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Sandvik SAF 3207 HD

(Tube and pipe, seamless)

Sandvik 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. Sandvik 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

- ASTM A789/A790
- UNS S33207

Product standards
Seamless tube and pipe: ASTM A789; A790

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	Others
max	max	max	max	max				
0.030	0.8	1.5	0.035	0.010	32	7	3.5	N=0.5

FORMS OF SUPPLY

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

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	%	%	
	min.	min.	min.	min.	max.
<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]	$A_{2"}$	HRC
in	MPa	MPa	%	%	
	min.	min.	min.	min.	max.
<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.

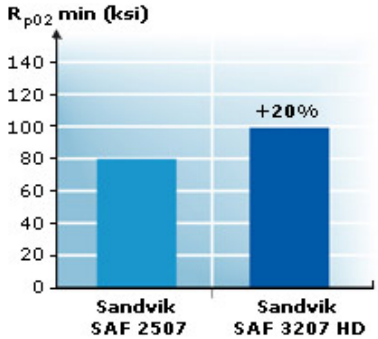

Figure1: Comparison of minimum Proof strength Rp0.2 , of Sandvik SAF 2507 and Sandvik SAF 3207HD

At high temperatures
If Sandvik 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

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

Fatique strength

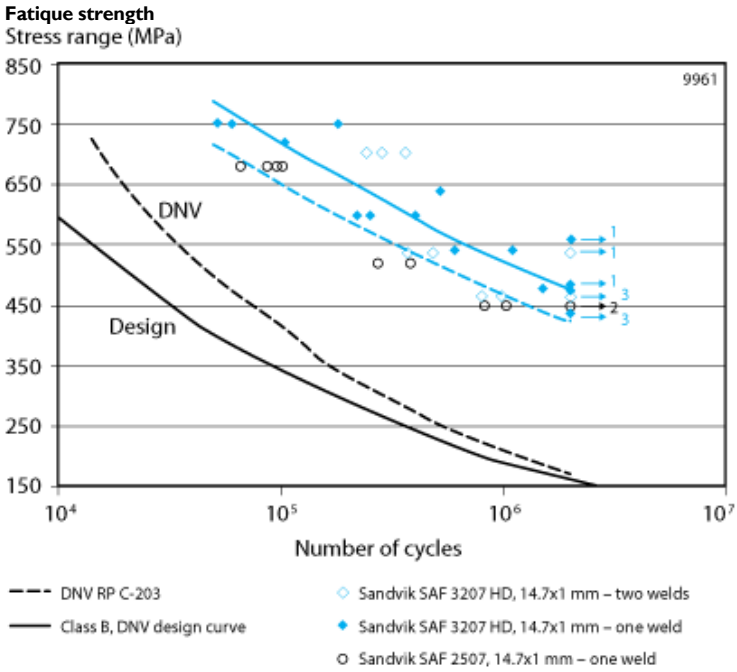

Figure2: S-N curves for Sandvik SAF 3207 HD, SAF 2507 and DNV design curves

Impact strength

Sandvik 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 Sandvik SAF 3207 HD.

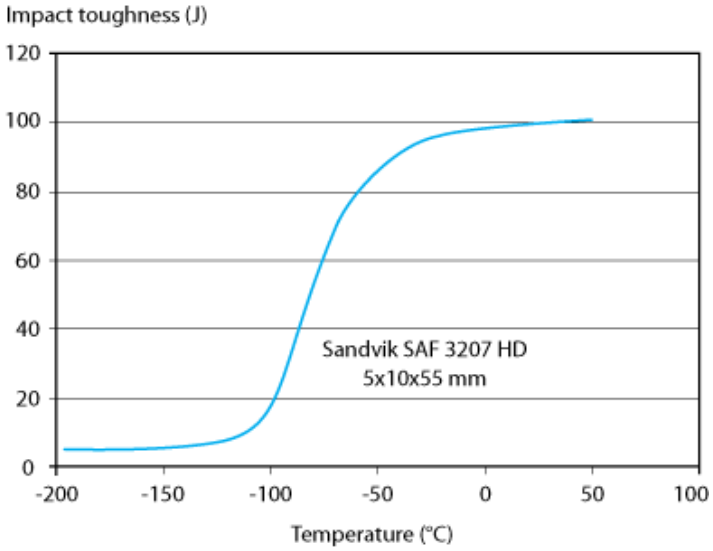

Figure 3. Impact energy curve for Sandvik SAF 3207 HD, using half size specimens (5x10x55mm) average of 3 at each temperature. Parent metal samples are taken in the longitudinal direction from

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

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
AISI 316L	8	9	10	10	12

Thermal expansion

Sandvik SAF 3207HD has a coefficient of thermal expansion close to that of carbon steel. This gives Sandvik 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
AISI 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
AISI 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

CORROSION RESISTANCE

General corrosion

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

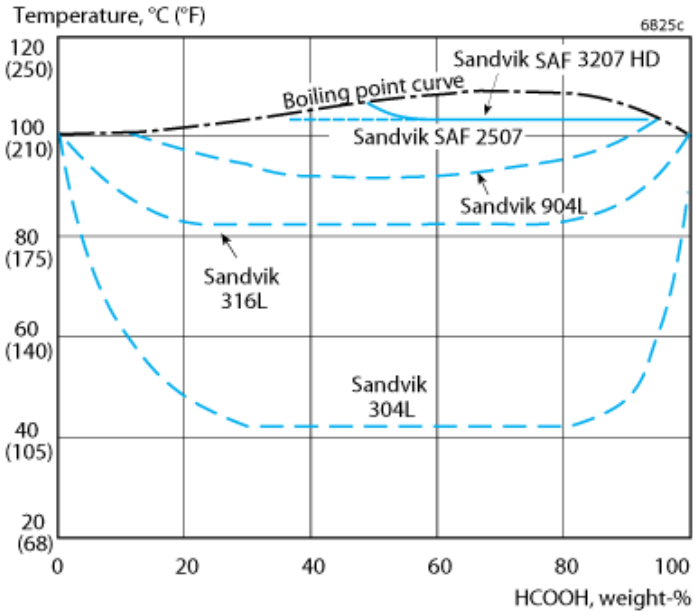

Figure 4. Isocorrosion diagram in formic acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

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 sulphuric acid and hydrochloric acid, respectively.

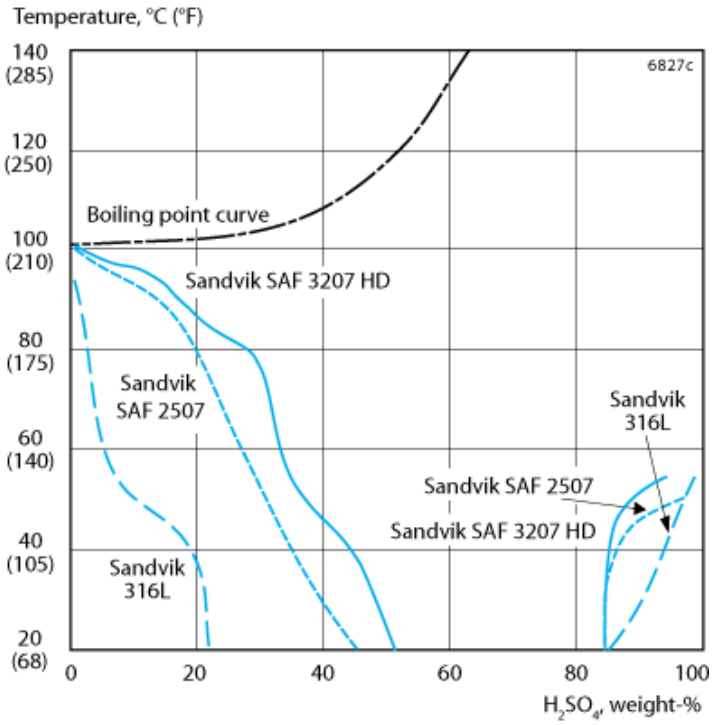

Figure 5. Isocorrosion diagram in sulphuric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

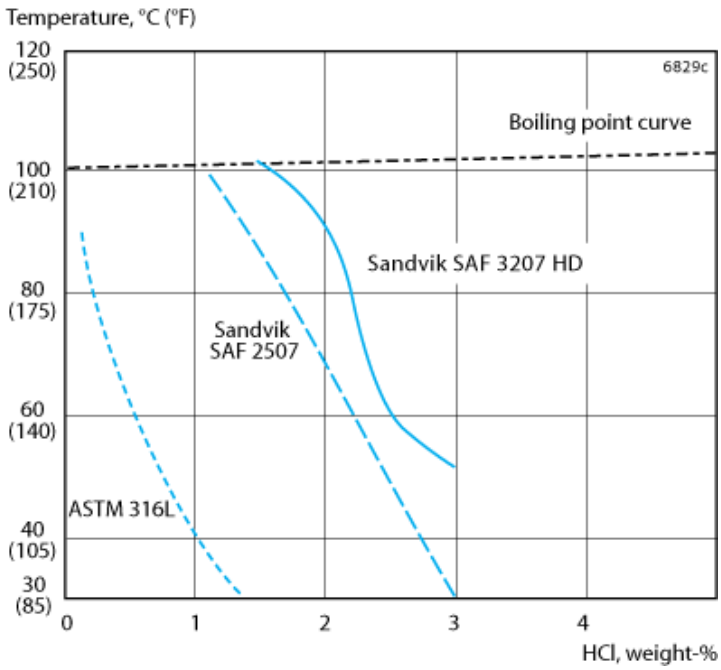

Figure 6. Isocorrosion diagram in hydrochloric acid. The curves represent acorrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

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 Sandvik 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% FeCl3.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% FeCl3, 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 Sandvik SAF 2507 are given in Figure 7. Sandvik SAF 3207 HD performs better than Sandvik SAF 2507.

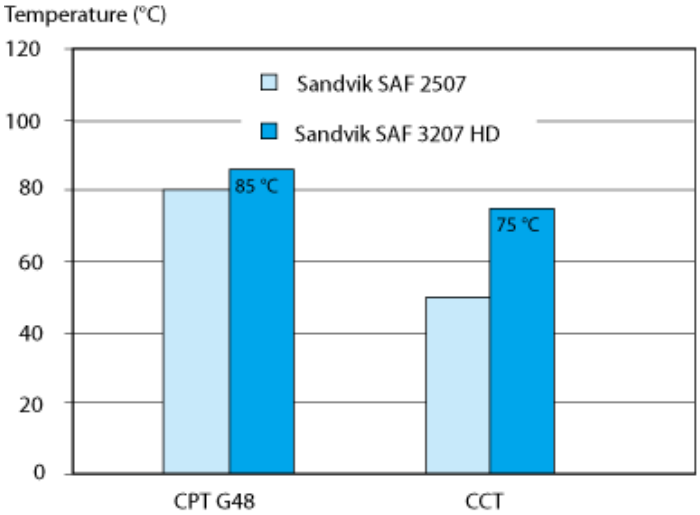

Figure 7. Critical pitting temperature measured in modified G48A, starting temperature 55°C. Critical crevice corrosion temperature obtained in testing with a crevice specified in the MTI-2 testing.

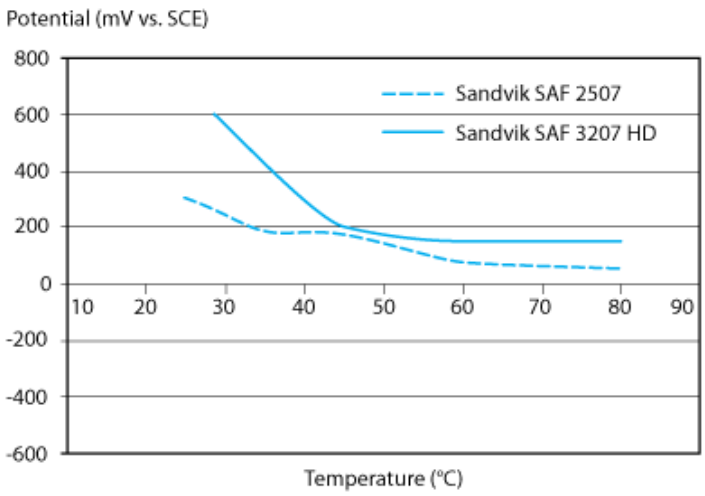

Figure 8: Design curve for butt welded Sandvik SAF 3207 HD and Sandvik SAF 2507 showing initiation of crevice corrosion in seawater versus potential and temperature.

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.

WELDING

Sandvik SAF 3207 HD has good weldability with a good austenite reformation in the heat affected zone. This gives the welded joint good toughness, strength and corrosion resistance.

Filler material of Sandvik 27.9.5.L is recommended in order to obtain a weld metal with optimum corrosion resistance and mechanical properties.

TIG welding is recommended. Welding should be undertaken within the heat input range of 0.2-1.0 kJ/mm and with an interpass temperature of 100°C (212°F) maximum. Shielding gas should consist of Ar + 2% N_2 and root gas should consist of pure welding grade N_2. Preheating or post-weld heat treatment is not necessary.

FABRICATION

Machining
Being a dual phase material (austenitic-ferritic), Sandvik 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.

APPLICATIONS

Sandvik 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, Sandvik 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 sulphide (H_2S) is a requirement, such as in raw seawater injection, control lines and chemical injection lines, Sandvik SAF 3207 HD offers high reliability and operational safety leading to lower operating costs.

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.