SANDVIK

SAF 3207 HD™
TUBE AND PIPE, SEAMLESS

DATASHEET

SAF 3207 HD™ is a hyper-duplex (austenitic-ferritic) stainless steel for service in highly corrosive conditions where also high mechanical strength is necessary. This makes the grade ideal for applications such as deepwater umbilicals. SAF 3207 HD™ is characterized by:

- Excellent resistance to pitting and crevice corrosion
- Excellent resistance to stress corrosion cracking (SCC) in hydrogen sulphide (H_2S) and chloride containing environments
- High resistance to general corrosion in acidic and caustic environments
- Excellent resistance to erosion corrosion
- Excellent corrosion fatigue properties
- Exceptionally high mechanical strength
- Exceptionally high fatigue strength
- Physical properties that offer design advantages
- Good weldability

STANDARDS

- UNS: S33207

Product standards

Seamless tube and pipe: ASTM A789; A790

CHEMICAL COMPOSITION (NOMINAL)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo
≤0.030	≤0.8	≤1.5	≤0.035	≤0.010	32	7	3.5

Others
N=0.5

APPLICATIONS

SAF 3207 HD™ hyper-duplex steel has been developed for deepwater umbilicals; an application with extreme requirements on pitting and crevice corrosion resistance, mechanical strength and fatigue properties.

Offering greater yield strength, greater corrosion resistance and superior fatigue properties compared with super-duplex steels, SAF 3207 HD™ hyper-duplex steel is also an excellent material choice for a range of other oil and gas applications. For example, when resistance to hydrogen sulfide (H_2S) is a requirement, such as in raw seawater injection, control lines and chemical injection lines, SAF 3207 HD™ offers high reliability and operational safety leading to lower operating costs.

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CORROSION RESISTANCE

General corrosion

SAF 3207 HD™ is highly resistant to corrosion by organic acids, e.g. formic acid and acetic acid, see Figure 4.

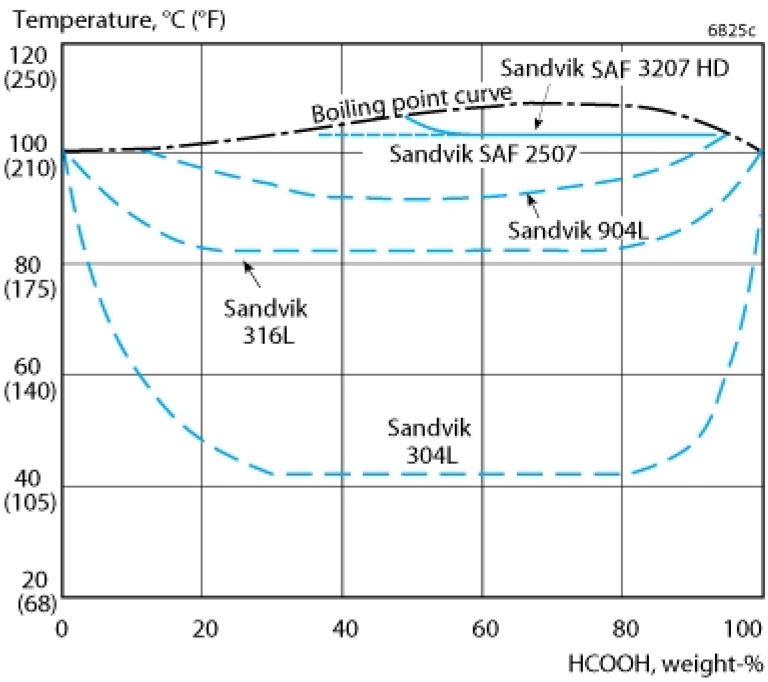

Figure 4. Isocorrosion diagram in formic acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

Resistance to inorganic acids is comparable to, or even better than that of high alloy austenitic stainless steels in certain concentration ranges. Figures 5 and 6 show isocorrosion diagrams for sulfuric acid and hydrochloric acid, respectively.

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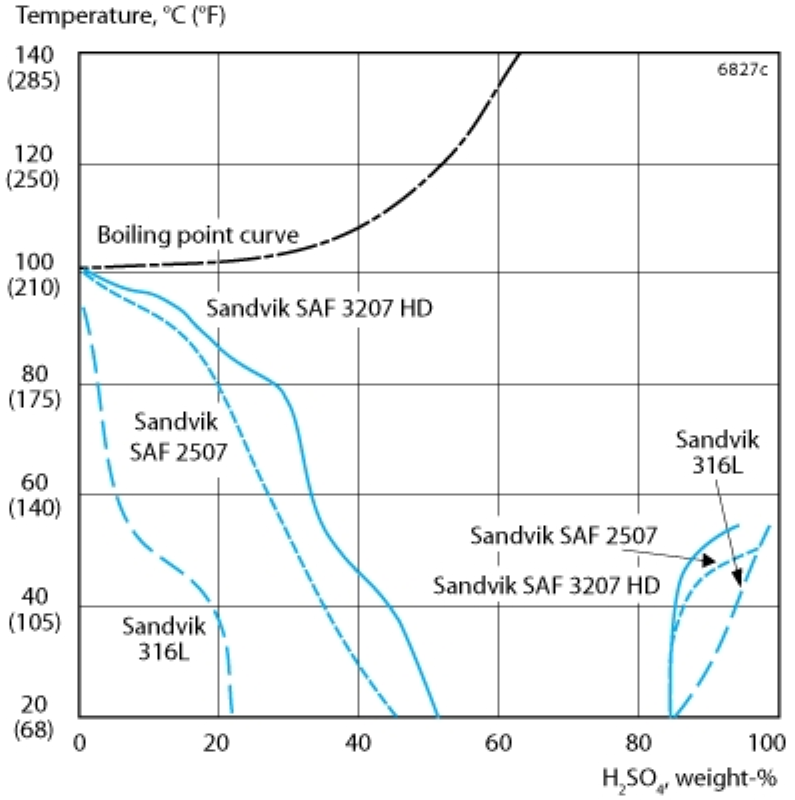

Figure 5. Isocorrosion diagram in sulphuric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

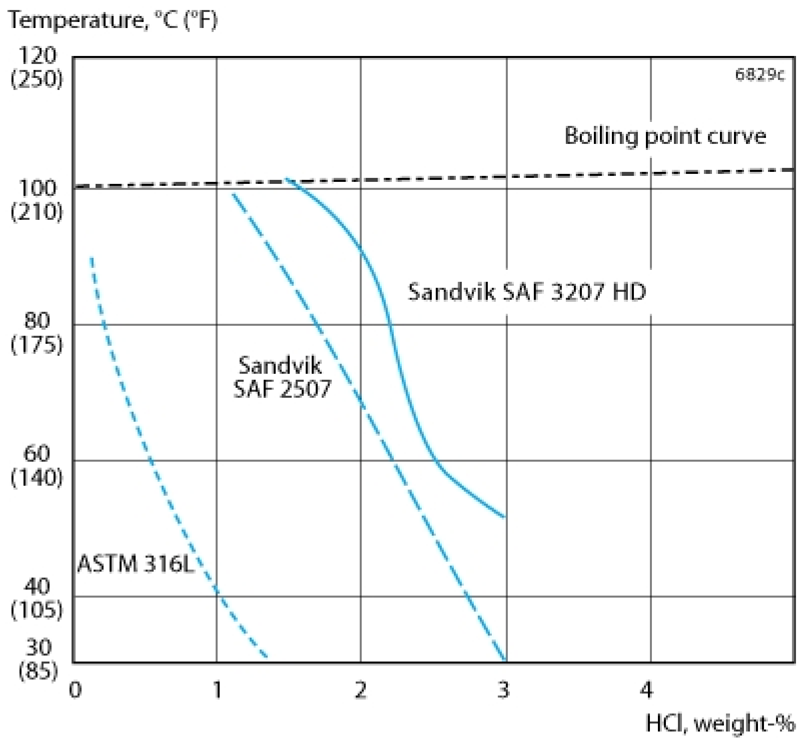

Figure 6. Isocorrosion diagram in hydrochloric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

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Pitting and crevice corrosion

The pitting and crevice corrosion resistance of stainless steel is primarily determined by the content of chromium, molybdenum and nitrogen. The manufacturing and fabrication practice, e.g. welding, are also of vital importance for the actual performance in service. A parameter for comparing the resistance to pitting in chloride environments is the PRE number (Pitting Resistance Equivalent).

The PRE is defined as, in weight-%
PRE = %Cr + 3.3 x %Mo + 16 x %N
The minimum PRE-value for SAF 3207 HD is 50.

One of the most severe pitting corrosion tests, applied to stainless steels, is ASTM G48 i.e. exposure to 6% $FeCl_3$. In a modified version of the ASTM G48A test, the sample is exposed for periods of 24 hours. When pits are detected, together with a substantial weight loss (> 5 mg), the test is interrupted. Otherwise, the temperature is increased by 5°C (9°F) and the test continued with the same sample.

The crevice corrosion test was performed in 6% $FeCl_3$, with a crevice specified in the MTI-2 procedure, where an artificial crevice is mounted on the sample with a torque of 0.28 Nm. The values obtained and comparisons with SAF 2507® are given in Figure 7. SAF 3207 HD™ performs better than SAF 2507®.

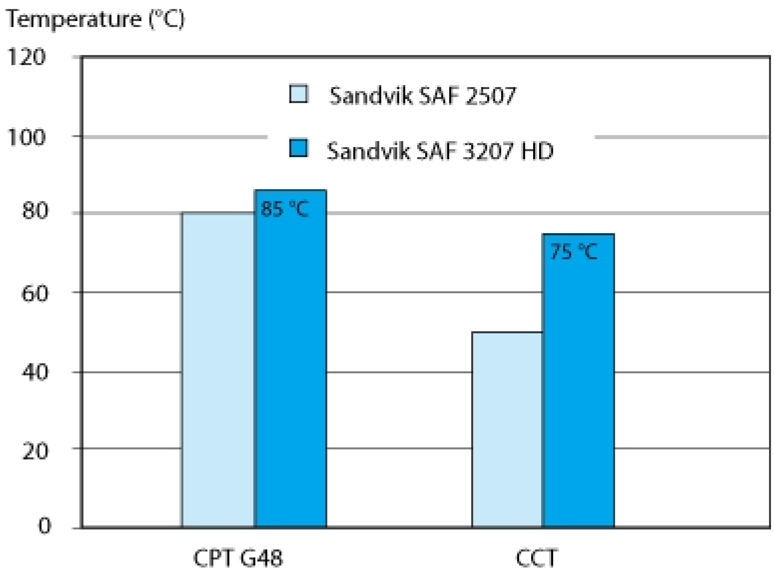


Figure 7. Critical pitting temperature measured in modified G48A, starting temperature 55°C. Critical crevice corrosion temperature obtained in testing with a crevice specified in the MTI-2 testing.

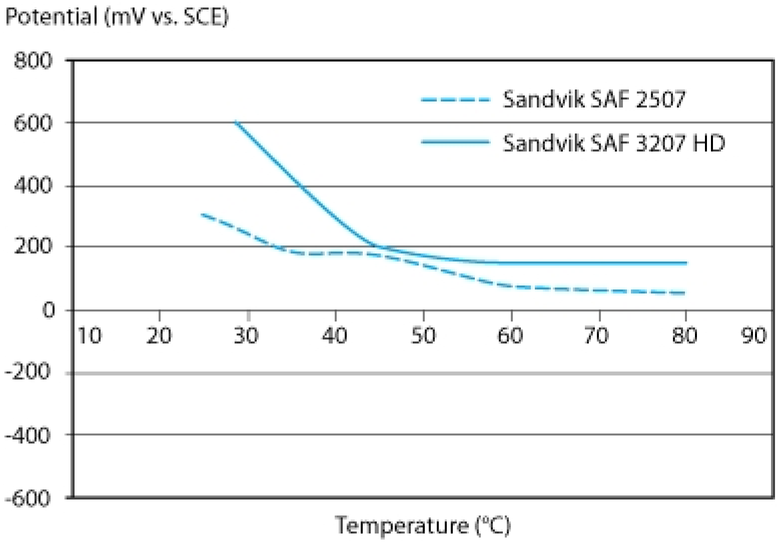


Figure 8: Design curve for butt welded Sandvik SAF 3207 HD and Sandvik SAF 2507 showing initiation of crevice corrosion in seawater versus potential and temperature.

FABRICATION

Machining

Being a dual phase material (austenitic-ferritic), SAF 3207 HD™ will present a different tool wear profile from that of austenitic stainless steels.

The cutting data (speed and feed) must, therefore, be lower than that recommended for austenitic grades.

FORMS OF SUPPLY

Seamless tube

Seamless tubes in SAF 3207 HD™ can be supplied in typical umbilical tube dimensions. The delivery condition is either solution annealed and either white pickled or polished.

HEAT TREATMENT

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

Solution annealing

1040-1140°C (1905-2085°F), rapid cooling in air, protective atmosphere or water.

MECHANICAL PROPERTIES

At 20°C (68°F)

Metric units

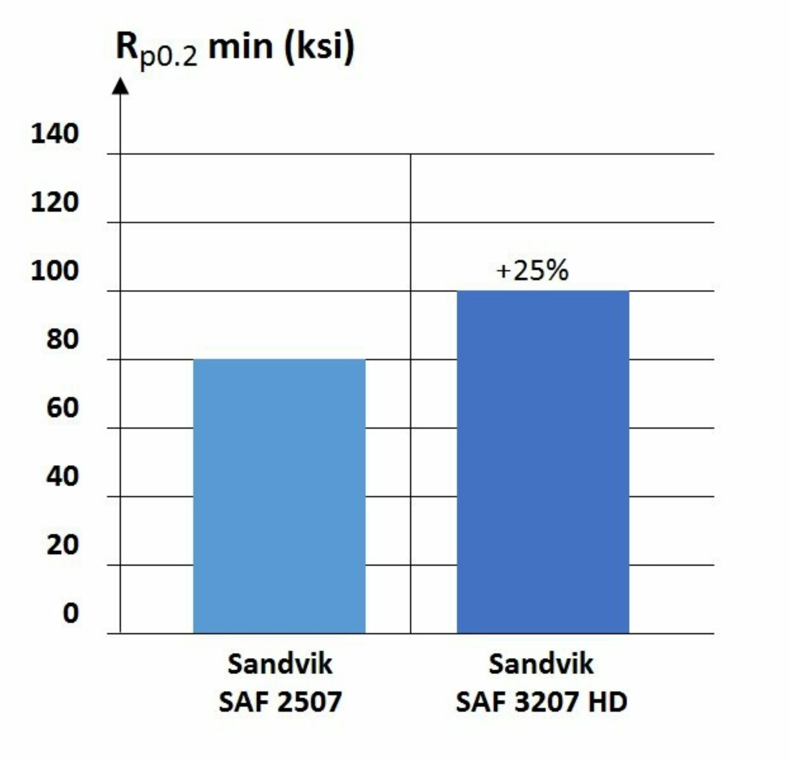
Wall thickness	Proof strength	Tensile strength	Elong.		Hardness
	$R_{p0.2}$[a]	R_m	A[b]	$A_{2"}$	HRC
mm	MPa	MPa	%	%	
<4	≥770	≥950	≥25	≥15	≤36
>4	≥700	≥850	≥25	≥15	≤36

Imperial units

Wall thickness	Proof strength	Tensile strength	Elong.	Hardness

	$R_{p0.2}$[a]	R_m	A[b]	A2"	HRC
in	ksi	ksi	%	%	
<0.157	≥112	≥138	≥25	≥15	≤36
>0.157	≥101	≥123	≥25	≥15	≤36

1 MPa = 1 N/mm^2
a) $R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% offset and 1.0% offset yield strength, respectively.
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

If SAF 3207 HD™ is exposed to temperatures exceeding 250 °C (480 °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. Please contact Sandvik for more information.

Metric units

Temperature	Proof strength	Tensile strength
	$R_{p0.2}$[a]	R_m
°C	MPa	MPa
	min.	min.
50	696	923
100	657	850
150	609	811
200	585	784
250	582	785
300	572	791

Imperial units

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Temperature	Proof strength	Tensile strength
	$R_{p0.2}$[a]	R_m
°F	ksi	ksi
	min.	min.
120	101	134
200	96	124
300	89	118
400	85	114
500	84	114
600	83	115

Fatigue strength

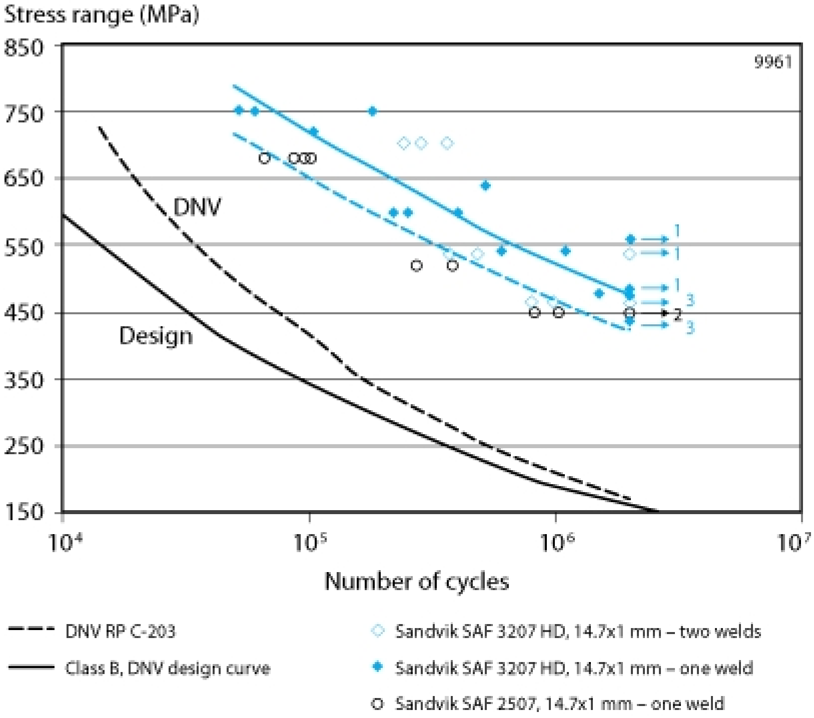

Figure2: S-N curves for Sandvik SAF 3207 HD, SAF 2507 and DNV design curves

Impact strength

SAF 3207 HD™ possesses good impact strength. The ductile-brittle transition temperature is below -50°C (-58°F). Figure 3 shows the impact strength for SAF 3207 HD™.

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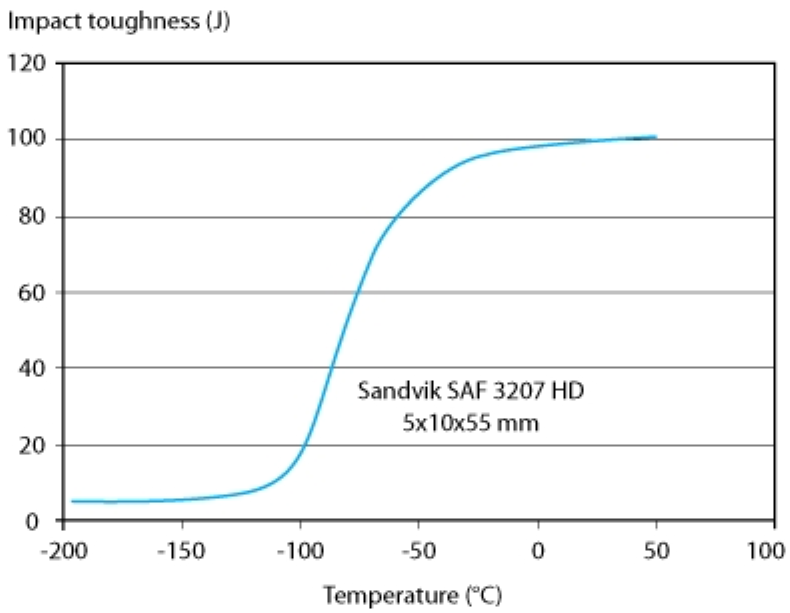

Figure 3. Impact energy curve for Sandvik SAF 3207 HD, using half size specimens (5x10x55mm) average of 3 at each temperature. Parent metal samples are taken in the longitudinal direction from 114,3x6,35 cold pilgered and annealed (1120°C, 2048°F) tube.

PHYSICAL PROPERTIES

Density: 7.7 g/cm^3, 0.28 lb/in^3

Resistivity

Temperature, °C	μΩm	Temperature, °F	μΩin.
20	0.87	68	34.1

Specific heat capacity

Metric units		Imperial units	
Temperature, °C	J/(Kg °C)	Temperature, °F	Btu/(lb °F)
20	480	68	0.12
100	510	200	0.12
200	540	400	0.13
300	570	600	0.13
400	590	800	0.14

Thermal conductivity

Metric units, W/(m °C)

Temperature, °C	20	100	200	300	400
SAF 3207 HD	13	15	16	18	20
SAF 2507	14	15	16	18	20
AISI 316L	14	15	17	18	20

Datasheet updated 23/09/2021 06:17:39 (supersedes all previous editions)

Imperial units, Btu/(ft h °F)

Temperature, °F	68	200	400	600	800
SAF 3207 HD	7	9	9	10	20
SAF 2507	8	9	9	10	12
ASTM 316L	8	9	10	10	12

Thermal expansion

SAF 3207HD™ has a coefficient of thermal expansion close to that of carbon steel. This gives SAF 3207HD™ definite design advantages over austenitic stainless steels in equipment comprising of both carbon steel and stainless steel. The values given below are average values in the temperature ranges.

Metric units, x10^{-6}/°C

Temperature, °C	30-100	30-200	30-300	30-400
SAF 3207 HD	13.5	13.5	14.0	14.5
SAF 2507	13.5	14.0	14.0	14.5
Carbon Steel	12.5	13.0	13.5	14.0
ASTM 316L	16.5	17.0	17.5	18

Imperial units, x10^{-6}/°F

Temperature, °F	86-200	86-400	86-600	86-800
SAF 3207 HD	7.5	7.0	8.0	8.0
SAF 2507	7.5	7.5	8.0	8.0
Carbon Steel	6.8	7.0	7.5	7.8
ASTM 316L	9.0	9.5	10.0	10.0

Modulus of elasticity, (x10^3)

Metric units, Imperial units

Temperature, °C	MPa	Temperature, °F	ksi
20	200	68	29.0

WELDING

The weldability of SAF 3207 HD™ is good. Welding must be carried out without preheating and subsequent heat treatment is normally not necessary. A suitable method of fusion welding is gas tungsten arc welding GTAW/TIG with shielding gas of Ar+2% N_2. For tube to tubesheet welding, it is recommended to use Ar+3% N_2 as shielding gas to have proper weld metal structure.

For SAF 3207 HD™, heat input of 0.2-1.0 kJ/mm and interpass temperature of <100°C (210°F) are recommended.

Recommended filler metals

GTAW/TIG welding

Exaton 27.7.5.L. For information on filler metal and welding method, please contact Sandvik.

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