Uddeholm

Tyrax® ESR

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Uddeholm Tyrax® ESR

Uddeholm Tyrax ESR is a premium high hardness and corrosion resistant plastic mould steel. It is designed with very high ductility/toughness and is easy and fast to polish to the highest surface finish levels. This grade is suited for moulding of high performance plastics often filled with glass fibre reinforcements and corrosive additives like flame retardants. It is also perfect for lens applications where the surface finish is important.

Classified according to EU Directive 1999/45/EC
For further information see our "Material Safety Data Sheets".

Edition 3, 11.2020

SS-EN ISO 9001
SS-EN ISO 14001

GENERAL

Uddeholm Tyrax ESR is a premium high hardness and corrosion resistant plastic mould steel with the following properties:

- good corrosion resistance
- excellent polishability
- good wear resistance
- good machinability
- high hardness 55-58 HRC for resistance against indentations
- excellent ductility and toughness
- good dimensional stability at heat treatment and in service
- even microstructure and small grain size
- good hardenability

Uddeholm Tyrax ESR is delivered in soft annealed condition to approximate 190 HB. Uddeholm Tyrax ESR is produced using the Electro-Slag-Remelting (ESR) technique, resulting in very low inclusion content.

Typical analysis %*	C 0.40	Si 0.2	Mn 0.5	Cr 12.0	Mo 2.3	V 0.5	N +
Delivery condition	Soft annealed to approx. 190 HB.						
Colour code	Black/purple						

** Patent pending.*

APPLICATIONS

Uddeholm Tyrax ESR is suitable for long run production moulds, moulds for reinforced plastics and for compression moulding. Engineering applications like plasticizing screws are also an option. Uddeholm Tyrax ESR can be used in corrosive conditions as moulds subjected to humid working/storage conditions or for production of corrosive plastics. Its high toughness/ductility makes it suitable for complex moulds. Uddehom Tyrax ESR is also suitable when high gloss surface finish is required.

- High performance plastics filled with glass fibers and corrosive additives
- Corrosive plastics like PVC
- High surface finish, i.e. for production of optical parts

PROPERTIES

PHYSICAL DATA

Hardened and tempered to 56 HRC. Data at room and elevated temperatures.

Temperature	20°C (68°F)	200°C (390°F)	400°C (750°F)
Density kg/m3 lbs/in3	7750	-	-
Modulus of elasticity MPa p.s.i	216 000 $31.3x10^6$		
Coefficient of thermal expansion /°C from 20°C /°F from 68°F	- -	$11.3x10^{-6}$ $6.3x10^{-6}$	$12.0x10^{-6}$ $6.7x10^{-6}$
Thermal conductivity* W/m °C Btu in/ft2h °F	- -	23,5 163	24,6 171
Specific heat capacity J/kg °C Btu/lb °F	460 0,11	- -	- -

** Thermal conductivity is very difficult to measure. The scatter can be as high as +-15%.*

TENSILE STRENGTH AT ROOM TEMPERATURE

The tensile strength values are to be considered as approximate. The test samples have been hardened at 1050-1080°C (1920-1975°F), gas quenched in a vacuum furnace and tempered twice at 530°C (985°F) for two hours to the given hardness. All specimens have been taken from a bar with the dimension 254x102 mm (10" x 4").

Hardness	56 HRC	58 HRC
Tensile strength Rm MPa p.s.i	2060 299 000	2260 328 000
Yield strength Rp0.2 MPa p.s.i	1460 212 000	1610 234 000

COMPRESSIVE STRENGTH

Approximately compressive strength is shown in the table below. The test samples have been hardened at 1050°C (1920°F), gas quenched in a vacuum furnace and tempered twice at 525°C (980°F) for two hours to the given hardness.

Hardness HRC	Compressive yield strength, Rc0,2 (MPa)
56	1820

IMPACT TOUGHNESS

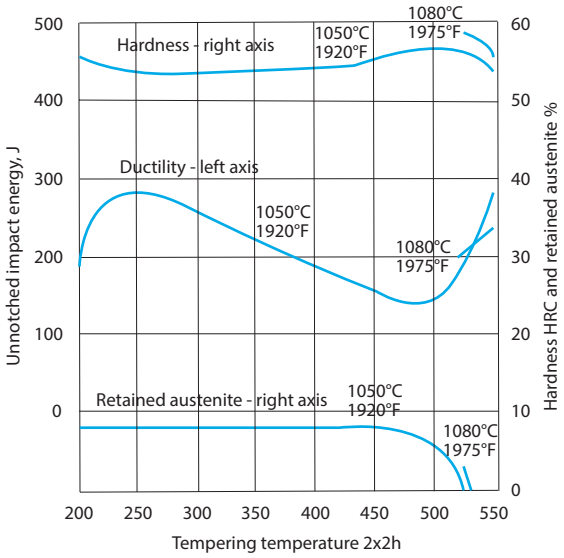
Uddeholm Tyrax ESR has much higher toughness/ductility compared to other stainless tool steel of W.-Nr. 1.2083/AISI 420 type.

Approximate room temperature impact strength as measured by samples removed from the centre of a forged block, tested in the short transverse direction is shown below. Original bar dimension: 250x80 mm (10" x 3") Specimen size: 7 x 10 x 55 mm (0.27" x 0.4" x 2.2") unnotched.

Hardened at 1050°C (1920°F) and 1080°C (1980°F) for 30 minutes. Quenched in a vacuum furnace. Tempered 2 x 2h.

INFLUENCE OF TEMPERING TEMPERATURE ON UNNOTCHED IMPACT TOUGHNESS

All tests has been carried out at room temperature.



CORROSION RESISTANCE

Uddeholm Tyrax ESR shows the best corrosion resistance when tempered at a low temperature and polished to a mirror finish. Uddeholm Tyrax ESR is resistant to corrosive attack by water, water vapour, weak organic acids, dilute solutions of nitrates, carbonates and other salts.

A tool made from Uddeholm Tyrax ESR will have good resistance to rusting and staining due to humid working and storage conditions and when moulding corrosive plastics under normal production conditions.

HEAT TREATMENT

SOFT ANNEALING

Protect the steel and heat through to 860°C (1580°F). Then cool in the furnace at 10°C/h to 650°C (1200°F), then freely in air.

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F) and held for 2h. Cool slowly to 500°C (930°F), then freely in air.

HARDENING AND HARDENABILITY

Use a preheating temperature of 600-850°C (1110-1560°F). Recommended austenitizing temperature is 1050-1080°C (1920-1975°F), holding time 30 minutes.

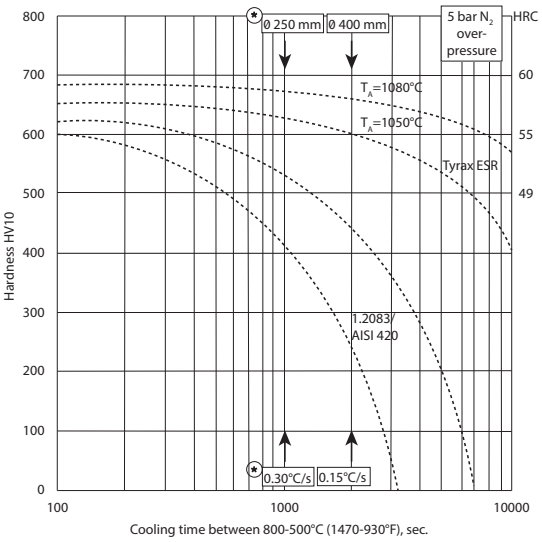
Quenching media recommended are:
- vacuum furnace (high speed gas with sufficient overpressure)
- fluidized bed or salt bath at 250-550°C (480-1020°F) then cool in air blast
- High speed gas/circulating atmosphere

In order to obtain optimum properties, the cooling rate should be as fast as possible while maintaining an acceptable level of distortion. When heating in a vacuum furnace, a minumum of 4-5 bar overpressure is recommended. Temper immediately when the tool reaches 50-70°C (120-160°F).

Uddeholm Tyrax ESR has a much better hardenability than the W.-Nr. 1.2083/AISI 420 type of material so the high hardness will be retained even in the centre of large dimensions. The very good hardenability will also have a decisive effect on other properties such as toughness and corrosion resistance.

HARDNESS AS A FUNCTION OF COOLING RATE

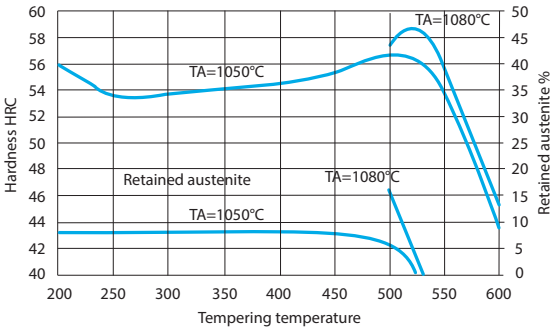
During hardening at 1050°C (1920°F) and 1080°C (1975°F).



**Cooling rate in the centre of two dimensions is indicated.*

TEMPERING

Tempering temperature should be selected depending on aimed hardness according to the graphs shown below. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature is 200 °C. Holding time at tempering is 2h.



The tempering curve is obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in a vacuum furnace.

Note: Tempering at 200-250°C (390-480°F) results in the best combination of toughness, hardness and corrosion resistance. However for complicated design it is recommended to use a high temperature tempering (lowest

525°C (980°F)) to reduce residual stresses and retained austenite to a minimum.

Hardening at 1080°C (1975°F) will give a hardness up to 58 HRC when tempering at 530°C (985°F), still with good ductility.

In special cases a hardening temperature of 1100°C (2010°F) may be used. Hardness is increased up to 60 HRC when tempering at 525-530°C (980-985°F). 1100°C (2010°F) is only recommended when toughness is of secondary importance.

Uddeholm Tyrax ESR may also be used at a normal AISI 420 hardness of 52 HRC using 1020°C (1870°F) as hardening temperature and tempering twice at 250°C (480°F) for two hours, giving <2% retained austenite.

DIMENSIONAL CHANGES

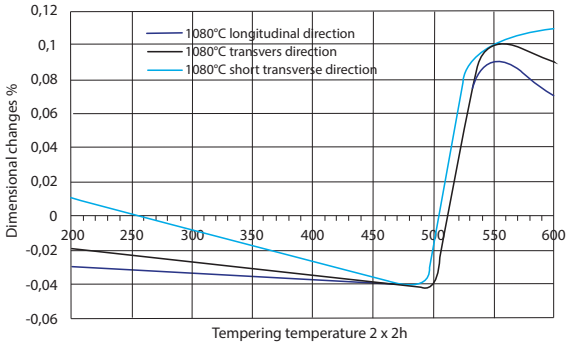
Dimensional changes have been measured after hardening and tempering.

Austenitizing: 1080°C/30 min. (1975°F/30 min.) cooling in vacuum furnace at 0,64°C/sec. (1,15°F/sec) between 800°C (1470°F) and 500°C (930°F).

Tempering: 2 x 2 h at various temperatures

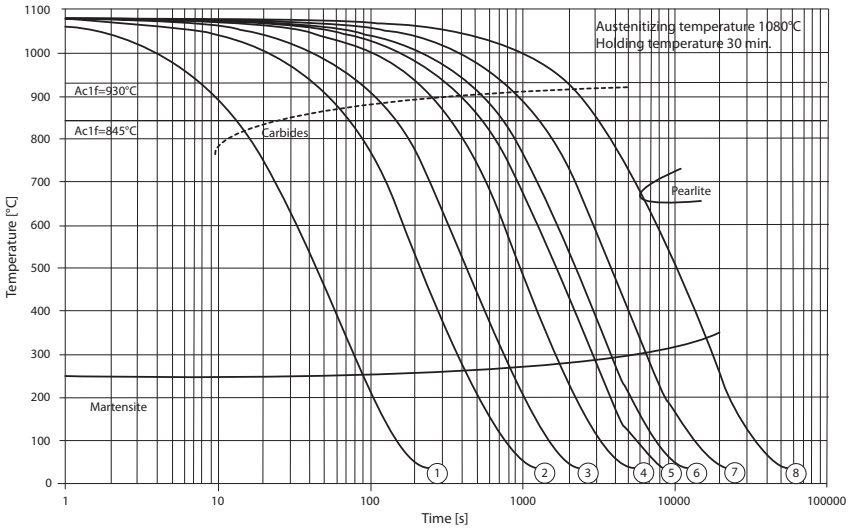
Sample size: 100 x 40 x 20 mm (4" x 1,6" x 0,8").

A machining allowance of 0,15 % is recommended for Uddeholm Tyrax ESR.



CCT-DIAGRAM

Austenitizing temperature 1080°C (1975°F).
Holding time 30 minutes.



Cooling curve no.	Hardness HV10	T800-500 (sec)
1	685	28
2	664	140
3	681	280
4	680	630
5	677	1030
6	688	1390
7	654	2400
8	609	6240

SUB-ZERO TREATMENT

Cryo-treatment in liquid nitrogen (-120°C to -196°C (-185°F to -320°F)) may be carried out for tools with high demands on dimensional stability after heat treatment. This treatment should be performed before tempering. Intricate shapes should however be avoided because of the risk of cracking. Cryo-treatment is especially interesting before low temperature tempering as the content of retained austenite will be eliminated/very low resulting in increased hardness and wear resistance. Corrosion resistance is improved using low temperature tempering at 200°C to 480°C (390°F-895°F) compared to tempering at temperatures 525°C (980°F) or higher.

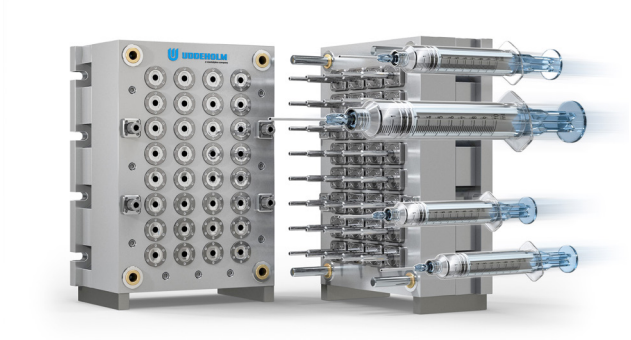
Hardening 1080°C/30min/ cryo- treatment at -196°C	Tempering 200°C/2x2h
Hardness	58,5 HRC
Retained austenite	<2 %

MACHINING AND GRINDING

TYRAX ESR MACHINING RECOMMENDATIONS

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions. More information can be found in the Uddeholm publication “Cutting data recommendations”.

The recommendations in following tables are valid for Uddeholm Tyrax ESR in soft annealed condition to ~ 190 HB.



TURNING

Cutting data parameters	Turning with carbide		Turning with HSS Fine turning
	Rough turning	Fine turning	
Cutting speed (v_c) m/min f.p.m	140-190 460-620	190-240 620-790	15-20 50-65
Feed (f) mm/r i.p.r	0.2-0.4 0.008-0.016	0.05-0.2 0.002-0.008	0.05-0.3 0.002-0.012
Depth of cut (a_p) mm inch	2-4 0.08-0.16	0.5-2 0.02-0.08	0.5-3 0.02-0.12
Carbide designation ISO	P20-P30 C6-C5 Coated carbide	P10 C7 Coated carbide or cermet	- -

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter		Cutting speed (v_c)		Feed (f)	
mm	inch	m/mm	f.p.m	mm/r	i.p.r
-5	-3-16	12-16*	40-52*	0.05-0.15	0.002-0.006
5-10	3/16-3/8	12-16*	40-52*	0.15-0.20	0.006-0.008
10-15	3/8-5/8	12-16*	40-52*	0.20-0.25	0.008-0.010
15-20	5/8-3/4	12-16*	40-52*	0.25-0.35	0.010-0.014

**For coated HSS drill v_c ~22-24 m/min (72-79 f.p.m)*

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip[1)]
Cutting speed (v_c) m/min f.p.m	160-200 525-650	80-100 260-330	60-90 195-295
Feed (f) mm/r i.p.r	0.03-0.10[2)] 0.001-0.004[2)]	0.10-0.25[3)] 0.004-0.01[3)]	0.15-0.25[4)] 0.006-0.01[4)]

1) Drills with replaceable or brazed carbide tip
2) Feed rate for drill diameter 20-40 mm (0.8"-1.6")
3) Feed rate for drill diameter 5-20 mm (0.2"-0.8")
4) Feed rate for drill diameter 10-20 mm (0.4"0.8")

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m	120-170 395-560	170-210 560-690
Feed (f_z) mm/tooth in/tooth	0.2-0.4 0.008-0.016	0.1-0.2 0.004-0.008
Depth of cut (a_p) mm inch	2-4 0.08- 0.16	0.5-2 0.02-0.08
Carbide designation ISO US	P30-P40 C6-C5 coated carbide	P20 C6 coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling		
	Solid carbide	Cardible indexable insert	High speed steel [1]
Cutting speed (v_c) m/min f.p.m	120-150 390-490	110-150 360-490	20-25[1] 66-80[1]
Feed (f) mm/tooth in/tooth	0.01-0.2[2] 0.0004-0.0008[2]	0.06-0.2[2] 0.002-0.008[2]	0.01-0.3[2] 0.0004-0.012[2]
Carbide designation ISO US	-	P30-240 C6-C5	-

1) For coated HSS end mill vc 35-40 m/min (115-130 f.p.m)

2) Depending on radial depth of cut and cutter diameter

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication “Grinding of tool steel”.

WHEEL RECOMMENDATION

Type of grinding	Annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 KV

POLISHING

Uddeholm Tyrax ESR has excellent polishability in the hardened and tempered condition. It can be polished up to the highest levels of surface finish in very few steps. More detailed information on polishing of Uddeholm Tyrax ESR is given in the brochure “Polishing of Tool Steel”.

WELDING

Good results can be obtained if proper precautions are taken before, during and after the welding operation. Joint preparation, preheating, interpass temperature, post weld heat treatment and handling of consumables are all crucial for the end result.

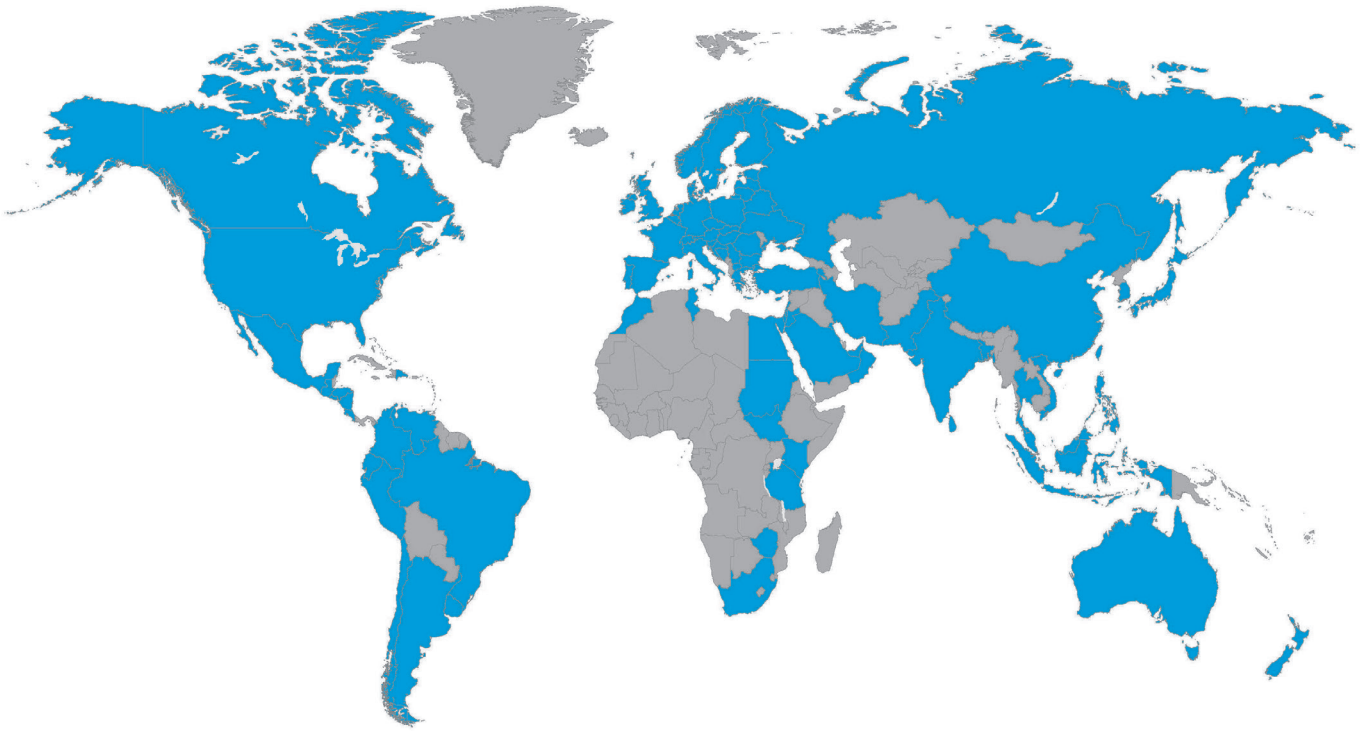
Use consumables with the same chemical composition as the tool steel for optimal results after polishing or photo etching.

Welding method	TIG
Welding consumables	TYRAX TIG WELD
Preheat temperature	330°C ± 25°C 625°F ± 50°F
Max interpass temperature	480ºC 895°F
Post weld cooling rate	20 - 40ºC/h (35 - 70°F/h) for the first 2 hours, then freely in air.
Hardness after welding	56-58
Post Weld Heat Treatment	
Hardened condition	Temper 25ºC (50°F) below the original tempering temperature.
Soft annealed condition	Soft anneal the material at 860ºC (1580°F) in a protected atmosphere. The subsequent cooling should be carried out in the furnace at 10°C/h (20ºF/h) to 650°C (1200ºF), then freely in air.

Further information is given in the Uddeholm broschure ”Welding of Tool Steel”.

FURTHER INFORMATION

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availabitlity of Uddeholm tool steels.



NETWORK OF EXCELLENCE

Uddeholm is present on every continent. This ensures you high-quality Swedish tool steel and local support wherever you are. We secure our position as the world's leading supplier of tooling materials.

For more information, please visit www.uddeholm.com

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UDDEHOLM 11.2020

Manufacturing solutions for generations to come

SHAPING THE WORLD

Since 1668 we have been providing a wide range of innovative cutting-edge solutions for our customers in demanding segments. Our dedicated employees work in almost ninety countries and together we deliver improved competitiveness to clients worldwide. Welcome to Uddeholm.

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