

## 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 hardness 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/m<sup>3</sup>.

\* 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	0.31	-	0.20	-	-	4.80	5.80	0.60	0.450	2.000
		Max	0.35	0.20	0.50	0.015	0.001	5.20	6.20	0.80	0.550	2.400

## Mechanical Properties

Variant	Condition <sup>①</sup>	Format	Yield strength min [MPa]	Tensile strength [MPa]	Elongation A <sub>5</sub> [%]	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

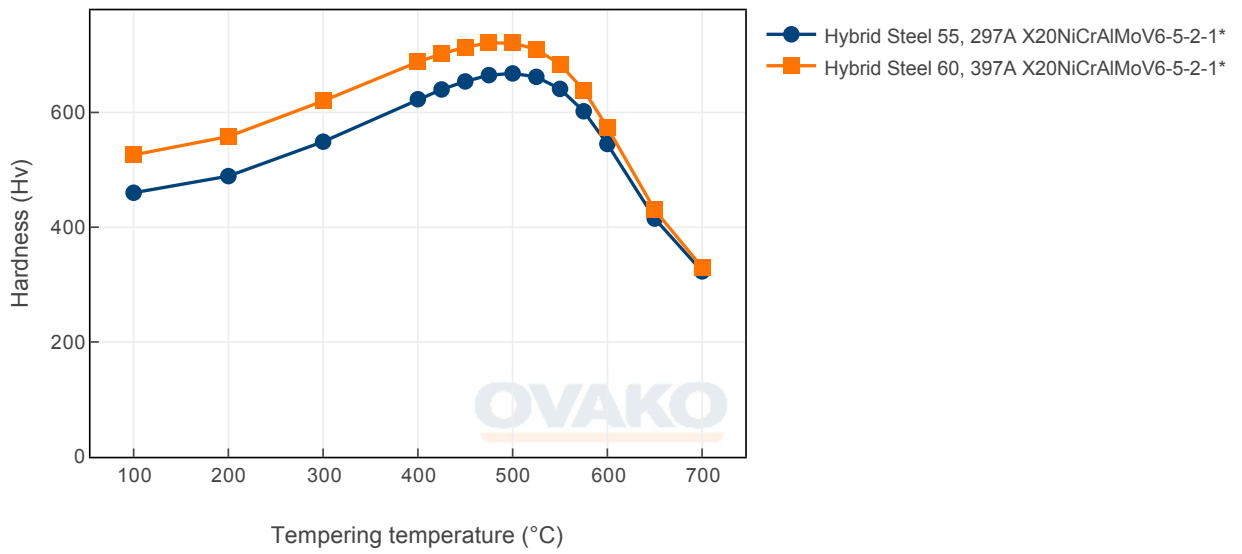
## Heat treatment recommendations

Treatment	Condition <sup>①</sup>	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	

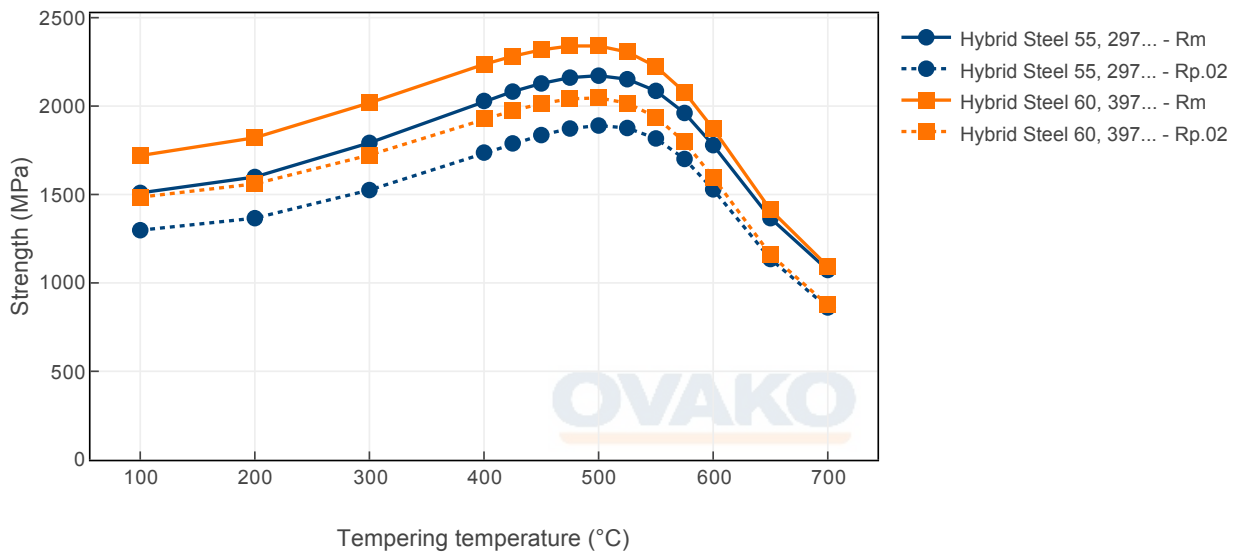
## Heat Treatment Guide generated Graphs

The following graphs are generated from a theoretical model. For further info see the Heat treatment guide module. Select a specific grade version for individual display.

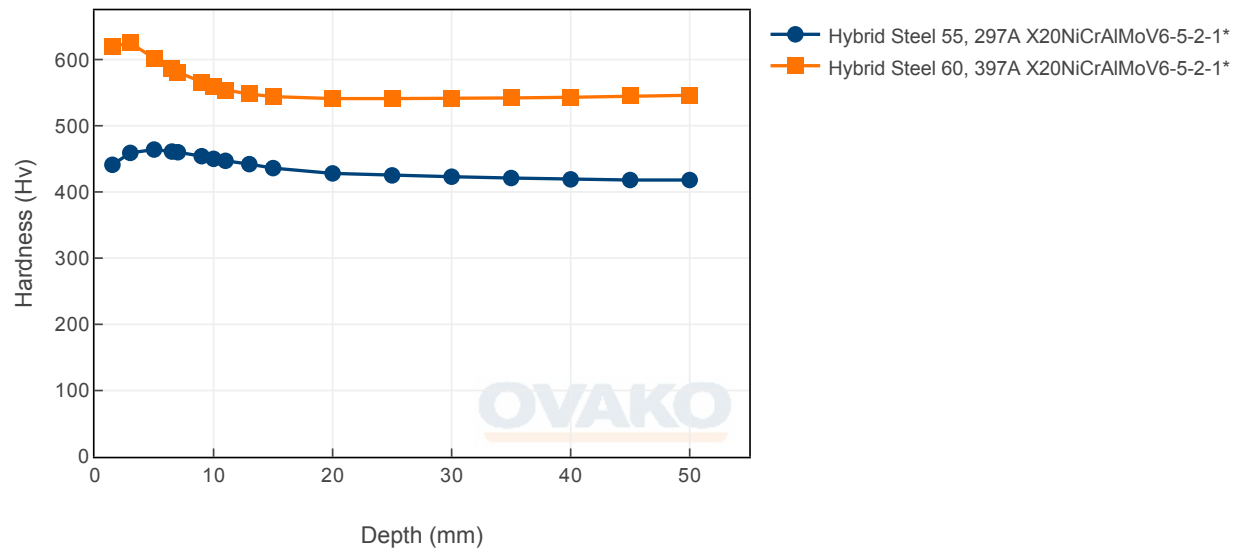
Tempering Diagram (hardness)



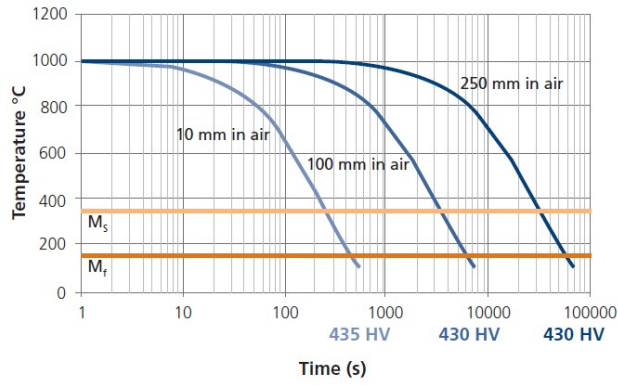
Tempering Diagram (strength)



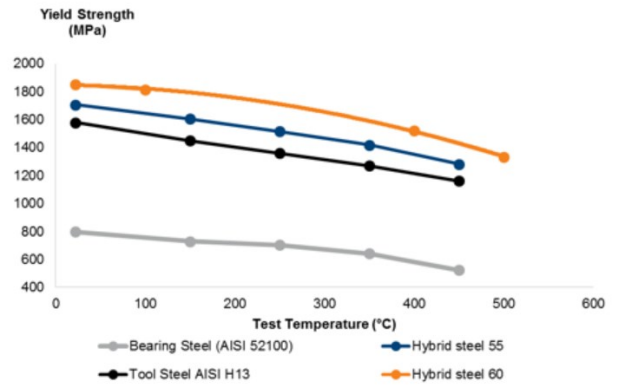
# Jominy



## Hybrid Steel

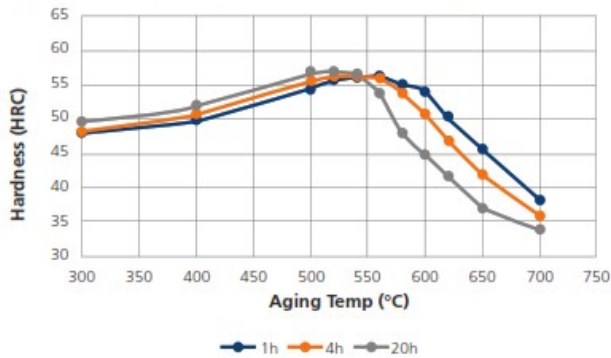


## Yield Strength at Elevated Temperatures

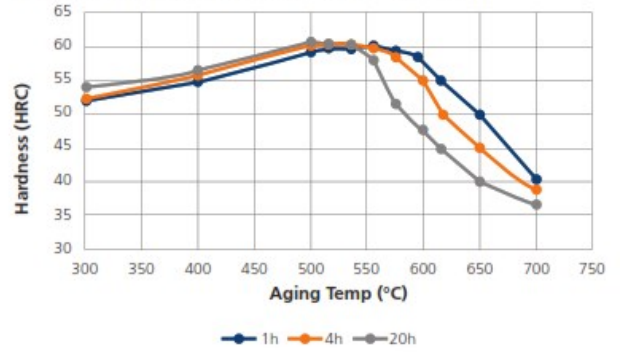


## Aging Characteristics

Hybrid Steel 55. Hardened. 950°C/45min.

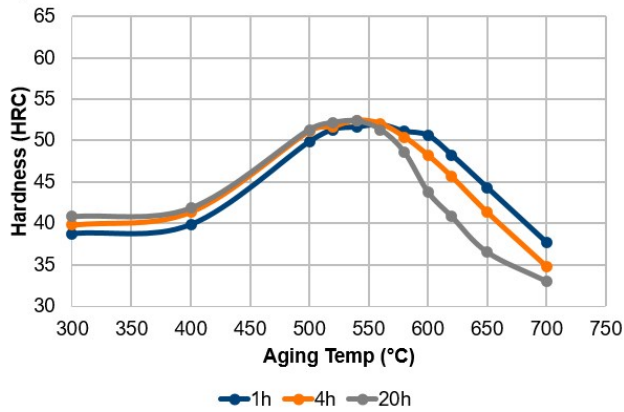


Hybrid Steel 60. Hardened. 1020°C/45min.



## Aging

Hybrid Steel 50. Hardened. 1000°C/45min.

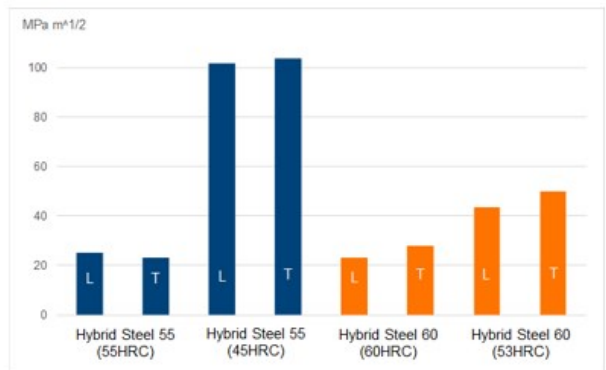


## Fracture Toughness (K1C)

According to ASTM E399.

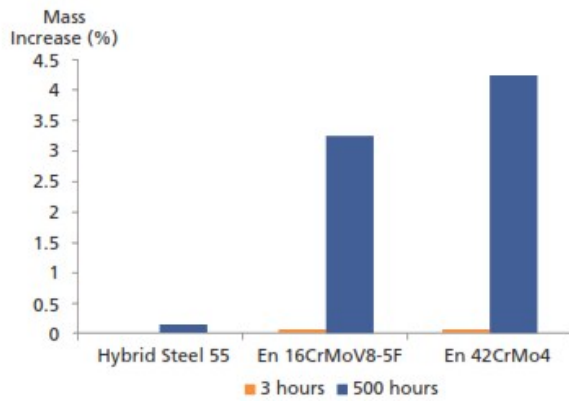
Performed in air at room temperature.

- 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

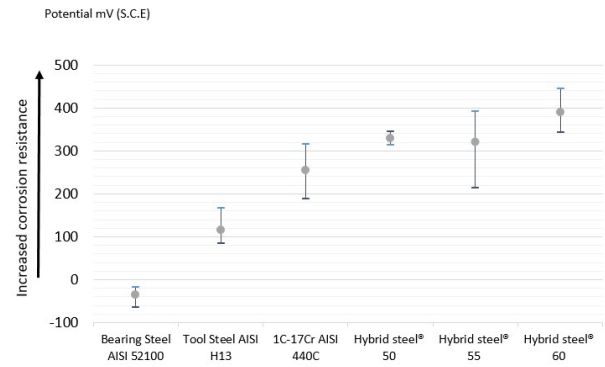


## Oxidation Resistance

Heating in air, 700°C.



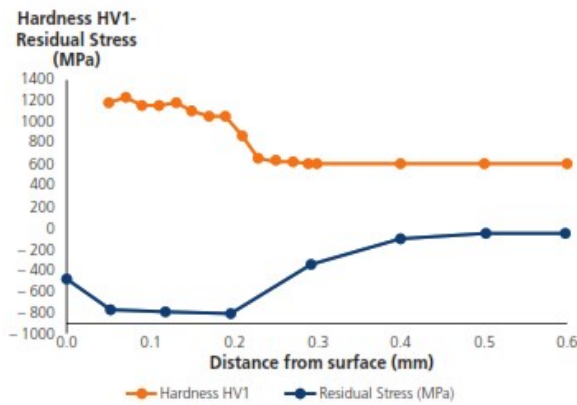
## Corrosion Resistance



## Nitriding

Hybrid Steel 55. Aged to 55 HRC.

Plasma Nitrided at 520°C for 20 hours.



## Welding

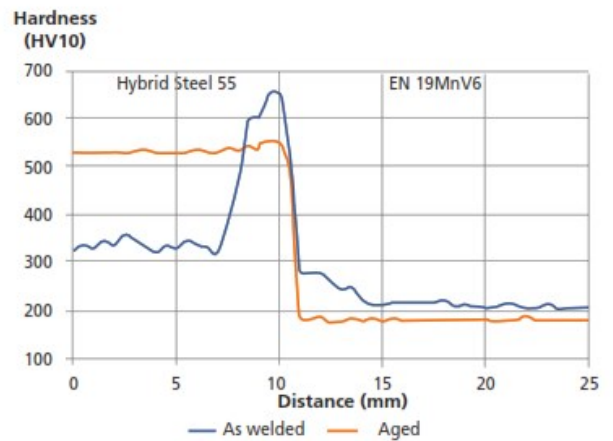
Friction welding. One piece rotating and one static.

Bar diameter 25 mm

Initial heating (22 bar)

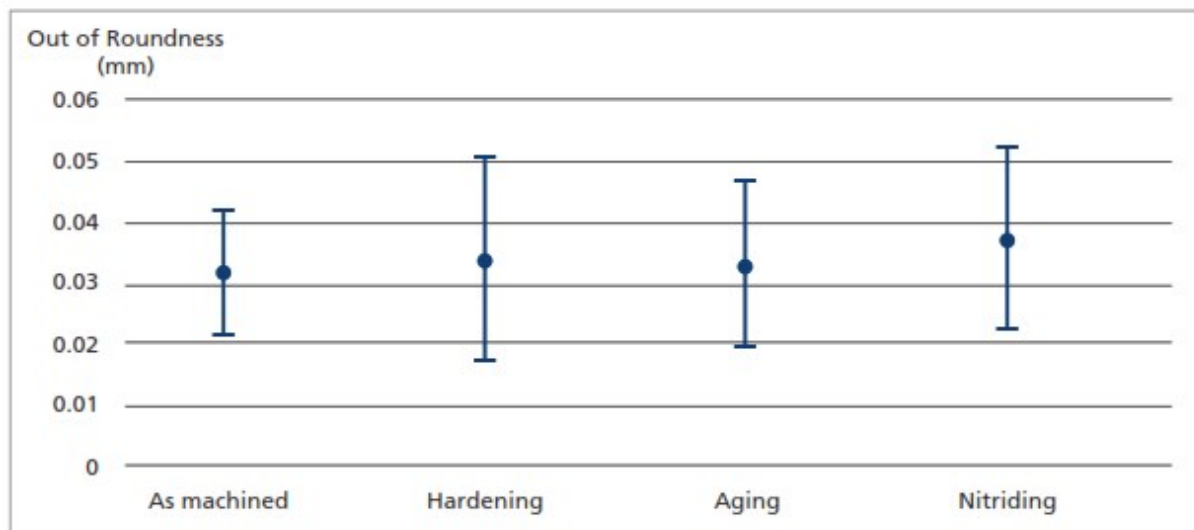
Max temperature (56 bar)

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	$10^{-6} \text{ }^{\circ}\text{C}^{-1}$		11.6	12.0	12.4	12.7	13.1
Thermal Conductivity	$\text{W m}^{-1} \text{ }^{\circ}\text{C}^{-1}$	18.4	21.0	22.5	24.1	24.9	26.1
Thermal Diffusivity	$10^{-6} \text{ m}^2 \text{ s}^{-1}$	5.37	5.56	5.69	5.67	5.54	5.28
Specific Heat	$\text{J g}^{-1} \text{ }^{\circ}\text{C}^{-1}$	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 $v_c$ (m/min)	Feed rate $f_n$ (mm/rev)	Cutting depth $a_p$ (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 $\varnothing$ (mm)	Cutting speed $v_c$ (m/min)	Feed rate $f_n$ (mm/rev)	Depth (mm)
Mitsubishi MVX2500X6F25 insert SOMX084005-UM VP15TF	25	70	0.18	$5 \times \varnothing$
Mitsubishi STAWMN1600S20 insert STAWN1600T VP15TF	16	40	0.30	$5 \times \varnothing$
Mitsubishi MPS1-0800-PC	8	70	0.27	$2 \times \varnothing$
Mitsubishi MPS1-0800-L20C	8	55	0.27	$20 \times \varnothing$
Mitsubishi MPS1-0400-PC	4	60	0.15	$2 \times \varnothing$
Mitsubishi MPS1-0400-L30C	4	45	0.18	$20 \times \varnothing$

## 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

## SUSTAINABILITY-ENVIRONMENTAL IMPACT DATA

At Ovako sustainability and reduction of our environmental impact is a major focus in everything we do. Further information is found [here](#).

In many international comparisons the crude steel Scope 1-2 emission is a key parameter, ie. the CO<sub>2</sub> emission from the steel works itself.

As of 1 January 2022 we carbon offset all our scope 1 and 2 volume shown below.

Steel works	Hofors	Smedjebacken	Imatra
CO <sub>2</sub> e/kg	120	62	76

To get the full picture of our products environmental impact we have to look at all of our CO<sub>2</sub> emission sources.



Not only the steel work Scope 1-2 itself, but all operations downstream in our production, heating and heat treatment furnaces etc (full scope 1-2) as well as all the emission from input material, eg. alloys, scope 3.

Steel Grade	Format	Condition	Scope 1-3 (CO <sub>2</sub> e kg /1000 kg steel)	Climate compensated Net emission = Scope 3 (CO <sub>2</sub> e kg /1000 kg steel) Scope 1 - 2 = 0 (compensated)
Hybrid Steel 50, 197A	Round bar	+AR	1543	1146
Hybrid Steel 50, 197A	Tube,wall	+AR	1625	1222
Hybrid Steel 60, 397A	Round bar	+AR	1762	1366
Hybrid Steel 60, 397A	Tube,wall	+AR	1860	1457
297A	Round bar	+AR	1748	1351
297A	Tube,wall	+AR	1844	1442

As of 1 January 2022 we use carbon offset for all our scope 1- 2 emissions, so in practice the climate compensated data is the same as the full Scope 3 level.

All above data are to be seen as typical values for the specified format and condition. Detailed information about your specific product please contact your sales contact.

### 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 resistivity Ambient temperature (µΩm)
12	460 - 480	40 - 45	0.20 - 0.25

### Contact us

Would you like to know more about our offers? Don´t hesitate to contact us:

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Via telephone: +46 8 622 1300

For more detailed information please visit <http://www.ovako.com/en/Contact-Ovako/>

### Disclaimer

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