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Sanicro 31HT

(Tube and pipe, seamless)

Sanicro 31HT is an austenitic nickel-iron-chromium alloy characterized by:

- High creep strength
- Very good resistance to oxidation
- Good resistance to combustion gases
- Very good resistance to carburization
- Good resistance to nitrogen absorption
- Good structural stability at high temperatures
- Good weldability

Sanicro 31HT can be used at temperatures up to about 1100°C (2010°F). In order to have the best ductility, it should be used above 700°C (1290°F).

The grade can also be supplied in a modified version for use in the temperature range between about 550 and 700°C (1020-1290°F). The chemical composition and heat treatment of this version have been adapted for the highest possible creep ductility. Contact us for further information.

Sanicro 31HT is not generally used under wet corrosive conditions. For this type of environment, we recommend Sanicro 30, which is specially adapted for wet corrosive conditions up to about 550°C (1020°F).

STANDARDS

- UNS N08810/N08811
- EN number 1.4959
- EN name X8NiCrAlTi32-21
- W.Nr. 1.4959*/1.4876**
- DIN X 10 NiCrAlTi 32 20*/X 5 NiCrAlTi 31 20**/X 10 NiCrAlTi 32 20 H***

Product standards
Seamless tube and pipe

- ASTM A213, A312, B163, B407
- EN 10216-5
- *) DIN 17459
- **) SEW 470

Approvals
Approved for use in ASME Boiler and Pressure Vessel Code, Section I and VIII, Division 1, Case 1987-2 and Section I, case 1325-16.
***) VdTÜV-Werkstoffblatt 434 (Temp. >700°C)

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P max	S max	Cr	Ni	Ti	Al	Fe
0.07	0.6	0.6	0.015	0.010	20.5	30.5	0.5	0.5	bal.

By agreement the material can be delivered with a maximum cobalt content of 0.020%.

FORMS OF SUPPLY

Seamless tube and pipe - finishes and dimensions
Seamless tube and pipe in Sanicro 31HT is supplied in dimensions up to 260 mm outside diameter in the solution annealed and white-pickled condition.
Pigtail tubes, which are solution annealed after bending are supplied unpickled.

Stock sizes
Sanicro 31HT is stocked in sizes from 3/8" to 2" outside diameter. Additional data concerning sizes and finishes is available on request from your nearest Sandvik office.

Other forms of supply
Welding wire
Covered electrodes
Billets

MECHANICAL PROPERTIES

At 20°C (68°F)

METRIC UNITS

Proof strength		Tensile Strength	Elong.		Hardness
$R_{p0.2}$ [1]	$R_{p1.0}$ [1]	R_m	A [2]	$A_{2"}$	HRB
MPa	MPa	MPa	%	%	
min	min		min	min	max
172	200	500-700	35	30	90

1 MPa = 1 N/mm^2

IMPERIAL UNITS

Proof strength		Tensile Strength	Elong.		Hardness
$R_{p0.2}$ [1]	$R_{p1.0}$ [1]	R_m	A [2]	A	HRB
ksi	ksi	ksi	%	%	
min	min		min	min	max
25	29	73-102	35	30	90

1) $R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% offset and 1.0% offset yield strength, respectively.
2) Based on $L_0 = 5.65 \sqrt{S_0}$ where L_0 is the original gauge length and S_0 the original cross-sectional area.

At high temperatures

METRIC UNITS

Temperature	Proof strength		Tensile strength
	$R_{p0.2}$	$R_{p1.0}$	R_m
°C	MPa	MPa	MPa
	min.	min.	min.
100	150	175	415
200	130	155	385
300	120	145	375
400	110	135	370
500	105	125	360
600	95	115	345
700	90	110	295

IMPERIAL UNITS

Temperature	Proof strength		Tensile strength
	$R_{p0.2}$	$R_{p1.0}$	R_m
°F	ksi	ksi	ksi
	min.	min.	min.
200	22.0	25.7	60.7
400	18.9	22.5	55.9
600	17.1	20.8	54.3
800	15.8	19.2	53.3
1000	14.6	17.6	51.4
1200	13.5	16.4	46.6
1400	12.8	15.2	40.9

Creep strength

Metric units Imperial units

CREEP RUPTURE STRENGTH 1)

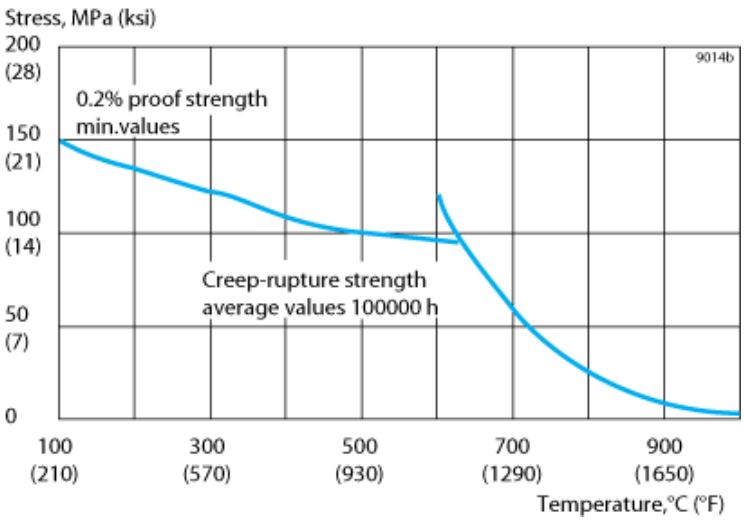
Temperature, °C	MPa	Temperature, °F	ksi
600	127	1100	19.2
625	106	1150	15.9
650	88	1200	12.9
675	71	1250	10.2
700	57	1300	8.0
750	40	1400	5.4
800	27	1500	3.6
850	19	1600	2.4
900	13	1700	1.6
950	8.6	1800	1.0
1000	6.2	1900	0.7
1050	4.0	2000	0.4
1100	2.7		

1) 100 000 h, average values

The above values generally exceed the corresponding data contained in ASME Code Case 1987 and VdTÜV-Wb 434.

The temperature above which design calculations are based on creep rupture strength instead of 0.2% proof strength can be read off from Fig. 1.

This shows that in the case of Sanicro 31HT, the temperature is about 650°C (1200°F).



PHYSICAL PROPERTIES

Density: 7.9 g/cm^3, 0.29 lb/in^3

SPECIFIC HEAT CAPACITY

Temperature, °C	J/kg °C	Temperature, °F	Btu/lb °F
20	470	68	0.11
100	495	200	0.12
200	520	400	0.12
300	545	600	0.13
400	570	800	0.14
500	585	1000	0.14
600	605	1200	0.15
700	615	1400	0.15
800	630	1600	0.15
900	640	1800	0.15
1000	655	2000	0.16
1100	665		

THERMAL CONDUCTIVITY

Temperature, °C	W/m °C	Temperature, °F	Btu/(ft h °F)
20	12	68	6.5
100	13	200	7.5
200	16	400	9
300	17	600	10
400	19	800	11.5
500	21	1000	12.5
600	22	1200	13.5
700	24	1400	14
800	25	1600	15
900	26	1800	16
1000	28	2000	16.5
1100	29		

THERMAL EXPANSION [1)]

Temperature, °C	Per °C	Temperature, °F	Per °F
30-100	15	86-200	8.5
30-200	16	86-400	9
30-300	16.5	86-600	9
30-400	16.5	86-800	9.5
30-500	17	86-1000	9.5
30-600	17	86-1200	9.5
30-700	17.5	86-1400	10
30-800	18	86-1600	10
30-900	18	86-1800	10.5
30-1000	18.5		

1) Mean values in temperature ranges ($x10^{-6}$)

RESISTIVITY

Temperature, °C	μΩm	Temperature, °F	μΩin.
20	0.99	68	38.9
100	1.01	200	39.9
200	1.03	400	40.5
300	1.05	600	41.4
400	1.08	800	43.0
500	1.12	1000	45.1
600	1.18	1200	46.9
700	1.21	1400	48.0
800	1.22	1600	48.3
900	1.23	1800	48.7
1000	1.24		

MODULUS OF ELASTICITY [1)]

Temperature, °C	MPa	Temperature, °F	ksi
20	200	68	29.0
200	190	400	27.5
400	175	800	25.0
600	160	1200	22.5
800	145	1400	21.5
1000	130	1800	19.0

1) ($x10^3$)

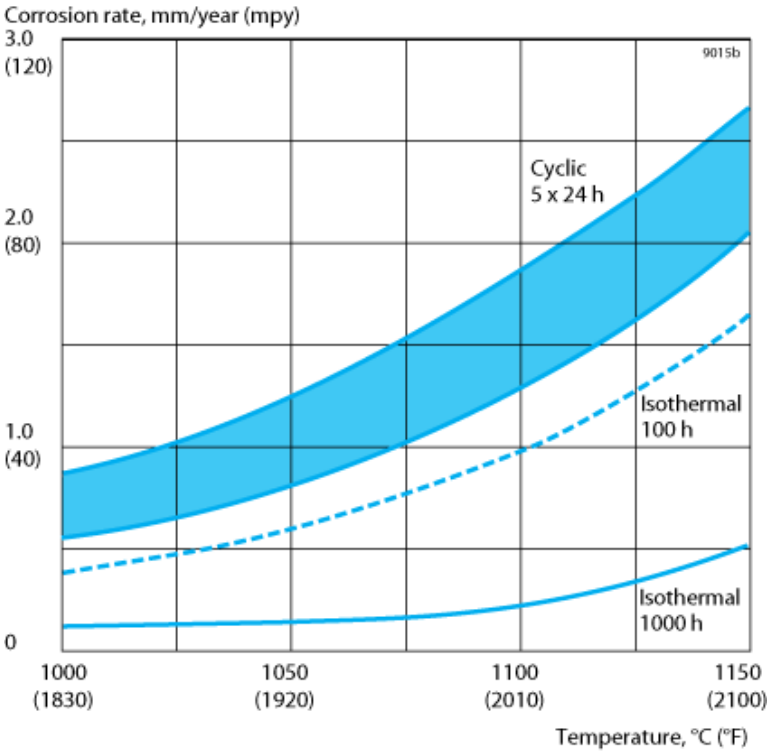
CORROSION RESISTANCE

Air
Sanicro 31HT is highly resistant to oxidation, both at constant and at cyclically varying temperatures. See Fig. 2. The service temperature in air should not exceed about 1100°C (2010°F).

Isothermal oxidation at 1100°C (2010°F) for 100h results in a corrosion rate of about 0.8 mm/year (32 mpy) and exposure at the same temperature for 1000 h causes about 0.2 mm/year (8 mpy). This corresponds to an oxide layer of about 0.1 mm (0.004 in.) thickness after the first year, in accordance with the law of parabolic growth.

Cyclic oxidation at 1100°C (2010°F) for 5 x 24 h, with cooling to room temperature every 24 hours gives a corrosion rate of less than 1.9 mm/year (75 mpy). The corresponding corrosion rate at 1150°C (2100°F) is less than 2.3 mm/year (92

mpy). The oxidation process is accelerated by temperature fluctuations and also by plastic deformation, e.g. creep.



Carburizing atmosphere
Carburization can occur when a material comes into contact with hot gases with high carbon activity, e.g. hydrocarbons. The degree of carburization depends on the composition of the material and on the carbon and oxygen contents. Consequently, a protective oxide is easily formed on the surface of the material, and this grade has, therefore, good resistance to carburization in carbon monoxide and carbon dioxide. See Fig. 3.

The material carburizes in gases with low oxygen content, but the depth of penetration is limited by the high content of chromium and nickel. Fig. 4 shows carburization in a mixture of 10% methane and 90 % argon. The figure also indicates to the influence of surface finish on carburization resistance.

In alternately oxidizing and carburizing atmospheres, alloys of high nickel content are sometimes attacked by what is known as "green rot". Sanicro 31HT has good resistance to this type of attack.

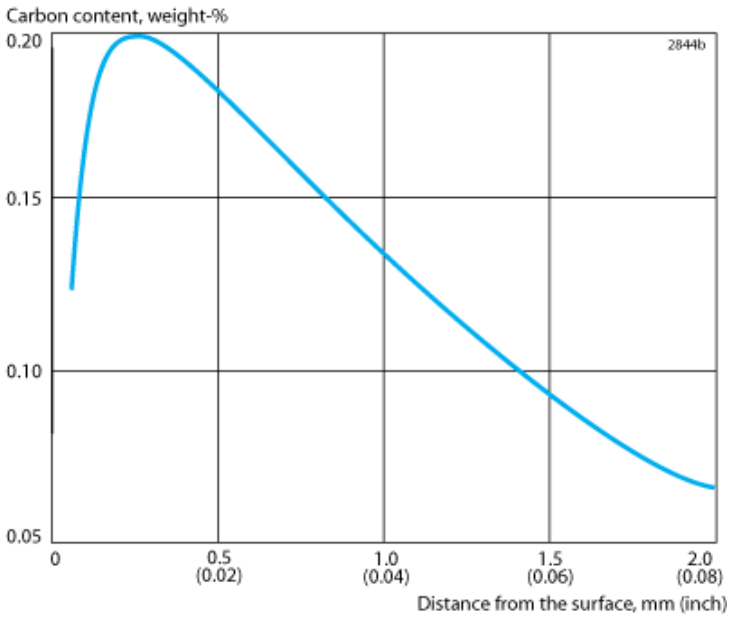


Figure 3. Carburization of a cylindrical test piece after exposure in charcoal, with barium carbonate added, for 500 h 1000°C (1830°F).

Other gaseous atmospheres
In addition to its very good resistance to oxidation and carburization, Sanicro 31HT also has good resistance to combustion gases and other aggressive gaseous mixtures. Its

maximum service temperature in a sulphurous atmosphere, however, is lower than in air, and is mainly determined by the oxygen and sulphur contents of the gas.

This grade can also be used in synthesis gas (ammonia synthesis) at high process temperatures since the material has a resistance to nitrogen absorption, which is far superior to that of the ordinary 18/8 grades, and in gases containing chlorides (e.g. EDC) up to 650 °C (1200 °F) if the Ti+Al content is restricted to 0.7 % (see "Structural stability").

Salt melts
Sanicro 31HT has good resistance to cyanide melts and neutral salt melts at high temperatures.

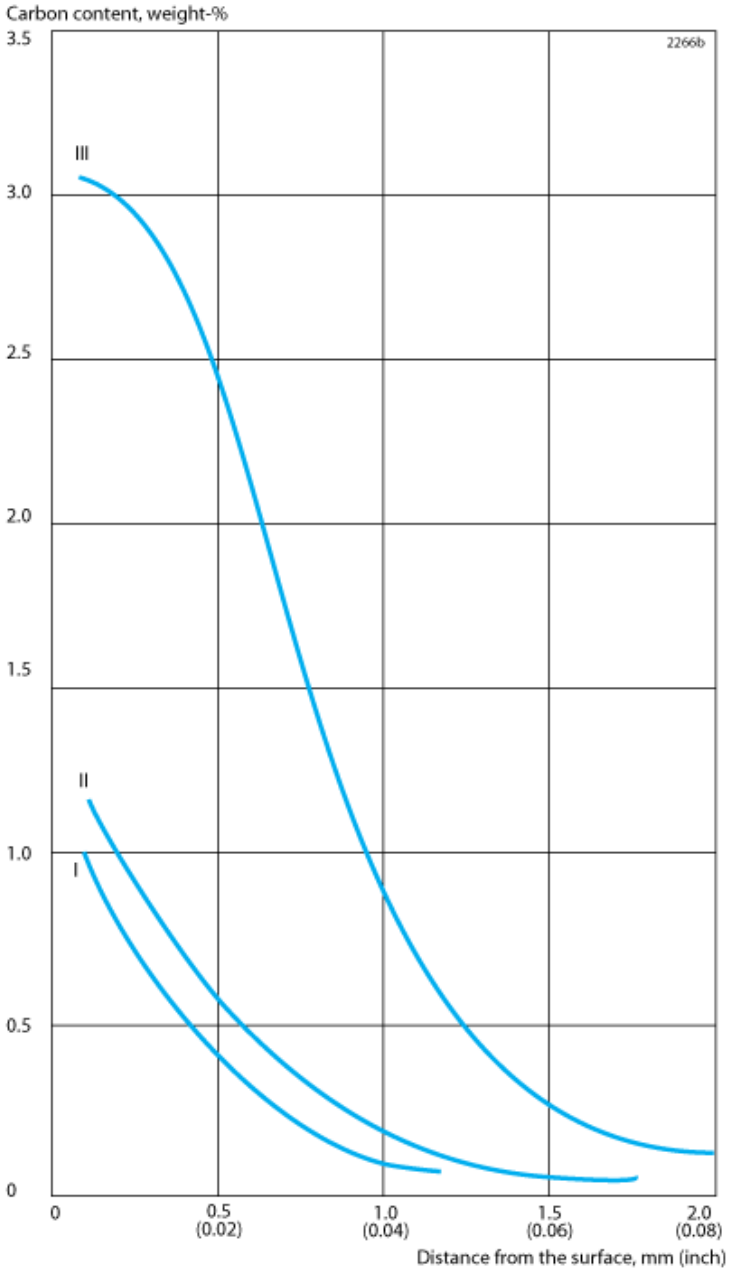


Figure 4. Carburization of samples with various surface finishes in 10% CH₄ + 90% Ar for 1000h at 900°C (1650°F).
I Electrolytically polished surface
II Machined surface
III Surface pre-oxidized in air for 5 hours at 1000°C (1830°F).

Wet corrosion
Sanicro 31 HT has roughly the same resistance as Alloy 800 to general corrosion and pitting. Thanks to the high nickel content its resistance to stress corrosion is good.

Owing to its relatively high carbon content and the heat treatment applied, Sanicro 31HT can be prone to intergranular corrosion. This problem can be disregarded where high temperature operation is concerned, but should be observed in cases when the alloy is exposed to corrosive condensates or pickling solutions.

STRUCTURAL STABILITY

Thanks to its high nickel content, Sanicro 31HT shows very little tendency to precipitate embrittling phases.

Within the 600-700°C (1110-1290°F) temperature range, an intermetallic phase, gamma prime, Ni_3 (Al, Ti), is precipitated, which reduces the ductility of the alloy. To avoid this precipitation some specifications prescribe maximization of the (Ti + Al) content.

Sandvik supplies a modified version of Sanicro 31HT in which chemical composition and heat treatment have been adapted to meet this requirement and give the highest possible creep ductility.

HEAT TREATMENT

Tubes are delivered in the heat treated condition. If another heat treatment is needed after further processing the following is recommended:

Solution annealing
1150-1200°C (2100-2190°F), 10-30 minutes, rapid cooling in air or water.

WELDING

The weldability of Sanicro 31HT is good. Suitable welding methods are manual metal-arc welding with covered electrodes and gas shielded arc welding, with the TIG and MIG methods as first choice. Preheating and post-weld heat treatment are not necessary.

The welding of high nickel materials calls for special cleanliness. Joint surfaces and filler metals have to be free from grease, dirt and other impurities. If necessary, the area to be welded should be cleaned with a suitable solvent, e.g. acetone.

Since the material has low thermal conductivity and high thermal expansion, welding should be carefully planned in advance, so that distortion of the welded joint can be kept under control.

Welding of fully austenitic steels often entails the risk of hot-cracking in the weld metal, particularly if the weldment is under constraint. To reduce the cracking risk, welding should be carried out with a low heat input.

As filler metal for **gas shielded arc welding**, we recommend Sanicro 72HP wire electrodes and rods. **In manual metal-arc welding** Sanicro 71 covered electrodes are recommended. These filler metals have a high nickel content and, therefore, lower creep strength than the parent metal at temperatures exceeding about 800°C (1470°F), and its resistance to sulphurous media is inferior in certain cases. Other filler materials with higher creep strength and better resistance to sulphidation are available and can be recommended on request.

BENDING

Annealing after cold bending is not normally necessary, but this should be reviewed depending on the degree of bending and the operating conditions. Figure 5 shows the connection between the degree of deformation, service temperature and creep rupture strength at 100 000 h for Sanicro 31HT. The curves are based on data from creep tests at 700, 800 and 900°C (1290, 1470 and 1650°F respectively). For degrees of deformation and service temperatures exceeding the curve for 100% creep strength, we recommend solution annealing after cold working in order to achieve the highest possible creep strength. Further information can be supplied on request.

Hot bending is carried out at 1100-850°C (2010-1560°F) and should be followed by solution annealing.

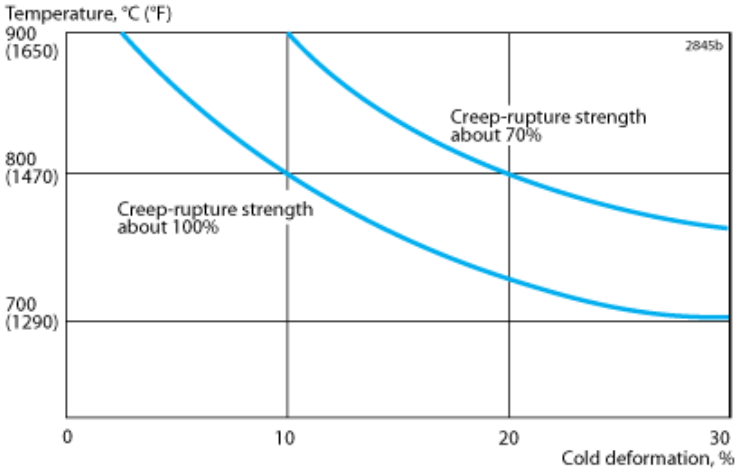


Figure 5. Connection between degree of deformation, service temperature and creep rupture strength at 100 000 h for Sanicro 31HT.

APPLICATIONS

Sanicro 31HT has high strength and structural stability at high temperature and very good ductility. The most common applications for this grade are :

- Pigtails and headers in plants for the production of synthetic gas for ammonia, methanol and town gas
- Furnace tubes in the production of vinyl chloride, ethylene and radiant tubes
- Heat exchanger tubing for fluidized bed combustion
- Muffle tubes in continuous wire annealing furnaces
- Thermocouple protection tubes

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.