P R O D U C T D A T A B U L L E T I N

409 ULTRA FORM
STAINLESS STEEL

UNS S40920

AK Steel

- Equiaxed Microstructure
- Improved Formability
- Good Oxidation Resistance
- Enhanced Weldability

Economical Oxidation Resistance

Applications Potential

AK Steel 409 ULTRA FORM® was created for applications needing oxidation or corrosion protection beyond the capability of carbon steel and some coated steels. In addition, the material is more formable than standard Type 409 stainless steels and is particularly suitable for parts requiring more complex shapes and improved weldability. Examples include automotive exhaust tubing and stampings, as well as parts such as brake shields, casket bottoms, fuel filters and heat exchangers.

Table of Contents

PRODUCT DESCRIPTION

AK Steel 409 ULTRA FORM Stainless Steel provides an outstanding combination of improved forming and welding characteristics, while providing superior resistance to oxidation, corrosion, ridging and roping in both automotive exhaust and non-exhaust applications. These benefits are achieved through precise control of chemistry and thermo-mechanical processing from melting to finishing.

AK Steel 409 ULTRA FORM is essentially non-hardenable by heat treatment because of its titanium and low-carbon levels. The titanium additions not only stabilize the steel to prevent hardening during welding, but also prevent the formation of harmful chromium carbides which can lead to intergranular corrosion in service.

Available Forms

AK Steel produces 409 ULTRA FORM Stainless Steel coils and cut lengths in thicknesses of 0.015" to 0.250" (0.381 to 6.350 mm) in widths up to and including 48" (1219 mm). For applications over 0.120" (3.048mm) thick, AK Steel 409 Ni Stainless Steel will provide improved toughness and weldability.

The surface finish of the alloy is obtained by annealing and pickling after rolling. The pickled surface is relatively dull and, like other titanium-stabilized stainless steels, may have cosmetic titanium streaks and will appear similar to typical Type 409.

Composition

	ASTM A240 UNS S40920 %	AK Steel 409 ULTRA FORM %
Carbon	0.03 max.	0.02 max.
Manganese	1.00 max.	0.75 max.
Phosphorus	0.040 max.	0.040 max.
Sulfur	0.010 max.	0.010 max.
Silicon	1.00 max.	1.00 max.
Chromium	10.5 - 11.7	10.5 - 11.7
Nickel	0.50 max.	0.50 max.
Titanium	8X(C+N) min.	8X(C+N) min.

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) = 6.8949 megapascals (MPa). Other units are discussed in ASTM E380.

Microstructure

AK Steel 409 ULTRA FORM Stainless Steel features a uniform grain structure that enhances material formability.

Figure 1
AK Steel 409 ULTRA FORM Typical Microstructure at 100X.

Mechanical Properties

Table 1
Mechanical Properties
Annealed Condition
Transverse Orientation

	Acceptable Specifications ASTM A240 UNS S40920	Typical AK Steel 409 0.050"-0.085" (1.27-2.16 mm)	Typical AK Steel 409 ULTRA FORM 0.050"-0.085" (1.27-2.16 mm)
UTS, ksi (MPa)	55 (379) min.	55-67 (379-462)	55-66 (379-455)
0.2% YS, ksi (MPa)	25 (172) min.	28-40 (193-276)	27-38 (186-262)
Elong., % in 2” (50.8 mm)	20 min.	28-42	33-43
Hardness, Rockwell	B88 max.	B60-B72	B64-B70
Typical r_m value*	–	1.3	1.5

*Modul-$\bar{r}$

Table 2

Effect of Cold Work on Mechanical Properties*
0.062" (1.545 mm)

Condition	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell B
Annealed	60.6 (418)	32.6 (225)	36.3	66.9
Cold Worked 5%	63.0 (434)	51.5 (352)	31.9	70.0
Cold Worked 10%	71.1 (490)	70.5 (486)	17.0	85.3
Cold Worked 15%	79.0 (545)	78.5 (541)	9.5	88.7
Cold Worked 30%	95.4 (657)	94.5 (652)	4.0	93.5
Cold Worked 50%	105.9 (730)	104.5 (721)	3.5	85.3

* Average results of duplicate laboratory tests on randomly selected coils. Cold work represents uniaxial cold reduction on laboratory coupons.

Table 3

Typical Elevated Temperature Properties*

Temperature °F (°C)	AK Steel 409 UTS ksi (MPa)	AK Steel 409 0.2% YS ksi (MPa)	AK Steel 409 ULTRA FORM UTS ksi (MPa)	AK Steel 409 ULTRA FORM 0.2% YS ksi (MPa)
Room	59.0 (407)	33.9 (233)	60.6 (418)	32.6 (225)
400 (204)	52.0 (358)	25.0 (172)	49.3 (340)	22.4 (154)
700 (371)	48.0 (331)	23.0 (159)	46.4 (320)	22.0 (152)
1000 (538)	34.9 (241)	17.4 (120)	35.7 (246)	18.4 (127)
1200 (649)	22.8 (157)	12.5 (86)	21.0 (145)	12.9 (89)
1300 (704)	10.6 (73)	7.5 (52)	10.6 (73)	6.8 (47)
1500 (816)	4.2 (29)	3.0 (21)	4.6 (32)	3.1 (22)

* Results of duplicate laboratory tests on randomly selected coils.

Table 4

Fatigue Properties

Temperature °F (°C)	Fatigue Strength (r = .1) to Surpass 10^7 Cycles – ksi (MPa) AK Steel 409	AK Steel 409 ULTRA FORM*
70 (21)	47 (324)	–
700 (371)	45 (310)	–
1100 (593)	17 (117)	–
1300 (704)	5.0 (34)	5.0 (34)
1500 (816)	1.5 (10)	1.5 (10)

* Duplicate heats of AK Steel 409 ULTRA FORM Stainless Steel were tested and found to have the same fatigue limits as typical Type 409.

Stress Rupture Properties

Preliminary results based on limited data indicate stress rupture properties of AK Steel 409 ULTRA FORM Stainless Steel are similar to those of typical AK Steel 409 Stainless Steels.

Fabrication

A uniform grain structure, improved r_m value, and improved ridging and roping resistance allow AK Steel 409 ULTRA FORM to be formed into more complex shapes than is possible with standard 409 stainless steels.

AK Steel 409 ULTRA FORM provides good fabricating characteristics and can be cut, blanked and formed without difficulty. Brake presses normally used on carbon steel can be used on this alloy.

Forming Limit Curves (Figure 2) provide guidelines to the forming capabilities of a specific material over a range of major-to-minor strain ratios. The Forming Limit Curves define the critical strain limit that a material can undergo prior to the onset of localized thinning. It is assumed that no previous deformation has taken place and that the strain path does not dramatically change during deformation.

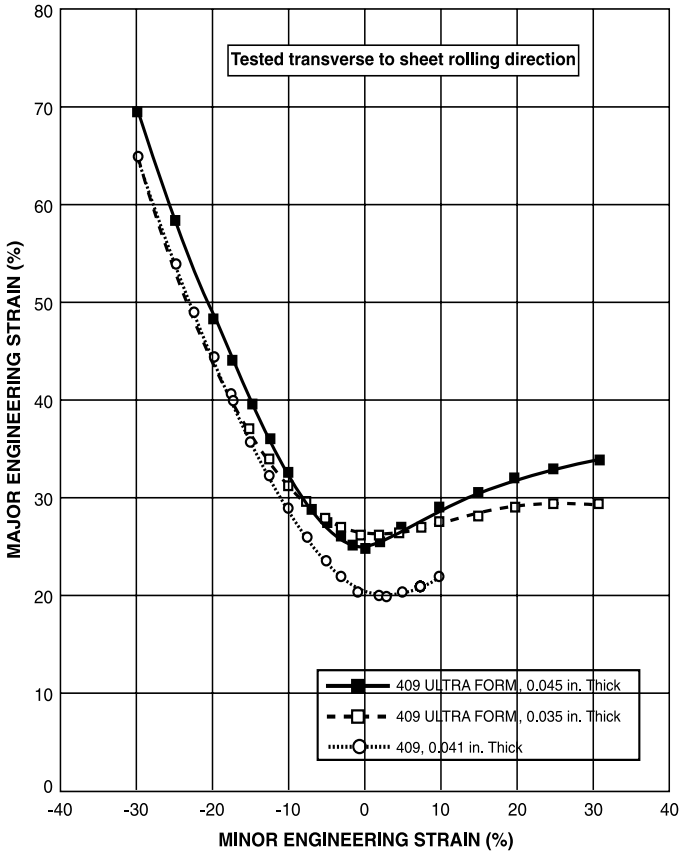
Forming Limit Curves have proven very useful in diagnosing potential problems in sheet forming. Sheets are premarked with a known strain grid pattern and formed using either prototype or production tools. Strains near suspected trouble regions are measured and compared with the Forming Limit Curves. If the measured strains are near the experimental forming limit curve, some production failures are likely. Measured strains plotted on the forming limit diagram can also help to identify forming process changes needed, that will take advantage of the material's ability to draw or stretch.

Physical Properties

Density, lb/in^3 (kg/m^3)	0.280 (7740)
Specific Electrical Resistance, microhm-cm	60.0
Modulus of Elasticity in Tension at Room Temperature, psi (MPa)	30.2 x 10^6 (20.8 x 10^4)

Figure 2

Typical Forming Limit Curves Defining “Incipient Neck”



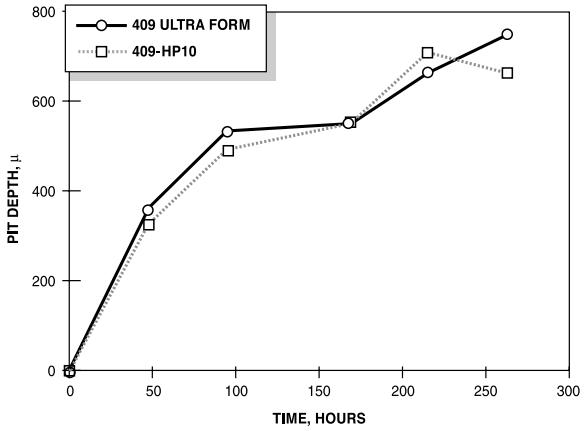
Most additional physical properties, including coefficient of thermal expansion, thermal conductivity and specific heat, are identical to those of Type 409 stainless steel.

Corrosion Resistance

In general, the corrosion resistance of AK Steel 409 ULTRA FORM Stainless Steel is the same as AK Steel 409 and Type 410 stainless steels. Corrosion resistance of welds and weld areas is comparable to that of the base metal. In this respect, the material is superior to Type 410 because welding does not greatly impair the corrosion resistance of weld areas prone to chromium carbide sensitization.

Figure 3 compares the corrosion resistance of AK Steel 409 ULTRA FORM and 409 Stainless Steels when partially immersed in a 3500 ppm chloride solution at a temperature of 185°F (85°C).

Figure 3
Continuous Corrosion Test
Partial immersion in 185°F (85°C),
3500 ppm chloride solution



Oxidation Resistance

The temperature at which AK Steel 409 ULTRA FORM Stainless Steel starts to exhibit destructive scaling in air is 1450°F (789°C). This is considered the general maximum service temperature for exposure in air. However, maximum service temperatures will vary appreciably, depending on the atmospheres involved. The material performs similarily to Type 409 in cyclic oxidation. Cyclic oxidation results at 1500°F (815°C) and 1600°F (871°C) are shown in Figures 4 and 5 in comparison to other higher chromium alloys.

Figure 4
Cyclic Oxidation Test Results for 409 ULTRA FORM
at 1500°F (815°C) (1 cycle = 25 min. heat/5 min. cool)

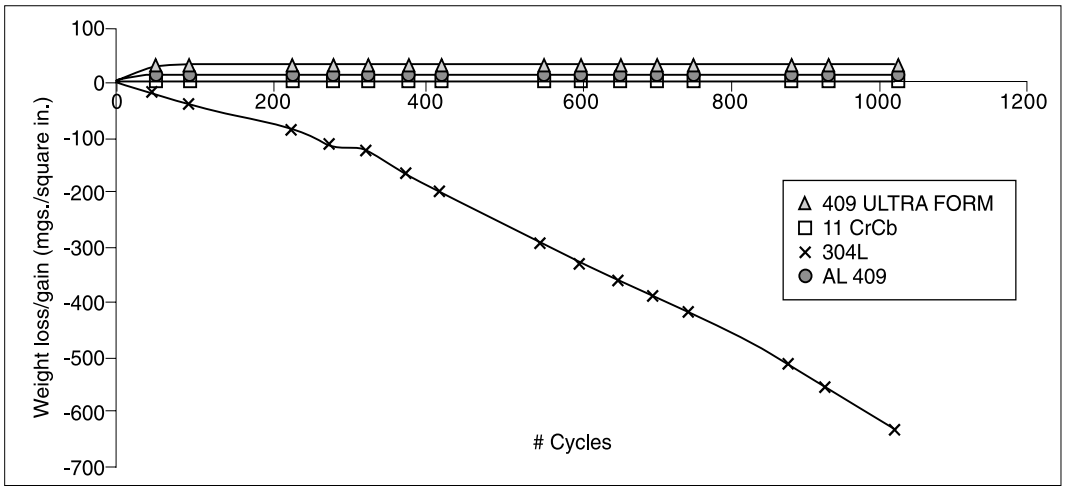
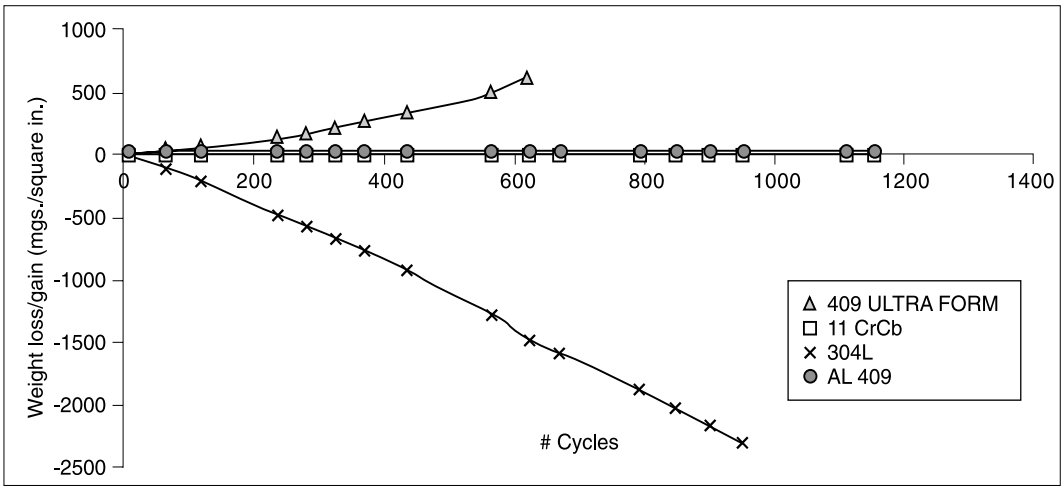


Figure 5
Cyclic Oxidation Test Results for 409 ULTRA FORM
at 1600°F (871°C) (1 cycle = 25 min. heat/5 min. cool)



Weldability

AK Steel 409 ULTRA FORM Stainless Steel offers improved GTA weldability when compared to standard 409 stainless steel. When gauge and weld joint geometry permit the use of gas metal-arc (GMA) or High Frequency welding, joints having good properties are easily obtained. The electrode wires most often suggested are AWS ER309 or ER308L austenitic stainless steel when the application does not include exposure to high temperatures. AWS ER309 or ER308L stainless wire may also be employed for joining these stainless steels to mild steel. Thin wall components for elevated temperature service should be weld fabricated with a matching weld filler such as 409 Cb. AWS ER430 and W18 Cr-Cb filler wires are suitable alternatives.

Guidelines for the Shielded Metal-arc (SMA) process and selection of electrodes are about the same as those employed for GMA and GTA welding, except that matching fillers for thermal application are not available in covered electrode form. Suitable substitutes are E410Ni Mo and E330.

AK Steel 409 ULTRA FORM Stainless Steel also is readily adaptable to resistance spot and seam welding and has shown enhanced high frequency weldability.

Specifications

AK Steel 409 ULTRA FORM Stainless Steel is covered by the following specification. It is suggested that the issuing agency be contacted for the latest specification revision.

ASTM A240 (S40920).

AK Steel

Customer Service 800-331-5050

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

www.aksteel.com

7180-0069 PDF 07/07