aperam

KARA Ferritic Stainless Steel

K44M 19% Chromium with Molybdenum, Niobium stabilized

KARA key for value

Chemical Composition

Elements (%)	C	N	Si	Mn	Cr	Nb	Mo
K44M	0.015	0.015	0.40	0.30	19	0.6	1.9

Typical values

European designation	American designation	IMDS
X2CrMoTi18-2/1.4521 [(1)]	Type 444 [(2)] UNS S44400	336853368

[(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 risk of σ phase formation at intermediate temperatures
- Resistance to high temperature oxidation and creep up to 1,050°C
- Good durability in thermal fatigue
- Good corrosion resistance in gas boiler and gas burner atmospheres
- Greater thermal conductivity and lower thermal expansion coefficient than austenitics
- Good weldability
- Easy to form

Applications

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

Product Range

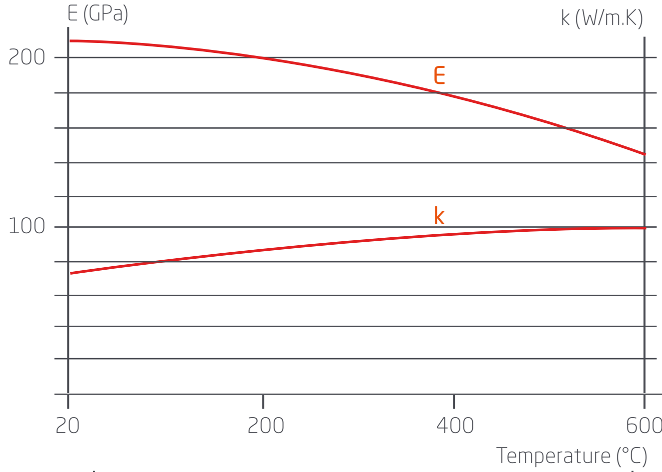
	Coils	Sheets / Blanks	Discs
Thickness (mm)	0.40 up to 4	0.40 up to 4	0.38 up to 2.50
Width (mm)	up to 1,524	up to 1,250	Ø 15 up to 1,000
Finish	2B / 2D / 2R	2B / 2D / 2R	2B / 2D / 2R

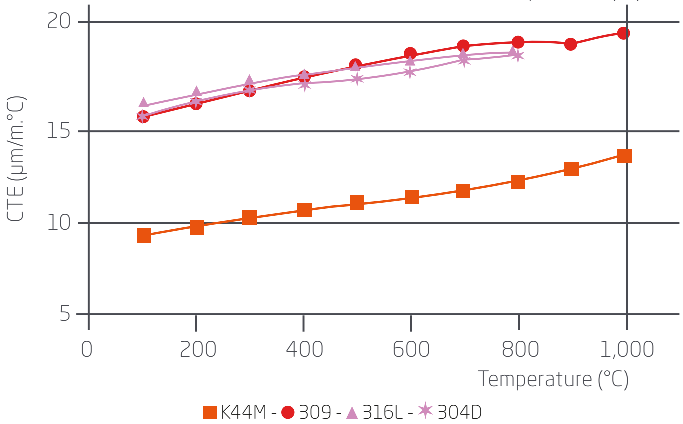
Please contact us regarding all other dimensions, forms and finishes.

Physical Properties

Cold rolled and annealed sheet

Density	d	kg/dm³	20°C	7.7
Melting temperature		°C	Liquidus	1,447
Specific heat	c	J/kg.K	20°C	452
Thermal conductivity	k	W/m.K	20°C 600°C	19.7 22.8
Mean thermal expansion coefficient	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 resistivity	μ	at 0.8 kA/m DC or AC	20°C	751
Young's modulus	E	GPa	Rolling direction 20°C	215





Mechanical Properties

Test piece

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

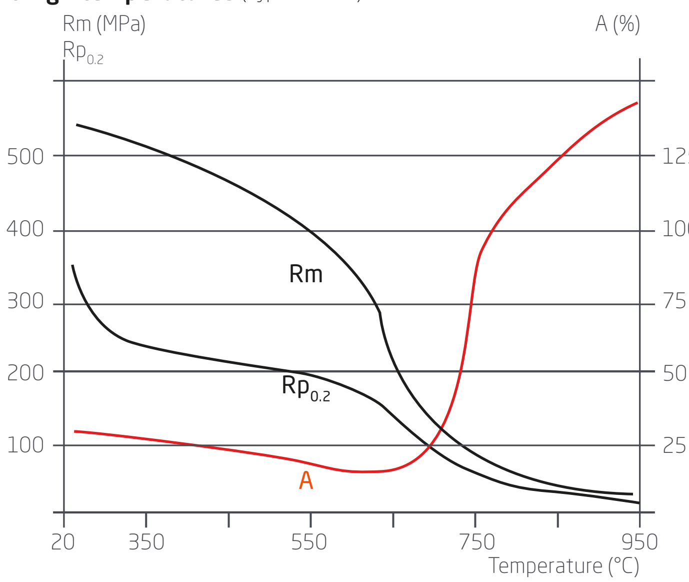
In the annealed condition

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
K44M	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)

At high temperatures (Typical values)



High Temperature Properties

K44M's chemical composition has been optimized to meet the high temperature needs of components and applications such as domestic boiler burners and fuel cells. Because these applications undergo regular start and stop cycles, one must factor in the material's resistance to creep and thermal fatigue, as well as the capacity to develop an oxidant protective layer.

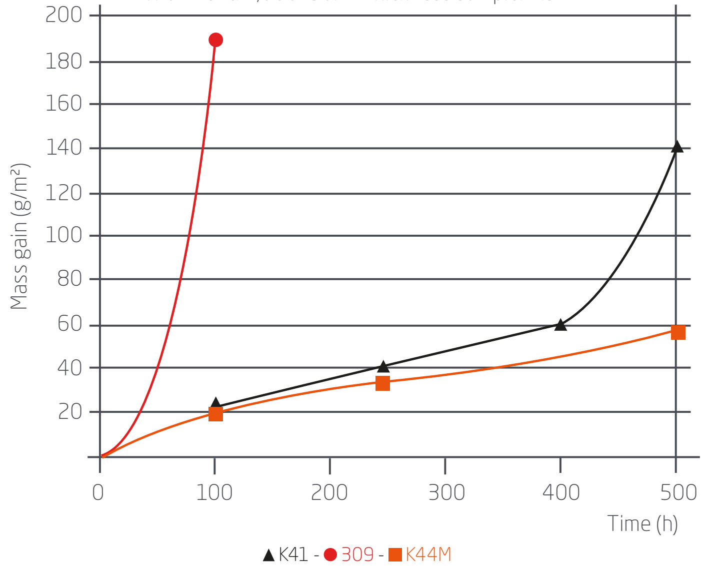
Creep sag test - 1,000°C - duration: 100 h - Thickness 1.5 mm

	K44M	K41	309
Deflection (mm)	6	35	> 17

K44M's high level of niobium ensures good mechanical resistance at high temperatures and an optimized creep resistance as described in the table with a test at 1,000°C.

Oxidation resistance

Environment: 1,000°C air - Thickness sample: 1.5 mm



Compared to an austenitic matrix, the chromium diffusion in K44M's ferritic is easier. This avoids any loss in chromium and favours the formation of an oxidant protective layer rich in chromium.

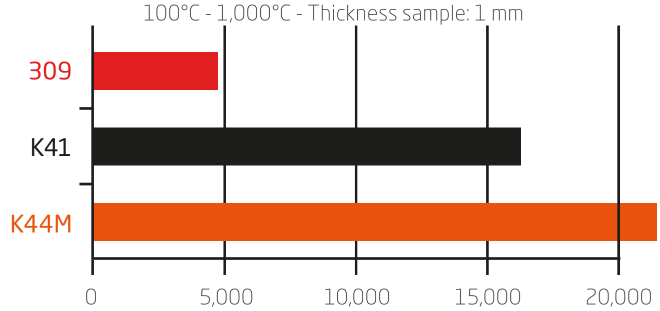
K44M 's expansion coefficient is closer to those from oxide layer which is developed, compared to austenitic grades.

Thermal stresses are also much lower. Practically no scaling of the layer is observed. This results in a low material loss.

At high temperatures, our K44M exhibits a high oxidation resistance, particularly in cyclic oxidation. This allows for its use up to 1,050°C.

Thermal fatigue

100°C - 1,000°C - Thickness sample: 1 mm



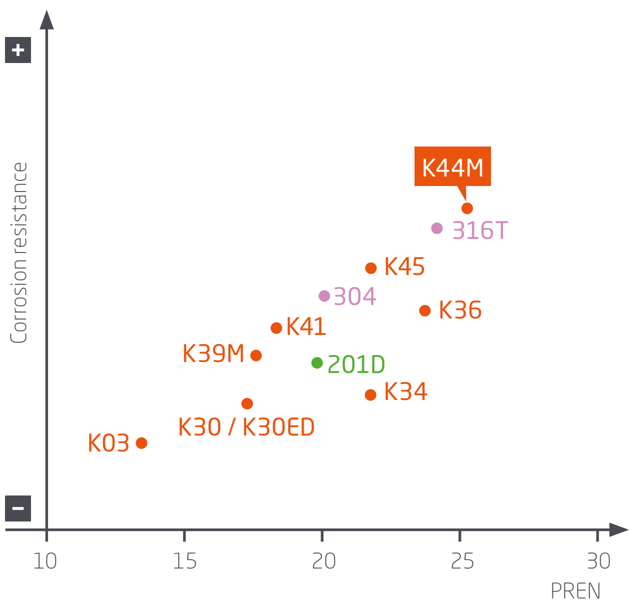
Our tests, carried out on V shape samples for 100-1,000°C, show that K44M exhibits good behaviour compared to austenitic 309 and to K41 grades.

Corrosion Resistance

K44M offers very good resistance to all types of corrosion. This is the result of its chromium level, molybdenum level and stabilization with niobium. Its PREN value is 26, which translates into a very good resistance to pitting corrosion, outperforming such austenitic grades as 304D, Type 304, 1.4301.

Pitting corrosion

Typical values of pitting corrosion potential in NaCl 0.02M, 23°C, pH6.6 as a function of PREN (%Cr+3.3%Mo+16%N).

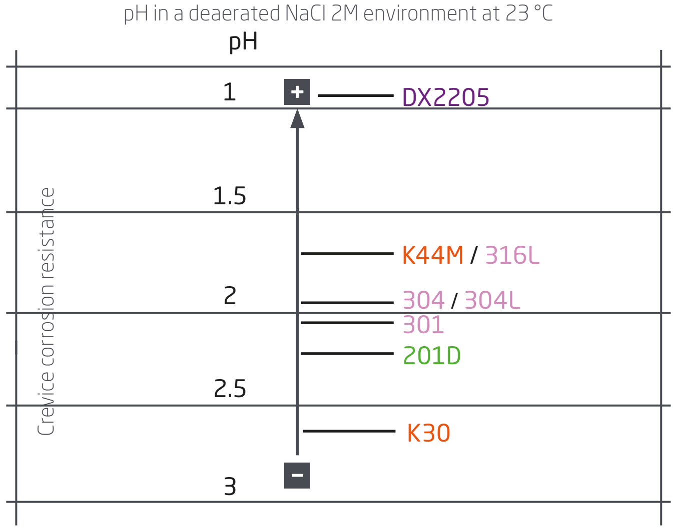


Crevice corrosion

Due to the presence of molybdenum, our K44M grade has good resistance to the initiation of crevice corrosion, similar to that of our 316L austenitic grade. This resistance is measured in terms of depassivation pH.
For K44M, this is in the order of 1.8, meaning it has minimal sensitivity to temperature.

Depassivation

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



Forming

K44M lends itself to current methods of cold forming (folding, profiling, bending, drawing, punching, etc).
It is recommended that ferritics be preferentially formed. For K44M, this means deep drawing (reflected in the LDR-Limit Drawing Ratio). This allows for metal feeding, thanks to an optimized blank-holder force, without causing any wrinkles to form.

Bending of welded tubes

Bending (laboratory results)	Ra = R/D mini
Tube Ø 35 mm x 1.5 mm	1.1

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

Stretching (Erichsen test) and Deep drawing (Swift test)

Grades	EN	Erichsen test (mm)	LDR* (mm)
K44M	1.4521	10	2.05
K41	1.4509	9.9	2.08

Tests performed on typical values using 1.5 mm thick samples with lubricant Mobilux EP00.
*Limiting drawing ratio

Welding

Our K44M grade can be resistance welded using both spot and seam techniques. Good results are obtained without post treatment so long as the weld is sufficiently forged.

<table>
<tr><th rowspan="3">Welding process</th><th>No filler material</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 material</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>Ar
Ar + He</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>Ar
Ar + He</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>Ar + 2% CO_2
Ar + 2% O_2
Ar + 2% CO_2 + He</td></tr>
<tr><td>SAW</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>He
Under conditions: Ar</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

The addition of hydrogen or nitrogen to the Ar must be avoided as this reduces weld ductility.
For similar reasons, one cannot use nitrogen and the CO_2 is restricted to 3%.
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.

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.

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