Material data sheet
Steel grade

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X20NiCrAlMoV6-5-2-1* All

General Information

Hybrid Steel® is a low carbon steel containing a number of carefully controlled alloying elements, most importantly nickel, chromium, aluminium, molybdenum and vanadium. These enable it to develop its full properties after aging at elevated temperature (500–620°C). The chromium and aluminium content also improves corrosion resistance. The variant 197A is offered under the name Hybrid Steel 50 and the variant 297A is offered under the name Hybrid Steel 55 and the variant 397A is offered under the name Hybrid Steel 60.

Hybrid Steel 50 - Engineering steel.

Hybrid Steel 55 - Engineering steel.

Hybrid Steel 60 - Bearing steel.

Maximum hardess after aging: Hybrid Steel 50, 50HRC. Hybrid Steel 55, 55HRC. Hybrid Steel 60, 60HRC.

Hybrid Steel offers superior mechanical and fatigue strength compared to conventional steel grades at elevated temperatures.

- Excellent elevated temperature strength
- Flexible hardness, achieved by an aging treatment in the temperature range 500–620°C
- Extremely good dimensional stability when aging is applied
- High uniformity of properties also for large components
- Good weldability, no preheating necessary
- Corrosion resistance comparable to AISI 440C

The density for these grades is 7582 kg/m3.

** Designation followed by "*" is not an official EN standard grade but named according to the rules in EN 10027.*

Similar designations

X20NiCrAlMoV6-5-2-1, X30NiCrAlMoV6-5-2-1 , Ovako197A, Ovako297A, Ovako397A

Chemical composition

Variant	Cast		C%	Si%	Mn%	P%	S%	Cr%	Ni%	Mo%	V%	Al%
Hybrid Steel 50, 197A	IC	Min	0.01	-	0.15	-	-	4.80	4.80	0.60	-	2.000
		Max	0.12	0.20	0.50	0.015	0.001	5.20	5.20	0.80	0.100	2.400
Hybrid Steel 55, 297A	IC	Min	0.16	-	0.20	-	-	4.80	5.80	0.60	0.450	2.000
		Max	0.20	0.20	0.50	0.015	0.001	5.20	6.20	0.80	0.550	2.400
Hybrid Steel 60, 397A	IC	Min	0.25	-	0.20	-	-	4.80	5.80	0.60	0.450	2.000
		Max	0.31	0.20	0.50	0.015	0.001	5.20	6.20	0.80	0.550	2.400

Mechanical Properties

Variant	Condition	Format	Yield strength min [MPa]	Tensile strength [MPa]	Elongation A_5 [%]	Hardness
Hybrid Steel 50, 197A	+AR	All formats	847	1151 typical	14.11	350 HV typical
	+AG, at 450°C	All formats	1102	1355 typical	13.32	430 HV typical
	+AG, at 550°C	All formats	1431	1582 typical	4.01	500 HV typical
Hybrid Steel 55, 297A	+AR	All formats	1136	1515 typical	12.89	450 HV typical
	+AG, at 450°C	All formats	1320	1639 typical	11.27	500 HV typical
	+AG, at 550°C	All formats	1706	1890 typical	10	600 HV typical
Hybrid Steel 60, 397A	+AR	All formats	1283	1819 typical	12.18	560 HV typical
	+AG, at 450°C	All formats	1504	1918 typical	11.53	600 HV typical
	+AG, at 550°C	All formats	1803	2405 typical	3.52	700 HV typical

$Rp_{0.2}$ * R_{eh}, ** R_{el}

Transformation temperatures

	Temperature °C
MS	350
AC1	800
AC3	950

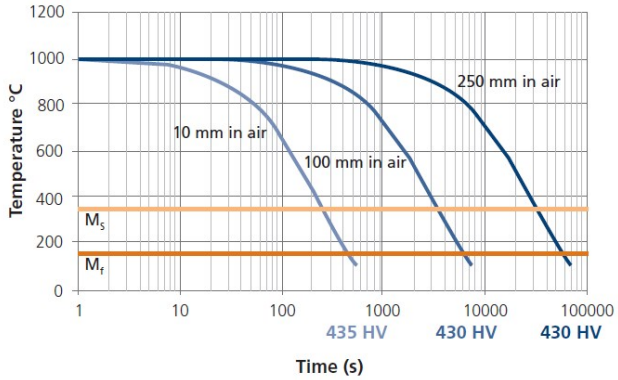
Transformation temperatures for Hybrid 55 above. AC3 for Hybrid Steel 50 is 950°C. AC3 for Hybrid Steel 60 is 1020°C.

Mf is 150°C for all three grades

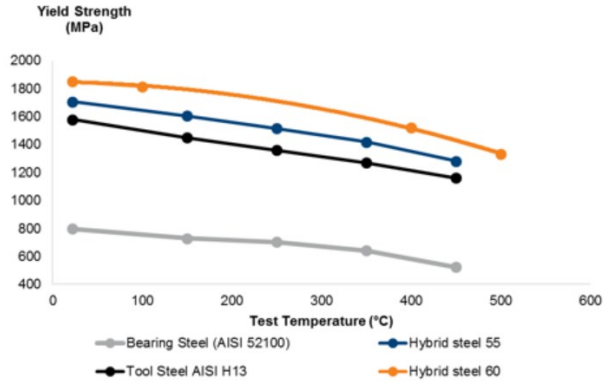
Heat treatment recommendations

Treatment	Condition	Temperature cycle	Cooling/quenching
As-rolled	+AR	Hybrid steel 50, Hardness 350HV	
Soft annealing	+A	Hybrid Steel 50, 800°C/3h, Hardness 260HV	Slow cooling from 800°C to 600°C, <20°C/h
Hardening	+Q	Hybrid Steel 50, 1000°C /45 min, Hardness 350HV	Air cool or quench in oil
Aging	+AG	Hybrid Steel 50, 500-620°C 1-20h. Hardness 300-500HV	
As-rolled	+AR	Hybrid steel 55, Hardness 450HV	
Soft annealing	+A	Hybrid Steel 55, 800°C/3h, Hardness 280HV	Slow cooling from 800°C to 600°C, <20°C/h
Hardening	+Q	Hybrid Steel 55, 950°C /45 min, Hardness 450HV	Air cool or quench in oil
Aging	+AG	Hybrid Steel 55, 500-620°C 1-20h. Hardness 400-600HV	
As-rolled	+AR	Hybrid Steel 60, Hardness 550HV	
Soft annealing	+A	Hybrid Steel 60, 800°C/3h, Hardness 300HV	Slow cool from 800°C to 600°C <20°C/h
Hardening	+Q	Hybrid Steel 60, 1020°C/45 min, Hardness 550HV	Air cool or quench in oil
Aging	+AG	Hybrid Steel 60, 500-620°C 1-20h, Hardness 430-700HV	

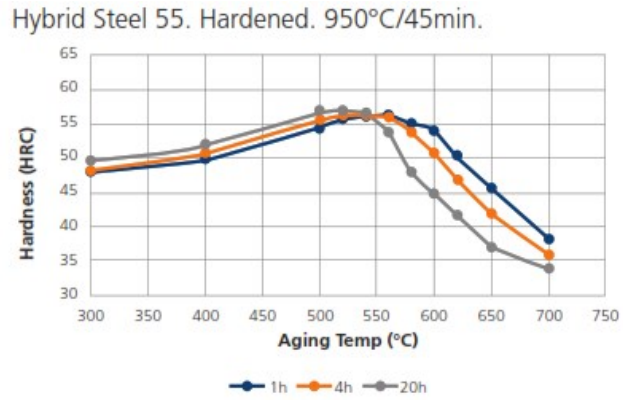
Hybrid Steel

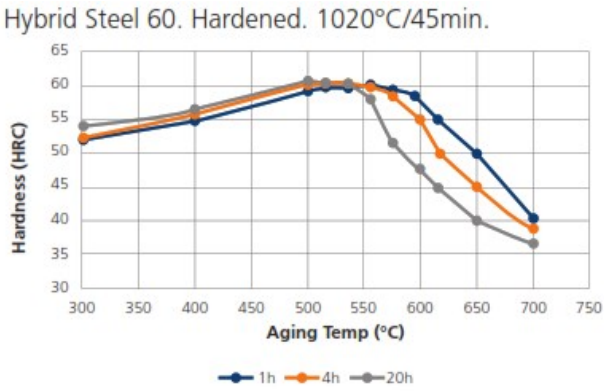


Yield Strength at Elevated Temperatures

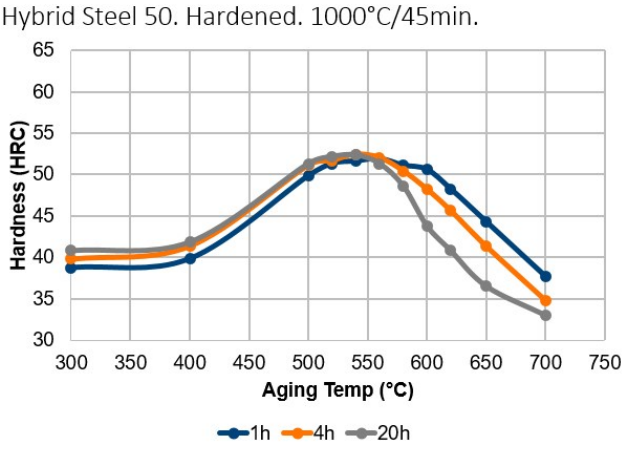


Aging Characteristics





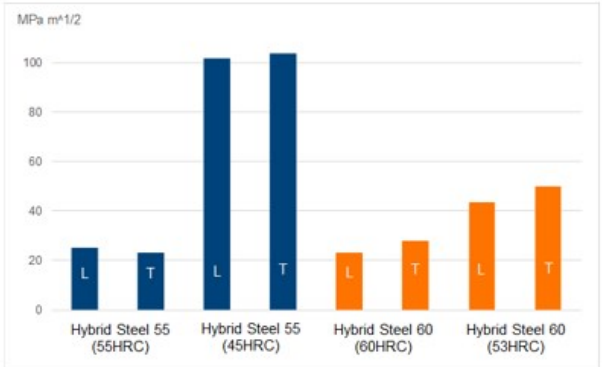
Aging



Fracture Toughness (K1C)

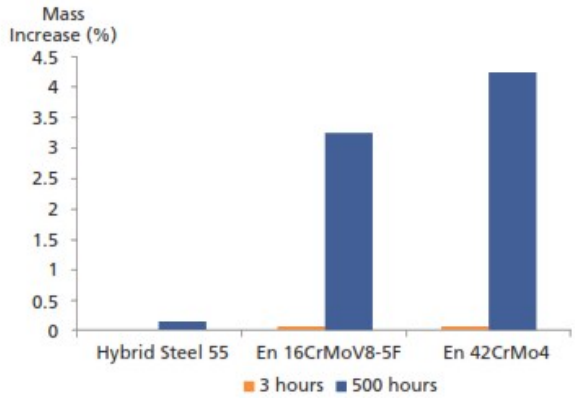
According to ASTM E399.
Performed in air at room temperature.

- Hybrid Steel 55 – 55HRC – solution treated and aged 520°C/3h
- Hybrid Steel 55 – 45HRC – solution treated
- Hybrid Steel 60 – 60HRC - solution treated and aged 520°C/3h
- Hybrid Steel 60 – 53HRC - solution treated

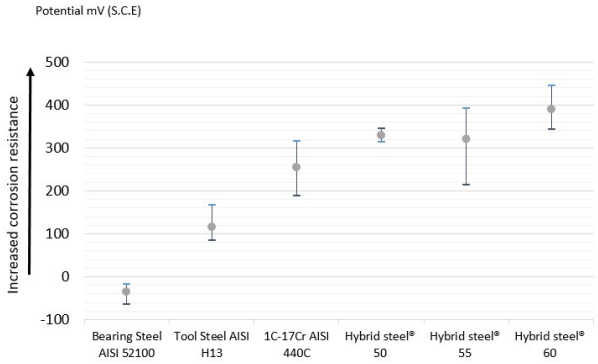


Oxidation Resistance

Heating in air, 700°C.

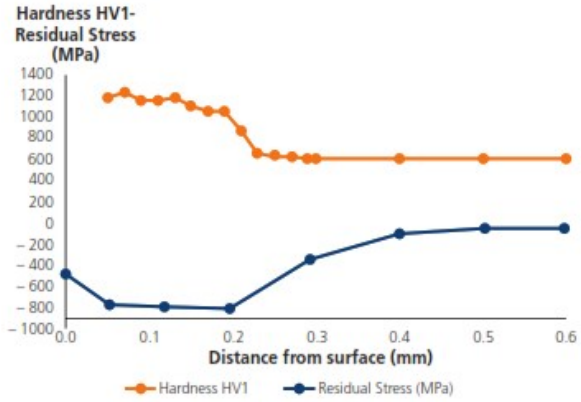


Corrosion Resistance



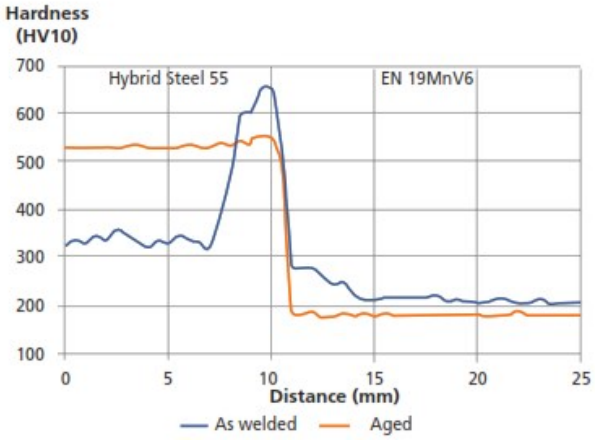
Nitiriding

Hybrid Steel 55. Aged to 55 HRC.
Plasma Nitrided at 520°C for 20 hours.



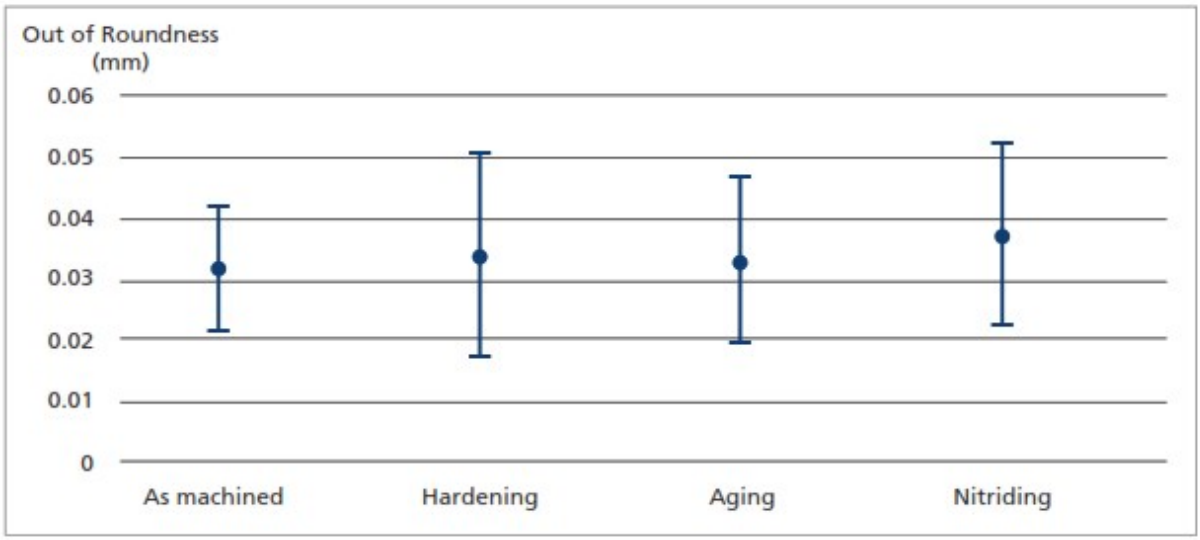
Welding

Friction welding. One piece rotating and one static.
Bar diameter 25 mm
Initial heating (22 bar)
Max temperature (56 bar)
Friction weld (79 bar)



Distortion Hybrid Steel 55

Rings with dimension 140*120*20 mm were machined from soft annealed Hybrid steel 55.
Out of roundness was measured after each process step.



Thermal Properties

Hybrid Steel 55. Aged at 580°C for 3 hours.
56HRC

(in aged condition)		RT	100°C	200°C	300°C	400°C	500°C
Linear Thermal Expansion	10^{-6} °C^{-1}		11.6	12.0	12.4	12.7	13.1
Thermal Conductivity	W m^{-1} °C^{-1}	18.4	21.0	22.5	24.1	24.9	26.1
Thermal Diffusivity	10^{-6} m^2 s^{-1}	5.37	5.56	5.69	5.67	5.54	5.28
Specific Heat	J g^{-1} °C^{-1}	0.45	0.49	0.53	0.56	0.60	0.66

Machining recommendations Hybrid Steel 50

Hybrid Steel 50, as rolled

Turning

	Insert/tool	Cutting speed vc (m/min)	Feed rate fn (mm/rev)	Cutting depth ap (mm)
Rough / medium	RCMT1204 MP-M3 2220	140-170	0.45-0.7	2-3
	CNMG120412-MM 2220	120-145	0.3-0.45	2-3
Fine	CNMG120408-MM 2220	125-150	0.25-0.40	1.5-2.5
	CNMG120404-MF 2220	125-150	0.20-0.35	0.5-1.5

Drilling

Tool	Diameter Ø (mm)	Cutting speed vc (m/min)	Feed rate fn (mm/rev)	Depth (mm)
Mitsubishi MVX2500X6F25 insert SOMX084005-UM VP15TF	25	70	0.18	5 x Ø
Mitsubishi STAWMN1600S20 insert STAWN1600T VP15TF	16	40	0.30	5 x Ø
Mitsubishi MPS1-0800-PC	8	70	0.27	2 x Ø
Mitsubishi MPS1-0800-L20C	8	55	0.27	20 x Ø
Mitsubishi MPS1-0400-PC	4	60	0.15	2 x Ø
Mitsubishi MPS1-0400-L30C	4	45	0.18	20 x Ø

Machining recommendations Hybrid Steel 55

Hybrid Steel 55, soft annealed

Turning

	Insert/tool	Cutting speed vc (m/min)	Feed rate fn (mm/rev)	Cutting depth ap (mm)
Rough / medium	RCMT1204MP-M3 2220	165-195	0.45-0.7	2-3
	CNMG120412-MM 2220	150-175	0.3-0.45	2-3
Fine	CNMG120408-MM 2220	160-180	0.25-0.40	1.5-2.5
	CNMG120404-MF 2220	160-180	0.20-0.35	0.5-1.5

Drilling

Tool	Diameter Ø (mm)	Cutting speed vc (m/min)	Feed rate fn (mm/rev)	Depth (mm)
Mitsubishi MVX2500X6F25 insert SOMX084005-UM VP15TF	25	100	0.18	5 x Ø
Mitsubishi STAWMN1600S20 insert STAWN1600T VP15TF	16	55	0.30	5 x Ø
Mitsubishi MPS1-0800-PC	8	100	0.27	2 x Ø
Mitsubishi MPS1-0800-L20C	8	70	0.27	20 x Ø
Mitsubishi MPS1--0400-PC	4	80	0.15	2 x Ø
Mitsubishi MPS1-0400-L30C	4	60	0.18	20 x Ø

Machining recommendations Hybrid Steel 60

Hybrid Steel 60, soft annealed

Turning

	Insert/tool	Cutting speed vc (m/min)	Feed rate fn (mm/rev)	Cutting depth ap (mm)
Rough / medium	RCMT1204 MP-M3 2220	155-185	0.45-0.7	2-3
	CNMG120412-MM 2220	150-180	0.3-0.45	2-3
Fine	CNMG120408-MM 2220	155-180	0.25-0.40	1.5-2.5
	CNMG120404-MF 2220	155-180	0.20-0.35	0.5-1.5

Drilling

Tool	Diameter Ø (mm)	Cutting speed vc (m/min)	Feed rate (mm/rev)	Depth (mm)
Mitsubishi MVX2500X6F25 insert SOMX0804005-UM VP15TF	25	85	0.18	5 x Ø
Mitsubishi STAWMN1600S20 insert STAWN1600T VP15TF	16	45	0.30	5 x Ø
Mitsubishi MPS1-0800-PC	8	85	0.27	2 x Ø
Mitsubishi MPS1-0800-L20C	8	60	0.27	20 x Ø
Mitsubishi MPS1-0400-PC	4	70	0.15	2 x Ø
Mitsubishi MPS1-0400-L30C	4	50	0.18	20 x Ø

Other properties (typical values)

Youngs module (GPa)	Poisson´s ratio (-)	Shear module (GPa)	Density (kg/m3)
210	0.3	80	7800
Average CTE 20-300°C (µm/m°K)	**Specific heat capacity 50/100°C (J/kg°K)**	**Thermal conductivity Ambient temperature (W/m°K)**	**Electrical resistivityAmbient temperature (µΩm)**
12	460 - 480	40 - 45	0.20 - 0.25

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