Alleima

Sanicro® 29 for OCTG

Tube and pipe, seamless

Datasheet

Den här sidan finns enbart på Engelska (This page is only available in English)

Sanicro® 29 is a high-alloy austenitic stainless steel (CRA) for OCTG downhole applications in particularly corrosive conditions. The grade is characterized by:

- Very good resistance to sulphide stress cracking and stress corrosion cracking (SCC) in H_2S environments
- Very high resistance to pitting and crevice corrosion
- Higher pitting resistance equivalent (PRE) than Sanicro® 28 (UNS N08028)

Sanicro® 29 is developed specifically for improved localized corrosion resistance where the environment contains high chloride concentrations, CO_2 and H_2S at high temperatures. Such an environment causes corrosion in lower alloyed materials. Sanicro® 29 offers a cost effective solution to such corrosion problems over the more expensive nickel alloys.

Standards

- UNS: N08029
- ISO: 13680 27-31-4

Product standards

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Seamless tubes for casing, tubing and coupling stock:	ISO 13680 PSL-1 and PSL-2A
	API 5CRA

Approvals

– NACE MR0175/ISO 15156-3 (Petroleum and natural gas industries - Materials for use in H_2S-containing environments in oil and gas production)

Chemical composition (nominal)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	Cu	N
≤0.020	≤0.7	<2.0	≤0.020	≤0.015	27	33.5	4.4	1.0	≤0.1

Applications

Sanicro® 29 is used for high strength downhole production tubing, casing, and liners in sour gas wells. This includes environments with high temperatures, high partial pressures of CO_2 and H_2S, and high chloride concentrations.

Corrosion resistance

Environments in sour wells, which commonly include high concentrations of hydrogen sulphide (H_2S), carbon dioxide (CO_2) and chlorides (Cl^-), are often very severe with respect to corrosion. However, the risk of corrosion attack can be significantly reduced by selecting a suitable material. In these environments, materials with high levels of nickel, chromium and molybdenum have proven to reduce the risk of corrosion. Sanicro® 29 has been specifically designed to optimize the contents of these elements for sour service corrosion resistance.

Pitting corrosion

Sanicro® 29 can withstand high temperatures in aggressive environments without pitting. A recognized method of ranking a material's susceptibility to localized corrosion is by means of the PRE number (Pitting Resistance Equivalent). This PRE number is based on the contents of chromium, molybdenum and nitrogen in the alloy according to the following formula:
PRE = %Cr + 3.3 × %Mo + 16 × %N

A PRE number is the relative measure of a material's ability to resist pitting corrosion in chloride containing environments. Sanicro® 29 has a minimum PRE number of 42, which confirms its high resistance to pitting corrosion when chlorides are present. For comparison, the minimum PRE number of Sanicro® 28 is shown in the table below.

Alloy	PRE (minimum values)
Sanicro® 29	42
Sanicro® 28	38

Critical pitting temperature (CPT) were determined on cold worked Sanicro® 28 per modified ASTM G150. The temperature of the test solution was started at 20°C, and heated at a rate of 1 °C/min. The tests were carried out in NaCl solutions of three chloride concentrations without pH adjusting; and also in 3 wt% Cl- with three fixed pH. The solution of 1.7 liter was purged with nitrogen during the test. The assessments were carried out at a potential of +634 mV vs. Ag/AgCl on triplicate specimens per test environment. The high CPT suggests the high pitting corrosion resistance of the material in the environments tested.

The CPT as the function of chloride as well as the function of pH are shown in Figure 1 and Figure 2 respectively. The results show a trend that CPT decreases with increasing chloride concentration whereas CPT increases with increasing pH of the solutions.

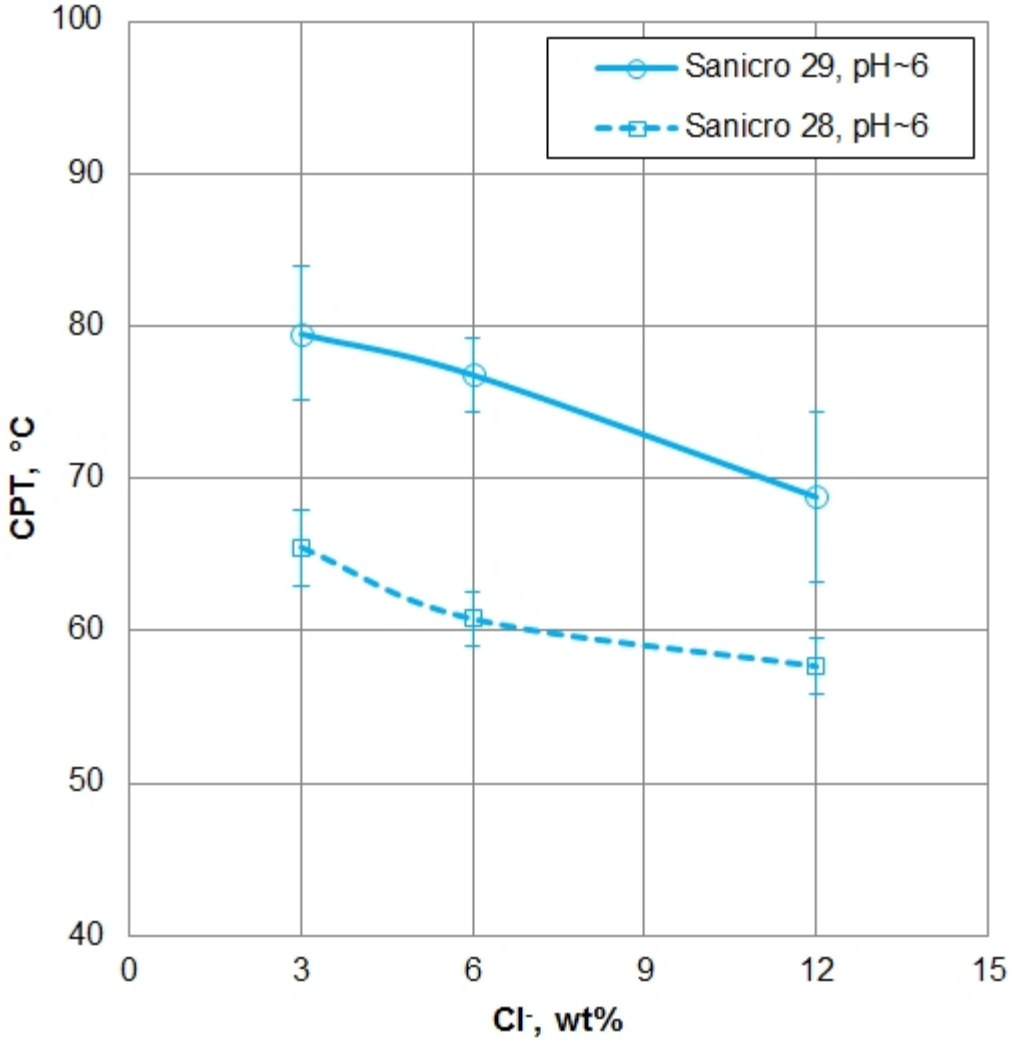

Figure 1. Critical pitting temperature (CPT) as a function of chloride concentrations for cold worked Sanicro® 29 and Sanicro® 28. The potential was +634 mV vs Ag/AgCl.

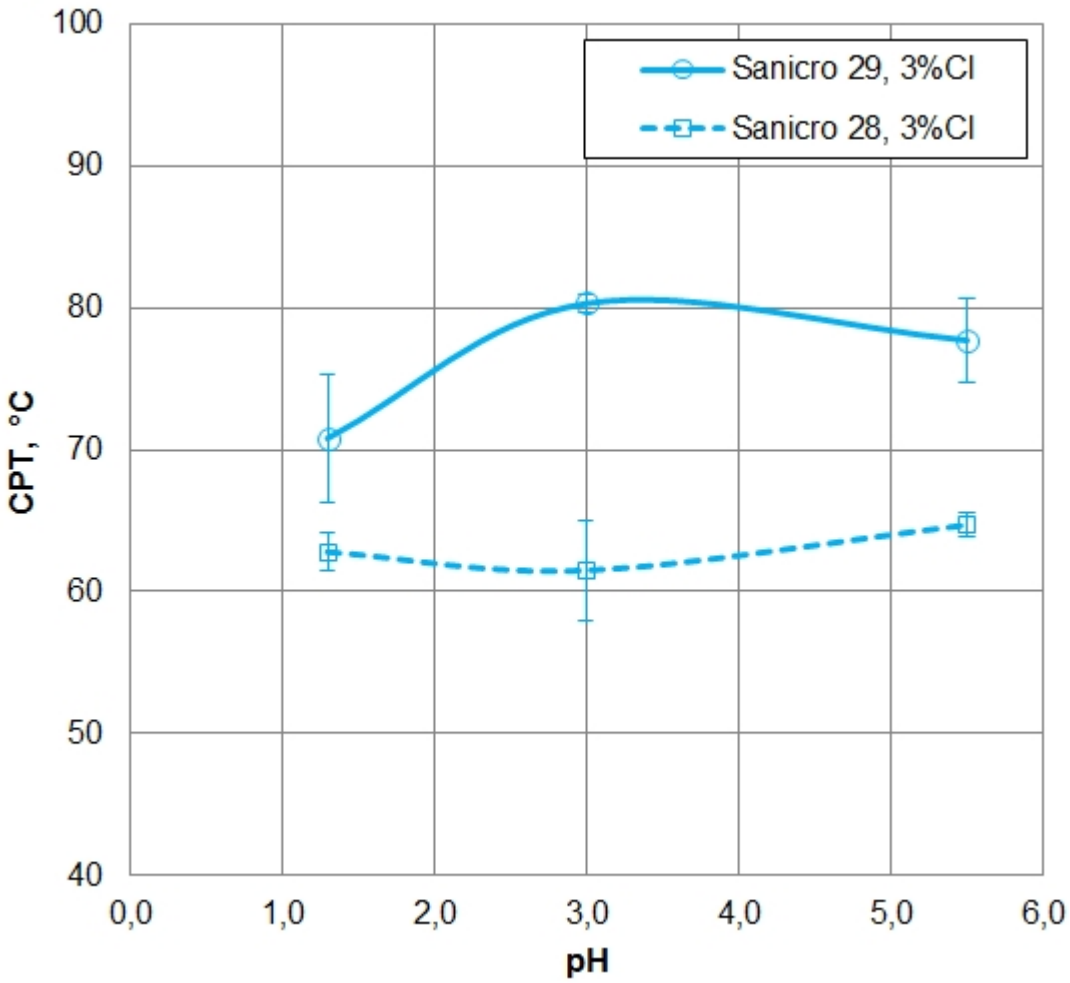

Figure 2. Critical pitting temperature (CPT) as a function of pH for cold worked Sanicro® 29 and Sanicro 28 in a 3% Cl- solution. The potential was +634 mV vs Ag/AgCl.

Stress corrosion cracking

Environmental assisted cracking, especially in the presence of hydrogen sulphide (H_2S), is one of the more serious forms of corrosion in sour environments. Failure of tubing as a result of environmental assisted cracking can occur rapidly without any warning. For that reason, the prevention of this form of corrosion must be considered when selecting tubing materials for sour wells.

According to ISO 15156-3 (2015), cold worked Sanicro® 29 belongs to type 4c material which can be safely used in the limited environmental combinations of temperature and H_2S in order to avoid the risk of SCC.

Laboratory testing data shows that cold worked Sanicro® 29 is not susceptible to SCC in sour environments even outside of the limits for 4c type materials.

Figure 3 illustrates SCC testing on Sanicro® 28 in Cl-H_2S-CO_2 environments with and without elemental sulfur compared to ISO 15156-3 limits for type 4c materials (under the green dashed line), type 4d materials (under the blue dashed line), and type 4e materials (under the red dashed line). The SCC testing has been performed on cold worked (minimum yield strength 110 ksi) Sanicro® 29 stressed at 100% actual yield strength (AYS) using tensile constant load per NACE TM 177 method A, as well as slow strain rate test (SSRT) per NACE TM0198 at strain rate of 4×10^{-6} in/in/sec. Sanicro® 29 showed good ductility in the tested sour environments with no failures.

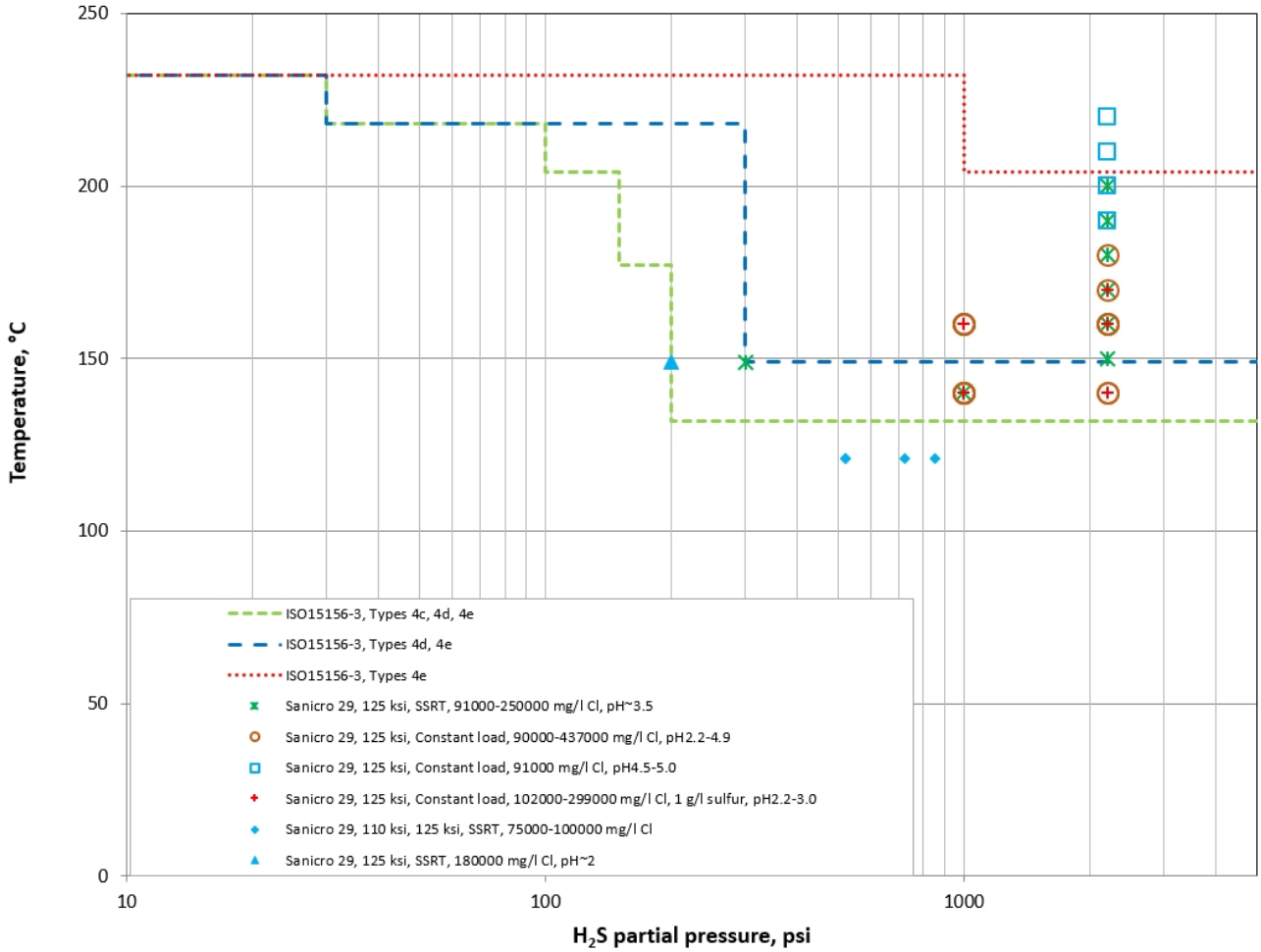

Figure 3: SCC testing data of cold worked Sanicro® 29 tube materials in sour environments in comparison with the ISO 15156-3 limits for 4c type materials. The SCC testing has been performed on Sanicro® 29 tube materials stressed at 100% actual yield strength (AYS) using tensile constant load per NACE TM0177 method A, as well as slow strain rate test (SSRT) per NACE TM0198 at strain rate of 4×10-6 in/in/sec. Sanicro® 29 showed good ductility in the tested sour environments with no failures.

Stress corrosion cracking tests have also been performed in the presence of elemental sulfur. Cold worked Sanicro® 29 tube with an $R_{p0.2}$ value of 910 MPa (132 ksi) has been tested. The tests were performed according to NACE TM0177, with tensile specimens stressed to 100% of the actual yield strength.

Temperature	pH_2S	pCO_2, psi	Chlorides (Cl^-)	Elemental sulfur	Stress corrosion cracking
°C (°F)	psi (MPa)	(MPa)	mg/l	g/l	
140 (284)	2200 (15.2)	1000 (6.9)	102000	1	No
160 (320)	2200 (15.2)	1000 (6.9)	102000	1	No
170 (338)	2200 (15.2)	1000 (6.9)	102000	1	No
160 (320)	2200 (15.2)	1000 (6.9)	299000	1	No

Fabrication

Sanicro® 29 tubes are supplied in the cold worked condition and are intended for use with threaded connections.

Forms of supply

Materials for oil and gas production

Cold hardened (cold worked) seamless tube and pipe

For production tubing, casing, liner, and coupling stock for downhole oil and gas applications, Sanicro® 29 is supplied cold hardened with high strength properties. (Sanicro® 29-110 ksi, -125 ksi)
Full details on sizes, finishes and mechanical properties are available on request.
Email: stog.smt@alleima.com

Heat treatment

Tubes for downhole oil and gas applications are delivered in the high strength, cold hardened condition. They are not annealed after cold working.

Mechanical properties

At 20°C (68°F)

Metric units and Imperial units

Grade	Proof strength		Tensile strength		Elong.	Hardness
	$R_{p0.2}$ [a)]		R_m		$A_{2"}$	HRC
	MPa	ksi	MPa	ksi	%	
Sanicro 29-110	760 - 965	110 - 140	≥795	≥115	≥11	≤35
Sanicro 29-125	860 - 1035	125 - 150	≥895	≥130	≥10	≤37

1 MPa = 1 N/mm^2
a) $R_{p0.2}$ corresponds to 0.2% offset yield strength.

The PSL-2 requirements in ISO 13680 can be fulfilled for certain products. Further information is available on request. Email:stog.smt@sandvik.com

At high temperatures

Sanicro® 29 cold worked material also displays very good mechanical properties at higher temperatures.

Metric units Imperial units

Temperature, °C	De-rating factor*	Temperature, °F	De-rating factor*
20	1.00	68	1.00
50	0.94	100	0.97
100	0.91	200	0.92
150	0.87	300	0.87
200	0.86	400	0.86

250	0.86	500	0.85

* Approximate yield strength at temperature is achieved by multiplying the corresponding de-rating factor and yield strength at 20°C (68°F).

Impact strength

Due to its austenitic microstructure, Sanicro® 29 has very good impact strength, both at room temperature and at lower temperatures. Tests have demonstrated that the steel readily fulfills the requirements in accordance with ISO 13680 (min. 40 J at -10°C (50°F)).

Physical properties

Physical properties of cold worked Sanicro® 29.
Density: 8.0 g/cm^3, 0.29 lb/in^3

Thermal conductivity

Metric units		Imperial units	
Temperature, °C	**W/(m °C)**	**Temperature, °F**	**Btu/(ft h °F)**
20	11	68	6
50	11	100	6.5
100	12	200	7
150	13	300	7.5
200	14	400	8
250	15	500	8.5
300	16	600	9

Specific heat capacity

Metric units		Imperial units	
Temperature, °C	**J/kg °C**	**Temperature, °F**	**Btu/lb °F**
20	460	68	0.11
50	465	100	0.11
100	480	200	0.11
150	490	300	0.12
200	495	400	0.12
250	505	500	0.12
300	515	600	0.12

Resistivity

Metric units		Imperial units	
Temperature, °C	**μΩm**	**Temperature, °F**	**μΩin.**
20	1.01	68	39.7
100	1.01	200	39.7
150	1.00	300	39.2
200	1.00	400	39.5
250	1.04	500	41.3
300	1.11	600	44.5

Thermal expansion, mean values in temperature ranges ($\times 10^{-6}$)

Metric units		Imperial units	
Temperature, °C	**Per °C**	**Temperature, °F**	**Per °F**
30-50	13	86-100	7
30-100	14.5	86-200	8
30-150	15	86-300	8.5
30-200	15	86-400	8.5
30-250	15	86-500	8.5
30-300	15	86-600	8.5

Modulus of elasticity ($\times 10^{3}$)

Metric units		Imperial units	
Temperature, °C	**MPa**	**Temperature, °F**	**ksi**
20	195	68	28.3
100	190	200	27.6
200	182	400	26.3
300	174	600	25.1

Poisson's ratio

The Poisson's ratio for Sanicro® 29 at room temperature is 0.30.

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.

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