

439 ULTRA FORM

STAINLESS STEEL

UNS S43035



- Equiaxed Microstructure

- Improved Formability

- More Oxidation Resistant Than Type 409

- More Corrosion Resistant Than Type 409

Applications Potential

AK Steel 439 ULTRA FORM™ was developed for applications requiring oxidation and corrosion resistance superior to Type 409 as well as superior formability to AK Steel 439 Stainless Steel. As a result, the material offers advantages for parts requiring more complex shapes than possible from these stainless steels. Examples include tubular manifolds and other exhaust system components where temperatures may exceed the oxidation limit of Type 409, or where wet corrosion resistance, particularly to chlorides, is needed.

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The information and data in this 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.

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PRODUCT DESCRIPTION

AK Steel 439 ULTRA FORM Stainless Steel provides an outstanding combination of improved forming characteristics plus oxidation and corrosion resistance superior to Type 409. These benefits are achieved through precise control of chemistry and thermo-mechanical processing from melting to finishing. This provides special advantages when producing difficult-to-form exhaust system components.

Available Forms

AK Steel 439 ULTRA FORM is available in thicknesses from 0.010" to 0.145" (0.25 to 3.68 mm) in widths up to 48" (1219 mm). For other sizes, inquire.

Composition

	AK Steel 439 Specification Limits %	Typical AK Steel 439 ULTRA FORM %
Carbon	0.04 max.	0.01
Manganese	1.00 max.	0.25
Phosphorus	–	0.02
Sulfur	–	0.0015
Silicon	0.60 max.	.35
Chromium	17.0-18.0	17.35
Nickel	0.50 max.	0.20
Molybdenum	–	0.10
Titanium	0.20-0.60	.335
Columbium	–	0.02
Nitrogen	–	0.01

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/m²). 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/m²) is used. The unit (N/m²) has been designated a pascal (Pa). The relationship between the U. S. and the SI units for stress is 1000 pounds/in² (psi) = 1 kip/in² (ksi) = 6.8948 meganewtons/m² (MN/m²) = 6.8948 megapascals (MPa). Other units are discussed in ASTM E380.

Microstructure

AK Steel 439 ULTRA FORM Stainless Steel features a uniform equiaxed grain structure that enhances material formability.

Figure 1

AK Steel 439 ULTRA FORM
Typical Microstructure at 100x as Etched
with Vilellas Reagent.



Mechanical Properties

Table 1

Mechanical Properties
AK Steel 439 ULTRA FORM
Annealed Condition
Transverse Orientation

	AK Steel 439	Typical AK Steel 439 ULTRA FORM™
UTS, ksi (MPa)	68 (469)	67 (462)
0.2% YS, ksi (MPa)	42 (290)	41 (283)
Elongation, % in 2" (50.8 mm)	33	35
Hardness, Rockwell	B75	B74

Table 2

Effect of Cold Work on Mechanical Properties
AK Steel 439 ULTRA FORM

Condition	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell B
Annealed	63.6 (438)	38.2 (263)	34.8	72.9
Cold Worked 5%	70.2 (484)	66.7 (460)	24.3	85.4
Cold Worked 10%	79.2 (546)	78.9 (544)	12.0	89.1
Cold Worked 15%	89.5 (618)	88.9 (613)	6.5	92.1
Cold Worked 30%	103.4 (713)	98.5 (680)	3.8	95.6
Cold Worked 50%	113.8 (785)	109.1 (753)	2.8	96.9

Table 3

Typical Elevated Temperature Properties
AK Steel 439 ULTRA FORM

Temperature °F (°C)	AK Steel 439		AK Steel 439 ULTRA FORM	
	UTS ksi (MPa)	0.2% YS ksi (MPa)	UTS ksi (MPa)	0.2% YS ksi (MPa)
400 (204)	N/A	N/A	58.6 (404)	29.7 (206)
700 (371)	N/A	N/A	54.1 (373)	27.7 (191)
1100 (593)	N/A	N/A	32.5 (225)	18.8 (130)
1300 (704)	9.5 (66)	7.2 (49)	10.2 (70)	7.08 (49)
1500 (816)	4.4 (35)	3.4 (24)	5.14 (35)	3.53 (25)

Fatigue Properties

Table 4

Temperature °F (°C)	Fatigue Strength (r = 0.1) to Surpass 10 ⁷ Cycles – ksi (MPa)	
	AK Steel 439	AK Steel 439 ULTRA FORM™
1300 (704)	5.5 (38)	4.0 (28)
1500 (816)	2.0 (14)	1.4 (10)

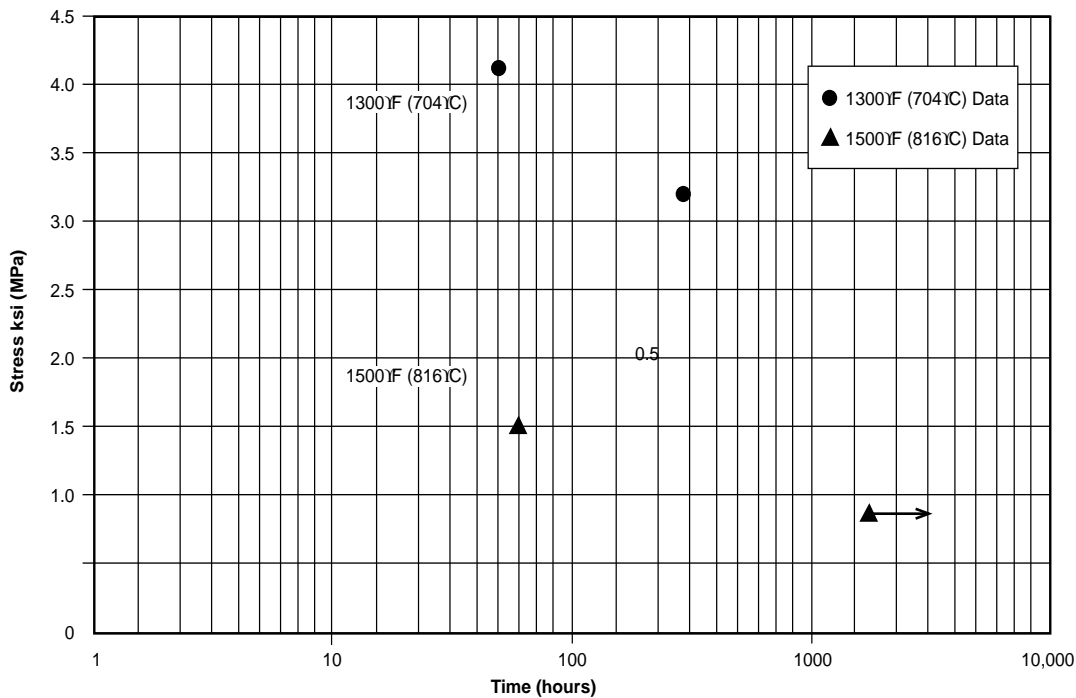
Stress Rupture Properties

Duplicate samples were tested for each stress level and temperature combination listed in the procedure. The averages of these tests are shown in Figure 2. Note the

tests at 900 psi (6 MPa) and 1500°F (816°C) were stopped because they had withstood more than 2000 hours.

Figure 2

Stress Rupture Behavior of AK Steel 439 ULTRA FORM



Impact Properties

Ductile to brittle transition curves were obtained from the Charpy V-notch test. Longitudinal and Transverse transition curves are shown in Figures 3 and 4. Material tested was 0.058" (1.47 mm) thick. The transition temperature is the point on the graph where the mate-

rial changes sharply from displaying ductile behavior to displaying brittle behavior. The transition temperature shown by the graph for the longitudinal samples tested is -130°F (-90°C) and for the transverse samples, -160°F (-107°C)

Figure 3

Longitudinal Impact
AK Steel 439 ULTRA FORM

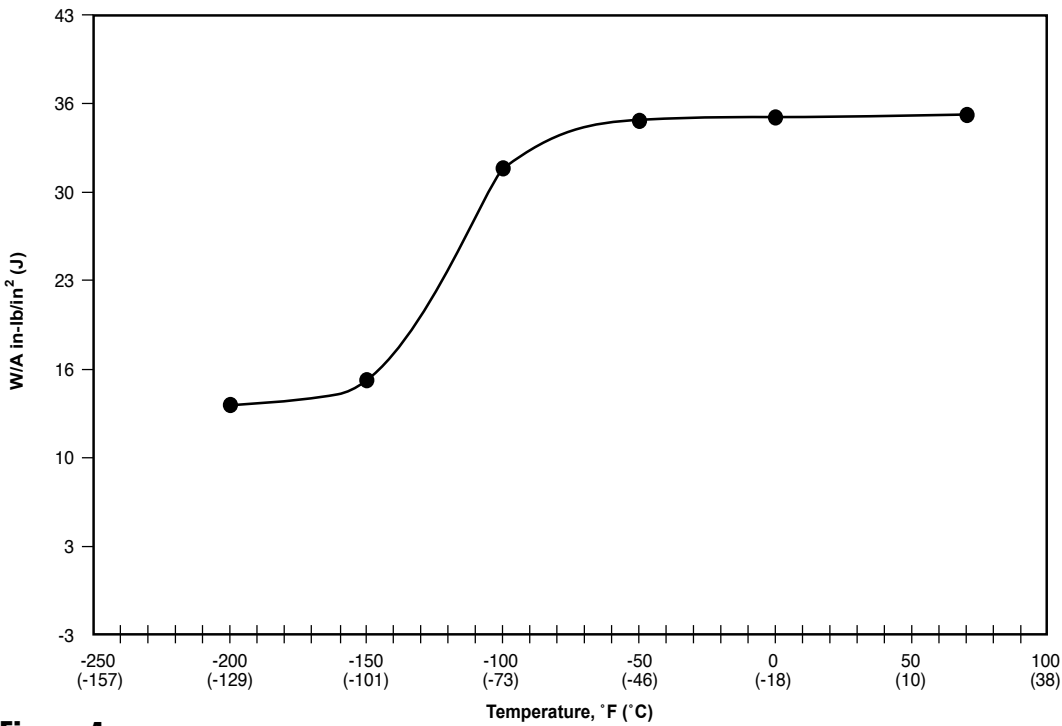
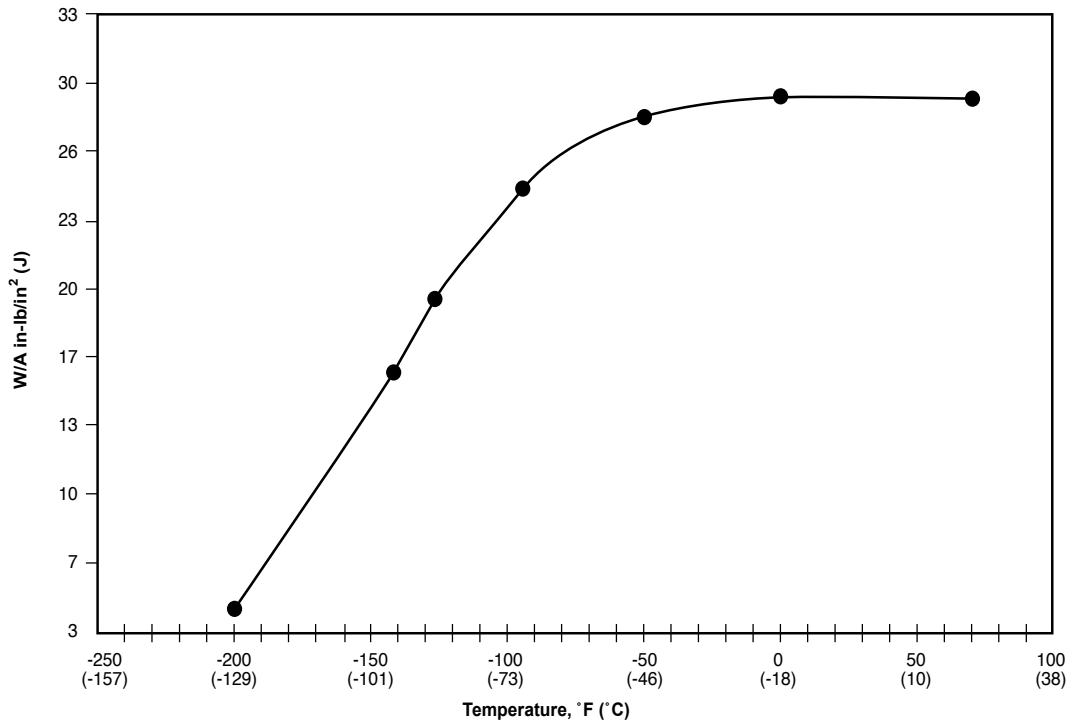


Figure 4

Transverse Impact
AK Steel 439 ULTRA FORM



Physical Properties

Density, lb/in³ (kg/m³) at 70°F (21°C)

0.278 (7685)

Figure 5

Relative Expansion

AK Steel 439 ULTRA FORM

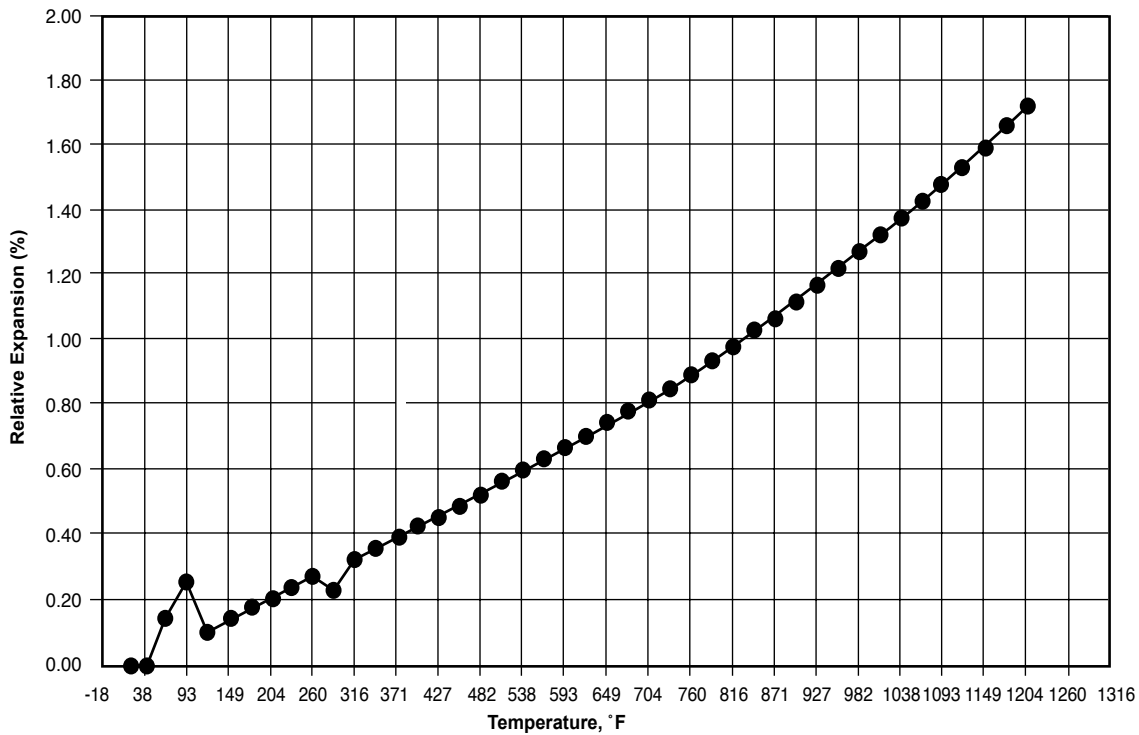
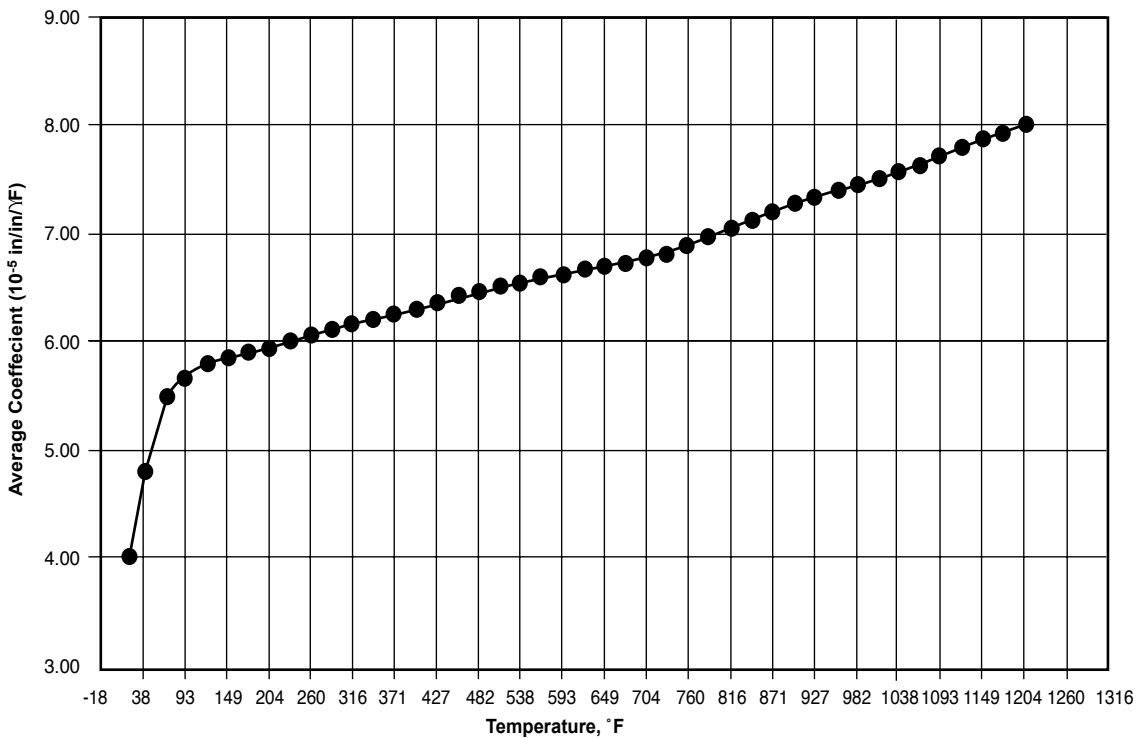


Figure 6

Average Coefficient of Thermal Expansion

AK Steel 439 ULTRA FORM



Formability

A uniform grain structure, improved r_m value, and improved ridging and roping resistance allow AK Steel 439 ULTRA FORM to be formed into more complex shapes than is possible with standard 439 stainless steel. The material provides good fabricating characteristics and can be blanked and formed without difficulty.

Results from the Olsen Cup and stretch- r_m formability tests are shown in Table 5. For the Olsen Cup test, duplicate sets were run for each coil tested and the data listed is the average of all tested coils.

Table 5

Formability
AK Steel 439 ULTRA FORM

Material Thickness, in (mm)	Dome Height, in (mm)	r_m -value
0.022 - 0.028 (0.56 - 0.71)	0.330 (8.38)	1.96
0.030 (0.76)	0.342 (8.69)	2.03
0.056 - 0.059 (1.42 - 1.50)	0.408 (10.36)	1.62
0.035 (0.89)	0.371 (9.42)	1.78

Oxidation Resistance

Figures 7, 8 and 9 provide results from 1500°F (816°C), 1600°F (871°C) and 1700°F (926°C) cyclic oxidation tests. The AK Steel 439 ULTRA FORM samples were tested until they gained sufficient weight to reach the point of breakaway oxidation and catastrophic failure. In the 1500°F (816°C) test, the samples gained less than 2 mg/in² after 1100 cycles, showing no sign of failure.

Samples in the 1600°F (871°C) test gained approximately 10 mg/in², still showing no sign of failure. The AK Steel 439 ULTRA FORM samples at 1700°F (926°C) gained 320 mg/in² after 1000 cycles, but were not determined as catastrophic failures. AK Steel 11 Cr-Cb and Aluminized 409 stainless steel data are shown for comparison.

Figure 7

Cyclic Oxidation

AK Steel 439 ULTRA FORM

1500°F (816°C)

1 cycle = 25 minute heat/5 minutes cool

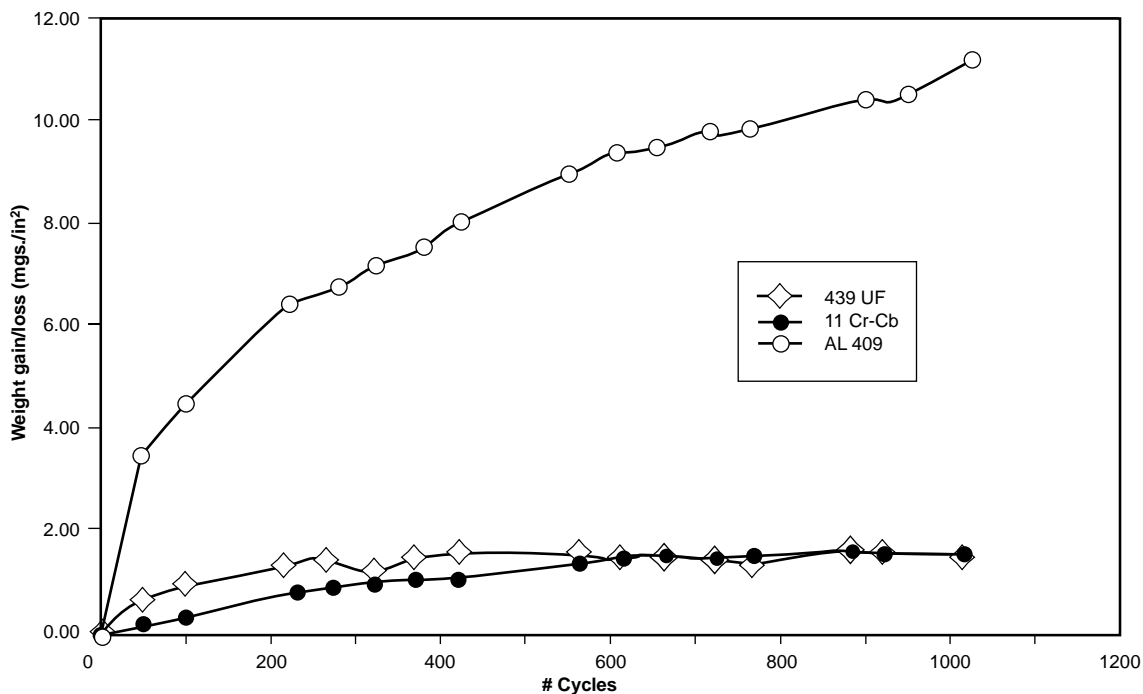


Figure 8

Cyclic Oxidation

AK Steel 439 ULTRA FORM

1600°F (871°C)

1 cycle = 25 minute heat/5 minutes cool

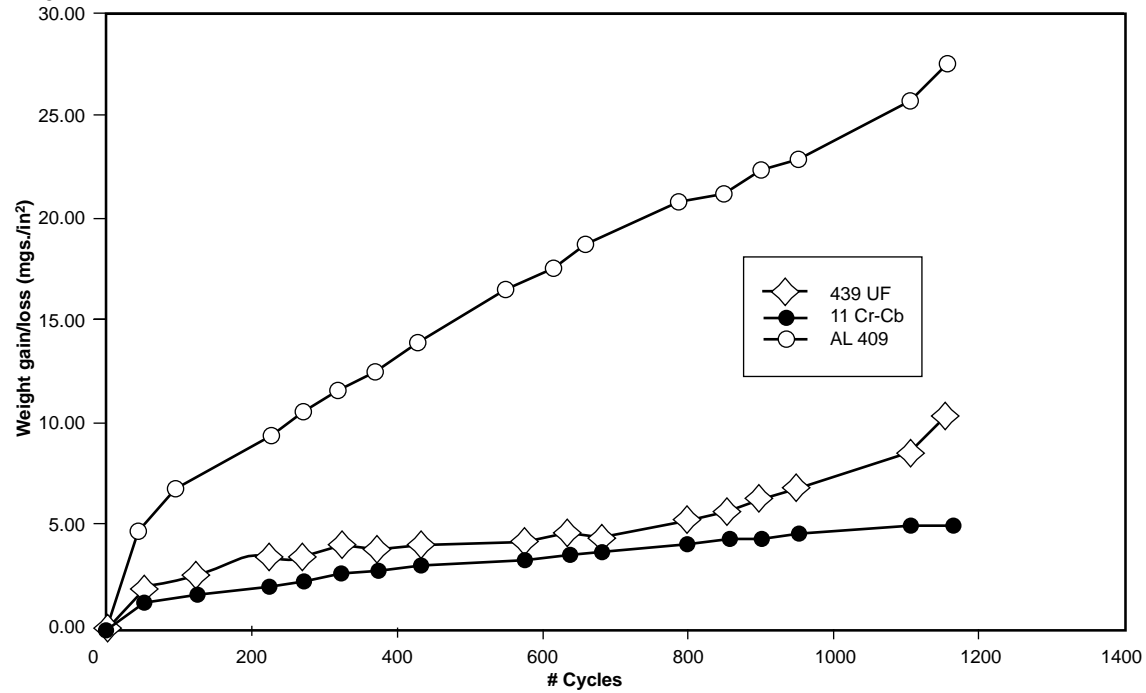


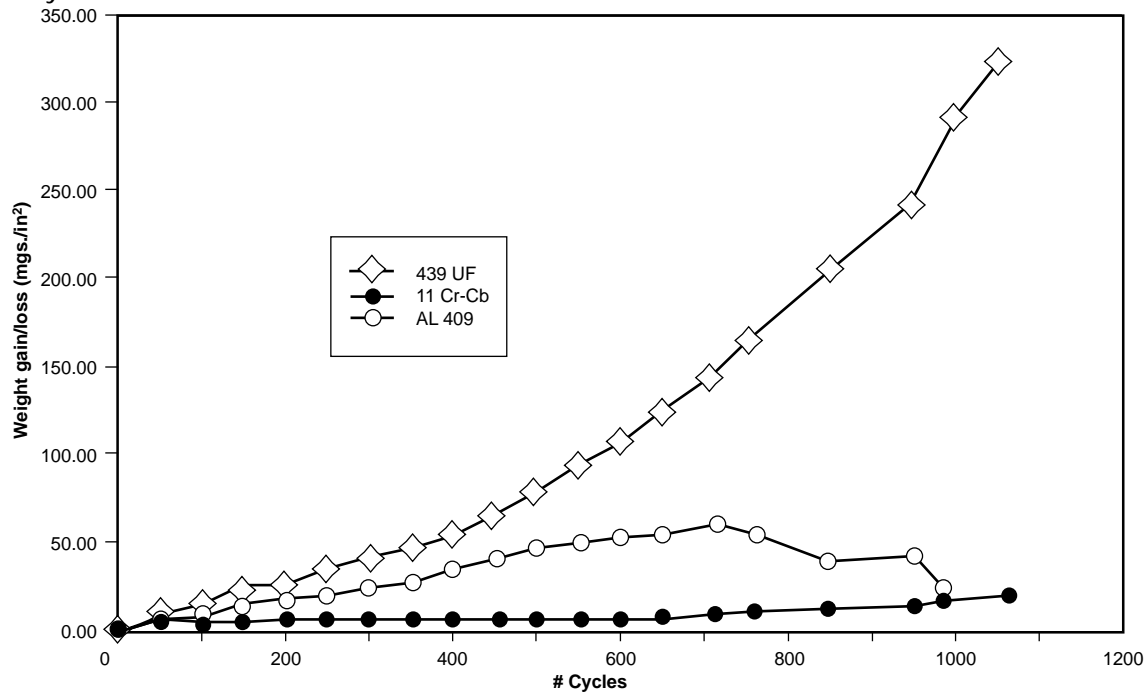
Figure 9

Cyclic Oxidation

AK Steel 439 ULTRA FORM

1700°F (926°C)

1 cycle = 25 minute heat/5 minutes cool



Weldability

AK Steel 439 ULTRA FORM is readily 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 and occasionally warming the part somewhat before forming.

When a weld filler is needed, AWS E/ER 439 is most often specified, but W18Cb is suggested for high-temperature service and E/ER 308L will develop better ductility if it will be used in ambient temperature conditions.

Specifications

AK Steel 439 ULTRA FORM is covered by the following specification. It is suggested that the issuing agency be contacted for the latest specification revision.

ASTM A 240 (UNS S43035)



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