KARA Ferritic Stainless Steel

K41X

18% Chromium, Titanium and Niobium stabilized

KARA key for value

"X" marks the spot for exhaust applications. K41X guarantees:

- Just in time deliveries
- Reliable quality
- The continuous improvement that the automotive market demands

Chemical Composition

Elements (%)	C	N	Si	Mn	Cr	Ti+Nb
K41X	0.015	0.015	0.60	0.30	17.80	0.65

Typical values

European designation	American designation	IMDS
X2CrTiNb18/1.4509 (1)	S43932 / S43940 Type 441 (2)	336816606

(1) According to NF EN 10088-2 (2) According to ASTM A 240

This grade complies with:

- Aperam Stainless Europe - Safety Information Sheet for Stainless Steel
- European Directive 2000/53/EC on end-of-life vehicles and later modifications

Key Features

- Elevated hot mechanical properties without the risk of σ phase formation at intermediate temperatures
- Greater thermal conductivity than austenitic and lower thermal expansion coefficient
- Good resistance to pitting corrosion
- Exceptional corrosion resistance when used in the cold part of exhaust applications
- Good oxidation resistance at high temperatures (up to 950°C)
- Excellent weldability
- Easy to form

Applications

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

Product Range

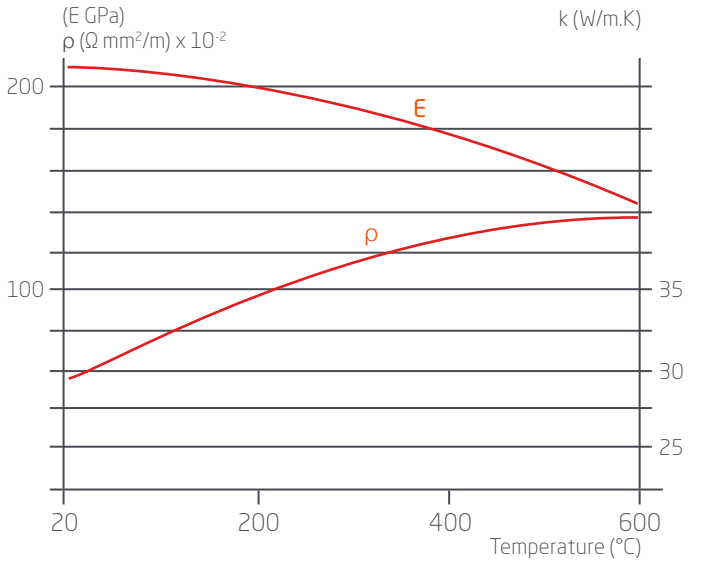
	Coils	Tubes
Thickness (mm)	0.40 up to 4	0.80 up to 2
Width (mm)	up to 1,500	Ø 8 up to 168
Finish	2B / 2D	2D

Please contact us regarding all other dimensions, forms and finishes.

Physical Properties

Cold rolled and annealed sheet

Density	d	kg/dm³	20°C	7.7
Melting temperature		°C	Liquidus	1,505
Specific heat	c	J/kg.K	20°C	460
Thermal conductivity	k	W/m.K	20°C 500°C	25 26.3
Mean thermal expansion coefficient	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 resistivity	μ	at 0.8 kA/m DC or AC	20°C	850
Young's modulus	E	GPa	20°C	220



Mechanical Properties

Test piece

Length = 80 mm (thickness < 3 mm)
Length = 5.65 √ S_o (thickness ≥ 3 mm)

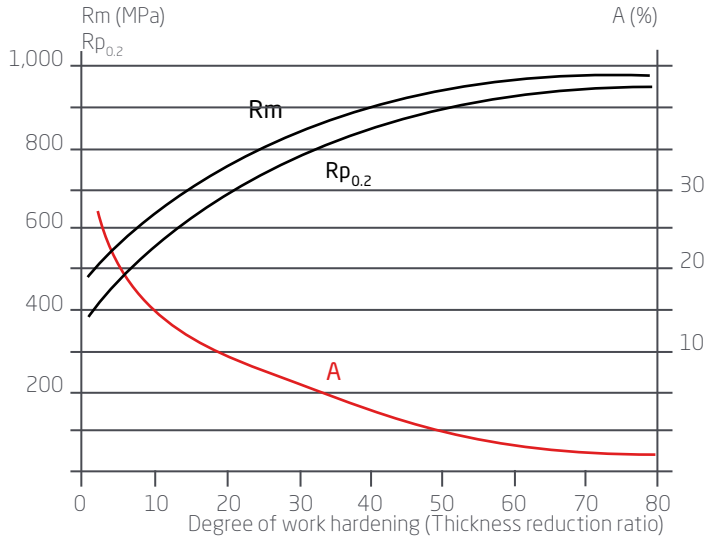
In the annealed condition

In accordance with ISO 6892-1, part 1
Test piece perpendicular to rolling direction

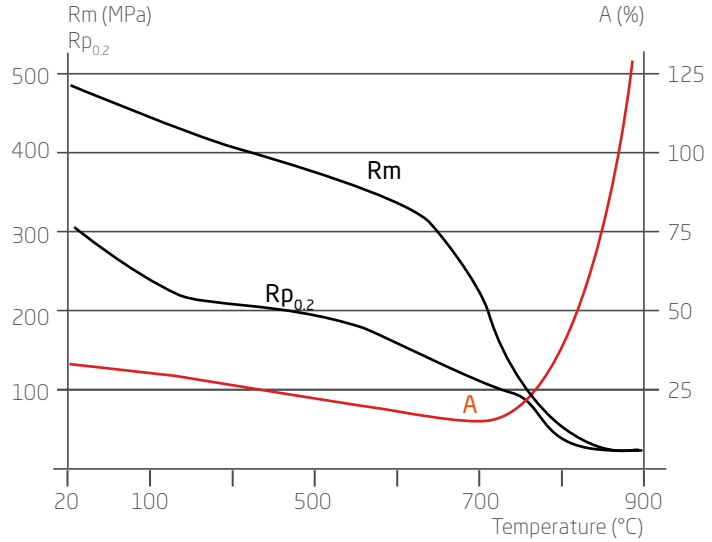
Grade	Condition	Rm(1) (MPa)	$Rp_{0.2}$(2) (MPa)	A(3) %	HRB
K41X	Cold- rolled	490	320	30	78

1 MPa = 1 N/mm² - Typical values
(1) Ultimate Tensile Strength (UTS) - (2) Yield Strength (YS) - (3) Elongation (A)

Work-hardened by cold rolling (Typical values)

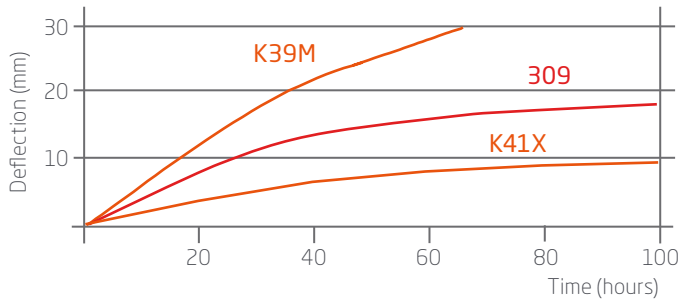


At high temperatures (Typical values)



High Temperature Properties

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



*According to analysis and based on Stainless Europe process

K41X's chemical composition has been optimized to meet the needs of a range of exhaust line parts, including the manifold and catalytic converter.

As many of these parts undergo regular stop and start cycles, K41X takes into account resistance to thermal fatigue and the need to develop an oxidant protective layer.

With appropriate mix of stabilisers, including titanium and niobium, gives the grade good ductility at any temperature and an optimized creep resistance, as shown in the figure during testing at a temperature of 950°C.

Corrosion Resistance

Pitting corrosion

Our K41X grade is not susceptible to stress corrosion cracking. Pitting corrosion resistance decreases according to temperature. The decrease of the pitting potential value is higher for austenitic grades than for ferritic grades. K41X exhibits good resistance to pitting corrosion in high temperatures.

Resistance to condensate corrosion

For exhaust applications, resistance to condensates corrosion is determined using successive 'Drip – Dry' simulation testing in chosen condensates and with regular cycles in the furnace simulates automotive driving cycles. K41X also resists the acid condensates corrosion in the exhaust line caused by diesel or gasoline engines (according to the car manufacturer simulation tests).

Accelerated "DIP-DRY" simulation tests -Cyclic tests in synthetic condensate furnace at 300°C, pH4

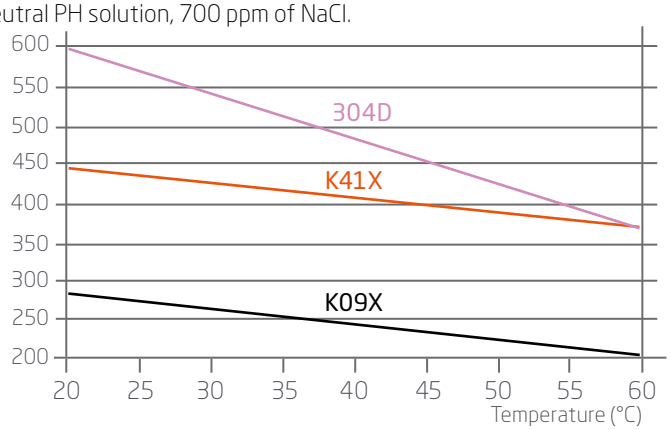
Grades	Maximum depth of corrosion (µm)						
	Free sheet surface		Crevice corrosion		Under deposit corrosion		
	500 hrs	1000 hrs	30 days	90 days	30 days	30 days+ $FeCl_3$ 6%	5 days+ pH1.6 +$FeCl_3$ 6%
K09X	6	18	180	500	18	108	500
K39M [1]	6	12	36	350	12.5	96	270
K41X	-	-	18	42	-	-	-

Resistance to localised corrosion

Grades	Norms		
	ASTM	UNS	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 temperature

Neutral PH solution, 700 ppm of NaCl.



Resistance in salt spray test

With associated thermal treatment at 300°C. K41X exhibits excellent compromise properties and costs for external corrosion compared to the 304D grade.

Aspect of K41X after exposure to road conditions

Cycle duration: 24 h

Test duration: 500 h

Thermal treatment: 300°C

Grade classifications in regards to cosmetic corrosion

Grade	K09X	K39M	304D	K41X	K33X	K09X Al [1]	K44X [2]
Cosmetic corrosion	--	0	+	+	+	++	++

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

-- : Insufficient / - : Acceptable / 0 : Medium / + : Good / ++ : Excellent

Forming

Our K41X is perfectly suited for the demands of cold forming. For mufflers, catalytic converter cones and manifolds, where forms are becoming increasingly complex, K41X offers excellent results. K41X also exhibits better performance than austenitic grade 1.4301 in deep drawing conditions. 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.

Erichsen trial (stretching trial) & LDR (Deep drawing trial)

Grades	European designation	Erichsen deflection*(mm)	LDR (mm)
K41X	1.4509	10.1	2.31
309	1.4828	12.0	2.14

*Typical values – 1.0 mm thick sheet

Bending of welded tubes

Bending (laboratory results)	Ra = R/D mini
Tube Ø 50 mm x 1.5 mm	1.3

Ra = bending ratio - D = tube diameter - R = bend radius
Angle 90°

Welding

Our K41X grade can be resistance welded using both spot and seam techniques. Good results are obtained without the need for post treatment so long as the weld is sufficiently forged.

Welding process	No filler material	With filler metal			Shielding gas*
	Typical thicknesses	Thicknesses	Filler material		* Hydrogen and nitrogen forbidden in all cases
			Rod	Wire	
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 or 1.4511 [5]	G 19 9L [1] or 18L Nb [1] ER 308L [2] or 430LNb 1.4316 or 1.4511 [5]	Ar Ar + He
PLASMA	< 1.5 mm	> 0.5 mm		G 19 9LSi [1] or 18L Nb [1] ER 308LSi [2] or 430LNb 1.4316 or 1.4511 [5]	Ar Ar + He
MIG		> 0.8 mm		G 19 9LSi [1] or 18L Nb [1] ER 308LSi [2] or 430LNb 1.4316 or 1.4511 [5]	Ar + 2% CO_2 Ar + 2% O_2 Ar + 2% CO_2 + He
Electrode		Repairs	E 19 9 L [3] E 308 L [4]		
Laser	< 5 mm				He Under certain conditions: Ar

[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 as this will decrease the ductility of the welds. For the same reason, nitrogen shielding must not be used and CO_2 additions 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 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 pickiling. 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)
- Use descaling pastes for weld zones

Passivation

- 20-25% cold nitric acid bath at 20°C
- Use passivating pastes for weld beads