



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), giving a real answer to abrasive wear. Thanks to its toughness, its elevated hardness, its high yield strength, FORA 400 can be used wherever resistance to wear by sliding or by moderate impacts is required.

FORA 400 offers a real benefit to equipments lifetime 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 an easy processing.

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

Standard

FORA 400 – INDUSTEEL Specification

Chemical analysis - % weight

C	Mn	P	S	Cr	Ni	Mo	B
.20	1.5	.02	.003	1.0	.7	.2	.003

Guaranteed maximum values

C. Equivalent

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

Thickness range - mm (")	C.Eq
4/12 (.16"/.47")	≤ .45
12,01/50 (.47"/1.97")	≤ .56
50.01/150 (1.97"/5.90")	≤ .64

Mechanical properties

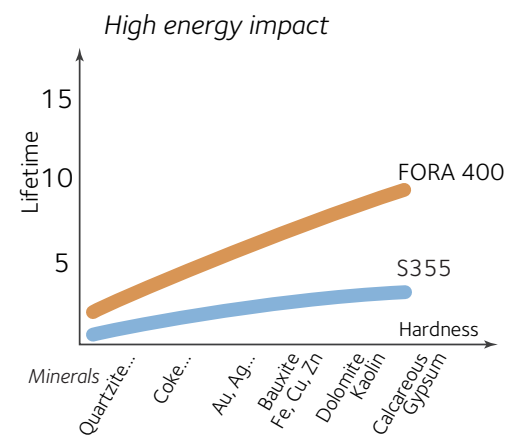
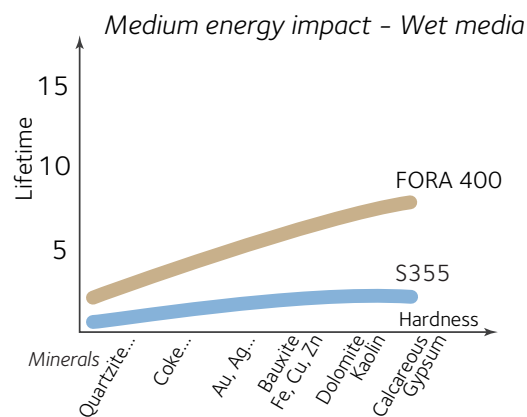
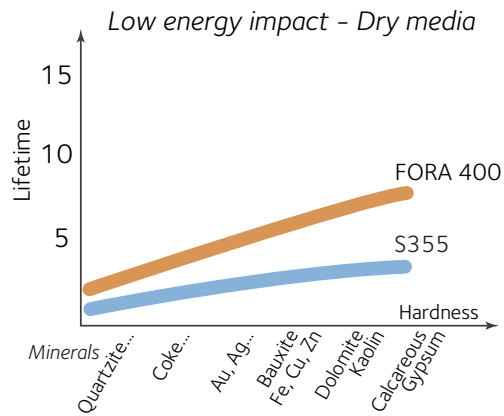
Hardness	Y.S. 0.2	UTS	El 5.65 ^{√s} % *	KCV Transv. -20°C (-4°F)	KCV Transv. -40°C (-40°F)
400 HB	1100 MPa	1350 MPa	13	t = 15mm → 20 J t = 5mm → 40 J	t = 15mm → 16 J t = 5mm → 36 J
42.5 HRC	160 KSI	195 KSI	13	t = .6" → 15 ft.lbs t = .2" → 29ft.lbs	t = .6" → 12 ft.lbs t = .2" → 27 ft.lbs

Typical values

Guaranteed hardness in delivery condition : 360/440 HB (39/47 HRC)

* Prismatic tensile probes

Wear resistant properties



Wear test data

Processing

Cutting

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

Plates from 4 to 40 mm (.16" to 1.6") thickness do not require preheating provided that thermal cutting is performed at a temperature higher 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 (210-300°F) is recommended.

Thickness →	4-40mm (.16"-1.6")	> 40mm (> 1.6")
Cutting temperature ↓	≥ 10°C (50°F)	Preheating 100-150°C (212-302°F)
	No preheating	
	< 10°C (50°F)	Preheating 100-150°C (212-302°F)

Water jet cutting or shearing can also be used

Machining

Drilling and milling should be performed with super-carburized 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 = 10mm (.40")	Ø 20mm (0.80")	Ø 30mm (1.18")
Cutting speed	m/min ft/min	6 - 12 20 - 40	6 - 12 20 - 40	6 - 12 20 - 40
Rotational speed	rev/min	190 - 380	90 - 190	60 - 120
Feed	mm/rev	0.1	0.2	0.3

Tapping

		Ø = 10mm (.40")	Ø 20mm (0.80")	Ø 30mm (1.18")
Cutting speed	m/min ft/min	2 - 4 6.5 - 13	2 - 4 6.5 - 13	2 - 4 6.5 - 13
Rotational speed	rev/min	60 - 120	30 - 60	20 - 40

Milling

	Depth mm (")	Cutting speed m/min (")	Feed (mm/tooth)
HSSCO AR 12.0.5.5 (T15)	1 (.04")	120 - 150 (4.7-5.9)	0.08
	4 (.16")	100 - 120 (3.9 - 4.7)	0.10
	8 (.31")	70 - 90 (2.7 - 3.5)	0.15
F40M	1 to 5 .04" to .20"	70 to 200 2.7" to 7.9"	.15 to .35

Bending

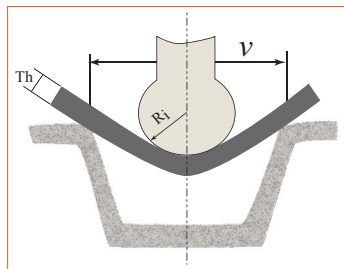
Thanks to the high refining level of the steel (low sulphur and phosphorous contents), FORA 400 is easy to bend provided that following conditions are respected :

- 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 (.8") thickness, forming conditions are summarized in following table ; beyond 20 mm (0.8"), consult us.

<i>th</i> = thickness	Perpendicular to the rolling direction	Parallel to the rolling direction
Bending internal radius R_i (mini)	3 x <i>th</i>	4 x <i>th</i>
Die opening <i>V</i> (mini)	10 x <i>th</i>	12 x <i>th</i>

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...

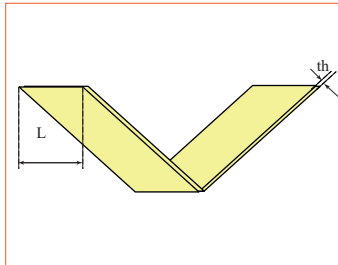


Bending angle = 90°

The following table shows the bending forces, for the minimum die opening ($V=10\ th$), required for V bending plates for for 1m bent.

Thickness mm (")	Bending force required per meter of bend* (tons/m)
5mm (.20")	90
10mm (.40")	175
15mm (.60")	260
20mm (.78")	350

* ± 10%



FORA 400 steel is unsuitable for hot forming at a temperature higher than 200°C (392°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.

Weld preparation

Weld surfaces must be dry, 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 between preheating temperature and 200/220°C (390-430°F) maxi.

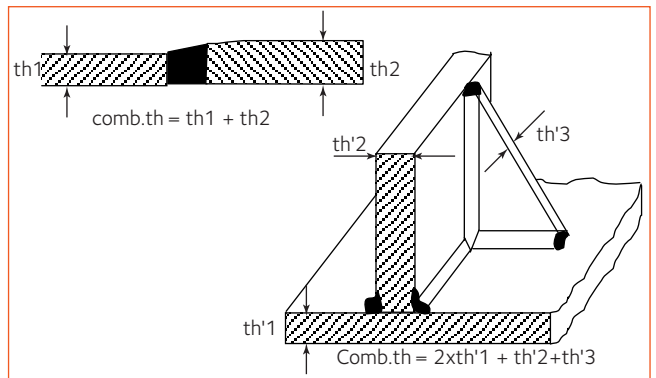
Welding consumable

All products in accordance with following standards are acceptable :

Stick Electrodes	MIG-MAG	Flux core wire gas protected	Submerged arc welding Wire-flux
AFNOR			
NF A81-340			NF A81-322
EY50 1NiMo			FP/x xx/xx xB xSA31
Bxxx1xTBH			47 05 04
ASW			
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			

Pre-Post heating conditions Combined thicknesses

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 :

Energy (kJ/cm)	30	40	50	60	70	80	90	100	110 mm
	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 T°Plate >5°C/40°F
 with slight pre-heating 75°C / 165°F
 with pre-post heating ≥ 100°C / 210°F

Sizes and tolerances

FORA 400 is available in a large dimensional programme :

Thickness		Coils			Quarto			Flatness	Typical lengths	
mm	inch	width mm	Width inches	Tol. th (mm)	width mm	width inches	Tol. th (mm)	mm/m (*)	mm	ft
4-6	3/16 - .24	1500	60"	± 0.25	1500-2500	60-98.4	± 0.6	5	6 000	19.68
7-8	.28 - .3				1500-2500	60-98.4	± 0.6	5	8 000	26.24
9-10	.35 - .39				1500-3100	60-122	± 0.6	5	10 000	32.80
11-14	.43 - .55				1500-3800	60-149.6	± 0.6	5	12 000	39.37
15-24	.60 - .94				1500-3800	60-149.6	± 0.7	5		
25-39	.98 - 1.53				1500-3800	60-149.6	± 0.8	5		
40-50	1.57 - 1.97				1500-3800	60-149.6	± 1.2	5		
51-59	2 - 2.32				1500-3500	60-137.8	± 1.2	5		
60-120	2.36 - 4.72				1500-3500	60-137.8	± 1.4	5		
121-150	4.76 - 5.90				1500-3500	60-137.8	± 1.6	5		

* .20" in every 40"

Weight maxi for a plate : 15 Tons.

Plates outside this dimensional programme can be available after agreement.

Please, ask us.

For any information

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Bunkers, various casing, guide and shifting plates...

Nota

Technical data and information are to the best of our knowledge at the time of printing. However, they may be subject to some slight variations due to our ongoing research programme on wear resistant grades. Therefore, we 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 are only for the purpose of description, and considered as guarantees when written formal approval has been delivered by our company.