SAF™ 3006
Tube and pipe, seamless
Datasheet

SAF™ 3006 is a high-alloy duplex (austenitic-ferritic) stainless steel optimized for general corrosion resistance, which gives benefits where traditional super duplex grades suffer from high corrosion rates due to general corrosion. The grade is characterized by:

- Excellent resistance to general corrosion in acid and caustic environments
- Excellent resistance to intergranular corrosion
- Excellent resistance to pitting and crevice corrosion
- Good weldability
- Very high mechanical strength

Standards

Material designation

- UNS: S83071

Product standards

- Seamless tube and pipe: ASTM A789, A790

Approvals

- ASME Code Case 2914. Boiler and Pressure Vessel Code, Section VIII, Division I and II
- Pre-approval for Particular Material Appraisal (PMA), TÜV file 1326W221701

Chemical composition (nominal)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	Cu	N
≤0.030	0.20	1.0	≤0.030	≤0.015	30	7	3.2	≤0.80	0.35

Applications

Due to the excellent general corrosion resistance in acid environments and excellent resistance to pitting and crevice corrosion, SAF™ 3006 is suitable to be used in demanding environments, such as acid production plants with or without seawater cooling.

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Corrosion resistance

General corrosion

SAF™ 3006 has high resistance to hydrochloric acid (HCl), which exceeds the resistance of SAF™ 2507 and AISI 904L, see Figure 1.

Figure 1 – Iso-corrosion in hydrochloric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.

The iso-corrosion diagram for SAF™ 3006 in sulfuric acid is presented in Figure 2. SAF™ 3006 has high resistance to sulfuric acid where the corrosion resistance in 40% sulfuric acid is equivalent to AISI 904L and far superior to SAF™ 2507.

Figure 2 - Iso-corrosion in naturally aerated sulfuric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.

SAF™ 3006 has high resistance to organic acids and can sustain 60% boiling formic acid (HCOOH), see Figure 3.

Figure 3 – Iso-corrosion in formic acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.

SAF™ 3006 has, owing to its high chromium content, a very good resistance in caustic environments, such as sodium hydroxide (NaOH) and potassium hydroxide (KOH).

Pitting and crevice corrosion

SAF™ 3006 has a carefully balanced composition with a high content of chromium and nitrogen and a moderate amount of molybdenum. This gives the material a high resistance to localized corrosion induced by chlorides. The PREN-number can be used to compare and rank alloys with respect to the chemical composition and possibility to resist pitting. The PREN is defined as, in weight-%;

PREN = %Cr + 3.3 x %Mo +16 x %N

The critical pitting temperature (CPT) and the critical crevice temperature (CCT) are the temperatures where pitting or crevice corrosion starts to develop on the material. SAF 3006 has excellent resistance to both pitting and crevice corrosion.

The CPT has been determined according to ASTM G48 method E in acidified 6 % ferric solution ($FeCl_3$) and according to ASTM G150 in 1 M sodium chloride (NaCl). The results are presented in Table 1. SAF™ 3006 has a CPT equivalent to SAF™ 2507.

The CCT has been determined according to ASTM G48 method F in acidified 6 % ferric solution ($FeCl_3$) and according to ASTM G150 in 1 M sodium chloride (NaCl). The results are presented in Table 2.

Table 1. CPT values for SAF 3006 compared with SAF™ 2507 and AISI 904L. Tube specimens with the inner and outer surface in delivery condition and the cut ends wet ground with P120 were tested for the ASTM G48 method E test. Coupons with the surface wet ground with P600 were tested for the ASTM G150 test. The applied potential was 700 mV vs. SCE as per ASTM G150.

		CPT (°C)	
Alloy	**PRE (min.)**	**ASTM G48 Method E**	**ASTM G150**
SAF™ 3006	43.5	75	87
SAF™ 2507	42.5	75	85
AISI 904L	32		48

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Table 2. CCT values for SAF 3006. Tube specimens were tested with the inner and outer surface in delivery conditions. The cut ends were wet ground with P120 for the ASTM G48 method F test and with P600 grit paper for the ASTM G150 test. The applied potential was 700 mV vs. SCE as per ASTM G150. Crevice formers according to ISO 18070.

	CCT (°C)	
Torque	**ASTM G48 Method F**	**ASTM G150**
0.28 Nm [1]	55	
2.2 Nm [2]	40	79

[1] Equal to 0.42 MPa crevice pressure according to ISO 18070 calibration curve.
[2] Equal to 3.32 MPa crevice pressure according to ISO 18070 calibration curve.

Fabrication

Bending

The force needed for bending SAF™ 3006 is higher than that for standard austenitic stainless steels which is a natural consequence of the higher yield strength.

Expanding

Compared with austenitic stainless steels, SAF™ 3006 has a higher proof and tensile strength. This must be kept in mind when expanding tubes into tube sheets. Normal methods can be used, but the expansion requires higher initial force and should be undertaken in a one-step operation. As a general rule, tube to tube sheet joints should be welded to ensure a leak free joint.

Machining

Being a dual phase material (austenitic-ferritic) SAF™ 3006 will present a different wear picture from that of a single phase material. The cutting speed must therefore be lower than that recommended for austenitic grades. Further information is available on request.

Forms of supply

SAF™ 3006 is available as seamless heat exchanger tubes. The tubes are supplied in the bright-annealed condition. Please contact Alleima for more information regarding other products.

Heat Treatment

Tubes are delivered in solution annealed condition. If additional heat treatment is needed after further processing, please contact Alleima.

1000-1150 °C (1830-2100°F), rapid cooling in water or by any other means.

Mechanical properties

The mechanical properties are determined for heat exchanger tubes. If SAF™ 3006 is exposed for prolonged periods to temperature ranges exceeding 280 °C (540 °F), the microstructure changes, which results in a reduction in toughness. This does not necessarily affect the behavior of the material at the operating temperature.

At 20 °C (68 °F)

Metric Units

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Proof strength	Tensile strength	Elong.	Hardness	
$R_{p0.2}$ [a)]	R_m	A[b)]	HBW	HRC
MPa	MPa	%		
Min.	Min.	Min.	Max.	Max.
680	830	25	300	32

1 MPa = 1 N/mm^2
a) $R_{p0.2}$ corresponds to 0.2% offset yield strength.
b) Based on $L_0 = 5.65 \sqrt{S_0}$ where L_0 is the original gauge length and S_0 the original cross-section area.

Imperial Units

Proof strength	Tensile strength	Elong.	Hardness	
$R_{p0.2}$ [a)]	R_m	A[b)]	HBW	HRC
ksi	ksi	%		
Min.	Min.	Min.	Max.	Max.
98	120	25	300	32

a) $R_{p0.2}$ corresponds to 0.2% offset yield strength.
b) Based on $L_0 = 5.65 \sqrt{S_0}$ where L_0 is the original gauge length and S_0 the original cross-section area.

At high temperatures

Metric units

Temperature	Proof strength	Tensile strength	Elong.
	$R_{p0.2}$	R_m	A
°C	MPa	MPa	%
	Min.	Min.	Min.
100	540	730	25
200	520	730	25
300	500	730	25

Imperial units

Temperature	Proof strength	Tensile strength	Elong.
	$R_{p0.2}$	R_m	$A_{2"}$
°F	ksi	ksi	%
	Min.	Min.	Min.

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200	78	106	25
400	75	106	25
600	71	106	25

Physical properties

Density: 7.74 g/cm^3, 0.28 lb/in^3

Thermal conductivity

Metric units, °C

Temperature, °C	20	100	200	300	400
W/m °C	12	14	16	18	20

Imperial units, °F

Temperature, °F	68	200	400	600	800
Btu/ft h°F	7	8	9	10	11

Specific heat capacity

Metric units, °C

Temperature, °C	20	100	200	300	400
J/kg °C	470	500	540	570	610

Imperial units, °F

Temperature, °F	68	200	400	600	800
Btu/ft h°F	0.11	0.12	0.13	0.14	0.15

Thermal expansion

SAF™ 3006 is a high-alloy duplex stainless steel and has a coefficient of thermal expansion close to that of carbon steel. This gives SAF™ 3006 definitive design advantages over austenitic stainless steels. The values given in the tables are average values in the temperature ranges.

Metric units, x10^{-6}/°C

Temperature, °C	**30-100**	**30-200**	**30-300**	**30-400**
SAF™ 3006	12.0	12.5	13.0	13.5
Carbon steel	12.5	13.0	13.5	14.0
ASTM 316L	16.5	17.0	17.5	18.0

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Imperial units, x10^{-6}/°F

Temperature, °F	**86-200**	**86-400**	**86-600**	**86-800**
SAF™ 3006	6.5	7.0	7.0	7.5
Carbon steel	7.0	7.0	7.5	8.0
ASTM 316L	9.5	9.5	10.0	10.0

Resistivity

Temperature, °C	**μΩm**	**Temperature, °F**	**mΩinch**
20	0.8	68	0.03

Modulus of elasticity, (x10^3)

Metric units, x10^3/MPa

Temperature, °C	20	100	200	300
MPa	190	185	180	170

Imperial units, x10^3/°C

Temperature, °C	68	200	400	600
ksi	28	27	26	25

Welding

SAF™ 3006 is a high-alloy duplex stainless steel with good weldability. Welding must be carried out without preheating and subsequent heat treatment is normally not necessary. Suitable method of fusion welding is gas tungsten arc welding GTAW/TIG with shielding gas of Ar+2% N2. For tube to tubesheet welding, it is recommended to use Ar+3% N2 as shielding gas to have proper weld metal structure.

For SAF™ 3006, heat input of 0.2-1.5 kJ/mm and interpass temperature of <100 °C (210°F) are recommended.

Recommended filler metals

GTAW/TIG welding

Exaton 29.8.2.L

Contact Alleima for more detailed information concerning welding.

Disclaimer:

Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice. This datasheet is only valid for Alleima materials.