SANDVIK 5R60 FOR WIRELINES WIRE

DATASHEET

Sandvik 5R60 is an austenitic stainless steel alloy suitable for service in less severe oil and gas wells. The grade is characterized by:

- Good resistance to general corrosion
- Better resistance to pitting than ASTM 304, because of the molybdenum content
- High tensile strength

PRE* value: 25

* PRE, Pitting Resistance Equivalent = %Cr + 3.3 x %Mo + 16 x %N

STANDARDS

- ASTM 316
- UNS S31600
- EN Number 1.4436

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo
≤0.04	≤0.6	≤1.2	≤0.030	≤0.015	17	11	2.6

FORMS OF SUPPLY

Sandvik 5R60 precision wire is supplied cold drawn and degreased, in continuous lengths, without welds, on metallic spools.

Product program

Diameter		Breaking load		Weight	
mm	in.	N	lbf	kg/1000 m	lb/1000 ft
2.083	0.082	5109	1149	27.5	18.4
2.337	0.092	6431	1446	34.6	23.2
2.667	0.105	8378	1883	45.0	30.2
2.743	0.108	8864	1992	47.6	32.0
3.175	0.125	11131	2491	63.8	42.8
3.810	0.150	15985	3587	91.4	61.27
4.064	0.160	18157	4082	103.8	69.60

MECHANICAL PROPERTIES

Datasheet updated 6/16/2015 1:34:06 PM (supersedes all previous editions)

Wire in Sandvik 5R60 is tested and certified in accordance with a minimum tensile strength. Proof strength is approximately 90 % of the tensile strength. Sandvik 5R60 is able, therefore, to resist high loads without permanent set of the wire.

At 20°C (68°F)

Proof strength, $R_{p0.2}$		Tensile strength, R_m		Dimension	
MPa	ksi	MPa	ksi	in.	mm
≥1350	≥196	≥1500	≥218	< 0.108	< 2.743
≥1260	≥183	≥1400	≥203	> 0.125	> 3.175

PHYSICAL PROPERTIES

Density: 8.0 g/cm^3, 0.29 lb/in^3
Specific heat capacity, at 20°C (68°F): 485 J/kg°C, 0.12 Btu/lb h°F
Thermal expansion: 30 - 100°C, 16.5 *10^{-6}/°C, 86 - 210°F, 9.5 *10^{-6}/°F
Thermal conductivity, at 20°C (68°F): 15 W/m°C, 9 Btu/ft· h °F
Permeability,at 20°C (68°F): 1.004
Resistivity,at 20°C (68°F): 0.76 µΩm, 30.1 µΩin.
Modulus of Elasticity, at 20°C (68°F)**:** 180 000 MPa, 26 100 ksi

Datasheet updated 6/16/2015 1:34:06 PM (supersedes all previous editions)

SANICRO 26MO FOR WIRELINES WIRE

DATASHEET

Sanicro 26Mo is a high-alloy austenitic stainless steel for service in highly corrosive conditions in oil and gas environments. The grade is characterized by:

- Very good resistance to stress corrosion cracking (SCC) in H_2S, chloride and CO_2 environments
- Very good resistance to pitting in chloride-containing environments because of its high PRE* value of 43 minimum
- Very good resistance to general corrosion
- High mechanical strength and correspondingly high breaking loads

* PRE, Pitting Resistance Equivalent = %Cr + 3.3 x %Mo + 16 x %N

STANDARDS

- UNS N08926
- W.Nr. 1.4529

STANDARDS

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	Cu	N
≤0.020	0.4	0.8	≤0.030	≤0.005	20.5	25	6.3	0.8	0.2

FORMS OF SUPPLY

Slicklines

Sanicro 26Mo slicklines are supplied cold drawn and degreased in continuous lengths.

Slicklines

Diameter		Breaking load		Weight	
mm	in.	N	lbf	kg/1000 m	lb/1000 ft
2.083	0.082	5398	1 214	27.3	18.31
2.337	0.092	6805	1 530	34.4	23.05
2.667	0.105	8851	1 990	44.8	30.02
2.743	0.108	9365	2 105	47.4	31.76
3.175	0.125	12545	2 820	63.4	42.55
3.556	0.140	15740	3 541	79.6	53.37
3.810	0.150	18064	4 061	91.4	61.27
4.064	0.160	20557	4 621	103.8	69.60

Datasheet updated 9/18/2015 2:10:24 PM (supersedes all previous editions)

Armor wire

Sanicro 26Mo logging cable armor wire is supplied cold drawn and degreased in continuous lengths without welds in sizes according to the table. The standard surface is matt, providing reduced friction in the pre-form head and increased productivity. Other armor wire dimensions can be manufactured on request.

Logging cable armor wire

Diameter		Breaking load		Weight	
mm	in.	N	lbf	kg/1000 m	lb/1000 ft
0.617	0.0243	495	111	2.39	1.60
0.787	0.0310	806	181	3.89	2.61
0.820	0.0323	875	197	4.22	2.83
0.909	0.0358	1075	242	5.19	3.48
1.130	0.0445	1660	373	8.02	5.38

MECHANICAL PROPERTIES

Sanicro 26Mo is tested and certified in accordance with a minimum tensile strength. Proof strength is in the range of 85 % of the tensile strength. This means that Sanicro 26Mo can resist high loads without permanent set of the wire.

Mechanical properties for slicklines, at 20°C (68°F)

Proof strength $R_{p0.2}$		Tensile strength R_m	
MPa	ksi	MPa	ksi
≥1350	≥195	≥1585	≥230

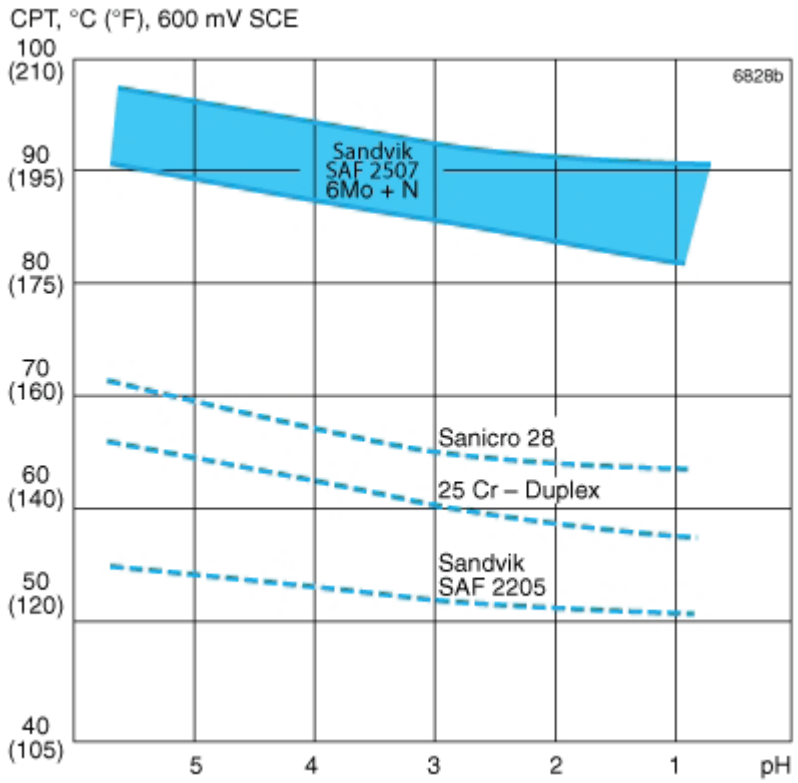
Mechanical properties for logging cable armor wire, at 20°C (68°F)

Proof strength $R_{p0.2}$		Tensile strength R_m	
MPa	ksi	MPa	ksi
≥1405	≥204	≥1655	≥240

CORROSION RESISTANCE

Pitting

Sanicro 26Mo can resist very high temperatures in aggressive environments without being attacked by pitting. All stainless steels have a critical pitting temperature above which there is a risk of pitting. Results of laboratoty tests of the critical pitting temperature (CPT) for Sanicro 26Mo and some other stainless steels, as a function of pH values in 3% NaCl solution, is shown in the diagram below.



Hydrogen sulphide induced corrosion

Sanicro 26Mo has been specially developed to be resistant in most common well conditions, including H_2S and CO_2 containing environments.

PHYSICAL PROPERTIES

Density: 8.0 g/cm^3, 0.29 lb/in^3
Thermal expansion: 20 - 100°C, 14x10^{-6}/°C, 68 - 210°F, 8x10^{-6}/°F
Thermal conductivity, at 20°C (68°F): 10 W/m°C, 6 Btu/ft h °F
Resistivity: at 20°C (68°F), 0.96 µΩm, 37.7 µΩin
Modulus of elasticity, at 20°C (68°F): 195 000 MPa, 283 000 ksi

Datasheet updated 9/18/2015 2:10:24 PM (supersedes all previous editions)

SANICRO 28 FOR WIRELINES WIRE

DATASHEET

Sanicro 28 is a high-alloy austenitic stainless steel suitable for service in highly corrosive oil and gas environments.

The grade is characterized by:

- Very good corrosion resistance in H_2S, CO_2 and chloride containing environments.
- Very good resistance to pitting owing to its high PRE* value of 38 minimum
- General corrosion comparable to or better than Alloy 825
- Tensile strength equivalent to ASTM 316
- Very good performance in elevated temperatures (geothermal wells)
- Entirely non-magnetic properties

* PRE, Pitting Resistance Equivalent = %Cr + 3.3 x %Mo + 16 x %N

STANDARDS

- Uns N08028
- EnNumber 1.4563
- EnName X 1 NiCrMoCu 31-27-4

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	Cu
≤0.020	0.6	2.0	≤0.025	≤0.010	27	31	3.5	1.0

FORMS OF SUPPLY

Sanicro 28 slicklines are supplied cold drawn and degreased, on steel spools, in continuous lengths, without welds.

Product program

Diameter		Breaking loads		Weight	
mm	in.	N	lbf	kg/1 000 m	lb/1 000 ft
2.083	0.082	5109	1149	27.5	18.4
2.337	0.092	6431	1446	34.6	23.2
2.667	0.105	8377	1883	45.0	30.2
2.743	0.108	8862	1992	47.6	32.0
3.175	0.125	11872	2669	63.8	42.8
3.810	0.150	17096	3843	91.4	61.27

Datasheet last updated 28/09/2015 16:51:03 (supersedes all previous editions)

Product program

Diameter		Breaking loads		Weight	
mm	in.	N	lbf	kg/1 000 m	lb/1 000 ft
4.064	0.160	19451	4373	103.8	69.60

MECHANICAL PROPERTIES

Sanicro 28 is tested and certified in accordance with a minimum tensile strength. Proof strength is approximately 90 % of the tensile strength. Sanicro 28 is able, therefore, to resist high loads without permanent set of the wire.

Proof strength		Tensile strength	
$R_{p0.2}$		R_m	
MPa	ksi	MPa	ksi
≥1350	≥200	≥1500	≥220

CORROSION RESISTANCE

Pitting

Sanicro 28 has very good resistance to pitting because of high contents of chromium and molybdenum. Critical pitting temperatures (CPT) as a function of the chloride content and pH are presented in Figures 1 and 2.

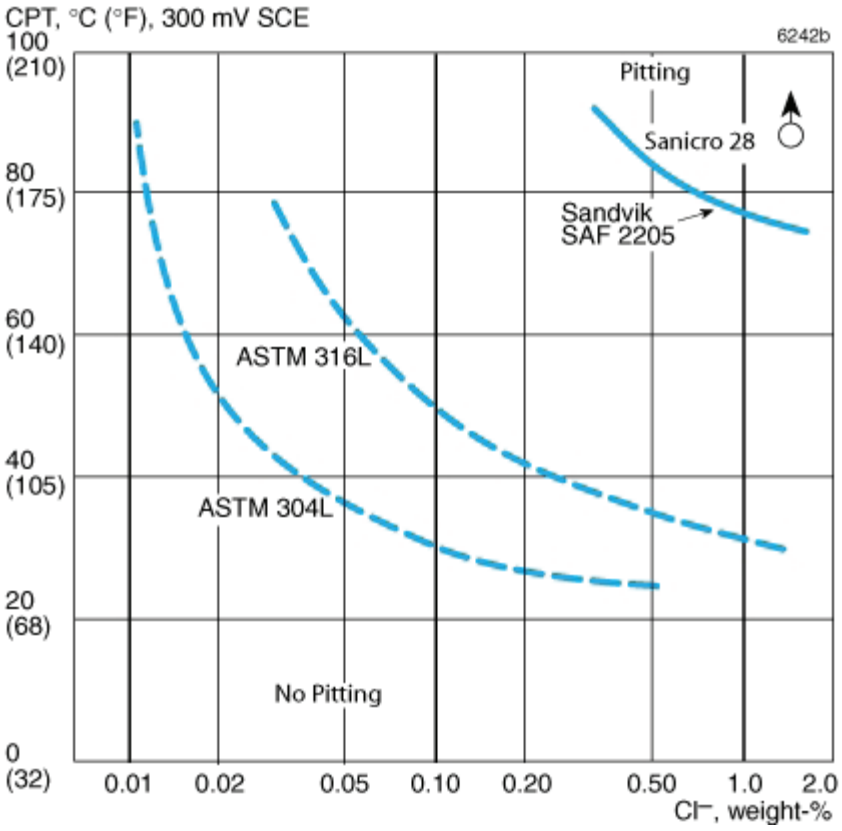


Figure 1. CPT for various alloys in neutral chloride solutions at 300 mV SCE.

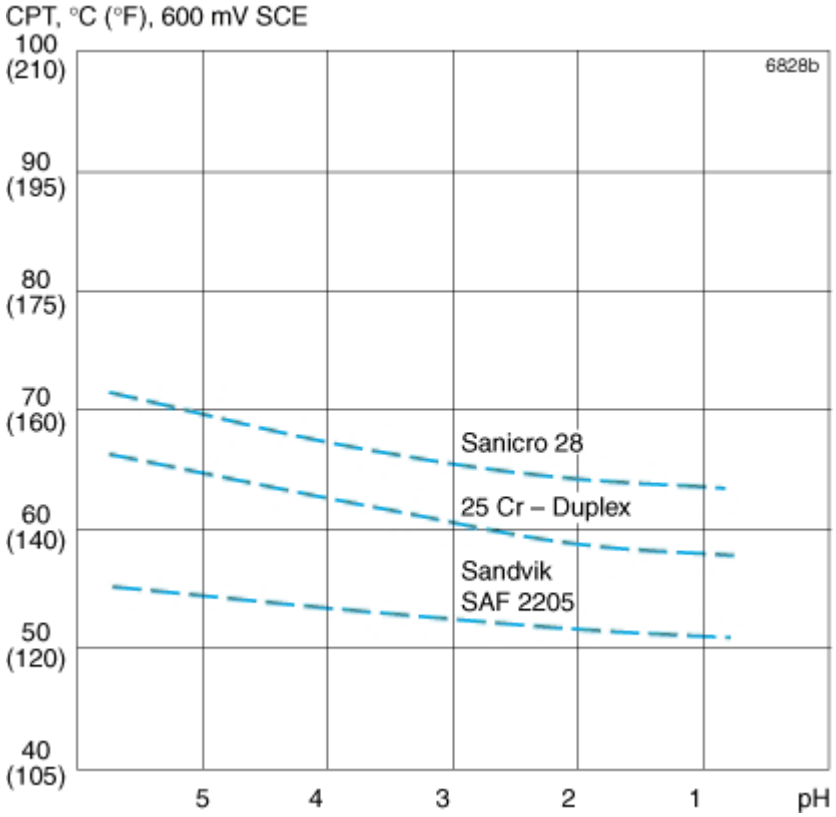


Figure 2. CPT in 3 % NaCl as a function of pH at 600 mV SCE.

Stress corrosion cracking (SCC) in chloride environments

The combination of stresses up to the proof strength and chlorides leads to a risk of stress corrosion cracking. In austenitic steels the increased nickel content together with an increased stability against pitting corrosion will lead to an increased resistance against stress corrosion cracking.

Datasheet last updated 28/09/2015 16:51:03 (supersedes all previous editions)

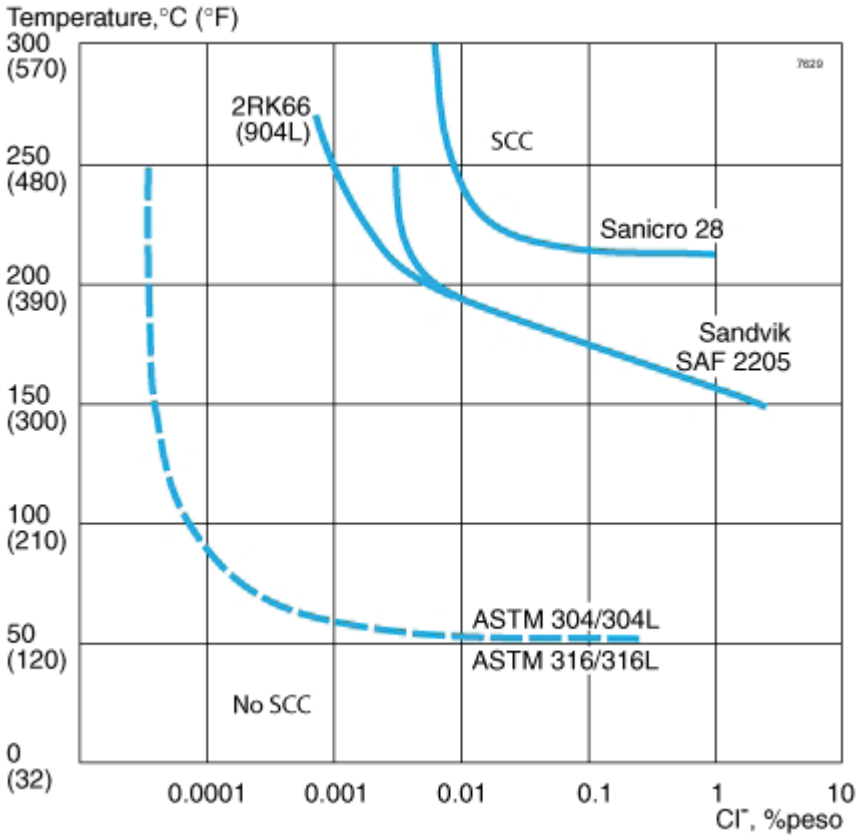


Figure 3. SCC resistance in oxygen-bearing (about 8 ppm) neutral chloride solutions. Testing time: 1 000 hours.

Applied strength equal to proof strength at testing time. The curve for AISI 304/304L and 316/316L is based on experimental data and practical experience. The data for the other grades are based on test results of tube material.

Stress corrosion cracking (SCC) in in H_2S/Cl^- environment

Tensile specimens from cold-worked Sanicro 28 and Sandvik SAF 2205 were tested in the NACE TM-01-77 type of environment, modified in that the temperature was increased to 90°C (194°F). At this temperature, 100% H_2S at atmosperic pressure corresponds to 100 kPa (14.5 psi) NaCl varied up to 10%.

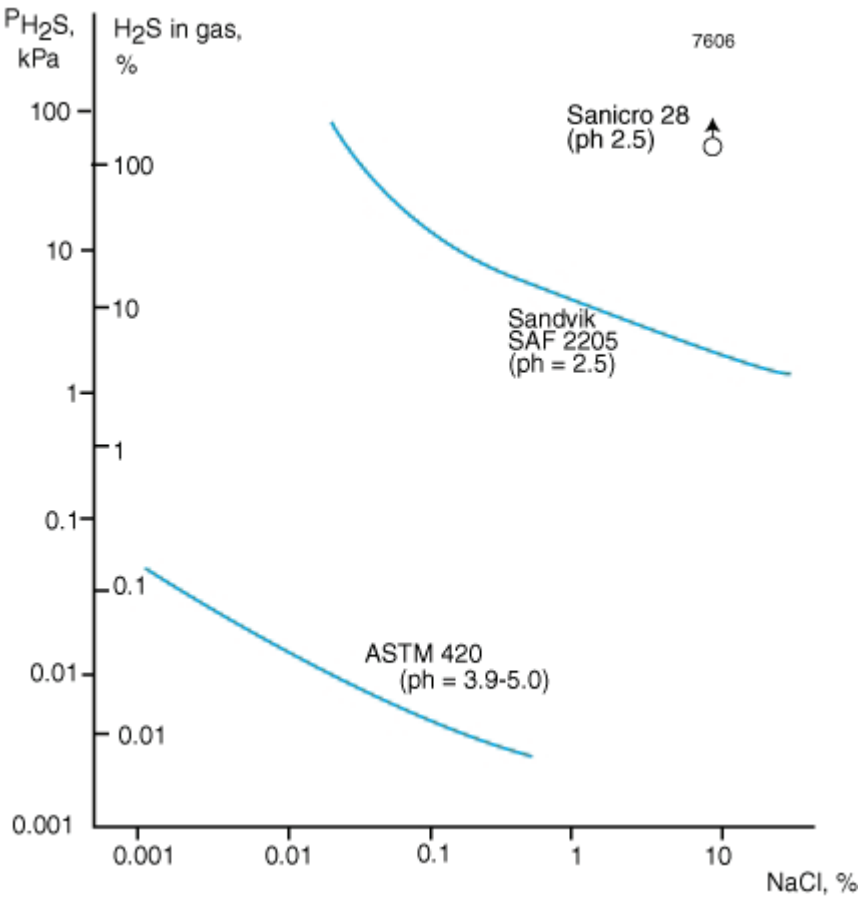


Figure 4. Constant-load SCC tests in acidified aqueous solution. Stress = 0.2% proof strength at testing temperature, 90°C (194°F). Testing time 500 hours. Sanicro 28 and Sandvik SAF 2205 tested in the cold worked condition. AISI 420 quenched and tempered.

Datasheet last updated 28/09/2015 16:51:03 (supersedes all previous editions)

SANICRO 56MO FOR WIRELINES WIRE

DATASHEET

Sanicro 56Mo is a nickel-base nickel-chromium-molybdenum alloy suitable for service in the most extreme corrosive oil and gas environments.

The grade is characterized by:

- Superior corrosion resistance in H_2S, CO_2 and chloride containing environments
- Excellent resistance to pitting corrosion owing to its high PRE* value of 68
- Excellent corrosion resistance in hydrochloric acid
- Good performance in high temperature wells up to 250°C (480°F)
- High strength – tensile strength higher than Sanicro 26Mo (UNS N08926)

* PRE (Pitting Resistance Equivalent) = %Cr + 3.3 x %Mo + 16 x %N

STANDARDS

- UNS N10276
- W.Nr. 2.4819

STANDARDS

CHEMICAL COMPOSITION (NOMINAL), %

C	Si	Mn	P	S	Cr	Ni	Mo	W	Fe	Co
≤0.010	≤0.08	≤1.0	≤0.030	≤0.015	16	Bal.	16	3.5	4.5	<2.5

FORMS OF SUPPLY

Sanicro 56Mo slicklines are supplied cold drawn and degreased in continuous lengths. All lines are 100% EC-tested.

Slicklines

Diameter		Breaking load		Weight	
mm	in.	N	lbf	kg/1000 m	lb/1000 ft
2.743	0.108	10637	2391	52.0	35.0
3.175	0.125	14251	3204	69.7	46.8

MECHANICAL PROPERTIES

Sanicro 56Mo is tested and certified in accordance with a minimum tensile strength. Proof strength is in the range of 85% of the tensile strength. This means that Sanicro 56Mo can resist high loads without permanent set of the wire.

Datasheet updated 12/17/2015 3:19:49 PM (supersedes all previous editions)

Mechanical properties for slicklines, at 20°C (68°F)

Proof strength $R_{p0.2}$*		Tensile strength R_m	
MPa	ksi	MPa	ksi
≥1530	≥222	≥1800	≥261

* Corresponds to 0.2% yield strength

CORROSION RESISTANCE

Sanicro 56Mo has excellent corrosion resistance in a wide range of aggressive environments occurring in downhole environments. It resists general corrosion, localized pitting corrosion and environmental cracking in a wide range of aggressive media.

Pitting and crevice corrosion

The relative resistance of alloys to pitting corrosion can be estimated based on the chemical composition using the Pitting Resistance Equivalent number (PRE). Alloys with higher PRE values generally have better corrosion resistance compared to alloys with lower PRE values.

There are several different equations available for calculating the PRE from the chemical composition. In this document the equation specified in NACE MR0175 is used: *PRE = %Cr+3.3(%Mo+0.5W)+16%N

Pitting resistance equivalent numbers (PRE) for some slickline alloys.

Alloy	UNS	PRE*
Sanicro 56Mo	N10276	68
Sanicro 26Mo	N08926	43
Sanicro 28	N08028	38

Stress corrosion cracking

The high levels of nickel, molybdenum and chromium in Sanicro 56Mo make the alloy highly resistant to sour environments containing high levels of H_2S, CO_2 and chlorides. The NACE standard MR 0175 is widely used for selecting material for use in H_2S-containing environments in the oil and gas industry. According to NACE MR0175 Sanicro 56Mo (UNS N10276) can be used in up to 1000 psi partial pressure H_2S at 232°C (450°F) with no limitation on the chloride concentration. Below 204°C (400°F) there is no limit on the H_2S level or chloride concentration.

PHYSICAL PROPERTIES

Density: 8.8 g/cm^3, 0.32 lb/in

Resistivity: at 20°C (68°F), 1.16 µΩm, 45.5µΩin

Modulus of elasticity: at 20°C (68°F), 205 000 MPa (29 700 ksi)

Datasheet updated 12/17/2015 3:19:49 PM (supersedes all previous editions)

SANDVIK

SANDVIK SAF 2205 FOR WIRELINES
WIRE

DATASHEET

Sandvik SAF 2205 is a duplex (austenitic/ferritic) stainless steel suitable for service in corrosive oil and gas wells. The grade is characterized by:

- High resistance to stress corrosion cracking (SCC) in chloride and CO_2 containing environments
- High resistance to pitting owing to its high PRE* value of 35 minimum
- High resistance to general corrosion
- High tensile strength

Sandvik SAF 2205 is suitable for service in wells with a H_2S partial pressure of max. 3 psi.

Service temperature: -50 to 280°C (-60 to 540°F)

* PRE, Pitting Resistance Equivalent = %Cr + 3.3 x %Mo + 16 x %N

STANDARDS

- Uns S31803, S32205
- EnNumber 1.4462

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	N
≤0.030	≤1.0	≤2.0	≤0.030	≤0.015	22	5.5	3.2	0.18

FORMS OF SUPPLY

Sandvik SAF 2205 for corrosive oil and gas environments is supplied in the form of cold-drawn and degreased wire in continuous lengths, without welds, on metallic spools.

PRODUCT PROGRAM

Sandvik SAF 2205 in corrosive oil and gas environments

Dimension		Breaking load		Weight	
mm	in.	N	lb	kg/1000 m	lb/1000 ft
2.083	0.082	5790	1302	26.6	17.81
2.337	0.092	7288	1639	33.5	22.42
2.667	0.105	9494	2134	43.7	29.21
2.743	0.108	10044	2258	46.2	30.90
3.175	0.125	13455	3025	61.9	41.39
3.556	0.140	16886	3795	77.6	52.0

Sandvik SAF 2205 in corrosive oil and gas environments

Dimension		Breaking load		Weight	
mm	in.	N	lb	kg/1000 m	lb/1000 ft
3.810	0.150	19384	4356	89.1	59.7
4.064	0.160	20757	4665	101.12	67.82

MECHANICAL PROPERTIES

Sandvik SAF 2205 in corrosive oil and gas environments

Sandvik SAF 2205 is tested and certified in accordance with minimum tensile strength. The proof strength is in the range of 90 % of the tensile strength. Sandvik SAF 2205 is thus able to resist high loads without permanent set of the wire.

Modulus of elasticity at 20°C (68°F): 200 000 MPa (29 000 ksi)

At 20°C (68°F)

Proof strength, $R_{p0.2}$		Tensile strength, R_m	
MPa	ksi	MPa	ksi
≥1530	≥222	≥1700	≥246

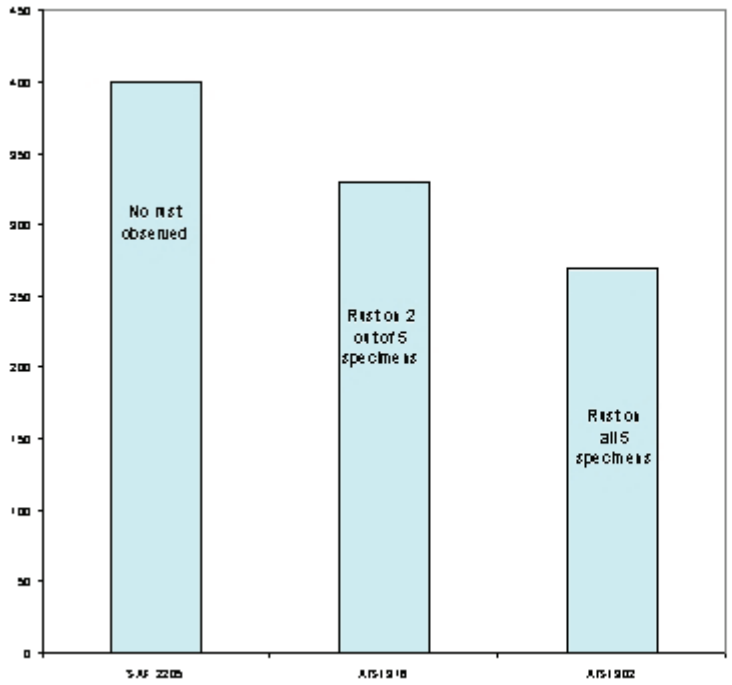
CORROSION RESISTANCE

Chloride induced corrosion

In seawater and other high chloride content environments, Sandvik SAF 2205 has better corrosion resistance than stainless steel of type AISI 316 owing to the high PRE-value. This can be demonstrated by e.g. salt spray testing where samples are sprayed with water containing 5 % NaCl at 35°C and checked every 24 hours. See the diagram below.

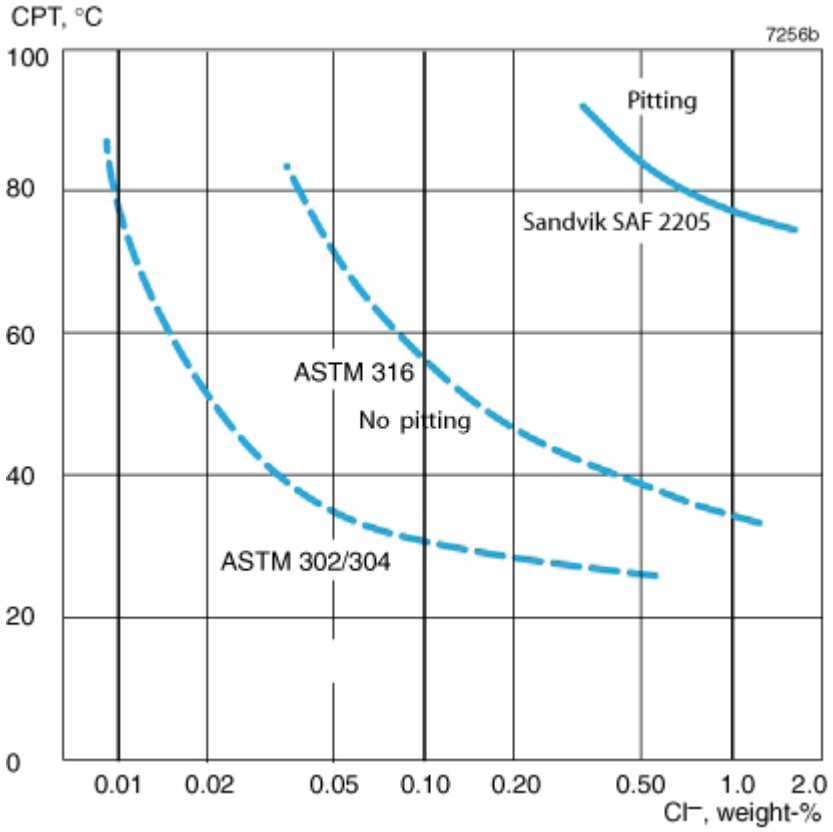
Neutral salt spray test according to ASTM B 117

Testing time, hours



Critical pitting temperature

In high saline content environments such as salt water, the aggressiveness of the environment increases as the temperature rises. All stainless steels have a critical pitting temperature above which there is a risk of pitting. The critical pitting temperature for Sandvik SAF 2205 and AISI 316 in seawater is shown in the diagram.

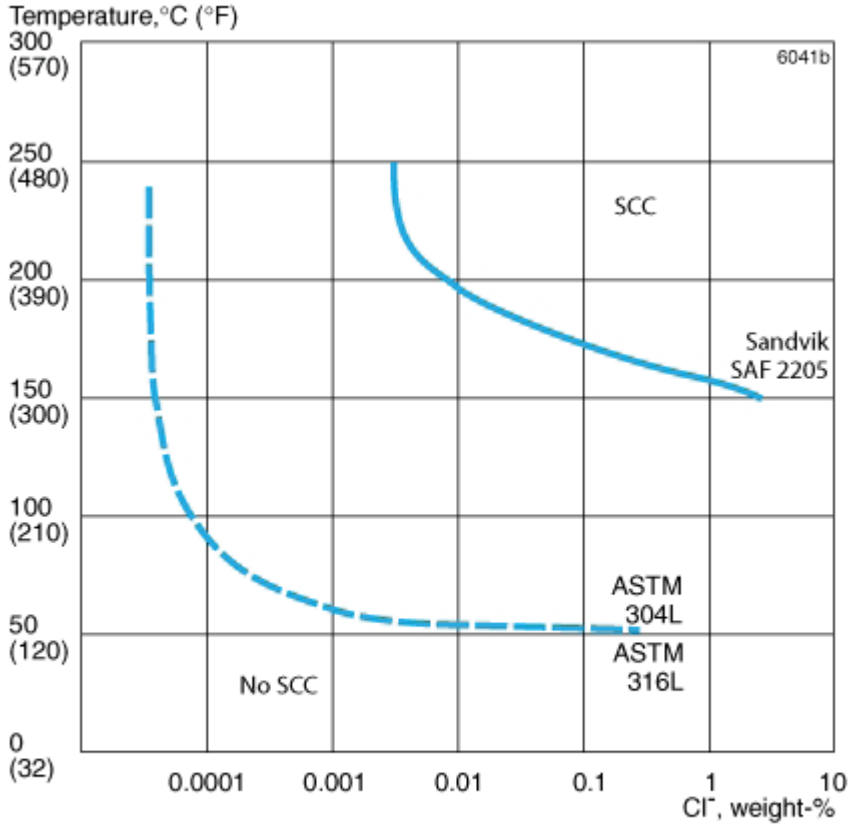


Crevice corrosion

Crevice corrosion is in principle the same as pitting corrosion, but occurs in crevices and cracks, e.g. between flange joints, under deposits on the metal surface or in welds with incomplete penetration. Crevice corrosion often occurs at lower temperatures and at lower chloride contents than those necessary for pitting to occur. Resistance is influenced by the content of Cr, Mo and N in the same way as pitting resistance.

Stress corrosion cracking

Stress corrosion cracking leading to catastrophic failures can occur with standard austenitic steels. The application of duplex stainless steels like Sandvik SAF 2205 will reduce this risk.



Oil & gas applications

Sandvik SAF 2205 is, thanks to its duplex structure, significantly more corrosion resistant than ASTM 316.

PHYSICAL PROPERTIES

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 at 20°C (68°F): 200 000 MPa (29 000 ksi)

SANDVIK CS-9A FOR WIRELINES WIRE

DATASHEET

Sandvik CS-9A is a carbon steel wire according to API9A for service in non-corrosive conditions in oil and gas wells.

STANDARDS

– DIN 17223 part 1

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cu
0.7	≤0.35	0.7	≤0.040	≤0.040	≤0.20

FORMS OF SUPPLY

Sandvik CS-9A is supplied in the form of cold drawn and oiled wire in continuous lengths without welds.

Sandvik CS-9A is available in two alternatives; ST (standard tensile) and UHT (ultra high tensile).

Dimension		Breaking load		Weight	
mm	in.	kN	lbf	kg/1000m	lbs/1000ft
		ST/UHT	ST/UHT		
2.083	0.082	5.53/6.56	1244/1475	26.5	17.8
2.337	0.092	6.97/8.26	1566/1857	33.4	22.4
2.667	0.105	8.89/10.76	1998/2419	43.5	29.2
2.743	0.108	9.10/11.38	2114/2559	46.0	30.9
3.175	0.125	12.6/15.25	2832/3428	61.6	41.4

MECHANICAL PROPERTIES

Sandvik CS-9A is tested and certified in accordance with minimum tensile strength.

At 20°C (68°F)

Tensile strength, R_m					
Dimension		Standard tensile		Ultra high tensile	
mm	in.	MPa	ksi	MPa	ksi
2.083	0.082	>1624	>236	>1926	>279
2.337	0.092	>1624	>236	>1926	>279
2.667	0.105	>1591	>231	>1926	>279

Datasheet updated 12/9/2015 9:19:18 AM (supersedes all previous editions)

Tensile strength, R_m					
Dimension		Standard tensile		Ultra high tensile	
mm	in.	MPa	ksi	MPa	ksi
3.175	0.125	>1591	>231	>1926	>279

PHYSICAL PROPERTIES

Density: 7.8 g/cm^3, 0.28 lb/in^3
Modulus of elasticity: 206 000 MPa, 29 800 ksi

Thermal expansion

20 - 100°C	11*10^{-6} / °C
68 - 210°F	8 * 10^{-6}/ °F

Thermal conductivity: 45 W/m°C, 26 Btu/ft h °F

Datasheet updated 12/9/2015 9:19:18 AM (supersedes all previous editions)

SANDVIK SAF 2507 FOR WIRELINES
WIRE

DATASHEET

Sandvik SAF 2507 is a super-duplex (austenitic-ferritic) stainless steel for service in highly corrosive conditions. The grade is characterized by:

- Excellent resistance to stress corrosion cracking (SCC) in chloride-bearing environments
- Excellent resistance to pitting and crevice corrosion
- High resistance to general corrosion
- High resistance to erosion corrosion and corrosion fatigue
- High mechanical strength and correspondingly high breaking loads in its slickline wire product form

STANDARDS

- UNS S32750
- EN Number 1.4410
- EN Name X 2 CrNiMoN 25-7-4
- SS 2328

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	Others
≤0.030	≤0.8	≤1.2	≤0.035	≤0.015	25	7	4	N=0.3

FORMS OF SUPPLY

Sandvik SAF 2507 slicklines are supplied cold drawn and degreased, in continuous lengths, without welds, on metallic spools.

Diameter		Breaking load		Weight	
mm	inch	N	lbf	kg/1000 m	lb/1000 ft
2.083	0.082	6134	1379	26.6	17.8
2.337	0.092	7721	1736	33.5	22.4
2.743	0.108	10637	2391	46.1	30.9
3.175	0.125	14251	3204	61.8	41.4
3.556	0.140	17877	4019	77.5	52.1
3.810	0.150	19382	4357	88.9	59.8
4.064	0.160	22052	4957	101.2	68.0

MECHANICAL PROPERTIES

Datasheet updated 2015-09-18 2:29:35 (supersedes all previous editions)

Wire in Sandvik SAF 2507 is tested and certified in accordance with a minimum tensile strength. Proof strength is approximately 90% of the tensile strength. Sandvik SAF 2507 is able, therefore, to resist high loads without permanent set of the wire.

At 20°C (68°F)

Diameter		Proof strength, $R_{p0.2}$*		Tensile strength, R_m	
mm	inch	MPa	ksi	MPa	ksi
2.083 - 3.556	0.082-0.140	≥1620	≥235	≥1800	≥261
3.810 - 4.064	0.150-0.160	≥1530	≥222	≥1700	≥247

* $R_{p0.2}$ corresponds to 0.2% offset yield strength.

CORROSION RESISTANCE

General corrosion

Sandvik SAF 2507 is highly resistant to corrosion by organic acids, e.g. experience less than 0.05 mm/year in 10% formic and 50% acetic acid where ASTM 316L has a corrosion rate higher than 0.2 mm/year. Pure formic acid, see Figure 2.

Sandvik SAF 2507 remains resistant even in contaminated acids. Figure 3 and Figure 4 show results from tests of Sandvik SAF 2507 and various stainless steels and nickel alloys in acetic acid contaminated with chlorides which in practice are frequently present in processes.

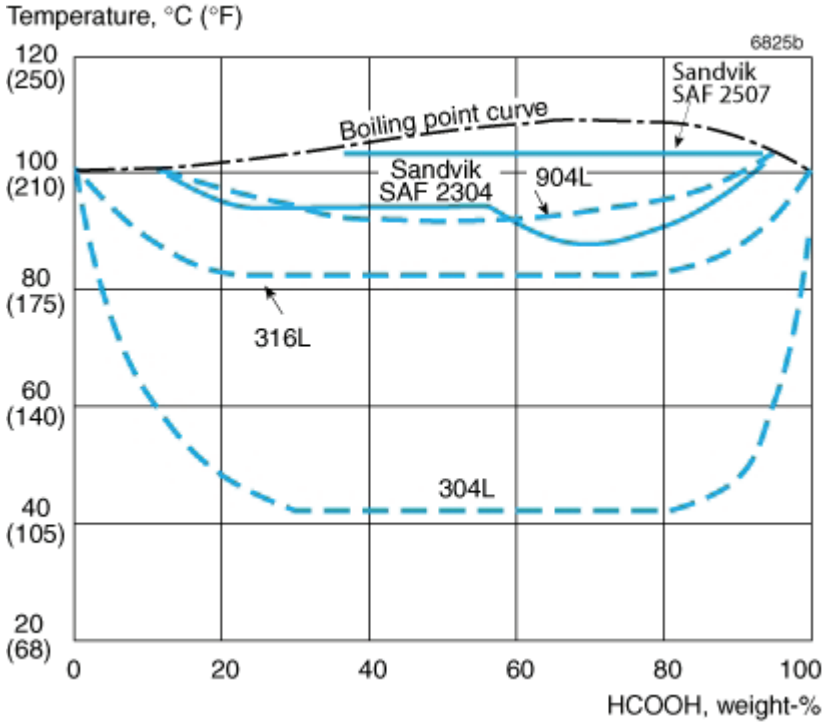


Figure 2. Isocorrosion diagram in formic acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.

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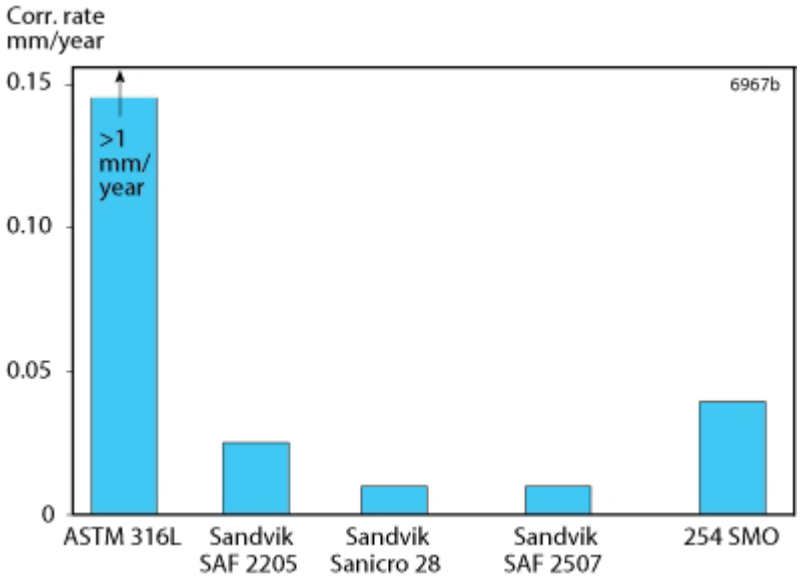

Figure 3. Corrosion rate of various alloys in 80% acetic acid with 2000 ppm chloride ions at 90°C (194°F).

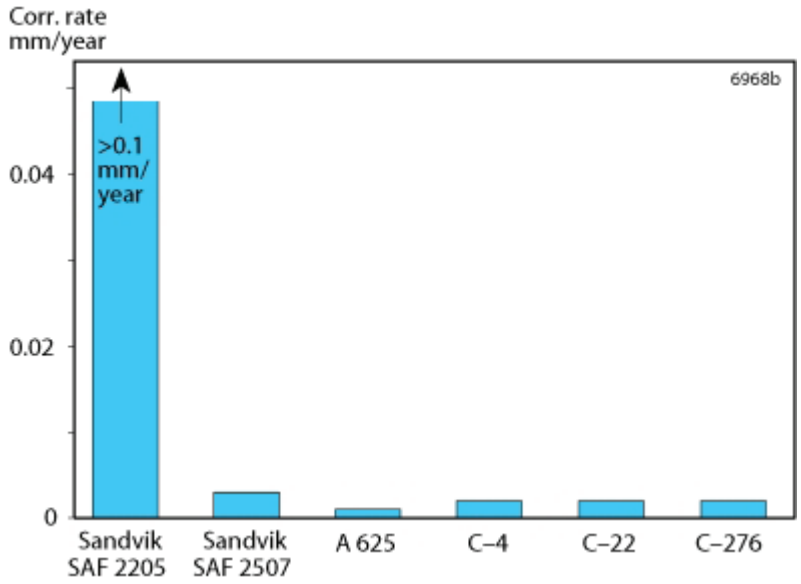

Figure 4. Corrosion rate of various alloys in concentrated acetic acid with 200 ppm chloride ions.

Practical experience with Sandvik SAF 2507 in organic acids, e.g. in teraphthalic acid plants, has shown that this alloy is highly resistant to this type of environment. The alloy is therefore a competitive alternative to high alloyed austenitics and nickel alloys in applications where standard austenitic stainless steels corrode at a high rate.

Resistance to inorganic acids is comparable to, or even better than that of high alloy austenitic stainless steels in certain concentration ranges. Figures 5 to 7 show isocorrosion diagrams for sulphuric acid, sulphuric acid contaminated with 2000 ppm chloride ions, and hydrochloric acid, respectively.

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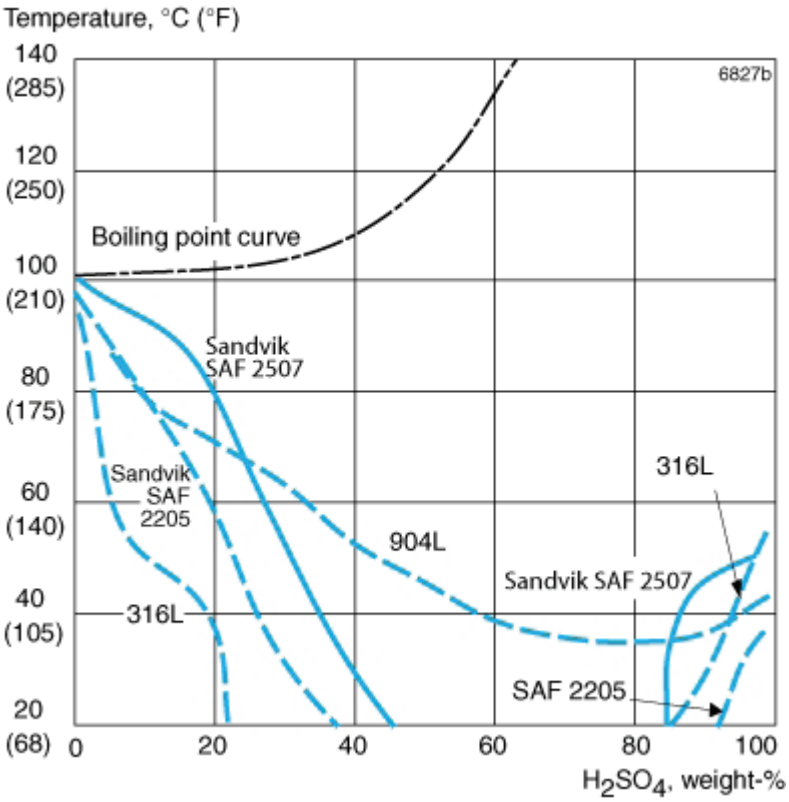

Figure 5. Isocorrosion diagram in naturally aerated sulphuric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

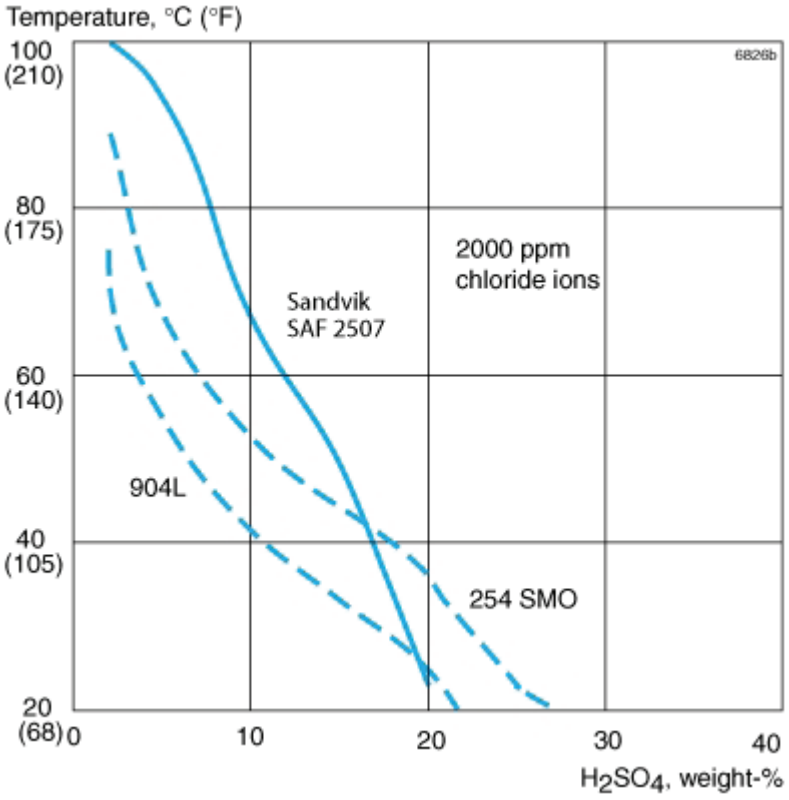

Figure 6. Isocorrosion diagram, 0.1 mm/year (4 mpy) in a naturally aerated sulphuric acid containing 2000 ppm chloride

ions.

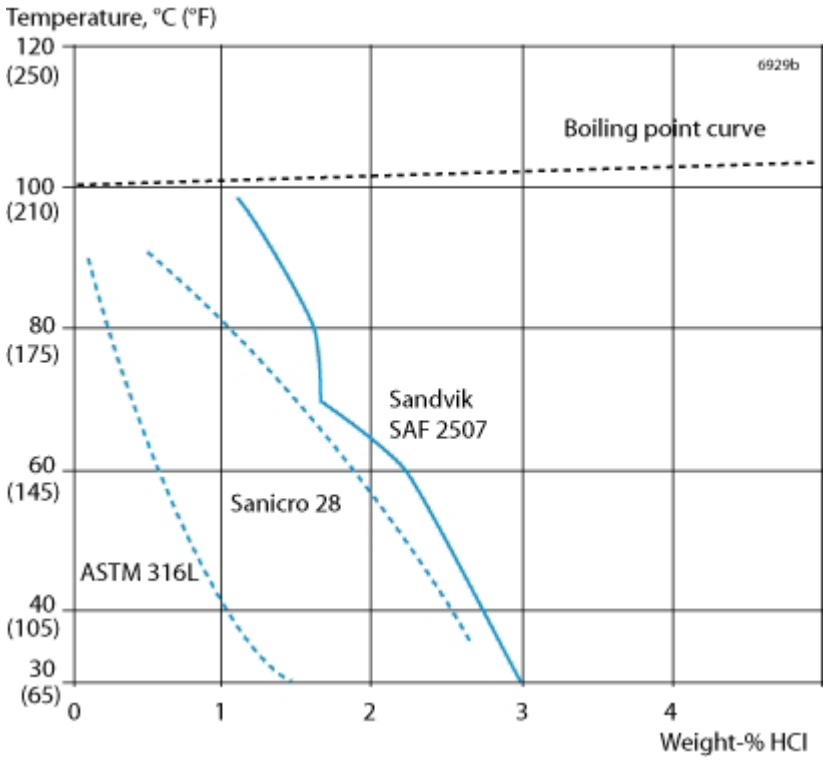

Figure 7. Isocorrosion diagram in a hydrochloric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.

Pitting and crevice corrosion

The pitting and crevice corrosion resistance of stainless steel is primarily determined by the content of chromium, molybdenum and nitrogen.

One 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

For duplex stainless steels the pitting corrosion resistance is dependent on the PRE value in both the ferrite phase and the austenite phase, so that the phase with the lowest PRE value will be limiting for the actual pitting corrosion resistance. In Sandvik SAF 2507 the PRE value is equal in both phases, which has been achieved by a careful balance of the elements.

The minimum PRE value for Sandvik SAF 2507 wirelines is 42.5.

Stress corrosion cracking

Sandvik SAF 2507 has excellent resistance to chloride induced stress corrosion cracking (SCC). Figure 8 clearly demonstrates that Sandvik SAF 2507 has better SCC resistance in chloride solutions in comparison with several duplex and austenitic alternative grades in the annealed condition.

There were no signs of SCC in Sandvik SAF 2507 up to 1000 ppm Cl-/300°C (572°F) and 10000 ppm Cl-/250°C (482°F).

The super-duplex stainless steel Sandvik SAF 2507 has a higher resistance to SCC in in sour environments in oil and gas production than lower alloyed duplex stainless steels. The partial pressure of hydrogen sulphide should not exceed 3 psi (0.20 bar).

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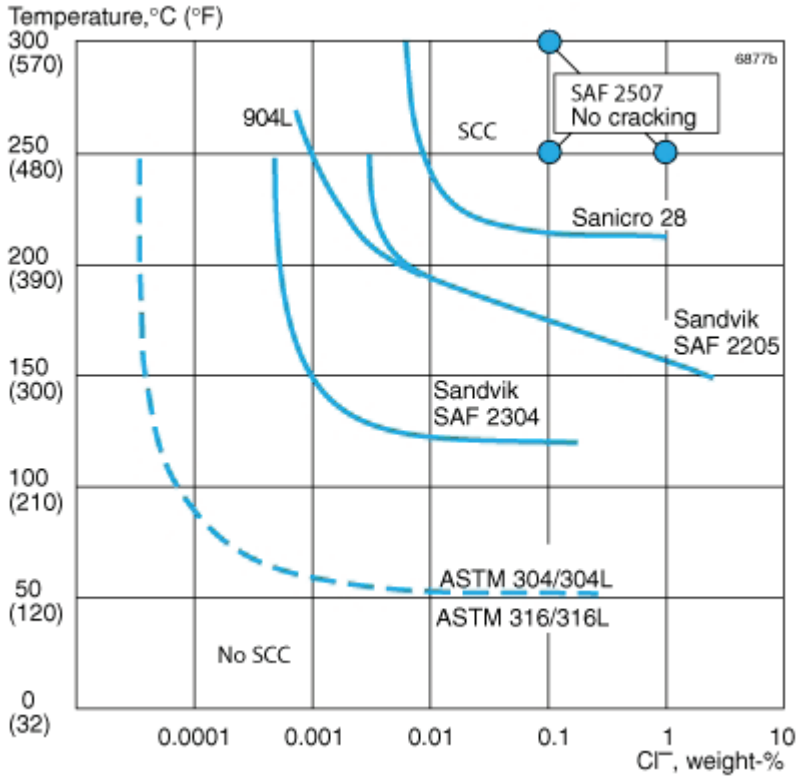

Figure 8. SCC resistance in oxygen-bearing (abt. 8 ppm) neutral chloride solutions. Testing time 1000 hours. Applied stress equal to proof strength at testing temperature.

Erosion corrosion

The mechanical properties combined with corrosion resistance give Sandvik SAF 2507 a good resistance to erosion corrosion. Testing in sand containing media has shown that Sandvik SAF 2507 has an erosion corrosion resistance better than corresponding austenitic stainless steels. Figure 9 below shows the relative mass loss rate of the duplex Sandvik SAF 2507, Sandvik SAF 2205 and an austenitic 6Mo+N type steel after exposure to synthetic seawater (ASTM D-1141) containing 0.025-0.25% silica sand at a velocity of 8.9-29.3 m/s (average of all tests is shown).

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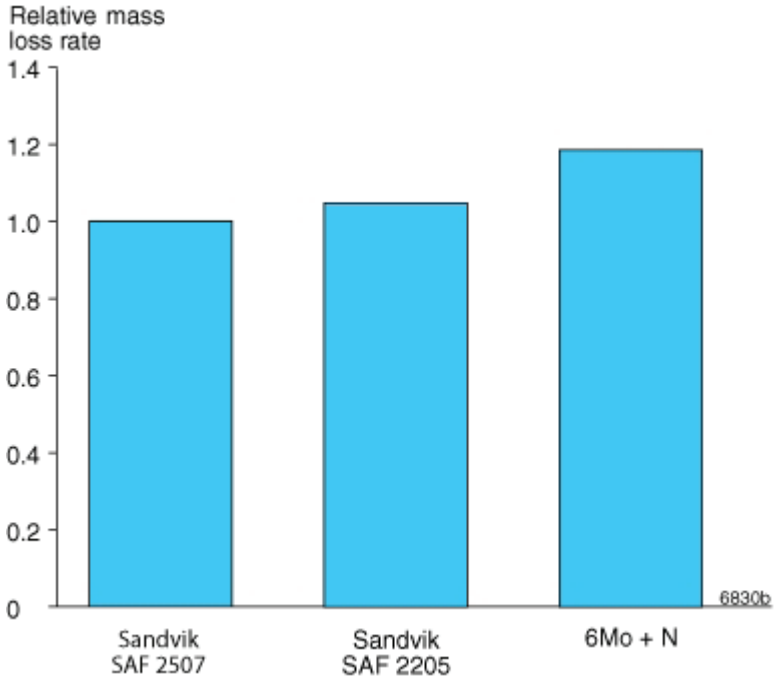

Figure 9. Relative mass loss rate after testing for resistance to erosion corrosion.

CORROSION FATIGUE

Duplex stainless steels which have a high tensile strength usually have a high fatigue limit and high resistance to both fatigue and corrosion fatigue.

The high fatigue strength of Sandvik SAF 2507 can be explained by its good mechanical properties, while its high resistance to corrosion fatigue has been proven by fatigue testing in corrosive media.

PHYSICAL PROPERTIES

Density: 7.8 g/cm^3, 0.28 lb/in^3

Specific heat capacity

Metric units		Imperial units	
Temperature, °C	J/(kg °C)	Temperature, °F	Btu/(lb°F)
20	490	68	0.12
100	505	200	0.12
200	520	400	0.12
300	550	600	0.13
400	585	800	0.14

THERMAL CONDUCTIVITY

Metric units, W/(m°C)

Temperature, °C	20	100	200	300	400
Sandvik SAF 2507	14	15	17	18	20
ASTM 316L	14	15	17	18	20

Imperial units, Btu/(ft h °F)

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Temperature, °F	68	200	400	600	800
Sandvik SAF 2507	8	9	10	11	12
ASTM 316L	8	9	10	10	12

THERMAL EXPANSION

Sandvik SAF 2507 has a coefficient of thermal expansion close to that of carbon steel. This gives Sandvik SAF 2507 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
Sandvik 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
Sandvik 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

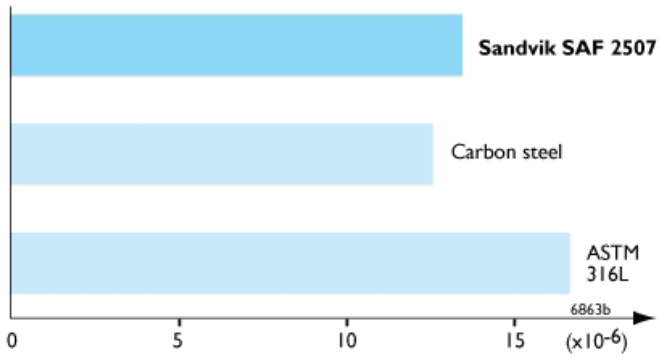

Figure 1. Thermal expansion, per°C (30-100°C, 86-210°F).

Resistivity

Temperature, °C	μΩm	Temperature, °F	μΩin
20	0.83	68	32.5
100	0.89	200	34.9
200	0.96	400	37.9
300	1.03	600	40.7
400	1.08	800	43.2

Modulus of elasticity, (x10^{3}). Metric units and imperial units

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

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Modulus of elasticity, (x10³). Metric units and imperial units

Temperature, °C	MPa	Temperature, °F	ksi
300	180	600	26.2

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