



FORA 450

A 450 HB wear resistant steel

FORA 450 is a martensitic water quenched steel, with a typical hardness of 450 HB constituting a real answer to abrasive wear. Its toughness, high hardness and yield strength confer it a very good resistance to plastic deformations and to both sliding and impact wear.

FORA 450 exhibits a wear resistance typically equal to 4 times and yield strength 3 times higher than those of a S355. Use of FORA 450 induces a strong improvement in term of lifetime and lightening of equipment through a thickness reduction.

FORA 450 is easy to process, it has a good weldability and a good aptitude to bending, considering its high mechanical properties.

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

FORA 450 is a grade specially adapted of truck bodies manufacturing.

Standard

FORA 450 – 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
4/15 (.16"/.59")	.50
15,01/50 (.59"/2")	.59

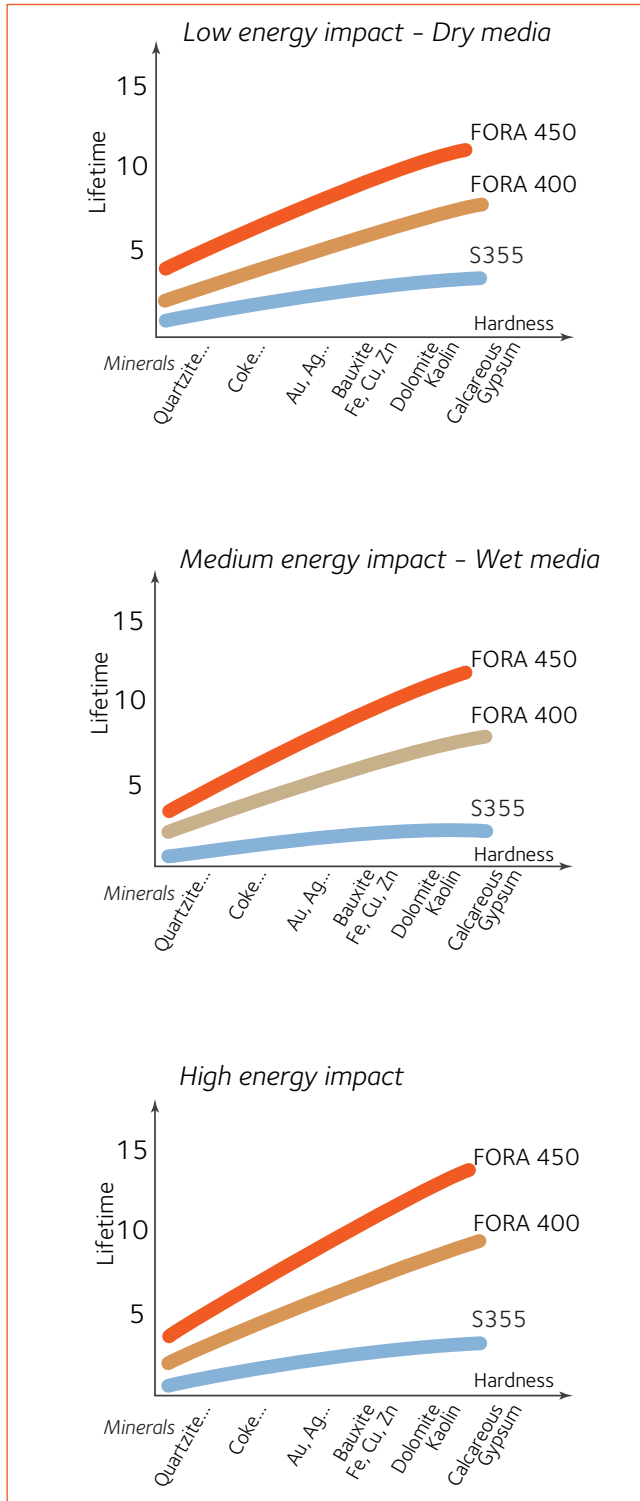
Mechanical properties

Hardness	Y.S. 0.2	UTS	El 5.65 ^{√s} %	KCVL -40 °C (-40 °F)
450 HB	1200 MPa	1400 MPa	10	30 J
47.5 HRC	174 KSI	203 KSI	10	22 ft.lbs

Typical values

Guaranteed hardness in delivery condition : 410 / 500 HB (44 /51.5 HRC)

Wear resistant properties



Wear tests data

Processing

Cutting

FORA 450 can be cut by all classical thermal processes (oxygen, plasma, and laser).

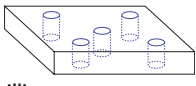
Plates 4 to 10 mm thick do not require any preheating, as far as processing is done at a temperature higher than 10°C (plate temperature). If steel temperature is below 10°C (50°F), a preheating is necessary to avoid cracking.

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

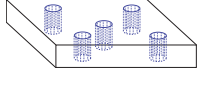
Water jet cutting can also be used

Machining

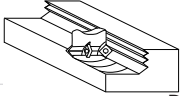
Drilling and milling should be performed with super-carburized cobalt high-speed steel type HSSCO, using wherever possible an oil lubricant. However, classical high-speed steels can be used. The typical cutting parameters are :



	Ø = 5mm (.20")	Ø 10mm (.40")	Ø 20mm (.80")	Ø 30mm (1.18")
Drilling				
Cutting speed	m/min ft/min	6 - 8 20 - 26	6 - 8 20 - 26	6 - 8 20 - 26
Rotational speed	rev/min	380 - 500	190 - 250	90 - 120
Feed	mm/rev	0.07	0.1	0.2



	Ø = 10mm (.40")	Ø 20mm (0.80")	Ø 30mm (1.18")
Tapping			
Cutting speed	m/min ft/min	1 - 3 3.3 - 10	1 - 3 3.3 - 10
Rotational speed	rev/min	30 - 95	15 - 45



	Depth mm (")	Cutting speed (m/min)	Feed (mm/tooth)
Milling			
HSSCO	1 (.04")	100-120 (3.9-4.7)	0.08
AR 12.0.5.5 (T15)	4 (.16")	80-110 (3.1-4.3)	0.12
F40M	1 to 5 .04" to .20"	70 to 200 2.7" to 7.9"	.15 to .35

Bending

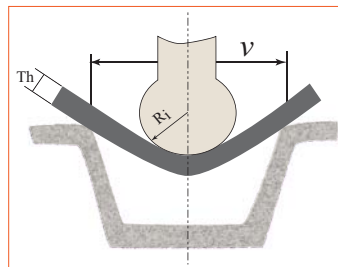
Due to its good refining (low sulfur and phosphorus content), FORA 450 is easy to cold bending provided that following conditions are respected :

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

$th = \text{thickness}$	Perpendicular to the rolling direction	Parallel to the rolling direction
Bending internal radius R_i (mini)	4 x th	4 x th
Die opening V (mini)	14 x th	14 x th

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=14 th), required for V bending plates for for 1m bent.

Thickness mm (")	Bending force required per meter of bend *
	Ton/m
5 (.20")	65
10 (.40")	125

* ± 10%

FORA 450 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 450 shows very good welding aptitude. 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).

Depending on thickness, heat input should be controlled within a range 5 to 15 KJ/cm.

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 EY50 1NiMo Bxxx1xTBH			NF A 81-322 FP/x xx/xx xB xSA31 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			

The following standards are met by following products on the market :

	Stick electrode	MIG-MAG	FCAW	SAW Wire	SAW Flux
BÖHLER	Fox Ev 50	EM K7		AM S3	
COMMERCY	CY2051	SG 6		CY 10	SP 1000
ESAB	OK 48.04	OK 12.51	OK 15.00	OK 12.32	OK 10.62
KLÖCKNER	FIRMA 5520 R	VDG 15/60	EWB1-MF	VDG-S3	
LINCOLN	CONARC 49C	LNМ 27	MC 710 H	L60	880M
MESSER	GRICON 515S			UP S2 Ni	LW 330
METRODE	MET-MILD MP51	ER 70-S6			
OERLIKON	TENACITO 38R		FLUXOFIL 31	SOUADOR SD3	OP 121TT
SAF	SAFDRY NF58	NIC 70S	SAFDUAL 200 AS 36	AS 589	
THYSSEN	B120	K52		S2	UV 421TT
UTP	613 KB				

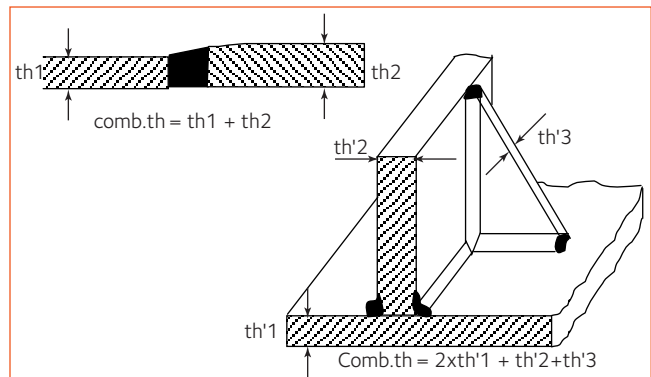
For truck bodies, this list is valid for classical welded structures without any special stress applied. However, it is recommended to check with each supplier of welding consumable.

Pre-Post heating conditions

Combined thickness

→ In the th. range 4 to 10mm (.15" to .39"), as far as welding sequences are optimized to avoid introduction of high welding stress, no preheating should be applied for FORA 450.

→ Case of combined thickness : FORA 450 can be welded without any 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
 $T^{\circ}\text{Plate} > 5^{\circ}\text{C} / 40^{\circ}\text{F}$
 With slight pre-heating
 $85^{\circ}\text{C} / 175^{\circ}\text{F}$
 With pre-post heating
 $\geq 130^{\circ}\text{C} / 265^{\circ}\text{F}$

Sizes - Tolerances

FORA 450 is available in a large dimensional programme :

Thickness		Coils			Quarto			Flatness mm/m (*)
mm	inch	width mm	width inches	Tol./th (mm)	width mm	width inches	Tol./th (mm)	
4-6	3/16 - .24	1200	47"	± 0.25	1200-2000	47-79	± 0.6	5
6-9	.24 - .35				1200-2500	47-98.4	± 0.6	5
9-12	.35 - .47				1200-3100	47-122	± 0.6	5
12-25	.47 - .98				1200-3800	47-149.6	± 0.6	5
25-50	.98 - 1.97				1200-3680	47-144	± 0.7	5

Typical lengths	
mm	ft
6 000	19.68
8 000	26.24
10 000	32.80
12 000	39.37

* .20" in every 40"

Plates outside this dimensional programme can be available after agreement.
Please ask us.

For any information

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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.