Stainless tubes for high temperature applications

SANDVIK

SANDVIK GROUP

The Sandvik Group is a global high technology enterprise with 38,000 employees in 130 countries. Sandvik's operations are concentrated on three core businesses: Sandvik Tooling, Sandvik Mining and Construction and Sandvik Materials Technology – areas in which the group holds leading global positions in selected niches.

SANDVIK MATERIALS TECHNOLOGY

Sandvik Materials Technology is a world-leading manufacturer of high value-added products in advanced stainless steels, special alloys, metallic and ceramic resistance materials, as well as process plants and sorting systems.

RESEARCH AND DEVELOPMENT

Sandvik has one of the largest steel research centers in Europe. New materials are constantly being developed and existing materials and production processes improved. In addition, we have a comprehensive program of liaison and cooperation with universities, research institutions and specialized companies that possess particular expertise.

QUALITY ASSURANCE

Sandvik Materials Technology has Quality Management Systems approved by internationally recognized organizations. We hold for example: the ASME Quality System Certificate as a Materials Organization; approval to ISO 9001, QS-9000 and PED 97/23/EC, as well as approvals from LRQA, JIS, TÜV and others as a materials manufacturer.

ENVIRONMENT

Environmental awareness is an integral part of our business and is at the forefront of all activities within our operation. We hold approval to ISO 14001.

Make the right choice

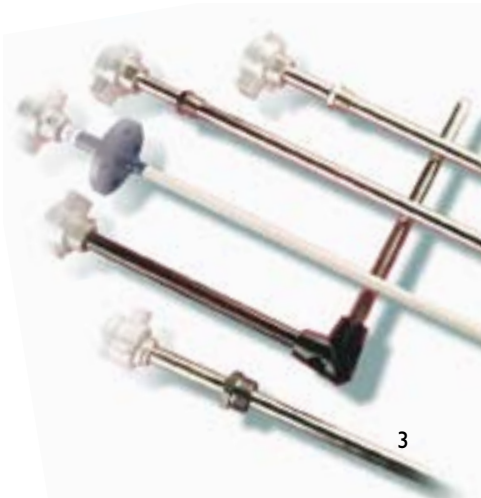
Sandvik is a leading supplier of high temperature tubes with a global network and local presence. With our expertise and experience, combined with an extensive product portfolio, we can offer you tailor-made solutions that give your business an edge.

The logic is simple and compelling: in the long run, it is much less expensive to buy the right material than to risk shutting down your production for unplanned repairs.

If you want the optimal price-performance combination, Sandvik is the right choice. In other words, with the right choice of tubes, we can help you achieve a longer service life at a lower cost of ownership.

In the following pages, you will find out more about the benefits of selecting Sandvik as your supplier. In the tables and graphs, you will be able to easily identify the steel grade most suitable for your particular process.

Contents



Technical knowledge and high-quality products

Using a combination of Sandvik knowledge and product quality, we can help you achieve the high performance and cost savings you want.

Process knowledge. With its years of experience and industry leading R&D programs, Sandvik has the process and application knowledge to help you achieve the optimal price-performance combination.

Technical knowledge. Our engineers are deeply familiar with the different materials, mechanical and corrosion properties, as well as creep strength and thermal conductivity – all key factors in reducing your lifecycle costs.

Product development. Supported by our R&D center, we are able to develop new materials and solutions even for the most challenging applications.

Integrated production. Our integrated production and quality control through the whole manufacturing chain, from our steel melting plant to the finished product, ensures traceability and a high and consistent product quality.

Delivery precision. Not only can we supply material from stock if urgent or manufacture according to required specifications, we can deliver the products you want when you want them.

Local presence. With our locally available staff, we are in a position to develop a long-term relationship by keeping in close contact with you and ensuring that all your service requirements are comprehensively met.

Consistent quality. From delivery to delivery, our products are of consistently high quality, ensuring long-term performance, reliability, reduced downtime and lower lifecycle costs. Our integrated production and testing procedures ensure that all material properties meet the specified requirements.

Corrosion resistance and creep strength. With a broad range of high temperature materials in the Sandvik product portfolio, we offer optimized solutions regarding corrosion properties and high temperature strength to maximize service life.

Welding consumables. Sandvik provides matching filler metals, as well as welding recommendations for optimum corrosion resistance.

High temperature applications

The selection of material for each application is often a compromise between demands on mechanical strength, structure stability and corrosion resistance. In many cases the corrosion problems are solved by frequent replacements, and not regarded as a problem. However, as new more corrosion resistant materials are continuously being developed, a change of material can often reduce maintenance costs and increase productivity.

Our website contains a lot of information regarding applications, service conditions and material selection, aimed at helping our customers maximize profitability by preventing unnecessary downtime.

Sandvik has a long history of offering advanced material solutions. Some examples include composite tubing for black liquor recovery boilers, internally finned tubes for improved heat-transfer in cracker furnaces, and boiler tubing for conventional boilers as well as a new generation of super-critical boilers. Close partnerships with end users, engineering companies and licensors will ensure that future developments meet customer needs.

Some high temperature applications are described in the following pages, along with examples of how Sandvik has helped our customers to increase productivity, reduce downtime and improve overall profitability.

Continuous material development

Higher energy prices during the last decade, combined with increasing pressure to reduce carbon dioxide emissions, are creating new challenges for high temperature applications. Changes in feedstocks, elevated process temperatures, improved energy efficiency and safety, are established key industry drivers.

The continued use of the most common high temperature materials will inevitably lead to increased downtime in critical processes, unless more corrosion resistant materials with increased creep strength are considered. Sandvik Materials Technology, as the leading producer and developer of stainless steels for high temperature environments, is of course commited to driving this development forward.

Better grade selection increases lance tubes' lifetime by 300 percent

By switching from TP 310 to Sandvik 253 MA pulverized coal injection lances, a Brazilian steel mill was able to increase the lifetime of their blast-furnace lances by 300 percent. Additional benefits were reduced maintenance costs and an increase in pig iron productivity.

High temperature application fields

Sandvik materials are used in a multitude of high temperature applications. For example in:

Air heaters
Heat exchangers
Reactors
Nozzles and other equipments

Contact your local sales engineer to discuss choice of material and best solutions.

Recuperators

Recuperators save energy by using the waste heat to preheat process gas, reducing fuel consumption and costs. They are found in many energy intensive industries, such as steel industry, glass production and carbon black production. As energy prices increase, recuperators may reduce costs significantly, even in industries with lower energy consumption.

A current trend is to increase the heat recovery by increasing air preheating temperatures, resulting in more energy savings.

Achieve longer service life

Depending on process parameters, such as flue gas temperature, flue gas composition and heat recovery ambitions, the material in the recuperator must be carefully selected to achieve a longer service life.

Sandvik supplies a wide range of materials for better recuperator performance.

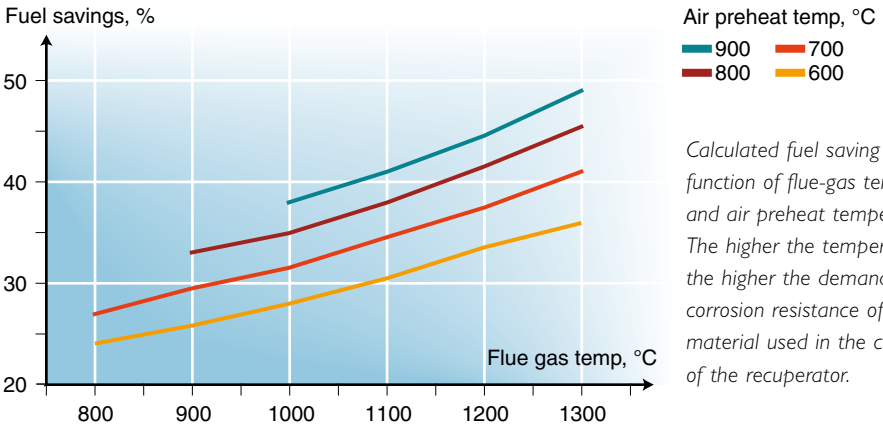
Sandvik 253 MA has been used in many different types of recuperators for many years. The success of this alloy is due to its excellent oxide properties that prevent material degradation, especially in the carbon black and direct reduction of iron ore (DRI) applications.

Example: payback time can be as quick as one year when changing from an air preheat of 650°C using common ferritic or austenitic materials to an air preheat of 800°C using the high performance Sandvik 253 MA.

Sandvik 4C54 is optimal in the glass industry with flue gas temperatures of 1,300°C and higher, because this material combines excellent corrosion resistance with low thermal expansion.

Kanthal APM and Kanthal APMT are high performance materials for use at the highest temperatures.

Savings in fuel consumption at different waste gas and air preheat temperatures



Calculated fuel saving as a function of flue-gas temperature and air preheat temperature. The higher the temperatures, the higher the demands on the corrosion resistance of the material used in the construction of the recuperator.

Sandvik 253 MA triples service life in steel mill

A Brazilian steel mill tripled lifetime of their air preheaters by switching from TP 310 to Sandvik 253 MA in the recuperator. Fewer maintenance shutdowns resulted in higher productivity in the hot rolling mills, as well as lower operating costs thanks to longer service life.

Industries

Industries in which Sandvik materials are used in recuperators are:

- **Metal industries, such as iron and steel production, DRI and copper smelters**
- **Petrochemical industry e.g. carbon black**
- **Glass industry**

Muffle tubes

Muffle furnaces are most often used in wire drawing mills and in bundy tube production, but they can also be found in other applications such as razor blade production and tube annealing. They are used to shield a product from the environment of the furnace during heat treatment, and to create conditions for a more even temperature distribution.

In most cases, some protective gas is fed into the muffle tube. This shielding gas can be hydrogen, nitrogen, cracked ammonia or endogas ($CO + H_2$). Some of these gases are very aggressive and will shorten the life of the muffle tubes significantly.

Choose the right material for longer service life

In some annealing furnaces, the temperature can reach above 1,200°C, but temperatures between 800 and 1,120°C are most common. These high temperatures often result in a short service life, leading to frequent stoppages for maintenance and muffle tube replacements.

As the value of lost production is high, the decision to select a better grade (tube material) will pay off in the long run.

Sandvik Sanicro 31HT is often used in environments with *cracked ammonia,* which is the most aggressive environment in this application. It causes rapid nitriding of the tube material, which leads to a loss of the mechanical strength. By selecting an alloy with higher nickel content, you can extend the service life. In this environment, **Sandvik Sanicro 61** offers much longer service life.

We recommend Sandvik Sanicro 31HT as a suitable material where pure *nitrogen* or a gas mixture of *nitrogen and hydrogen* is used. Nitrogen is a less severe environment than cracked ammonia.

The *endogas* will cause a rapid carburization, which also reduces the muffle tube's mechanical strength. In these conditions, **Sandvik 353 MA** is the most cost-effective material. For severely carburizing conditions, **Kanthal APM** or **APMT** is a better choice than Sandvik 353 MA.

Hydrogen is a less aggressive environment. In these conditions, the most cost-effective material is **Sandvik 253 MA,** followed by Sandvik Sanicro 31HT.

Sandvik 4C54 is a cost effective choice for annealing of carbon steel as it is done in a lower temperature range.

Address the challenges of your environment

Certain operational conditions will shorten the service life. Residuals, such as hydrocarbons, soap or drawing powder, can increase the risk of corrosion. Frequent temperature cycling will also shorten the service life. If premature failures happen, we recommend a careful analysis of the process, which may result in the selection of a more suitable material optimized for your special conditions.

New muffle tubes increase French automobile supplier's productivity

A French automobile supplier using muffle tubes in a bundy tube application had coking problems with Alloy 800HT extruded tubes. By switching to Sandvik 353 MA cold finished tubes, the bundy tube service life was doubled and coking problems significantly reduced.

Industries

Industries in which Sandvik materials are used as muffle tubes are:

- **Wire drawing mills**
- **Bundy tube production**
- **Razor blade production**
- **Tube annealing**

Environments

Environments where Sandvik materials are used as muffle tubes are:

- **Hydrogen up to 1,250°C**
- **Nitrogen up to 1,150°C**
- **Cracked ammonia up to 1,100°C**
- **Endogas up to 1,150°C**
- **Air up to 1,250°C**

Pyrometer tubes

A pyrometer tube protects temperature-measuring devices. These devices are produced by thermocouple and cable tube manufacturers and are used in all industries and applications where measurement and/or control of high temperatures are needed, such as metal industries, glass manufacturing, petrochemical industries, cement industry and the food and beverage industry.

Pyrometer tubing is often exposed to corrosive gases or liquid metals at high temperatures without any form of cooling. The purpose is to protect the thermal sensors from the hostile environment. This is a challenging task since a lost temperature control can jeopardize both process and equipment.

Get the right pyrometer tubing for better control

Material selection is important but often complex. Following is a brief guide on tube material, maximum operating temperatures and conditions.

Sandvik 4C54 the ideal alloy in sulfurous atmospheres or when in contact with molten copper or brass in temperatures up to 1,125°C. However, it is a ferritic material and consequently special care is needed to avoid potential problems with brittle structures.

Sandvik Sanicro 31HT is a traditional material for use in cracked ammonia (NH_3) and in hydrogen (H_2) up to 1,100°C. Considering its mechanical properties, Sandvik Sanicro 31HT is an excellent all-round tube.

Sandvik 7RE10 (TP 310) is an all-round material with good oxidation properties that has been around for decades. It can be recommended for service in nitriding environments at temperatures up to 1,100°C.

Sandvik Sanicro 70 is renowned for its good performance in salt baths. It is also an all-round material used from low temperatures and wet conditions to temperatures up to 1,170°C in chlorine-containing environments.

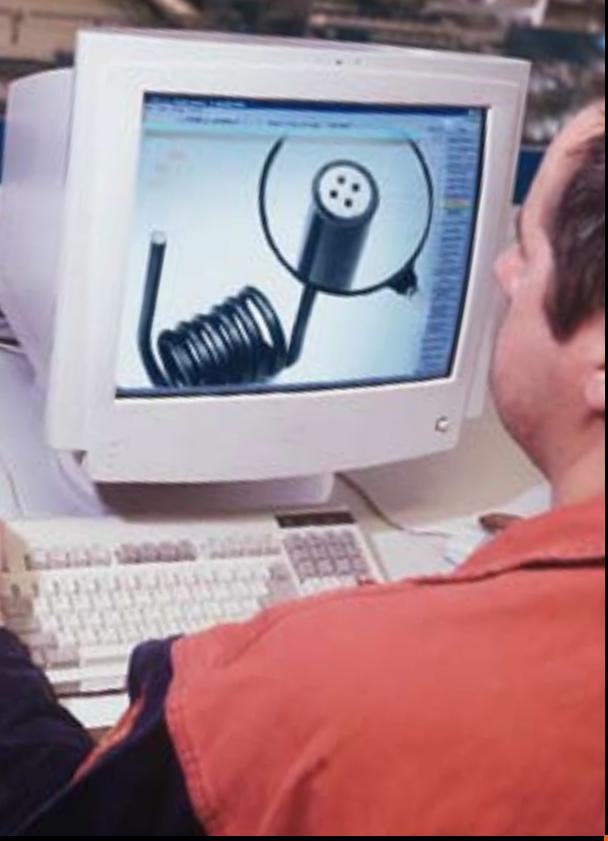
Sandvik Sanicro 61 is a good choice when the environment is too severe for Sanicro 70.

Sandvik 253 MA offers outstanding performance in oxidizing atmospheres with temperatures up to 1,150°C. It can replace TP 310 in most applications, although in a nitriding atmosphere an alloy with higher nickel content should be used.

When carburizing conditions prevail, then **Sandvik 353 MA** offers the best properties at temperatures up to 1,150°C. In atmospheres fluctuating between oxidizing and reducing conditions, 353 MA is often the best compromise.

Kanthal APM and **APMT,** with their high aluminum content, can offer a longer service life in severe environments where traditional chromia forming alloys are consumed rapidly. Kanthal APM and APMT are recommended for use at temperatures above 1,000°C.

Sandvik has **additional grades** in its material program that, under your specific conditions, can offer a better choice compared to the grades mentioned above.



Get the right pyrometer tubing for better control

Alloy 600 used as a pyrometer tube in the flue gas zone of the pre-bake area of the smelter in an alumina plant had a service life of four to five days. Changing to Sandvik 353 MA more than doubled the service life. Correct material selection can save money through lower purchasing price and increased productivity.

Industries

Examples of industries in which Sandvik materials are used as pyrometer tubes:

- **Metal industries**
- **Glass manufacturing**
- **Petrochemical industries**
- **Cement industry**
- **Food processing industry**

In view of demanding conditions, replacements will be needed sooner or later. The Sandvik stock of special alloys in different sizes means a cost-effective solution.

Steel grades

Chemical compositions and standards

Designation Sandvik	Chemical composition (nominal), % C	Cr	Ni	Mo	Others	Standards* UNS	ASTM TP	EN Steel number	SS	AFNOR
5R10	0.04	18.5	9.5	–	–	S30400/S30409	304/304H	1.4301/1.4948	2333	Z6CN18-09
6R35	0.05	17.5	10.5	–	Ti	S32100/S32109	321/321H	1.4541/1.4940	2337	(Z6CNT18-10)
8R40	0.06	17.5	11	–	Nb	S34700/S34709	347/347H	1.4550/1.4912	2338	Z6CNNb18-10
6LR62	0.05	17	11.5	2.1	–	S31600/S31609	316, 316H	1.4401	–	Z6CND17-12
8RE18	0.07	22.5	14	–	–	S30908/S30909	309S, 309H	1.4833**	–	–
7RE10	0.06	24.5	21	–	–	S31008/S31009	310S, 310H	1.4845**	2361	Z12CN25-20
253 MA	0.08	21	11	–	Si,N,Ce	S30815	–	1.4835**	2368	–
353 MA	0.05	25	35	–	Si,N,Ce	S35315	–	1.4854**	–	–
Sanicro 31HT	0.07	20.5	30.5	–	Ti,Al	N08811/N08810	–	1.4959	–	–
Sanicro 61	0.07	23	60	–	Si,Mn,Al	N06601	Alloy 601	–	–	–
Sanicro 70	0.05	16.5	72.5	–	Fe	N06600	Alloy 600	–	–	–
4C54	≤0.20	26.5	–	–	N	S44600	446–1	1.4749**	2322	–
2C48	0.09	23.5	–	–	N	S44600	446–2	–	–	–
Kanthal APM	≤0.08	22	–	–	Al =5.8	–	–	–	–	–
Kanthal APMT	≤0.08	22	–	3	Al =5.0	–	–	–	–	–

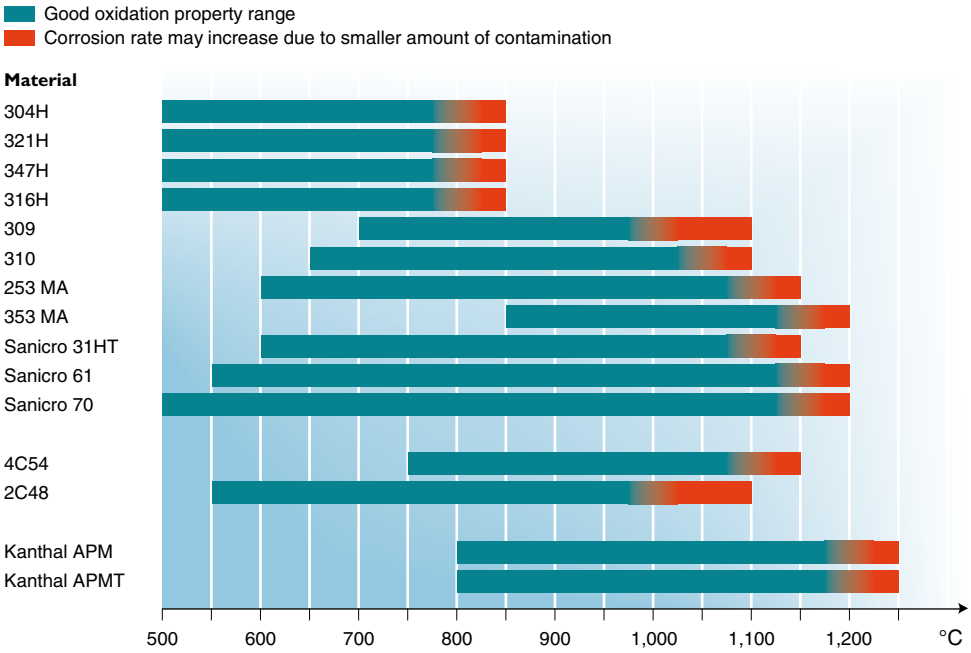
* In brackets, nearest equivalent steel grade.
** Not applicable for tube and pipe. Only for information.

Mechanical properties at room temperature

Material	Mechanical properties Proof strength $R_{p0.2}$, MPa, min.	Tensile strength R_m, MPa	Elongation A %, min.
304H	210	515–690	45
321H	210	515-690	45
347H	220	515–690	35
316H	205	515-790	45
309	205	≥515	35
310	220	515–750	35
253 MA	310	650–850	40
353 MA	270	650–750	40
Sanicro 31HT	170	500–700	35
Sanicro 61	205	≥550	≥30
Sanicro 70	245	≥560	35
4C54	275	500–700	20
2C48	275	≥450	20
Kanthal APM	475*	685*	11
Kanthal APMT	545*	740*	26

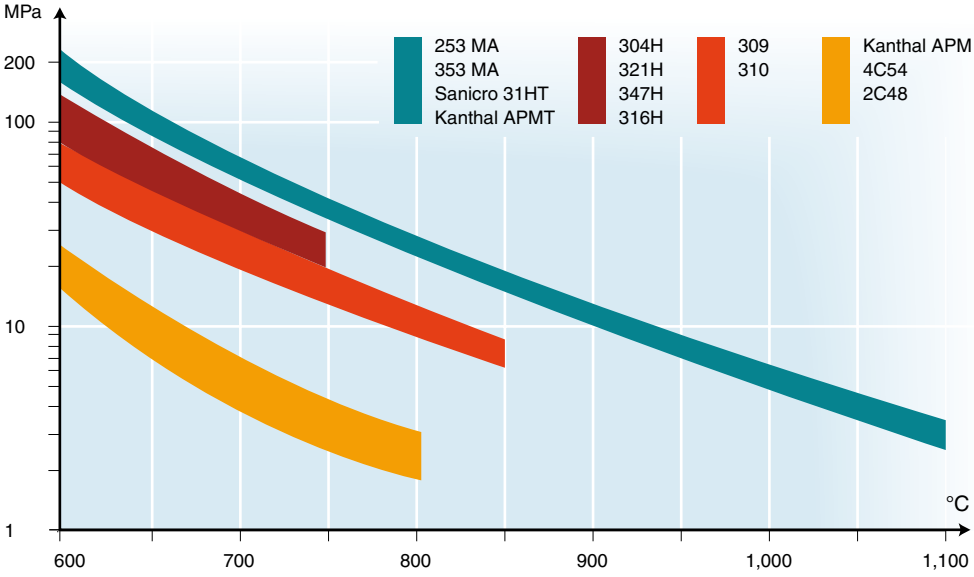
* Typical values
Sandvik, Sanicro and Kanthal are trademarks owned by Sandvik AB.
253 MA and 353 MA are trademarks owned by Outokumpu Stainless.

Recommended operating temperatures in air



Creep rupture strength

R_{km}/100,000 h, for some Sandvik stainless steels and high nickel alloys



High temperature corrosion properties

A comparison between Sandvik high temperature materials and TP 304H

Material	In air	Oxidizing sulfur	Reducing sulfur	Carburizing	Nitriding
304H	0	0	0	0	0
321H	0	0	0	0	0
347H	0	0	0	0	0
316H	0	0	0	0	0
309	++	++	+	+	++ (**)
310*	+++	++	0	++	++
253 MA*	++++	+++	++	+++	++ (**)
353 MA*	++++	+	0	++++	++++
Sanicro 31HT*	++	+	0	+++	+++
Sanicro 61	++++	0	-	+	++
Sanicro 70	+++	0	-	+	++++
4C54*	++++	+++	++++	-	-
2C48	+++	+++	+++	-	-
Kanthal APM	+++++	++++	++++	++++	+++(***)
Kanthal APMT	+++++	++++	++++	++++	+++(***)

* Sandvik stock standard
** In low oxygen potential (<100ppm O_2) nitriding may occur
*** In low dew point (<-20°C) severe nitriding may occur
0 = reference value + = superior to - = inferior to

Consider structural stability

Almost all steels developed to combat corrosive environments at elevated temperatures can suffer from embrittlement due to a secondary phase formation. A common type is sigma-phase, which is formed after a longer period of service in the temperature range 600 to 850°C.

The amount of sigma-phase formed is related to the chemical composition of the material. Chromium rich materials are, in general, more prone to form a sigma-phase. On the other hand, elements like nickel and nitrogen hinder the formation of sigma-phase. Nitrogen is a very efficient sigma-phase blocker, which is why Sandvik 253 MA, with high chromium and low nickel, is less prone to sigma-phase formation than some of the more common materials such as TP 309 and TP 310.

Ferritic steels with more than 16% chromium are very sensitive to sigma-phase formation. Ferritic chromium steels are also prone to embrittlement in the temperature range 400 to 550°C (475°C-embrittlement). Heat treatment at 1,000 to 1,100°C dissolves most embrittling phases and returns the material to a ductile state.

Extend life expectancy

Several factors influence the service life of material. These are, for example, thermal cycling, gas contaminants (e.g. halogens, sulfur, vanadium alkali and steam), and mechanical load.

Different alloys are affected in different ways. For example, a nickel based alloy will handle chlorine rich environments well, but will corrode quickly in sulfur containing environments. In carburizing environments, the balance of iron, nickel and chromium in the alloy affects the service life. A chromium content that is too low results in a poor oxide scale, while a high nickel (or low iron content) may result in severe carburization. Ferritic materials are good at handling thermal cycling, but they are, in general, poor load carriers at higher temperatures.

Define your environment

It is important that the environment should be well defined before selecting a steel grade. As an unscheduled shut-down may result in major production losses, it is vital that you carefully consider the financial effects of better grade selection.

Changing to a high performance material is often perceived as expensive, but the long-term costs are much lower when you take into account lifecycle costing. Many of our major end user customers are putting more and more emphasis on reduction of downtime to improve production output, stability and profitability. Often, the cost for a more corrosion resistant material can be offset by just a few minutes of increased production.

Quick material selection chart

Material	Main application	Main temperature,°C	Main service condition
310	Muffle tube, pyrometer	600–1000	Nitrogen/hydrogen
253 MA	Recuperator, pyrometer	600–1000	Oxidizing
353 MA	Recuperator, muffle tube	800–1150	Oxidizing, carburizing
Sanicro 31HT	Muffle tube, pigtails	700–1100	Cracked ammonia, carburizing
Sanicro 61	Muffle tube, pyrometer	600–1100	Oxidizing, chloride
Sanicro 70	Pyrometer	500–1100	Oxidizing, chloride, cracked ammonia
4C54	Recuperator, pyrometer	600–1000	Reducing sulfurous
Kanthal APM	Muffle tube, pyrometer	800–1250	Oxidizing, carburizing, sulfidizing
Kanthal APMT	Muffle tube, pyrometer	800–1250	Oxidizing, carburizing, sulfidizing

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.

Stock program

● = Cold-worked ■ = Hot-worked

Outside diameter mm	Wall thickness mm	Nominal size		Weight kg/m	4C54 TP 446-1	253 MA UNS S30815	353 MA UNS S35315	Sanicro 31HT UNS N08811/N08810 EN 1.4959	7RE10 TP 310
13.5	2.35			0.656					●
17.15	2.31	3/8"	Sch 40S	0.858	● *	●			●
	3.20		Sch 80S	1.12		●			
21.3	2.65			1.24	● **				●
21.34	2.11	1/2"	Sch 10S	1.01			● *		
	2.77		Sch 40S	1.29		●	● *	● *	●
	3.73		Sch 80S	1.65					●
22	2			0.954	●				
26	4.0			2.20	●				
26.67	2.11	3/4"	Sch 10S	1.30		●			
	2.87		Sch 40S	1.71		●	● *	● *	●
	3.91		Sch 80S	2.23					●
26.9	2.65			1.61	●				●
33.40	3.38	1"	Sch 40S	2.54		■	● *	■ *	■
	4.55		Sch 80S	3.29		■			■
33.7	3.25			2.48	■ *				■
42.16	3.56	1 1/4"	Sch 40S	3.44		■ *	■ *	■	■
42.4	3.25			3.19	■ *				■
44.5	3.0			3.12	■ *				
48.26	2.77	1 1/2"	Sch 10S	3.15		■ *			
	3.68		Sch 40S	4.11		■ *	■	■	■
	5.08		Sch 80S	5.49		■			■
48.3	3.25			3.67	■ *				■
60.3	3.65			5.18	■ *				■
60.33	2.77	2"	Sch 10S	3.99		■ *			
	3.91		Sch 40S	5.52		■ *	■	■	■
	5.54		Sch 80S	7.60	■				■
73.03	5.16	2 1/2"	Sch 40S	8.77		■			■
76.1	3.65			6.62	■ *				■
88.9	4.05			8.60	■ *				■
88.90	5.49	3"	Sch 40S	11.5		■	■		■
114.3	4.5			12.4					■
114.30	6.02	4"	Sch 40S	16.3		■			■
168.28	7.11	6"	Sch 40S	28.7		■			■

* are stocked in double random lengths.

** are stocked in both standard random lengths and double random lengths.

Standards

4C54 (TP 446-1)
ASTM A268 (tube)
253 MA (UNS S30815) and 353 MA (UNS S35315)
ASTM A312 (pipe)
Sanicro 31HT (UNS N08811/N08810)
Cold-worked ASTM B407
Hot-worked ASTM B407, tolerances acc. to ASTM A999

7RE10 (TP 310)
ASTM A312
DIN 17458, PK1
NFA 49-117
Hot-worked ASTM B407, tolerances acc. to ASTM A999

■ = Hot-worked

Outside diameter mm	Wall thickness mm	Weight Kanthal APM kg/m	Kanthal APMT kg/m	Max. length m	Kanthal APM	Kanthal APMT
26.67	2.87	1.52		13.0	■	
33.4	3.38	2.26		13.0	■	
33.7	6.0	3.71		10.5	■	
40	3.0	2.48		13.0	■	
50.8	6.35	6.30	6.39	7.0	■	■
60.33	3.91	4.92		8.0	■	
64	4.0	5.35	5.43	7.0	■	■
75	4.5	7.08	7.19	12.0	■	■
83	5.0	8.70	8.83	12.0	■	■
89	5.5	10.2	10.4	12.0	■	■
100	5.0	10.6	10.8	11.5	■	■
109	5.0	11.6		10.0	■	
115	5.5	13.4	13.6	8.0	■	■
128	5.5	15.0		12.0	■	
146	6.0	18.7		9.5	■	
154	6.0	19.8	20.1	8.0	■	■
164	6.0	21.2		7.0	■	
178	8.0	30.3		6.5	■	
198	9.0	37.9		5.0	■	

Tolerances

Sandvik 4C54 and 7RE10, according to EN ISO 1127

Condition	Outside diameter	Wall thickness
Cold-worked tube	±0.75%, but min. ±0.3 mm (D3)	±10% (T3), but min. ±0.2 mm
Hot-worked tube	±1.5%, but min. ±0.75 mm (D1)	±15% (T1), but min. ±0.6 mm

Tolerances on wall thickness

Size mm	Wall thickness	TH/OD Ratio
10.3–73.03	+20/-12.5%	All
88.90–219.10	+22.5/-12.5%	Less or equal to 0.05
88.90–219.10	+15/-12.5%	Above 0.05

Kanthal APM and APMT

Size mm	Outside diameter	Wall thickness
≤50	±1.5%, min ±0.75 mm	±15%, min ±0.6 mm
>50	±1%	±15%

Tolerances on straightness is max. height of arc 3mm/1000mm

Sandvik 253 MA, 353 MA and 7RE10, according to ASTM A312/A999

Size mm	Outside diameter mm
10.3–48.3	+0.4/-0.8
(48.3)–114.3	±0.8
(114.3)–219.1	+1.6/-0.8

Sandvik Sanicro 31HT, according to ASTM B407

Size mm	Outside diameter mm	Wall thickness %
Cold-worked:		
15.8–38.1	±0.19	±10.0
Hot-worked:		
Tolerances according to ASTM A999, see above table Sandvik 253 MA and 353 MA.		

Sandvik produces stainless steel boiler tubes. For further information, see brochure S-1302-ENG.

Sandvik Materials Technology
SE-811 81 Sandviken, Sweden, Phone: +46 26-26 30 00, Fax +46 26-26 02 20
www.smt.sandvik.com

S-130-ENG. 04.2006. Printed in Sweden. Sandvikens Tryckeri AB. Photo by: Jan Carlsson/Fotografen i Gavle. Stefan Estassy. Jörgen Svendsen. Mats Jonholt. Maarten Dings.