

# Aluminized Steel Type 1 STAINLESS 409 and 439



- Excellent Resistance to Pitting Corrosion from Road Salt
- Excellent Resistance to Muffler Condensate Corrosion
- Red Rust Protection to 800°F (427°C)
- Oxidation Resistance to 1550°F (843°C) (Aluminized 409) and 1700°F (927°C) (Aluminized 439)
- Excellent Formability for Exhaust System Components
- Easier to Post-paint or Coil-coat than Uncoated Stainless



AK Steel's Aluminized 409 and 439 Stainless Steel products have been developed to provide the automotive industry with life-of-the-car exhaust system materials. The Type1 hot dip aluminum coating provides excellent resistance to pitting from muffler condensate and road salt, allowing the exhaust system to resist internal chlorides and retain good external appearance, even at uncoated welds. The aluminum coating significantly extends the life of the exhaust system over that of bare stainless.

# AK STEEL ALUMINIZED STEEL TYPE 1 STAINLESS 409 AND 439

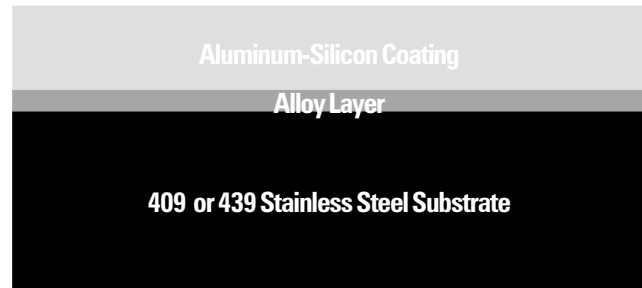
## Coating

The coating is Type 1 Aluminized containing approximately 91% aluminum and 9% silicon that is metallurgically bonded to the stainless steel substrate. The hot dip coating process assures a tightly adherent, uniform coating on both sides of the product. A thin alloy layer readily permits normal forming practices without incurring significant damage to the coating.

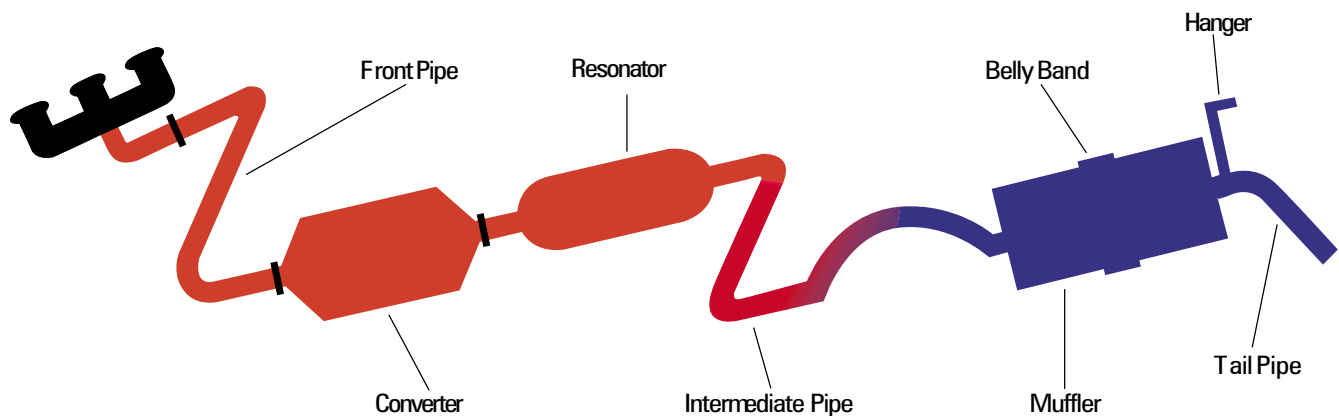
Aluminized Steel Type 1 Stainless 409 and 439 are currently available in a coating weight of 0.25 oz/ft<sup>2</sup> minimum. A schematic of a cross section is shown in Figure 1.

Figure 1

Coating Cross Section



APPLICATIONS FOR ALUMINIZED 409/439

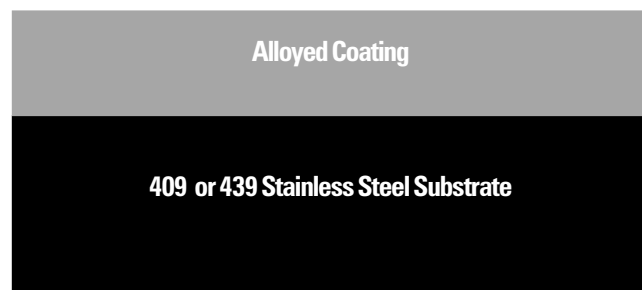


## High Temperature Properties

- Oxidation resistance of the stainless substrate is enhanced by diffusion of the aluminum coating (Figure 2). AL409 is resistant to 1550°F (843°C). AL439 is resistant to 1700°F (927°C).
- At temperatures above 800°F (427°C), the diffused aluminum coating provides long-term resistance to hot salt attack and wet salt pitting in front pipes, converter shells and intermediate pipes. The diffused aluminum coating will take on a dark gray appearance and is subject to cosmetic red rusting.
- Creep and fatigue strength equal to the stainless steel substrate.

Figure 2

Cross Section of Diffused Coating



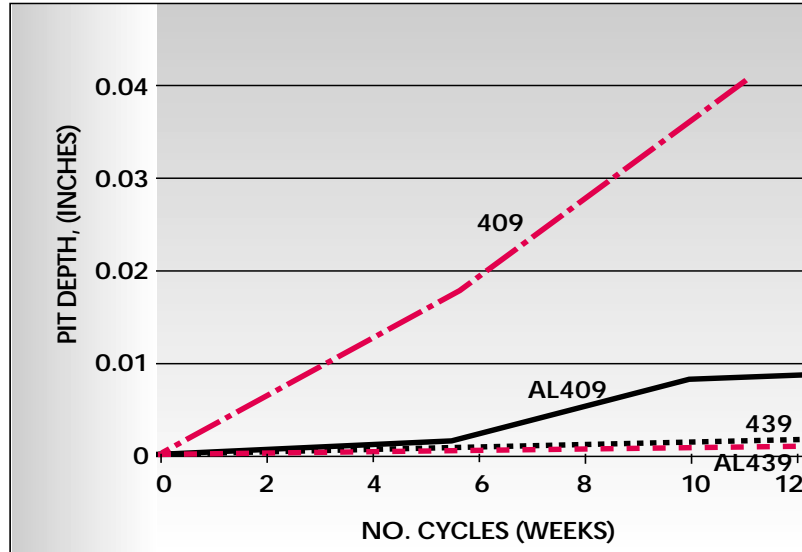
### External Exhaust Salt-Humidity Pitting Corrosion

At relatively low temperatures (e.g. 600°F [316°C]), 409 forms a heat tinted (oxidized) surface and pits readily after exposure to moist salt. The hot dip aluminum coating provides long term galvanic protection against pitting corrosion.

Uncoated 439 is only slightly affected by pitting after 600°F (316°C) exposure, but will form surface red rust due to heat tinting. Aluminized 439 provides long term protection against cosmetic red rusting.

**Figure 3**

Muffler Simulation  
600°F (316°C) HEAT TREAT - BOLD EXPOSURE



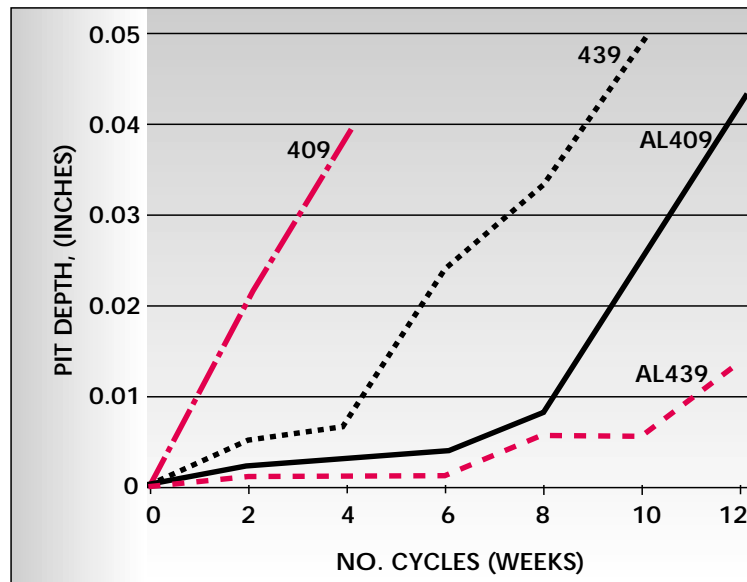
**Figure 4**

I-Pipe Simulation  
800°F (427°C) HEAT TREAT - BOLD EXPOSURE

After 800°F (427°C) heat treatment, the four materials tested all show at least double the pitting rates compared to 600°F (316°C). However, the effects of increased heat tint are much greater for uncoated 439.

Test cycle:

- Sample - 4" by 6" (102mm by 152mm) formed
- Heat 1 hour in air once per week
- Daily dip 15 min - 5% NaCl
- Air dry (75 min.)
- Humidity cabinet - 85% RH, 140°F (60°C) (remainder of day)



**External Exhaust Salt-Humidity  
Pitting Corrosion (continued)**

A 1000°F (538°C) heat treat in the corrosion cycle test fully alloys the aluminum coating with the stainless steel substrate. The lower galvanic potential of the thick alloy coating provides longer term protection against pit initiation. The effects of oxidation plus salt on the higher chromium uncoated grades cause earlier perforation compared to lower temperature testing. In Figure 5, bare 409 shows a shelf in pitting rate and eventually exhibits large weight loss due to development of a loose scale jacket.

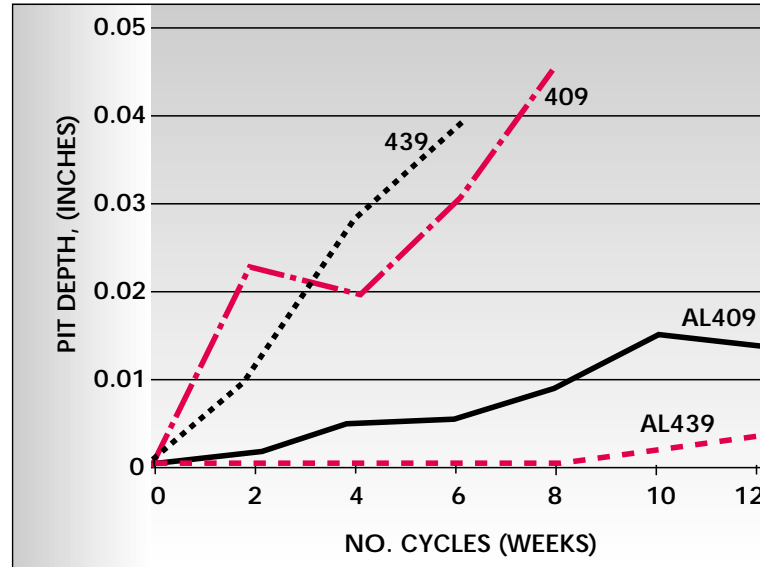
A thinner walled AL439 product can result in improved catalytic converter life and reduced weight compared to bare 409.

Field corrosion data indicate that the 1000°F (538°C) test equivalence is approximately 1 week = 1 year in severe salt climate service. At lower test temperatures the indicated equivalence is more than 1 year.

Because of very rapid pitting rates after 1400°F (760°C) heat treat, the measurement is switched to weight loss. All bare stainless grades tested exhibit similar behavior, while the coated grades continue to benefit from extended galvanic protection by the fully alloyed coating. Salt corrosion of this type is generally associated with salt held on a pipe by insulation or shielding.

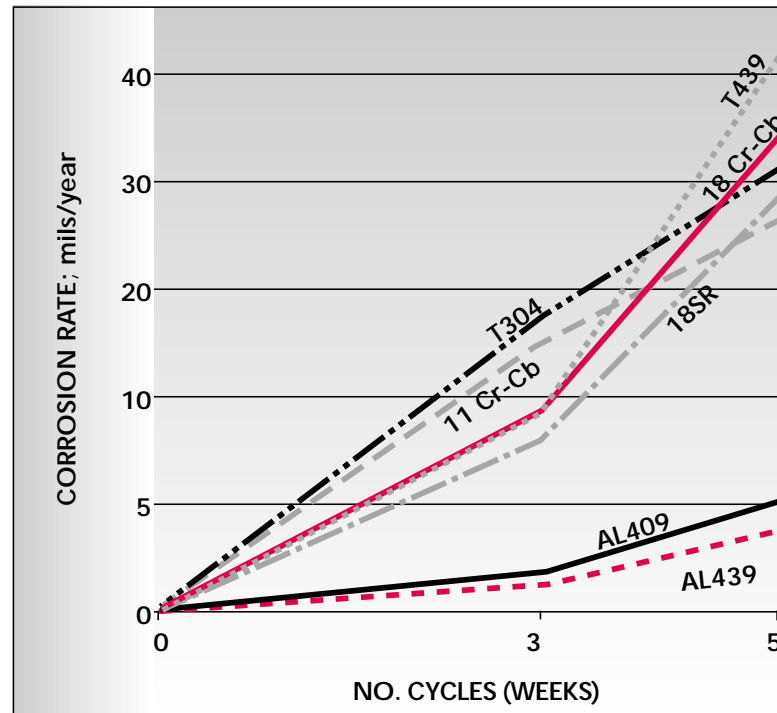
**Figure 5**

Converter Simulation  
1000°F (538°C) HEAT TREAT - BOLD EXPOSURE



**Figure 6**

Front Pipe Simulation  
1400°F (760°C) HEAT TREAT - BOLD EXPOSURE



## Muffler Condensate Corrosion

Aluminized Steel Type 409 and Type 439 are highly resistant to acid condensate pitting. The aluminum coating provides protection against the start of pitting for much of the vehicle life. It galvanically protects against initial converter chloride corrosion at very low pH levels. This protection can be even further extended by avoiding dissimilar material contacts. Figure 7 shows pitting rates in a synthetic condensate boil-down test.

### Daily Test Cycle:

- Partially immerse flat sample in synthetic condensate\* and slowly evaporate to dryness at 194°F (90°C) - approx. 12 – 16 hours
- When dry, heat sample to 482°F (250°C) for 1 hour - Humidity cabinet at 122°F (50°C) 85% RH - approx. 6 hours

### \*Synthetic Condensate:

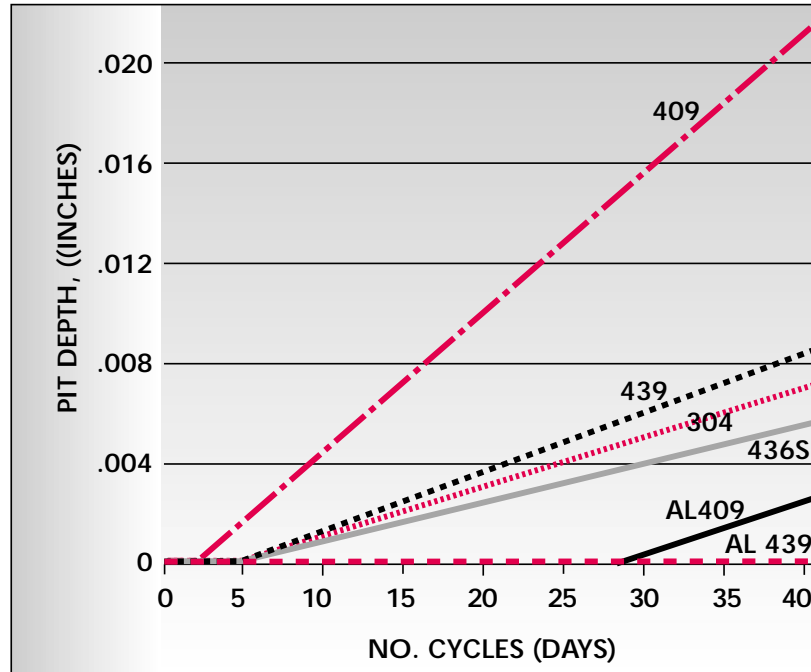
Ammonium salts of Cl<sup>-</sup>(100ppm);  
NO<sub>3</sub>(100ppm); CO<sub>3</sub>(3000ppm);  
SO<sub>4</sub>(5000ppm); initial pH=8.5

## Mechanical Properties

Typical mechanical properties for Aluminized Steel Type 1 Stainless 409 are shown in Table 1. See Table 2 for Aluminized Steel Type 1 Stainless 439.

**Figure 7**

Boiling Beaker Cycle Test for Muffler  
CONDENSATE CORROSION



**Table 1**

Mechanical Properties  
ALUMINIZED 409

Sheet Thickness (Nom.)	0.2% YS		UTS		Avg. % Elong. in 2" (51mm)
	ksi	MPa	ksi	MPa	
.022" to under .030" (.56mm to under .76mm)	43	297	65	448	26
≥.030" (.76mm)	38	262	60	414	32

**Table 2**

Mechanical Properties  
ALUMINIZED 439

Sheet Thickness (Nom.)	0.2% YS		UTS		Avg. % Elong. in 2" (51mm)
	ksi	MPa	ksi	MPa	
.022" to under .030" (.56mm to under .76mm)	48	331	73	504	26
≥.030" (.76mm)	43	297	68	469	32

