specific modifications of the grade's components as well as additional smelting and secondary metallurgy ensure Formadur® 320's outstanding properties. We recommend the use of Formadur® 320 Superclean (ESR) for the highest demands.						
Physical properties	**Coefficient of thermal expansion**						
	at °C	20 - 100	20 - 200	20 - 300	20 - 400	20 - 500	20 - 600	20 - 700
	10^{-6} m/(m • K)	11.1	12.9	13.4	13.5	13.8	14.1	14.3
	Thermal conductivity at °C	20	350	700				
	W/(m • K)	36.0	37.4	33.0				
Applications	Formadur® 320 is highly suitable for large-format plastic injection and extrusion moulds with deep engraving and high demands on core strength, such as with bumpers, tailgates, fenders, spoilers, instrument panels and TV housings to name a few. At a supplied hardness of 310 – 355 HB, maximum wear resistance is guaranteed.						
Heat treatment	**Soft annealing °C**	**Cooling**			**Hardness HB**		
	710 – 740	Furnace			max. 235		
	Hardening °C	**Quenching**			**Hardness after quenching HRC**		
	820 – 850	Polymer or oil			51		
	Tempering °C	100	200	300	400	500	600	700
	HRC	51	50	48	47	42	35	28

Time-temperature-transformation-diagram



Tempering diagram



Corroplast®

	C 0.05 Mn 1.30 S 0.15 Cr 12.50 Additions +
Steel properties	Corroplast is a new corrosion-resistant steel for plastic moulding, featuring extremely good machinability at a supplied hardness of approx. 320 HB. The reduced carbon content endows Corroplast® with excellent welding properties.
Physical properties	**Coefficient of thermal expansion**

at °C	20 – 100	20 – 150	20 – 200	20 – 250	20 – 300	20 – 350	20 – 400	20 – 450	20 – 500
10^{-6} m/(m • K)	10.3	10.6	10.9	11.1	11.2	11.4	11.6	11.8	12.0
Precipitation hardened									

Thermal conductivity at °C	23	150	300	350	400	500
W/(m • K)	24.6	25.7	25.8	25.7	25.4	24.7
Precipitation hardened						

Density at °C	20
kg/dm³	7.7

Modulus of elasticity at °C	20	150	350
MPa	214600	208600	198000

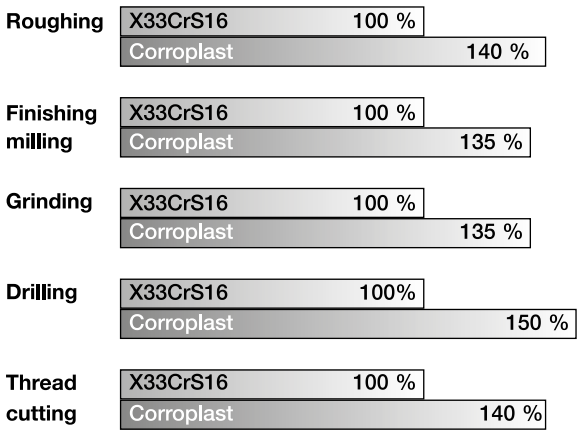
Applications	Base plates, mould bases and plastic moulds with standard requirements on polishability, as well as being resistant to condensation and cooling water.

Typical mechanical properties

in as-delivered condition

Heat treatment diameter in mm Ø	**Yield stress in MPa, $R_{p0,2}$ min.**	**Tensile strength in MPa, R_m**	**Elongation at fracture in % A min.**	**Reduction of area at fracture in % Z min.**
170	890	1100	13	42

Machinability of X33CrS16 and Corroplast® in % (hardness 325 HB)



Hardness comparison table

Tensile strength	Brinell hardness		Vickers hardness	Rockwell hardness		
	Ball indentation					
R_m MPa	mm d	HB	HV	HRB	HRC	HR 30 N
255	6.63	76.0	80	–	–	–
270	6.45	80.7	85	41.0	–	–
285	6.30	85.5	90	48.0	–	–
305	6.16	90.2	95	52.0	–	–
320	6.01	95.0	100	56.2	–	–
335	5.90	99.8	105	–	–	–
350	5.75	105	110	62.3	–	–
370	5.65	109	115	–	–	–
385	5.54	114	120	66.7	–	–
400	5.43	119	125	–	–	–
415	5.33	124	130	71.2	–	–
430	5.26	128	135	–	–	–
450	5.16	133	140	75.0	–	–
465	5.08	138	145	–	–	–
480	4.99	143	150	78.7	–	–
495	4.93	147	155	–	–	–
510	4.85	152	160	81.7	–	–
530	4.79	156	165	–	–	–
545	4.71	162	170	85.0	–	–
560	4.66	166	175	–	–	–
575	4.59	171	180	87.1	–	–
595	4.53	176	185	–	–	–
610	4.47	181	190	89.5	–	–
625	4.43	185	195	–	–	–
640	4.37	190	200	91.5	–	–
660	4.32	195	205	92.5	–	–
675	4.27	199	210	93.5	–	–
690	4.22	204	215	94.0	–	–
705	4.18	209	220	95.0	–	–
720	4.13	214	225	96.0	–	–
740	4.08	219	230	96.7	–	–
755	4.05	223	235	-	–	–
770	4.01	228	240	98.1	20.3	41.7

Tensile strength	Brinell hardness		Vickers hardness	Rockwell hardness		
	Ball indentation					
R_m MPa	mm d	HB	HV	HRB	HRC	HR 30 N
785	3.97	233	245	–	21.3	42.5
800	3.92	238	250	99.5	22.2	43.4
820	3.89	242	255	–	23.1	44.2
835	3.86	247	260	(101)	24.0	45.0
850	3.82	252	265	–	24.8	45.7
865	3.78	257	270	(102)	25.6	46.4
880	3.75	261	275	–	26.4	47.2
900	3.72	266	280	(104)	27.1	47.8
915	3.69	271	285	–	27.8	48.4
930	3.66	276	290	(105)	28.5	49.0
950	3.63	280	295	–	29.2	49.7
965	3.60	285	300	–	29.8	50.2
995	3.54	295	310	–	31.0	51.3
1030	3.49	304	320	–	32.2	52.3
1060	3.43	314	330	–	33.3	53.6
1095	3.39	323	340	–	34.4	54.4
1125	3.34	333	350	–	35.5	55.4
1155	3.29	342	360	–	36.6	56.4
1190	3.25	352	370	–	37.7	57.4
1220	3.21	361	380	–	38.8	58.4
1255	3.17	371	390	–	39.8	59.3
1290	3.13	380	400	–	40.8	60.2
1320	3.09	390	410	–	41.8	61.1
1350	3.06	399	420	–	42.7	61.9
1385	3.02	409	430	–	43.6	62.7
1420	2.99	418	440	–	44.5	63.5
1455	2.95	428	450	–	45.3	64.3
1485	2.92	437	460	–	46.1	64.9
1520	2.89	447	470	–	46.9	65.7
1555	2.86	(456)	480	–	47.7	66.4
1595	2.83	(466)	490	–	48.4	67.1
1630	2.81	(475)	500	–	49.1	67.7
1665	2.78	(485)	510	–	49.8	68.3

Hardness comparison table

Tensile strength	Brinell hardness		Vickers hardness	Rockwell hardness		
	Ball indentation					
R_m MPa	mm d	HB	HV	HRB	HRC	HR 30 N
1700	2.75	(494)	520	–	50.5	69.0
1740	2.73	(504)	530	–	51.1	69.5
1775	2.70	(513)	540	–	51.7	70.0
1810	2.68	(523)	550	–	52.3	70.5
1845	2.66	(532)	560	–	53.0	71.2
1880	2.63	(542)	570	–	53.6	71.7
1920	2.60	(551)	580	–	54.1	72.1
1955	2.59	(561)	590	–	54.7	72.7
1995	2.57	(570)	600	–	55.2	73.2
2030	2.54	(580)	610	–	55.7	73.7
2070	2.52	(589)	620	–	56.3	74.2
2105	2.51	(599)	630	–	56.8	74.6
2145	2.49	(608)	640	–	57.3	75.1
2180	2.47	(618)	650	–	57.8	75.5
–	–	–	660	–	58.3	75.9
–	–	–	670	–	58.8	76.4
–	–	–	680	–	59.2	76.8
–	–	–	690	–	59.7	77.2
–	–	–	700	–	60.1	77.6
–	–	–	720	–	61.0	78.4
–	–	–	740	–	61.8	79.1
–	–	–	760	–	62.5	79.7
–	–	–	780	–	63.3	80.4
–	–	–	800	–	64.0	81.1
–	–	–	820	–	64.7	81.7
–	–	–	840	–	65.3	82.2
–	–	–	860	–	65.9	82.7
–	–	–	880	–	66.4	83.1
–	–	–	900	–	67.0	83.6
–	–	–	920	–	67.5	84.0
–	–	–	940	–	68.0	84.4

Conversion of hardness values using this table is only approximate. See DIN 50150, December 1976.

Process and process parameters		
Brinell hardness (calculated from: HB = 0.95 · HV) (0.102 F/D^2 = 30) D = 10	Diameter of ball indentation in mm Hardness value = $\frac{0.102 \cdot 2F}{\varpi D(D - \sqrt{D^2 - d^2})}$	d HB
Vickers hardness	Diamond pyramid Test forces ≥ 50 N	HV
Rockwell hardness	Ball 1.588 mm ($^1/_{16}$“) Total test force = 98 N Diamond cone Total test force = 1471 N Diamond cone Total test force = 294 N	HRB HRC HR 30 N

Swiss Steel Group
www.swisssteel-group.com

Deutsche Edelstahlwerke
Specialty Steel GmbH & Co. KG

Auestr. 4
58452 Witten
GERMANY

Phone: +49 (0)2302 29 - 0
Fax: +49 (0)2302 29 - 4000

info@dew-stahl.com
www.dew-stahl.com

2014-0005