

RECENT DEVELOPMENT OF NEW AUSTENITICS STAINLESS STEELS FOR BRAZILIAN MARKET

RECENTES DESENVOLVIMENTOS DE NOVOS AÇOS INOXIDÁVEIS AUSTENÍTICOS PARA O MERCADO BRASILEIRO

José Antônio Nunes de Carvalho - Researcher – Research Center of ArcelorMittal Inox Brasil

Rodney Santandrea - Researcher – Research Center of ArcelorMittal Inox Brasil

Ricardo Augusto Faria - Researcher – Research Center of ArcelorMittal Inox Brasil

Abstract

In order to supply products for industrial segments like pulp and paper, oil and gas, chemical and high temperature applications, ArcelorMittal Inox Brazil has started to produce last year the stainless steels AISI 310S, 317L and 347/347H.

AISI 310S

This chromium-nickel stainless steel with 25%Cr-19%Ni has very good corrosion resistance at high temperature, and additions of carbon are optimized to improve its creep resistance. This grade is designed for high temperature applications up to 1100 °C in oxidizing atmospheres. The steel can also be used under conditions of slightly oxidizing atmosphere, sulfuring atmosphere, nitriding and carburizing, as well as thermal cycling, although the temperature must be reduced in this case. It is widely used in industry for heat treatment furnace parts, conveyor belts, lining furnaces, fans, etc. In food industry is used in contact with citric acid and heated acetic acid.

AISI 317L

The main characteristic of this molybdenum-bearing alloy (18%Cr, 11%Ni, 3%-4%Mo) is the increased corrosion resistance compared to austenitic chromium-nickel type AISI 304. In addition, the 317L offers the best features of creep resistance and high mechanical strength. The Mo and N content increases the pitting corrosion and crevice resistance, especially in acid environments containing chlorides and sulfur compounds at elevated temperatures. The 317L applications are focused on oil and gas segment, pulp and paper industry, and condensers in power generation facilities based on the fossil and nuclear fuel.

AISI 347 / 347H

With niobium stabilization ($Nb/C > 10$), the austenitic stainless steel 347/347H (17%Cr, 9%Ni, 0,44Nb) gives excellent intergranular corrosion resistance, especially when exposed to a range of temperature in which there are risks of $Cr_{23}C_6$ precipitation (450° - 850°C). AISI347 is recommended for use in corrosive environments and subjected to high temperatures. It's typically used for aeronautical applications, expansion joints and equipments for chemical processes at high temperatures. The 347/347H also finds applications in oil and gas industry, especially refining processes like pipes, fittings or flat plates.

The products so far produced have shown excellent characteristics, surface quality, corrosion resistance and mechanical properties, taking into account international standards requirements. For all kinds of these SS the total production was around 2.000t.

Resumo

Atendendo a demandas de novos aços para os segmentos de papel e celulose, óleo e gás, indústrias químicas e aplicações em altas temperaturas, a ArcelorMittal Inox Brasil iniciou a produção, ao longo do ano de 2009, dos aços inoxidáveis austeníticos AISI 310S, 317H e 347/347H.

As principais características técnicas são mostradas abaixo:

– AISI 310S

O aço inoxidável austenítico AISI310S contém cerca de 25 % Cr, 0,6%Si e 20% Ni. A liga é conhecida por seu comportamento em resistência à corrosão em alta temperatura. As adições do carbono são otimizadas a fim de melhorar sua resistência à fluência. O aço 310S pode ser facilmente soldado. A liga é projetada para aplicações de alta temperatura até 1100°C em atmosferas oxidantes.

O aço pode, também, ser usado em condições de atmosfera ligeiramente oxidante, nitretação, cementação e sulfurante bem como com ciclos térmicos, embora a temperatura deva ser reduzida.

O aço 310S é usado amplamente na indústria de tratamento térmico para partes de forno tais como suporte de refratários, partes dos queimadores, correias transportadoras, forração de forno, ventiladores, etc. na indústria alimentícia, são usados em contato com ácido cítrico e acético aquecidos.

– AISI 317L

O aço inoxidável 317L (18%Cr, 11%Ni, 3%-4%Mo) tem como principal característica a adição de molibdênio em sua composição química o que garante o aumento da resistência à corrosão, quando comparado aos aços austeníticos cromo-níquel do tipo AISI 304.

O aço 317L oferece ainda melhores características de fluência e resistência mecânica elevadas quando comparadas aos aços inoxidáveis convencionais. A combinação de molibdênio e nitrogênio da composição química do aço P317A é particularmente efetiva em aumentar a resistência à corrosão por pites e por frestas, especialmente em meios ácidos contendo cloretos e compostos de enxofre a elevadas temperaturas.

As principais aplicações do aço P317L estão voltadas para a indústria química e petroquímica, nas indústrias produtoras de papel e celulose, e em condensadores de estações geradoras de energia a base de combustível fóssil e nuclear.

– AISI 347 / 347H

Este aço inoxidável austenítico (17%Cr, 9% Ni, 0,44% Nb) é estabilizado ao Nióbio, (Nb/C > 10), que confere excelente resistência à corrosão intergranular, especialmente quando exposto a faixa de temperatura na qual ocorreria a precipitação de carbonetos de Cromo, isto é, de 450 a 850°C. O aço AISI347 é recomendado em ambientes corrosivos e sujeitos às temperaturas elevadas. É o aço típico para aplicações aeronáuticas, juntas de expansão e também para equipamentos de processos químicos em alta temperatura. Também encontra aplicação na indústria petrolífera, especialmente durante o refino, em forma de tubos, conexões ou chapas planas.

Os produtos até agora produzidos tem apresentado excelentes qualidades internas, superficiais e de resistência à corrosão, atendendo, plenamente, a todos os requisitos de normas internacionais. Para estes aços a produção até o momento é da ordem de 2.000 t.

1 – INTRODUCTION

In order to supply products for industrial segments like pulp and paper, oil and gas, chemical and high temperature applications, ArcelorMittal Inox Brazil has started to produce last year the stainless steels AISI 310S, 317L and 347/347H.

2 – MATERIALS

AISI 310S

This chromium-nickel stainless steel with 25%Cr-19%Ni has very good corrosion resistance at high temperature, and additions of carbon are optimized to improve its creep resistance. This grade is designed for high temperature applications up to 1100 °C in oxidizing atmospheres. The steel can also be used under conditions of slightly oxidizing atmosphere, sulfuring atmosphere, nitriding and carburizing, as well as thermal cycling, although the temperature must be reduced in this case. It is widely used in industry for heat treatment furnace parts, conveyor belts, lining furnaces, fans, carburizing boxes, heat exchangers and heat treatment baskets and jigs. In food industry is used in contact with citric acid and heated acetic acid (ASM Specialty Handbook 1994; HANDBOOK OF CORROSION DATA 1995).

ACE P310A is an internal designation from ArcelorMittal Inox Brasil for the development of refractory austenitic stainless steel, which typical chemical composition is presented in Table 1 and microstructure on Figure 1. This designation concerns the dual certification as UNS S31009 (AISI 310H) and UNS S31008 (AISI 310S).

Table 1 – Typical chemical composition (% weight) and physical properties of the grade P310A (ASM Specialty Handbook 1994).

C	Cr	Ni	Si	N	Mn	Others
0.05	25.0	19.0	0.6	0.025	1.5	S < 0.010 P < 0.040

Density (g/cm ³)	8,03
Thermal conductivity (100°C) – (W/m.K)	14
Coefficient of thermal expansion (20-100°C) - (µm/m/°C)	16
Coefficient of thermal expansion (20-500°C) - (µm /m/°C)	17
Coefficient of thermal expansion (20-1000°C) -(µm /m/°C)	19
Elastic modulus at 20°C (GPa)	200

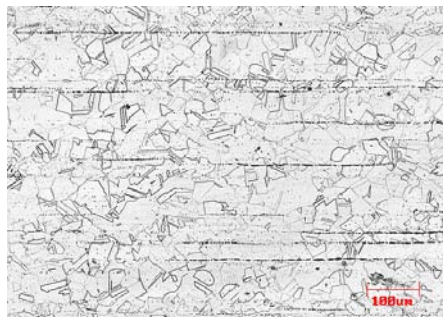


Figure 1 – Microstructure of P310A as hot band (6.00mm thick) (ARCELORMITTAL INOX BRAZIL – Internal Catalog, 2010).

The high chromium content of grade P310A is intended in order to increase the high temperature properties. In terms of corrosion resistance, it also gives a good aqueous corrosion resistance. In high temperature service, P310A exhibits good resistance to oxidizing and carburizing atmospheres.

Grade P310A has good resistance to oxidation at temperatures up to 1040°C in intermittent service in air and 1150°C in continuous one. This grade has good resistance to thermal fatigue and cyclic heating and it is widely used where Sulphur dioxide gas is encountered at elevated temperatures (HANDBOOK OF CORROSION DATA, 1995).

P310A is susceptible to sensitization and hence intergranular corrosion after elevated temperature exposure or welding due to its high carbon content. Although P310A can be subject to stress corrosion cracking, its resistance is higher than AISI 304 and 316 grades.

Continuous use in 450-850°C range is not recommended due to carbide precipitation, if subsequent aqueous corrosion resistance is needed, but it often performs well in temperatures fluctuating above and below this range. P310A grade is generally used at temperatures starting from about 800 or 900°C, above the temperatures at which 304H and 321 are effective.

Table 2 presents the typical mechanical properties of P310A grade at room temperature for longitudinal tensile specimen. The mechanical behavior at high temperature (yield strength and creep resistance) of P310A, compared to AISI 304, is showed on Figure 2,

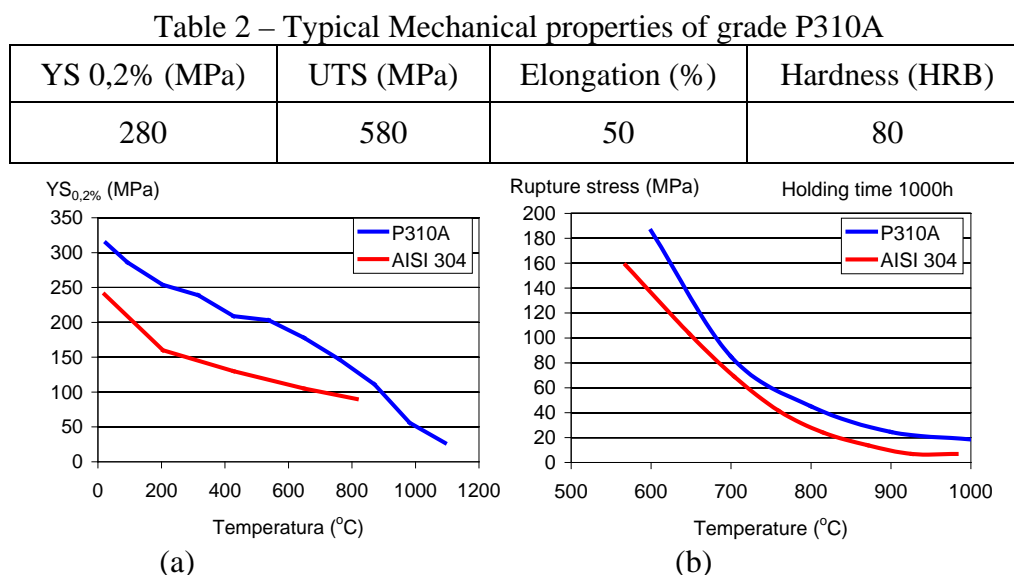


Figure 2 – comparison of mechanical behavior at high temperature between P310A and AISI304. (a) Yield strength, (b) creep resistance (ARCELORMITTAL INOX BRAZIL – Internal Catalog; 2010).

P310A grade presents a good weldability. It is possible to produce welded joints with quite same properties as the parent metal due to the use of similar filler metal. Due to its molten zone is completely austenitic. P310A grade presents higher susceptibility to hot cracking (R.D.Kane and R.G.Taraborelli 1993; A.I.Asphahani and J.L.Nickerson 1992; Swindeman, R. W. 1992).

In order to reduce this risk, P310A grade has very low Phosphorus and Sulphur content and the maximum heat input must be lower than 1.0 k J/mm. The most usual shielding gas is Ar + 2% O₂ or 2 – 3% CO₂ with gas flow around 12 – 16 l/min (A.I.Asphahani and J.L.Nickerson 1992; Swindeman, R. W. 1992).

AISI 317L

The main characteristic of this molybdenum-bearing alloy (18%Cr, 11%Ni, 3%-4%Mo) is the increased corrosion resistance compared to austenitic chromium-nickel type AISI 304. In addition, the 317L offers the best features of creep resistance and high mechanical strength. The Mo and N content increases the pitting corrosion and crevice resistance, especially in acid environments containing chlorides and sulfur compounds at elevated temperatures. The 317L applications are

focused on oil and gas segment, pulp and paper industry and condensers in power generation facilities based on the fossil and nuclear fuel.

The stainless steel 317L differs from others austenitic stainless steels being a molybdenum-bearing alloy with about 3-4%Mo on its chemical composition. Typical composition is shown in Table 3 (ASM Specialty Handbook – Stainless Steels 1994).

Table 3 – Typical AISI 317L Chemical Composition (% weight)

C	Mn	Si	Cr	Ni	Mo	P	S	N
0,03	2,00	0,75	18,00	11,00	3,00	0,04	0,03	0,10
max	max	max	20,00	15,00	4,00	max	max	max

Besides its different chemical composition and corrosion improved behavior, physical properties shown by 317L are very similar to austenitic chromium-nickel stainless steels. It can be found that mechanical properties are also similar but strength and yield values which are slightly higher than AISI 304 type (ASM Specialty Handbook – Stainless Steels 1994).

Table 4 – AISI 317L Physical Properties

Density	8.0 g/cm ³
Young Modulus	200 GPa
Thermal Expansion Coefficient 0°C - 100°C 0°C - 538°C	16.5 µm/m.°C 18.1 µm/m.°C
Thermal Conductivity at 100°C	14.4 W/m.K
Specific Heat	500 J/kg.K
Electrical Resistance	790 nW.m
Melting Range	1375°C – 1400°C

Table 5 – AISI 317L typical Mechanical properties (ASM Specialty Handbook – Stainless Steels 1994).

Mechanical Property	Maximum Strength (MPa)	Yield Strength (MPa)	Elongation (%)	Hardness (HRB)
Typical value	650	330	45	87

The main characteristic of 317L is the corrosion resistance. It can be seen when it's used a number called Pitting Resistance Equivalent Number – PREN, which is an empirical mathematic equation. This equation gives a value based on chromium, molybdenum and nitrogen alloy content. Table 6 shows the PREN for a 316L and 317L. The higher its value, the higher is the corrosion resistance in chloride mediums (Figure 3). The same behavior can be found with crevice corrosion resistance, which is also very good in 317L (NiDI – Nickel Development Institute 1977).

Table 6 – PREN values for AISI 316L and 317L
 $PREN = Cr + 3,3Mo + 30N$ (for austenitic stainless steels)

Element (%)	C	Cr	Ni	Mo	N (ppm)	PREN
316L	0,03	17	10,0	2,0	300	25
317L	003	18	11,5	3,0	600	30

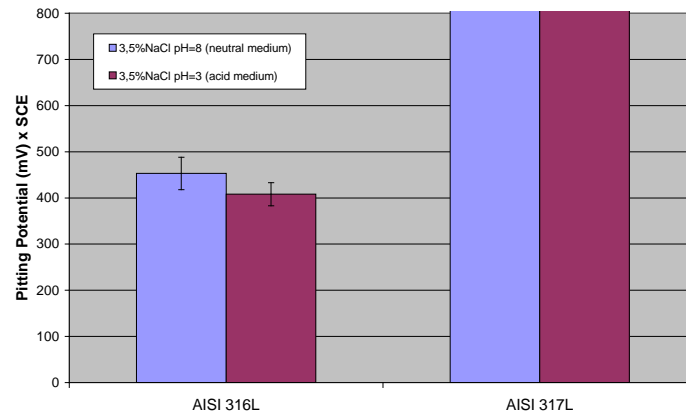


Figure 3 – AISI 316L and AISI 317L Pitting Potential.

AISI 317L values are over the equipment range (over 1000mV) (ARCELORMITTAL INOX BRAZIL – Internal Catalog 2010).

The uniform corrosion of AISI 317L is considered good in many organic and inorganic chemicals media since the corrosion rate shown is less than 0.1 mm/year. The 317L alloy also exhibit good resistance to oxidation and a low rate of scaling in air atmospheres at temperatures about 900°C. With low Carbon content, no problems of intergranular corrosion can be considered.

Besides good corrosion characteristics, 317L is susceptible to stress corrosion cracking (SCC) like all austenitic stainless steels. In other words, when a combination of conditions are found, like tensile stresses, temperatures above 50°C and certain solutions like those containing chlorides, stress corrosion cracking may occur.

The stainless steel 317L is commonly used in Pulp and Paper Industry and also in Petroleum Industry, where aggressive mediums can be easily found. The use of molybdenum-bearing stainless steels for naphthenic acid corrosion (NAC) is a common practice in the refining industry. The use of molybdenum as an alloy element against naphthenic acid environments is not well known since a lot of theories can be found in literature, but all of them considers that Mo stabilizes the stainless steel passive film against organic acids like naphthenic, acetic and formic (QU, D.R. et al.2006; GALLO, G. et EDMONDSON, J. 2008).

As an example of Mo behavior, it was found that a minimum of 2.2% Mo is needed for acceptable corrosion resistance in condensate from boiling acetic acid. A minimum of 2.5% Mo alloy content is commonly used for NAC when condensing conditions do not exist. Since there are many cases of failures of 316L with Mo < 2.5% and with Mo > 2,5% has not failures in NAC services, the use of 3-4%Mo 317L became suitable.

Once Mo has become the key alloy addition for organic acids, including naphthenic acid, it's important to say that besides its good results, Mo bearing stainless steels like 317L should be tested in each industrial condition due to differences found in each plant process and mediums contents.

AISI 347 / 347H

With niobium stabilization (Nb/C > 10), according to table 7, below, the austenitic stainless steel 347/347H (17%Cr, 9%Ni, 0,44Nb) gives excellent intergranular corrosion resistance, especially when exposed to a range of temperature in which there are risks of Cr₂₃C₆ precipitation (450° - 850°C). AISI347 is recommended for use in corrosive environments and subjected to high temperatures. It's typically used for aeronautical applications, expansion joints and equipments for chemical processes at high temperatures. The 347/347H also finds applications in oil and gas

industry, especially refining processes like pipes, fittings or flat plates (ATI Technical Data Blue Sheet 2003).

Type 347 stainless steel is also advantageous for high temperature service because of their good mechanical properties. Type 347 stainless steels offer higher creep and stress rupture properties than Type 304 and, particularly, Type 304L which might also be considered for exposures where sensitization and intergranular corrosion are concerned. This result in higher temperatures allows these stabilized alloys for ASME Boiler and Pressure Vessel Code applications. The Type 347 alloy has maximum use temperature at 850°C for code applications, like Type 304, whereas 304L is limited to 425°C (ATI Technical Data Blue Sheet 2003).

Table 7 – Chemical Composition (% in weight)

C	Mn	Si	Cr	Ni	Nb	P	S
0.08	2.00	0.75	17.00	9.00	10xC min	0.045	0.030
max	max	max	19.00	13.00	1.0% max.	max	max

Note: Also H Grade, with Carbon % 0.04 – 0.10% (ASM Specialty Handbook 1994).

Corrosion Behavior

General Corrosion

Type 347 alloys offer similar resistance to general, overall corrosion as the unstabilized chromium nickel Type 304. Heating for long periods of time in the chromium carbide precipitation range may affect the general resistance of Type 347 in severe corrosive media.

In most environments, both Type 321 and 347 will show similar corrosion resistance; however, Type 321 in the annealed condition is somewhat less resistant to general corrosion in strongly oxidizing environments than annealed Type 347.

For this reason, Type 347 is preferable for aqueous and other low temperature environments. Exposure in the 425 to 850°C temperature range lowers the overall corrosion resistance of Type 321 to a much greater extent than Type 347 (ATI Technical Data Blue Sheet 2003).

Type 347 is used primarily in high temperature applications where high resistance to sensitization is essential, thereby preventing intergranular corrosion at lower temperatures.

Intergranular Corrosion

The Stainless Type 347 has been developed for applications where the unstabilized chromium-nickel steels, such as Type 304, would be susceptible to intergranular corrosion.

When the unstabilized chromium-nickel steels are held in or slowly cooled through the range of 425 to 850°C, chromium carbide is precipitated at the grain boundaries. In the presence of certain strongly corrosive media, these grain boundaries are preferentially attacked, a general weakening of the metal results, and a complete disintegration may occur (ASM Specialty Handbook 1994).

Organic media or weakly corrosive aqueous agents, milk and other dairy products, or atmospheric conditions rarely produce intergranular corrosion even when large amounts of precipitated carbides are present. When thin gage material is welded the time in the temperature range of 425 to 850°C is so short that with most corroding media the unstabilized types are generally satisfactory (ATI Technical Data Blue Sheet 2003).

The high resistance of the stabilized Type 347 stainless steels to sensitization compared with 304, 304L and 321 in the Copper-Copper Sulfate –16% Sulfuric Acid Test (ASTM A262, Practice E) is presented below. Annealed samples were submitted at a sensitizing heat treatment - soaking at 570°C for 48 hours - prior to the test. After that, it was done the Long Term Sensitization heat treatment at 600 °C during 240h. (Table 8).

Table 8 – Intergranular Corrosion Tests – ASTM A262 – Practice E (Long Term Sensitization heat treatment) (ATI Technical Data Blue Sheet 2003).

Alloy	Bend Condition	Rate (mpy)
304	Dissolved	9720,00
304L	IGA	15,60
321	IGA	9,60
347	NO IGA	6,0

The absence of intergranular attack (IGA) in the Type 347 specimens shows that they did not sensitize during this thermal exposure. The low corrosion rate exhibited by the Type 321 shows that even though it suffered some IGA, it was more resistant than Type 304L under these conditions. In general, Types 321 and 347 are used for heavy welded equipment which cannot be annealed and for equipment which is operated between 425 to 850°C or slowly cooled through this range. (ATI Technical Data Blue Sheet 2003).

Stress Corrosion Cracking

The Type 321 and 347 austenitic stainless steels are susceptible to stress corrosion cracking (SCC) in halides similar to Type 304 stainless steel. This results because of their similarity in nickel content. Conditions which cause SCC are: Presence of halide ion (generally chloride) and (2) Residual tensile stresses and (3) Environmental temperatures in excess of about 50°C (ARCELORMITTAL INOX BRAZIL – Internal Catalog 2010).

Stresses may result from cold deformation during forming operations, or from thermal cycles encountered during welding operations. Stress levels may be reduced by annealing or stress-relieving heat treatments following cold deformation. The stabilized Types 321 and 347 alloys are good choices for service in the stress relieved condition in environments which might otherwise cause intergranular corrosion for unstabilized alloys.

The Types 321 and 347 are particularly useful under conditions which cause polythionic acid stress corrosion of non-stabilized austenitic stainless steels, such as 304. On cooling to room temperature in a sulfide-containing environment, the sulfide (often hydrogen sulfide) reacts with moisture and oxygen to form polythionic acids which attack the sensitized grain boundaries.

Under conditions of stress, intergranular cracks form. Polythionic acid SCC has occurred in oil refinery environments where sulfides are common. The stabilized Types 321 and 347 alloys offer a solution to polythionic acids SCC by resisting sensitization during elevated temperature service. For optimum resistance, these alloys should be used in the thermally stabilized condition if service-related conditions may result in sensitization (R.D.Kane and R.G.Taraborelli 1993; ATI Technical Data Blue Sheet 2003; A.I.Asphahani and J.L.Nickerson 1992).

Pitting / Crevice Corrosion

The resistance of the stabilized Types 321 and 347 alloys to pitting and crevice corrosion in the presence of chloride ion is similar to that of Type 304 or 304L stainless steels because of similar chromium content. Generally, 100 ppm chloride in aqueous environments is considered to be the limit for both the unstabilized and the stabilized alloys, particularly if crevices are present.

Higher levels of chloride ion might cause crevice corrosion and pitting. For more severe conditions of higher chloride level, lower pH and/or higher temperature, alloys with molybdenum, such as Type 316 or 316L alloy, should be considered. The stabilized Types 321 and 347 alloys pass the 100 hour, 5 percent neutral salt spray test (ASTM B117) with no rusting or staining of samples. However, exposure of these alloys to salt mists from the ocean would be expected to cause pitting and crevice corrosion accompanied by severe discoloration. (ASM Specialty Handbook 1994).

Physical Properties

The physical properties of Types 321 and 347 are quite similar and may be considered to be the same.

When properly annealed, the Types 321 and 347 stainless steels consist principally of austenite and carbides of Titanium or Niobium. Small amounts of ferrite may or may not be present in the microstructure. Small amounts of sigma phase may form during long time exposure in the 600 to 820°C temperature range.

The stabilized Types 321 and 347 stainless steels are not hardenable by heat treatment.

Typical Physical Properties: (ASM Specialty Handbook 1994)

Density	7.96 g/cm ³
Modulus of Elasticity in Tension	193Gpa
Mean Coef. of Linear Thermal Expansion	
20 – 100 ° C	16.6 x 10 ⁻⁶ cm/cm ° C
20 – 600 ° C	18.9 x 10 ⁻⁶ cm/cm ° C
20 – 1000 ° C	20.5 x 10 ⁻⁶ cm/cm ° C
Thermal Conductivity	
20 – 100 ° C	16.3 W/m. K
20 – 600 ° C	21.4 W/m. K
Specific Heat	
0 – 100 ° C	500 J/Kg.K
Electrical Resistivity	
20 ° C	72 microhm.com
Melting Range	1400 – 1450 ° C

Mechanical Properties

Room Temperature Tensile Properties (ASM Specialty Handbook 1994).

Minimum mechanical properties of the stabilized Types 321 and 347 chromium-nickel grades in the annealed condition 1090°C, air cooled are:

Type	Yield Strengths 0,2% MPa	Ultimate Yield Strength MPa	Elongation % 50,8 mm	Hardness HRb
321	205	515	40	95
347	205	515	40	92

Fabrication

Welding (ARCELORMITTAL INOX BRAZIL Internal Catalog 2010; ATI Technical Data Blue Sheet 2003).

Austenitic stainless steels are considered to be the most weldable of the high-alloy steels and can be welded by all fusion and resistance welding processes.

Two important considerations in producing weld joints in the austenitic stainless steels are:

1) Preservation of corrosion resistance and 2) Avoidance of cracking.

It is important to maintain the level of stabilizing element present in Types 321 and 347 during welding. Type 321 is more prone to loss of titanium. Type 347 is more resistant to loss of Niobium. Care needs to be exercised to avoid pickup of carbon from oils and other sources and nitrogen from air. Weld practices which include attention to cleanliness and good inert gas shielding are recommended for these stabilized grades as well as other non-stabilized austenitic alloys.

Weld metal with a fully austenitic structure is more susceptible to cracking during the welding operation. For this reason, Types 321 and 347 alloys are designed to resolidify with a small amount of ferrite to minimize cracking susceptibility. Niobium stabilized stainless steels are more prone to hot cracking than titanium stabilized stainless steels.

Matching filler metals are available for welding Types 321 and 347 stabilized stainless steels. The Type 347 filler metal is sometimes used to weld the Type 321 alloy.

These stabilized alloys may be joined to other stainless steels or carbon steel. Type 309 (23% Cr-13.5% Ni) or nickel-base filler metals have been used for this purpose.

Heat Treatment (ASM Specialty Handbook 1994; ARCELORMITTAL INOX BRAZIL Internal Catalog 2010 ; ATI Technical Data Blue Sheet 2003).

The annealing temperature range for Types 321 and 347 is 930 to 1100°C. While the primary purpose of annealing is to obtain softness and high ductility, these steels may also be stress relief annealed within the carbide precipitation range 450 to 850°C, without any danger of subsequent intergranular corrosion. Relieving strains by annealing for only a few hours in the 450 to 850°C range will not cause any noticeable lowering in the general corrosion resistance, although prolonged heating within this range does tend to lower the general corrosion resistance to some extent. As emphasized, however, annealing in the 450 to 850°C temperature range does not result in a susceptibility to intergranular attack.

For maximum ductility, the higher annealing range of 950 to 1100°C is recommended.

When fabricating chromium-nickel stainless steel into equipment requiring the maximum protection against carbide precipitation obtainable through use of a stabilized grade, it is essential to recognize that there is a difference between the stabilizing ability of Nb and Ti. For these reasons the degree of stabilization and of resulting protection may be less pronounced when Type 321 is employed.

When heat treatments are done in an oxidizing atmosphere the oxide should be removed after annealing in a descaling solution such as a mixture of nitric and hydrofluoric acids. These acids should be thoroughly rinsed off the surface after cleaning. These alloys cannot be hardened by heat treatment.

Cleaning (ARCELORMITTAL INOX BRAZIL Internal Catalog 2010; ATI Technical Data Blue Sheet 2003).

Despite their corrosion resistance, all these three stainless steels need care in fabrication and during use to maintain their surface appearance even under normal conditions of service.

In welding, inert gas processes are used. Scale or slag that forms from welding processes is removed with a stainless steel wire brush. Carbon steel wire brushes will leave carbon steel particles in the surface which will eventually produce surface rusting. For more severe applications, welded areas should be treated with a repassivation solution such as a mixture of nitric and hydrofluoric acids to remove the heat tint, and these acids should be subsequently washed off.

AISI 347 / 347H Surface Finishing

Number 1 Finish – is hot rolled, annealed and pickled.

It is available for plate and sheet and is used for functional applications where a smooth decorative finish is not important. Only N. 1 finish is available in the range of products produced by ArcelorMittal Inox Brazil.

3 – CONCLUSION

The products so far produced have shown excellent characteristics, surface quality, corrosion resistance and mechanical properties, taking into account international standards requirements. For all kinds of these SS the total production was around 2.000t.

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José Antônio Nunes de Carvalho - Research Center of ArcelorMittal Inox Brasil – Praça 1º Maio 09 – 35.180-018 TIMÓTEO MG – jose-antonio.carvalho@arcelormittal.com.br

Rodney Santandrea - Research Center of ArcelorMittal Inox Brasil – Praça 1º Maio 09 – 35.180-018 TIMÓTEO MG – rodney.santandrea@arcelormittal.com.br

Ricardo Augusto Faria - Research Center of ArcelorMittal Inox Brasil – Praça 1º Maio 09 – 35.180-018 TIMÓTEO MG – ricardo.faria@arcelormittal.com.br