18 Cr-Cb
STAINLESS STEEL

AK Steel

- More Oxidation Resistant Than Type 409
- More Creep Resistant Than Type 409

Applications Potential

AK Steel 18 Cr-Cb™ Stainless Steel is a highly effective automotive exhaust material, especially for high-temperature component applications. What makes this material so effective? Superior oxidation resistance and better creep strength than Type 409. Potential applications include exhaust system catalytic converters, mufflers and pipes; heat exchangers and heat-exchanger tubing; and nonstructural furnace parts.

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The information and data in this product data bulletin are accurate to the best of our knowledge and belief, but are intended for general information only. Applications suggested for the materials are described only to help readers make their own evaluations and decisions, and are neither guarantees nor to be construed as express or implied warranties of suitability for these or other applications.

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

PRODUCT DESCRIPTION

AK Steel 18 Cr-Cb Stainless Steel provides a more effective solution than Type 409 to many automotive exhaust and heat applications, due to its higher oxidation resistance and improved creep resistance.

AK Steel 18 Cr-Cb is a ferritic stainless steel that is stabilized with both titanium and columbium. When given a high-temperature final solution anneal, the alloy exhibits dramatic creep resistance. The dual stabilization prevents carbide sensitization during welding and high-temperature exposures, and makes the alloy thermally nonhardenable.

Typical Composition

	%
Carbon	0.02
Manganese	0.30
Silicon	0.45
Chromium	18.00
Titanium	0.25
Columbium	0.55

Available Forms

AK Steel produces 18 Cr-Cb Stainless Steel in coils and cut lengths in thicknesses from 0.018" to 0.100" (0.457 to 2.54 mm) and widths up to and including 48" (1219 mm). For other thicknesses, 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

Room-Temperature Mechanical Properties

Table 1

Typical Mechanical Properties*

UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell	ASTM Grain Size	n
67-75 (462-517)	44-52 (303-359)	30-38	77-83	5-7	.180

*Annealed 18 Cr-Cb, 0.060" (1.52 mm) thickness.

Table 2

Properties Acceptable for Material Specification

UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell
60 min (414)	38 min (262)	25 min	B88 max

Effect of Cold Work on Mechanical Properties

Like most metals, AK Steel 18 Cr-Cb Stainless Steel work hardens when fabricated. Data in Table 3 show the work-hardening behavior as measured by tensile tests on laboratory cold-rolled sheet samples.

Table 3

Effect of Cold Work on Mechanical Properties*

Condition	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell
Annealed	69.0 (476)	42.8 (296)	34.0	B75.8
CW 5%	76.1 (525)	71.9 (496)	20.8	B88.2
CW 10%	82.8 (571)	79.6 (549)	10.2	B91.5
CW 14.7%	89.4 (617)	87.5 (604)	5.5	B92.8
CW 29.8%	105.4 (727)	104.4 (720)	2.8	B97.0
CW 44.1%	114.8 (792)	112.6 (776)	2.0	C20.5

*Annealed 18 Cr-Cb, 0.051" (1.14 mm) thickness.

Elevated Temperature Mechanical Properties

The addition of columbium to AK Steel 18 Cr-Cb Stainless Steel, coupled with a final high-temperature solution anneal, imparts improved elevated temperature creep resistance over other standard ferritic stainless steels. Sag strength is represented in Figure 1 as a strip material's resistance to sagging under its own weight with the passage of time at a constant temperature. Samples for this 1600°F (871°C) exposure were 0.060" (1.52 mm) thick x 1" (25.4 mm) wide and were supported over a distance of 10" (254 mm). Figure 1 clearly demonstrates the alloy's superior resistance to sag (creep) over Type 409.

Elevated-temperature fatigue problems are a major concern to ferritic stainless steel users, particularly when used in critical exhaust applications such as manifolds. AK Steel 18 Cr-Cb Stainless Steel provides improved resistance to elevated-temperature fatigue when compared to standard ALUMINIZED STEEL or Type 409.

885° Embrittlement

Most 18 Cr ferritic alloys exhibit a significant loss of ductility when exposed to the temperature range of 800 to 1000°F (427-538°C). This phenomenon is known as 885°F (474°C) embrittlement.

AK Steel 18 Cr-Cb Stainless Steel is less susceptible to this phenomenon than other 18 Cr alloys such as Type 439. Tensile results after exposure for 1000 hours at 900°F (482°C) are shown in Table 7 for AK Steel 18 Cr-Cb and Type 439 stainless steels.

Figure 1

1600°F (671°C) Sag Test

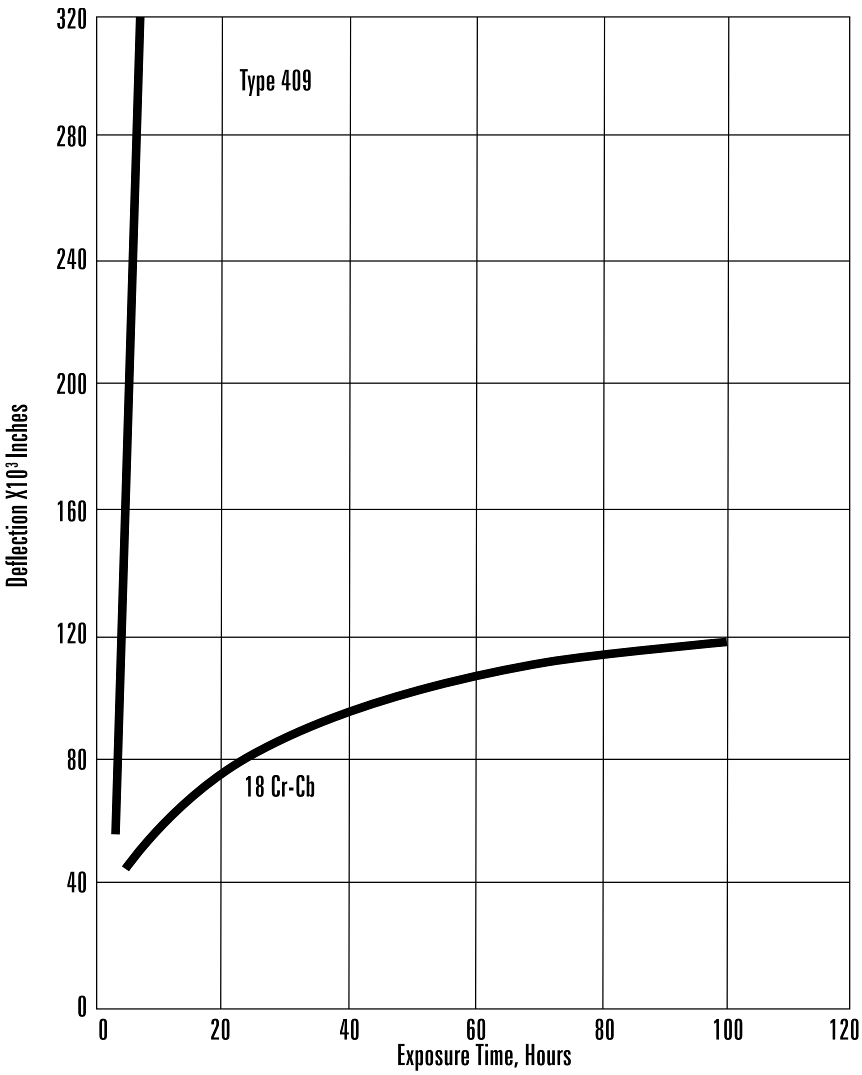


Table 4

Short-Time Elevated Temperature Properties

		Temperature, °F (°C)					
Property	Alloy	1000 (538)	1200 (649)	1300 (704)	1400 (760)	1500 (816)	1600 (871)
UTS, ksi (MPa)	Type 409	34.9 (241)	22.8 (157)	10.6 (73)	6.1 (42)	4.2 (29)	3.0 (21)
	Type 439	37.8 (261)	18.0 (124)	9.5 (66)	6.1 (42)	4.4 (30)	3.2 (22)
	18 Cr-Cb	54.3 (374)	43.5 (300)	21.4 (148)	9.3 (64)	7.3 (50)	5.2 (36)
	Type 304	62.9 (434)	47.1 (325)	36.3 (250)	27.8 (192)	21.0 (145)	16.5 (114)
0.2% YS, ksi (MPa)	Type 409	17.4 (120)	12.5 (86)	7.5 (52)	4.4 (30)	3.0 (21)	2.4 (16)
	Type 439	21.5 (148)	12.2 (84)	7.1 (49)	4.6 (32)	3.4 (23)	2.6 (18)
	18 Cr-Cb	25.4 (175)	21.1 (145)	13.6 (94)	6.8 (47)	5.8 (40)	4.2 (29)
	Type 304	22.0 (152)	20.0 (138)	18.0 (124)	15.0 (103)	13.0 (90)	10.0 (69)

Table 5

Elevated-Temperature Fatigue Strength
(Strength to surpass 10^7 cycles)

	Fatigue Strength*, ksi (MPa)	
Alloy	1300°F (704°C)	1500°F (816°C)
ALUMINIZED STEEL Type 1	3.1 (22)	1.5 (10)
Type 409	6.6 (45)	2.0 (14)
Ak Steel 18 Cr-Cb	7.5 (52)	3.0 (21)

*Tension/Tension R=0.1

Table 6

Stress Rupture Elevated Temperature Properties

Property	Alloy	Temperature, °F (°C) 1300 (704)	1500 (816)
Stress, ksi (MPa) to Rupture in 100 hours	Type 409	4.1 (28.3)	1.5 (10.3)
	Type 439	4.0 (27.6)	1.6 (11.0)
	AK Steel 18 Cr-Cb	5.8 (40.0)	2.4 (16.5)
	Type 304	16.9 (116.0)	6.2 (42.7)
Stress, ksi (MPa) to Rupture in 1000 hours	Type 409	3.2 (22.1)	0.9 (6.2)
	Type 439	3.0 (20.7)	1.0 (6.9)
	AK Steel 18 Cr-Cb	4.4 (30.3)	1.8 (12.4)
	Type 304	11.6 (80.0)	3.7 (25.5)

Table 7

Effect of 900°F (482°C) Exposure on Room-Temperature Properties

Alloy	Condition	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell
AK Steel 18 Cr-Cb	Annealed	69.0 (476)	42.8 (297)	34.0	B75.8
	1000 hours @ 900°F (482°C)	79.6 (549)	61.6 (425)	30.0	B83.8
Type 439	Annealed	71.1 (491)	44.0 (303)	33.0	B77.0
	1000 hours @ 900°F (482°C)	111.4 (768)	98.2 (677)	21.5	C20.2

Physical Properties

Room Temperature Properties

Density, 0.277 lbs/in^3
7.65 g/cm^3

Electrical Resistivity, microhm-in (microhm-cm) 23.29 (59)

Oxidation Resistance

The 17.5% minimum-chromium content of AK Steel 18 Cr-Cb Stainless Steel provides an improved oxidation-resistance level compared to lower chromium alloys such as Type 409 stainless. Under cyclic heating conditions, this alloy will outperform austenitic alloys of similar chromium content like Type 304 stainless due to the ferritic alloy's lower coefficient of thermal expansion. (See Figure 2, Figure 3 and Table 8.)

Under laboratory simulated exhaust gas atmosphere, the material demonstrated lower weight gains compared to Type 409, with no indication of catastrophic attack up to 1650°F (899°C).

Table 8

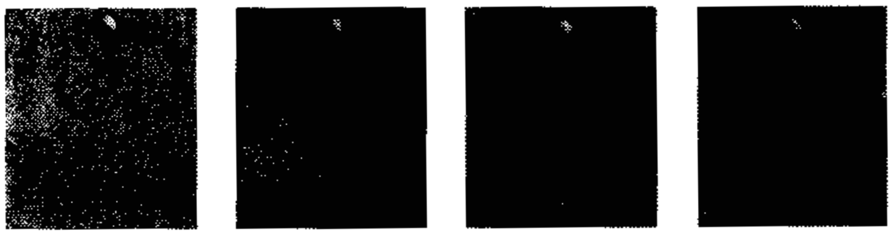
1700°F (927°C) Cyclic Oxidation*
Oxidation Weight Gain (mg/in^2)

	Hours of Testing										
Alloy	24.5	46.5	163	210	257	321	393.5	511.5	610	777.5	1022
ALUMINIZED STEEL Type 1	22.1	36.8	65.4	117	152	Discontinued					
Type 409	18.3	93.9	310	Discontinued							
AK Steel 18 Cr-Cb	0.9	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.4	1.2	0.8
Type 304	1.1	1.2	1.1	-9.8	-36.9	-112	-322	-710	Discontinued		

*Cycle: 25 minutes heat, 5 minutes cool. Average of duplicate tests.

Figure 2

1700°F (927°C) Cyclic Oxidation
2044 Cycles

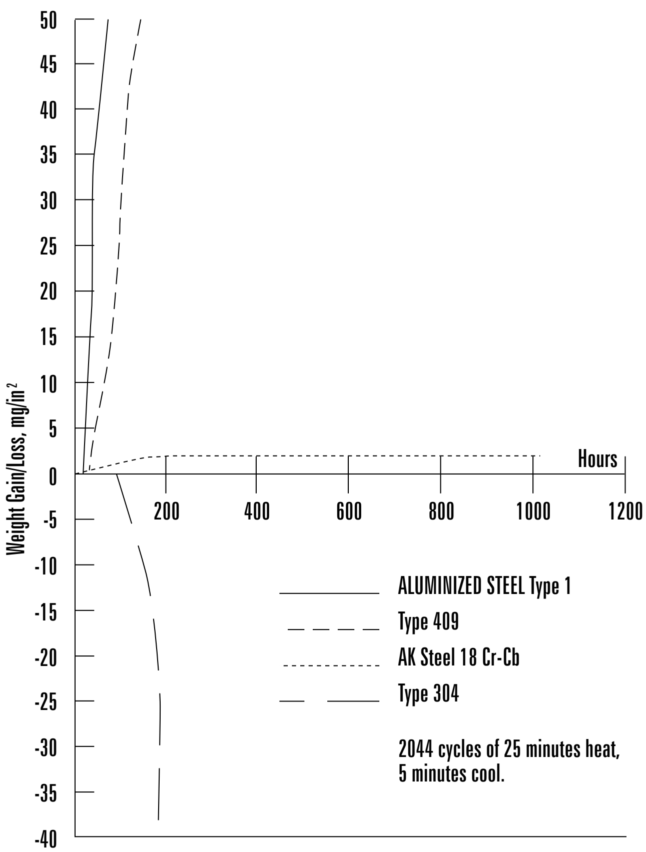


ALUMINIZED STEEL Type 1 | Type 409 | AK Steel 18 Cr-Cb | Type 304

Visual comparison of cyclic oxidation coupons after 1022 hours of testing at 1700°F (927°C)

Figure 3

1700°F (927°C) Cyclic Oxidation
1022 Hours of Exposure



Corrosion Resistance

AK Steel 18 Cr-Cb Stainless Steel is notably superior to Type 409 stainless steel in wet corrosion resistance, particularly to chlorides, and is more resistant to Synthetic Muffler Condensate attack as shown in Table 9 and Figure 4. Note the lower corrosion rate of AK Steel 18 Cr-Cb Stainless Steel, approaching the corrosion of Cr-Ni stainless steel.

Table 9

Synthetic Muffler Condensate Resistance*

Alloy	Corrosion Rate, mils per year
ALUMINIZED STEEL Type 1	8.0-24.0**
Type 409	7.17
AK Steel 18 Cr-Cb	4.69
Type 304	3.07

*Average of duplicate tests.
**Experience has shown this to be a typical range.

Figure 4

Muffler Condensate
Corrosion Resistance

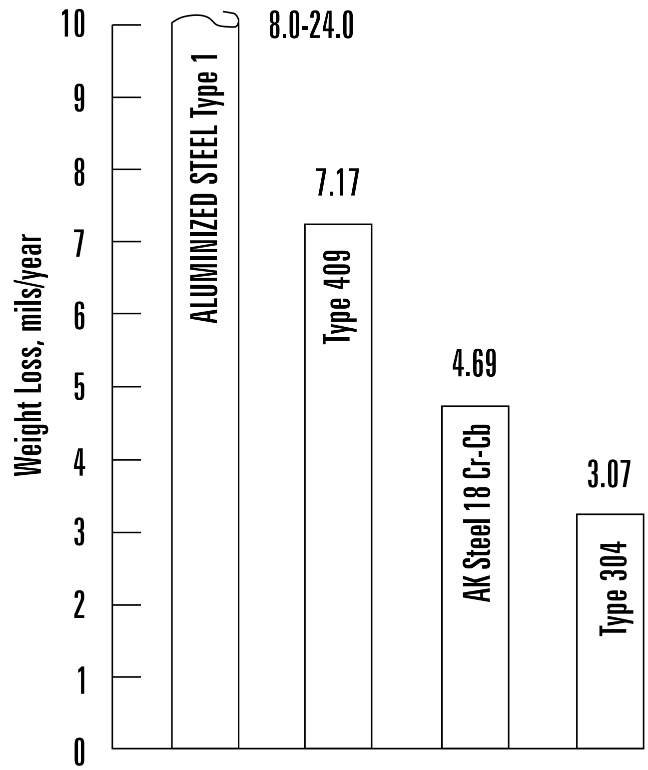
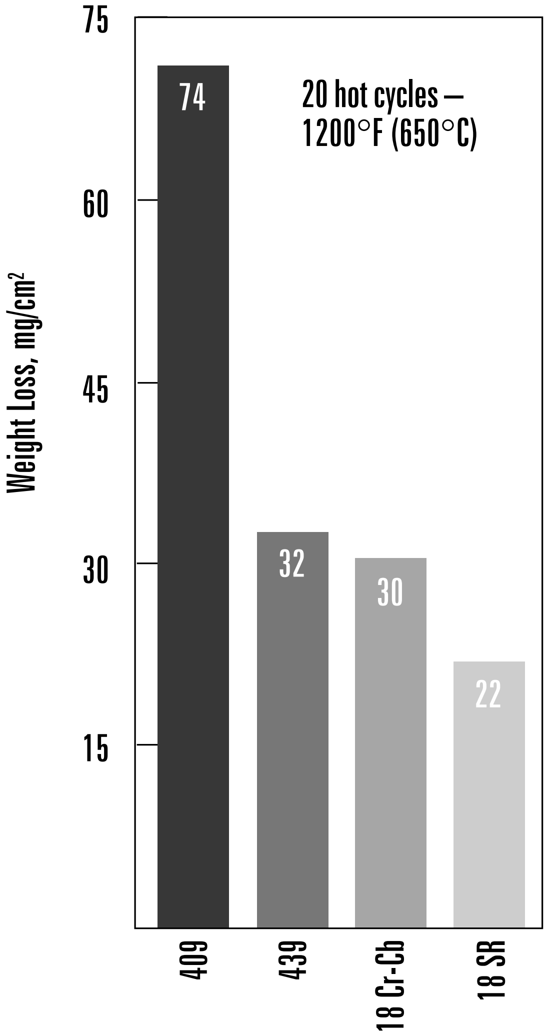


Figure 5

Hot Salt Corrosion Test



Test Procedure:

Sheet sample with 90° bend and 0.2" (5 mm) Olsen cup dome.

Hot Cycle:

Dip 5 min. in 5% NaCl and then expose 1200°F (650°C)/90 min., water quench 1 min., repeat 4 times/ day, humidity 85% RH/140°F (60°C) 18 hours/day.

Formability

AK Steel 18 Cr-Cb Stainless Steel can be cut, blanked and formed. Brakes, presses and roll-forming normally used on carbon steel can be used on this alloy.

Caution: Cold weather impact loads should be avoided with material 0.100" (2.54 mm) and heavier, particularly with welds, because the ductile-to-brittle transition temperature (DBTT) could fall close to ambient temperature.

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 slightly poorer weldability than the most common alloy of this stainless class, Type 409. A major difference is that the weld deposits themselves, while possessing reasonable ductility, will not be as ductile as the base metal. When a weld filler is needed, W 18 Cb filler is suggested. Type 409 Stainless Steel 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.

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