Technical Data Sheet

ATI 439™/ ATI 439 HP™/ ATI 430 Ti™

Stainless Steel: Ferritic

(UNS S43035, S43036)

INTRODUCTION

ATI 439™, a titanium stabilized, 18 percent chromium alloy, is also known as ASTM XM-8 and by the UNS designation S43035, is a ferritic stainless steel designed to resist corrosion in a variety of oxidizing environments from fresh water to boiling acids. It may be used in either the annealed, cold formed or as-welded condition in many applications where other stainless steel alloys such as Type 304, Type 410, Type 409 and Type 430 are used. ATI 439™ alloy may also be used in many oxidizing environments where Type 304 is considered adequate in terms of general corrosion resistance but is subject to chloride stress corrosion cracking.

ATI 430 Ti™ (UNS S43036) material is essentially equivalent to type 439 (UNS S43035) material. It is used for heat exchanger tube, etc. ("430Ti" may also refer to UNS K91800, ASTM F256, a controlled expansion alloy for glass-to-metal sealing. ATI Allegheny Ludlum no longer produces the K91800 material.)

The composition of ATI 439™ stainless steel has been balanced to provide a completely ferritic structure at all temperatures, to avoid the loss of ductility after welding and to provide resistance to intergranular corrosion. Similar ferritic stainless steels such as ATI 430 and ATI 434 alloys are susceptible to brittle martensite formation after welding and to intergranular corrosion sensitivity in the as-welded condition. ATI 439™ alloy does not require annealing after welding to restore ductility or to provide intergranular corrosion resistance.

Excellent resistance to stress corrosion cracking, good weldability, high thermal conductivity and low thermal expansion characteristics make ATI 439™ stainless steel an ideal consideration for many applications. For shell and tube heat exchangers where carbon steel shells are used with ATI 439™ tubes, the close match of thermal expansion coefficients may possibly eliminate the need for an expansion joint in the heat exchanger. ATI 439™ alloy has a low cobalt content, compared to Type 304, making it an attractive consideration for nuclear applications.

When aplication temperatures are too high for ATI 409 alloy, ATI 439™ alloy provides good oxidation and corrosion resistance for many automotive exhaust system components and residential furnace primary heat exchangers.

ATI Allegheny Ludlum currently supplies only an improved formability version of this alloy, known as ATI 439HP™. This is especially beneficial for the severe tube bending required for automotive exhaust manifolds.

STRUCTURE

ATI 439™ stainless steel has a ferritic, body-centered cubic crystal structure at all temperatures below the melting point. Angular titanium carbonitride particles occur randomly in the ferritic matrix.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Specifications

ATI 439™ stainless steel (as XM-8 or UNS S43035) is listed in a number of codes and specifications. Among these are:

Pipe and Tubing	Flat Rolled Products	Bar Products
ASTM-A268 ASME-SA268 ASTM-A803	ASTM-A240 ASME-SA240	ASTM-A479 ASME-SA479
ASME Boiler & Pressure Vessel Code Sections I, IV, VIII Division I, and XII		

Welded ATI 439™ tubing is assigned the same allowable stresses as welded Type 430 tubing in ASME Section 8, Division 1, Table UHA 23. Similarly, allowable stresses are the same for both alloys in the bar and seamless tube product forms.

Availability

ATI 439 HP™ stainless steel is available as sheet and strip coil in the annealed condition with widths to 48" and thicknesses to 0.125". Tube or pipe products using ATI 439 HP™ steel are available from tube/pipe manufacturers.

ALLOY DEVELOPMENT

ATI 439™ stainless steel was developed in the 1950s for use in direct-fired hot water heater tanks, an application requiring good weldability and stress corrosion cracking resistance, and was successfully employed in potable waters throughout the United States and Europe. Lower cost immersion heating equipment and glass lined tanks replaced ATI 439™ alloy in the United States, but ATI 439™ continues to be used successfully for direct-fired hot water tanks in Europe. Some early ATI 439™ alloy hot water tanks have documented service histories of 25 years.

The advent of the AOD (Argon Oxygen Decarburization) process has aided the improvement of many stainless alloys, such as ATI 439™, by providing an efficient method to remove carbon and sulfur with minimal losses of chromium. This has helped to improve material properties. ATI 439™ alloy is now used in a wide variety of applications in the power generation, petroleum refining and chemical process industries as heat exchanger tubing, in the residential furnace market, in some small hot water tank applications and automotive exhaust manifolds and mufflers.

The major advantages of this alloy are:

- Excellent resistance to chloride stress corrosion cracking
- Good general corrosion resistance, especially in fresh waters and mildly oxidizing environments
- Weldability
- Long term cost advantages
- High thermal conductivity coefficient
- Low thermal expansion coefficient
- Good continuous and cyclic oxidation resistance.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

TYPICAL COMPOSITION

Element	ASTM A240 ASTM A268 ASTM A479	Typical
	UNS S43035	ATI 439 HP™
Carbon	0.07 max	0.012
Manganese	1.00 max	0.45
Phosphorus	0.04 max	0.020
Sulfur	0.03 max	<0.0010
Silicon	1.00 max	0.55
Chromium	17.00-19.00	17.5
Nickel	0.5 max	0.23
Titanium	.20+4 (C+N) min 1.10 max	0.40
Nitrogen	0.04 max	0.013
Iron	Balance	Balance

ATI 439 HP™ stainless steel meets ASTM A240 chemistry requirements (UNS S43035). Compared to the general T439 specifications shown above, the much lower carbon level of ATI 439 HP™ stainless enhances its formability.

Coefficient of Linear Thermal Expansion

Coefficient of Linear Thermal Expansion			
Temperature Range		Coefficients	
°C	°F	cm/cm·°C	in/in·°F
20-100	68-212	10.2x10-6	5.6x10-6
20-500	68-932	11.6x10-6	6.4x10-6
20-800	68-1472	12.5x10-6	6.9x10-6
20-1000	68-1832	13.6x10-6	7.5x10-6

PHYSICAL PROPERTIES

The thermal expansion coefficients are slightly lower than equivalents for carbon steel and substantially lower than Type 304 and copper-nickel alloy 90-10 (CA 706). The close match between thermal expansion coefficients of carbon steel and ATI 439™ alloy is utilized in some heat exchangers, especially when upgrading tubing from carbon steel to stainless steel.

Thermal Conductivity

Alloy	Temperature		W/m·K	Btu·in/hr·ft2·°F
	°C	°F		
ATI 439 HP™	20-100	68-212	24.2	168.0
Type 304	20-100	68-212	16.3	112.8
Copper Nickel Alloy 90-10 (CA 706)	20-100	68-212	44.6	312.0
Carbon Steel (AISI 1020)	20-100	68-212	51.9	360.0

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

ATI 439™ stainless steel provides good heat transfer performance in most environments. Where raw natural waters are used, ATI 439™ alloy provides heat transfer performances on par with or better than those achieved with many materials with higher coefficients of thermal conductivity because of its corrosion resistance.

Specific Heat

Alloy	°C	°F	J/kg·°K	Btu/lb·°F
ATI 349 HP™	0-100	32-212	460	0.11
ATI 304™	0-100	32-212	500	0.12

Other Physical Properties

	ATI 439 HP™	ATI 304™	Copper-Nickel Alloy 90-10	Carbon Steel
Density lb/in^3 gm/cm^3	0.278 7.695	0.323 8.940	0.323 8.940	0.283 7.830
Electrical Resistivity microhm-cm at 20°C	63	72	19.1	12.5
Modulus of Elasticity* psi x 10^{-6} GPa	29 200	28 190	18 125	30 205

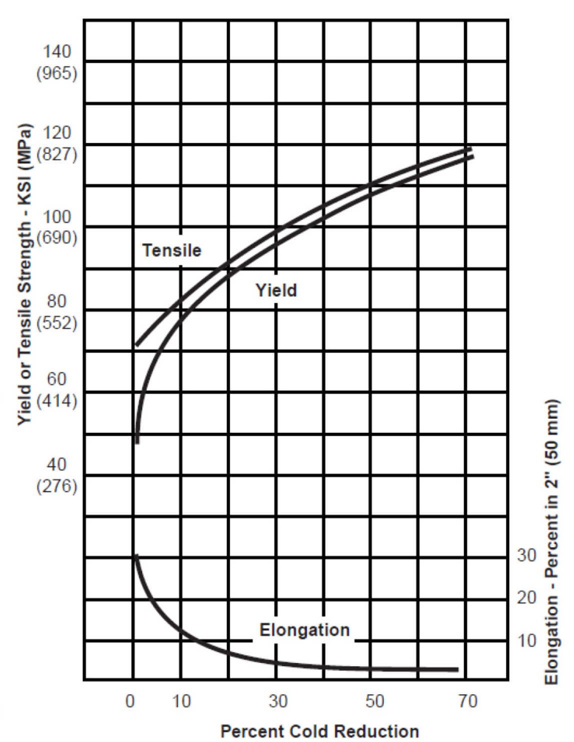
*Important to design of heat exchangers, the higher values combating vibration problems.

Typical Annealed Mechanical Properties

	ATI 439 HP™	Type 304	Copper-Nickel Alloy 90-10	Carbon Steel
Yield Strength psi MPa	42,000 290	40,000 275	16,000 110	43,000 295
Tensile Strength psi MPa	66,000 455	90,000 620	44,000 300	57,000 395
Elongation % in 2" GPa	34	56	40	36
Hardness Rb	78	88	15	63

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

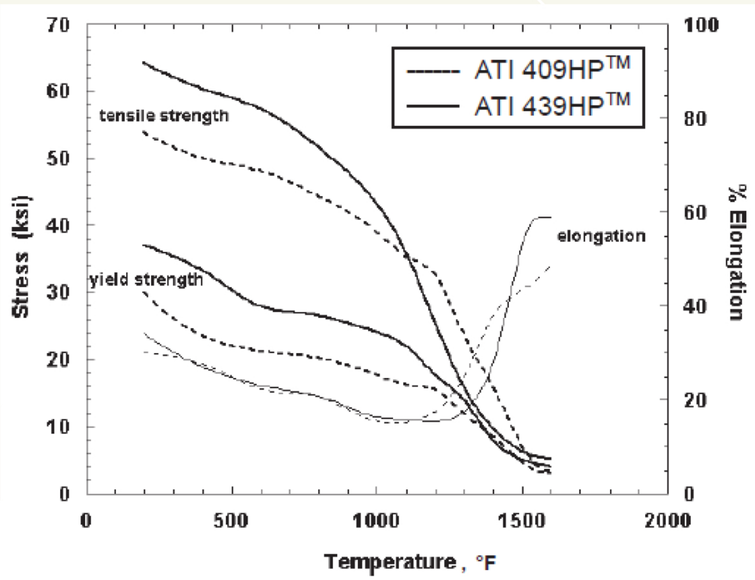
Effect of Cold Forming on ATI 439 HP™ Alloy Tensile Properties



Elevated Temperatures Properties

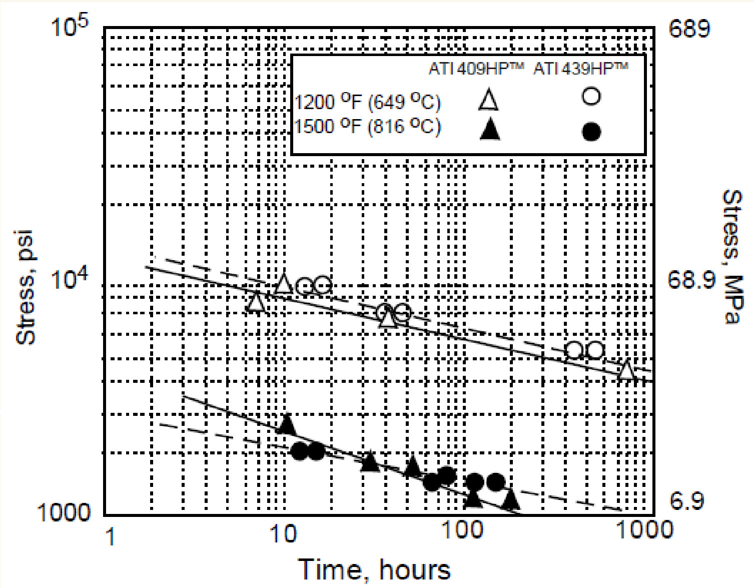
Tensile properties and stress rupture properties are shown in the following figures.

Short Time Tensile Properties

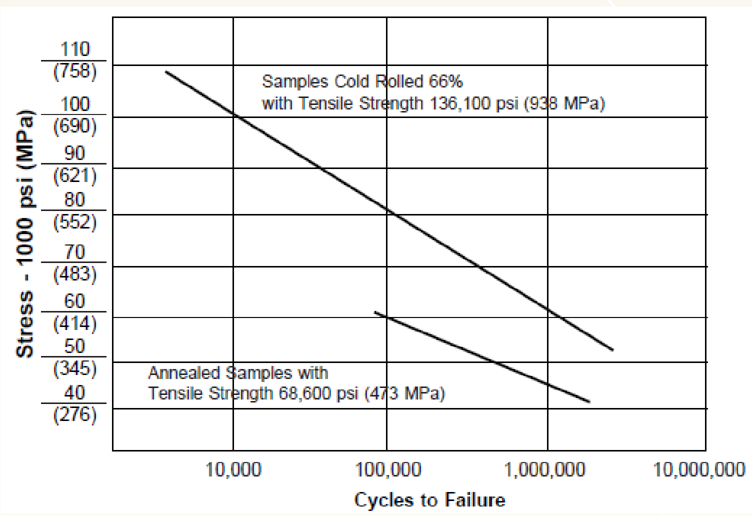


Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Stress Rupture Properties



Fatigue Tests on ATI 439HP™ Strip



Fatigue

Strip samples initially .040" (1 mm) thick were tested as annealed or following 66 percent cold reduction. The endurance limit of the annealed material was 40,000 psi (275 MPa) or slightly over 54 percent of tensile strength. The endurance limit of the cold rolled material was about 51,000 psi (350 MPa), or about 37 percent of tensile strength.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Impact Resistance

ATI 439™ alloy, like other ferritic stainless steels, undergoes a transition from ductile to brittle impact behavior as the test temperature is lowered. The specific temperature at which this transition occurs is dependent on section thickness and prior thermal history. Thin (versus heavy) sections and a fast (versus slow) cool following annealing or welding produce relatively lower transition temperatures.

The typical transition temperature of mill produced products is below normal fabrication and use temperatures indicating that the material is expected to behave in a ductile manner. Typical transition of .100” thick annealed strip is 0°F (-18°C) with .049” strip near – 100°F (-73°C).

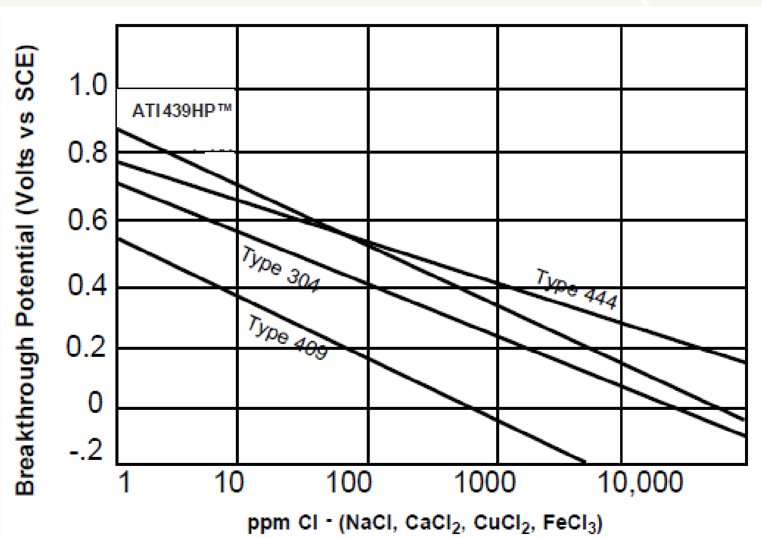
CORROSION RESISTANCE

ATI 439™ alloy is resistant to attack by potable water and many mildly or moderately corrosive chemical environments which are oxidizing in nature. In various chloride solutions, study has shown pitting resistance of ATI 439™ alloy to be superior to that of Type 304. In addition, ATI 439™ alloy is not subject to stress corrosion cracking which may cause premature failure of austenitic steels in chloride bearing environments such as hot waters used in heat exchangers.

Chloride Pitting Corrosion

An extensive program to define the pitting characteristics of ATI 439™ alloy versus other stainless steels were conducted by ATI Allegheny Ludlum. Specimens were exposed to various types and concentrations of chloride solutions and the breakthrough potentials were determined. Sodium, calcium, copper and iron chloride solutions were used in concentrations varying from 10 to 10,000 parts per million (ppm) chloride ion. The results, as shown in the following figure, illustrate the pitting resistance of ATI 439™ alloy and various other stainless steels in a wide range of chloride environments.

Effect of Chloride Concentration on the Breakthrough Potentials of Stainless Steels at Room Temperature



Stress Corrosion Cracking

One of the most important corrosion properties of ATI 439™ alloy is resistance to chloride stress corrosion cracking beyond the capabilities of conventional austenitic grades. This resistance is provided by the ferritic structure and low nickel content of ATI 439™ alloy. Results are equivalent for annealed, U-bent and autogenously welded ATI 439™ alloy.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Typical Chloride Stress Corrosion Test Results in Boiling Solutions

Typical Chloride Stress Corrosion Test Results in Boiling Solutions			
	42% $MgCl_2$	33% LiCl	26% NaCl
ATI 304L™	F (20 hrs.)	F (96 hrs.)	F (744 hrs.)
ATI 316L™	F (21 hrs.)	F (21 hrs.)	R (1000 hrs.)
ATI 439™	R (1000 hrs.)	R (1000 hrs.)	R (1000 hrs.)

Intergranular Corrosion Resistance
Titanium stabilized ATI 439™ alloy resists intergranular corrosion attack as specified in ASTM Procedure A-763, Recommended Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels (see top of next page). In that procedure, Practice Z is applied to ATI 439™ alloy with absence of intergranular fissuring after testing the evaluation criterion. Practice W, oxalic acid etch, is also applied. Photomicrographs are shown in the A-763 procedure for rating by Practice W.

Typical General Corrosion Data

Boiling Solution	Corrosion Rate in Inches Per Month and (Millimeters per year)		
	ATI 409™	ATI 439 HP™	ATI 304™
20% Acetic Acid	0.0101 (3.08)	0.0003 (0.09)	0.00001 (0.003)
65% Nitric Acid	0.0274 (8.35)	0.0020 (0.61)	0.0007 (0.22)
20% Phosphoric Acid	0.0017 (0.52)	0.00002 (0.006)	0.00002 (0.006)
10% Sodium Bisulfate	0.2058 (62.7)	0.00001 (0.003)	0.005 (1.53)
10% Sulfamic Acid	0.2712 (82.7)	0.00008 (0.025)	0.013 (4.0)
10% Oxalic Acid	0.1510 (46.0)	0.18 (55.0)	0.004 (1.22)

Standard ASTM Test Procedures for Intergranular Corrosion Resistance of Ferritic Stainless Steels and Typical Results

Procedure	ATI 430™	ATI 439 HP™
A-763 (1) Practice W	High Carbon Grade may show "ditching" which **Fails**	Step Structure **Pass**
A-763 (2) Practice Z	1 period-24 hrs. Fissures **Fails**	1 period-24 hrs. No Fissures **Pass**

(1) Oxalic acid etch
(2) Cu/CuSO4/16%H2S$_O$4

Automotive Exhaust System Environments
Two corrosion tests designed to simulate automotive exhaust system conditions were used to compare performance of ATI 439™ alloy with that of other ferritic alloys.

A. Exhaust System Condensate Corrosion Tests
This test is designed to simulate effects of condensates which form inside automotive exhaust systems. Samples are placed in a one liter tall form beaker containing 100 ml of a simulated exhaust system condensate consisting of water with:

- 1000 ppm chloride ion
- 2000 ppm carbonate ion
- 3740 ppm ammonium ion
- 5000 ppm sulfate ion
- 100 ppm nitrate ion
- pH 8.7 - 8.9

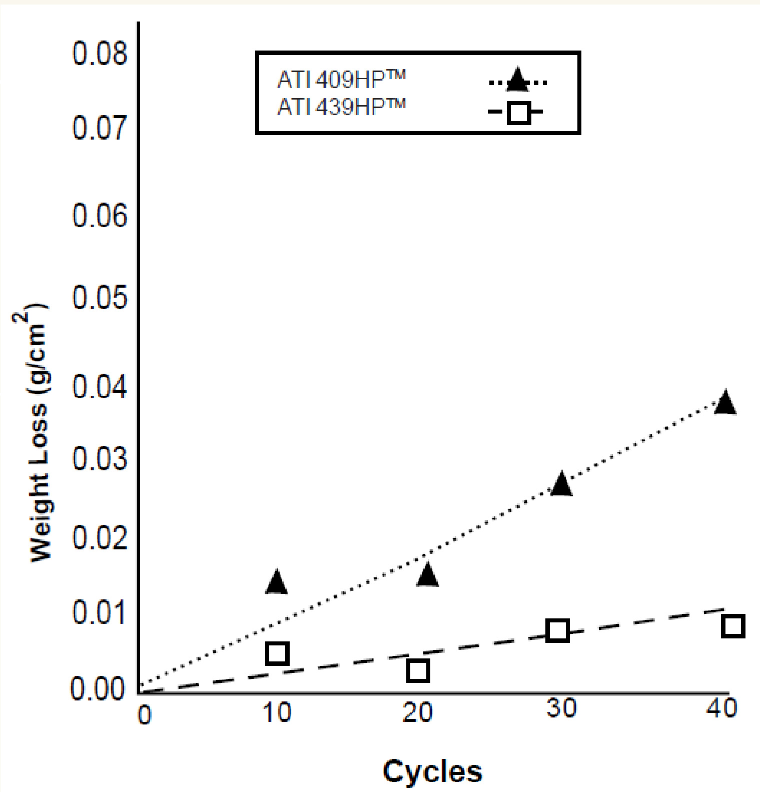
Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

The alloy sample is immersed in the beaker containing solution and then exposed to controlled temperature cycles consisting of

1. heating from ambient temperature to 482°F (250°C) in one hour,
2. holding at 482°F (250°C) for two hours,
3. cooling to ambient temperature in three hours.

Since only a solid residue remains from the original test solution following the six hour test cycle, another 100 ml of test solution is added to the beaker with alloy sample and the cycle is repeated. Samples exposed to 10, 20, 30, 40, etc. cycles are cleaned to bare metal and weighed. Weight loss (corrosion) data for the ATI 439™ alloy are compared to similar data for ATI 409HP™ stainless steel in the following figure.

Cyclic exhaust system condensate corrosion



ATI 439™ alloy (UNS S43035) with its higher chromium content is shown to offer significantly improved corrosion resistance (lower weight loss) than the ATI 409 alloy. Published information emphasizes that chlorides, which may be present on startup of new automobiles or new catalytic convertors due to carryover from catalytic converter manufacture, makes the initial condensate more aggressive than would be expected at normal automotive operating conditions.

Although the test solution is slightly alkaline when introduced into the beaker (pH about 8.8), conditions become more and more acidic with increasing number of cycles, eventually reaching pH 3 after 10 or more cycles. These acid conditions are believed to simulate conditions on the inside of an exhaust system where condensation occurs and which cause corrosion.

Exhaust System Cyclic Oxidation/Corrosion Tests

The outside surface of an automotive exhaust system in use is hot and exposed to air. Resistance to oxidation, also, is important for an exhaust system alloy. Road deicing salts may also come in contact with the exhaust system alloy. Pitting and/or crevice corrosion resistance is also an important characteristic for exhaust system alloys.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

A cyclic oxidation/corrosion test was designed and ATI 439™ alloy and other stainless steels were exposed to this test to provide comparative data. The test consists of heating alloy samples in air at 1200°F (649°C) for one hour followed by natural cooling in air to ambient temperature. The oxidized samples are then exposed per ASTM B117 to a 5 percent salt spray at 95°F (35°C) for 24 hours, to complete the cycle. Weight loss (corrosion) is determined at five cycle intervals. Data for ATI 439HP™ alloy following 100 cycles are compared to similar data for ferritic ATI 409HP™ stainless steels, austenitic stainless steel and ATI 625 nickel alloy below.

The alloys with 18 percent chromium, ATI 439HP™ and ATI 304, experienced less but still significant weight loss than the 11 percent chromium alloy ATI 409HP™. Presence of 2 percent molybdenum in addition to 18 percent chromium in the ATI 444 alloy provided the lowest weight loss (corrosion) of the stainless steels tested. Complete resistance (slight weight gain) was shown by the nickel-base ATI 625 alloy which has excellent resistance to both oxidation and corrosion by chlorides.

OXIDATION RESISTANCE

ATI 439™ alloy provides very good oxidation resistance for many automotive exhaust system components that are too hot for ATI 409. Since oxidation rates are greatly affected by service conditions such as atmospheres, thermal cycling and structural design, laboratory test results should only be used as a guide for estimating service temperature limitations. The following figure compares projected maximum use temperature for ATI 439™ alloy with other exhaust system stainless steels.

Cyclic Oxidation/Corrosion Test Results

Alloy		Typical Composition, Weight Percent			Weight Change (%) Following 100 Test Cycles
		Cr	Mo	Ni	
ATI 409HP™	(UNS S40930)	11	-	-	-57.4
ATI 439HP™	(UNS S43035)	18	-	-	-28.9
ATI 444™	(UNS S44400)	18	2	-	-8.1
ATI 304™	(UNS S30400)	18	-	8	-47.5
ATI 625™	(UNS N06625)	21	9	62	+01

Projected temperature limits are arbitrarily selected at 0.01 g/in² (0.00155 g/cm²) weight gain in 100 hours for continuous oxidation, and 2000 minimum cycles for cyclic oxidation testing.

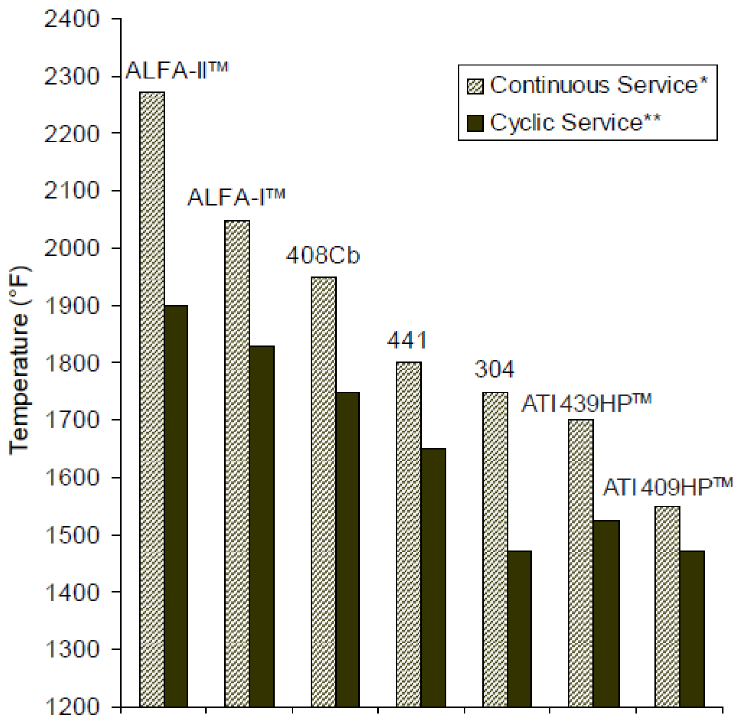
Continuous oxidation tests are conducted in still air and total weight gain measurement procedures are used to determine weight gain.

The cyclic oxidation test procedure consists of repetitively resistance heating 0.002” x 0.250” strip samples to temperature for two minutes and subsequently cooling to room temperature for two minutes in still air. Failure occurs when the 0.002” thick strip oxidizes through and breaks.

The temperature limit for ATI 439™ alloy ranges from 1525°F (829°C) to 1700°F (927°C) depending on the severity of thermal cycling.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Projected Maximum Use Temperature in Still Air Oxidizing Atmospheres



*Continuous Service - 0.01g/m^2, weight gain in 100 hours
**Cyclic Service-2000 cycles, 2 minutes at temperature and 2 minutes cooling.

MACHINEABILITY

The following table shows approximate starting speeds for various machining operations and tool alloys.

Surface Feet Per Minute

Surface Feet Per Minute				
Operation	High Speed Steel	Cast Alloy	Carbide	Feed (in. per rev.)
Turning	92	110	160	.010-.018 rough
Drilling	30-60	-	-	.001-.005 finish cut
Reaming	20-60	-	-	003-.008 (Hole Diameter.065")
Tapping	10-25	-	-	-

For operations not listed, a safe operating speed would be about 60 percent of the speed specified for a similar operation on the free-machining carbon steel grade B- 1112 which is normally used as a standard.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

WELDABILITY

ATI 439™ stainless steel is weldable by the usual stainless steel methods including spot welding, TIG, MIG, laser and high frequency tube welding. Conventional gas shielding is used with the tungsten or metal arc process. If filler wire is added to the weld deposit, a stabilized stainless steel or a nickel base alloy should be considered in order to maintain corrosion resistance in the weld metal. For elevated temperature applications such as automotive exhaust systems, ATI 439 and ATI 444 alloys would be preferred to maintain thermal expansion compatibility.

Properly welded, ATI 439™ alloy retains the corrosion resistance and almost all of the mechanical properties of the base metal in the weld fusion and heat affected zones. Due to the titanium content, the weld metal will be free of the martensite normally associated with the ferritic stainless welds. Further, due to this titanium content, the heat affected zone is resistant to intergranular corrosive attack in environments in which the base metal is satisfactorily used.

Welding this alloy even with adequate gas protection may cause some heat tint or oxidation that should be removed to insure maximum corrosion resistance.

Seal Welding

In applications in which ATI 439™ tubing is seal welded, an austenitic filler is most frequently used. A typical combination is ATI 439™ tubing seal welded to an ATI 600TM tubesheet using a stabilized austenitic weld wire. Intergranular corrosion resistance of the weld joint is best maintained by use of a well stabilized filler material.

FORMABILITY

ATI 439 alloy shares the ferritic structure with ATI 409 stainless and carbon steels, and the mechanical behavior of these materials can be described in similar terms. Parameters extensively used by the automotive industry are the strain hardening exponent, n, the average strain ratio, r-bar, and the forming limit diagram, FLD.

ATI 439HP™ stainless behaves similar to ATI 409HP™alloy in sheet metal forming operations, though it has higher strength. Typical n-values are between 0.21 and 0.26, similar to ATI 409 HP™ alloy, while typical r-bar values are 1.4 to 1.8, slightly higher than in ATI 409 HP™ alloy. The forming limit diagrams of both alloys are very similar. Compared to carbon steels, the FLDs of the two ferritic stainless steels are less sensitive to the material gage.

Roller Expansion and Flaring

ATI 439™ alloy can be roller expanded into tubesheets and headers using equipment and procedures utilized for other tube materials. Strong, tight, leak-free joints are possible without tubesheet distortion in a wide variety of tubesheet materials. Tubes can be flared after rolling to reduce inlet turbulence, although the excellent erosion resistance of this material normally eliminates the necessity of flaring. The outside diameter of the finished flare should be kept within the elongation limitation of the material to prevent excessive flaresplits. Because ferritic stainless steels exhibit lower work hardening and are less stretch formable than familiar austenitic alloys, modest flaring is suggested.

Tube Bending

ATI 439™ tubing is capable of being bent to a minimum bend radius twice that of the tube diameter (2D). The bends do not require stress relieving to maintain resistance to chloride stress corrosion cracking as indicated by the U-bend test results in boiling magnesium chloride shown on page 5.

The ATI 439 HP™ alloy is generally preferred for the very severe tube bending operations required for auto- motive exhaust manifold runners where bend radii are often less than 2D. The ATI 409HP™, ATI 439HP™ and ATI 441 HP™ ferritic stainless steels have been developed by ATI Allegheny Ludlum specifically to enhance tube bending and forming properties. The carefully controlled melting and mill processing of ATI 439 HP™ alloy tube skelp facilitates tighter bends and faster tube bending speeds. Additional benefits are tougher, more ductile welds.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

HEAT TREATMENT

ATI 439™ alloy should be annealed between 1450 and 1600°F (790 and 871°C) and quickly cooled. Cooling rates affect impact transition with slow cooling producing higher, less desirable impact transition.

Ferritic stainless steels containing more than about 12% chromium have a susceptibility to a phenomenon known as 885°F (475°C) embrittlement. This embrittlement is observed as a degradation of impact properties at room temperature resulting from very long exposures in the temperature range of 700 to 1000°F (371 to 537°C).

If service temperatures are cycling through this range, exposure above about 1050°F (565°C) restores the room temperature toughness properties. When there have been long dwell times near 885°F (475°C), service temperatures that cycle above about 1050°F (565°C) are beneficial rather than detrimental.

POTENTIAL APPLICATIONS

The unique blend of properties of ATI 439™ stainless steel make it a desirable choice for many applications. It has been used with 25 years of documented service in hot water tank applications requiring good overall corrosion resistance, resistance to stress corrosion cracking and good weldability. The alloy's oxidation resistance permits its use in residential furnaces and automotive exhaust system components. ATI 439™ alloy corrosion resistance, fabricability and reflective color compatibility have resulted in its use as small diameter tube to replace solid wire spokes in automotive wheelcover applications. The alloy has replaced carbon steel heat exchanger tubes without expansion joints because of its low coefficient of thermal expansion. ATI 439™ alloy higher thermal conductivity, compared to conventional stainless steel, has resulted in its choice over Type 304 in a number of feedwater heater applications.

The successful application of any alloy is dependent upon many variables. It is important to consider these carefully before selecting any material, including ATI 439™ stainless steel.

REFERENCES FOR ADDITIONAL DETAILS ON ATI 439™ STAINLESS STEEL

New Ferritic Stainless Steel Tube for Heat Exchangers
H. E. Deverell and Jack R. Maurer
POWER ENGINEERING, August 1980, pp. 70-72

Sensitivity Study to Evaluate Condenser Replacement Alternative and Effects on Plant Performance
J. H. Phillips and P. B. Corson
EPRI Symposium on State-of-the Art Condenser Tubing, Orlando, Florida, June 1983

Relative Critical Potentials for Pitting Corrosion of Some Stainless Steels
M. J. Johnson
Localized Corrosion - Cause of Failure, ASTM STP 516, 1972, pp. 262-272

The 885°F (475°C) Embrittlement of Ferritic Stainless Steels
P. J. Grobner
METALLURGICAL TRANSACTIONS, Vol. 4, January 1973, pp. 251-260

Stainless Steel for Portable Water Service
M. J. Johnson and J. P. Ziemianski
NACE CORROSION/75, Toronto, Ontario, Paper No. 25, April 1975

Development Contribution to Compact Condenser Design
E. L. Lustenader and F. W. Staub
Inco Power Conference, May 1964, Wrightsville Beach, North Carolina

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

Alloy Selection Considerations and Service Experience of the First "In-Service" 439 Stainless Steel Moisture Separator-Reheater Tube Bundles at Kewannee Nuclear Power Plant
J. L. Kratz, P. G. Minard and D. E. Weinberg
1982 Joint Power Generation Conference, Denver, Colorado, Paper No. 9, October 1982

A Study of Scaling and Corrosion in Condenser Tubes Exposed to River Water
R. A. McAllister, D. H. Eastham, N. A. Dougherty and M. Hollier
CORROSION, Vol. 17, No. 12, pp. 579t-588t, December 1961

Corrosion Analysis of 439 Stainless Steel Integrally-Finned Tubes for Use in Power Plant Condensate
J. L. Kratz, A. Madeyski, F. W. Pement and J. G. Cleary
NACE CORROSION/83, Anaheim, California, Paper No. 132, April 1983

Embrittlement of Ferritic Stainless Steels
T. J. Nichol, A. Datta, and G. Aggen
METALLURGICAL TRANSACTIONS A, Vol. 11A, pp. 573-585, April 1980

Redesign and Replacement of Connecticut Yankee Moisture Separator/Reheater (MSR) Tube Bundles
J. N. Gibson
1981 Joint Power Generation Conference, St. Louis, Missouri, Paper No. 2, October 1981

Stress Corrosion Cracking Resistance of Alternative Reheater Tube Materials
A. Molander and B. Rosborg
Proceedings of the International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors
Myrtle Beach, South Carolina, August 1983

Stabilization of AISI 439 (S43035) Stainless Steel
Harry E. Deverell
Materials Performance, Vol. 24, No. 2, pp. 47-50, February 1985

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com