aperam
made for life

KARA ferritic stainless steel offer grade K41X

k41x

18% chromium titanium and niobium-stabilized ferritic stainless steel

Chemical composition

Elements	C	N	Si	Mn	Cr	Ti+Nb
%	0.015	0.015	0.60	0.30	17.80	0.65

Typical values

European designation [1]

X2CrTiNb18

1. 4509

[1] In accordance with EN 10088-2

American designation [2]

S43932 / S43940

Type 441

[2] In accordance with ASTM A 240

IMDS n°

336816606

This grade complies with:

- Stainless Europe Material Safety Data Sheet no.1: stainless steels (European Directive 2001/58/EC).
- European Commission Directive 2000/53/EC for end of-life vehicles, and to Annex II dated 27 June 2002.

General characteristics

Our K41X grade is characterised by:

- Elevated hot mechanical properties without risk of σ phase formation at intermediate temperatures
- Greater thermal conductivity than austenitic with a lower coefficient of expansion.
- Good resistance to pitting corrosion
- Good corrosion resistance in the cold part of the exhaust
- Good oxidation resistance at high temperature up to 950 °c
- Good weldability
- Ease of forming

KARA
key for value

"X" for exhaust means the warranty of:

- Just in time deliveries
- Reliable quality
- Continuous improvement as required by the automotive market

Applications

- Various parts of the vehicles exhaust systems (manifold, tube, catalytic converter and muffler shell)

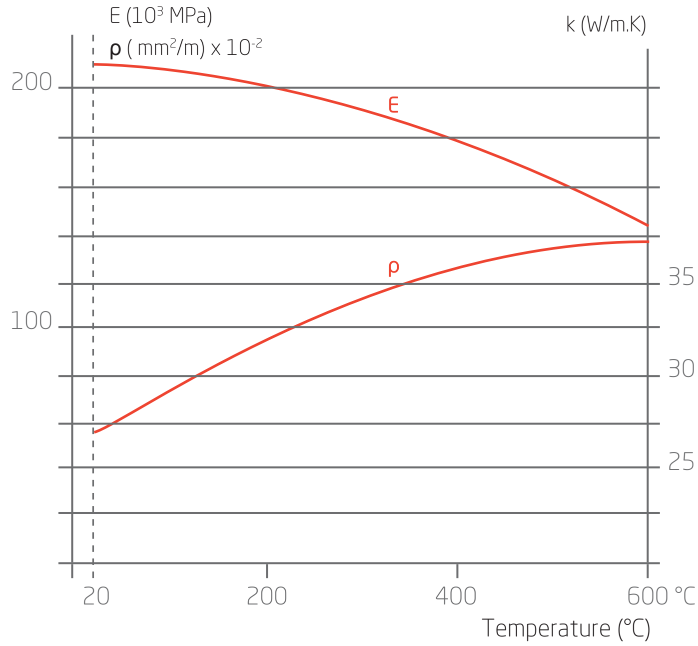
Product range

Forms : sheets, blanks, coils, strips, circles
Thicknesses : 0.4 to 6.0 mm
Width : according to the thickness, consult us
Finishes : cold rolled, hot rolled according to the thickness

Physical properties

Cold rolled sheet In the annealed condition
(Typical values)

Density	d	kg/dm³	20 °C	7.7
Melting temperature		°C	Liquidus	1505
Specific heat	c	J/kg.K	20 °C	460
Thermal conductivity	k	W/m.K	20 °C 500 °C	25 26.3
Mean coefficient of thermal expansion	α	10^{-6}/K	20-200 °C 20-400 °C 20-600 °C 20-800 °C	11.0 11. 12.1 12.8
Electric resistivity	ρ	Ω mm²/m	20 °C	0.60
Magnetic permeability	μ	at 0.8 kA/m DC or AC	20 °C	850
Modulus of elasticity	E	10^3.MPa	20 °C	220



Mechanical properties

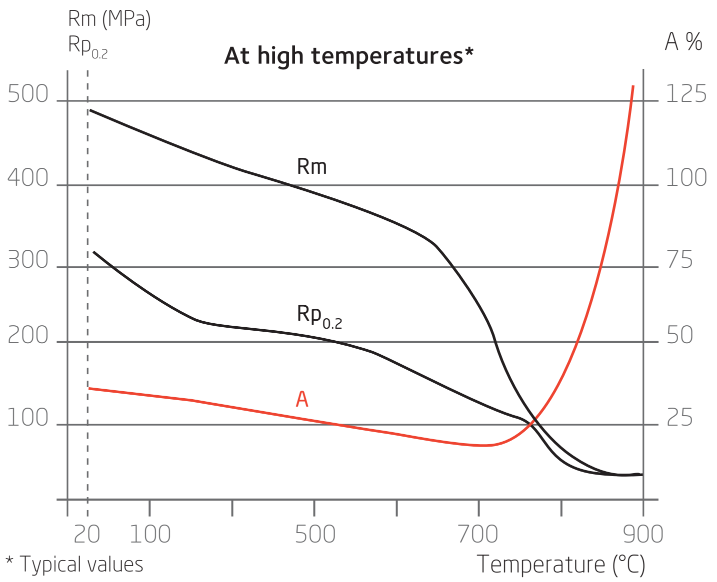
In the annealed condition
In accordance with ISO 6892-1, test specimen perpendicular to the rolling direction.

Test specimen
Lo = 80 mm (thickness < 3 mm)
Lo = 5.65 √ So (thickness ≥ 3 mm)

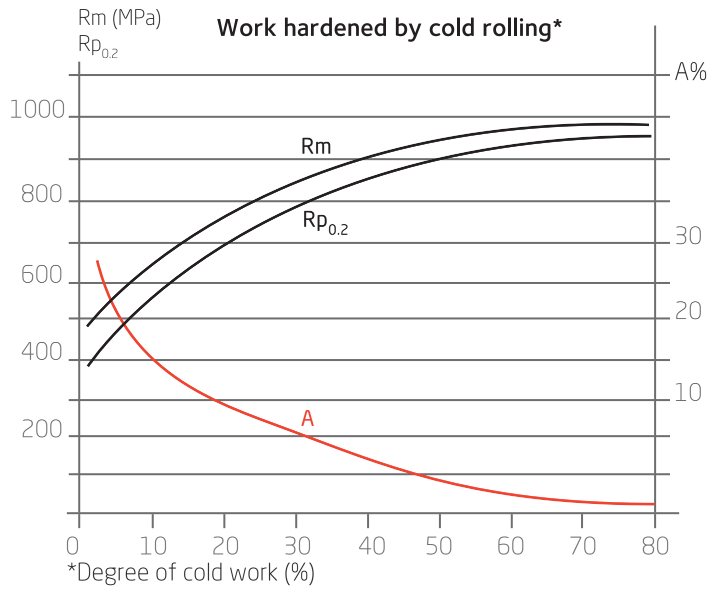
Présentation	Rm[1] (MPa)	$Rp_{0.2}$ [2] (MPa)	A[3] (%)	HRB
Cold-rolled*	480	310	30	78

1 Mpa = 1 N/mm². *Typical values

[1] Ultimate Tensile Strength (UTS) [2] Yield Strength (YS) [3] Elongation (A).



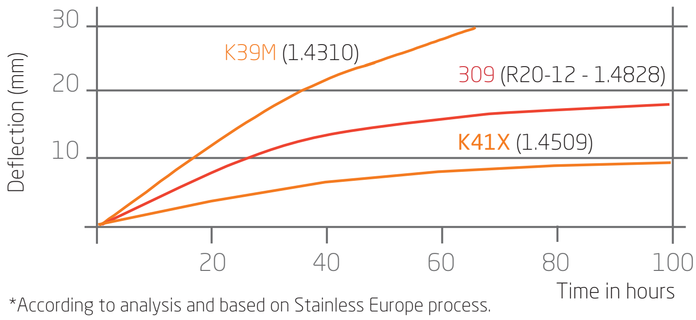
* Typical values



High temperature properties

K41X characteristics at high temperatures

Creep Sag test at 950° C* (thickness 2 mm)

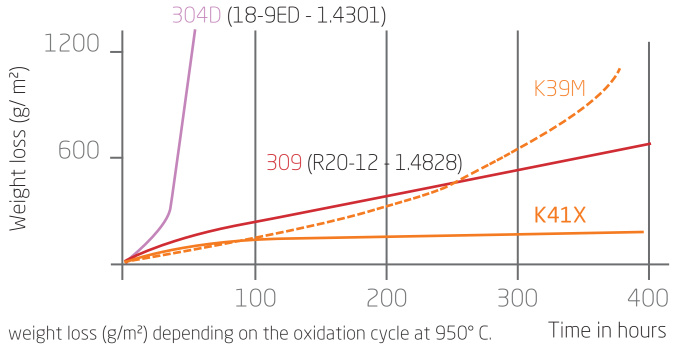


*According to analysis and based on Stainless Europe process.

The chemical composition of the K41X has been optimized in order to meet the required characteristics of the various parts of an exhaust system such as the manifold or the catalytic converter. These parts are subjected to numerous cycles of vehicle's starting and stopping. Therefore, the first criteria considered have been the thermal fatigue resistance and the capacity of the material to develop a protective oxidant layer.

The appropriate mix of stabilisers, such as titanium and niobium in the K41X, gives the grade good ductility at any temperature and an optimized creep resistance as shown in the figure during a test realised at a temperature of 950° C.

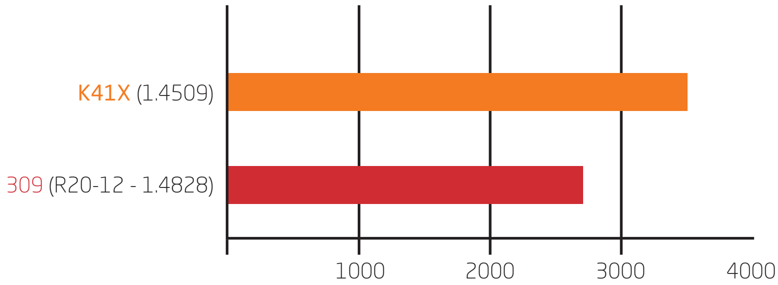
The chrome diffusion is facilitated in the K41X ferritic matrix compared to an austenitic matrix thus allowing avoiding a chrome "impoverishment" and favouring the creation of a protective chrome-containing oxide layer.
Compared to an austenitic grade, the K41X thermal expansion is closer to the oxide layer it develops. Consequently, the thermal stresses are greatly reduced and almost no scaling of this layer is registered.



weight loss (g/m²) depending on the oxidation cycle at 950° C.
Environnement: air
Sample Thickness: 1.5mm

It results in low weight loss.
At high temperature, our K41X has a high resistance to oxidation and especially to cyclic oxidation permitting its use up to 950°C.

Thermal fatigue
Our tests, realised in V shape for a cycle 100 - 1000°C, show a very good behaviour when compared to the austenitic grade 1.4828



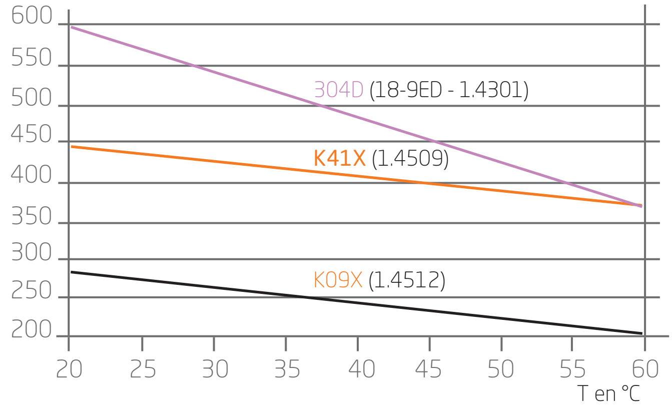
Number of cycles before break at 1000°C
Distance between jaws: 82 cm
Sample Thickness: 1.45 mm

Corrosion resistance

Pitting Corrosion
Our K41X grade is insensitive to stress corrosion cracking. The pitting corrosion resistance decreases according to the temperature. The decrease of the pitting potential value is higher for austenitic grades than for ferritic grades. The K41X exhibits a good resistance to pitting corrosion with high temperatures.

Resistance to localized corrosion

Grades[1]	Norms ASTM	Norms UNS	Norms EN
K09X	409	S40900	1.4512
K39M	430Ti	S43036	1.4510
K41X	441	S43936	1.4509
304D	304	S30400	1.4301
309	309		1.4828



Pitting potential according to the T°. Neutral PH solution, 700 ppm of NaCl.

Resistance to condensates corrosion
For the exhaust market, the qualification for resistance to condensates corrosion is done by successive 'Drip – Dry' simulation testing in chosen condensates with regular passing into the oven to simulate automotive driving cycles. Our K41X resists to acid condensates corrosion in exhaust line from diesel or gasoline engines according to the simulation test of car manufacturers.

Grades[1]	Accelerated "DIP-DRY" simulation tests Cyclic tests in synthetic condensate furnace at 300°C, pH4 — Maximum depth of corrosion in µm						
	Free sheet surface		Crevice corrosion		Under deposit corrosion		
	500 h	1000 h	30 j	90 j	30 j	30 j	5 j
K09X	1.2	3.6	36	100	3.6	21.6	100
K39M	1.2	2.4	7.2	70	2.5	19.2	54
K41X	-	-	3.6	8.5	-	-	-

Resistance in Salt Spray Test with associated thermal treatment at 300°
The K41X exhibits excellent compromise properties & costs for the external corrosion compared to grade 304D (18-9ED - 1.4301).

Grade designation	Insufficient	acceptable	medium	good	very good
K09X	■				
K39M	■	■	■		
304D	■	■	■	■	
K41X	■	■	■	■	
K33X	■	■	■	■	
K09X Al [1]	■	■	■	■	■
K44X [2]	■	■	■	■	■

Aspect of K41X after exposure to road conditions Cycle duration: 24h Test duration: 500h Thermal treatment: 300°C

[1] EN 1.4512 Alusi®, type 409Al, [2] EN 1.4521, Type 444

Forming

Our K41X is perfectly suitable to the demand of cold forming. For mufflers, catalytic converter cones and also for manifolds where forms are more and more complex, the K41X offers excellent results.

The K41X exhibits better performances than austenitic grade 1.4301 in deep drawing condition. With the design of exhaust systems becoming more complex, tubes should be able to present a bending radius as low as possible.

The bending capacity is measured by the Limit Bending Ratio which is the ratio between the mean radius and the tube diameter.

Grade designation	European designation	Erichsen deflection (mm)*	LDR*
K41X	1.4509	**10.1**	**2.31**
309 (R20-12)	1.4828	12.0	2.14

* On sheet thickness 1.0mm

Bending of welded tubes

Bending	Ra=R/Dmini
Tube 50 mm ø x 1.5 mm	1.3

* Ra= bending ratio, D = Tube diameter, R = Bending Radius

Welding

Our K41X grade can be resistance welded by spot or seam techniques. Good results are obtained without post treatment provided if the weld is sufficiently forged.

Welding process	Without filler metal	With filler metal			Shielding gas*
	Typical thicknesses	Thicknesses:	Filler metal: Rod	Filler metal: Wire	* Hydrogen and nitrogen forbidden in all cases
Resistance: spot, seam	≤ 2 mm				
TIG	< 1.5 mm	> 0.5 mm	G 19 9L (1) or 18L Nb (1) ER 308L (2) or 430LNb 1.4316 ou 1.4511 (5)		Argon Argon + Helium
PLASMA		> 0.5 mm		G 19 9LSi(1) or 18L Nb (1) ER 308LSi(2) or 430LNb 1.4316 ou 1.4511 (5)	Argon Argon + Helium
MIG		> 0.8 mm		G 19 9LSi(1) or 18L Nb (1) ER 308LSi(2) or 430LNb 1.4316 ou 1.4511 (5)	Argon + 2% CO_2 Argon + 2% O_2 Argon + 2% CO_2 + Helium
Electrode		Repair	E 19 9 L (3) E 308 L (4)		
Laser	< 5 mm				Helium Under conditions: Argon

(1) In accordance with EN ISO 14343, (2) In accordance with AWS A5.9, (3) In accordance with 1600, (4) In accordance with AWS A5.4, (5) In accordance with VDEH

The addition of hydrogen or nitrogen to the argon must be avoided since these gases decrease the ductility of the welds. For the same reason nitrogen shielding must not be employed, while additions of CO2 must be limited to 3 %. In order to restrict grain growth in the HAZ, the use of high welding powers must be avoided. For example, in automatic TIG welding, the power should not exceed 2.5 kJ/cm for a sheet thickness of 1.5 mm. Pulsed MIG/MAG welding has a lower power input than conventional MIG welding and enables better control of both bead geometry and grain size. K41X has a excellent medium and high frequency induction weldability. Post-weld heat treatment is generally not necessary. The welds must be mechanically or chemically descaled, then passivated and decontaminated after pickling. Oxyacetylene torch welding must be avoided.

Heat treatment and finishing

Annealing
Parts must be thoroughly descaled prior to any heat treatment operation. Do not exceed 1 000°C.
Parts must be thoroughly degreased prior to any heat treatment operation.

Pickling
Nitric-hydrofluoric acid mixture (10% HNO_3 + 2% HF). Descaling pastes for weld zones.

Passivation
20-25% cold nitric acid bath. Passivating pastes for weld beads.

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