

16CrMnNiMo9-5-2* All

General Information

Ovako 277 is an air hardenable steel that is suitable for case hardening, nitriding or quench and tempering. By using air-hardening or gas quenching it is possible to reduce the amount of quenching distortion. Additionally the use of quenching medias such as oil and salt can be avoided, which improves both safety and environment. It is produced in two quality classes.

Ovako 277 steels has very good welding properties. The steels high hardenability and good toughness properties provide a heat-affected zone that meets the high stated demands for the bulk material. Ovako 277Q will be classified as a Group 3 steel according to the standard Welding - Guidelines for a metallic materials grouping system (ISO/TR 15608:2005). Depending on heat treatment execution (yield strength) Ovako 277Q may be classified into subgroup 3.1 or 3.2. Maximum hardness that may be obtained in the HAZ of Ovako 277Q will be 450 HV10kg.

277L - Variant with regulated sulphur content for optimized machinability.

277Q - IQ Isotropic Quality for improved properties transverse to the rolling direction and better fatigue strength due to higher cleanliness level with a finer size distribution of non-metallic inclusions. The steel grade is made according to new process that modifies the the inclusion morphology, i.e. a lower number of elongated sulfides and reduced size distribution of oxides, both in average and in the spread. By using air hardening or gas quenching it is feasible to reduce the amount of quenching distortion.

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

Similar designations

16CrMoV8-5, 16CrMoV8-5*

Chemical composition

Variant	Cast	Weldability		C %	Si %	Mn %	P %	S %	Cr %	Ni %	Mo %	V %
277L	IC	CEV 1.08 _{max}	Min	0.14	0.05	1.20	-	0.015	2.10	0.45	0.45	0.150
		Pcm 0.45 _{max}	Max	0.17	0.15	1.40	0.020	0.023	2.30	0.55	0.55	0.250

Mechanical Properties

Variant	Condition ⓘ	Format	Yield strength min [MPa]	Tensile strength [MPa]	Elongation A ₅ [%]	Reduction of area Z _{min} [%]	Hardness	Impact (ISO-V) strength _{min}
277L	+AR	All formats	860*	1200 typical	10	60	350 HB typical	-
	+QT	All formats	600*	< 800	15	75	220 HB typical	-20 °C 70 J (long)
		All formats	650*	< 800	15	75	240 HB typical	-20 °C 70 J (long)
		All formats	700*	< 800	15	75	260 HB typical	-20 °C 27 J (long)
	+Q	All formats	-	-	-	-	430 HB typical	-
	+SA	All formats	-	-	-	-	170 HB typical	-

*R_{p0.2} * R_{eh}, ** R_{el}*

Condition "Q" is water quenched.

Transformation temperatures

	Temperature °C
MS	399
AC1	741
AC3	852

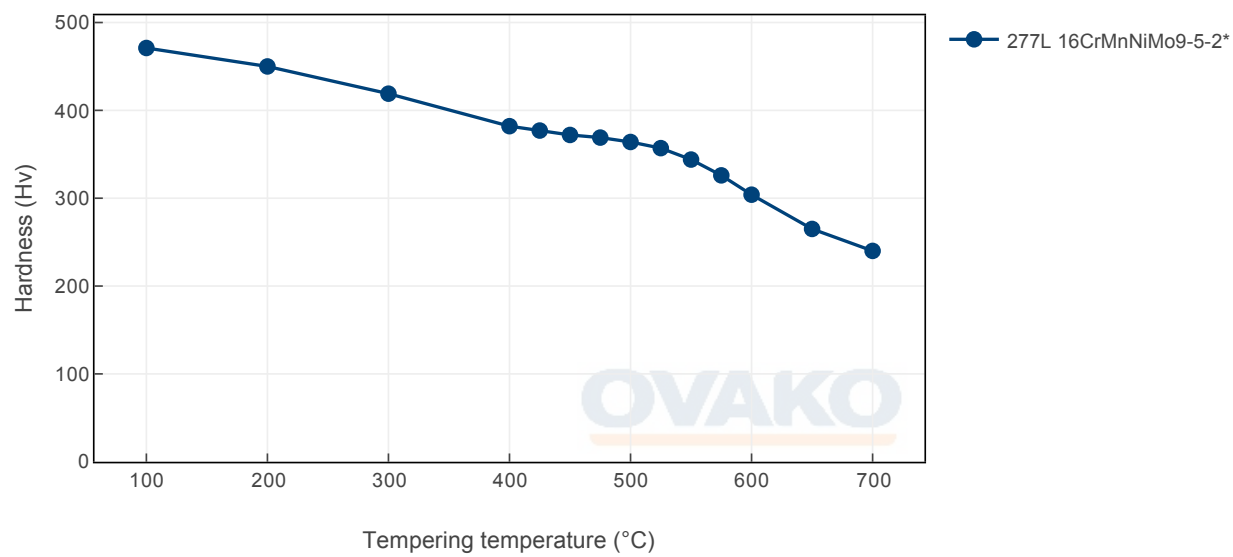
Heat treatment recommendations

Treatment	Condition ⓘ	Temperature cycle	Cooling/quenching
Hot forging	+AR	850-1200°C	Air cool
Quenching	+Q	860-1000°C	In air/gas, oil or water
Soft annealing	+SA	Slow cooling from 750°C to 690°C (8h)	In air
Carburizing	+C	850-930°C See Carbon potential in diagram	
Nitriding	+Nt	450-550°C Surface and core hardness, see diagram	
Tempering	+T	160-700°C See tempering diagram	In air

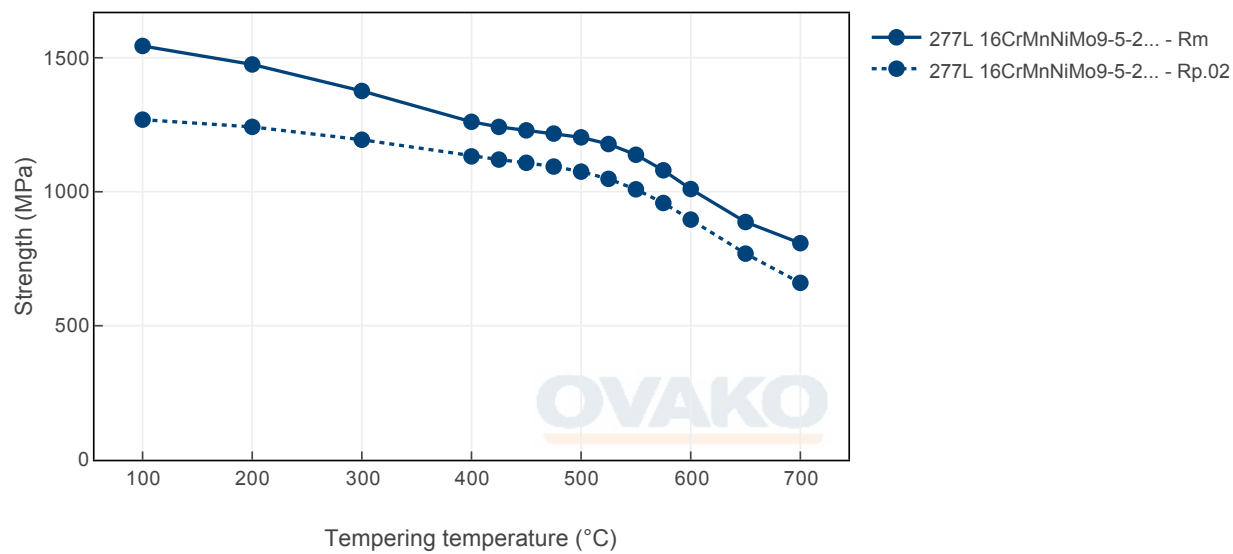
Heat Treatment Guide generated Graphs

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.

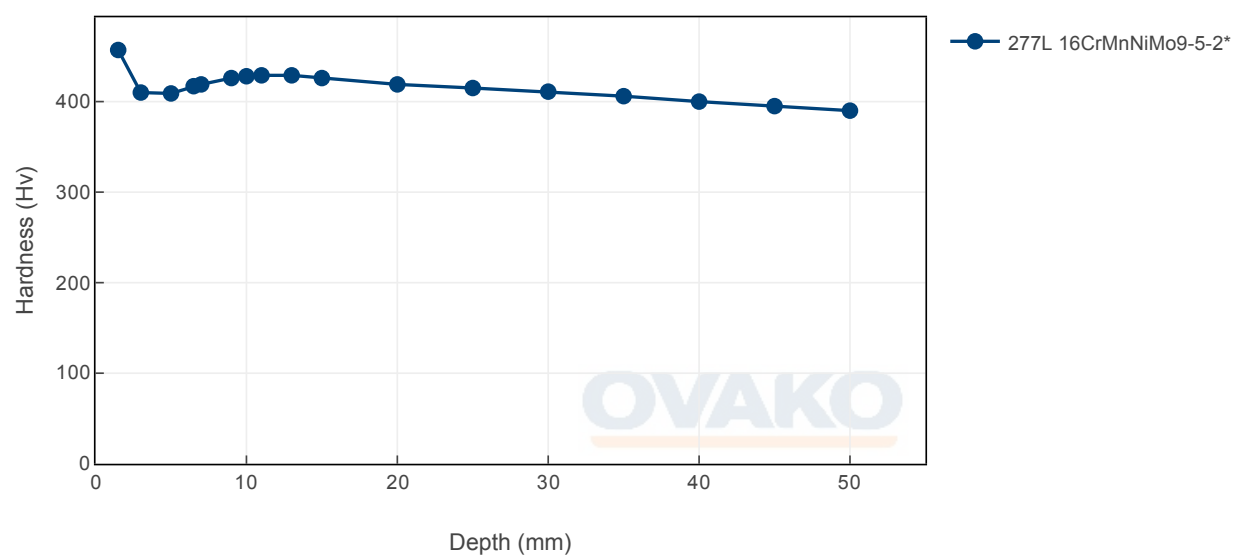
Tempering Diagram (hardness)



Tempering Diagram (strength)

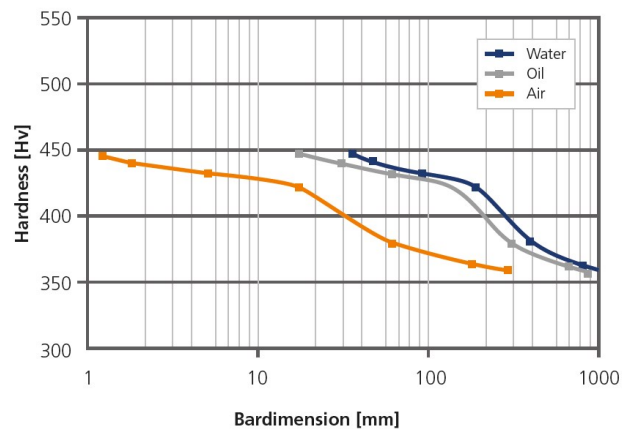


Jominy

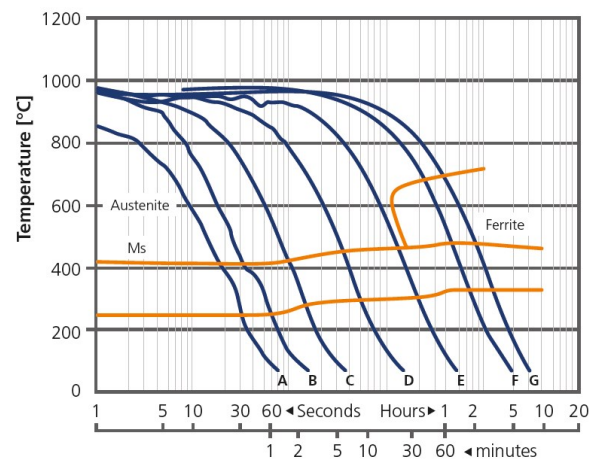


Ovako 277

Hardenability for various cooling media



CCT - Ovako 277



	A	B	C	D	E	F
t ₈₋₅ [s]	10	15	50	200	800	3000
Hv ₃₀	446	440	432	422	383	366

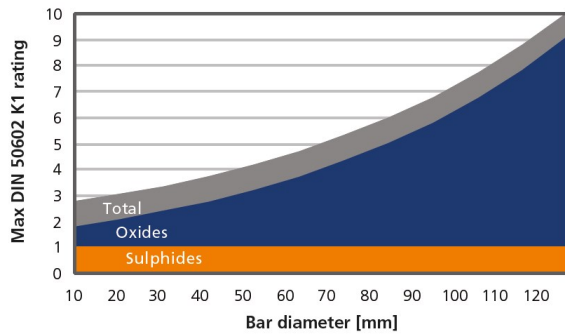
Steel cleanliness 277

Micro inclusions - 277L									Macro inclusions - 277L		
Applied standard	ASTM E45								Applied standard	ISO 3763 (Blue fracture)	
Sampling	ASTM A295								Sampling	Statistical testing on billets.	
Maximum average limits	A		B		C		D		Limits	< 5 mm/dm ²	
	Th	He	Th	He	Th	He	Th	He			
	2,0	1,5	1,0	0,5	0	0	0,5	0,5			

Micro inclusions - 277Q									Macro inclusions - 277Q		
Applied standard	DIN 50602 K1								Applied standard	ISO 3763 (Blue fracture)	10 M Hz UST (Ovako internal procedure)
Sampling	Six random samples from final product dimension								Sampling	Statistical testing on billets	
Limits	The limit is dimension dependent. The average rating of six samples should not exceed the limits given in the graph								Limits	< 1 mm/dm ²	< 10 defects/dm ³ > 0,2 mm FBH

IQ

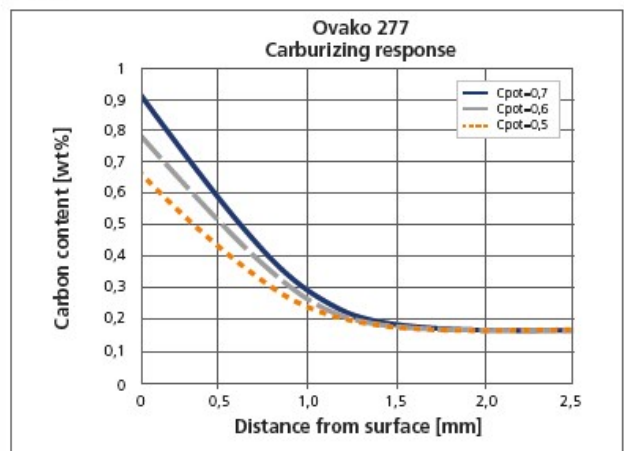
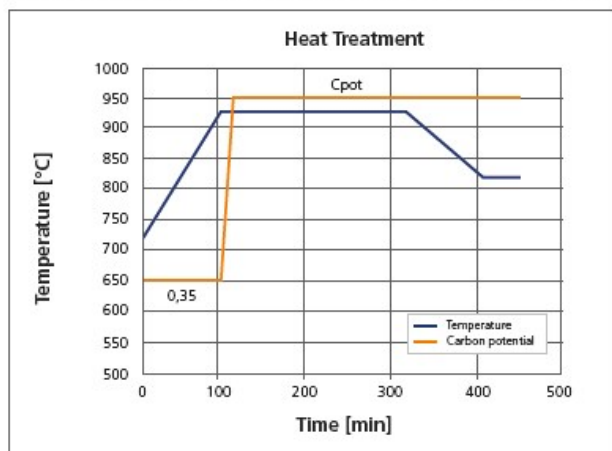
Inclusion limits IQ-processed steel



Carburizing

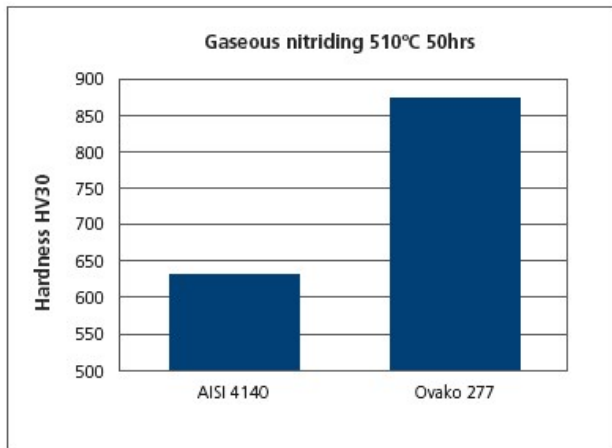
Case carburizing response

Maximum carbon potential should be 0,7wtC to avoid carbide precipitation

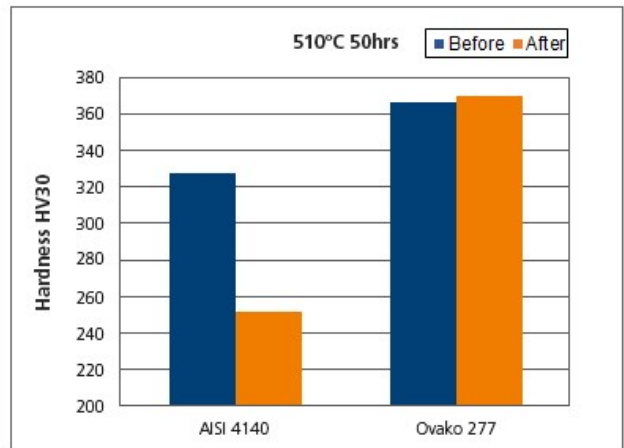


Carburization response for Ovako 277 for the cycles shown in the left figure.

Nitriding response

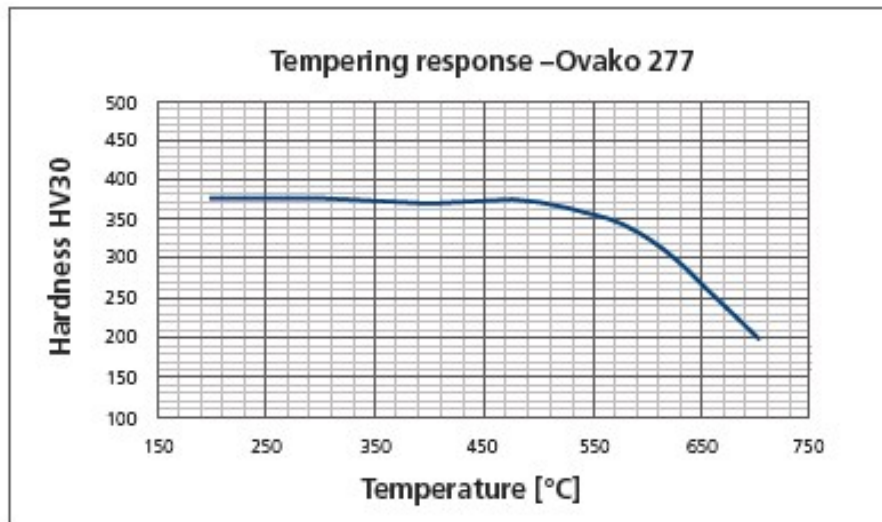


Expected surface hardness after nitriding of Ovako 277 compared with AISI 4140.



Expected core hardness after nitriding of low temperature tempered Ovako 277 compared with AISI 4140.

Tempering



Tempering response
after austenitization
and air-hardening.
Tempering time 1h.

Welding properties

Ovako 277 steels have very good welding properties. The steels high hardenability and good toughness properties provide a heat-affected zone that meets the high stated demands for the bulk material. Ovako 277Q will be classified as a Group 3 steel according to the standard Welding - Guidelines for a metallic materials grouping system (ISO/TR 15608:2005). Depending on heat treatment execution (yield strength) Ovako 277Q may be classified into subgroup 3.1 or 3.2. Maximum hardness that may be obtained in the HAZ of Ovako 277Q will be 450 HV_{10kg}.

- For the best results welding should be continuous, and slowly cooled in ambient air conditions.
- Preheat before welding. If the welding is performed in a damp environment or if the temperature is below 5°C the preheating temperature should be increased by 25°C.
- Consumables should be selected on the basis of strength and toughness requirements of the weld joint. A consumable with low strength, that still fulfils the strength requirements, minimizes the residual stresses over the weld. The consumable should also be selected with a as similar as possible chemical composition as the base material.
- Hydrogen content should not exceed 5ml/100g weld metal.
- Post heat treatment is a good alternative to preheating. It should be performed at 200°C, directly after welding, holding for 5min/mm material thickness, for at least one hour.
- If stress relieve annealing is necessary it should be performed between 500°C and 680°C with 1h holding time.

Recommended pre-heating temperatures for welding with ferritic consumables

Combined wall thickness [mm]						
10	20	30	40	50	60	70
100°C	125°C	150°C	175°C			

The recommended preheating temperatures are based upon a heat input around 1.7KJ/mm and that the hydrogen content does not exceed 5ml/100g weld metal.

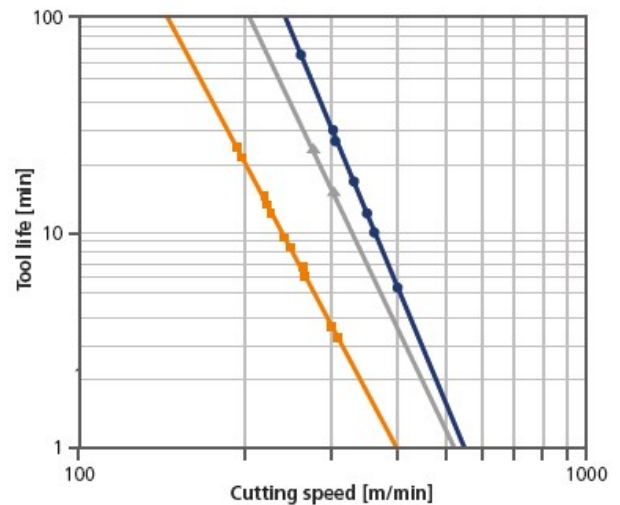
Machining

Ovako 277 has good machining properties. ISO 3685 test show tool life for various cutting speeds in Q&T 277Q. Because of the very high cleanliness the variant 277Q may have a reduced chip breaking propensity. The controlled sulphur content of Ovako 277L will enhance chip breaking.

Tool wear test

Test material:	Ovako 277Q Q&T
Test procedure:	ISO 3685
Insert:	SNMA 120408 P15
Tool holder:	CSRNL
Feed rate:	0.4 mm/r
Cutting depth:	2.5 mm
Wear criteria:	vB_{mean} 0.3mm

	Cutting speed					CI
	V ₅	V ₁₀	V ₁₅	V ₃₀	V ₆₀	
221Hv	405	357	332	293	259	0,18
230Hv	374	325	300	261	227	0,20
280Hv	264	242	221	189	162	0,23



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 CO₂ 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 ₂ e/kg	120	62	76

To get the full picture of our products environmental impact we have to look at all of our CO₂ 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 ₂ e kg /1000 kg steel)	Climate compensated Net emission = Scope 3 (CO ₂ e kg /1000 kg steel) Scope 1 - 2 = 0 (compensated)
277	Round bar	+T	702	314
277	Tube, wall	+T	750	348

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/m ³)
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:

Via e-mail: info@ovako.com

Via telephone: +46 8 622 1300

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

Disclaimer

The information in this document is for illustrative purposes only. The data and examples are only general recommendations and not a warranty or a guarantee. The suitability of a product for a specific application can be confirmed only by Ovako once given the actual conditions. The purchaser of an Ovako product has the responsibility to ascertain and control the applicability of the products before using them. Continuous development may necessitate changes in technical data without notice. This document is only valid for Ovako material. Other material, covering the same international specifications, does not necessarily comply with the properties presented in this document.