

FORA 400

A 400 HB wear resistant steel

FORA 400 is a water quenched martensitic steel, with a typical hardness of 400HB (42.5 HRC), constituting a real answer to abrasive wear. Thanks to its toughness, its elevated hardness, its high yield strength, FORA 400 can be used wherever a wear resistance to wear by sliding or by moderate impacts is required.

Compared to conventional steels, such as S355, FORA 400 offers a real benefit to equipment life times and allows a significant thickness reduction in designs since its wear resistance is up to 3 times longer than S355 grade.

Moreover, FORA 400 is very easily welded and has good forming properties thereby contributing to ease off fabrication.

This steel is particularly suitable for applications in quarries, construction industry, mines, cement plants, iron and steel industry, etc...

STANDARD

FORA 400

CHEMICAL ANALYSIS

Typical values (% weight)

C	S max	P max	Cr	Mn	Mo
0.20	0.005	0.02	1.00	1.60	0.30

t = 3/16 mm (0.12/0.62") $C_{eq} \leq 0.49\%$

t = 17/50 mm (0.66/1.97") $C_{eq} \leq 0.55\%$

t > 50 mm (>1.97") $C_{eq} \leq 0.64\%$

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$$

MECHANICAL PROPERTIES

Typical values

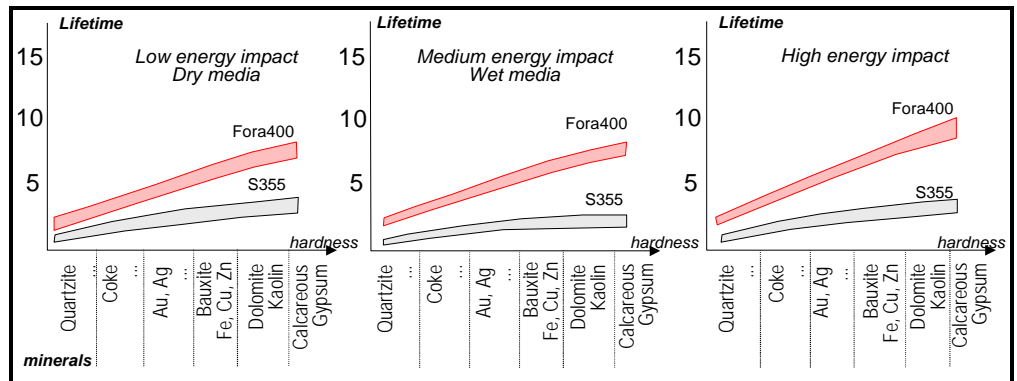
Hardness	Yield Strength ¹	UTS ¹	EI%	KCV long. -20°C (-4°F)	KCV long. -40°C (-40°F)
400 HB	1100 N/mm ²	1350 N/mm ²	13	35 J/cm ² (t=15mm) 65 J/cm ² (t=5mm)	20 J/cm ² (t=15mm) 45 J/cm ² (t=5mm)
42.5 HRC	160 KSI	195 KSI	13	21 ft.lb (t=15mm) 38 ft.lb (t=5mm)	12 ft.lb (t=15mm) 27 ft.lb (t=5mm)

Hardness guaranteed at delivery: 360 / 440 HB (39 / 47 HRC) mini

¹ Prismatic tensile values.

ABRASION RESISTANCE PROPERTIES

Wear tests data :



Typical relative lifetime data issued from field tests
 Fora 400 performs two times better than S355 in all wear conditions.

PROCESSING

Cutting

All the classical thermal cutting processes are compatible with FORA 400 (gas, plasma, laser).

Plates between 4 to 40 mm (0.16" to 1.6") thick do not require preheating provided that thermal cutting is performed at a temperature greater than 10°C (50°F). Where this is not the case or where the plates are thicker than 40mm (1.6"), preheating at 100-150°C (200-300°F) is recommended.


Thickness →	4 – 40 mm (0.16" – 1.6")	> 40 mm > 1.6"
Cutting Temperature ↓	≥ 10°C (50°F)	< 10°C (50°F)
	No pre-heating	Preheating at 100–150°C (212-302°F)
	Preheating at 100–150°C (212-302°F)	

Water jet cutting or shearing can also be used.

Machining

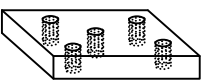
Drilling and milling should be performed with supercarburized cobalt high-speed steel type HSSCO, using wherever possible an oil lubricant. However, classical high-speed steels can be used. The typical cutting parameters are :

Drilling



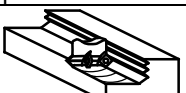
		Ø = 10 mm	Ø = 20 mm	Ø = 30 mm
Cutting Speed	m/min	6-12	6-12	6-12
	ft/min	20-40	20-40	20-40
Rotational speed	rev/min	300	150	100
Feed	mm/rev	0,1	0,2	0,3

Tapping



		Ø = 10 mm	Ø = 20 mm	Ø = 30 mm
Cutting Speed	m/min	2-4	2-4	2-4
	ft/min	6.5-13	6.5-13	6.5-13
Rotational speed	rev/min	120	70	50

Milling



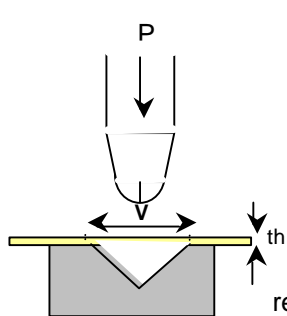
		Ø = 10 mm	Ø = 20 mm	Ø = 30 mm
Cutting Speed	m/min	25-30	25-30	25-30
	ft/min	80-100	80-100	80-100
Rotational speed	rev/min	625	450	250
Feed	mm/rev	0,2	0,18	0,13

Bending

Thanks to the high refining level of the steel (low sulphur and phosphorous contents), FORA 400 is easy to bend provided that following conditions are respected :

- Dressing (or grinding) of the ridges caused by gas-cutting to limit hardened zones
- Sufficiently powerful equipment
- Respect of minimum forming radius

For plates below 20 mm (0.8") thick, forming conditions are summarised in following table ; beyond 20 mm (0.8"), consult us.

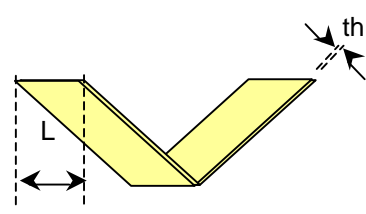


	Perpendicular to the rolling direction	Parallel to the rolling direction
Bending internal radius R (mini)	3 x th	4 x th
Die opening V (mini)	10 x th	12 x th

Bending angle $\approx 90^\circ\text{C}$

Whitin these allowable bending parameters, the force required to form a plate is function of the bent length, the metal thickness, die opening, die form (V or U), punch form etc...

The following table shows the bending forces, for the minimum die opening (V=10 th), required for V bending plates for different bent plate width.



Thickness	Bending force required bend plate width*
	Tons/m
5 mm	88
10 mm	175
15 mm	260
20 mm	350

* ($\pm 10\%$)

FORA 400 steel is unsuitable for hot forming at a temperature higher than 200°C (400°F)

WELDING

Thanks to its chemical analysis with a low carbon content, FORA 400 shows very good welding characteristics. It can be welded in easy conditions in total safety. Welding consumables are generally E7018 or E13018 types according to AWSA5-1 or AWS A5-5.

Weld preparation

Welded surface must be dry and clean and superficially ground in order to eliminate any rust, scale, grease or paint traces as well as any gas-cutting ridges.

Welding process

Any conventional fusion welding method can be used, such as submerged arc welding (SAW), manual metal arc welding (SMAW), flux core wire arc welding (FCAW), MIG, MAG (GMAW) and TIG (GTAW).

Heat input should be limited to 10-30 kJ/cm with maximum interpass temperature of 200°C (392°F)

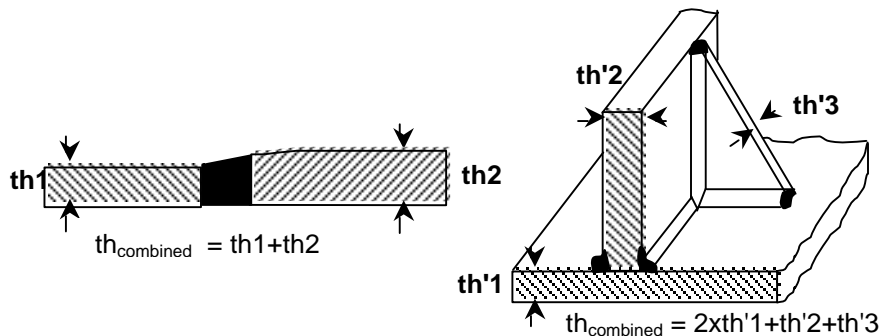
Welding consumable

All products in accordance with following standards are acceptable

	Stick electrodes	MIG-MAG	Flux core wire gas protected	Submerged arc welding Wire / flux
AFNOR	NFA81-340 EY50 1niMo Bxxx1xTBH			NF A81-322 FP/x xx/xx xB x SA31 47 05 04
AWS	A5-5-81 E 70xx	A5-28 ER 70 S-x	A5-29 E 7xT5-x	A5-23 F7P4-Exxx-A2
DIN	DIN 1913 E51 55 Bx			

Preheating

FORA 400 can be welded without crack risk and without preheating up to a combined plate thickness of 50 mm (2"). For higher thicknesses, the following conditions are recommended.



Pre-post heating conditions - Combined thickness – mm (in)

Welding processes	Energy (kJ/cm)	30	40	50	60	70	80	90	100	110
		1.18	1.57	1.96	2.36	2.75	3.14	3.54	3.93	4.33
GMAW	15									
	30									
SMAW	10									
	20									
SAW	20									
	30									

Without pre-heating, θ° plate $>5^\circ\text{C}$ (40°F)
 with slight pre-heating 75°C (165°F)
 with pre-post heating $\geq 100^\circ\text{C}$ (210°F)

APPLICATIONS

- Quarries, Construction- Earth moving Skimmers, crushers, screens, bunkers, bulldozers, etc...
- Cement plant Buckets, crushers, bunkers...
- Mines, Coal mines Excavator, winding and discharging machines, conveyors, etc...
- Iron and steel industry Bunkers, various casing, guide and shifting plates, etc...

DIMENSIONAL PROGRAMME

FORA 400 grade is available in a large dimensional programme :

Thickness mm (in)	Flatness mm/2m (in/7ft)	Available Width		
		Coil - mm (in)	Steckel - mm (in)	Quarto - mm (in)
4 (3/16")	8 (0.31)	1500 (60")	1800/2250 (70"/96")	
5 (0.2")	8 (0.31)	1500 (60")	1800/2500 (70"/98")	1200/2500 (47"/98")
6 (0.24")	6 (0.24)	1500 (60")	1800/2750(70"/108")	1200/2750 (47"/108")
7-10 (0.28"-0.4")	6 (0.24)			1200/3100 (47"/122")
10-25 (0.4"/1")	6 (0.24)			1200/3800 (47"/150")
25-50 (1"-2")	6 (0.24)			1200/3680 (47"/145")
50-100 (2"-4")	6 (0.24)			1200/3500 (47"/138")
Tolerances		± 0.2 mm ± 0.008 "	± 0.3 mm ± 0.012 "	$\pm 0.6 \rightarrow \pm 1.4$ mm $\pm 0.024 \rightarrow \pm 0.055$ "

Typical lengths: 6000 – 8000 – 10 000 – 12 000mm

Plates outside this dimensional programme can be available after agreement.

NOTE :

1. This technical data and information represents our best knowledge at the time of printing. However, it may be subject to some slight variations due to our ongoing research programme on wear resistant grades. We therefore suggest that information be verified at time of enquiry or order. Furthermore, in service, real conditions are specific for each application. The data presented here is only for the purpose of description, and may only be considered as guarantees when our company has given written formal approval. Further information may be obtained from the following address.
2. FORA 400 : Application range.
Fora 400 has been developed specifically for its abrasion resistance. Customer's usage of Fora 400 for any other purposes, not directly resulting from its abrasion resistance, is his own prerogative but won't, in any way, engage USINOR INDUSTRIEL's responsibility. In addition to the recommendations given in this document, Customer will have to follow the Industry standard quality rules for any processing operation performed on this material

USINOR INDUSTRIEL IS CERTIFIED ISO 9001

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