Technical Data Sheet

ATI 610™/ATI 611™

Stainless Steel: Austenitic

(UNS S30600/ UNS S30601)

GENERAL PROPERTIES

ATI 610™ and ATI 611™ alloys are low-carbon, silicon-containing, austenitic stainless steels. These alloys are typically used for applications in the chemical industry. The high silicon content provides them with very good resistance to oxidizing environments, such as concentrated nitric acid, over a wide range of temperatures. Because of its higher alloy content, ATI 611™ material will be more resistant to highly concentrated (98.5%) nitric acid than ATI 610™ alloy.

TYPICAL COMPOSITION

Table 1 lists the compositions of ATI 610™ (UNS S30600) and ATI 611™ (UNS S30601) material as required by ASTM Standard A240-97A.

Element	ASTM A240 Specification for UNS S30600 (ATI 610™)	ASTM A240 Specification for UNS S30601 (ATI 611™)
C	0.018 max.	0.015 max.
Mn	2.00 max.	0.50 to 0.80
Si	3.70 to 4.30	5.00 to 5.60
P	0.020 max.	0.030 max.
S	0.020 max.	0.013 max.
Cr	17.0 to 18.5	17.0 to 18.0
Ni	14.0 to 15.5	17.0 to 18.0
Cu	0.50 max.	0.35 max.
Fe	Balance	Balance

Table 1 Composition ranges of ATI 610™ and ATI 611™ per ASTM A240.

PHYSICAL PROPERTIES

The density of the ATI 610™ alloy is 0.277 lb/in (7.674 g/cm3).
The density of the ATI 611™ alloy is 0.274 lb/in (7.589 g/cm3).

MECHANICAL PROPERTIES

Typical room temperature mechanical properties of ATI 610™ and ATI 611™ material are shown in Table 2, along with the requirements of ASTM Standard A240-97A for these grades.

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Pittsburgh, PA 15222-5479 U.S.A.
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	0.2%Offset Yield Strength Ksi (MPa)	Ultimate Tensile Strength Ksi (MPa)	Elongation in 2 inches	Rockwell Hardness
Typical ATI 610™ Alloy	46.8 (323)	103 (710)	58%	86 RB
ASTM A240 Specification for UNS S30600	35 min. (240)	78 min. (540)	40% min.	-
Typical ATI 611™ Alloy	52.2 (360)	103 (710)	63%	91 RB
ASTM A240 Specification for UNS S30601	37 min. (255)	78 min. (540)	30% min.	-

Table 2 Typical room temperature mechanical properties of ATI 610™ and ATI 611™ material and requirements of ASTM A240.

Table 3 shows the results of elevated temperature tensile tests performed on ATI 610™ and ATI 611™ specimens.

Temperature		ATI 610™					ATI 611™				
		Yield Stress		Tensile Stress		Elongation 2 in"	Yield Stress		Tensile Stress		Elongation 2 in"
°F	°C	ksi	MPa	ksi	MPa	%	ksi	MPa	ksi	MPa	%
70	21	47	324	103	710	58	52	359	103	710	63
200	93	40	276	92	634	54	45	310	98	676	65
400	204	37	255	82	565	45	38	262	90	621	61
600	316	34	234	79	545	42	34	234	83	572	70
800	427	31	214	76	524	40	34	234	81	558	67
1000	538	30	207	73	503	39	33	228	74	510	55
1200	649	28	193	59	407	61	30	207	63	434	51
1400	760	23	159	34	234	104	22	152	34	234	53
1600	871	12	83	16	110	128	11	76	17	117	137
1800	982	5	35	9	62	120	5	35	9	62	139
2000	1093	2	14	4	28	104	-	-	-	-	-

Table 3 Elevated temperature tensile tests of ATI 610™ and ATI 611™ specimens.

WELDABILITY

ATI 610™ and ATI 611™ alloys are readily weldable by a gas-shielded arc welding procedure, such as gas tungsten arc welding. The use of filler metal having a composition within the range specified for the base alloy is recommended. However, since it is more highly alloyed than ATI 610™ material, ATI 611™ weld wire may also be used as filler metal when welding ATI 610™ material. It is important to minimize any sources of carbon or nitrogen contamination during welding, through good cleaning prior to welding and good shielding during welding. It is also recommended that the heat input during welding be kept low enough to prevent the formation of second phase precipitates, which could lower corrosion resistance. GTA welded tubes have been made from these alloys on the same equipment and using the same procedures as are used for more conventional austenitic grades. Welded constructions using ATI 610™ and ATI 611™ steels are addressed in Code Cases 1953-2 and 2125-1 of the ASME Boiler and Pressure Vessel Code, respectively.

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CORROSION RESISTANCE

Because of their high chromium and silicon contents, ATI 610™ and ATI 611™ alloys are very resistant to oxidizing environments, such as concentrated nitric acid. Table 4 displays the average corrosion rate for each alloy in 98.5%

Alloy	Test Duration	Test Temperature	Average Corrosion Rate	
			MPY	mm/a
ATI 610™	168 hours	68° F (20° C)	0.0094	0.00024
	168 hours	100° F (38° C)	0.291	0.00740
	168 hours	122° F (50° C)	1.229	0.0312
	92.5 hours	180° F (82° C)	15.881	0.403
ATI 611™	168 hours	68° F (20° C)	0.0000	0.0000
	168 hours	100° F (38° C)	0.0091	0.00023
	168 hours	122° F (50° C)	0.0762	0.00193
	92.5 hours	180° F (82° C)	10.461	0.266

Table 4 The average corrosion rate for AL610™ and ATI 611™ alloys in 98.5% nitric acid.

nitric acid. The data shows that, while both alloys have excellent corrosion resistance at 100°F in 98.5% nitric acid, the ATI 611™ alloy performs better at this concentration. At lower concentrations, other alloys may be more appropriate for nitric acid service. For example, Figure 1 shows that an alloy such as Type 304L has superior corrosion resistance at concentrations near 65%.

Additional corrosion data available for ATI 610™ sheet is presented in Table 5.

Both ATI 610™ and ATI 611™ alloys are resistant to Stress Corrosion Cracking (SCC) after 1000 hour exposures in boiling MgCl2 or in boiling acidified NaCl solutions. Be-cause of their low carbon contents, both alloys are also resistant to intergranular corrosion.

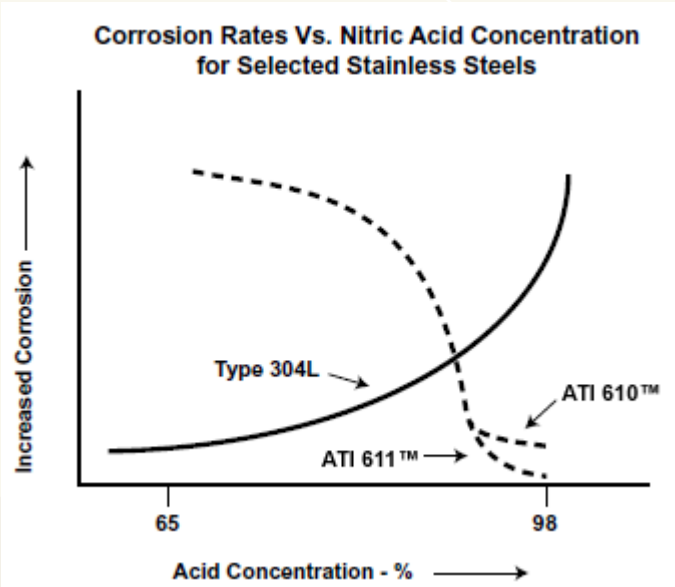

Figure 1 A schematic diagram showing the relative corrosion performance of alloys ATI 610™, ATI 611™ and T 304L as a function of nitric acid concentration.

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Solution*	Average Corrosion Rate	
	MPY	mm/a
Typical ATI 610™ Alloy	32.3	0.82
ASTM A262 Practice C 65% Nitric Acid	16.3	0.41
ASTM A262 Practice E Copper–Copper Sulfate–Sulfuric Acid	3.0	0.08
20% Acetic Acid	0.00	0.00
45% Formic Acid	116.4	2.96
1% Hydrochloric Acid	684.2	17.38
10% Oxalic Acid	267.8	6.80
20% Phosphoric Acid	7.3	0.18

*Concentrations are given in percent by weight. All solutions are boiling

Table 5 Weight change of ATI 610™ and ATI 611™ alloys after 100hours at temperature.

OXIDATION RESISTANCE

The oxidation data summarized in Table 6 and Figure 2 are representative of ATI 610™ and ATI 611™ materials. Specimens prepared from standard mill–finish production material were degreased, cleaned and dried prior to exposure. Specimens were placed in inert ceramic crucibles and exposed in still laboratory air for 100 hours at temperature in a continuous oxidation test. All data reflect the average results from a minimum of two different test specimens. Since oxidation rates are greatly affected by the conditions of actual exposure, the data presented in this publication can only serve as approximate guidelines. Personnel at Allegheny Ludlum's Technical Center can discuss specific applications and environments.

Temperature		Specific Weight change after 100 hours (mg/cm^2)	
°F	°C	ATI 610™	ATI 611™
1200	649	0.0224	-
1300	704	0.0035	-0.0037
1400	760	0.0525	0.0435
1500	816	0.1293	0.1196
1600	871	0.1110	0.1550
1800	982	0.2562	0.3225
2000	1093	-1.0608	0.3922

Table 6 Weight change of ATI 610™ and ATI 611™ alloys after 100hours at temperature.

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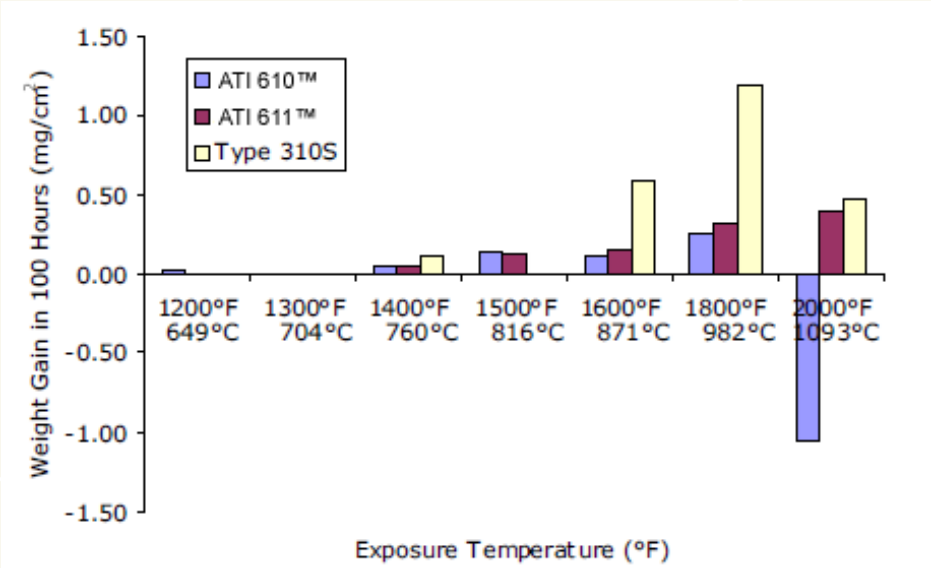

Figure 2 Weight change of ATI 610™ and ATI 611™ alloys compared to that of 310S material after 100 hours at temperature.

Figure 3 is a plot (760°C) for times of weight change as a function of time for ATI 610™ and ATI 611™ at 1300°F (704°C) and 1400°F of up to 3000 hours.

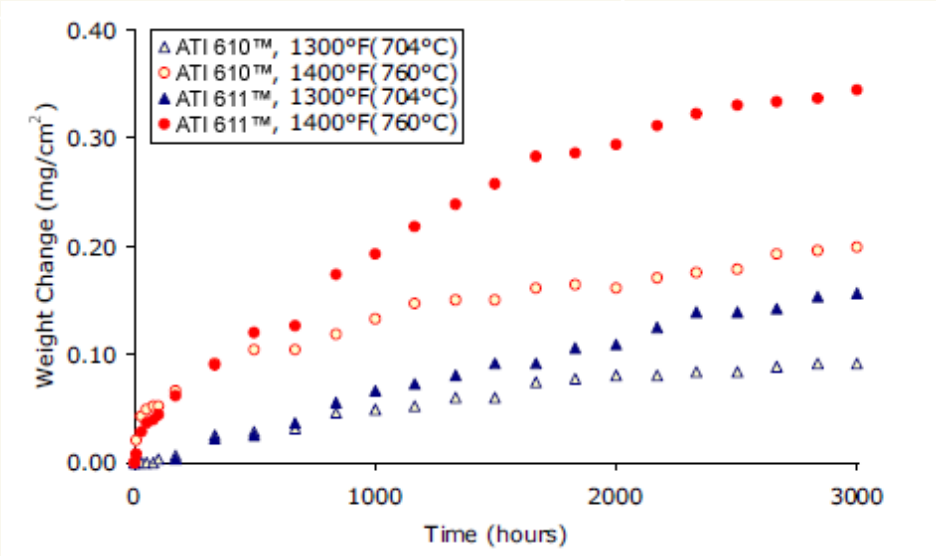

Figure 3 Weight change as a function of time for ATI 610™ and ATI 611™ alloys at 1300°F (704°C) and 1400°F (760°C).

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TYPICAL APPLICATIONS

ATI 610™ and ATI 611™ alloys are generally useful for the fabrication of any item that will be in contact with highly concentrated nitric acid. Typical applications include vessels, heat exchangers, piping, valves, pumps and other items associated with the production and storage of highly concentrated nitric acid.

PRODUCT FORMS

ATI 610™ and ATI 611™ alloys can be produced to plate sizes from 3/16” up to 7/8" x 72" x 240". Sheet and strip are also available.

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