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KARA ferritic stainless steel offer
grade K44M

Chemical composition

Elements	C	N	Si	Mn	Cr	Nb	Mo
%	0.015	0.015	0.40	0.30	19	0.6	1.9

Typical values

European designation [1]

X2CrMoTi18-2

1. 4521

[1] In accordance with EN 10088-2

American designation [2]

type 444 UNS S44400

IMDS n° 336853368

[2] In accordance with ASTM A 240

This grade complies with:

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

General characteristics

The principal features of our K44M grade are:

- Elevated hot mechanical properties without risk of σ phase formation at intermediate temperatures
- Resistance to high temperature oxidation and creep up to 1050°C
- Good durability in thermal fatigue
- Good corrosion resistance in gas boiler and gas burner atmospheres
- Greater thermal conductivity than austenitics and a lower thermal expansion coefficient
- Good weldability
- Ease of forming

Applications

- Domestic boilers burners
- Fuel cells
- Catering burners
- Furnaces
- Industrial boilers components

Product range

Forms: sheets, blanks, coils, strips, tubes
Thicknesses: from 0.2 to 4.0 mm
Width: according to thicknesses, consult us
Finishes: cold-rolled

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Physical properties

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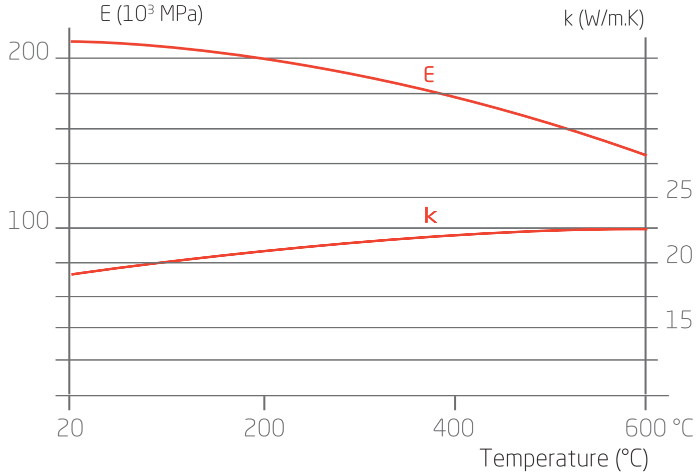
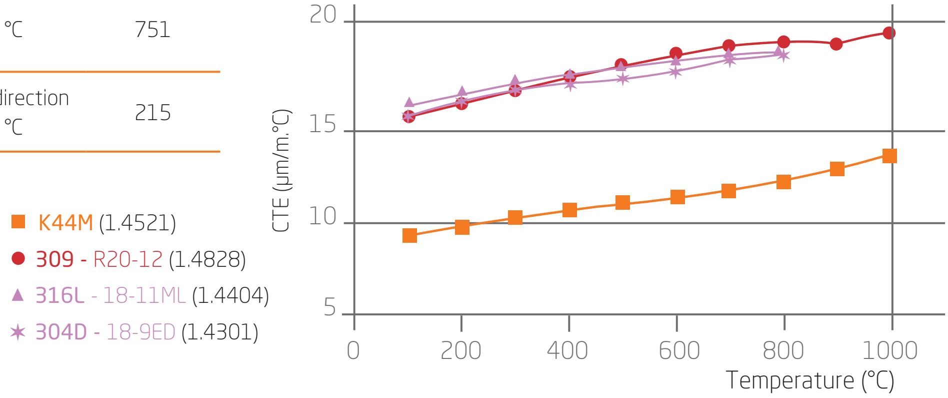


On cold-rolled sheet. In the annealed condition
(Typical values)

Density	d	kg/dm³	20 °C	7.7
Melting temperature		°C	Liquidus	1447
Specific heat	c	J/kg.K	20 °C	452
Thermal conductivity	k	W/m.K	20 °C 600 °C	19.7 22.8
Mean coefficient of thermal expansion	α	10^{-6}/K	20-200 °C 20-400 °C 20-600 °C 20-800 °C	10.6 11 11.4 11.9
Electric resistivity	ρ	Ω mm²/m	20 °C	0.66
Magnetic permeability	μ	at 0.8 kA/m DC or AC	20 °C	751
Modulus of elasticity	E	10³.MPa	Rolling direction 20 °C	215



Mechanical properties

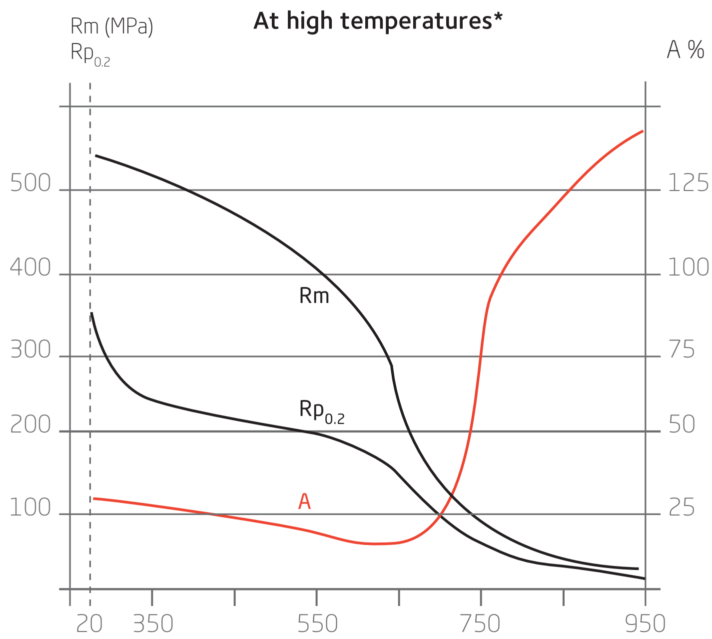
In the annealed condition
In accordance with ISO 6892-1, test specimen perpendicular to the rolling direction

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

Présentation	Rm[1] (MPa)	$Rp_{0.2}$[2] (MPa)	A[3] (%)	HRB
Cold-rolled*	540	370	29	86

1 Mpa = 1 N/mm². *Typical values

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



* Typical values

Temperature (°C)

High temperature properties

The chemical composition of K44M has been optimized to fulfill characteristics required by components running at high temperature, such as domestic boiler burners or fuel cells. Indeed such devices undergo a lot of start & stop cycles. Criteria to take into account in such cases are resistance to creep, resistance to thermal fatigue and the capacity to develop an oxidant protective layer.

Creep Sag-Test at 1000°C
Thickness = 1.5mm

The high level of niobium in the K44M permits a good mechanical resistance at high temperature and an optimized creep resistance as described in the table with a test at 1000°C.

Creep sag test 1000°C- duration: 100 h	K44M	1.4509 K41	1.4828 309 (R20-12)
Deflection (mm)	6	35	>17

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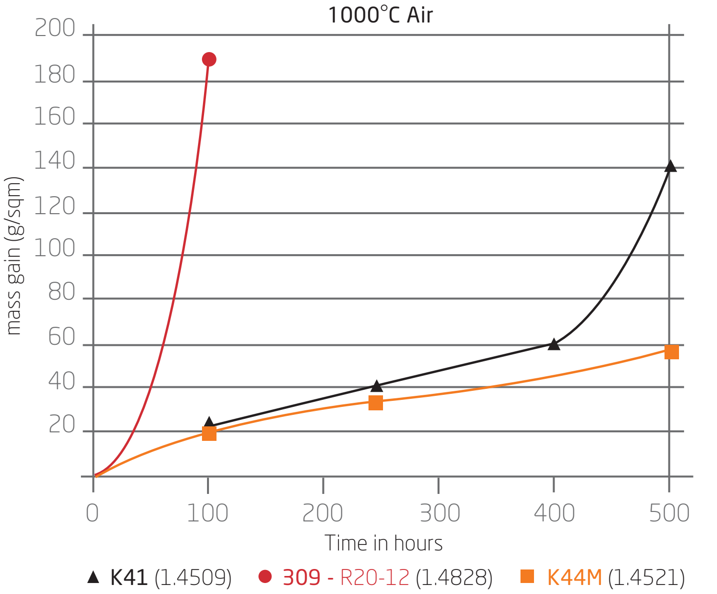
Oxidation resistance
Environment: air
Thickness sample: 1.5mm

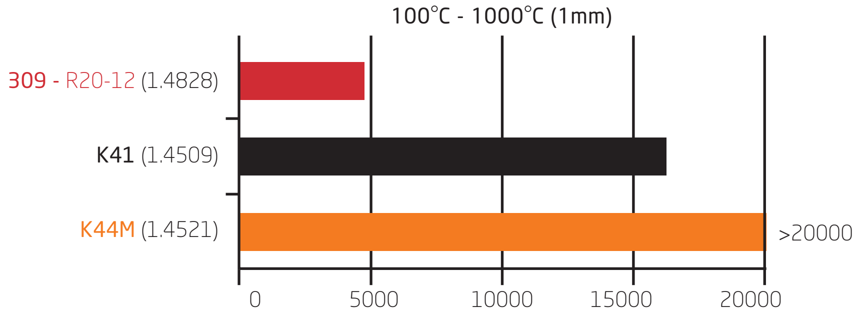
The chromium diffusion in the matrix ferritic of the K44M is made easier compared to an austenitic matrix. This permits to avoid the impoverishment in chromium and favours the formation of an oxidant protective layer rich in chromium.
The expansion coefficient of the K44M is closer to those from oxide layer which is developed, compared to austenitic grades.

The thermal stresses are also much lower. Practically no scaling of the layer is observed. This results to a low material loss.
At high temperature, our K44M exhibits a high oxidation resistance, particularly in cyclic oxidation, which allows his use up to 1050°C.



Thermal fatigue
Thickness sample: 1 mm

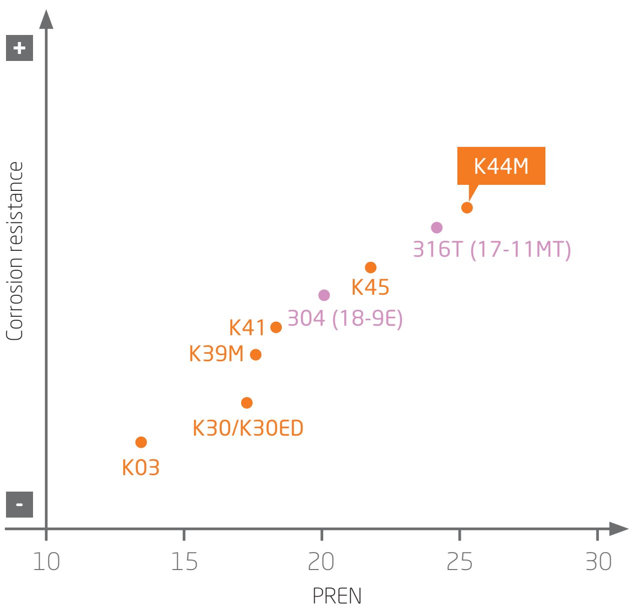
Our tests, carried out on V shape samples for 100-1000°C, exhibit a very good behaviour of the K44M compared to austenitic 1.4828 and to the 1.4509.



Corrosion resistance

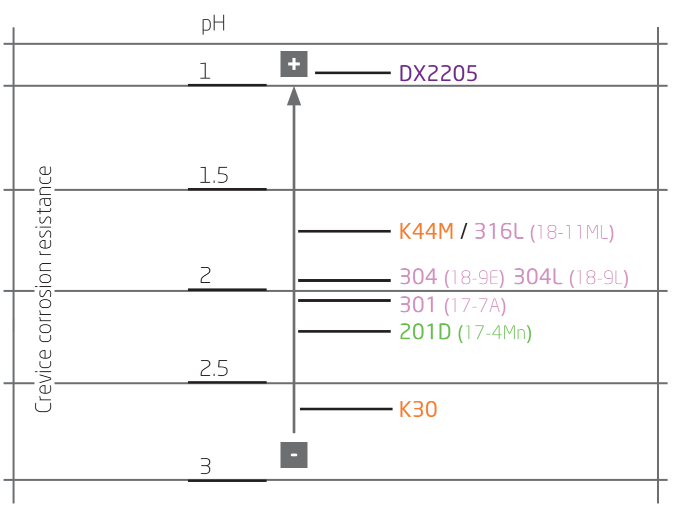
Pitting Corrosion Resistance
The K44M presents a very good resistance to all types of corrosion thanks to its Cr level, its Mo level and its stabilization with Nb. Its PREN value is 26 translating into a very good pitting corrosion resistance, superior to those of austenitic grades like 304D (18-9ED), Type 304, 1.4301.

Typical pitting potential values in NaCl 0.02M at 23 °C and pH6 as a function of the PREN (%Cr+3.3%Mo+16%N).



Crevice Corrosion
Due to the presence of molybdenum, our K44M grade has a good resistance to the initiation of crevice corrosion, similar to 316L (18-11ML) austenitic grade one. This resistance is measured in terms of depassivation pH, which for K44M is in the order of 1.8, and is little sensitive to temperature.

Depassivation pH in a deaerated NaCl 2M environment at 23 °C



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Forming

K44M lends itself to current methods of cold forming (folding, profiling, bending, drawing, punching, etc).
It is suggested to preferentially form ferritics, and therefore K44M, by deep drawing (reflected in the LDR-Limit Drawing Ratio), which allows metal feeding thanks to an optimized blank-holder force without any wrinkles phenomenon.

Bending of welded tubes

Bending	Ra=R/Dmini
Tube Ø 35 x 1.5	1.1

results laboratory

Ra: Bending ratio
D: Tube diameter
R: Bending radius

Stretching (Erichsen test)

Grade designation	EN	Deflection Erichsen (mm)*
K44M	1.4521	10
K41	1.4509	9.9

* on samples thickness 1.5mm with lubricant mobilux EP00

Deep drawing (Swift test)

Grade designation	EN	LDR*
K44M	1.4521	2.05
K41	1.4509	2.08

* on samples thickness 1.5mm with lubricant mobilux EP00

Welding

Our K44M grade can be resistance welded by spot or seam techniques. Good results are obtained without post treatment provided if the weld is sufficiently forged.
The addition of hydrogen or nitrogen to the argon must be avoided as this reduces weld ductility.
For similar reasons, the use of nitrogen is forbidden and use of CO_2 is restricted to 3%.
In order to restrict grain growth in the HAZ, the use of excessive welding power 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.
As a further example, pulsed MIG/MAG welding has a lower power input than conventional MIG welding and enables better control of both bead geometry and grain size.

The K44M also exhibits excellent high- and medium-frequency induction weldability.
Post-weld heat treatment is generally not necessary. Welds must be mechanically or chemically descaled and then passivated and decontaminated.
Oxyacetylene torch welding must be avoided.

<table>
<tr><th rowspan="3">Welding process</th><th>Without filler metal</th><th colspan="3">With filler metal</th><th>Shielding gas*</th></tr>
<tr><th rowspan="2">Typical thicknesses</th><th rowspan="2">Thicknesses:</th><th colspan="2">Filler metal</th><th rowspan="2">* Hydrogen and nitrogen forbidden in all cases</th></tr>
<tr><th>Rod</th><th>Wire</th></tr>
<tr><td>Resistance: spot, seam</td><td>≤ 2 mm</td><td></td><td></td><td></td><td></td></tr>
<tr><td>TIG</td><td>< 1.5 mm</td><td>> 0.5 mm</td><td colspan="2">G 19 12 3L
Or G 18 LNb</td><td>Argon
Argon + Helium</td></tr>
<tr><td>PLASMA</td><td>< 1.5 mm</td><td>> 0.5 mm</td><td></td><td>G 19 12 3L
or G 18 LNb</td><td>Argon
Argon + Helium</td></tr>
<tr><td>MIG</td><td></td><td>> 0.8 mm</td><td></td><td>G 19 12 3L (Si)
or G 18 LNb</td><td>Argon + 2% CO_2
Argon + 2% O_2
Argon + 2% CO_2 +
Helium</td></tr>
<tr><td>Electrode</td><td></td><td>Repair</td><td>E 19 12 3L</td><td></td><td></td></tr>
<tr><td>Laser</td><td>< 5 mm</td><td></td><td></td><td></td><td>Helium
Under conditions:
Argon</td></tr>
</table>

G 18LNb according to EN ISO 14343 A or 430LNb according to EN ISO 14343 B, 1.4511 according to EN 1600: for high thermal fatigue requirement
G 19 12 3L (Si) according to EN ISO 14343 A or ER 316L (Si) according to ISO 14343B, 1.4430 according to ISO 1600 :
for optimized corrosion resistance requirement

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