

# 436L ULTRA FORM<sup>®</sup>

**STAINLESS STEEL**




**Cold End Mufflers**


**Exhausts**

**Fuel Filler Tubes**

**Heat Exchangers**



Cleveland-Cliffs **436L ULTRA FORM<sup>®</sup> STAINLESS STEEL** is a ferritic grade of stainless steel that outperforms Types 409, 430 and 439 in oxidation and corrosion resistance. This product is resistant to stress corrosion cracking (SCC) in the presence of chlorides and has excellent formability. This material is ideally suited to automotive exhaust and other applications where high temperatures or resistance to chlorides in a wet corrosive environment is needed. Applications include fuel filler tubes, heat exchangers and automotive exhaust components.



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## Product Description

Cleveland-Cliffs 436L ULTRA FORM Stainless Steel is a nominal 17% chromium (Cr), titanium (Ti) stabilized alloy with molybdenum (Mo) added to improve crevice and pitting corrosion resistance. The addition of molybdenum enhances pitting resistance when compared to other ferritic materials such as Type 409, Type 430, and Type 439. It is readily welded and resists intergranular corrosion. Its general corrosion resistance is superior to Type 430 and Type 439. It has a higher thermal conductivity and lower coefficient of expansion than Type 304. It is non-hardening when heated over 1000 °F (538 °C).

Composition		(wt %)
Carbon	(C)	0.03 max.
Manganese	(Mn)	1.00 max.
Phosphorus	(P)	0.04 max.
Sulfur	(S)	0.03 max.
Silicon	(Si)	1.00 max.
Chromium	(Cr)	16.0 – 18.0
Molybdenum	(Mo)	0.75 – 1.5
Titanium	(Ti)	0.50 max.

## AVAILABLE FORMS

Cleveland-Cliffs offers 436L ULTRA FORM Stainless Steel in thicknesses from 0.015 – 0.100 in. (0.381 – 2.51 mm). Widths are available up to 48 in. (1219 mm). For other sizes, contact your Cleveland-Cliffs sales representative.

Values shown in this bulletin were established in U.S. customary units. The metric equivalents of U.S. customary units may be approximate.

**TABLE 1 – TYPICAL MECHANICAL PROPERTIES ANNEALED CONDITION**

UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, B
71 (490)	47 (324)	31	78

## OXIDATION RESISTANCE

Cleveland-Cliffs 436L ULTRA FORM Stainless Steel is more resistant to high temperature oxidation than Type 409. This is especially true for temperatures exceeding 1500 °F (816 °C).

## WELDABILITY

This stabilized ferritic stainless steel grade is generally considered to be weldable by common fusion and resistance techniques. Special consideration is required to avoid brittle weld fractures during fabrication, by minimizing discontinuities and maintaining low-weld heat input. American Welding Society (AWS) classification filler wire EC439 Nb may be used for light-gauge, high-temperature service (> 1000 °F), where thermal cycling is expected. ER/EC 309 filler is generally recommended for welds in light-gauge material where high temperatures are not anticipated.

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## Corrosion Resistance

### CORROSION RESISTANCE

Cleveland-Cliffs 436L ULTRA FORM Stainless Steel exhibits superior corrosion resistance in synthetic muffler condensate testing when compared to Type 409, Type 430 and Type 439.

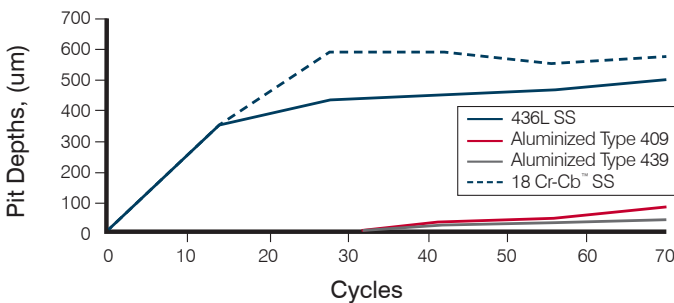
### SALT TEST

When comparing the pitting resistance of various alloys used for automotive exhaust applications, a cyclic 5% sodium chloride exposure is used to mimic road salt exposure experienced during service. Flat sheet samples are heat treated for 1 hr. at 316 °C (600 °F) once per week and then immersed in neutral, sodium chloride solution for 15 mins. followed by 1 hr. 30 mins. ambient air dry. The balance of the 24-hour period is held in a fixed temperature/humidity chamber set at 60 °C (140 °F)/85% RH. This process is repeated five days/week. Samples are removed from test every two weeks, cleaned and pit depth measurements are collected.

**TABLE 2 – SALT CYCLE PIT DEPTH**

Alloy	Pit Depth, (μm)					
	Cycles					
	0	14	28	42	56	70
Cleveland-Cliffs 18 Cr-Cb™ SS	0	357	586	484	554	573
Cleveland-Cliffs 436L SS	0	356	436	454	467	504
Aluminized Type 409	0	0	0	38	52	84
Aluminized Type 439	0	0	0	27	38	46

**FIGURE 1 – SALT CYCLE TEST HEAT TREATMENT 316 °C (600 °F)**



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## Corrosion Resistance

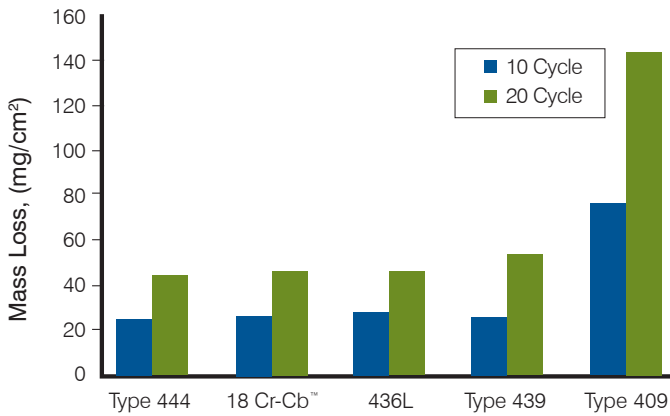
**TABLE 3 – HOT SALT TEST**

Alloy	10 Cycle	
Type 444	25	44
Cleveland-Cliffs 18 Cr-Cb™ SS	26	46
Cleveland-Cliffs 436L SS	28	46
Type 439	26	54
Type 409	76	143

### TEST PROCEDURE

Four-inch by four-inch sheet specimens are exposed to a 5 minute immersion to 5% sodium chloride solution followed by a heat treatment exposure to 677 °C (1250 °F) for 90 minutes. Upon completion of the 90-minute heat treatment the test specimens are water quenched for 1 minute. This salt dip-heat treatment cycle is repeated four times per day with the balance of the day exposed to 60 °C (140 °F)/85% RH. This is equal to four cycles within a 24 hour period. Specimens are removed at 10 and 20 cycles, bead blasted and measured for mass loss.

**FIGURE 2 – HOT SALT CORROSION TEST**



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## Corrosion Resistance

### TEST SETUP:

Partial immersion of 2 x 4 in. (7.6 x 10.2 cm) coupon in synthetic condensate

Test Solution:

- 5,000 ppm SO<sub>4</sub><sup>2-</sup>
- 100 ppm Cl<sup>-</sup>
- 100 ppm NO<sub>3</sub>
- 100 ppm Formic Acid
- Solution pH is adjusted to 3.3 – 3.5 using sulfuric acid by adding approximately 300 – 400 ppm SO<sub>4</sub><sup>2-</sup>

### TEST CYCLE PROCEDURE:

- Heat one-hour at 500 °C (932 °F)
- Humidity exposure for six hours at 60 °C (140 °F)/85% RH
- 16 hours exposed to boiling test solution (boil to dryness)

FIGURE 3

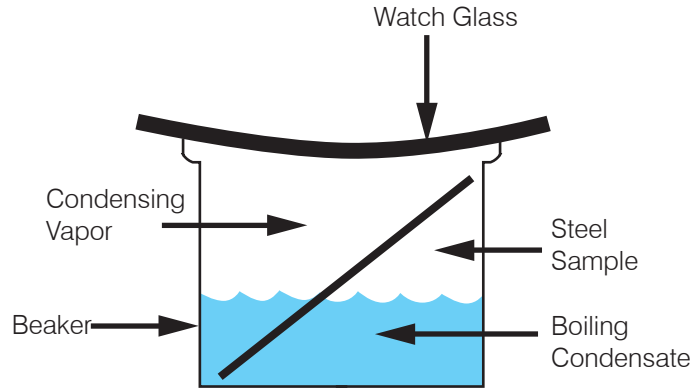
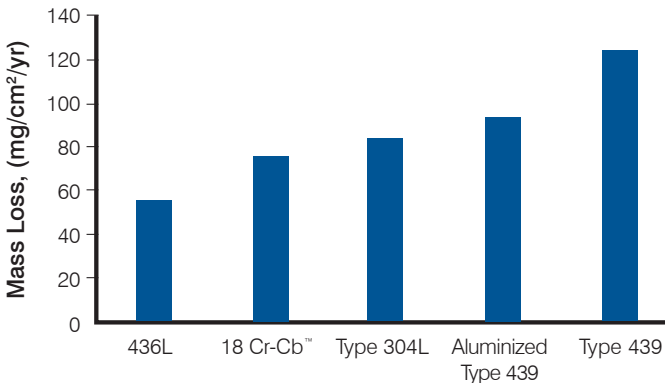


TABLE 4 – MUFLER CONDENSATE MASS LOSS

Alloy	Mass Loss, (mg/cm <sup>2</sup> /yr)
Cleveland-Cliffs 436L SS	56
Cleveland-Cliffs 18 Cr-Cb™ SS	76
Type 304L	84
Aluminized Type 439	94
Type 439	124

FIGURE 4 – MUFLER CONDENSATE MASS LOSS



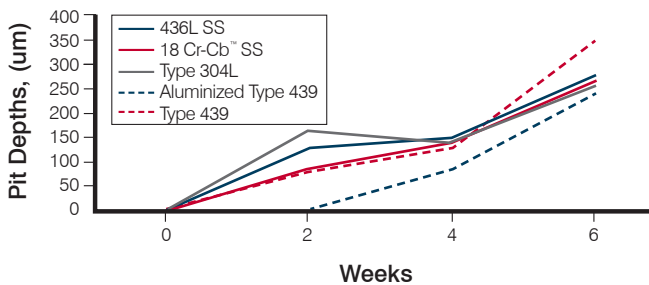
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## Corrosion Resistance

TABLE 5 – MUFLER CONDENSATE PIT DEPTH

Alloy	Pit Depth, ( $\mu\text{m}$ )			
	Weeks			
	0	2	4	6
Cleveland-Cliffs 436L SS	0	125	146	278
Cleveland-Cliffs 18 Cr-Cb SS	0	83	143	266
Type 304L	0	160	142	257
Aluminized Type 439	0	0	81	241
Type 439	0	78	133	348

FIGURE 5 – MUFLER CONDENSATE PIT DEPTH



### About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials and direct reduced iron to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest steel supplier to the automotive industry in North America. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 25,000 people across its mining, steel and downstream manufacturing operations in the United States and Canada.



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