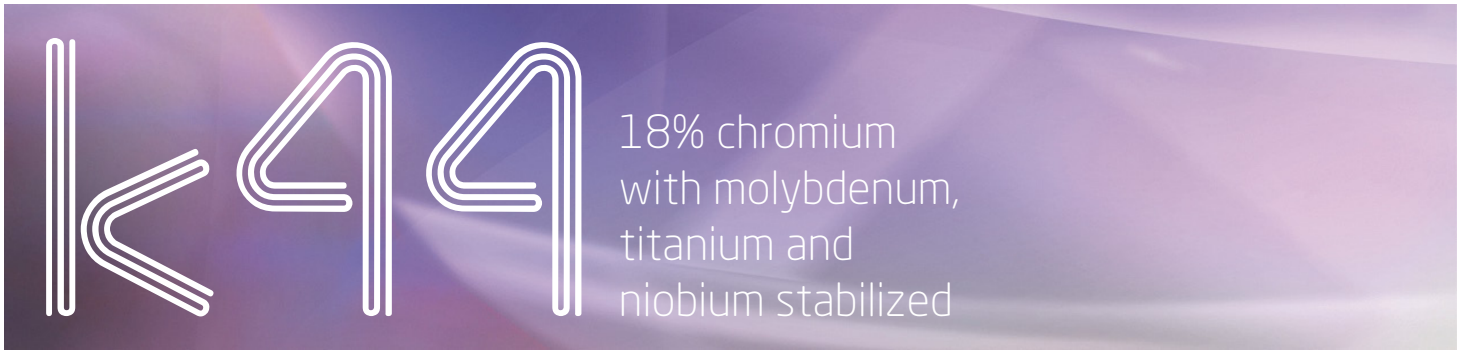
KARA ferritic stainless steel offer
grade K44



Chemical composition

Elements	C	Si	Mn	Cr	Mo	Ti+Nb
%	0.015	0.50	0.30	17.70	1.85	0.45

Typical values

European designation

X2CrMoTi18-2 1. 4521 (1)

(1) According to NF EN 10088-2

American designation

Type 444 (2)

(2) According to ASTM A 240

This grade complies with:

- Stainless Europe Material Safety Data Sheet n°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.
- Standard NFA 36 711 "Stainless steel intended for use in contact with foodstuffs, products and beverages for human and animal consumption" (non packaging steel).
- The requirements of NSF/ANSI 51 – 2009 edition International Standard for "Food Equipment Materials" and of the F.D.A. (United States Food and Drug Administration) regarding materials used for food contact.
- French Decree No.92-631 dated 8 July 1992 and Regulation No. 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food (and repealing Directives 80/590/EEC and 89/109/EEC).
- French Order dated 13 January 1976 relating to materials and articles made of stainless steel in contact with foodstuffs.
- PED (Pressure Equipment Directive) according to EN 10028-7.

General characteristics

The principal features of our K44 grade are:

- Very good resistance to pitting corrosion in chloride media, better than 304L (18-9L) and 316L (18-11ML) grades.
- Insensitivity to stress cracking corrosion and intergranular corrosion.
- Low toughness at transition temperature, even in welded zones
- good drawability
- good weldability
- thermal conductivity higher than that of austenitic grades, with a lower thermal expansion coefficient.

Applications

- Agrofood industry
- Hot water tanks
- Boilers
- Fume ducts
- Heat exchangers
- Sugar and sanitary tubes
- Photovoltaic frames
- Solar tanks
- Solar panels
- Cooking and catering equipment
- Water tanks

Product range

Forms: sheets, blanks, coils, discs.
Thicknesses: 0.40 to 4 mm
(for other thicknesses, please consult us).
Width: according to thickness, consult us.
Finish: cold rolled, 2R and 2B (other finishes, please consult us).

KARA
key for value

Physical properties

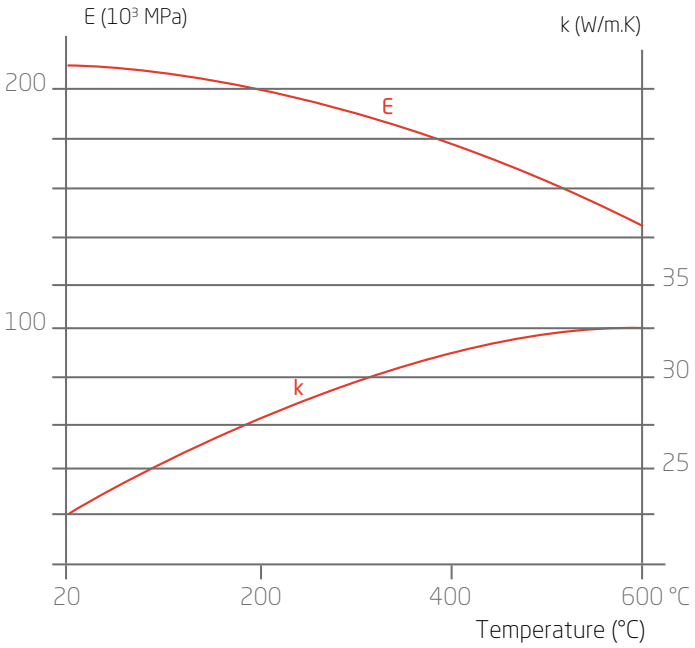
(Cold rolled sheet - annealed)*

* Typical values

Density	d	kg/dm³	20 °C	7.7
Melting temperature		°C		1495
Specific heat	c	J/kg.K	20 °C	430
Thermal conductivity	k	W/m.K	20 °C	23
Mean coefficient of thermal expansion	α	10-⁶/K	20-200 °C 20-400 °C 20-600 °C 20-800 °C	10,8 11,6 12,0 12,5
Electric resistivity	ρ	Ω mm²/m	20 °C	0.8
Magnetic permeability	μ	at 0.8 kA/m DC or AC	20 °C	800
Young's modulus	E	MPa.10³	20 °C	220

Curie point: 650°C

K44 thermal conductivity is superior to austenitic stainless steel 304L (18-9L)L - 316L (18-11ML). (k = 15W/m.°C) and the mean coefficient of thermal expansion is lower (**α**=17x10-6 - 20°C to 200°C for 304L (18-9L) or 316L (18-11ML).



Tensile properties

Delivery condition

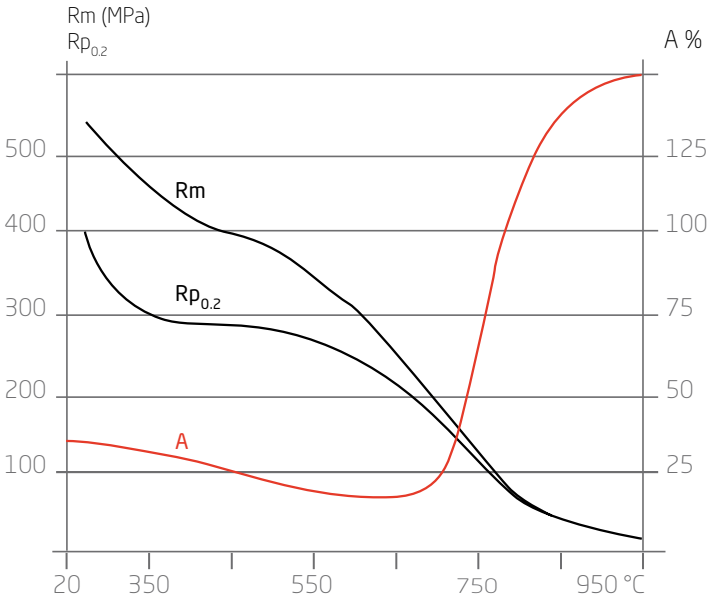
According to ISO 6892-1, part 1,
specimen perpendicular to the rolling direction
Lo = 80 mm (thickness < 3 mm)
Lo = 5,65 √ So (thickness ≥ 3 mm)

Condition	Rm(1) (MPa)	Rp0.2 (2) (MPa)	A(3) (%)	HRB
Cold-rolled*	520	370	29	84

* Typical values 1 MPa = 1 N/mm²

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

At high temperatures*



* Typical values

At 100°c the $Rp_{0.2}$ of K44 is > 300MPa

Grade designation	$R_{p0,2}$ - 20°C (MPa)	$R_{p0,2}$ - 100°C (MPa)
K44/444	370	330
304L (18-9L)	320	260
316L (18-11ML)	320	170

- The yield stress of ferritic steels is higher than for austenitic grades.
Like all ferritic grades, K44 is prone to embrittlement after long exposure at a temperature around 475°C.

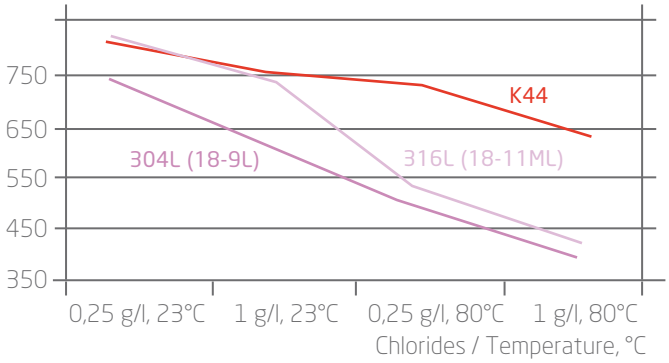
It is important to take into account this characteristic in certain structure calculations, in hot water tanks for example.
In effect, the superior proof stress at room temperature, subjected to operating temperatures found in this type of product application, enables the same level of strain to be applied preventing the risk of explosion thereby limiting the thickness.
Within the construction codes for pressure vessel applications, the EN 13445, CODAP 2005, ASME VIII and DIN 44899.

Corrosion resistance

Localised corrosion resistance

K44 presents a very good resistance to all types of corrosion thanks to its Cr level, its Mo and its bi-stablisation with both Nb and Ti. Its PREN value is 24/25 translating into a very good pitting corrosion resistance, superior to those of austenitic grade variants 304L (18-9L), 316L (18-11ML) and 316Ti.

The effect of Cl concentration and temperature on pitting corrosion resistance



Salt spray

After 2000h of exposure in a salt-spray test in accordance with the norm NFX 41002, K44 in 2B or BA finish shows no sign of corrosion.

Intergranular corrosion

Our **K44** grade has good resistance to intergranular corrosion (Strauss test), due to effective stabilization of carbon and nitrogen with titanium and niobium. Because of the high chromium content and the presence of molybdenum, precipitates of Laves phase can appear on heating in the range 600 to 900°C.

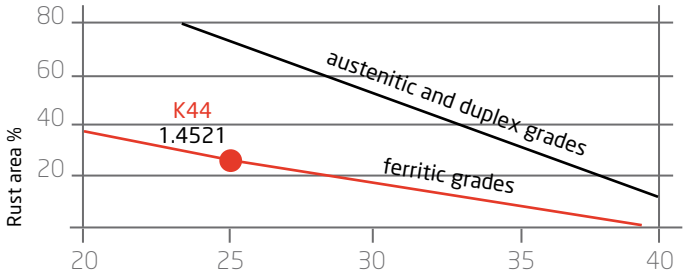
These precipitates can alter the intergranular corrosion resistance in highly oxidizing media (e.g. Huey test), but do not modify the behaviour in the more usual Strauss test. For applications in such severe conditions, heat treatment in the above range should therefore be avoided.

*PREN = %Cr+3.3%Mo+16%N.

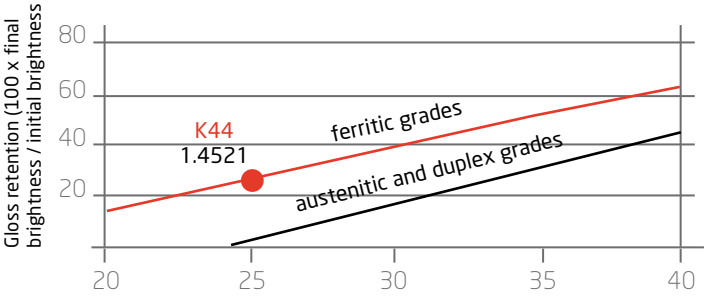
Atmospheric corrosion

Recent studies in various countries have shown that ferritic stainless steels have greater resistance to atmospheric corrosion than austenitic or duplex grades of equivalent PREN, particularly with regard to rust area and glass retention criteria.

Relation between rust area and PREN after exposure for 3 years in a marine/industrial atmosphere / Relation between PREN and gloss retention after exposure for 3 years in a marine/industrial atmosphere



PREN = % Cr + 3.3% Mo + 16% N for austenitic steel.
PREN = % Cr + 3.3 % Mo for ferritic steel.



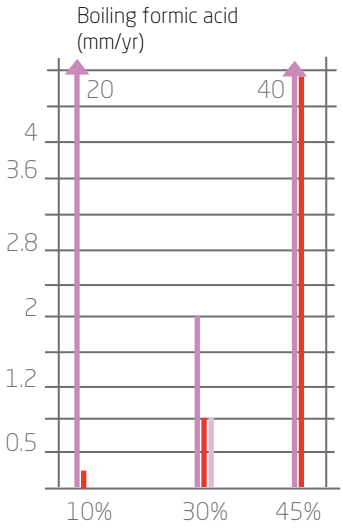
Atmospheric Corrosion Resistance of High Cr ferritic Stainless Steels for Architectural Exterior Applications Y. Yazawa, T. Ujiro, K. Yamato, H. Kalto «Stainless steeel 95», Düsseldorf 1996.

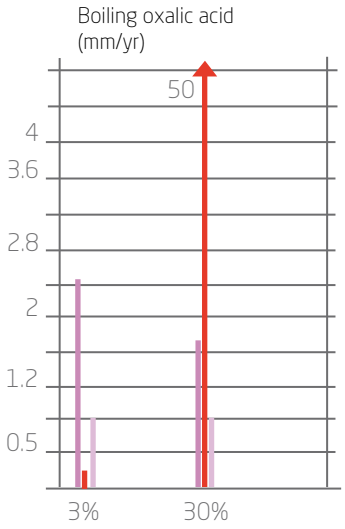
Acid corrosion

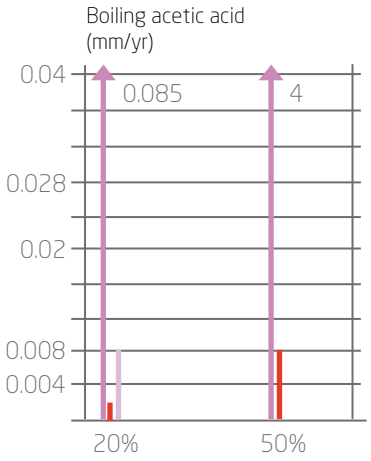
Although the corrosion rate is generally higher for ferritic steels than for austenitic grades with a similar molybdenum content, our **K44** grade is perfectly suitable for use in numerous organic and mineral acids, as shown below.

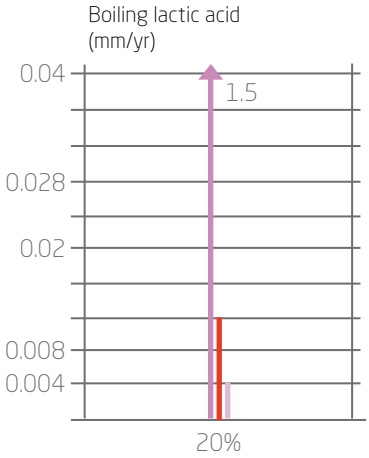
Furthermore, it is highly resistant to fume condensates and has been certified by the French building industry (CSTB - France) for use with high yield domestic heating oils.

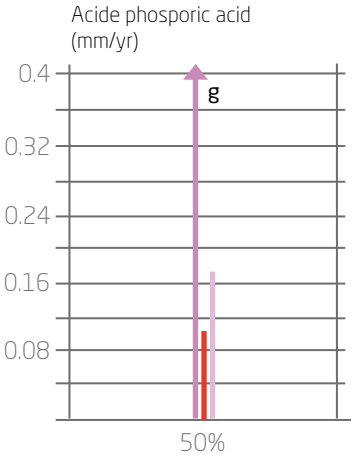
- K44
- 304L (18-9L)
- 316 (18-11ML)

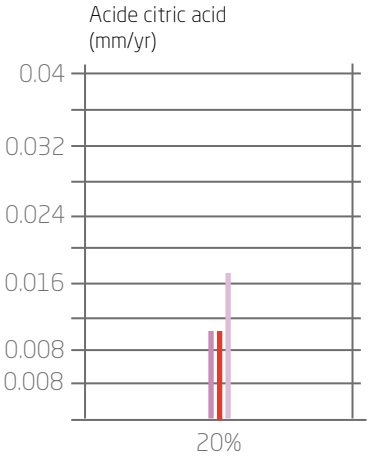


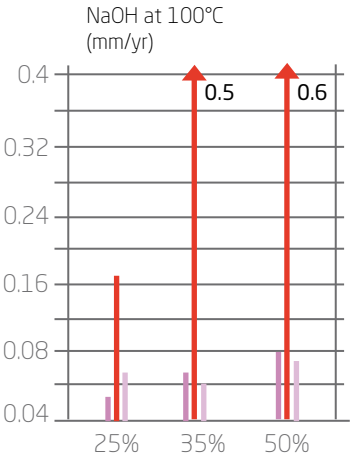


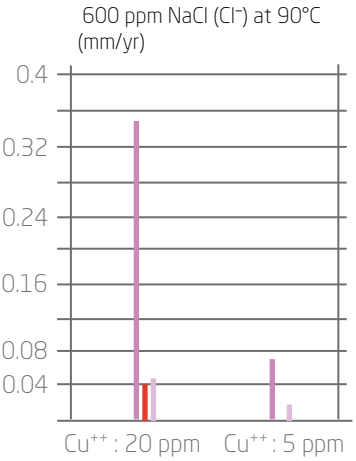


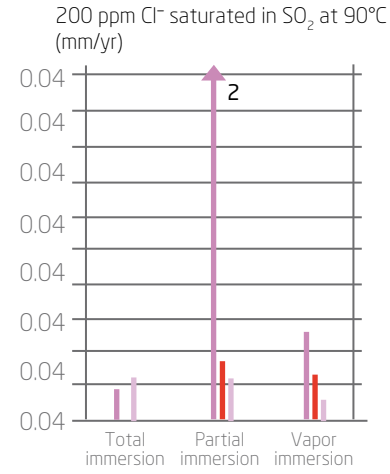






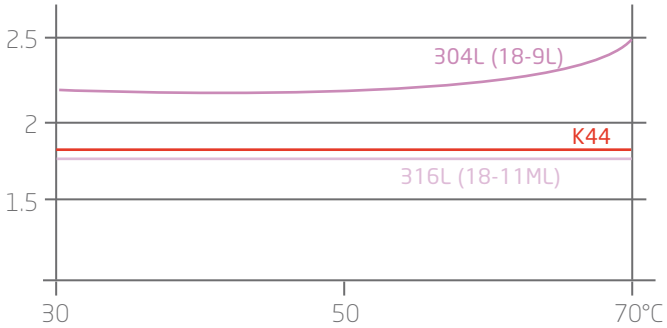






Crevice corrosion

Due to the presence of molybdenum, our **K44** grade has good resistance to the initiation of crevice corrosion, similar to that of the 316L (18-11ML) austenitic grade. This resistance is measured in terms of the depassivation pH, which for K44 is in the order of 1.8, and is little sensitive to temperature.



Stress corrosion cracking

Like all ferritic grades, our **K44** grade is insensitive to stress corrosion. For example, in hot seawater, loaded to 95 % of the yield stress, no failure is observed after 3000 hours.

Time to crack initiation (hours)

	304L (18-9L)	316L (18-11ML)	K44
boiling 42 % $MgCl_2$	< 2	< 16	> 1700 no crack initiation
42 % $CaCl_2$ at 100°C	< 25	< 75	> 1700 no crack initiation

Forming

K44 lends itself to current methods of cold forming (folding, profiling, bending, drawing etc) We suggest forming all ferritics including K44 by deep drawing (reflected in the LDR ratio) allowing the metal to be absorbed into the punch minimising the amount of blank holder pressure to be applied in order to avoid creasing.

Stretching (Erichsen test)*

Grade designation	European designation	ASTM A240	Bend (mm)
K44	1.4521	Type 444	8.6

* 0.8mm thick

Deep drawing (Swift test)

Grade designation	European designation	ASTM A240	LDR* (mm)
K44	1.4521	Type 444	2.10-2.15

Bending

180° bending can be performed up to 0.8 mm, but above 0.8 mm thick a radius of at least ½ the thickness should be allowed.

Welding

Our **K44** grade is weldable by these processes: resistance (spot, seam), electrical arc, high frequency, LASER and electron beam.

Welding process	Without filler metal	With filler metal			Shielding gas*
	Typical thicknesses	Thicknesses:	Filler metal		* Hydrogen and nitrogen forbidden in all cases
			Rod	Wire	
Resistance: spot, seam	≤ 2 mm				
TIG	< 1.5 mm	> 0.5 mm	G 19 12 3L (1) ER 316L (2) n°1.4430 (5)		Argon Argon + Helium
PLASMA	< 1.5 mm	> 0.5 mm		G 19 12 3L Si (1) ER 316L Si (2) n°1.4430 (5)	Argon Argon + Helium
MIG		> 0.8 mm		G 19 12 3L Si (1) ER 316L Si (2) n°1.4430 (5)	Argon + 2% CO_2 Argon + 2% O_2 Argon + 2% CO_2 + Helium
Electrode		Repairs	E 19 12 3L (3) E 316L (4)		
Laser	< 5 mm				Helium Argon in certain conditions

(1) In accordance with EN ISO 14343, (2) In accordance with AWS A5.9, (3) In accordance with EN 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 CO_2 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 without filler metal, the power should not exceed 1.5 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. Post-weld heat treatment is generally not necessary. The welds must be mechanically or chemically descaled, then passivated. Oxyacetylene torch welding is to be avoided.

Heat treatment and finishing

Polishing

Stabilised ferritic stainless steels in general, and **K44** in particular, can be readily polished with abrasive belts from 3 to 6 finishes. However, because of the presence of the stabilizing elements (Ti, Nb), they do not give a good mirror finish. Polishing with abrasives containing iron salts is to be avoided. If the steel has nevertheless been contaminated with iron or iron salts, a final decontamination treatment must be performed. Before any heat treatment, the metal must be carefully degreased.

Annealing

After cold work, annealing is performed by treating for a few minutes at 925°C followed by air cooling. For treatments longer than 5 minutes, it is essential never to exceed 1000°C.

Pickling

Nitric-hydrofluoric acid mixture (20% HNO_3 + 1% HF). Descaling pastes for weld zones.

Passivation

20-25 % HNO_3 solution at 20°C. Passivating pastes for weld zones.

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