High Pressure Die Casting

Special steels for increasing customer demands

Swiss Steel Group

Provided by VETIMEC Soc Coop.

Deutsche Edelstahlwerke - your partner for high quality tool steel solutions

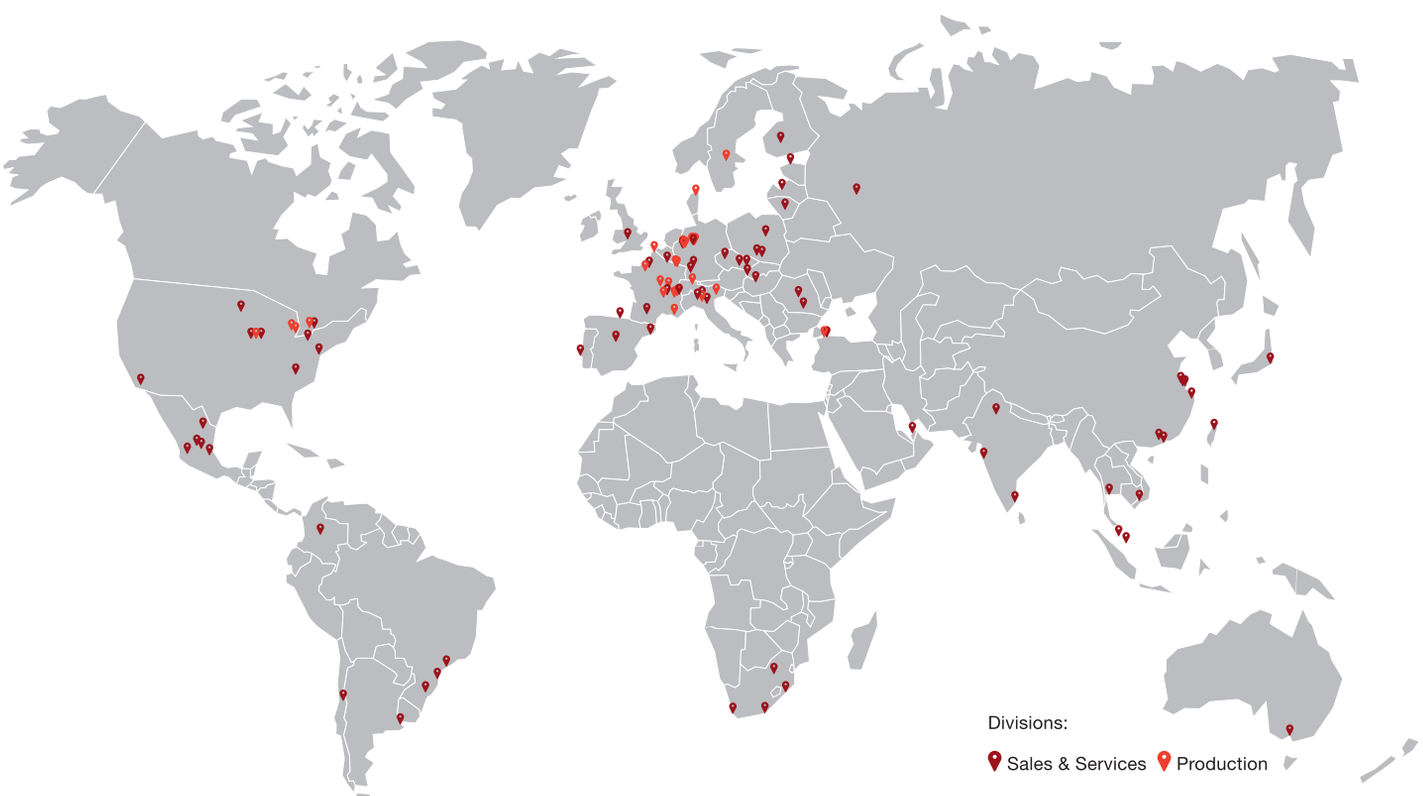
Deutsche Edelstahlwerke is one of the world's leading manufacturers of special steel long products. Deutsche Edelstahlwerke look back on over 170 years of experience in the production of high-grade steel products.

The range of products is unique worldwide and includes tool steels, stainless, acid and heat-resistant steels, engineering and bearing steels, and special materials. The product portfolio ranges from 5 mm drawn wire to forged products of up to 1,100 mm in diameter.

Customers of Deutsche Edelstahlwerke receive the entire manufacturing chain from a single source: from production to pre-machining to heat and surface treatment. Deutsche Edelstahlwerke is a member of the Swiss Steel Group.

The Swiss Steel Group is one of the world's leading providers of individual solutions in the sector of special steel long products. The Group is one of the leading manufacturers of tool steel and non-corrosive long steel on the global market and one of the two largest companies in Europe for alloyed and high-alloyed quality and engineering steels.

With more than 10,000 employees and its own manufacturing and distribution companies in more than 30 countries on 5 continents, the Swiss Steel Group guarantees global support and supply for its customers and offers them a complete portfolio of production and sales & services around the world. Customers benefit from the company's technological expertise, consistently high product quality around the world as well as detailed knowledge of local markets.



High Pressure Die Casting

High pressure die casting (HDPC) is one of the most cost-effective manufacturing processes used in the foundry industry and is renowned for its high dimensional accuracy and homogeneity during series production.

This method entails injecting molten metal into a die cavity at a very high speed. The pressure applied to transport the molten foundry metal stream into even the narrowest cross section is imperative for precise shape reproduction, which is one of the special benefits of high pressure die casting.

Die castings are predominantly designed to be as thin-walled as possible in order to allow shorter cycle times and reduce casting material. However, the die casting molds are exposed to considerable mechanical and thermal stresses during the casting process. The material properties of the mold therefore directly affect its service life.

The effects that the choice of suitable steels and the specific adjustment of individual alloys can have on the die's quality, reliability, and service life should therefore not be underestimated.

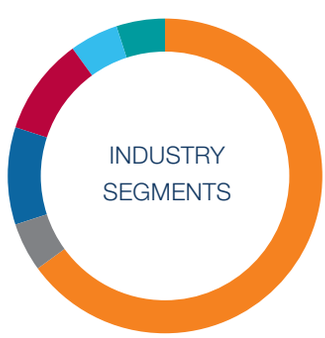
During the die casting process, temperatures fluctuate immensely and the intervals of temperature variation are very short and vary depending on the casting material used. This makes the thermal shock resistance of the hot work tool steel a top priority for the die caster.

The steel to be employed for a performing mold should offer the following properties:

- **Excellent thermal shock resistance**
- **High hot strength**
- **High toughness at elevated temperatures**
- **High thermal conductivity**
- **Excellent wear resistance at elevated temperatures**
- **High compression strength**
- **Good weldability**

Die casting parts are used in numerous applications as shown in the diagram below. By far the most important application area is the automotive industry, wherein the parts are used in cars, trucks or two-wheelers.

The changing powertrain technology will significantly influence the market, while also offering new opportunities in the area of electric vehicles.



Transportation (incl. electric vehicles)	**65%**
Instruments/hand tools	**10%**
Constructions/builders hardware	**10%**
Energy	**5%**
Telecommunication	**5%**
Others	**5%**

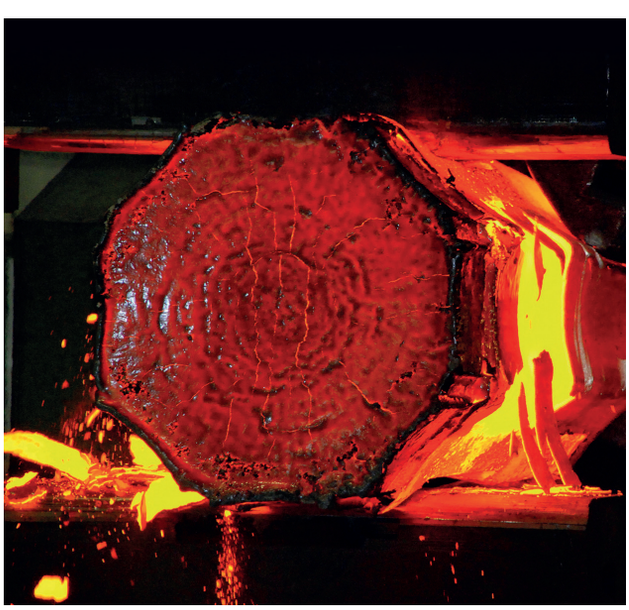
At Deutsche Edelstahlwerke you will always receive high performance steels, which set global standards for hot work tool steels.

Benefits for the tool manufacturer

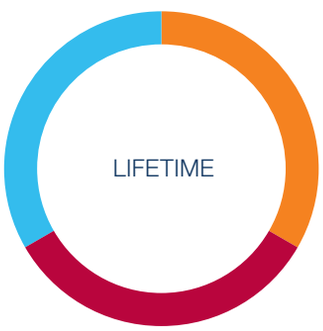
- Consistent quality
- Cost-effective machinability
- Uncomplicated heat treatment
- Good repair weldability
- Competent consulting
- Short delivery times

Benefits for the die caster

- Long service life
- Low die costs and low costs per unit
- Low susceptibility to heat checking
- Negligible repair efforts
- Good repair weldability
- Technical consulting
- Good dimensional stability
- Reproducible die casting quality



The main criterion of a die is the lifetime as strong key figure for the efficiency of the process. Besides the right choice of material for the die casting mold, various other factors influencing the service life of the mold must be considered.



Material properties:

- Chemical composition
- Steel production
- Heat treatment condition

Process parameters/ Operation method:

- Preheating
- Thermal shock
- Closing pressure

Tool design:

- Construction
- Machining
- Material flow
- Gate design

In the die casting industry new and challenging trends emerge that lead to new constraints but also new opportunities:

- Higher efficiency
- Number of shots (standardization/platform strategy)
- Wide diversity of casting alloys (aluminum, magnesium, zinc, etc.)
- Weight reduction of the produced parts to achieve less CO_2 emissions
- Increasing complexity of the parts produced
- Additive manufactured 3D-printed tools
- Dies of larger dimensions for structural parts
- Coating of the surface to avoid abrasion and to achieve better sliding and ejection properties

Steel selection for highest demands

For the increasing demands in the high pressure die casting industry we recommend using our high performance hot work tool steels from our Thermodur® Superclean range for more durable, reliable and cost-effective dies. These Electro-Slag Remelted (ESR) grades offer the required property profile with highest toughness values combined with a homogeneous microstructure and the finest grain size. Additionally we also offer the standard materials in our special condition with Extra Fine Structure (EFS) as Thermodur® 2343 EFS, Thermodur® 2344 EFS and Thermodur® 2367 EFS in non ESR condition.

Thermodur® 2343 Superclean is an electro slag remelted hot work tool steel, which can be applied universally. It offers high toughness potential and is thus particularly successful in large dies for processing light metal alloys. The most notable properties of Thermodur® 2343 Superclean are its high-temperature strength and toughness as well as the good thermal conductivity and insusceptibility to hot cracking.

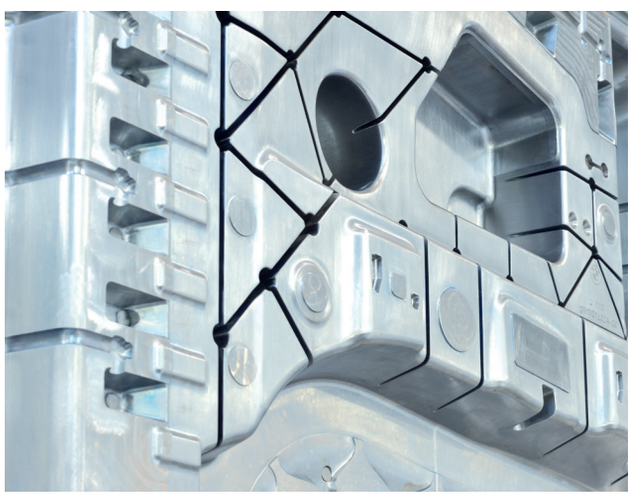
Thermodur® 2344 Superclean is a versatile hot work tool steel, which can be used in a wide range of applications. Compared to Thermodur® 2343 Superclean, it features increased tempering and wear resistance, but somewhat slightly lower hot toughness. Thus, it is especially suitable for small- to medium-sized molds in the production of light metal die castings.

Thermodur® 2367 Superclean combines the positive properties of Thermodur® 2343 Superclean and 2344 Superclean at improved high temperature strength and temperature stability. Its excellent tempering and heat checking resistance makes Thermodur® 2367 Superclean perfect for the production of light metal die castings frequently subjected to high temperatures.

Thermodur® E 38 K Superclean is an electro slag remelted hot work tool steel, which can be applied universally. The outstanding toughness values in comparison with Thermodur® 2343 Superclean make Thermodur® E 38 K Superclean the best solution for large high pressure die casting dies with complex geometry.

Thermodur® E 40 K Superclean is the premium hot work tool steel for HPDC dies and improves the lifetime due to an outstanding heat checking resistance. It combines highest toughness values with improved high temperature strength and is thus the perfect solution for die casting dies. With its high wear resistance at elevated temperatures and good isotropy of mechanical values Thermodur® E 40 K Superclean is the best choice for medium- to large-sized dies.

Thermodur® 2999 Superclean is a special hot work tool steel with maximum high-temperature strength, excellent thermal shock resistance and high thermal conductivity. Due to its high temperature wear resistance at elevated temperatures, Thermodur® 2999 Superclean was especially developed for use at highest temperatures. This property profile makes Thermodur® 2999 Superclean a special solution for inserts in light and heavy metal die casting.



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Brand	NADCA #207-2018*	
	Grade	**Type**
Thermodur® 2343 Superclean	D	D 1830
Thermodur® 2344 Superclean	A and B	A 1885 and B 1885
Thermodur® 2367 Superclean	C	C 1885
Thermodur® E 38 K Superclean	E	E 1850
Thermodur® E 40 K Superclean	H	H 1885

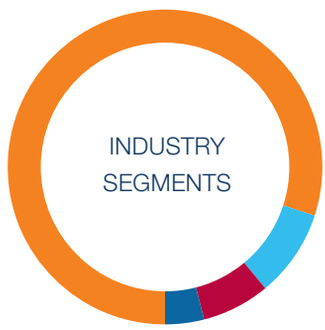
* Special Quality Die Steel & Heat Treatment
Acceptance Criteria for Die Casting Dies, NADCA #207-2018

Causes of failure in die casting applications

In the die casting industry, the demand for higher lifetime expectancy is unbroken.

For this reason, DEW has focused on the major failure modes of die casting dies to identify opportunities for improvement.

As roughly 80 % of all failures were caused by heat checking, the improving resistance to this failure type is the biggest challenge.



	Heat checking	**80%**
	Stress cracks	**9%**
	Corrosion	**7%**
	Soldering	**4%**

Choice of steel

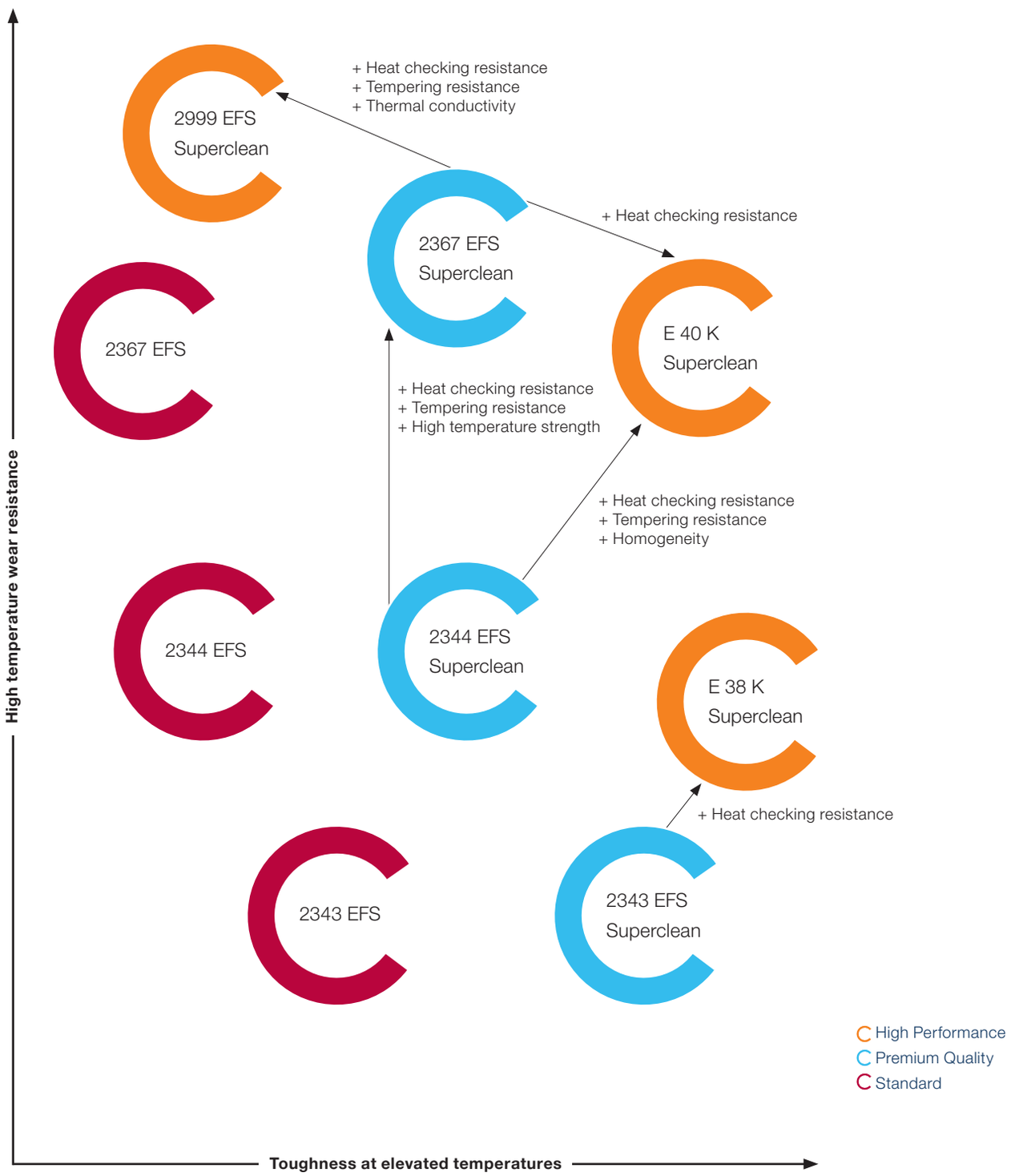
Depending on the application, shape, casting alloy, dimension of the tool and further factors, the steel selection should be made taking into account the overall property profile offered by each steel grade.

The table below shows a comparison of the main properties of our hot work tool steels used in die casting applications.

We divide our hot work tool steels into Standard material in the conventionally produced condition, Premium Quality in ESR condition and High Performance materials which are specially developed to reach outstanding results even in highly stressed HPDC tools.

Brand	Thermal shock resistance	Toughness	Tempering resistance	Wear resistance	Thermal conductivity	Polishability
Thermodur® 2343 EFS	•	••	••	••	••	••
Thermodur® 2343 Superclean	••	••••	••	••	••	•••
Thermodur® 2344 EFS	•	•	••	•••	••	••
Thermodur® 2344 Superclean	••	•••	••	•••	••	•••
Thermodur® 2367 EFS	•••	•	•••	••••	•••	••
Thermodur® 2367 Superclean	••••	•••	•••	••••	•••	•••
Thermodur® E 38 K Superclean	•••	•••••	••	••	••	•••••
Thermodur® E 40 K Superclean	••••	••••	•••	••••	•••	••••
Thermodur® 2999 Superclean	•••••	•	••••	•••••	••••	••

Decision tree



Machining notes for drilling

Grade	Treatment condition	Cutting speed v = m/min			Feed rate s = mm/rev.			Drill diameter mm		
		3343/ 3243	3343/ 3243 +TIN	HM K 10	3343/ 3243	3343/ 3243 +TIN	HM K 10	3343/ 3243	3343/ 3243 +TIN	HM K 10
Thermodur® 2343	Annealed	8–14	18–23	40–60	0.04–0.14	0.12–0.20	0.06–0.20	8–16	8–16	20–47
Thermodur® 2344	Annealed	8–14	18–23	40–60	0.04–0.14	0.12–0.20	0.06–0.20	8–16	8–16	20–47
Thermodur® 2367	Annealed	8–14	18–23	40–60	0.04–0.14	0.12–0.20	0.06–0.20	8–16	8–16	20–47
Thermodur® E 38 K	Annealed	8–14	18–23	40–60	0.04–0.14	0.12–0.20	0.06–0.20	8–16	8–16	20–47
Thermodur® E 40 K	Annealed	8–14	18–23	40–60	0.04–0.14	0.12–0.20	0.06–0.20	8–16	8–16	20–47
Thermodur® 2999	Annealed	8–14	18–23	40–60	0.04–0.14	0.12–0.20	0.06–0.20	8–16	8–16	20–47

All data refer to material in remelted (Superclean) condition

Machining notes for turning, using HSS and carbide cutting tools

Grade	Treatment condition	HSS tool RAPIDUR® 3207				Carbide cutting tool Coated with P25/P25 TIALAN			P10/P15
		Rough-machining		Finish-machining		Rough-machining		Finish-machining	
		Cutting speed Vc (m/min)	Feed rate s = mm/U	Cutting speed Vc (m/min)	Feed rate s = mm/U	Cutting speed Vc (m/min)	Feed rate s = mm/U	Cutting speed Vc (m/min)	Feed rate s = mm/U
Thermodur® 2343	Annealed	15–25	0.2–0.4	25–50	0.1–0.2	125–195	0.4–1.0	250–370	0.1–0.4
Thermodur® 2344	Annealed	15–25	0.2–0.4	25–50	0.1–0.2	125–195	0.4–1.0	250–370	0.1–0.4
Thermodur® 2367	Annealed	15–25	0.2–0.4	25–50	0.1–0.2	125–195	0.4–1.0	250–370	0.1–0.4
Thermodur® E 38 K	Annealed	15–25	0.2–0.4	25–50	0.1–0.2	125–195	0.4–1.0	250–370	0.1–0.4
Thermodur® E 40 K	Annealed	15–25	0.2–0.4	25–50	0.1–0.2	125–195	0.4–1.0	250–370	0.1–0.4
Thermodur® 2999	Annealed	10–20	0.2–0.4	20–30	0.1–0.2	115–175	0.4–1.0	235–350	0.1–0.4

All data refer to material in remelted (Superclean) condition

Machining notes for milling, using HSS and carbide cutting tools

Grade	Treatment condition	HSS tool RAPIDUR® 3207				Carbide cutting tool Coated with P40 TIALAN			P25
		Rough-machining		Finish-machining		Rough-machining		Finish-machining	
		Cutting speed Vc (m/min)	Feed rate s = mm/U	Cutting speed Vc (m/min)	Feed rate s = mm/U	Cutting speed Vc (m/min)	Feed rate s = mm/U	Cutting speed Vc (m/min)	Feed rate s = mm/U
Thermodur® 2343	Annealed	10–18	0.1–0.2	15–30	0.05–0.1	110–170	0.3–0.6	110–170	0.1–0.2
Thermodur® 2344	Annealed	10–18	0.1–0.2	15–30	0.05–0.1	110–170	0.3–0.6	110–170	0.1–0.2
Thermodur® 2367	Annealed	10–18	0.1–0.2	15–30	0.05–0.1	110–170	0.3–0.6	110–170	0.1–0.2
Thermodur® E 38 K	Annealed	10–18	0.1–0.2	15–30	0.05–0.1	110–170	0.3–0.6	110–170	0.1–0.2
Thermodur® E 40 K	Annealed	10–18	0.1–0.2	15–30	0.05–0.1	110–170	0.3–0.6	110–170	0.1–0.2
Thermodur® 2999	Annealed	8–10	0.18–0.25	10–15	0.2–0.4	80–160	0.2–0.4	90–180	0.15–0.25

All data refer to material in remelted (Superclean) condition

Heat treatment

Stress-relief annealing

Residual stresses occur during machining and chipless forming. These stresses may result in distortion and possibly expensive rework in the course of subsequent heat treatment. Stress-relief annealing should be performed at a temperature of 600 to 650 °C after rough machining, especially for tools with a complex geometry.

Hardening | Heating

As a result of low thermal conductivity and different tool cross-sections, considerable thermal stresses occur in the event of rapid heating to hardening temperature. These stresses may lead to deformation or even cracks in the tool. Certain preheating stages specified in the time-temperature sequences in the material data sheets must be observed.

Austenitizing

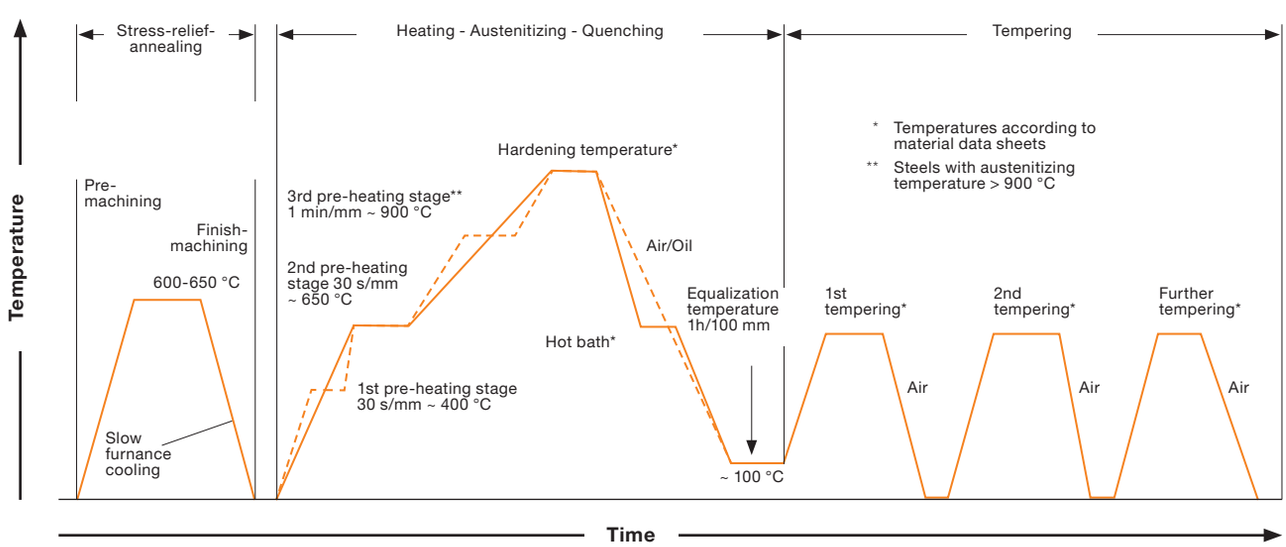
After the final preheating stage, the tools are heated to the material's specific hardening temperature (see material data sheet). After through heating (temperature equalization), the tool must be kept at this temperature to ensure complete transformation.

Quenching

Quenching of the tools is the most critical phase of the heat treatment process. There is a risk of hardness stress cracking as a result of thermal and microstructural transformation stresses. Design-related factors promoting cracking are abrupt material transitions, different wall thicknesses, and large hardening cross sections. For the material, it would be ideal to aim for the fastest possible cooling in order to achieve a purely martensitic transformation. However, compromises are necessary due to the risk of cracking addressed earlier. These compromises must be agreed between the steel manufacturer, the heat treatment company and the toolmaker for each individual case.

Tempering

Tempering is necessary in order to obtain the appropriate combination of hardness and toughness for the intended application. Tempering must be performed immediately after quenching and equalizing to prevent tension cracks.



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