

Going beyond alloy selection

Five considerations that can reduce fabrication risk,
improve reliability, and prevent costly project surprises



1. Why tube specifications matter

A heat exchanger tube specification defines much more than alloy, size and quantity

ASME or ASTM requirements may cover dimensional tolerances, heat treatment, mechanical testing and surface condition, but often leaves out important requirements concerning the manufacturing route or corrosion testing. A well-defined specification helps ensure the tubing supplied is fit for the intended service – and ready for fabrication when it arrives.

The consequence is that two tubes meeting the same ASTM specification may perform very differently in service.



Here is a quick guide of the typical additional requirements recommended for seamless tubes in different alloy groups:

Alloy family	Examples	Typical additional / supplementary testing seen in specifications	What it verifies
Austenitic stainless	304L, 316L	ASTM A262 selected practice where required by alloy and service environment; Practice C (Huey) for certain nitric-acid/high-alloy applications	Susceptibility to intergranular attacks after processing/heat treatment
High-alloy austenitic	Alleima® 2RK65 (904L), Alleima® 254 SMO*, Alleima® 2RE10, Alleima® 2RE69	ASTM A262 where applicable; ASTM G48 pitting/crevice testing may be specified for chloride service	Verifies intergranular corrosion resistance and/or resistance to localized corrosion. G48 covers pitting and crevice corrosion testing of stainless steels and related alloys
Duplex Stainless Steel	SAF® 2205	API 938-C ASTM A923 Methods A /C; ASTM G48 ISO 17781 Ferrite/phase-balance examination	Detects detrimental intermetallic phases; corrosion testing can confirm that improper heat treatment has not significantly degraded corrosion resistance
Super/Hyper Duplex	SAF® 2507, SAF® 2906, SAF® 3006, SAF® 3007	ASTM A923 where the grade is covered; ASTM G48 Method A or project-specific ferric-chloride testing; impact testing; ferrite/phase-balance examination	Particularly important because inappropriate heat treatment can form detrimental phases and reduce toughness and corrosion resistance
Nickel alloys	Sanicro® 625, Sanicro® 825, C-276, C-22, Alloy 200	ASTM G28 for applicable Ni-Cr alloys; ASTM G48 for localized-corrosion evaluation where appropriate; application-specific testing	G28 evaluates susceptibility to intergranular corrosion in wrought nickel-rich, chromium-bearing alloys
Reactive metals	Titanium, zirconium	Material-specific corrosion testing is less universally applied; chemistry, mechanical properties, surface condition and contamination controls often become particularly important	Confirms material condition and compliance; specialized corrosion tests may be specified for particular process environments

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Why tube specification matters

The tube specification involves far more than just selecting an alloy, diameter, and wall thickness. A properly written specification determines:

- Corrosion performance
- Fabrication success
- Delivery reliability
- Long-term equipment life
- Total lifecycle cost

2. Understanding the different metallurgical families

A materials portfolio designed for every level of process severity

1. Austenitic Stainless Steels

The workhorse family for process industry heat exchangers. Versatile corrosion resistance in general service

Examples

- Alleima® 3R12 (304/L)
- Alleima® 3R65 (316L)
- Alleima® 3R64 (317L)
- Alleima® 6R35 (321/H)
- Alleima® 8R40 (347/H)

Key characteristics

- Most commonly used stainless family
- Good general corrosion resistance
- Good weldability and fabrication
- Suitable for broad process applications

Limitations

- Susceptible to chloride stress corrosion cracking
- Limited performance in severe chloride environments

2. High-Alloy Austenitic Stainless Steels

The bridge between traditional stainless steels and nickel alloys, greater corrosion resistance in chlorides and acids.

Examples

- Alleima® 2RK65 (904L)
- Alleima® 254 SMO*
- Sanicro® 28
- Alleima® 2RE10
- Alleima® 2RE69
- Alleima® 7RE10 (310S/H)
- Sanicro® 31H/HT (800H/HT)
- Alloy 20



Jane Lipko (Inside Sales), Tony Donato (Business Development) and Karen Picker (Account Manager) at Alleimas facility in Scranton Pennsylvania.

Key characteristics

- Elevated chromium, nickel and molybdenum contents
- Better pitting resistance
- Improved chloride resistance
- Higher resistance to acids

Limitations:

Depending on service may have limitations under deposit corrosion or SCC.

3. Ferritic

A nickel-lean solution for selected applications where resistance to SCC matters. Efficient performance with Chloride SCC resistance.

Examples

- 400 series alloys
- Specialty ferritic grades

Key characteristics

- Nickel free or low nickel
- High resistance to SCC vs austenitic stainless steels
- Good high temperature performance

Limitations

- Reduced ductility
- Lower weldability
- More brittle at low temperatures

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PRE= Pitting Resistance Equivalent, SCC= Stress Corrosion Cracking



4. Duplex Stainless Steel

The sweet spot where strength meets corrosion resistance.
High corrosion resistance and excellent SCC resistance.

Examples

- Alleima® 3RE60
- SAF® 2205
- SAF® 2304

Key characteristics

- Mixed austenitic/ferritic microstructure
- Roughly double the strength of 316L
- Excellent chloride resistance
- Improved erosion and fatigue performance

5. Super Duplex and Hyper Duplex

Designed for environments where standard stainless steels simply cannot survive.

Maximum strength and corrosion resistance

Severe chlorides → seawater and highly aggressive environments

Examples

- SAF® 2507
- SAF® 2906
- SAF® 3006
- SAF® 2707 HD

Key characteristics

- Very high PRE values
- Outstanding localized corrosion resistance
- Exceptional chloride tolerance

Limitations:

- Upper service-temperature limit for DSS limited to ~600 °F (grade dependent).
- Improper heat treatment or welding may lead to an imbalance microstructure

6. Nickel Alloys

Engineered for the harshest combinations of temperature, pressure, and corrosion.

Engineered for severe environments

Acids → chlorides → high temperatures

Examples

- Sanicro® 825
- Sanicro® 625
- Sanicro® 35
- C-276
- Sanicro® 70 / Sanicro® 61 (600/601)
- Sanicro® 69 (690)

Key characteristics

- Highest corrosion resistance
- Excellent high temperature capability
- Strong resistance to aggressive acids

7. Reactive Metals

Specialized solutions for conditions where even advanced stainless steels and nickel alloys may not be enough.

Exceptional corrosion resistance

Titanium → zirconium → specialized severe service

Examples

- Titanium grades: 1, 2, 3, 7, 9, 11, 12, 16, 17, 26 and 28
- Alleima® Zr 702 (Zirconium 702)

Key characteristics

- Exceptional corrosion resistance
- Specialized solutions
- Long equipment life
- Reserved for applications where even advanced stainless steels and nickel alloys may not be sufficient

3. Alloy selection/application

Examples of typical applications for the different alloys are provided below:

Heat Exchanger and Process Equipment Application-by-Alloy Matrix

Application / Service Environment	Austenitics	Super Austenitic	Duplex SS	Super Duplex	Sanicro® 35	Nickel Alloys	Titanium	Zirconium
Cooling Water		○ Alleima® 254 SMO	● SAF® 2205	○ SAF® 2507	○			
Seawater Cooling		● Alleima® 254 SMO		● SAF® 2507	○		○	
REAC / Sour Water					●	● A825 ○ A625		
Crude Unit Overheads		○ 904L	○ SAF® 2205	○ SAF® 2507	●	● A625 ● C276		
Sulfuric Acid (Dilute)	○ 316L	● 904L	○ SAF® 2205	○ SAF® 2507	○			
Sulfuric Acid (Severe)		○ 904L		● SAF® 3006	●	○		○
Wet Process Phosphoric Acid		● Sanicro® 28			○			
Nitric Acid Plants	● 304L	● 2RE10	○ SAF® 2304					●
Acetic Acid	○ 316L	○ 904L		○	●	○		○
Formic Acid				○	●	○		
Organic Acids (General)	○ 316L	○ 904L	○ SAF® 2205	● SAF® 2507 ● SAF® 3006	●	○		
Chlorinated Organics				○	●	●		
Sour Service (H ₂ S)			○ SAF® 2205	○	○	○		
Offshore Topsides		○ Alleima® 254 SMO	○ SAF® 2205	● SAF® 2507	●			
Bleaching Plants (Chlorine Dioxide)				● SAF® 2507			○	
Urea Condenser	○ 316UG	○ Alleima® 2RE69		● SAF® 2906				
Urea Strippers		○ Alleima® 2RE69		● SAF® 2906				
High Temperature Process Tubing	○ H Grades	○ Alleima® 253 MA, ○ 310S/H				● 800H/HT, 600/1, 690		
Hydrochloric Acid Service					○	●	○	●

* 253 MA and 254 SMO are trademarks owned by Outokumpu.

Key:

● = Frequently considered primary alloy

○ = May be suitable depending on service conditions / commonly used

Blank = Generally not a common choice

This matrix illustrates typical areas of application and is not a material-selection guide. Final material selection must consider process chemistry, concentration, temperature, chlorides/halides, contaminants, velocity, fouling/crevice conditions, fabrication requirements and applicable design codes.

4. Tube production

Fully integrated production delivers consistency and repeatability



1. Melting: The DNA of the Tube

Everything starts with:

- Scrap selection
- Chemical composition control
- Decarburization
- Inclusion control

Benefits:

Small differences in chemistry can dramatically affect:

- Corrosion resistance
- Weldability
- Fabrication behavior

Not all 316L, SAF® 2205, or Sanicro® 825 is the same. Chemistry optimization matters.



2. Integrated Production Matters

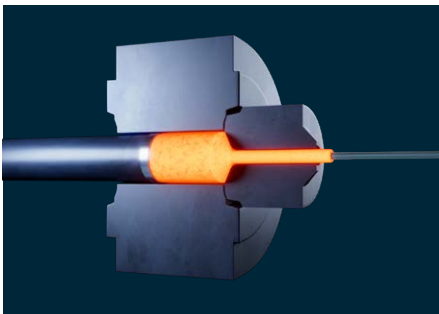
Integrated flow:

- Melting
- Casting
- Rolling
- Extrusion
- Pilgering
- Heat treatment
- Final testing

Benefits:

- Complete traceability
- Better chemistry control
- Consistent quality
- Faster alloy development
- Supply chain security

Control from melt to finished tube reduces manufacturing risk and improves consistency.



3. Hot extrusion vs Piercing

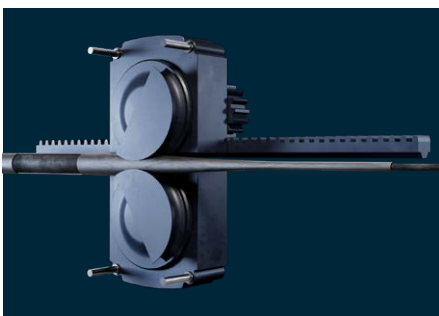
We use hot extrusion rather than traditional piercing:

- The center of the bar is removed
- The hollow billet is heated for forming
- Pressure forces it through a die to form the tube

Benefits:

- Better ID surface quality
- Removes center defects
- Better concentricity
- Improved wall thickness uniformity
- Better dimensional control

The manufacturing route directly impacts tube quality and reliability.



4. Cold Pilgering

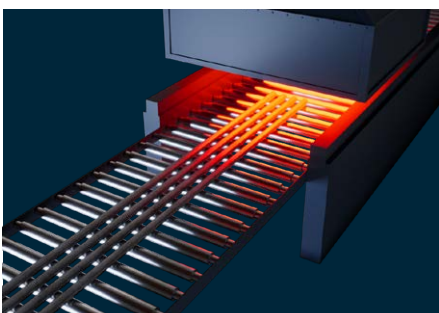
Cold pilgering refines tube dimensions through controlled cold working:

- Reduces outside diameter and wall thickness
- Controls concentricity and ovality
- Produces tight, consistent final dimensions

Benefits:

- Easier fabrication
- Better finning
- Better bending
- More reliable tube-to-tubesheet fit-up

Precision cold working improves fabricator productivity and exchanger reliability.



5. Bright Annealing

Provides:

- ID Surface finish < 0.08 micro meter (31 microinch) Ra,
- OD <1.0 micrometer (40 microinch) Ra
- Reduced fouling tendency
- Improved corrosion performance
- Cleaner fabrication surfaces

Benefits:

- Lower deposit formation
- Reduced crevice formation
- Improved cleanliness

Surface condition can have an important influence on cleanability, fouling behavior and localized-corrosion performance.

5. Hard-to-find alloys, made locally

Alleima is a world-leading producer of seamless stainless-steel and special alloys tubing up to 8-inches in outer diameter

Local capabilities in North America

Alleima USA is the only seamless tube mill in the country with hot extrusion capability, enabling us to use billets supplied from our integrated mill in Sandviken, Sweden.

Hot finished tubes:

Outside Diameter range (OD): 1.0" – 3.5" (25 mm – 88.9 mm)

Cold finished tubes:

Large flow (straight length)

- Outer diameter: 0.5"–1.5" (12.7–38 mm)
- Wall thickness: 0.035"–0.250" (0.89–6.35 mm)
- Lengths: 10'–100' (3–30 m)

Small flow (straight length or coil)

- Outer diameter: 0.25"–0.5" (6.35–12.7 mm)
- Wall thickness: 0.035"–0.083" (0.89–2.10 mm)
- Straight length: 10'–66' (3–20 m)

Alloy Portfolio

Complete range of austenitic, duplex, high-alloy austenitic stainless steel, nickel, titanium, zirconium and bi-metallic tubes.

Austenitic stainless steels

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

High-alloy austenitic

Alleima grade	ASTM grade
Sanicro® 28	N08028
Alleima® 2RK65	904L
Alleima® 254 SMO*	S31254
Alleima® 2RE10	S31002
Alleima® 7RE10	310S/310H
Alleima® 2RE69	S31050
Alleima® SX	S32615
Sanicro® 31HT	Alloy 800H/HT
Sanicro® 30	Alloy 800
Sanicro® 32	Alloy 20

High nickel grades

Alleima grade	ASTM grade
Sanicro® 61	Alloy 601
Sanicro® 70	Alloy 600
Sanicro® 625	Alloy 625
Sanicro® 69	Alloy 690
Sanicro® 41	Alloy 825
Sanicro® 35	N08935
• Sanicro® 276	Alloy 276
• Sanicro® 200	Ni200

Duplex stainless steels

Alleima grade	ASTM grade
Alleima® 3RE60	S31500
SAF® 2205	S32205
SAF® 2304	S32304
SAF® 2507	S32750
• SAF® 2707 HD	S32707
• SAF® 2906	S32906
• SAF® 3006	S83071

• = grades we do not produce locally

Ti, Zr and Bi-metallic

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

Tube material represents only one part of a successful heat exchanger project. Availability, dimensional tolerances, fabrication behavior, testing requirements, corrosion resistance and delivery configuration can all affect cost, schedule and ultimately exchanger performance.

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About Alleima

Alleima, is a global manufacturer of high value-added products in advanced stainless steels and special alloys as well as solutions for industrial heating. Based on long-term customer partnerships and leading materials technology, we develop products for the most demanding applications and industries. Our offering includes products like seamless steel tubes for the energy, chemical and aerospace industries, precision strip steel for white goods compressors, air conditioners and knife applications, based on more than 900 active alloy recipes. It also includes ultra-fine wires for medical and micro-electronic devices, industrial electric heating technology and coated strip steel for fuel cell technology for cars, trucks, and hydrogen production. Our fully integrated value chain, from R&D to end-product, ensures industry-leading technology, quality, sustainability, and circularity. Alleima, with headquarter in Sandviken, Sweden, had approximately 6,800 employees and revenues of about 19 billion SEK in about 80 countries in 2025. Alleima is listed on Nasdaq Stockholm under the ticker 'ALLEI'.