

# SANDVIK SAF 31803™

## TUBE AND PIPE, SEAMLESS

### DATASHEET

Sandvik SAF 31803™ is a duplex (austenitic-ferritic) stainless steel characterized by:

- High resistance to stress corrosion cracking in chloride-bearing environments
- High resistance to stress corrosion cracking in environments containing hydrogen sulphide
- High resistance to general corrosion, pitting, and crevice corrosion
- High resistance to erosion corrosion and corrosion fatigue
- High mechanical strength - roughly twice the proof strength of austenitic stainless steel
- Physical properties that offer design advantages
- Good weldability

#### STANDARDS

- UNS: S31803

#### Product standards

Seamless and welded tube:	ASTM A789
Seamless and welded pipe:	ASTM A790

#### Approvals

- ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 and Div. 2
- NACE MR0175/ISO 15156 (Petroleum and natural gas industries - Materials for use in H<sub>2</sub>S-containing Environments in oil and gas production - Part 1: General principles for selection of cracking-resistant materials Published:2003)
- ASME B31.3 Process Piping

#### CHEMICAL COMPOSITION (NOMINAL) %

##### Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	N
≤0.030	≤1.0	≤2.0	≤0.030	≤0.015	21.5	4.5	2.7	0.16

#### FORMS OF SUPPLY

##### Seamless tube and pipe- finishes and dimensions

Seamless tube and pipe in Sandvik SAF 31803™ is supplied in dimensions up to 260mm outside diameter. The delivery condition is solution annealed and either white pickled or bright annealed.

## MECHANICAL PROPERTIES

The following values apply to material in the solution annealed condition. Tube and pipe with wall thicknesses above 20 mm (0.787 in.) may have slightly lower values.

More detailed information can be supplied on request.

### At 20 °C (68°F)

Tube and pipe with a wall thickness max. 20 mm (0.79 in.)

#### Metric units

Proof strength	Tensile strength	Elong.	Hardness
R <sub>p0.2</sub> <sup>a</sup>	R <sub>m</sub>	A <sub>2</sub> <sup>''</sup>	HRC
≥450	≥620	≥25	≤30

#### Imperial units

Proof strength	Tensile strength	Elong.	Hardness
R <sub>p0.2</sub> <sup>a</sup>	R <sub>m</sub>	A <sub>2</sub> <sup>''</sup>	HRC
ksi	ksi	%	
≥65	90	≥25	≤30

1 MPa = 1 N/mm<sup>2</sup>

a) R<sub>p0.2</sub> corresponds to 0.2% offset yield strength.

### Impact strength

Sandvik SAF 31803™ possesses good impact strength both at room temperature and at low temperatures, as is evident from Figure 1. The values apply for standard Charpy-V specimens (10 x 10 mm, 0.39 x 0.39 in.).

The impact strength of welded Sandvik S31803™ is also good, despite the impact strength values in the as-welded condition being slightly lower than for weld-free material. Tests demonstrate that the impact strength of material, welded by means of gas-shielded arc welding, is good in both the weld metal and the heat-affected zone down to -50°C (-58°F). At this temperature, the impact strength is a minimum of 27 J (20 ft lb). If very high impact strength demands are made on the weld metal at low temperatures, solution annealing is recommended. This restores the impact strength of the weld metal to the same level as that of the parent metal.

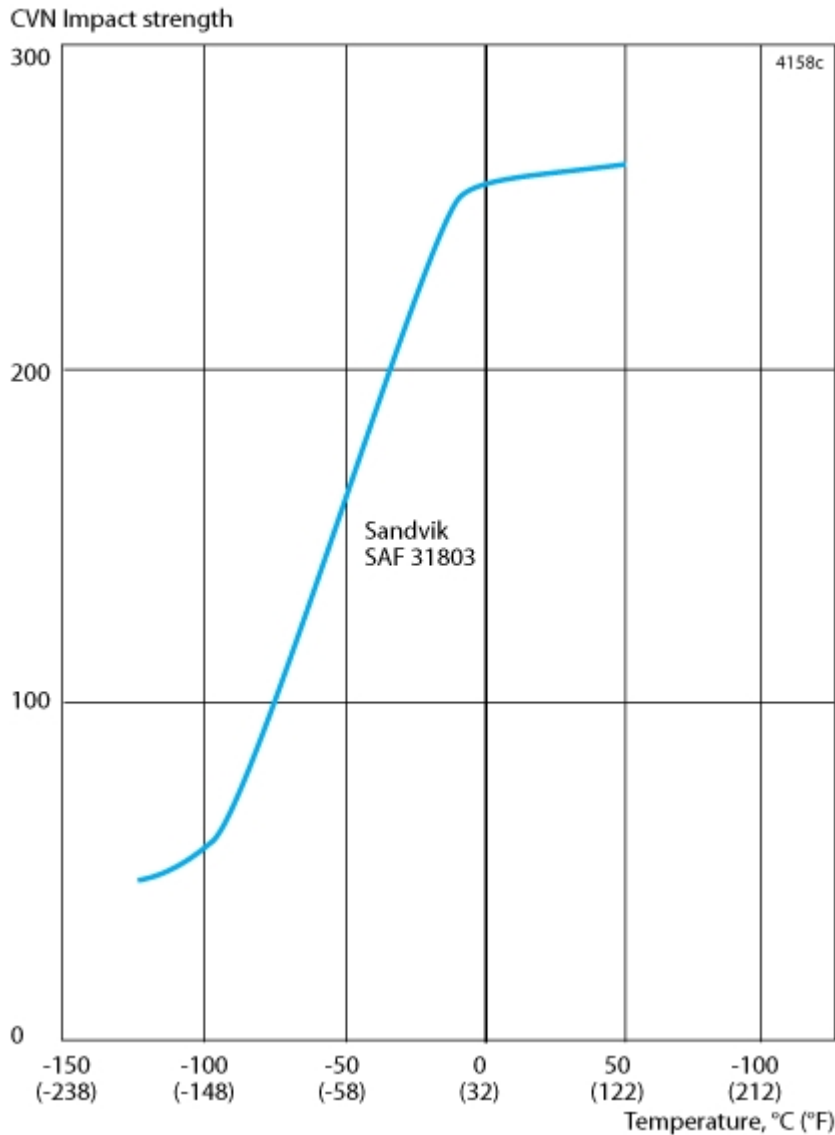


Figure 1. Curve showing typical impact strength values (Charpy-V) for Sandvik SAF 31803. Specimen size 10x10 mm (0.39 x 0.39 in.).

**At high temperatures**

If Sandvik SAF 31803™ is exposed to temperatures exceeding 280°C (540°F), for prolonged periods, the microstructure changes, which results in a reduction in impact strength. This does not necessarily affect the behavior of the material at the operating temperature. For example, heat exchanger tubes can be used at higher temperatures without any problems. Please contact Sandvik for more information. For pressure vessel applications, 280°C (540°F) is required as a maximum according to VdTÜV-Wb 418.

Tube and pipe with wall thickness max. 20 mm (0.79 in.)

**Metric units**

Temperature	Proof strength
	Rp0.2
°C	MPa
	min
50	415
100	360

### Metric units

Temperature	Proof strength
	R <sub>p0.2</sub>
°C	MPa
	min
150	335
200	310
250	295
300	280

### Imperial units

Temperature	Proof strength
	R <sub>p0.2</sub>
°C	ksi
	min
120	60.5
200	53.5
300	48.5
400	45.0
500	42.5
600	40.0

According to ASME B31.3 the following design values are recommended for UNS S31803 (Sandvik S31803™)

Temperature, °F	°C	Stress ksi	MPa
100	38	30.0	207
200	93	30.0	207
300	149	28.9	199
400	204	27.9	192
500	260	27.2	188
600	316	26.9	185

### PHYSICAL PROPERTIES

Density: 7.8 g/cm<sup>3</sup>, 0.28 lb/in<sup>3</sup>

### Specific heat capacity

Temperature, °C	J/(kg °C)	Temperature, °F	Btu/(lb °F)
20	480	68	0.11
100	500	200	0.12
200	530	400	0.13
300	550	600	0.13
400	590	800	0.14

Thermal conductivity

**Metric units**

Temperature, °C	20	100	200	300	400
	W/(m °C)				
Sandvik SAF 31803	14	16	17	19	20
AISI 316L	14	15	17	18	20

**Imperial units**

Temperature, °F	68	200	400	600	800
	Btu/(ft h °F)				
Sandvik SAF 31803	8	9	10	11	12
AISI 316L	8	9	10	10	12

Thermal expansion, mean values in temperature ranges (X10<sup>-6</sup>)

**Metric units**

Temperature, °C	30-100	30-200	30-300	30-400
	Per °C			
Sandvik SAF 31803	13.0	13.5	14.0	14.5
Carbon steel	12.5	13.0	13.5	14.0
AISI 316L	16.5	17.0	17.5	18.0

**Imperial units**

Temperature, °F	86-200	86-400	86-600	86-800
	Per °F			
Sandvik SAF 31803	7.0	7.5	8.0	8.0
Carbon steel	6.8	7.0	7.5	7.8
AISI 316L	9.0	9.5	9.8	10.0

Sandvik SAF 31803™ has a far lower coefficient of thermal expansion than austenitic stainless steels and can therefore offer certain design advantages.

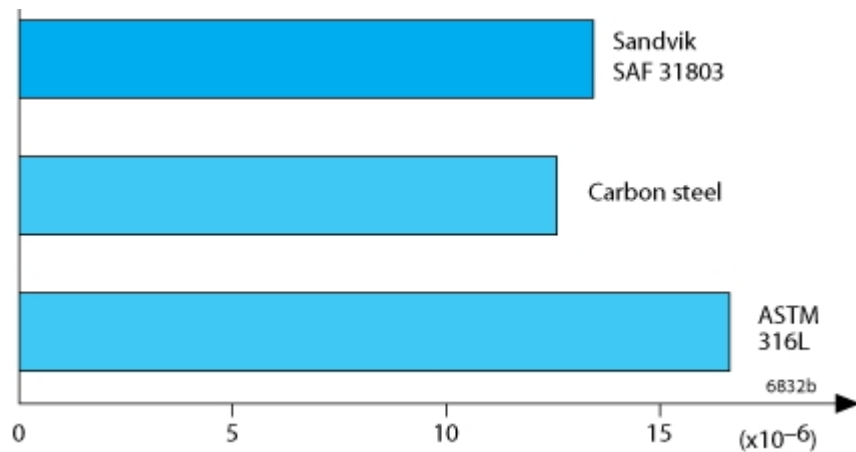


Figure 2. Thermal expansion per °C (30-100°C).

**Resistivity**

Temperature, °C	μΩm	Temperature, °F	μΩin.
20	0.74	68	29.1
100	0.85	200	33.1
200	0.96	400	39.8
300	1.00	600	43.3
400	1.10	800	43.3

**Modulus of elasticity 1)**

Temperature, °C	MPa	Temperature, °F	ksi
20	200	68	29.0
100	194	200	28.2
200	186	400	27.0
300	180	600	26.2

1) (x10<sup>3</sup>)

**CORROSION RESISTANCE**

**Pitting corrosion**

The pitting resistance of a steel is determined primarily by its chromium and molybdenum contents, but also by its nitrogen content and its slag composition and content. The manufacturing and fabrication practices, e.g. welding, are also of vital importance for actual performance in service.

A parameter for comparing the resistance of different steels to pitting, is the PRE number (Pitting Resistance Equivalent). The PRE is defined as, in weight-%:  $PRE = \% Cr + 3.3 \times \% Mo + 16 \times \% N$

The PRE number for Sandvik SAF 31803™ is compared with other materials in the following table:

Alloy	% Cr	% Mo	%N	PRE
Sandvik SAF 2205 a)	22	3.2	0.18	>35
Sandvik SAF 31803	21.5	2.7	0.16	>31
Alloy 825	20	2.6	-	29
AISI 317L	18	3.5	-	30
AISI 316L	17	2.2	-	24

a) Sandvik SAF 2205™ has a chemical composition within UNS S32205, which is optimized within the UNS S31803 range in order to provide a high PRE value.

The ranking given by the PRE number has been confirmed in laboratory tests. This ranking can generally be used to predict the performance of an alloy in chloride containing environments. Because of the high Mo and N contents, the PRE number for Sandvik SAF 2205™ is significantly higher than what would be the case with lower Mo and N contents which are still within the limits of UNS S31803.

Nevertheless, based on practical experience, Sandvik SAF 31803™ can be used at considerably higher temperatures and chloride contents than AISI 304 and AISI 316 without pitting. Sandvik SAF 31803™ is, therefore, far more serviceable in chloride-bearing environments than standard austenitic steels.

**Stress corrosion cracking**

The standard austenitic steels AISI 304L and AISI 316L are prone to stress corrosion cracking (SCC) in chloride-bearing solutions at temperatures above 60 °C (140 °F).

Duplex stainless steels are far less prone to this type of corrosion. Laboratory tests reveal good resistance to stress corrosion cracking of Sandvik SAF 31803™. Results from the tests are presented in Figure 3. The diagram indicates the temperature-chloride range within which Sandvik SAF 31803™ and the standard steels AISI 304L and AISI 316L have low susceptibility to stress corrosion cracking.

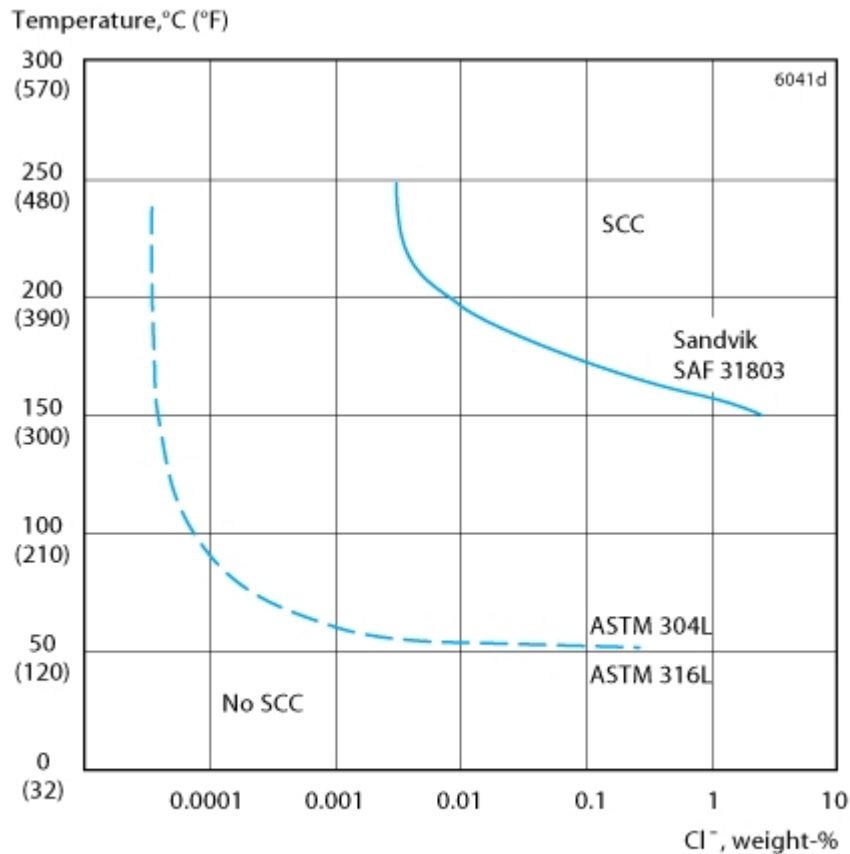


Figure 3. Resistance to stress corrosion cracking (SCC) in neutral chloride solutions with an oxygen content of about 8 ppm. Laboratory results for Sandvik SAF 31803 of constant load specimens loaded to the proof strength at the test temperature.

### HEAT TREATMENT

Tubes are normally delivered in the heat-treated condition. If additional heat treatment is needed due to further processing, the following is recommended.

#### Solution annealing

1020 - 1100 °C (1870-2010 °F), rapid cooling in air or water.

### WELDING

The weldability of Sandvik SAF 31803™ is good. Welding must be carried out without preheating and subsequent heat treatment is normally not necessary. Suitable methods of fusion welding are manual metal-arc welding (MMA/SMAW) and gas-shielded arc welding, with the TIG/GTAW method as first choice.

For Sandvik SAF 31803™, heat input of 0.5-2.5 kJ/mm and interpass temperature of <150°C (300°F) are

recommended.

### Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 14343 S 22 9 3 N L / AWS A5.9 ER2209 (e.g. Exaton 22.8.3.L)

MMA/SMAW welding

ISO 3581 E 22 9 3 N L R / AWS A5.4 E2209-17 (e.g. Exaton 22.9.3.LR)

ISO 3581 E 22 9 3 N L B / AWS A5.4 E2209-15 (e.g. Exaton 22.9.3.LB)

ISO 14343 S 22 9 3 N L / AWS A5.9 ER2209 (e.g. Exaton 22.8.3.L) wire or strip electrodes are recommended for overlay welding of tube sheets and high-pressure vessels in cases where corrosion resistance, equal to that of Sandvik SAF 31803™, is required.

## FABRICATION

### Bending

The starting force needed for bending is slightly higher for Sandvik SAF 31803™ than for standard austenitic grades (ASTM 304L and 316L). Sandvik SAF 31803™ can be cold-bent to 25% deformation without requiring subsequent heat treatment. For pressure vessel applications in Germany and the Nordic countries, heat treatment may be required after cold deformation in accordance with VdTÜV-Wb 418 and NGS 1606.

Under service conditions where the risk of stress corrosion cracking starts to increase, heat treatment is recommended even after moderate cold bending, for example, where the material temperature is nearly 150°C (300°F) in an oxygen-bearing, environment with around 100 ppm Cl<sup>-</sup>.

Heat treatment is carried out in the form of solution annealing (see under Heat treatment) or resistance annealing. Hot bending is carried out at 1100-950°C (2010-1740°F) and should be followed by solution annealing.

### Expanding

Compared with austenitic stainless steels, Sandvik SAF 31803™ has higher proof and a tensile strengths. This must be borne in mind when expanding tubes into tube-sheets. Normal expanding methods can be used, but the expansion requires higher initial force and should be undertaken in one operation.

### Machining

Being a two-phase (austenitic-ferritic) material, Sandvik SAF 31803™ will present a different tool wear profile from that of single phase steels of types ASTM 304/304L and 316/316L. The cutting speed must, therefore, be lower than that recommended for ASTM 304/304L and 316/316L. Built-up edges and chipping are to be expected. It is recommended that a tougher insert grade is used than when machining austenitic stainless steel, e.g. ASTM 304L.

A version with improved machinability, Sanmac® 2205, is available form of bar and hollow bar.

## APPLICATIONS

Due to its excellent corrosion properties, Sandvik SAF 31803™ is a highly suitable material for service in environments containing chlorides and hydrogen sulphide. Sandvik SAF 31803™ is mainly available as heat exchanger tubing and is particularly suitable for heat exchangers where chloride-bearing water or brackish water is used as a cooling medium.

The high strength of Sandvik SAF 31803™ makes the material an attractive alternative to the austenitic steels in structures subjected to heavy loads.

The good mechanical and corrosion properties make Sandvik SAF 31803™ an economical choice in many



applications by reducing the life cycle cost of equipment.

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**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 Sandvik materials.