SANDVIK

SANDVIK 2RE69
ROHRE, NAHTLOS

DATENBLATT

Sandvik 2RE69 is a fully austenitic stainless steel with extra low carbon and impurity contents. The grade is characterized by:

- Excellent resistance to corrosion in ammonium carbamate and nitric acid
- Excellent resistance to intergranular corrosion
- High resistance to pitting and crevice corrosion
- Good weldability

Sandvik 2RE69 has been developed primarily to cope with the severe corrosive conditions existing in the urea industry. The longest service life is so far 35 years, which confirms the optimal properties for the grade Sandvik 2RE69 in urea strippers.

STANDARDS

- S31050
- 1.4466
- X1CrNiMoN25-22-2
- 1.4466* 1), 1.4465* 2)
- X 2 CrNiMo 25 22 2* 1), X 1/CrNiMoN 25 25 2* 2)
- Z 1 CND25.22AZ

* Obsolete. Replaced by EN.

1) Appearing in TÜV Wien-Werkstoffblatt 093
2) Appearing in SEW400

Urea specifications issued by:

- Stamicarbon
- Saipem
- Kellogg
- Urea Casale

Product standards

- ASTM A213, A312
- EN 10216-5
- SEW 400

Approvals

- Approved by the American Society of Mechanical Engineers (ASME) for use in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2

Aktualisiertes Datenblatt 20.09.2019 13:53:37 (ersetzt alle vorherigen Ausgaben)

– ASME Code Case 2038-5 for forgings
– TÜV Wien-Werkstoffblatt 093

CHEMICAL COMPOSITION (NOMINAL)

Chemical composition (nominal) %

C	Si	Mn	P	S	Cr	Ni	Mo	N
≤0.020	≤0.4	1.7	≤0.015	≤0.010	25	22	2.1	0.12

APPLICATIONS

Sandvik 2RE69 is used successfully in all critical high-pressure units of modern urea processes, such as:

Stripper tubes	Stamicarbon, Montedison IDR
Outer layer of bimetallic (stripper tubes)	Saipem
Ferrules	All processes
Carbamate condensers	All processes
Decomposers	Montedison
Reactor coils	UTI

Sandvik 2RE69 has also found extensive use in other corrosive environments in fertilizer plants, such as:

– Nitric acid cooler/condensers cooled with polluted cooling water
– Heating coils and pipe in NPK plants – Norsk Hydro process

CORROSION RESISTANCE

General corrosion

Sandvik 2RE69 was originally developed for stripper tubes used in the production of urea. Practical experience has confirmed its excellent corrosion resistance in urea/carbamate solutions at high pressures and temperatures.

Sandvik 2RE69 is also highly resistant to inorganic acids, as illustrated by the iso-corrosion diagram for nitric acid, Figure 1.

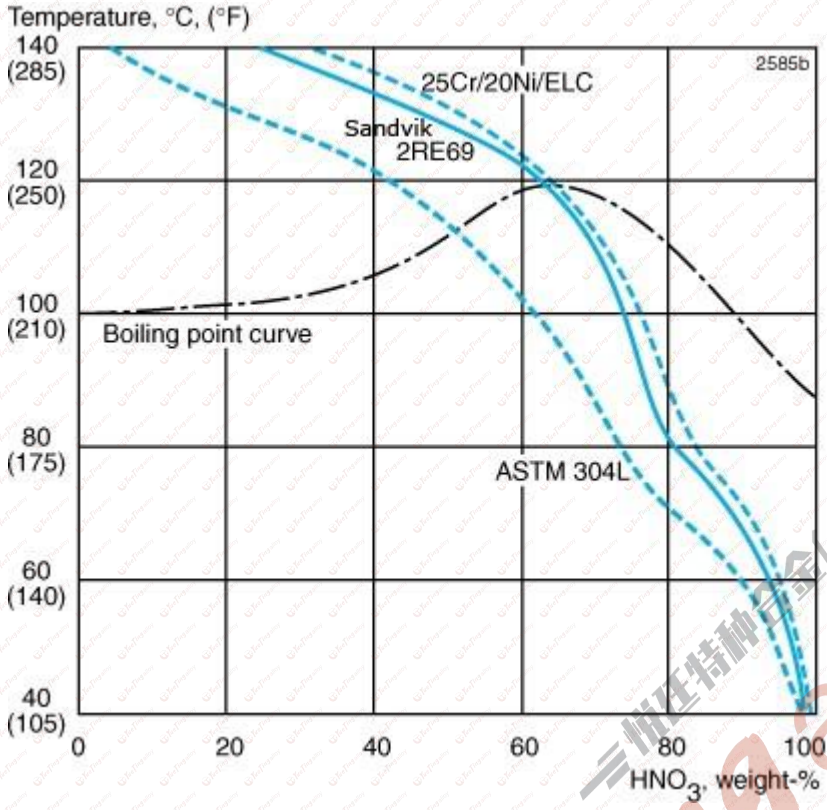

Figure 1. Iso-corrosion diagram for Sandvik 2RE69, Sandvik 2RE10 (25 Cr/20Ni/ELC) and ASTM 304L in natural aerated nitric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy).

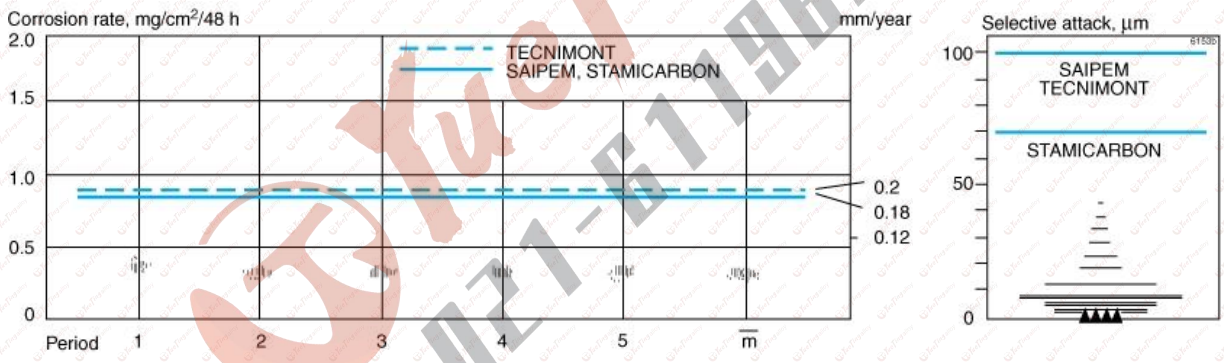

Figure 2. Statistical evaluation of Huey tests for Sandvik 2RE69. As can be seen from the figure to the right, the selective attack values for Sandvik 2RE69 are typically below 10 microns (µm), i.e. well below licensors' maximum values.

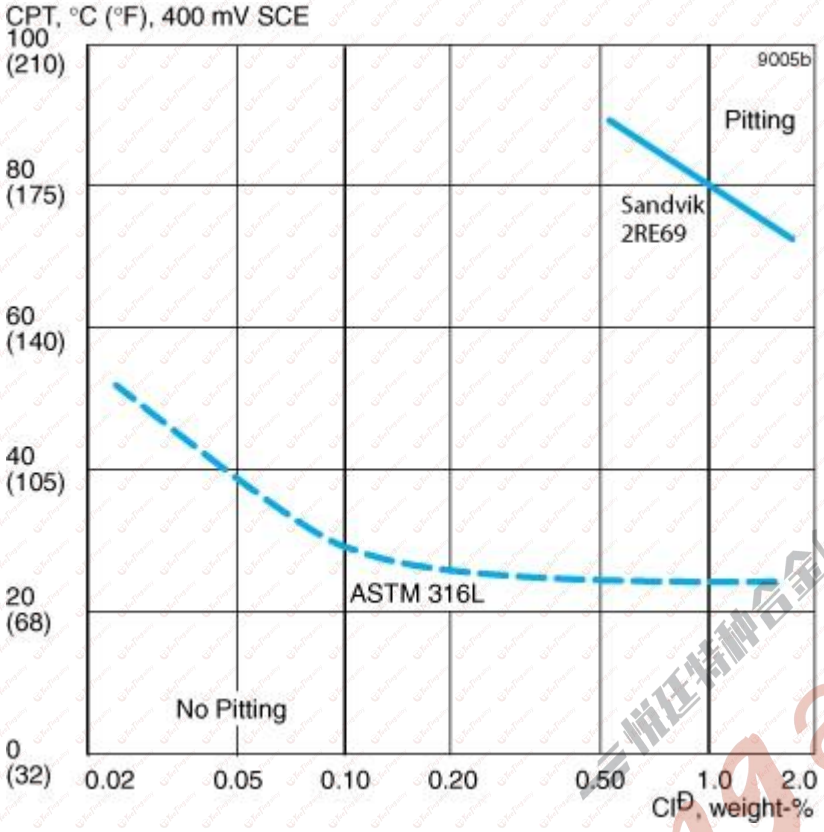

Figure 3. Critical pitting temperature (CPT) for Sandvik 2RE69 and ASTM 316L in neutral chloride solutions (potentiostatic determination at +400 mV SCE).

Intergranular corrosion

Sandvik 2RE69 is highly resistant to intergranular corrosion after welding. Huey test values for TIG welded specimens are typically below 0.12 mm/year for unsensitized material (4.8 mpy, 0.66 µm/48 h).

A statistical evaluation of Huey tests, as specified in the urea specifications, is shown in Figure 2. A maximum value of 0.12 mm/year (4.8 mpy, 0.66 µm/48 h) can be guaranteed for straight Sandvik 2RE69 tubes in the 'as delivered' condition. Max. 20 µm (8 mils) selective attack is similarly guaranteed.

Pitting and crevice corrosion

Sandvik 2RE69 has very good resistance to pitting, as illustrated in Figure 3, and is also far more resistant to crevice corrosion than ASTM316L.

Stress corrosion cracking (SCC)

Conventional austenitic stainless steels of type ASTM 304 and 316 are susceptible to stress corrosion cracking (SCC) in chloride-bearing solutions at temperatures exceeding about 60°C (140°F). The higher nickel content makes Sandvik 2RE69 slightly more resistant, as assessed in laboratory tests, see Figure 4.

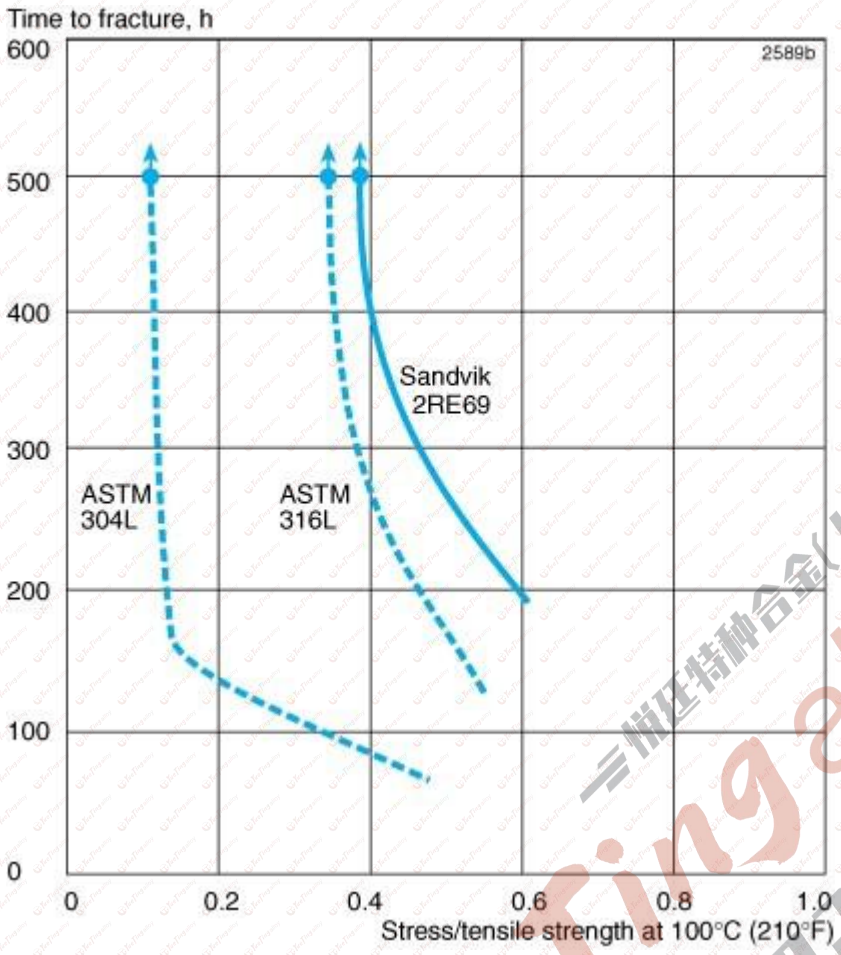

Figure 4. Results of SCC tests on Sandvik 2RE69, ASTM 316L and 304L in aerated 40% CaCl₂ at 100C (210F).

Erosion corrosion

The good mechanical strength of Sandvik 2RE69 makes it resistant to erosion-corrosion. Ferrules for urea strippers are one application where this property is utilized.

FABRICATION

Bending

The excellent formability of Sandvik 2RE69 permits cold bending to small bending radii. Annealing is not normally necessary after cold bending. Heat treatment, if any, should take the form of solution annealing, see under 'Heat treatment'.

Hot bending is carried out at 1100–850°C (2010–1560°F), usually without subsequent heat treatment.

Expanding

Sandvik 2RE69 tubes can be expanded into tube sheets in the same way as tubes of austenitic stainless steel of type ASTM 316L.

Machining

The chip removing machining of stainless steels always requires an adjustment of cutting data and machining method to give satisfactory results. When turning is undertaken with carbide tipped tools, the cutting speed should be reduced by 30% for finish machining and 60% for rough machining compared with the cutting speeds applied for ASTM 316L. Much the same applies to other operations. If high speed steel tools are used, the cutting speed should be reduced by 20 % compared with the cutting speeds applied for ASTM 316L.

Sandvik can provide detailed recommendations for the choice of tools and cutting data. Data to be selected as

for grade Sanmac 316/316L, taking into account the above comments.

FORMS OF SUPPLY

Sandvik 2RE69 seamless tube and pipe is supplied in dimensions up to 355 mm (14.0 in.) outside diameter in the solution annealed and white pickled condition, or solution annealed by a bright annealing process. U-tubes can be supplied on request.

Other forms of supply

– Urea high-pressure pipe fittings and flanges
– Bar steel
– Plate and sheet
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HEAT TREATMENT

If heat treatment is needed after further processing the following is recommended.

Solution annealing
1070–1120°C (1960–2050°F), 5–15 minutes, depending on size, followed by rapid cooling in water or air.

MECHANICAL PROPERTIES

The strength values stated refer to tube and pipe. Lower values may apply to bar, plate, sheet and forgings.

Metric units, at 20°C

Proof strength		Tensile strength	Elong.	
$R_{p0.2}$ a)	$R_{p1.0}$ a)	R_m	A_b b)	A2"
MPa	MPa	MPa	%	%
≥270	≥300	580–780 c)	≥30 c)	≥25

1 MPa = 1 N/mm²

Imperial units, at 68°F

Proof strength		Tensile strength	Elong.	
$R_{p0.2}$ a)	$R_{p1.0}$ a)	R_m	A_b b)	A2"
MPa	MPa	MPa	%	%
≥39	≥43	84–113 c)	≥30 c)	≥25

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-sectional area.
c) Requirements according to EN 1.4466, W.-Nr. 1.4465 and AFNOR can be fulfilled on request.

Impact strength

Due to its austenitic microstructure, Sandvik 2RE69 has very good impact strength both at room temperature and at cryogenic temperatures.

Tests have demonstrated that the steel fulfils the requirements of European standards EN 13445-2 (UFPV-2) ((min. 60 J (44 ft-lb) at -270°C (-455°F)) and
EN 10216-5 (min. 60 J (44 ft-lb) at -196°C (-320°F)).

Hardness (HRB): max. 95

At high temperatures

Metric units

Temperature	Proof strength	Tensile strength

°C	$R_{p0.2}$	$R_{p1.0}$	R_m
	MPa	MPa	MPa
	min.	min.	min.
50	250	285	555
100	230	260	530
150	215	245	510
200	200	230	500
250	190	215	490
300	175	205	480
350	165	195	470
400	155	185	460
450	145	175	455
500	140	170	450

Imperial units

Temperature	Proof strength		Tensile strength
°F	$R_{p0.2}$	$R_{p1.0}$	R_m
	ksi	ksi	ksi
	min.	min.	min.
200	33.5	38	77.5
400	29	33	72.5
600	25	39	69
800	21.5	26	66.5
900	20.5	25	65.5

PHYSICAL PROPERTIES

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

Relative magnetic permeability
at 6400–55700 A/m: 1.003

Thermal conductivity

Temperature, °C	W/m °C	Temperature, °F	Btu/ft h °F
20	13	68	7.5
100	15	200	8.5
200	17	400	9.5
300	19	600	11
400	21	800	12.5
500	23	1000	13.5
600	25	1200	14.5
700	26	1300	15

Specific heat capacity

Temperature, °C	J/kg °C	Temperature, °F	Btu/lb °F
20	485	68	0.12
100	505	200	0.12
200	540	400	0.13
300	565	600	0.14
400	585	800	0.14
500	605	1000	0.15
600	615	1200	0.15
700	625	1300	0.15

Thermal expansion, **mean values in temperature ranges (x10^{-6})**

Temperature, °C	Per °C	Temperature, °F	Per °F
30–100	15.5	86–200	8.5
30–200	16	86–400	9
30–300	16.5	86–600	9
30–400	17	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

Modulus of elasticity, **(x10^{3})**

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
400	166	800	23.8
500	158	1000	22.5

WELDING

The weldability of Sandvik 2RE69 is good. Welding must be carried out without preheating, and normally there is no need for any subsequent heat treatment. Suitable methods of fusion welding are manual metal-arc welding (MMA/SMAW) and gas-shielded arc welding, with the TIG/GTAW method as first choice.

In common with all fully austenitic stainless steels, Sandvik 2RE69 has low thermal conductivity and high thermal expansion. Welding plans should therefore be carefully selected in advance, so that distortions of the welded joint are minimized. If residual stresses are a concern, solution annealing can be performed after welding.

For Sandvik 2RE69, heat-input of <1.0 kJ/mm and interpass temperature of <100°C (210°F) are recommended. A string bead welding technique should be used.

Recommended filler metals

TIG/GTAW or MIG/GMAW welding

ISO 14343 S 25 22 2 N L (e.g. Exaton 25.22.2.LMn)

MMA/SMAW welding

ISO 3581 E 25 22 2 N L B (e.g. Exaton 25.22.2.LMnB)

ISO 14343 S 25 22 2 N L wire or strip electrodes are recommended for overlay welding of tube sheets and high-pressure vessels in cases where corrosion resistance, equal to that of Sandvik 2RE69, is required.

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