SANICRO 67*/4L7

COMPOSITE TUBES FOR BLACK LIQOUR RECOVERY AND OTHER BOILER APPLICATIONS

TECHNICAL SPECIFICATION

A NEW COMPOSITE TUBE PRODUCT

Sandvik has produced composite tubes since the early 1970's and more than 3 million meters have been delivered for boiler installations around the world.

A higher alloyed composite tube product, Sanicro™ 38 was developed in the late 1980's, to solve problem with thermal fatigue and stress corrosion cracking of 304L composite tubes in boiler floors. Since then, over 100 000 meters of Sanicro38 have been delivered mainly for use in recovery boilers.

To meet future demands for an even more resistant product than Sanicro 38, FP Innovations-Paprican, Canada and Sandvik jointly developed a the new product Sanicro 67.

The key attributes of Sanicro 67 are excellent resistance against stress corrosion cracking and very good general corrosion resistance. These properties are gained by a higher chromium content and a low work-hardening rate. This results in a premium composite tube product for severe service, such as air port openings.

The corrosion properties and resistance to stress corrosion cracking have been verified in both extensive laboratory testing and in boilers. Most boiler installations have been in airports. First installation was in 2009. Evaluation of taken out samples after 6 years operation showed tubes to be in very good condition.

GRADES

OUTER COMPONENT
Sanicro 67, EN 2.4642,
UNS N06690.

INNER COMPONENT
Sandvik 4L7, EN 1.0425,
P265GH, ASME SA-210 A1,
or ASME SA210 C

INNER COMPONENT
Sandvik 3Mo1, EN 1.5415,
16Mo3 (ASME SA 209 T1,
lower Mo content).

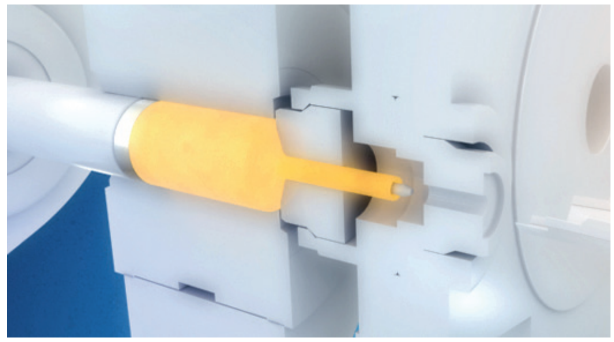

Figure 1. Hot extrusion.

PRODUCTION ROUTE OF COMPOSITE TUBES

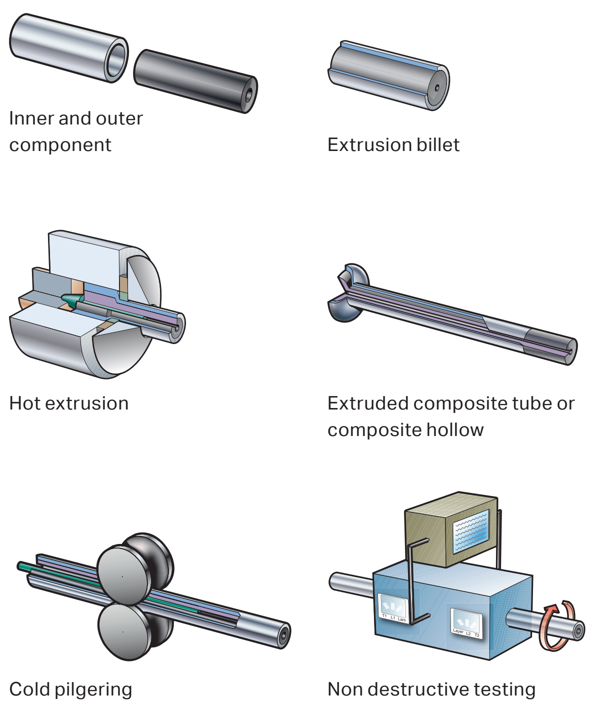

Figure 2. Sandvik composite tubes consist of two different materials metallurgically bonded together through hot extrusion. By selecting the correct alloy for the outside and inside component, the corrosion resistance and the mechanical properties are optimised and a tube that meets conflicting material requirements inside and outside is obtained.

CHEMICAL COMPOSITION, SANICRO 67 (NOMINAL %)

C	Si	Mn	P	S	Cr	Ni	Fe
0.02	≤ 0.5	≤ 0.5	≤ 0.020	≤ 0.015	30	bal (60)	10

CHEMICAL COMPOSITIONS, LOAD CARRYING INNER COMPONENTS (NOMINAL %)

SANDVIK	C	Si	Mn	P	S	Cr	Ni	Mo
4L7	≤0.20	0.3	0.7	≤0.025	≤0.020	≤0.30	-	≤0.08
3Mo1	0.012-0.20	0.35	0.40-0.90	≤0.025	≤0.020	≤0.30	0.3	0.25-0.35

DIMENSIONS, STANDARD SIZES

OUTSIDE DIAMETER		TOTAL MINIMUM WALL THICKNESS		AVERAGE THICKNESS OF STAINLESS STEEL COMPONENT		MINIMUM THICKNESS OF CARBON STEEL COMPONENT	
mm	inch	mm	inch	mm	inch	mm	inch
38	1.5	5.0	0.197	1.40	0.055	3.60	0.142
63.5	2.5	6.53	0.257	1.82	0.072	4.71	0.185
76.2	3	6.58	0.259	1.86	0.073	4.72	0.186

SPECIFICATIONS

Sandvik specification 7-1-0009, PED 97/23/EC, EN 10216-2, EN 12952-2 Annex C, (VD-TÜV Werkstoffblatt 541 03.2001).

THERMAL EXPANSION /CONDUCTIVITY

The composite tube values below have been calculated on a typical size dimension 63.5 x 6.53 mm min. (2.5 inch x .257 inch)

Sanicro 38 and 67	= 1.82 mm (0.072 inch) ave
4L7	= 4.71 mm (0.185 inch) min.
	= 6.53 mm (0.257 inch) min.

TOLERANCES

Permissible variations in O.D. and wall thickness

Outside diameter	38 mm (1 1/2 inch)	± 0.2 mm	(0.008 inch)
	50.8 mm (2 inch)	± 0.25 mm	(0.010 inch)
	63.5 mm (2 1/2 inch)	± 0.3 mm	(0.012 inch)
	76.2 mm (3 inch)	± 0.38 mm	(0.015 inch)

Total wall thickness	O.D. <50.8 mm (2 inch); +22%-0
	O.D. ≥50.8 mm (2 inch); +15%-0

Thickness of stainless steel component
+ 0.60 mm (0.024 inch) – 0.40 mm (0.016 inch)
The thickness of the stainless steel component is verified by Eddy current testing of the entire length of each tube.

THERMAL EXPANSION, MEAN VALUES IN TEMPERATURE RANGES (10-6) PER °C

TEMPERATURE °C	SANDVIK 4L7	SANICRO 67	SANICRO 38	SANICRO 38/4L7	SANICRO 67/4L7
30-100	12.3	13.6	14.9	13.0	12.7
30-200	12.8	14.1	15.3	13.5	13.2
30-300	13.5	14.5	15.7	14.1	13.8
30-400	14.0	14.9	16.1	14.6	14.3
30-500	14.3	15.3	16.2	14.8	14.6

THERMAL CONDUCTIVITY W/M °C (BTU/FT H °F)

TEMPERATURE °C		SANDVIK 4L7		SANICRO 67		SANICRO 38		SANICRO 38/4L7		SANICRO 67/4L7	
°C	°F										
23	(73)	46	(26.5)	11	(6.5)	11	(6.5)	25	(14.5)	25	(15)
100	(200)	48	(27.5)	13	(7.5)	12	(7)	27	(15.5)	29	(17)
200	(400)	47		14	(8.5)	-	(-)	-	(-)	29	(17)
300	(600)	46	(26.5)	16	(9.5)	16	(9.5)	31	(18)	31	(18)
400	(800)	44		18	(10.5)	-	(-)	-	(-)	32	(19)
500	(1000)	42	(24.5)	19	(11.5)	19	(11)	32	(18.5)	32	(19)

IMPROVED CORROSION RESISTANCE

SULPHIDATION RESISTANCE

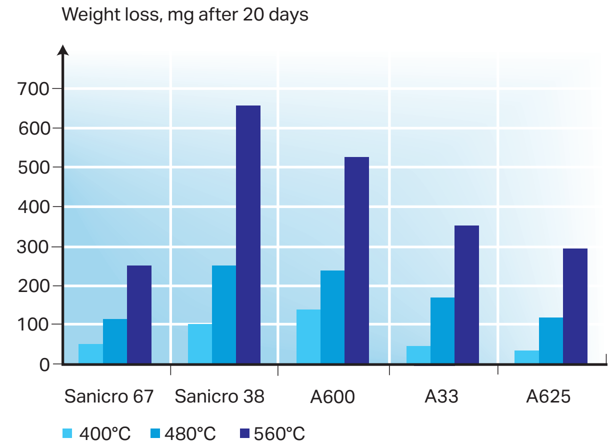

Figure 3. Sanicro 67 has good resistance to sulphidation in standard test. By courtesy of FPInnovations/Paprican

CRACKING RESISTANCE

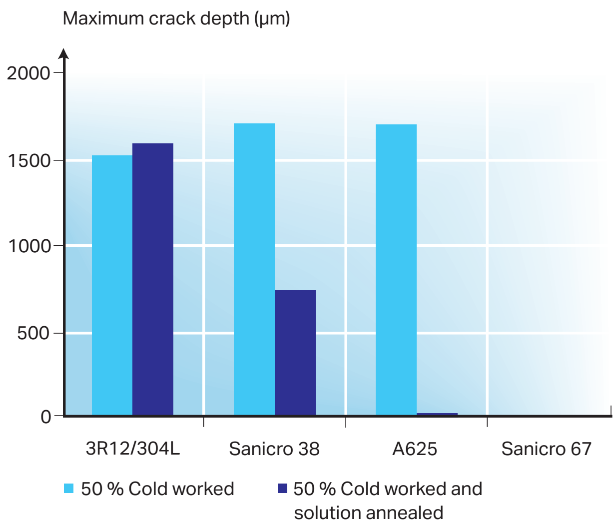

Figure 4. Sanicro 67 has excellent resistance to cracking in annealed and cold worked state.
By courtesy of FPInnovations/Paprican

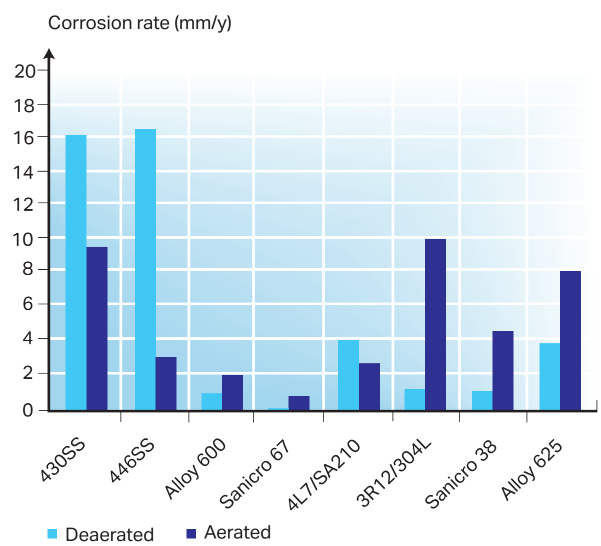

Figure 5. Corrosion tests in simulated air port opening environment. By courtesy of FPInnovations/Paprican.

WELDING

BUTT WELDING

Butt welding of composite tubes should be carried out in such a way that dilution is kept under control. The melting point of the bonding zone is lower than the melting point of the stainless steel. If the bonding zone is exposed to excessive heat input, local melting may occur.

The preferred welding method is MMA (SMAW/111) with covered electrodes. TIG (GTAW/141) is also an acceptable method.

In order to obtain the optimum corrosion resistance and mechanical properties of the welding joints, the following edge preperation, figure 6, and welding sequence, figure 7, are recommended. Recommendations of welding methods, filler metal and welding parameters are listed in table 1.

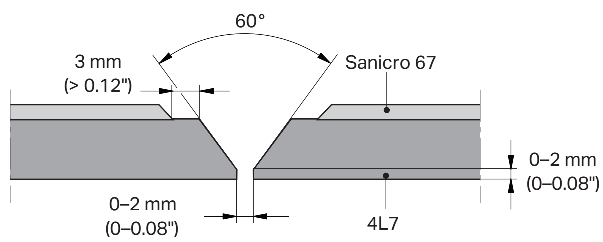

Figure 6. Edge preparation.

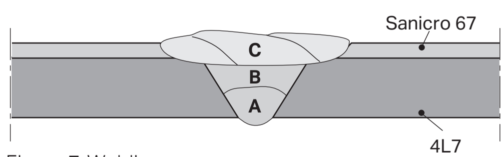

Figure 7. Welding sequence.

PANEL WELDING

The regular way to fabricate panels with Sanicro 67 composite tubes would be to produce membrane panels, with tubes linked by membranes, see figure 8.

Shop welding of panels should be carried out with a machine specially designed for the purpose. The welding should be performed so that penetration is kept under control and in accordance with customer requirements. Excessive penetration may result in hot cracking or formation of brittle weld structures. Furthermore, if carbon steel membranes are used excessive dilution of the filler metal could lead to hot cracking or a brittle weld structure.

Submerged arc welding is suitable for fabricating membrane panels, see table 2. The choice of filler metals depends on the membrane material to be used. A basic flux should be used in SAW welding. The impurity level in carbon steel membrane materials should be considered due to susceptibility for hot cracking.

TABLE 1. FILLER METALS AND WELDING METHODS FOR BUTT WELDING

PASS REF. TO FIGURE 7	WELDING METHOD	FILLER METAL & SPECIFICATION		MAX. HEAT INPUT KJ/MM (KJ/IN)	PREHEAT & INTERPASS TEMP. °C (°F)
Root & filler run - A & B Carbon steel	MMA	Matching filler	AWS A5.1 E7018	2,5 (63)[1]	250 (480)
	TIG	Matching filler	AWS A5.18 ER70S-6	2,5 (63)[1]	250 (480
Top run - C Stainless	MMA	Sanicro 69	AWS A5.11 ENiCrFe-7	1,0 (25)	150 (300)
	TIG	Sanicro 68HP	AWS A5.14 ERNiCrFe-7	1,0 (25)	150 (300)

[1] A higher heat input may be applied for the root and filler runs if the stainless peel off is increased.

TABLE 2. WELDING METHOD AND CONSUMABLES FOR PANEL WELDING WITH MEMBRANE MATERIAL SIMILAR TO ALLOY 690 (SANICRO 67) AND ALLOY 825 (SANICRO 38).

WELDING METHOD	WELDING CONSUMABLES	MAX. HEAT INPUT KJ/MM (KJ/IN)
SAW	Sanicro 68HP AWS A5.14 ERNiCrFe-7 & flux Sandvik 50SW	1,0 (25)

Thick membranes should be bevelled in order to minimize the amount of membrane material in the weld, see figure 8.

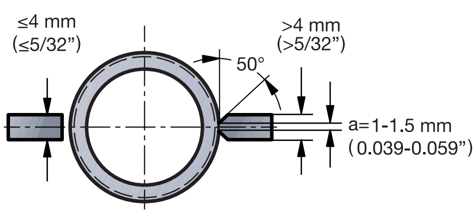

Figure 8. Edge preparation of fins.

BENDING

Composite tubes can be bent by the same methods as those used for single component tubes.

Cold bending is recommended for radii down to 1.3 x D (≈38 % deformation). For tighter radii, hot bending is recommended.

Temperatures, holding and quenching times are the same as recommended for carbon steel tubing.

The low work-hardening rate of Sanicro 67 significantly reduces the risk of cracking compared to other corrosion resistance alloys such as alloy 625.

FOR HIGHER STEAM PRESSURES

Recovery boiler steam pressure has increased during later years which means that the saturated steam temperatures and thereby the surface metal temperatures are increasing (100bar=311C and 150bar=343C).

This means that thicker load inner component walls are required to cope with the design standards.

To reduce the need for increased tube wall thickness Sandvik offers two stronger inner component options as follows.

For boilers designed under ASME Boiler and Pressure Vessel Code:

1. ASME SA210 Grade C which has 7% - 17% higher max allowable stress values than the standard SA210 A1 component

Table showing max allowable stress values for ASME SA210 Grade A1 and Grade C (internal denomination for both 4L7)

GRADE	TC	300	325	350	375	400	425	450
SA210A1	MPa	118	118	117	105	88.9	75.3	62.7
SA210 C	MPa	138	138	135	123	101	83.8	67
Relation		1.17	1.17	1.15	1.17	1.14	1.11	1.07

For Boilers designed under European PED rules:

2. EN10216-2 EN1.5415, 16Mo3 with 13% to 95% higher strength values than the standard P265GH component

Table showing creep rupture and minimum proof RP02 at elevated temperature and creep strength according EN 10216-2 for P265GH (internal denomination 4L7) and 16Mo3 (internal denomination 3Mo1)

GRADE	TC	350C	360C	370C	380C	390C
P265GH	MPa	141	141	141	141	134
16Mo3	MPa	159	159	169	159	156
Relation		1.13	1.13	1.13	1.13	1.16

GRADE	TC	400C	410C	430C	440C	450C
P265GH	MPa	128	114	100	88	77
16Mo3	MPa	156	156	156	156	150
Relation		1.22	1.37	1.56	1.77	1.95

These two optional higher strength materials, SA210 Grade C and EN10216-2 16Mo3 allow for design with thinner tube walls compared to normal SA210A1 and P265GH components.

Sandvik Group
The Sandvik Group is a global high technology enterprise with 50,000 employees in 130 countries. Sandvik's operations are concentrated on five business areas in which the group holds leading global positions in selected niches: Sandvik Mining, Sandvik Machining Solutions, Sandvik Materials Technology, Sandvik Construction and Sandvik Venture.

Sandvik Materials Technology
Sandvik Materials Technology is a world-leading developer and manufacturer of products in advanced stainless steels and special alloys for the most demanding environments, as well as products and systems for industrial heating.

Quality management
Sandvik Materials Technology has quality management systems approved by internationally recognized organizations. We hold, for example, the ASME Quality Systems Certificate as a materials organization, approval to ISO 9001, ISO/TS 16949, ISO 17025 and PED 97/23/EC. We also have product and/or shop approvals from bodies such as TÜV, JIS, DNV and Lloyd's Register.

Environment, health and safety
Environmental awareness, health and safety are integral parts of our business and are at the forefront of all activities within our operation. We hold ISO 14001 and OHSAS 18001 approvals.

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 printed matter is only valid for Sandvik material. Other material, covering the same international specifications, does not necessarily comply with the mechanical and corrosion properties presented in this printed matter.

Trademark
Sandvik and Sanicro are trademarks owned by Sandvik Intellectual Property AB.

HOME.SANDVIK

S-12114-PS-ENG.10.2016