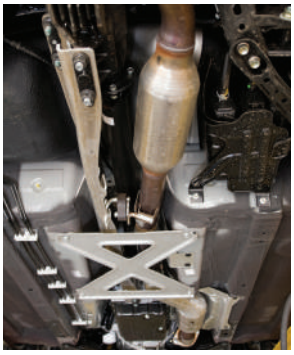
# 18 Cr-Cb™ STAINLESS STEEL

PRODUCT DATA BULLETIN



## More Oxidation Resistant Than Type 409

## More Creep Resistant Than Types 409 and 439

## Economical Oxidation Resistance

AK Steel 18 Cr-Cb™ Stainless Steel is a highly effective automotive exhaust material, especially for high-temperature component applications. The alloy exhibits superior oxidation resistance and better creep strength than Type 409, and Type 439. Potential applications include exhaust system catalytic converters, mufflers and pipes; heat-exchangers and heat-exchanger tubing; and nonstructural furnace parts. Other applications include appliances, food and kitchen equipment as well as architectural structures such as elevator and decorative panels.

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# PRODUCT DESCRIPTION

18 Cr-Cb is a ferritic stainless steel that is stabilized with both titanium and niobium (columbium). In service the alloy exhibits age-strengthening at exhaust operating temperatures resulting in excellent creep resistance. The dual stabilization prevents carbide sensitization during welding and high temperature exposures, and makes the alloy thermally non-hardenable.

## AVAILABLE FORMS

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

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.

| COMPOSITION | | (wt %) |
|---|---|---|
| Carbon | (C) | 0.03 max. |
| Manganese | (Mn) | 1.00 max. |
| Phosphorous | (P) | 0.04 max. |
| Sulfur | (S) | 0.03 max. |
| Silicon | (Si) | 1.00 max. |
| Chromium | (Cr) | 17.5 – 19.5 |
| Nickel | (Ni) | 1.0 max. |
| Nitrogen | (N) | 0.03 max. |
| Titanium | (Ti) | 0.10 – 0.50 |
| Niobium | (Nb) | 0.30 + 9xC min., 0.90 max. |

# MECHANICAL PROPERTIES

### TABLE 1 – TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

| UTS ksi. (MPa) | 0.2% YS ksi. (MPa) | Elongation % in 2" (50.8 mm) | Rockwell Hardness |
|---|---|---|---|
| 72 (496) | 47 (324) | 30 | B80 |

### TABLE 2 – PROPERTIES ACCEPTABLE FOR MATERIAL SPECIFICATION

| UTS ksi. (MPa) | 0.2% YS ksi. (MPa) | Elongation % in 2" (50.8 mm) | Rockwell Hardness |
|---|---|---|---|
| 60 (414) min. | 38 (262) min. | 25.0 min. | B88 max. |

### EFFECT OF COLD WORK ON MECHANICAL PROPERTIES

Like most metals, 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) | Rockwell Hardness |
|---|---|---|---|---|
| Annealed | 69.0 (476) | 42.8 (296) | 34.0 | B76 |
| CW 5% | 76.1 (525) | 71.9 (496) | 20.8 | B88 |
| CW 10% | 82.8 (571) | 79.6 (549) | 10.2 | B92 |
| CW 14.7% | 89.4 (617) | 87.5 (604) | 5.5 | B93 |
| CW 29.8% | 105.4 (727) | 104.4 (720) | 2.8 | B97 |
| CW 44.1% | 114.8 (792) | 112.6 (776) | 2.0 | C21 |

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

# ELEVATED TEMPERATURE MECHANICAL PROPERTIES

### TABLE 4 – SHORT-TIME ELEVATED TEMPERATURE TENSILE PROPERTIES

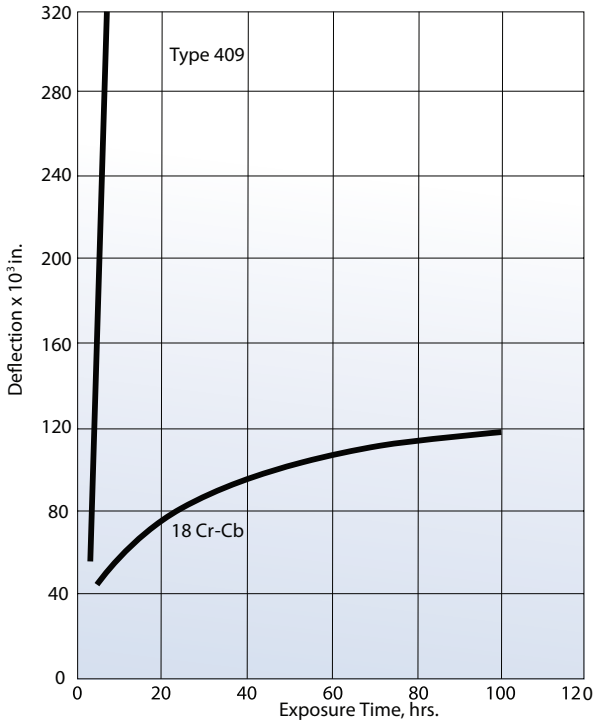
| | | Temperature, °F (°C) | | | | | |
|---|---|---|---|---|---|---|---|
| **Property** | **Alloy** | **1000 (538)** | **1200 (649)** | **1300 (704)** | **1400 (760)** | **1500 (816)** | **1600 (871)** |
| UTS, ksi. (MPa) | Type 409 | 34.9 (241) | 22.8 (157) | 10.5 (73) | 6.1 (42) | 4.2 (2.9) | 3.0 (21) |
| | Type 439 | 37.8 (261) | 18.0 (124) | 9.5 (66) | 6.1 (42) | 4.4 (30) | 3.2 (22) |
| | 18 Cr-Cb SS | 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 SS | 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 – STRESS RUPTURE ELEVATED TEMPERATURE PROPERTIES

| | | Temperature, °F (°C) | |
|---|---|---|---|
| **Property** | **Alloy** | **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) |
| | 18 Cr-Cb SS | 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) |
| | 18 Cr-Cb SS | 4.4 (30.3) | 1.8 (12.4) |
| | Type 304 | 11.6 (80.0) | 3.7 (25.5) |

The addition of Sag Resistance niobium to 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 in. (1.52 mm) thick x 1 in. (25.4 mm) wide and were supported over a distance of 10 in. (254 mm). Figure 1 clearly demonstrates the alloy's superior resistance to sag (creep) over Type 409.

**FIGURE 1 – 1600 °F (671 °C) SAG TEST**




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

**TABLE 6 – ELEVATED TEMPERATURE FATIGUE STRENGTH (STRENGTH TO SURPASS $10^7$ CYCLES)**

| Alloy | Fatigue Strength*, ksi. (MPa) | |
|---|---|---|
| | 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) |
| 18 Cr-Cb SS | 7.5 (52) | 3.0 (21) |

**Tension/Tension R = 0.1*

## 885° EMBRITTLEMENT

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

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 18 Cr-Cb and Type 439 Stainless Steels.

### 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) | Rockwell Hardness |
|---|---|---|---|---|---|
| 18 Cr-Cb SS | Annealed | 69.0 (476) | 42.8 (297) | 34.0 | B76 |
| | 1000 hours @ 900 °F (482 °C) | 79.6 (549) | 61.6 (425) | 30.0 | B84 |
| Type 439 | Annealed | 71.1 (491) | 44.0 (303) | 33.0 | B77 |
| | 1000 hours @ 900 °F (482 °C) | 111.4 (768) | 98.2 (677) | 21.5 | C20 |

## PHYSICAL PROPERTIES

| | |
|---|---|
| Density, lbs./in$^3$ (g/cm$^3$) | 0.277 (7.65) |
| Electrical Resistivity, μΩ•in. (μΩ•cm) | 23.29 (59) |

# OXIDATION RESISTANCE

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

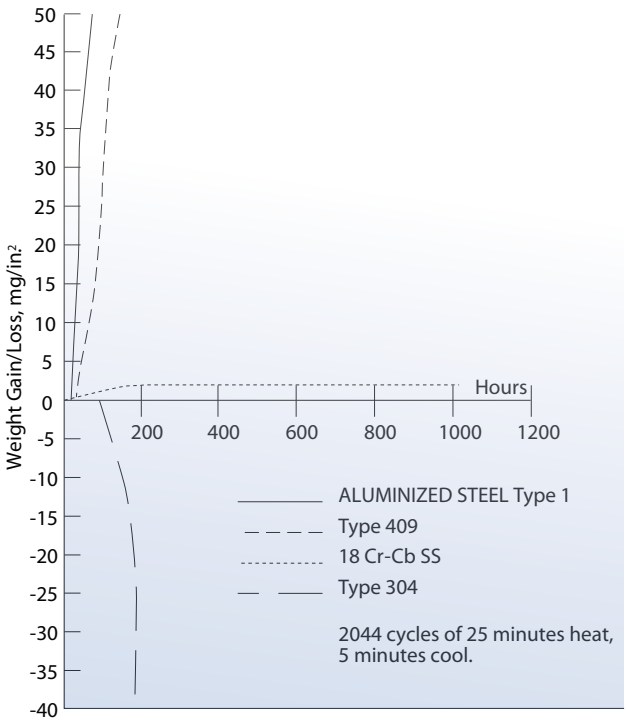
Under laboratory simulated exhaust gas atmosphere, the material demonstrated lower weight gains compared to Type 409, with no indication of catastrophic attack up to 1650 °F (899 °C).

**TABLE 8 – 1700 °F (927 °C) CYCLIC OXIDATION* OXIDATION WEIGHT GAIN, mg/in²**

| Alloy | Hours of Testing | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | | | | | | |
| Type 409 | 18.3 | 93.9 | 310 | | | | | | | | |
| 18 Cr-Cb SS | 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 | | | |

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

**FIGURE 2 – 1700 °F (927 °C) CYCLIC OXIDATION 1022 HOURS OF EXPOSURE**



# CORROSION RESISTANCE

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 18 Cr-Cb Stainless Steel, approaching the corrosion of Cr-Ni Stainless Steel.

**TABLE 9 – SYNTHETIC MUFFLER CONDENSATE RESISTANCE***

| Alloy | Corrosion Rate, mills per year |
|---|---|
| ALUMINIZED STEEL Type 1 | 8.0 – 24.0** |
| Type 409 | 7.17 |
| 18 Cr-Cb SS | 4.69 |
| Type 304 | 3.07 |

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

**FIGURE 3 – MUFFLER CONDENSATE CORROSION RESISTANCE**

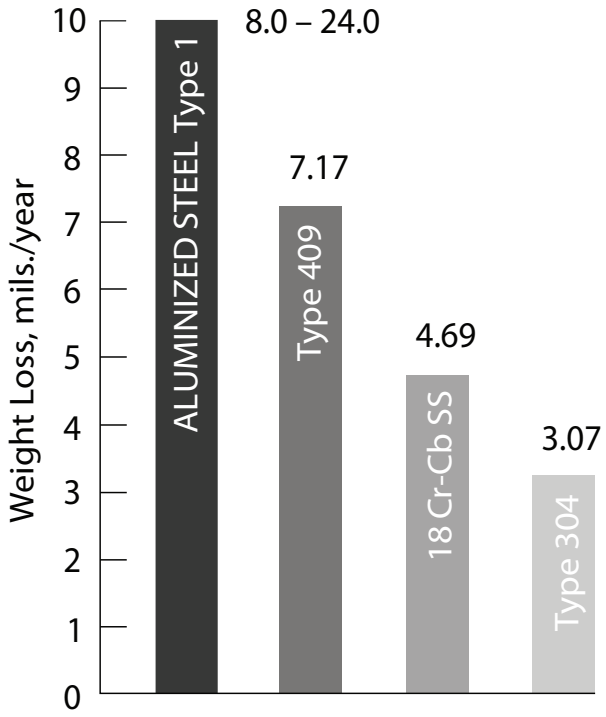
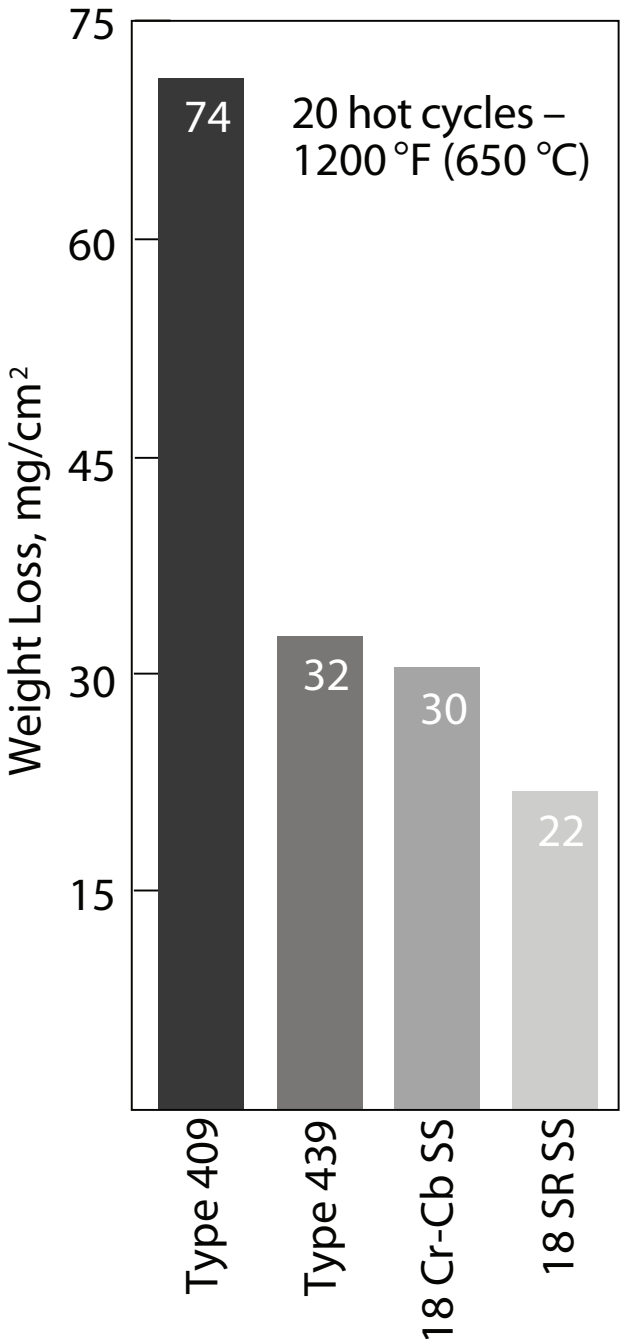



**FIGURE 4 – HOT SALT CORROSION TEST**




**Test Procedure:**
Sheet sample with 90° bend and 0.2 in. (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

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 in. (2.54 mm) and heavier, particularly with welds, because the ductile-to-brittle transition temperature (DBTT) could fall close to ambient temperature.

## WELDABILITY

18 Cr-Cb Stainless Steel is generally considered to be weldable by the common fusion and resistance welding processes, including laser and high frequency induction tube welding. This grade is generally considered to have diminished weldability compared to the most common alloy of this stainless class, Type 409. Application of weld heat can cause grain growth and reduced toughness in the heat affected zone. Use of a low heat input weld procedure, minimizing stress concentrations, and warming of parts slightly prior to forming will reduce the tendency for brittle weld fracture in subsequent processing. The balanced dual stabilized (titanium and columbium) 18 Cr-Cb chemistry is not susceptible to the formation of continuous intergranular carbides that could lead to intergranular corrosion. When a matching weld filler is required, 18 Cr-Cb (No AWS Class) and EC439Nb wires are often recommended for light gauge high temperature (>1000 °F) service where thermal cycling is expected. The addition of hydrogen to weld shielding gases for increased welding speed is discouraged, as the ferritic stainless steels are subject to hydrogen embrittlement. More information on the welding of ferritic stainless steels may be obtained from the following sources.

1. ANSI/AWS A5.9, A5.22, and A5.4 (stainless welding electrode specifications).
2. “Welding of Stainless Steels and Other Joining Methods,” SSINA, (www.ssina.com).

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AK Steel is a world leader in the production of flat-rolled carbon, stainless and electrical steel products, primarily for automotive, infrastructure and manufacturing, construction and electrical power generation and distribution markets. Headquartered in West Chester, Ohio (Greater Cincinnati), the company employs approximately 8,000 men and women at eight steel plants, two coke plants and two tube manufacturing plants across six states: Indiana, Kentucky, Michigan, Ohio, Pennsylvania and West Virginia. Additional information about AK Steel is available at www.aksteel.com.



*04.14.15*