PRODUCT DATA BULLETIN

18 SR STAINLESS STEEL

AK Steel

- Excellent High-Temperature Scaling Resistance
- Readily Welded
- Not Subject to Embrittlement

Applications Potential

AK Steel 18 SR™ Stainless Steel is especially valuable for applications requiring high-temperature scaling resistance superior to Types 409, 430 and 304 stainless steels,Types 309 and 310 stainless steels under cyclic conditions, and for those applications where Types 442 and 446 give only marginal protection. In addition, it is more economical than many of the higher-temperature stainless steels. Typical uses include industrial ovens, blowers, exhaust systems, furnace equipment, heaters, induction furnaces and furnace tubes, annealing boxes, baffle plates, heat exchangers, resistor grids, kiln liners and pyrometer tubes.

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Data referring to mechanical properties and chemical analyses are the result of tests performed on specimens obtained from specific locations with prescribed sampling procedures; any warranty thereof is limited to the values obtained at such locations and such procedures. There is no warranty with respect to values of the materials at other locations.

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AK Steel 18 SR Stainless Steel provides excellent resistance to high-temperature scaling — far superior to that of Type 446 stainless steel. In addition, this material is readily welded by conventional methods. It is not subject to troublesome embrittlement or loss of corrosion resistance in the heat-affected zones that affects many other straight chromium alloys.

AK Steel 18 SR Stainless is a Recognized Component Steel by Underwriters' Laboratories, carrying a temperature rating of 1730°F (943°C) maximum temperature rise for normal operation and 1930°F (1054°C) maximum temperature rise for peak conditions.

Typical Composition

	%
Carbon	0.015
Manganese	0.30
Chromium	17.30
Nickel	0.25
Aluminum	1.7
Titanium	0.25

Available Forms

AK Steel produces 18 SR Stainless Steel in coils and cut lengths in thicknesses from 0.018" to 0.100" (0.46 to 2.54 mm) and widths up to and including 48" (1219 mm). For thicknesses from 0.101" to 0.25" (2.57 to 6.35 mm), inquire.

Metric Practice

The values shown in this bulletin were established in U.S. customary units. The metric equivalents of U.S. customary units shown may be approximate. Conversion to the metric system, known as the International System of Units (SI) has been accomplished in accordance with ASTM E380.

The newton (N) has been adopted by the SI as the metric standard unit of force. The term for force per unit of area (stress) is the newton per square meter (N/m^2). Since this can be a large number, the prefix mega is used to indicate 1,000,000 units and the term meganewton per square meter (MN/m^2) is used. The unit (N/m^2) has been designated a pascal (Pa). The relationship between the U.S. and the SI units for stress is 1000 pounds/in^2 (psi) = 1 kip/in^2 (ksi) = 6.8948 meganewtons/m^2 (MN/m^2) = 6.8948 megapascals (MPa).

Mechanical Properties

Table 1

Typical Room Temperature Properties

Property	
UTS, ksi (MPa)	78 (538)
0.2% YS, ksi (MPa)	56 (386)
Elongation, % in 2" (50.8 mm)	30
Hardness, Rockwell B	84
n value	0.18
r value	1.3 - 1.5

Table 2

Elevated Temperature Tensile Properties

Temperature °F (°C)	UTS ksi (MPa)	0.2% YS ksi (MPa)
Room	78 (538)	56 (386)
1000 (538)	49 (338)	34 (234)
1100 (593)	36 (248)	28 (193)
1200 (649)	26 (179)	22 (152)
1300 (704)	16 (110)	14 (97)
1400 (760)	13 (90)	7 (48)
1500 (816)	11 (76)	5 (34)
1600 (871)	5 (34)	3 (21)

Table 3

Weight Change After 1600 - 1700°F (871 - 927°C) Exposure*

Alloy	288 Cycles	480 Cycles	750 Cycles	958 Cycles
Type 430	63.6	Destroyed	–	–
Type 442	4.7	7.5	9.4	9.4
Type 446	2.0	2.4	1.2	0.3
Type 309	1.7	-30.0	-153.0	-210.0
AK Steel 18 SR	1.9	2.7	3.4	3.8

*mg/in^2 – 15 minutes heating - 15 minutes cooling.

Table 4

Weight Change After 1800 - 1900 °F (982 - 1038°C) Exposure*

Alloy	130 Cycles	368 Cycles	561 Cycles	753 Cycles	1029 Cycles
Type 446	2.8	3.4	-1.1	+45.0	-125.0
Type 309	-156.0	-500.0	-1150.0	-1560.0	-2310.0
Type 310	9.5	-73.0	-189.0	-405.0	-690.0
AK Steel 18 SR	4.2	6.8	9.6	13.9	19.5
RA 330	8.3	12.2	-75.0	-345.0	-590.0

* mg/in^2 – 15 minutes heating - 15 minutes cooling.

Table 5

Elevated Temperature Fatigue Strength

Alloy	Fatigue Strength* at 1500°F (816°C), ksi (MPa)
409	1.0 (7)
439	1.4 (10)
AK Steel 11 Cr-Cb	3.0 (21)
AK Steel 18 Cr-Cb	3.0 (21)
AK Steel 12 SR	3.5 (24)
AK Steel 18 SR	2.0 (14)

*Stress for 10^7 cycles.

Tension/Tension r=0.1

Table 6

Stress Rupture Properties of Stainless Automotive Exhaust Alloys

	Exposure Temperature			
	1300°F (704°C)		1500°F (816°C)	
Alloy	Stress, ksi (MPa) 100 hours	Stress, ksi (MPa) 1000 hours	Stress, ksi (MPa) 100 hours	Stress, ksi (MPa) 1000 hours
409	4.1 (28.7)	3.2 (22.4)	1.5 (10.5)	0.9 (6.3)
439	4.0 (28.0)	3.0 (21.0)	1.6 (11.2)	1.0 (7.0)
AK Steel 11 Cr-Cb	5.1 (34.7)	3.7 (25.9)	1.8 (12.6)	1.4 (9.8)
AK Steel 18 Cr-Cb	5.8 (39.6)	4.4 (30.8)	2.4 (16.8)	1.8 (12.6)
AK Steel 12 SR	6.0 (41.0)	4.2 (29.4)	2.3 (16.1)	1.5 (10.5)
AK Steel 18 SR	3.8 (26.6)	2.6 (45.2)	1.7 (11.9)	0.9 (6.3)
304	16.9 (116.3)	11.6 (80.2)	6.2 (41.5)	3.7 (25.9)

Physical Properties

Density, 0.27 lbs/in^3
7.45 g/cm^3

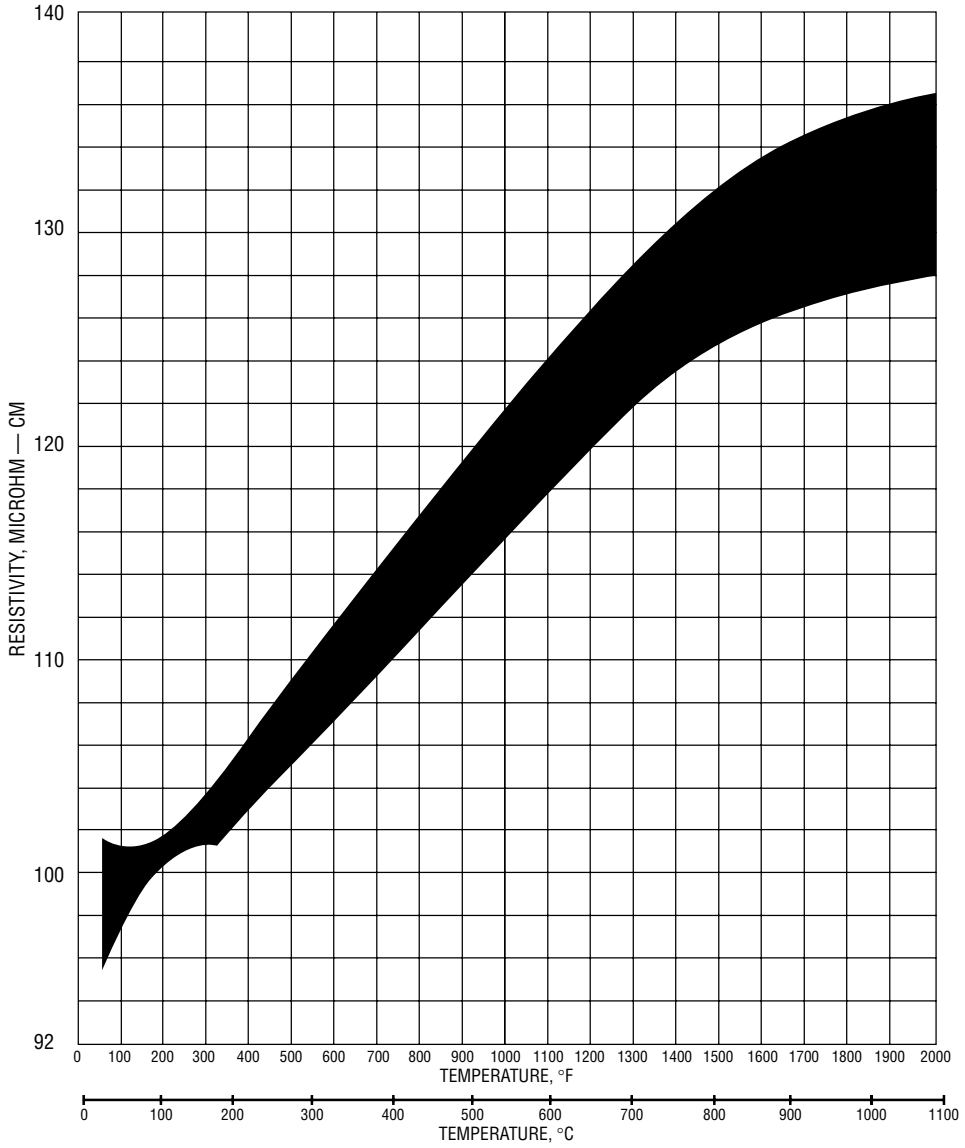
Electrical Resistivity, 37.40-41.34 microhm-in (95-101 microhm-cm) at room temperature

Table 7

Thermal Expansion

Temperature Range °F (°C)	Mean Coefficient of Thermal Expansion Micro-inches/in/°F (µm/m•°C)
70- 212 (21- 100)	5.9 (10.6)
70- 600 (21- 316)	6.3 (11.3)
70-1000 (21- 538)	6.4 (11.5)
70-1200 (21- 649)	7.0 (12.6)
70-1600 (21- 871)	7.5 (13.5)
70-2000 (21-1093)	8.0 (14.4)

Figure 1: Electrical Resistivity as a Function of Temperature of Sheet Material
(0.024" - 0.047" {0.61 - 1.19 mm} thickness)



Oxidation Resistance

The comparison in Figure 2 is based on laboratory tests of weight gain versus temperature and data available in the literature. The upper limit of 2000°F (1093°C) on AK Steel 18 SR Stainless Steel is based on 100-hour tests in still air in which the alloy was tested at as high as 2200°F (1204°C) and exhibited weight gains of 33 mg/in^2 versus over 800 mg/in^2 for Type 446. At 2000°F (1093°C), these rates were 25 mg/in^2 for 18 SR Stainless Steel and 50 mg/in^2 for Type 446. In very thin thicknesses (<.018" {.45 mm}), the upper oxidation limit is lower.

Corrosion Resistance

AK Steel 18 SR Stainless Steel provides corrosion resistance comparable to other ferritic 18% Cr stainless alloys and approaches the well-known austenitic 18 Cr-8 Ni stainless steel, Type 304, in many aqueous media (Table 8).

Figure 2: Oxidation Data – 100-Hour Tests in Still Air

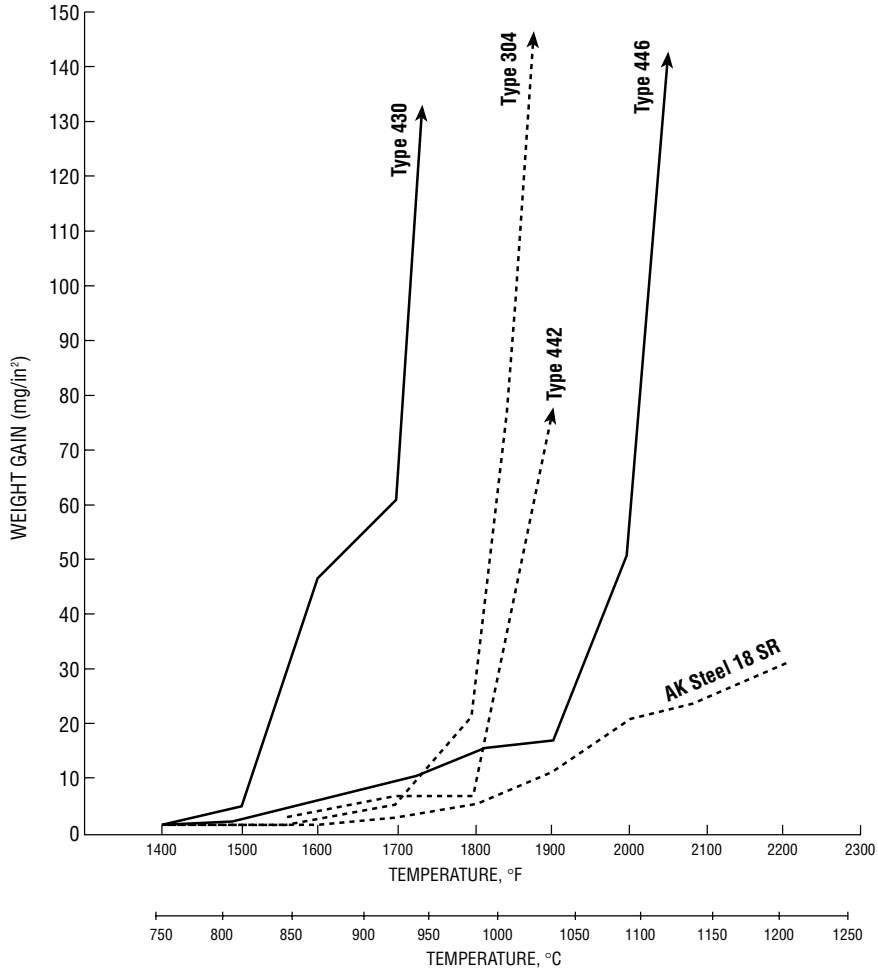


Table 8

Synthetic Muffler Condensate*

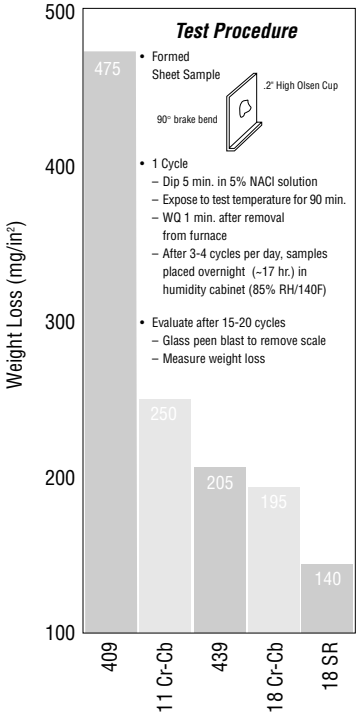
Alloy	Corrosion Rate mils/year	(µm/year)
Type 430	4.1	(104)
Type 442	2.3	(58)
Type 446	2.2	(56)
Type 304	2.8	(71)
AK Steel 18 SR	2.7	(69)

*Dilute H_2SO_4 - HBr Vapors, 240 hours.

Hot Salt Cycle:

Dip 5 minutes in 5% NaCl solution and then expose 1200°F (649°C) for 90 minutes. Water quench one minute after removal from the furnace. Repeat 4 times/day. Humidity (85% RH/140°F {60°C}) 18 hours/day. AK Steel 18 SR Stainless Steel outperformed all other uncoated exhaust ferritic stainless alloys in resistance to high temperature salt attack.

Figure 3: Hot Salt Test



Test Procedure:

Sheet sample with 90° bend and 0.2" (5.08 mm) Olsen cup dome.

Formability

Use the same techniques employed with Type 430 to fabricate AK Steel 18 SR Stainless Steel. The Olsen Cup Value for this alloy is .330 as compared with .350 to .360 for Type 430. In the annealed condition, AK Steel 18 SR Stainless Steel exhibits good bend ductility. Up to 0.050" (1.3 mm), the alloy bends flat without breaking. Over 0.050" (1.3 mm), bends of 180° can be made with a diameter of 1xT. The annealing temperature for this material is 1700°F (927°C) for one minute at temperature.

Caution: Cold weather impact loads should be avoided with material 0.125" (3.18 mm) and heavier, particularly with welds, because the ductile-to-brittle transition temperature (DBTT) could fall close to ambient temperature or above.

Embrittlement

AK Steel 18 SR and Type 446 stainless steels were exposed in the annealed condition at 1400°F (760°C) for various times up to 3000 hours. After 3000 hours, neither material showed any sign of sigma phase or embrittlement.

As experience has been gained with the alloy, the chemistry has been rebalanced. As a result, resistance to 885°F (475°C) embrittlement has been improved to the point where it is equivalent to, if not better than, Type 446 stainless steel. Although embrittlement develops, as the data in Table 9 indicate, a reasonable level of ductility remains after three weeks' exposure at 900°F (482°C).

Both alloys were also exposed in the annealed condition at 1100°F (593°C) for up to 2000 hours. After 2000 hours, Type 446 was embrittled by the formation of sigma phase. No sigma phase was present in the AK Steel 18 SR alloy after 2000 hours at 1100°F (593°C). However, the material exhibited some loss of ductility when bent 180° flat on itself after 100 hours at 1100°F (593°C), apparently by the same mechanism as 885°F (475°C) embrittlement.

Table 9

Room Temperature Properties After Exposure at 900°F (482°C)*

Exposure Time 900°F (482°C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell
Unexposed	86.8 (598)	63.6 (438)	25.2	B89
1 Week	112.0 (771)	99.0 (682)	17.8	C20.5
2 Weeks	115.7 (797)	100.7 (696)	17.8	C22.5
3 Weeks	115.9 (798)	101.0 (697)	17.2	C22.8

*Average of duplicate tests.

Weldability

The ferritic class of stainless steels is generally considered to be weldable by the common fusion and resistance techniques. Special consideration is required to avoid brittle weld fractures during fabrication by minimizing discontinuities, maintaining low weld heat input, and occasionally warming the part somewhat before forming. This particular alloy is generally considered to have diminished weldability when compared to the most common alloy of this stainless class, Type 409. A major difference is the high Al content for scaling resistance, which causes penetration and slagging problems during arc welding. When a weld filler is needed, AWS E/ER 18Cb is most often specified, and AWS E/ER 308L or 309L can be used at ambient temperatures when maximum weld ductility is required or when welding to dissimilar metals. Type 409 is well known in reference literature and more information can be obtained in the following ways:

1 ANSI/AWS A5.9, A5.22, and A5.4 (filler metals, minimum UTS and elongation).

2. "Welding of Stainless Steels and Other Joining Methods," SSINA, (800:982-0355).

3. "Welding Stainless Steels," FDB #SF-71.

Table 10

AK Steel 18 SR Weld Ductility*

Material	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)
AK Steel 18 SR (or no filler)	88 (607)	64 (441)	19
Base metal	84 (579)	61 (421)	28

*GTAW – 0.067" (1.7 mm) gauge.

AK Steel

Customer Service 800-331-5050

AK Steel Corporation
9227 Centre Pointe Drive
West Chester, OH 45069

www.aksteel.com

Stainless Steel The Value Option

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PD-106 7180-0036 PDF 7/07