12-02-2026

From Recurrent Failures to Safer Operations: Metallurgy Selection for Efficient Chlor-Alkali Heat Exchangers

Ganesh Prasad
Technical Marketing Specialist

Alleima

Safety first

At Alleima our objective is zero harm to our people, the environment we work in, our customers and our suppliers.


Protective equipment


Emergency number


Psychological safety


First aid kit


Emergency exit


Alarm


Assembly point


Health & well-being


Speak Up

Our proud history

1862

Founded in Sandviken
The Bessemer process makes it possible to produce steel on an industrial scale

1880

Leading Supplier
Becomes a leading supplier of cold rolled strip steel and flat wire

1888

Seamless Tubes
Started supplying the new power industry with seamless steel tubes

1921

Stainless Steel
Production start. Already then, scrap from our own production was remelted in the new induction furnace

1924

Stainless Tubes
The first seamless tubes made of stainless steel are introduced in the market

1975

High-Strength Steel
High-strength steel developed for oil sources located at great depth in difficult conditions

1985

Duplex Material
The first duplex material, SAF™ 2205 made it possible to extract oil in the North Sea (~100m)

1991

Super-duplex
SAF™ 2507 super-duplex umbilical tubes for deep-water oil extraction were introduced.

1997

Acquisition of Kanthal
Kanthal acquired to supplement the product offering with products for industrial heating and resistance materials

KANTHAL®

2010

High-Temperature Materials
Introduces a full range of materials in iron-chromium-aluminum (FeCrAl) and nickel-chromium (NiCr) alloys that withstand high temperatures

2012

New tube mill
A new state of the art tube mill for steam generator tubes for nuclear power was inaugurated and opened for operation in Sandviken, Sweden.

2018

Divestment of Wire
Alleima completes the divestment of its Wire business, improving profitability

Acquisition of Custom Electric Manufacturing
A manufacturer of original equipment and replacement heating elements

2019

Acquisition of Thermaltek
A manufacturer of high temperature furnace systems and metallic heating elements

2020

Acquisition of Summerill Tube Corporation
A manufacturer of high precision tubes

2021

Acquisition of Accuratech Group
A niched medical wire forming and component manufacturer

2022

Listed Company
Alleima is carved out of Sandvik and becomes a publicly listed company

Acquisition of Gerling
A precision tube engineering company

World-class capabilities

Sandviken, Sweden

One of Sweden's largest industrial sites in terms of ground area with c. 2,500 people working for Alleima

- Primary melting and hot rolling
- Hot extrusion (3 extrusion presses)
- Tube mills (Seamless tube and pipe, steam generator tubing, Zirconium tubing)
- Rock Drill Steels
- Precision Strip
- R&D

Sales in

90 markets

5 R&D centers

40+ sales offices

29 production sites across the globe

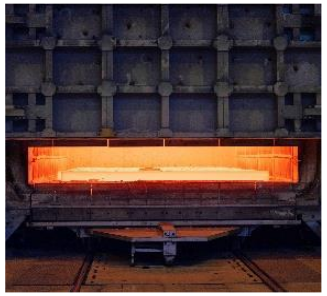
- Global presence and proximity to customers; ~6,500 employees
- Creating flexibility and back-up
- Enabling specialization

Advancing industries through materials technology

Industrial
- Solid round bar and hollow bar
- High pressure tubing
- Composite tubing
- Wear resistance strip

Chemical and petrochemical
- Fertilizer tubing
- Hydraulic and instrumental tubing
- Heat exchanger tubing

Oil and gas
- Umbilical tubing
- Control lines
- Oil Country Tubular



Industrial heating
- Metallic heating elements
- Ceramic heating elements
- Radiant Kanthal® APM / Kanthal APMT® tubes
- Diffusion cassettes

Consumer
- Compressor valve steel
- Stainless knife steel
- Razor blade steel
- Appliance wire

Power generation
- Steam generator tubes
- Cladding tubing
- Nuclear tubes and pipes
- Strip steel spacers

Mining and construction
- Rock drill steel

Transportation
- Titanium and stainless steel tubes
- Gasoline Direct Injection (GDI) tubes
- Compressor valve steel
- Shock absorber steel

Medical
- Medical precision wire
- Medical tubing
- Medical strip

Hydrogen and renewable energy
- Coated strip steel for fuel cells
- High pressure tubing for hydrogen applications
- High nickel alloy tubing for concentrated solar power applications

Fully integrated value chain

Control of the supply chain from R&D to final product.

— Ensure independence
— Industry-leading technology
— Secure product quality
— Prerequisite for new materials and product development

Customer need identification

Research & Development

Primary Melting

Hot Working

Cold Working

Finishing

Sales & Marketing

Materials innovator and technology leader

— R&D team focused on evolutionary refinements, expansion of existing portfolio as well as product innovation to capitalize on the on global mega trends

— Scope of R&D objectives extends beyond products – unique ability to innovate along whole value chain, incl. process and manufacturing

How we win, today and tomorrow

Customer partnerships | Relationship with academia

Shared R&D platforms | Application specific R&D

↓

Products focusing on growth industries | Defend core | Widen materials portfolio

# Active recepies	# Patents	# FTE:s Dec 2021	R&D % sales '19-21
>900	~850	230	1.5%

Examples of new products

Megawatt process gas heater, which is developed to heat hydrogen up to 1,000 degrees Celsius

Next generation of compressor valve steel. Freeflex is a hardened and tempered martensitic stainless compressor valve steel alloyed with copper.

New super austenitic high strength steel with high structure stability to simplify welding and heat treatment.

Complete range of Austenitic, Duplex, High-alloy Austenitic stainless steel, Nickel, Titanium, Zirconium and Bi-Metallic

Austenitic Stainless Steels	
Alleima® 3R12	304L/304
Alleima® 3R60	316L/316
Alleima® 3R65	316L (Ni, Mo)
Alleima® 3R64	317L
Alleima® 5R10	304/304H
Alleima® 6LR62	316/316H
Alleima® 6R35	321/321H
Alleima® 6R44	347/347H

Duplex Stainless Steels	
Alleima® 3RE60	S31500
SAF™ 2205	S31803/ S32205
SAF™ 2304	S32304
SAF™ 2507	S32750
SAF™ 2707 HD	S32707
SAF™ 2906	S32906
SAF™ 3006	S38071

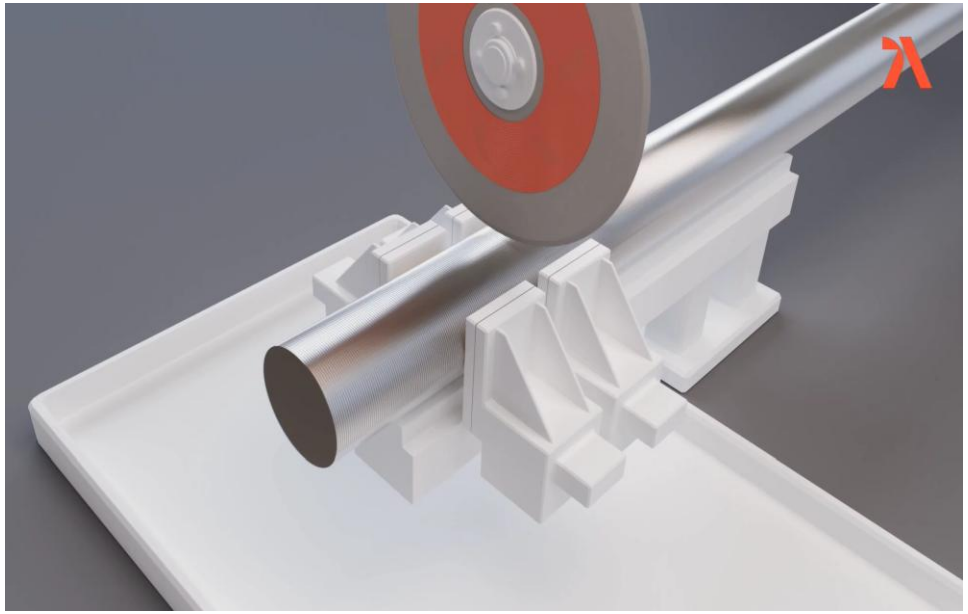
High Alloyed Austenitic and Nickel	
Sanicro® 70	Alloy 600
Sanicro® 625	Alloy 625
Sanicro® 69	Alloy 690
Sanicro® 41	Alloy 825
Sanicro® 28	N08028
Alleima® 2RK65	N08904
Alleima® 254 SMO*	S31254
Alleima® 276	N10276
Alloy 200	N02200
Allory C22	N06022
Sanicro® 35	N08935

Ti, Zr & Bimetallic	
Titanium	Pure titanium and titanium grades: 1, 2, 3, 7, 9, 11, 12, 16, 17, 26 and 28
Zirconium	Zirconium 702 (ZR-702)
Bi-metallic	ZR-702 / 2RE69

2 Tube Manufacturing

Hot extrusion

- Latest Technology
- Impurities from core removed with 20% loss of material ensures defect free product
- Lubrication in ID & OD during extrusion, results in low friction.
- Induction heating of billet results in negligible scaling.
- Compression forces resulting in fine grain defect free micro structure.
- Uniform thickness through the length.



Hot piercing

- Older method
- No Material removal hence more defect on ID
- Difficult to process high alloyed grades/high deformation resistance
- No Lubrication between mandril and billet results in high friction causing wear & tear on mandril.
- Gas fired rotary furnace heating resulting in heavy scaling, carburization and sulfer impregnation.
- Shearing forces results in cracks & lamination in ID
- Higher time in piercing might result in temperature drop of billet during process and defect creation.
- Thickness variation though out the length.

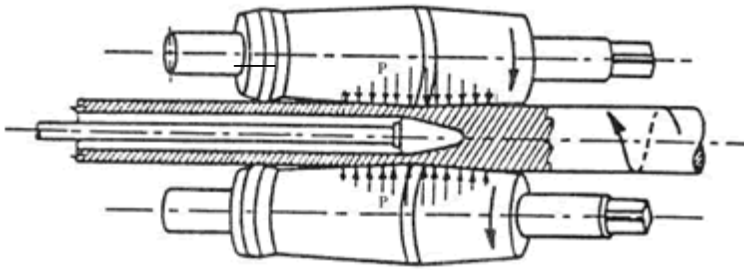


Figure 2: Mannesmann process

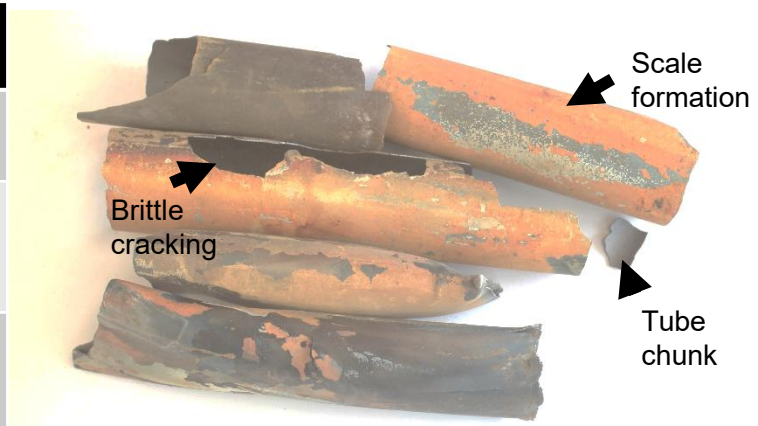
Figure 11: Accelerated plug wear

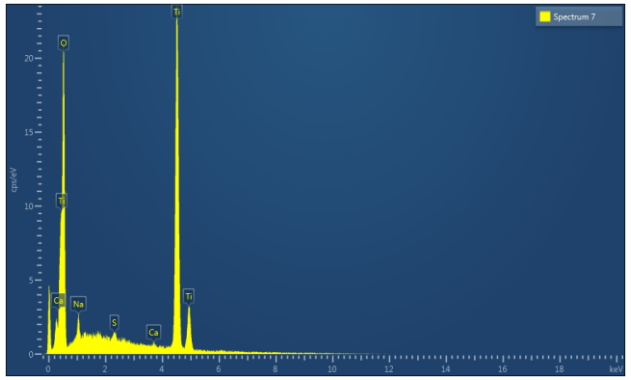
Defect from Production – Piercing method

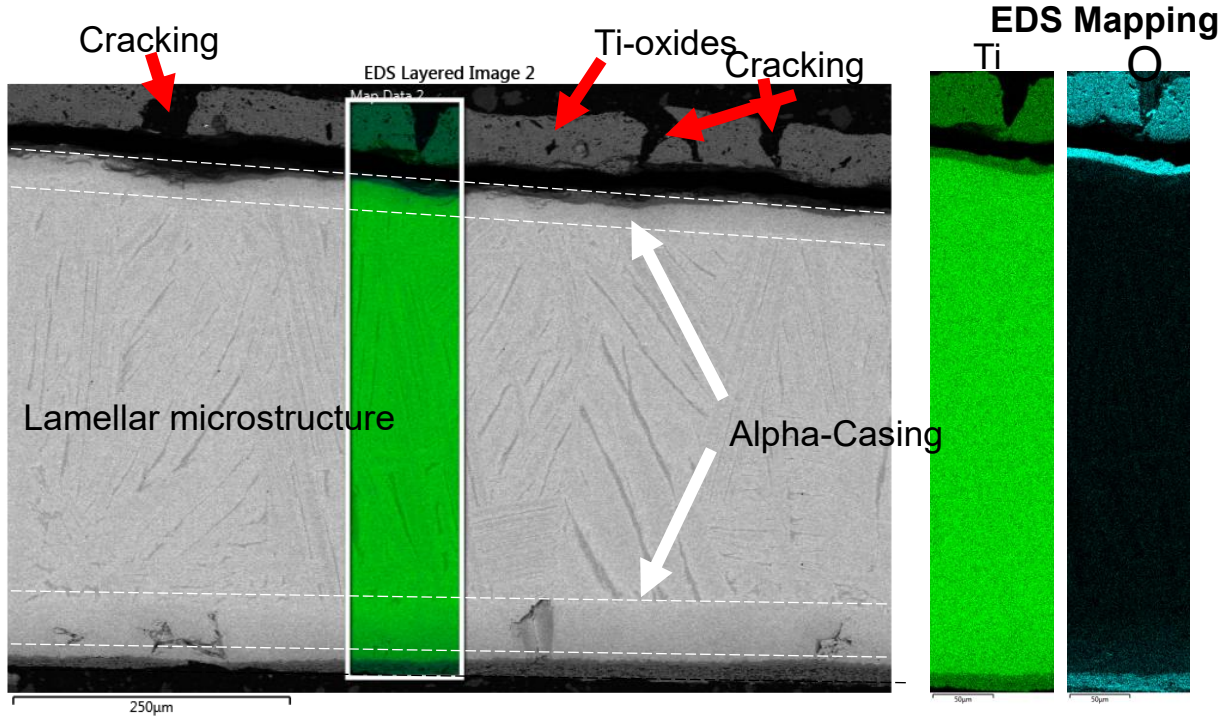
Failure Cases

Case-1: Soda ash plant WLDS preheater tube

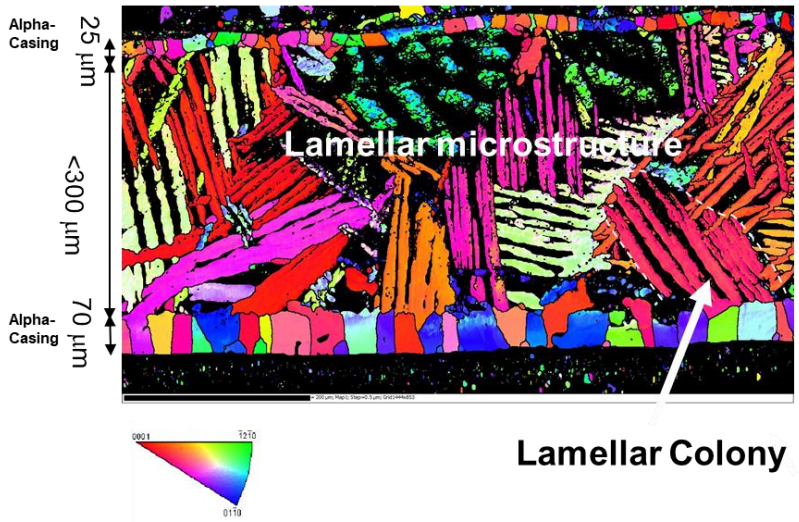
1. Application	Ammoniacal liquor & gas		
2. Process in which tubes are being used	Ammoniacal feed liquor pre-heating	Tube side: Ammoniacal gas	
3. Media tube side – Concentration of each element in %		Shell side: Ammoniacal Liquor	
3. Media shell side – Concentration of each element in %	Parameter	Unit	Result
(Tube outer surface contact)	Sodium	mg/kg	60
	Sulphide	mg/kg	<0.01
	Ammonia	%	6.43
3. Media shell side – Concentration of each element in %	NH3	%	17.76
(Tube inner surface contact)	CO2	%	63.82
	N2 + O2	%	14.74
	H2O	%	3.68
4. Working temperature on both shell and tube side	Tube side Temperature	Degree C	88-95
	Shell side temperature	Degree C	35-45
5. Working and design pressure on both shell and tube side	Tube side Pressure	Psig	0.5 -3
	Shell side Pressure	Psig	50-55

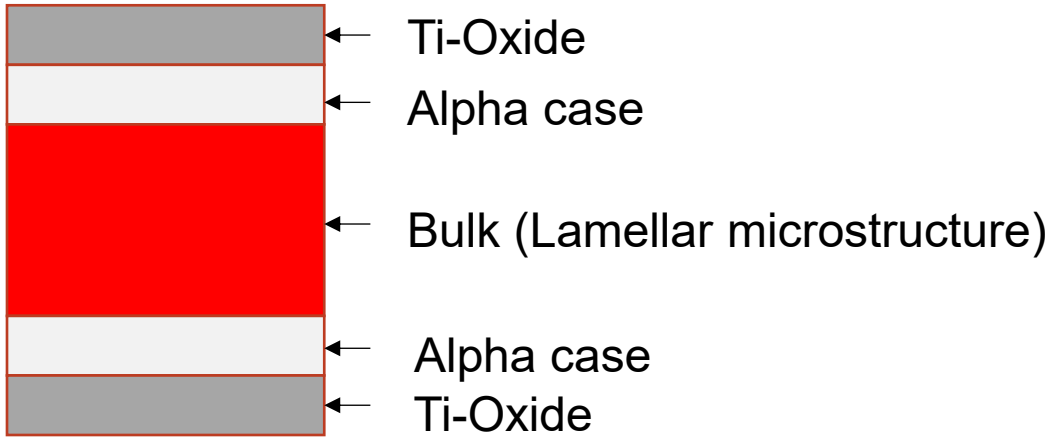






Crystallography Orientation Map





- Titanium Grade 2 is a commercially pure Titanium

$$\beta - Ti(BCC) \xrightarrow{915℃} \alpha - Ti(HCP)$$

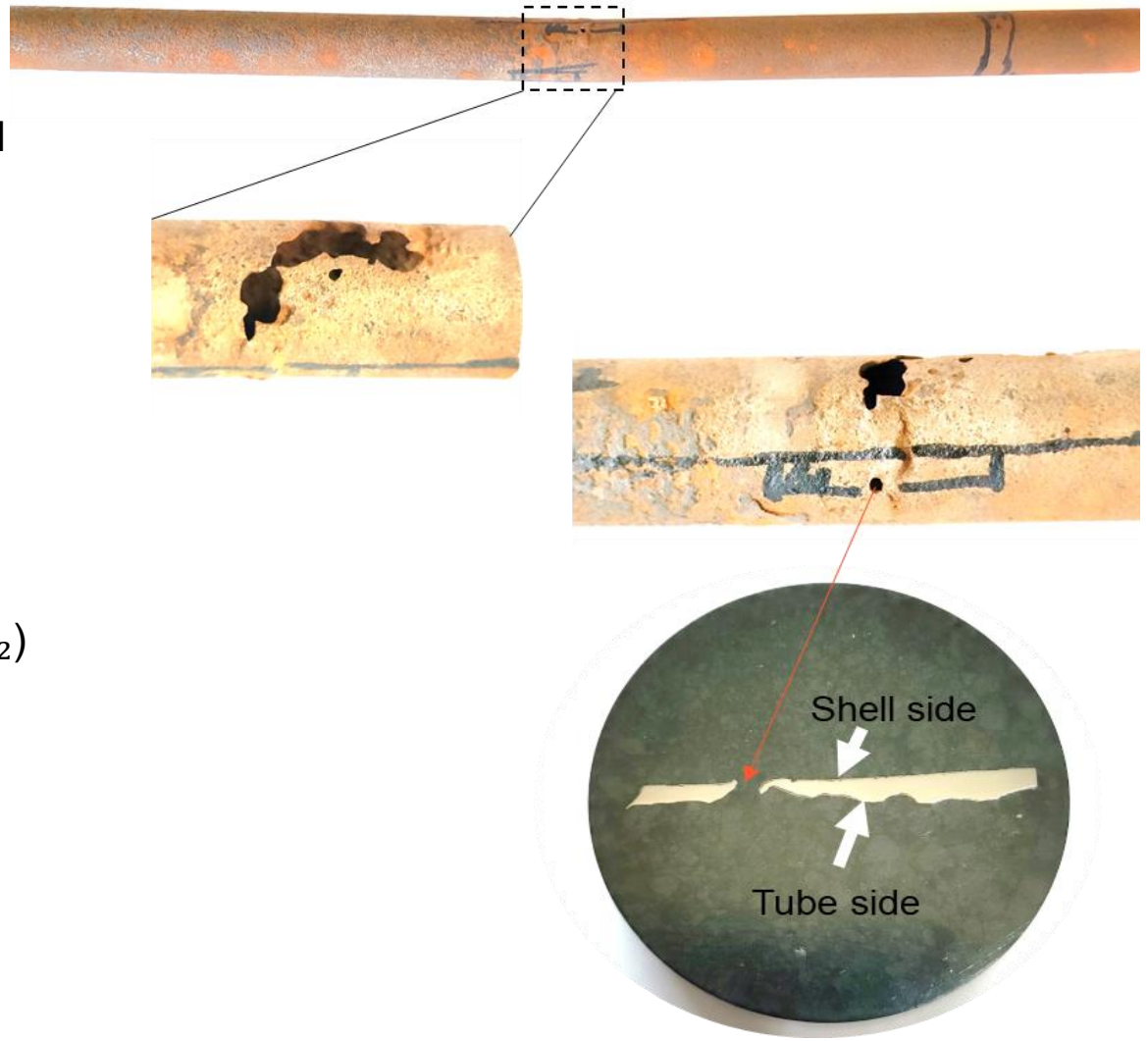
- When cooled from β_{trans}, Lamellar microstructure forms
- Alpha case may form when heat treatment is in oxidizing/nitriding environment above 800℃
- Thinning of the tube due to oxidation, corrosion, erosion
- Embrittlement due to the combined action of Ti-oxide, alpha case formation and lamellar microstructure (Poor processing route)

Recommendation:

Sanicro35 was suggested and it is working since 1.5 years without any issues and interruptions.

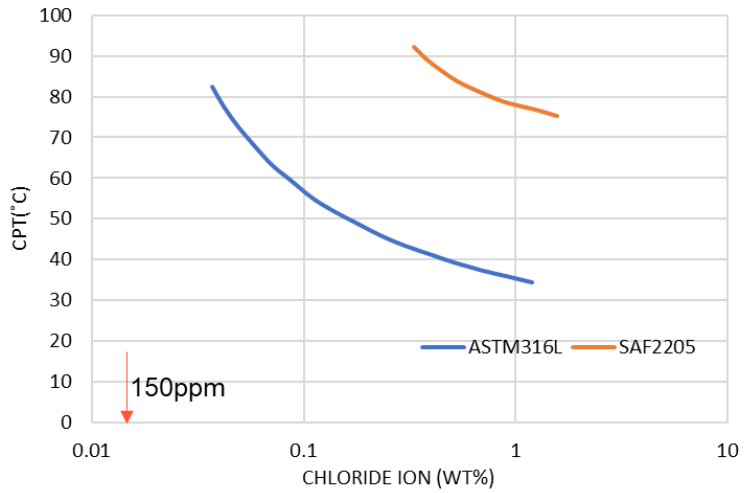
Case:2 Chlorine compressor cooling system

- **System:** Chlorine gas compression and interstage cooling section
- **Purpose:** To compress dry chlorine gas from cell house and remove heat between stages through gas coolers
- **Equipment Type:** Shell & tube heat exchangers
  - **Shell side:** Dry chlorine gas (multi-stage compression, up to ~100 °C)
  - **Tube side:** Cooling water (~32–38 °C)
- **Material of Construction:**
  - Carbon steel
- **Operating Environment:**
  - Chlorine purity: 98–98.3 %
  - Trace moisture (<100 ppm) and impurities (O_2, N_2, H_2)
  - Cooling water containing ~150 ppm Cl^-, 350 ppm SO_4, moderate hardness
- **Observed Issue:**
  - Tube leakage and wall thinning noticed within **9 months** of operation

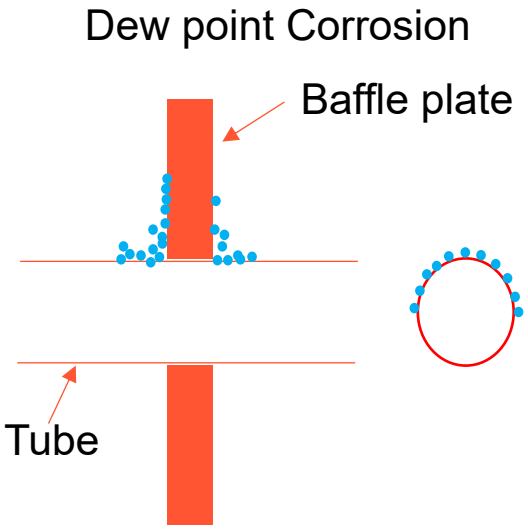


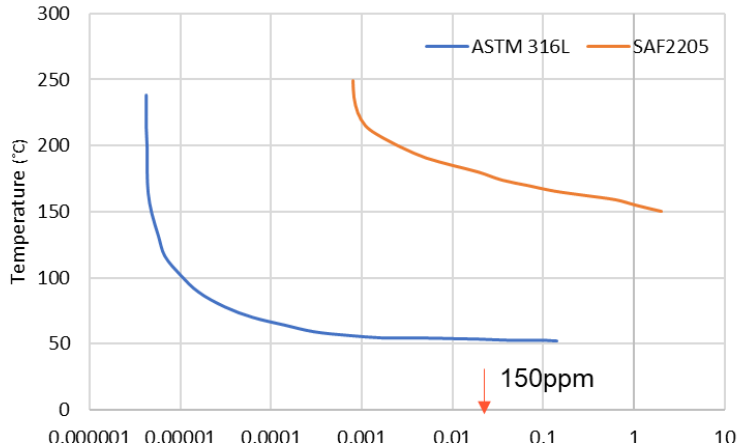
Dew Point Corrosion

When dry chlorine gas contains even slight moisture, it can lead to the formation of **ferric chloride hydrates**, which are highly hygroscopic. These hydrates can absorb more moisture, dissolve, and initiate **rapid corrosion** of carbon steel surfaces. This is especially problematic in cooler sections of chlorine systems where condensation can occur, leading to **dew point corrosion**



The critical pitting temperature of Alleima 316L in a neutral chloride solution





SCC resistance in oxygen-bearing (abt. 8 ppm) neutral chloride solutions. Testing time 1000 hours. Applied stress equal to proof strength at testing temperature.

Dry Chlorine + Moisture → HCl

Material Recommendation

- Replace carbon steel with **corrosion resistant alloys**:
  - **3R60 (SS316L):** Good resistance to pitting, CPT > 80°C at 150 ppm Cl^-
  - **SAF 2205 Duplex:** Superior resistance to pitting & SCC → **safer choice**
- Benefits:
  - Improved service life
  - Reduced downtime
  - Lower maintenance cost

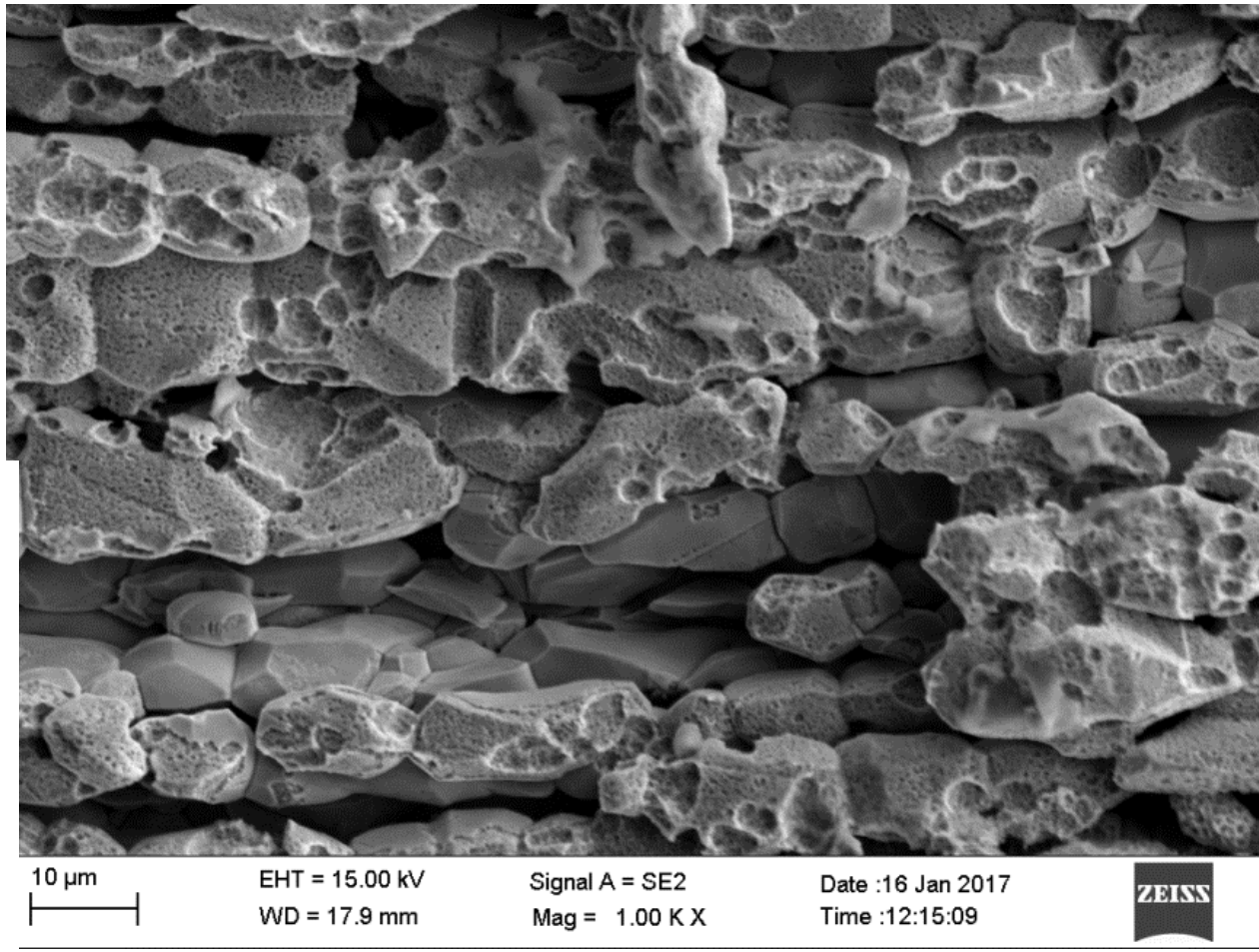
Alleima 316L is working since 3 year without any issues and interruptions.

New tube bundle with Alleima 316L Tubes

Old MOC tube bundle MOC- SA179

Case 3- PR Heater in a chemical plant

Non-Alleima UNS S32750 leaked within 1 year



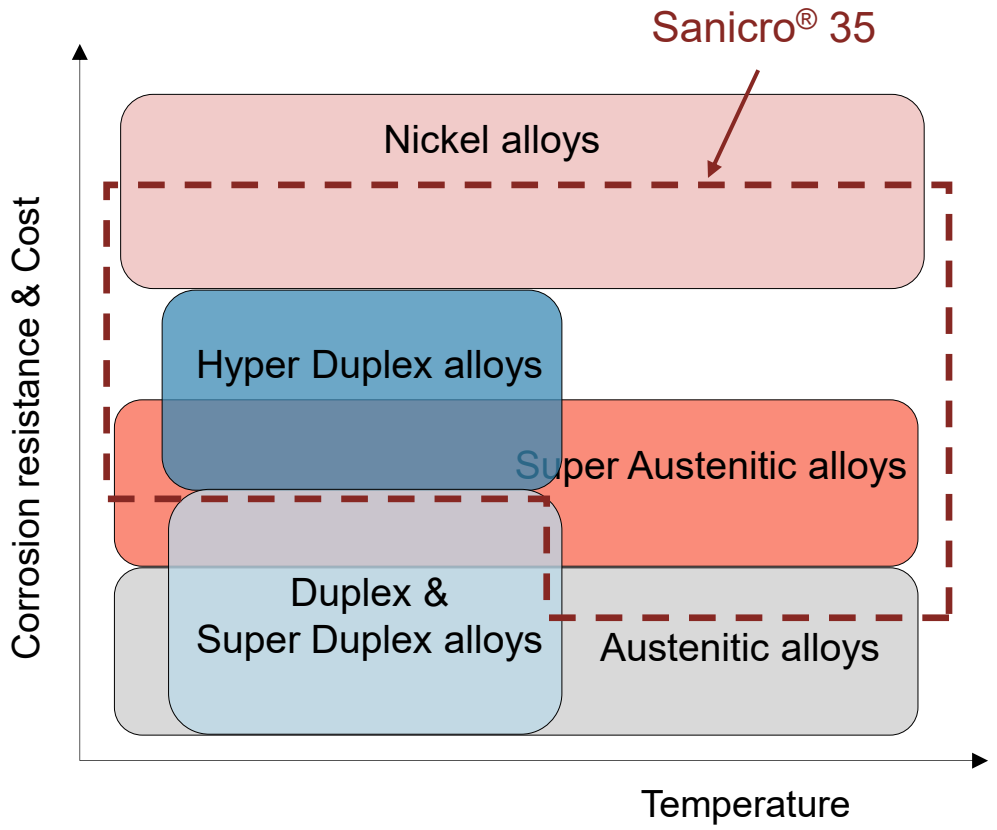
Selective Corrosion of ferrite

Sanicro 35

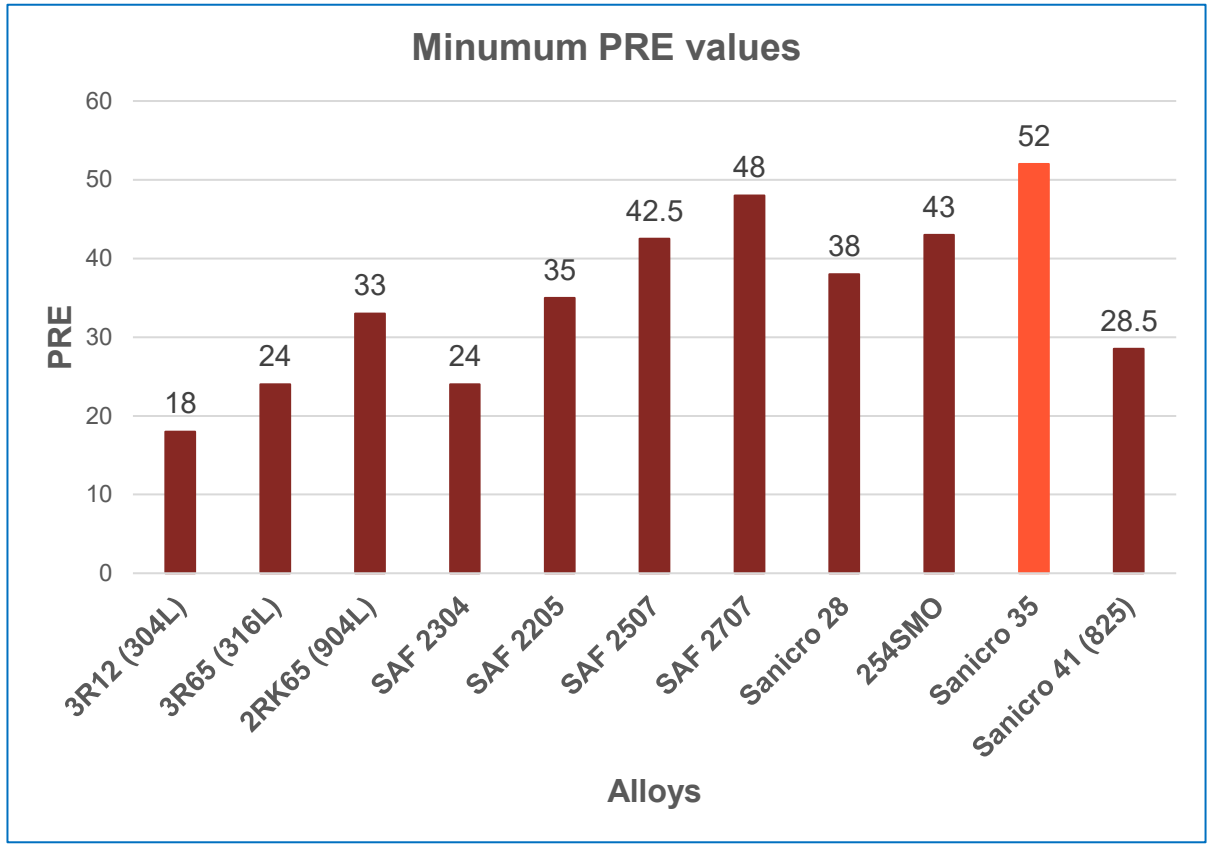
Bridging the gap between Stainless Steel and High Nickel Alloys

Sanicro® 35

TARGET AREA



Pitting Resistant Equivalent (PRE)



The target area for Sanicro® 35 is to fill the gap where austenitic grades are not enough property wise and where higher nickel alloys are not a cost-efficient solution

Sanicro® 35 - Chemistry and structural stability

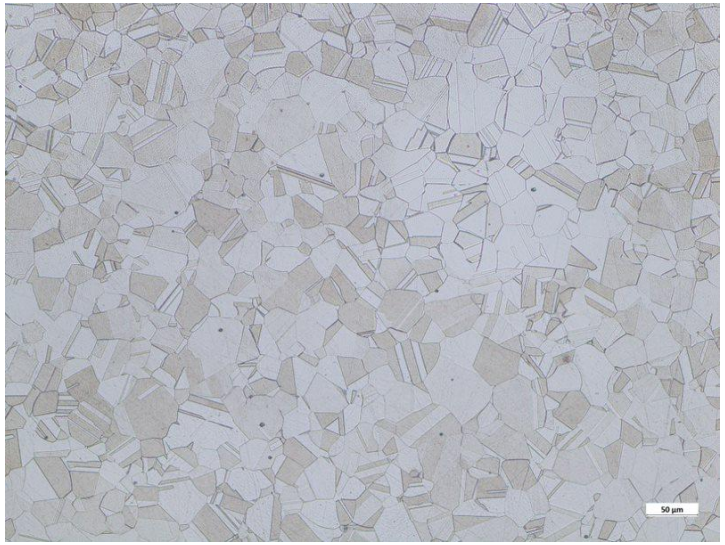
Chemical composition (nominal)%

UNS N08935

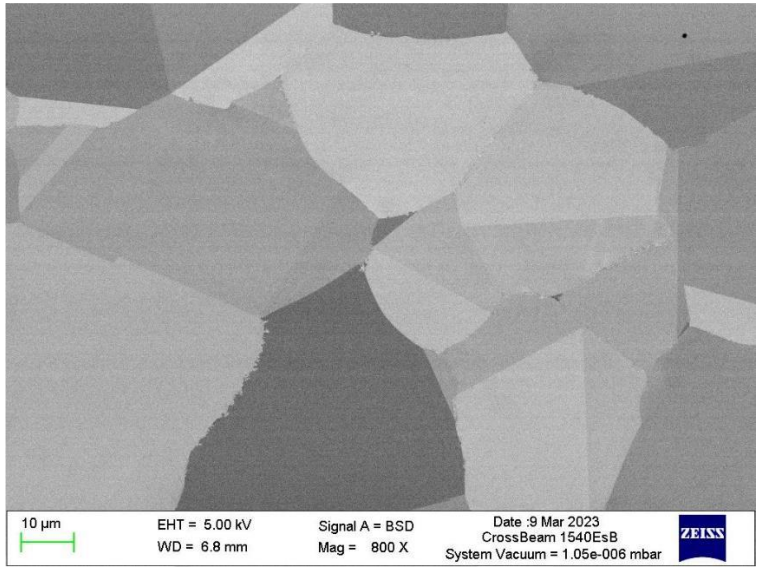
C	Si	Mn	P	S	Cr	Ni	Mo	Cu	N	Fe
≤0.030	≤0.5	0.8	≤0.030	≤0.020	27	35	6.5	0.2	0.3	Remainder

PREN:
52

Austenitic Microstructure



Microstructure after 10,000h ageing at 550°C



Standards/Approvals

- ASTM B163
- ASME code case 2982. Boiler and pressure vessel code, section VIII, division I and II.
  - 550°C (1022°F)
- Particular material appraisal (PMA), TÜV file 1326W043219
  - 550°C (1022°F)

SAF 3006
Super Duplex Stainless Steel optimized for general corrosion Resistance

Duplex stainless steels (DSSs)

- Pitting and crevice corrosion
- Mechanical strength
- Chloride SCC resistance
- Thermal expansion close to CS
- Often optimized for high chloride resistance, and therefore the performance in acid environments can be limited

SAF™ 3006 (UNS S83071)

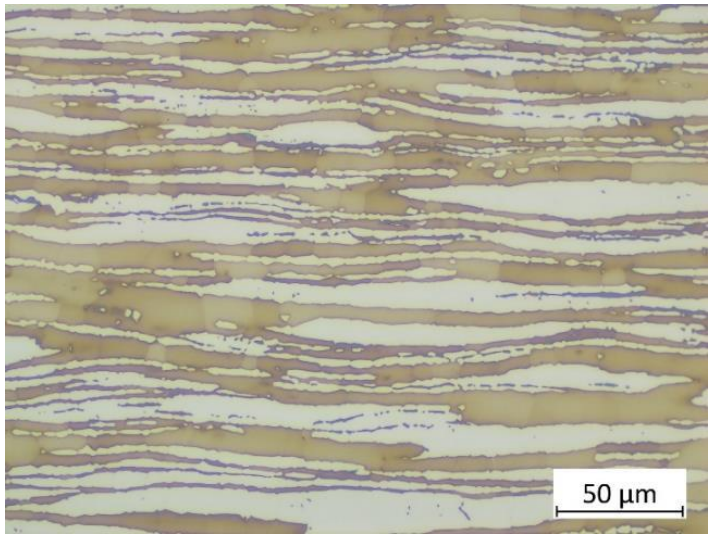
- All benefits of traditional DSSs
- Optimized for general corrosion resistance

SAF™ 3006 – Chemistry and structural stability

Chemical composition (nominal)%

UNS S83071

C	Si	Mn	P	S	Cr	Ni	Mo	N	Fe
≤0.030	0.2	1.0	≤0.030	≤0.015	30	7	3.2	0.35	Remainder



Balanced composition
Good microstructural stability
Equal amounts of Austenite and Ferrite.

Standards/Approvals

- ASTM SA 789 / SA 790
- ASME code case 2914. Boiler and pressure vessel code, section VIII, division I and II.
- Particular material appraisal (PMA), TÜV file 1326W221701

Comparison in different media

	SAF™ 3006	SAF™ 2707 HD	SAF™ 2507	904L	SAF™ 2205
Hydrochloric acid (HCl)	+++	++	0	−−−	−−−
Sulfuric acid (H_2SO_4)	++	+	0	−	−−
Sulfuric acid with chlorides (2000 ppm)	++	+	0	−−	−−−
Formic acid (HCOOH)	+++	++	0	−−	−−
Nitric acid (HNO_3)	++	0	0	−−	−
Sodium hydroxide (NaOH)	+++	0	0	−	−−
Pitting resistance	++	+++	0	−−	−−

Let’s Advance Together

Collaborative Partnership

Alleima emphasizes collaboration to address specific customer challenges and deliver tailored solutions.

Innovation and Sustainability

Alleima focuses on innovation and sustainability to improve plant reliability and reduce environmental impact.

Expertise and Global Reach

Alleima leverages global infrastructure and technical expertise to help customers achieve strategic objectives and competitive advantage.

Technical and Quality Support

Dedicated guidance on material selection and quality assurance helps customers meet complex requirements.

Thank you

alleima.com

Swapnil Waghale
Swapnil.Waghale@alleima.com
+91-8007000914

Ganesh Prasad
Ganesh.prasad@alleima.com
+91-9901483864

Alleima