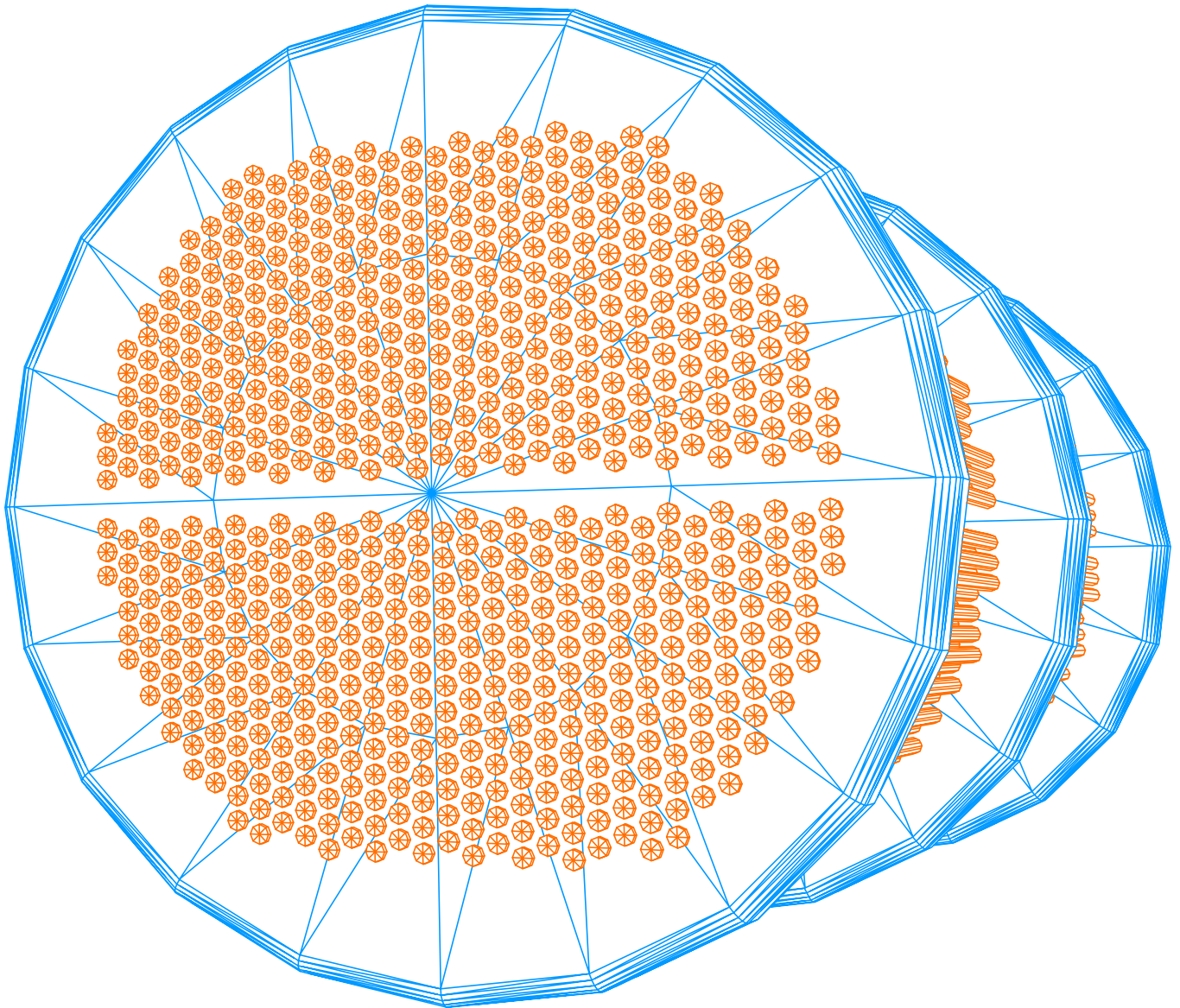




# EMBRACE THE HEAT RESIST THE CORROSION

SANDVIK HEAT EXCHANGE PORTFOLIO OF SEAMLESS TUBE





## EXPECT MORE FROM US

Every day, advanced materials from Sandvik are used in thousands of heat exchangers around the world. Regardless of the application, our aim is to help you boost productivity and meet tough technical and sustainability goals. But more than just assuring excellent corrosion resistance, high mechanical strength and good weldability, when you work with us, you gain access to our:

### **UPTIME SPECIALISTS**

To help you solve technical materials challenges, we offer a worldwide network of sales engineers, backed by metallurgists and research engineers from our R&D centers.

### **LEADING-EDGE R&D**

Our world-leading R&D program is committed to developing new and superior products and innovative, proactive solutions in close collaboration with you.

### **INTEGRATED PRODUCTION**

Our integrated production facilities ensure the consistency and quality of our materials, from batch to batch. In other words, no unwanted surprises!

### **ONE-STOP SHOPPING**

A worldwide local network of sales units is available to address your needs with a wide range of grades and sizes to cover most material requirements.



# TOTAL CONTROL – FROM MELT TO FINISHED PRODUCT

All of our customers place a high value on trouble-free production, reduced maintenance costs and low downtime. In this respect, your choice of fabrication materials for heat exchangers is naturally vital to achieving this. But you also need to consider the larger picture of who you are working with as a partner.

To truly secure safe and reliable materials, you need a supplier known for its attention to detail in every step of the manufacturing process. That is why many industrial producers turn to Sandvik. Having manufactured steel for more than 150 years, we've built our reputation on high-quality and reliable products. But more than this, we've earned the trust of our customers by also providing excellent technical and after-sales service.

Sandvik controls the entire production process – from melting and alloying in the electric arc and high frequency furnaces, the AOD converter and continuous casting plant to the finishing operations, such as cold rolling, cold drawing or heat treatment.

## RESEARCH AND DEVELOPMENT

Sandvik has one of the largest steel research centers in Europe. Altogether the Sandvik Group has 2,700 R&D personnel in 50 centers and holds 8,000 patents. New materials are constantly being developed and existing materials and production processes improved. We also cooperate closely with leading universities, research institutions and specialist companies.

## HEALTH, SAFETY & ENVIRONMENT

Environmental awareness, health and safety (HSE) consideration are at the forefront of all activities. Our vision of Zero Accidents for our own people and customers is a key part of our HSE program. We also hold ISO 14001 and OHSAS 18001 approvals. Stainless steel can be 100% recycled and our steel plant in Sandviken operates a full materials recovery process.

## ETHICS AND FAIR PLAY

Our core values and code of conduct include promoting equality in all respects. We actively fight against corruption and operate in a highly ethical manner in relation to employees, customers, suppliers and all other industry contacts.

## QUALITY POLICIES AND STANDARDS

Our fully integrated steel mill ensures close control of the entire production process – from the initial melting of the steel to the finished product. Sandvik follows Quality Management Systems that are approved by internationally recognized organizations. For example, we hold the ASME Quality Systems Certificate as a Materials Organization, approval for ISO 9001, ISO 17025, and PED 97/23/EC, as well as product approvals from TÜV, JIS and Lloyd's Register. In terms of both products and services, quality is a major objective for us, as described in the company's Quality Policy. All employees are involved and committed to continuous improvement.

## PRODUCTION FACILITIES – CLOSE TO YOU

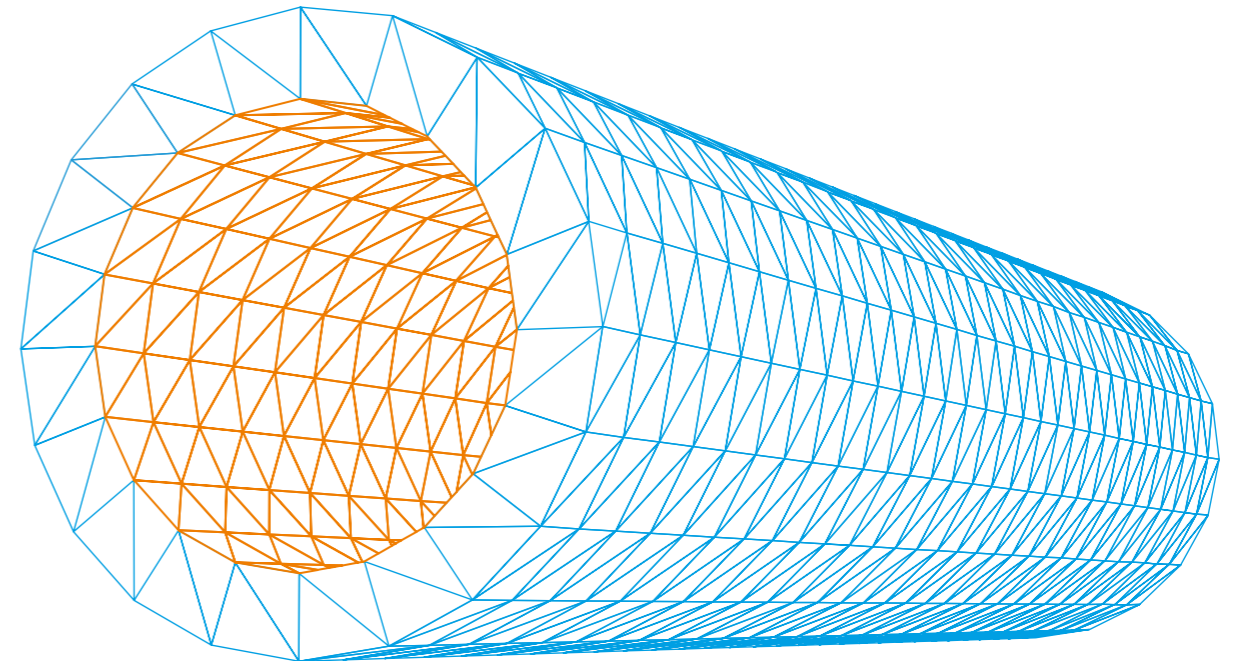
Sandvik tube manufacturing facilities are located strategically around the world. Our combined resources, connected through a worldwide electronic network of information and planning systems, enable us to offer a reliable supply of high-quality products – regardless of where you are located.

Sandvik is taking material technology into the next level, providing a wide range of industries with even better material properties, improved efficiencies and lower lifecycle costs.



# FIND THE OPTIMAL SOLUTION FOR YOUR PLANT CONDITIONS

Regardless of the heat exchanger design or size, the initial capital expenditure (CAPEX) is likely to be low compared to the cost of your entire plant. And yet, your ability to achieve sustained energy efficiency and uptime can have a significant impact on total operating expenses (OPEX) over the long run. But making the right choice of fabrication material will depend a lot on your specific operating conditions.



Experience shows that no two plants are exactly the same. Why? Because every plant faces a unique set of circumstances, from service conditions to other operating parameters. In other words, when choosing seamless tube, flanges, fittings and other material for a heat exchanger you want to know that your supplier offers a broad range of grades and enough flexibility in production processes to meet specific requirements.

## MORE CHOICES, MORE POSSIBILITIES

That's why many choose Sandvik stainless steel tubes. Many appreciate our extensive experience in the production of special stainless steels and tubes, flexibility in raw material sourcing and ability to find the optimal materials solutions. It allows them to obtain special steel grades with chemical compositions tailored to specific applications, markets or country requirements.

The Sandvik supply package for heat exchanger tubes includes standard seamless stainless steel and special grades. It also covers welded tubes, sheet and plate, tube fittings for butt welding and socket welding as well as threaded joints and flanges.

## EXTREME CONDITIONS DEMAND SUPERIOR TUBES

Our tubes are suitable for all types of heat exchangers: coolers, condensers, evaporators, preheaters, re-heaters, reboilers, steam generators and air coolers. Extreme conditions can be handled by developing competitive and innovative solutions through close cooperation with our customers. Together, we can achieve lower operating costs and increase long-term operating reliability.

## TAKE ADVANTAGE OF OUR GLOBAL ASSETS

From advanced logistics systems to state-of-the-art product delivery and communication systems, Sandvik offers a wide range of services to ensure rapid global distribution from strategically placed locations worldwide. These include sophisticated plant programming capabilities that secure your inventory replenishment.

## GRADES, STANDARDS AND SIZE RANGE

Sandvik has an extensive manufacturing program for seamless heat exchanger tubes covering most types of standard austenitic, duplex (austenitic-ferritic) and high alloy austenitic stainless steels as well as titanium and zirconium. Our program meets both European and American quality standards.

Our main size range, produced in imperial and metric dimensions ranges from 12 mm on up to 40 mm outer diameter. Special sizes can be made to order. Tubes are supplied in straight lengths up to 30 meters, or as U-bends. See the table to the right for the most common standards and grades for heat exchangers.

### Product standards

Sandvik grade	American standards		European standards			
	ASTM	ASME	EN	DIN/VD TÜV	AFNOR	SS
<b>AUSTENITIC STAINLESS STEELS</b>						
Sandvik 3R60™	A213 A269	SA213	10216-5	DIN 17458	NFA 49-217	219711 219713
Sandvik 3R12	A213 A269	SA213	10216-5	DIN 17458	NFA 49-217	219711 219713
Sandvik 3R19	A213					
Sandvik 6R35	A213 A269	SA213	10216-5	DIN 17458	NFA 49-217	219711 219713
Sandvik 3R64	A213 SA213					219711 219713
Sandvik 3R65	A213 A269	SA213	10216-5	DIN 17458	NFA 49-217	219711 219713
Sandvik 5R75	A213		10216-5	DIN 17458	NFA 49-117	219711 219713
Sandvik 254 SMO*	A213 A269		10216-5			
Sandvik 2RK65™	A269	SB677	10216-5	VD TÜV Blatt 421	NFA 49-217	219711 219713
<b>DUPLEX STAINLESS STEELS</b>						
Sandvik SAF 2707 HD™	A789	SA789				
Sandvik SAF 2507®	A789	SA789	10216-5	VD TÜV Blatt 508		
Sandvik SAF 2205™	A789	SA789	10216-5	VD TÜV Blatt 418	NFA 49-217	
Sandvik SAF 2304®	A789	SA789	10216-5			
Sandvik 3RE60	A789	SA789		VD TÜV Blatt 385	NFA 49-217	
<b>NI ALLOYS</b>						
Sanicro® 28	B668	SB668	10216-5	VD TÜV Blatt 483		
Sanicro® 30	B163 B407	SB163 SB407	10216-5			
Sanicro® 41	B163 B423	SB163 SB423				
Sanicro® 60	B444 SB444				NC 22D Nb	
Sanicro® 69	B163 B167	SB163 SB167				
Sanicro® 70	B163 B167	SB163 SB167		VD TÜV Blatt 305		-

\* 254 SMO is a trademark owned by Outokumpu OY.



# WHAT CHALLENGE ARE YOU FACING?

Over the years, our global network of technical sales experts has worked closely with a wide range of industries using heat exchangers, including the oil and gas industry, petrochemicals, power generation, chemicals and more. Based on our experience from installations worldwide, we'd be happy to help you select just the right materials.

When selecting a material grade for a heat exchanger operating under certain conditions, a number of considerations have to be made. The grade needs to have sufficient corrosion resistance combined with suitable mechanical and physical properties.

## SEAWATER COOLERS

Selecting the right tube material for heat exchangers using seawater as a cooling medium is critical. Seawater contains large amounts of sodium chlorides and solid particles, such as sand silt and organic solids. In such a severe environment, you need to select a grade with high resistance against both localized corrosion and erosion corrosion. Sandvik SAF 2707 HD™ is a grade specifically developed for these types of severe environments.

## OIL REFINING

Refinery process streams involve many corrosive elements that can shorten the lifetime of low alloyed steels – especially as more complex stages are now added. To recover heat in the different processes, heat exchangers are deployed in plants where they typically operate under severe corrosion conditions. Most leakage in heat exchangers is attributable to corrosion on the tubing. Stainless steel and, in particular, duplex grades, including Sandvik SAF 2205™, Sandvik SAF 2507® or Sandvik SAF 2707 HD™, can overcome such problems.

## PETROCHEMICALS

Corrosion in petrochemical plants can lead to contamination of manufactured products. Sandvik's high-quality, corrosion-resistant stainless steels include a wide range of grades, from high-alloyed austenitic grades to hyper-duplex Sandvik SAF 2707 HD™.

## CHEMICALS

Sandvik's special grades are used in heat exchangers in many demanding chemical processes, including the production of inorganic acids and caustics. Sandvik seamless tubes offer the required high reliability in these often critical applications.

## SALT EVAPORATION

Various types of salt production processes involve severe environments for tubular products with high levels of chlorides. It is thus important to choose materials with high resistance to localized corrosion. Sandvik manufactures a number of suitable grades for these severe environments, such as Sandvik SAF 2707 HD™, Sandvik SAF 2507®, Sanicro® 28 and 254 SMO.

## POWER GENERATION

Sandvik heat exchanger tubes can be found in condensers, feedwater heaters and wastewater handling equipment. Sandvik steel grades fulfil the high quality standards for use in both conventional fossil fuelled power plants as well as nuclear power stations.

## LNG AND NATURAL GAS PROCESSING

Cryogenic conditions and corrosive seawater are common challenge in the offshore processing of LNG and natural gas. An ideal solution is Sandvik's new grade program for LNG, which is a new family of super austenitic (highly alloyed) seamless stainless tube with 5-7% molybdenum. Due to its superior corrosion resistance and high mechanical strength Sandvik offers i.e. LNG vaporizers substantially longer service life, compared with standard stainless steel. Our duplex stainless steels are also corrosion-resistant weight-savers for a range of applications due to wall-thickness reductions enabled by their higher strength than standard steel.

## FLUE GAS CLEANING/DESULPHURISATION

Environmental demands call for effective gas cleaning equipment. For heat exchangers handling sour gas under condensing conditions, look into our high alloyed austenitic grades such as Sanicro® 41 and, in particular, Sanicro® 28 and 254 SMO. Our higher alloyed duplex stainless steels can also be suitable.

## HYDROMETALLURGY

Slurry processing under high pressures and temperatures may give rise to severely corrosive conditions. For these types of applications, duplex stainless steels such as Sandvik SAF 2304® with its combination of corrosion resistance, high strength and erosion resistance, is a particularly well-suited alternative.





# CUT COSTS BY USING DUPLEX STAINLESS STEELS

Significant cost savings can be achieved by using duplex steel when designing a heat exchanger. The cost-effective combination of high mechanical strength, superior corrosion resistance and the fabricating compatibility of duplex stainless steels allows for the reduction in tube wall thickness and thus lighter equipment designs.

## Short-term carbon steel option

- Low initial cost
- Increased inspection cost
- More frequent maintenance required
- More frequent replacement required
- Greater risk of production stoppages

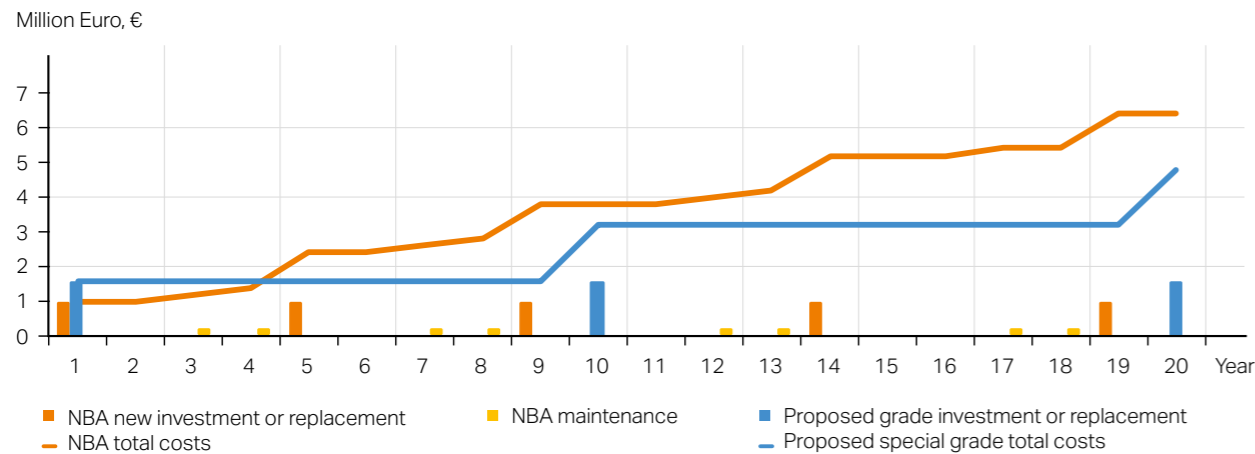
## Long-term stainless steel/special grades option

- Higher initial cost
- Less maintenance required
- Less frequent replacement required
- More reliable operation
- Lower lifecycle cost

## LIFECYCLE COST CONSIDERATIONS

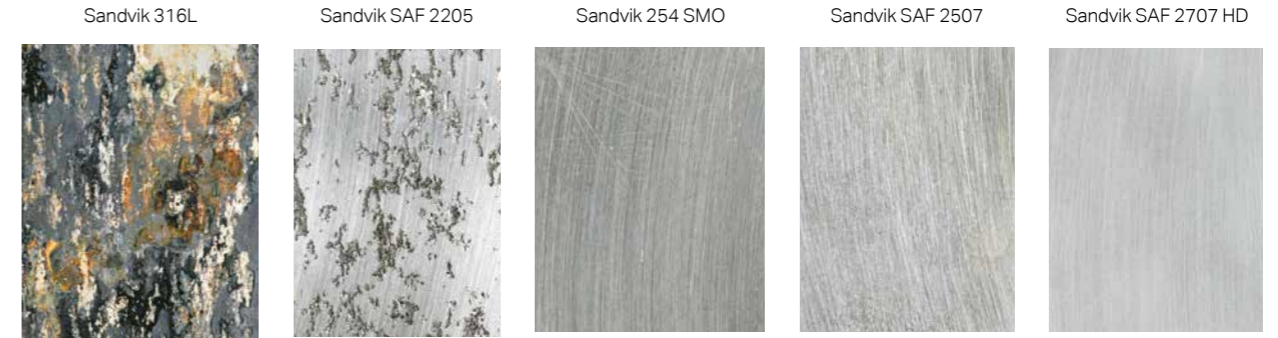
The two different ways of looking at the cost of products depend on whether you choose the next-best alternative (e.g. carbon steel) or a material designed for being the ultimate solution for a specific application.

## Sandvik proposed special grade versus next-best alternative grade (NBA)



Sandvik Grade	UNS	Chemical compositions					Mechanical properties		
		C max	Cr	Ni	Mo	N	Proof strength R <sub>p0.2</sub> , MPa, min.	Tensile strength R <sub>m</sub> , MPa	Elongation A%, min.
<b>AUSTENITIC STAINLESS STEELS</b>									
Sandvik 2RK65™ (904L)	N08904	0.020	20	25	4.5	-	230	520-720	35
Sandvik 3R65 (316L)	S31603	0.030	17	11.5	2.1	-	220	515-690	45
Sandvik 254 SMO*	S31254	0.020	20	18	6.1	0.2	310	675-850	35
<b>DUPLEX STAINLESS STEELS</b>									
Sandvik SAF 2707 HD™	S32707	0.030	27	6.5	4.8	0.4	700	920-1100	25
Sandvik SAF 2507®	S32750	0.030	25	7	4	0.3	550	800-1000	25
Sandvik SAF 2205™	S32205/ S31803	0.030	22	5	3.2	0.2	485	680-880	25
Sandvik SAF 2304®	S32304	0.030	22.5	4.5	-	0.18	400	630-820	25
<b>NI ALLOYS</b>									
Sanicro® 28	N08028	0.020	27	31	3.5	-	220	550-750	40
Sanicro® 41	N08825	0.030	20	38.5	2.6	-	240	≥590	30
Sanicro® 60	N06625	0.025	21.5	61	8.7	-	≥415	≥827	≥30

\* 254 SMO is a trademark owned by Outokumpu OY.



Stainless steel samples following G48 testing at 85°C for 24 hours.

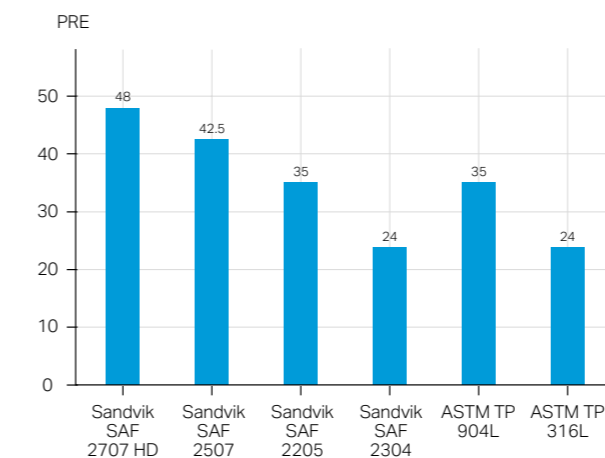
## PITTING CORROSION

There are a range of tests that can be employed to determine approximate ranking according to the Pitting Resistance Equivalent (PRE) formula. One popular test method for determining the performance of intermediate and high-alloy grades, in particular, is ASTM G48A.

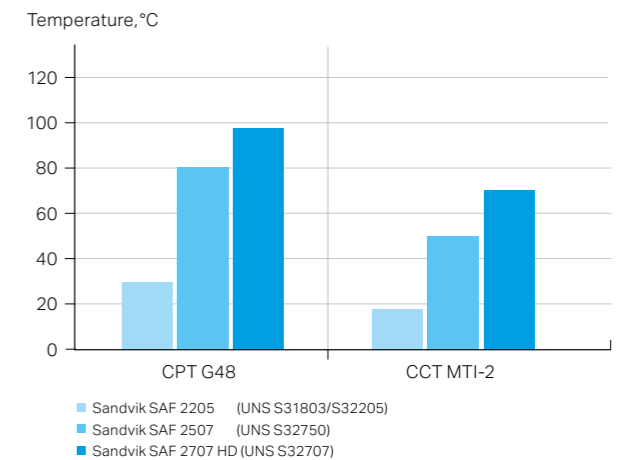
ASTM G48, practice A (6% FeCl<sub>3</sub>) is one of the toughest pitting corrosion tests for stainless steels. It gives the same ranking order for the steels as in slightly chlorinated seawater. In Sandvik's laboratory, a modified version of the G48 is used, raising the temperature step-by-step. This allows the determination of the critical pitting temperature. The results from such a test are shown at the top of this page.

As shown in the graph below, Sandvik SAF 2707 HD™ and Sandvik SAF 2507® have the highest PRE values while Sandvik SAF 2205™ and 904L represent an intermediate level. Sandvik SAF 2304® has a PRE value at the same level as 316L.

## Minimum PRE values for duplex stainless steels and some other alloys.



## Critical pitting temperature (CPT) and critical crevice corrosion temperature (CCT) in standardised 6% FeCl<sub>3</sub> testing.



## EFFECT OF ALLOYING ELEMENTS

In stainless steel, the main alloying elements that contribute to improving pitting and crevice corrosion resistance are chromium, molybdenum and nitrogen. Chromium is the most important element due to its ability to form a protective oxide layer. In general, the higher the chromium content the better the corrosion resistance. One common cause of corrosion is the presence of chlorides in a process. In such environments, the presence of molybdenum and nitrogen also contribute strongly to improved corrosion resistance.

The pitting resistance of stainless steels can be defined with the PRE. The PRE number is calculated from the chemistry of the steel according to the following formula: PRE=%Cr+3.3%Mo+16%N.

# TITANIUM AND ZIRCONIUM TUBING

**Titanium and zirconium are optimal for challenging environments where not even the best stainless steels meet the corrosion resistance requirements.**

At Sandvik, we manufacture seamless titanium and zirconium heat exchanger tubes in a dedicated, state-of-the-art tube mill using a fully integrated process. It starts with the melting of raw materials in high vacuum furnaces and ends with the finished seamless tubes. The manufacturing process is specially designed to work with non-ferrous metals like titanium and zirconium.

For more than 50 years, the Sandvik group has been the world's largest independent manufacturer of seamless zirconium and titanium tubing. We supply advanced tube to a wide range of sectors including the chemical, petrochemical, aerospace and nuclear industries.

## TITANIUM

Titanium has a unique set of properties that makes it suitable for a variety of demanding applications. For example, it has high environmental resistance, relying primarily on a very thin and highly protective surface oxide film. It is also highly resistant to wet chlorine chemicals, virtually all types of salt solutions, including seawater, a range of acids, organic and inorganic chemicals and gases. The same oxide film provides a high resistance to erosion in high-velocity process streams. Its excellent corrosion and erosion resistance makes titanium a preferred heat-transfer material for shell-and-tube heat exchangers, since it permits the use of thin heat transfer walls and high fluid flow rates. In addition, titanium has only half the weight of steel. It is non-magnetic and is characterized by a high melting point, high strength-to-weight ratio and a low modulus of elasticity.

## AVAILABLE SANDVIK ASTM/ASME DEFINED GRADES:

1, 2, 3, 7, 9, 11, 12, 16, 17, 26, 28.

Other grades can be offered upon request

- The range of dimensions covers outer diameters from 8 mm on up to 40 mm and lengths up to 16.5 meters with certain OD/L and OD/Wt limitations.
- All tubing can be supplied as straight lengths or as U-bent tubes.
- Non-destructive testing facilities include ultrasonic testing and eddy current testing.
- Tubes are supplied in cold pilgered, vacuum annealed and polished conditions.

## ZIRCONIUM

Zirconium is highly resistant to a wide range of acids and bases, both organic and inorganic. This makes it an interesting and exceptional long-life alternative for highly demanding applications, compared to standard steels. Sandvik Zirconium 702\*, our seamless zirconium grade produced for heat exchanger applications, offers the process industry a high-quality and competitive product concept. Sandvik works in close partnership with many companies to enable complete Zr-702/Zr-700 product packages for the global market, including tube, pipe, plate, forgings, fittings & flanges, welding materials etc.

\* As per ASTM/ASME B, SB523 or equivalent.

# U-BENT TUBES FOR HEAT EXCHANGERS

**Sandvik is one of the world's leading suppliers of U-bent tubes for heat exchangers. These are manufactured from our precision straight tubes, using the cold-pilgering method, and feature a bright annealed surface. Production is strictly controlled in a step-by-step process to fulfill all technical demands from our customers.**

## DESCRIPTION OF U-BEND

- a..... difference in length of legs
- c..... distance between points of tangency
- $d_g$ ..... nominal outer diameter of tube
- e..... distance between legs measured on OD
- f..... distance between legs
- l..... leg length
- $l_g$ ..... developed length
- $r_m$ ..... nominal bend radius
- s..... nominal wall thickness
- $s_{min}$ ..... minimum wall thickness at the back of the bend
- t..... deviation from plane of the bend
- $s_0$ ..... minimum wall thickness defined by specification

## HEAT TREATMENT

If specified, we are equipped to carry out heat treatment of bends plus min. 150 mm of leg.

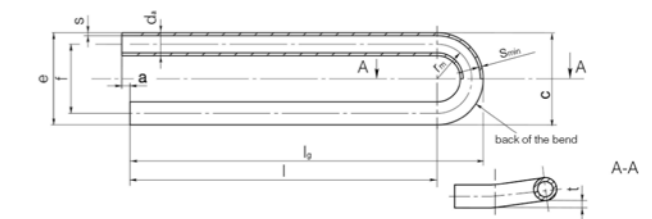
- Furnace is computer controlled and all data is recorded.
- We use an argon protective atmosphere inside the tubes.
- We can provide all types of annealing:
  - Solution
  - Stress relieving
  - Stabilization

Sandvik SAF 2507 and Sandvik SAF 2707 HD have excellent resistance to stress corrosion and therefore there is no need for stress relieving of U-bends for these tube materials.

## TECHNICAL PARAMETERS

OD 12.7-38 mm  
 Bending radii from 1.5xOD up to 1250 mm. Minimum bending radii for OD's over 28 mm after agreement.  
 Leg length min. 1,000 mm  
 Leg length max. 13,500 mm  
 Heat treatment for radii up to 1,000 mm

## U-BEND DEFINITIONS



## TECHNICAL STANDARDS FOR BENDING

Sandvik standard specification 7-2-1179

DIN 28179, TEMA RCB 2.31

Other specifications or special requirements are made available upon request. Copies of common standard specifications are also available upon request.

## HYDROTESTING

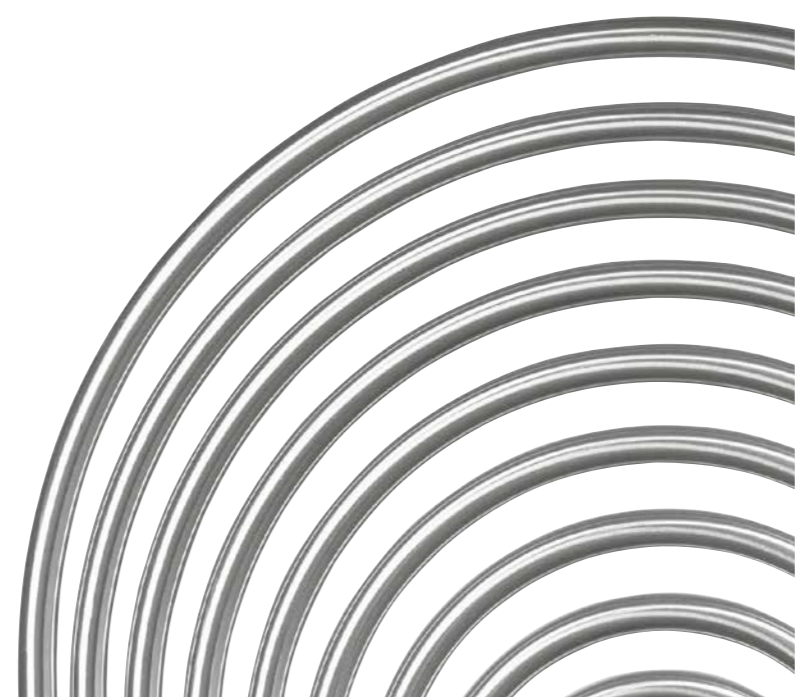
- After heat treatment all U-tubes are hydrotested.
- Minimum holding time at the required pressure is 5 sec.
- All tubes are dried and carefully cleaned after testing.

## MEASURING, CUTTING, DEBURRING, CLEANING

- U-bends are measured exactly in accordance with relevant standards, or to customer's specification.
- All tubes are cut to the specified leg lengths, ends are deburred and the tubes are internally cleaned with air.
- Before packing, both ends are sealed with plastic caps.

## PACKING

- In strong, open or closed, wooden boxes, depending on the destination - max. 8,000 kg.
- Ends of tubes protected by plastic caps.
- Vertical separators for each radius.
- Chloride-free plastic separators between each row, every 2 meters.
- Each bundle is covered with plastic.
- Customers can provide a packing drawing or Sandvik can prepare a packing plan.
- Packing lists, covered with plastic, are placed on each wooden box for easy identification of order details - including exact list of radii and lengths inside.



# MANUFACTURING PROGRAM SELECTED GRADES

Grade	STANDARDS					CHEMICAL COMPOSITION (nominal), %					PRESSURE PURPOSE		MECHANICAL PROPERTIES		
	UNS	ASTM TP	EN steel no.	W.-NR.	AFNOR	C	Cr	Ni	Mo	Others	PED <sup>1)</sup> PREN 10216-5	ASME	Proof strength R <sub>p0.2</sub> MPa min.	Tensile strength R <sub>m</sub> MPa	Elong. A % min.
<b>Duplex stainless steels</b>															
Sandvik SAF 2707 HD™	S32707	–	–	–	–	≤0.030	27	6.5 t	4.8	N, Si	X	X	700	920–1100	25
Sandvik SAF 2507®	S32750	–	1.4410	–	–	≤0.030	25	7	4	N	X	X	550	800–1000	25
Sandvik SAF 2205™	S31803/S32205	–	1.4462	1.4462	Z2CND22-05-03	≤0.030	22	5	3.2	N	x	X	485	680–880	25
Sandvik SAF 2304®	S32304	–	1.4362	1.4362	Z2NC23-04AZ	≤0.030	23	4.5	–	N	X	X	400	600–820	25
Sandvik 3RE60	S31500	–	1.4424	1.4417	Z2CND18-05-03	≤0.030	18.5	4.5	2.6	Si, N	X	X	450	700–800	30
<b>High-alloy austenitic stainless steels and nickel alloys</b>															
Sandvik 254 SMO <sup>2)</sup>	S31254	–	1.4547	(1.4529) <sup>3)</sup>	Z1CNDU20-18-06AZ	≤0.020	20	18	6.1	N, Cu	X	X	310	655–850	35
Sandvik 2RK65™	N08904	–	1.4539	1.4539	Z1NCDU25-20-04	≤0.020	20	25	4.5	Cu	X	X	230	520–720	35
Sanicro® 28	N08028	–	1.4563	1.4563	Z1NCDU31-27-03	≤0.020	27	31	3.5	Cu	X	X <sup>4)</sup>	220	550–750	40
Sanicro® 30	N08800	Alloy 800	1.4558	1.4558	–	≤0.030	20	32	–	Ti, Al	X	X <sup>4)</sup>	205	520–690	30
Sanicro® 41	N08825	Alloy 825	–	2.4858	–	≤0.030	20	38.5	2.6	Cu, Ti	–	X	240	590–750	30
Sanicro® 60	N06625	B444	–	2.4856	NC 22D Nb	0.025	21.5	61	8.7	Nb	–	X <sup>5)</sup>	≥415	≥827	≥30
Sanicro® 69	N06690	Alloy 690	–	2.4642	NC 30FE (RCCM)	≤0.020	30	60	–	Si, N	X	X	240	585	30
Sanicro® 70	N06600	Alloy 600	–	2.4816	–	≤0.050	16.5	72.5	–	Cu, N	X	X	245	>560	35
<b>Austenitic stainless steels</b>															
Sandvik 3R12	S30403	304/304L	1.4306/1.4301	1.4306/1.4301	Z2CN18-10	≤0.030	18.5	10	–	–	X	X	210	515–680	45
Sandvik 3R60™	S31603	316/316L	1.4435	1.4435/1.4436	Z2CND17-13	≤0.030	17.5	13	2.6	–	X	X	220	515–690	45
Sandvik 3R65	S31603	316/316L	1.4404	1.4404/1.4401	Z2CND17-12	≤0.030	17	11.5	2.1	–	X	X	220	515–690	45
Sandvik 6R35	S32100/S32109	321/321H	1.4541/1.4940	1.4541/1.4878 <sup>6)</sup>	Z6CNT18-10	0.05	17.5	10.5	–	Ti	X	X	210	515–690	35
Sandvik 5R75	S31635	316Ti	1.4571	1.4571	Z6CNDT17-12	0.05	17	12	2.1	Ti	X	–	220	510–710	35
Sandvik 3R19	S30453	304LN	1.4311	1.4311	(Z2NC18-10AZ) <sup>3)</sup>	≤0.030	18.5	9	–	N	X	X	275	550–750	40
Sandvik 3R64	S31703	317L	–	(1.4438) <sup>3)</sup>	–	≤0.030	18.5	14.5	3.1	–	–	X	220	515–690	35
Sandvik 8R40	S34700/S34709	347/347H	1.4550/1.4912	1.4550	Z6CNNb18-10	0.06	17.5	11	–	Nb	X	–	220	515–690	35

1) Pressure Equipment Directive 97/23/EC

2) 254 SMO is a trademark owned by Outokumpu OY.

3) In brackets, nearest equivalent steel grade.

4) Code Case exists (1325-18 for Sanicro® 30; ASME 1987 for Sanicro® 30)

5) Particular Material Appraisal (PMA) is the process by which the pressure equipment manufacturer ensures that each proposed material that is not

in a harmonized standard or covered by a European Approval for Materials (EAM) conforms to the applicable Essential Safety Requirements (ESR) for materials in the Pressure Equipment Directive (PED). Sandvik will support the pressure equipment manufacturer and have together with TÜV prepared the information for the pressure equipment manufacturer.

6) Valid for SEW 470

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