Marubeni Itochu Steel | Marubeni-Itochu Tubular Oceania (MITO)

MI INSIGHTS

“CRAs, an ally for Carbon Capture and Storage (CCS).”

With host Christian Tedaldi

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Dedicated to delivering customer solutions across resource and energy industries in Australia and New Zealand

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Our Product Offer

OCTG

Casing Accessories

Linepipe and Fittings

Sucker Rod

MI INSIGHTS

Introducing our Guest Speaker

Vikram Pandit

Regional Sales Director & Managing Director

TUBACEX GROUP

MARUBENI ITOCHU STEEL

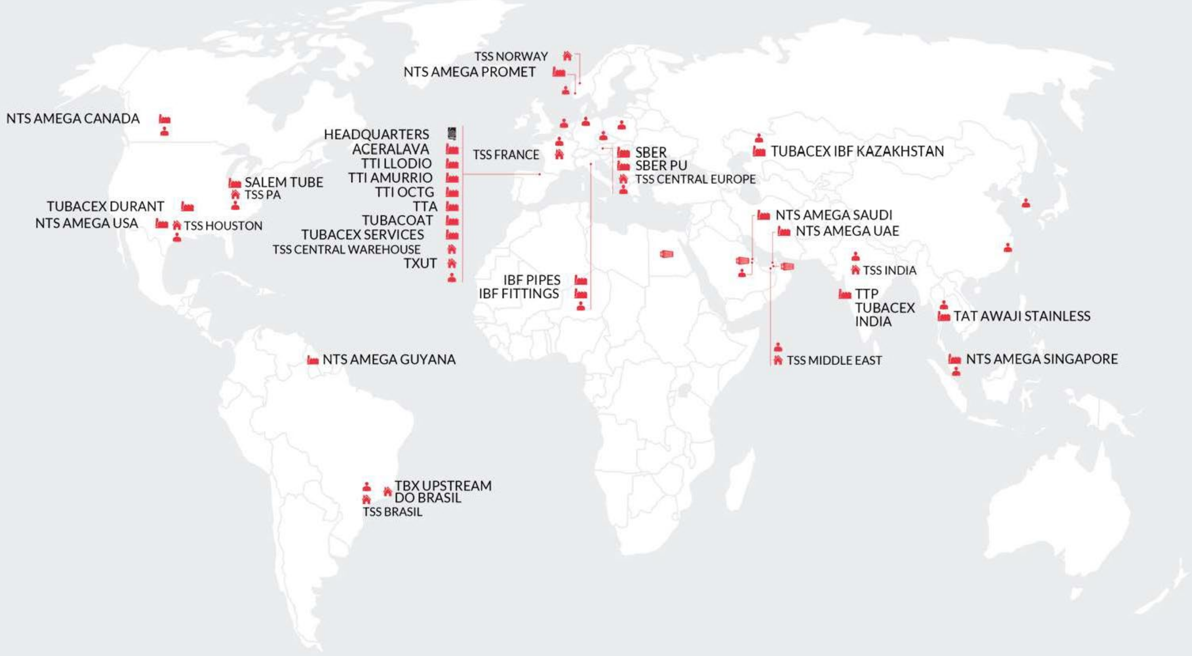
TUBACEX IS A GLOBAL INDUSTRIAL ADVANCED PRODUCT & SERVICE PARTNER

- FULLY INTEGRATED SUPPLIER OF ADVANCED INDUSTRIAL PRODUCTS AND SERVICES
- HIGH PRECISION MACHINED COMPONENTS
- GLOBAL LOGISTICS
- PERSONALIZED HIGH VALUE SERVICES

A GLOBAL LEADER IN

PRODUCTS AND SERVICES FOR ENERGY AND MOBILITY

GLOBAL PRESENCE AND THREE MAIN HUBS



2500 EMPLOYEES

24 PRODUCTION PLANTS

14 SERVICE CENTERS

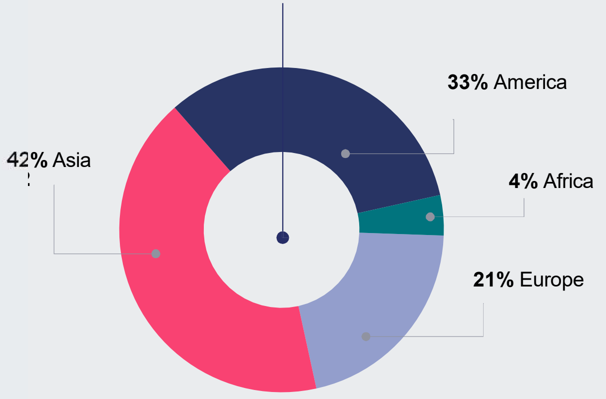
2 INNOVATION CENTERS

60 COUNTRIES SUPPLIED

15 COMMERCIAL OFFICES

400 QUALITY CERTIFICATIONS

Sales by geography
(as of 2023E)



2023E Sales: ≈ €900M

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Agenda

1. Challenges in CCS
2. Material Selection for CCS / CCUS
3. Materials Definitions and Characteristics
4. Process Technology

Challenges in CCS
Corrosion

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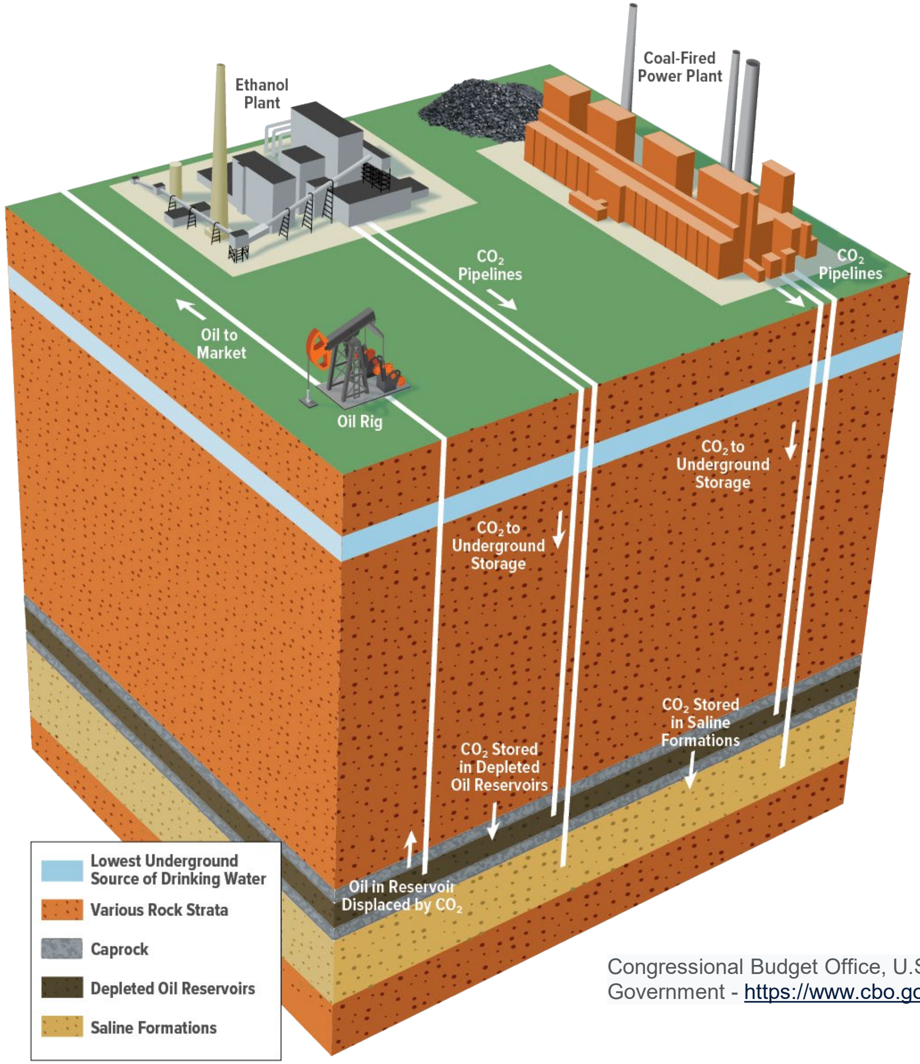
Considerations for CCS Corrosion

1. Where is the CO2 coming from?
2. How is it injected?
3. Where is it being injected to?



Congressional Budget Office, U.S. Federal Government - https://www.cbo.gov/publication/59832

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Considerations for CCS Corrosion

1. **CO2 Source**

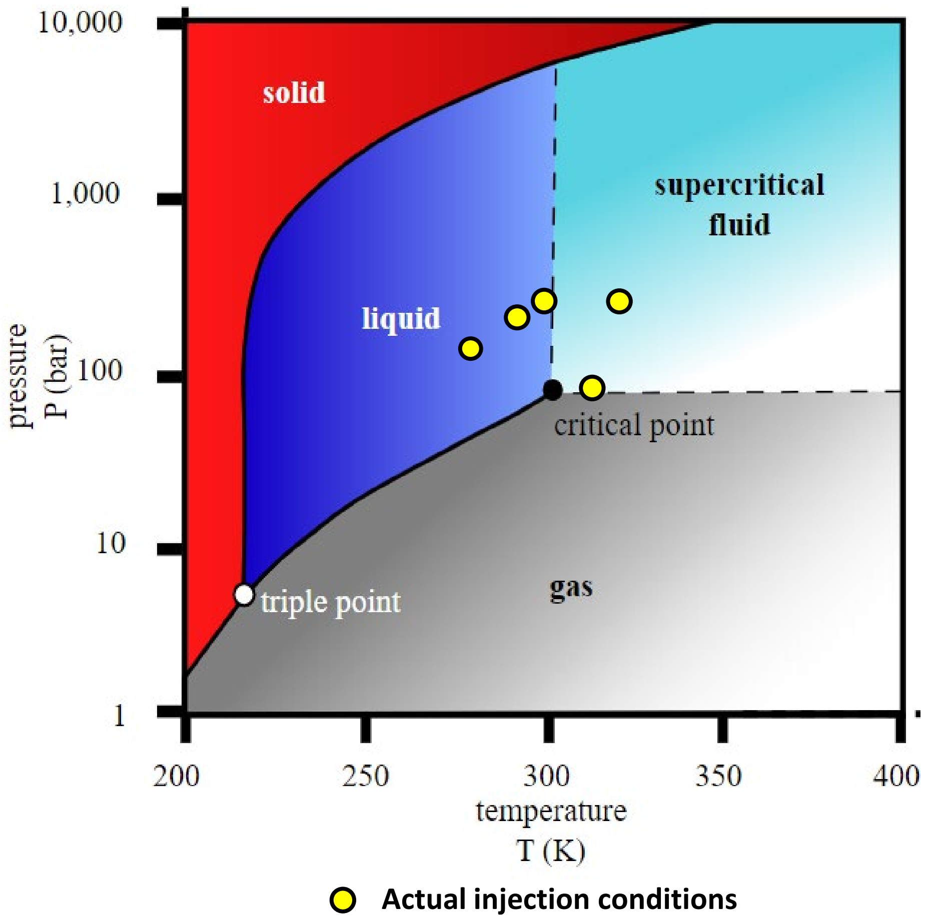
   Impurities could be a cause of corrosion
   - NOx, SOx, O2 (power plant/cement plant)
   - H2S (oil & gas)
   - H2 (precombustion at power plant)

2. **Injection condition**

   Phase change could cause
   - Joule Thomson effect
   - Change of corrosion gas pressure

3. **Reservoir**

   Reservoir environment have below concerns;
   - Low pressure: phase change
   - High pressure: Back flow when Shut-In
   - Impurities of formation water: corrosion



The Significant Cost of Corrosion

NACE International (AMPP) released the

"**International Measures of Prevention, Application and Economics of Corrosion Technology (IMPACT)**" study,

Estimates the global cost of corrosion to be:

2.5 Trillion USD

A two-year global study released at the CORROSION 2016 conference study found that implementing corrosion prevention best practices could result in global savings of between –

15-35 percent of the cost of damage, $375-875 billion (USD)

Corrosion Evaluation

Main Causes

- ✓ Water
- ✓ Carbon dioxide (CO_2)
- ✓ Hydrogen sulfide (H_2S)
- ✓ Microbiological activity

Factors

- ✓ Temperature
- ✓ Chloride ion (Cl^-) concentration
- ✓ Partial pressure CO_2
- ✓ Partial pressure H_2S
- ✓ pH
- ✓ Presence or absence of sulfur

CORROSION TYPES

- ✓ Sweet corrosion
- ✓ Sour corrosion → SSC, SCC
- ✓ Pitting corrosion
- ✓ Crevice corrosion
- ✓ Erosion corrosion
- ✓ Microbiologically induced corrosion

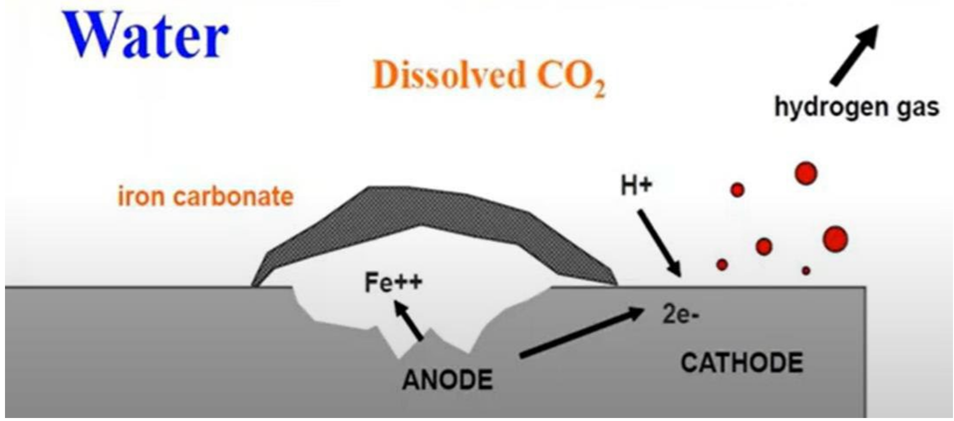
Corrosion Evaluation: Sweet Corrosion (CO_2 corrosion)

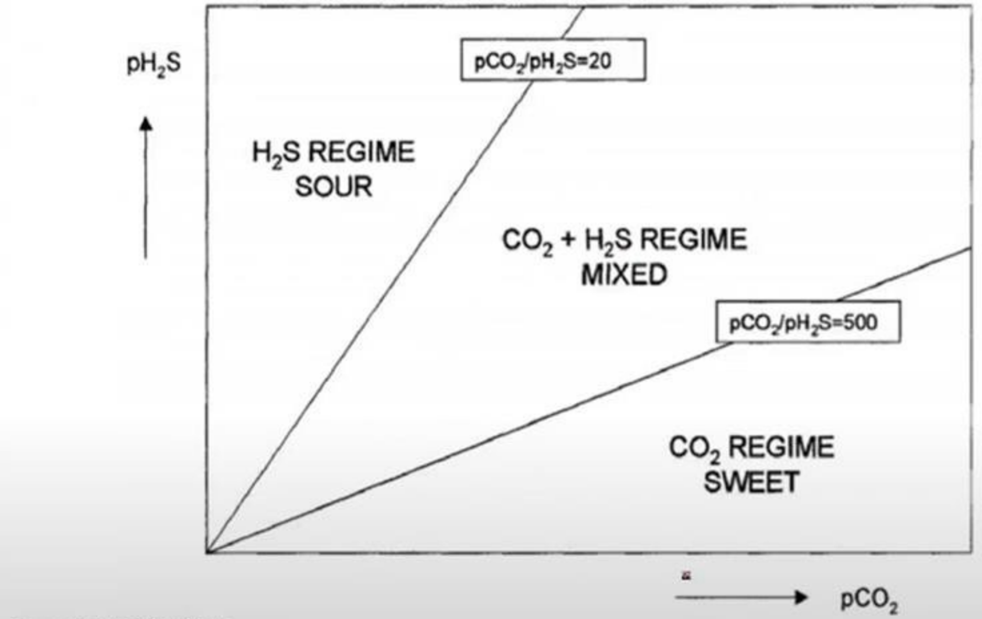
- **Fundamentals:** *Sweet corrosion occurs when CO_2 dissolves in water to form carbonic acid H_2CO_3. The acid may lower the pH by promoting general corrosion and pitting corrosion in the steel.*

  ✓ *The corrosion product is **iron carbonate $FeCO_3$** or **siderite***

  ✓ *Increasing partial pressure of CO_2 the decrease of pH may accelerate the corrosion rate.*

  ✓ *Oxygen should be limited (usually <10 ppb)*





Source: NACE-2002-02235

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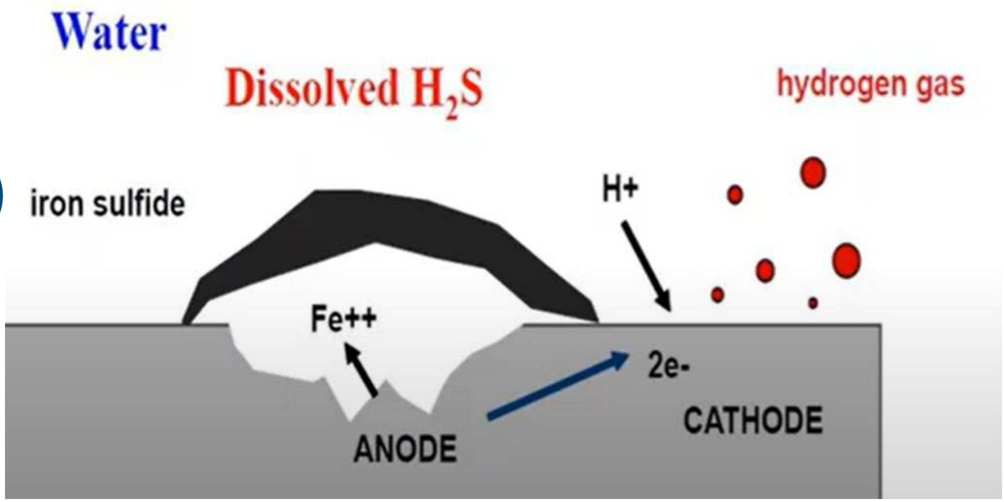
Corrosion Evaluation: Sour Corrosion (H_2S corrosion)

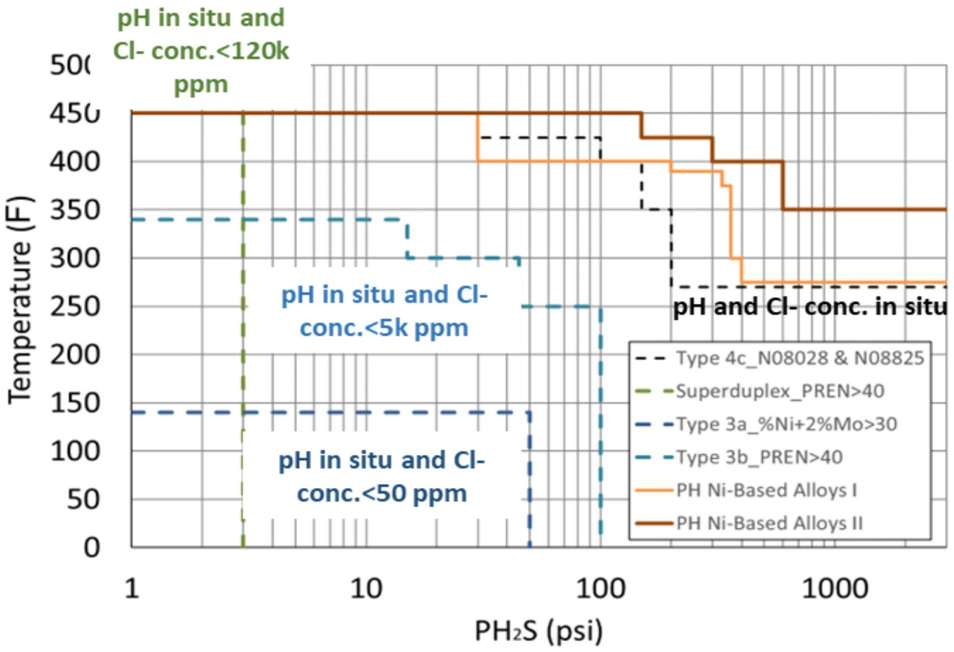


- **Fundamentals:** *Sour corrosion occurs when H_2S dissolves in water and it can cause material failure at stress levels less than their normal yield strength.*

  ✓ *The corrosion product is* ***iron sulfide FeS.***

  ✓ *Hydrogen permeation increases with increasing partial pressure of H_2S. Lower pH increases the susceptibility to corrosion*

  ✓ *Standard ISO 15156-3:* Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production —



Material Selection

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Material Selection Example

Specimen Type	Applied Stress	Liquid Phase	Gaseous Phase	Temperature (°F)	Duration (days)
FPB	100% AYS	1.648 g/L NaCl 0.41 g/L CH_3COONa In-situ pH – 2.9 w. CH_3COOH	2.32 psi H_2S 2900 psi CO_2 TP = 2951 psi	194 ± 5	30
Crevice Coupons	--				

Corrosion Evaluation: Material Selection

- CO_2 > 2 bar (30 psi)
  - H_2S > 34,5 bar (500 psi) → ≤ 205 °C → TXG50(*) / TXG3
  - H_2S > 7 bar (100 psi) → ≤ 200 ºC → TX825 / TX28
  - H_2S < 1 bar (15 psi) → ≤ 250 ºC → TX25
- 0,2 bar (3 psi) < CO_2 < 2 bar (30 psi)
  - H_2S < 0,2 bar (3 psi) → ≤ 200 ºC → TX22

(*) positive results in presence of free sulphur

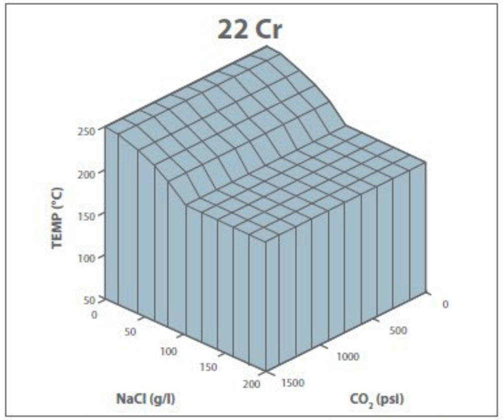


Figure 5 *The corrosion resistance of 22Cr duplex stainless steel in CO_2/NaCl environments in the absence of oxygen and H_2S. Corrosion rates of ≤0.05 mm/yr (2 mpy) and no SSC or SCC.*

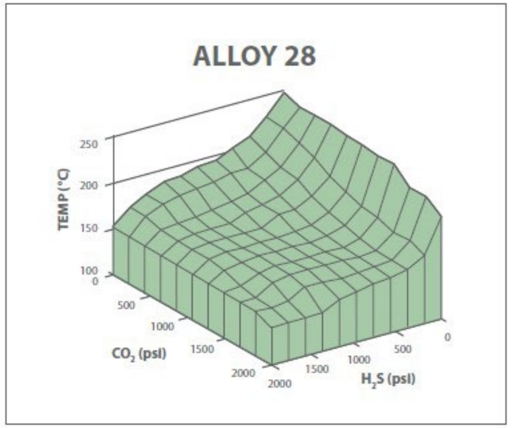


Figure 6 *The corrosion resistance of Alloy 28 in H_2S/CO_2 environments in the absence of elemental sulphur. Corrosion rates of ≤0.05 mm/yr (2 mpy) and no SSC or SCC.*

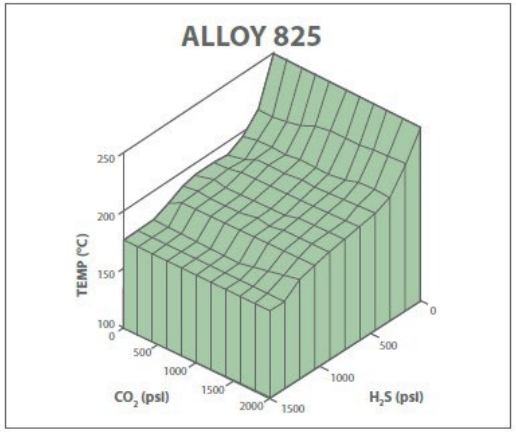


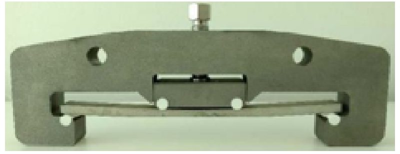
Figure 7 *The corrosion resistance of Alloy 825 in H_2S/CO_2 environments in the absence of elemental sulphur. Corrosion rates of ≤0.05 mm/yr (2 mpy) and no SSC or SCC.*

Corrosion Evaluation: Types of Testing

Stress/strain application on the material immerse in the corrosive environment

SLOW STRAIN RATE (NACE TM0198)

- ✓ Up to the specimen breaks
- ✓ More conservative
- ✓ Faster (4 days)



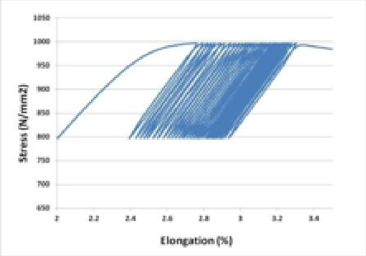
FOUR POINT BEND (NACE TM0316)

CONSTANT LOAD (NACE TM0177 method A)

C-RING (NACE TM0177 method C)

- ✓ Within the elastic zone
- ✓ Longer duration: 720 h (1 month)
- ✓ Usually localized corrosion is also evaluated in coupons within the same autoclave.

RIPPLE LOAD TEST (TM21452 under standardization)



- ✓ SSRT frame
- ✓ "Fatigue cycling" within the elastic zone
- ✓ Intermediate duration: 1 week

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Test Results- TX25

No corrosion observed after 30 days of testing

Materials Definitions and Characteristics

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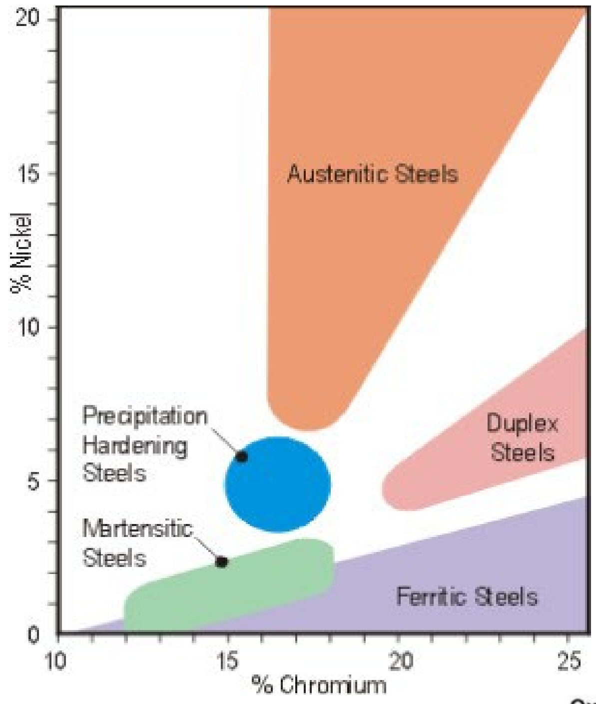
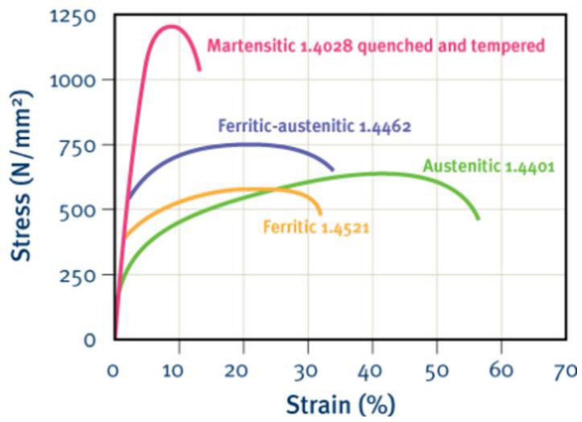
Materials Definition:
Stainless Steels

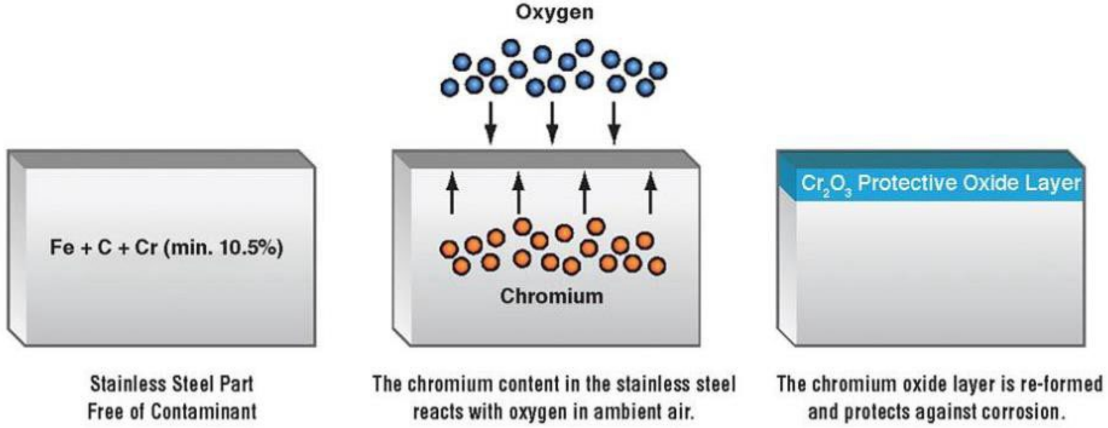
- ~ 11% Cr minimum

- Thin and adherent protective oxide layer
- Cr_2O_3 (+Al, Si, Mo, REM...↑ protection)

- 5 stainless steel families:
    - **Austenitic stainless steels**
    - Ferritic stainless steels
    - Martensitic stainless steels
    - **Duplex stainless steels**
    - Precipitation hardening stainless steels

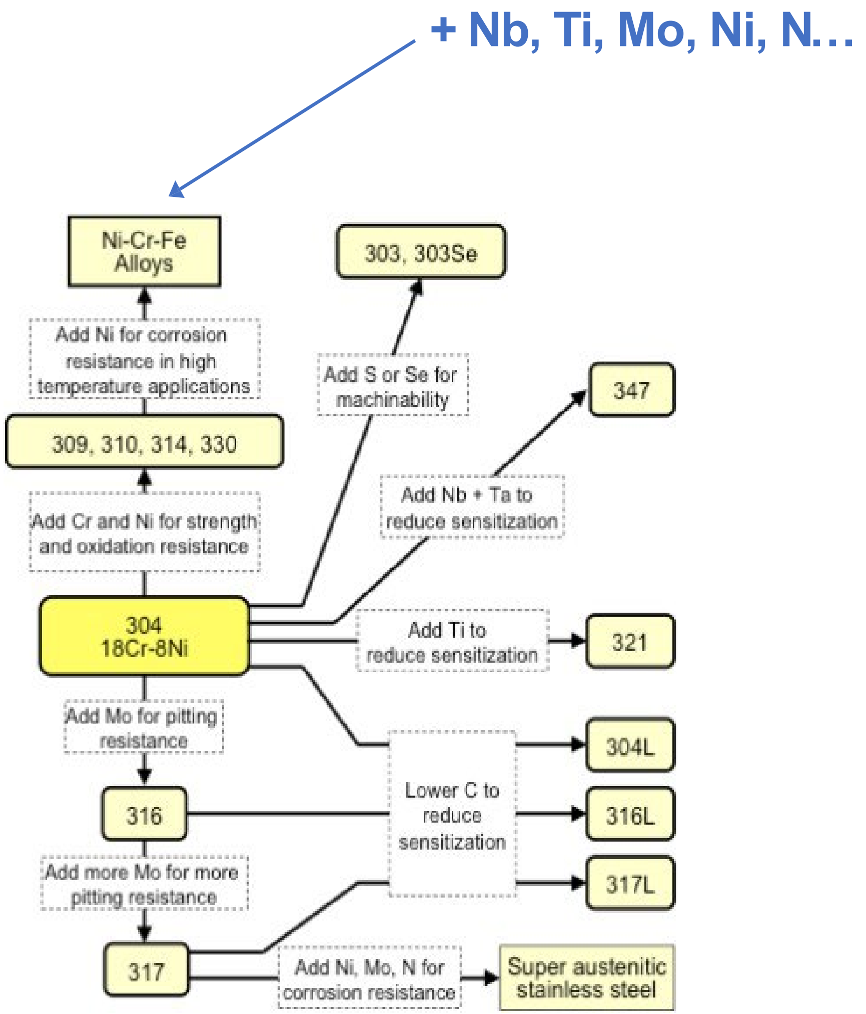






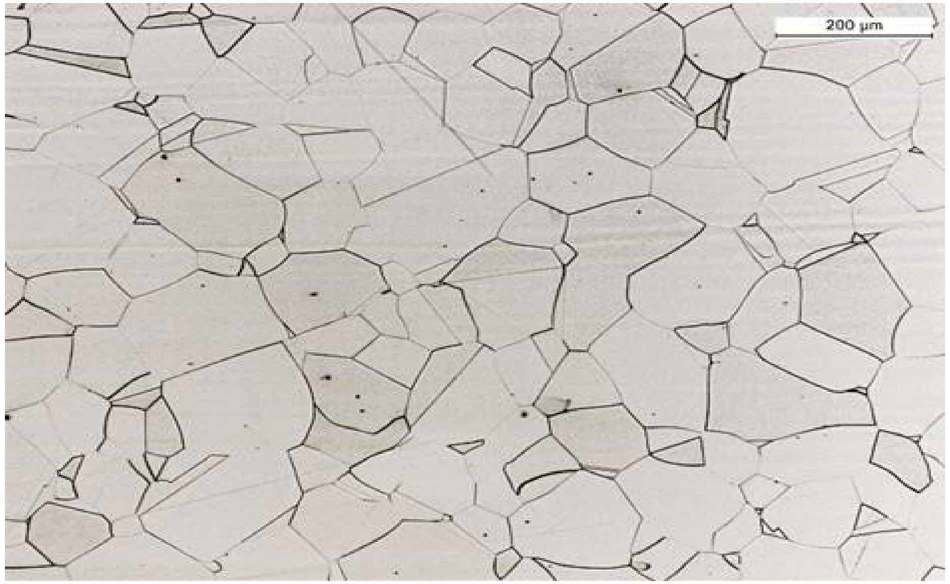
Materials Definition:
Austenitic Stainless Steels

- Fe-Cr-Ni grades – AISI 300: based on 304
- Fe-Cr-Mn-Ni grades – AISI 200: Mn replaces Ni, N addition: ↑strength ↓corrosion resistance
- Highly alloyed Fe-Ni-Cr grades: Ni~30% (Alloy 800, Alloy 20…): ↑corrosion resistance @ high temperature
- **Superaustenitic grades: Mo, Ni, Cr, N additions (6Mo, 904L…): ↑corrosion resistance**



Main Characteristics:
Austenitic Stainless Steels

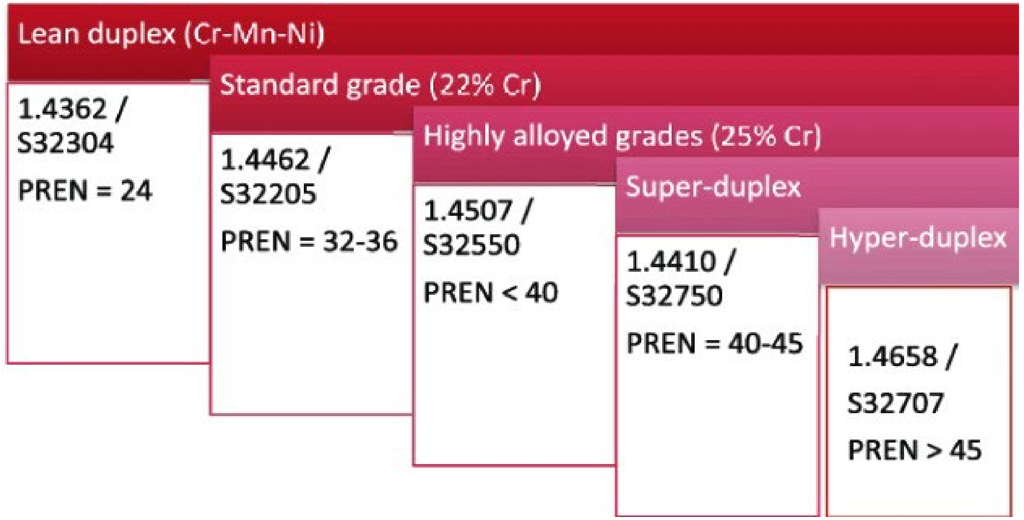
- Non-magnetic
- Very good formability
- Very good weldability
- High toughness and ductility down to absolute zero
- **High strength can be achieved by cold-working**
- Very good creep resistance
- **Very good corrosion resistance in many environments**
- Susceptible to chloride-induced stress corrosion cracking
- Susceptible to thermal fatigue



MICROSTRUCTURE:
- Grain size according to ASTM E112
- Precipitation: carbides, sigma…

Materials Definition:
Duplex Stainless Steels

- **Duplex grades:** 22% Cr, 4.5-6.5% Ni, 2.5-3.5% Mo, 0.1-0.2 N, PREN≥35
- **Superduplex grades:** 25% Cr, 6-8% Ni, 3-5% Mo, 0.2-0.3 N, 0-1% W, PREN>40, ↑strength, ↑corrosion resistance
- Hyperduplex grades: ↑ %Cr, ↑ %Ni, ↑ %Mo, %N, PREN>45:
- ↑↑strength,↑↑corrosionResistance
- Lean duplex grades: ↓ %Ni, ↓ %Mo, PREN<30:
- High strength with↓corrosion resistance and ↓price



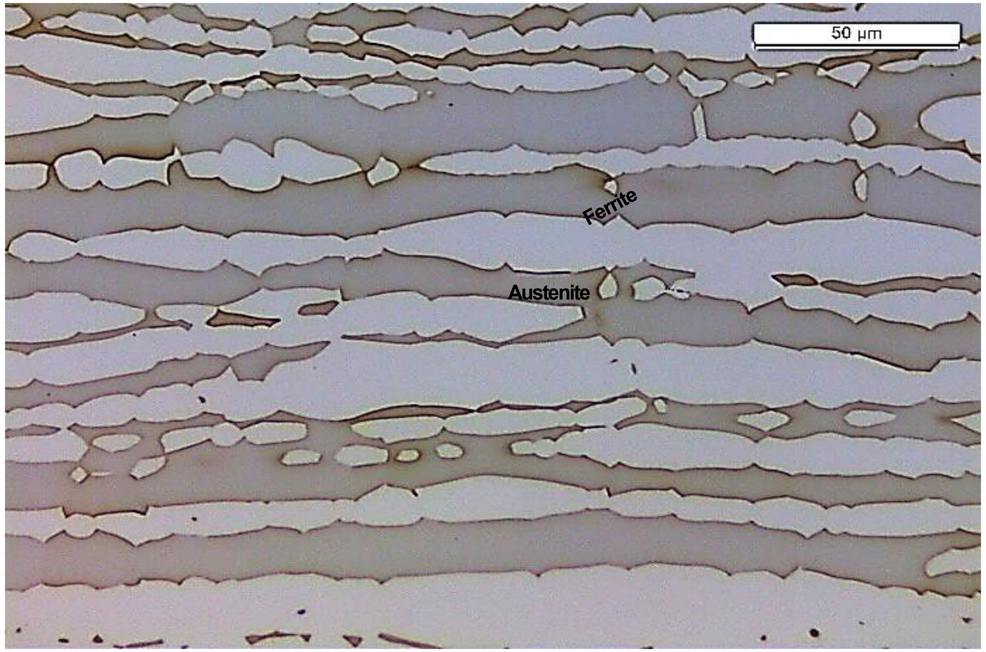
PREN = %Cr+3.3 x %Mo + 16 x %N

PREW = %Cr+3.3 x (%Mo + 0.5 x %W) + 16 x %N

Pitting Resistance Equivalent Number: predictive measurement to localized pitting corrosion resistance based on the chemical composition

Materials Characteristics:
Duplex Stainless Steels

- Ferro-magnetic
- Good formability
- High strength
- Good toughness
- They can be hardened by cold working
- High resistance to pitting and crevice corrosion
- High resistance to chloride-induced stress corrosion cracking
- Reasonable weldability
- Very limited use at high temperatures:
  - ✓ 475ºCembrittlement(spinodal decomposition of ferrite phase in the temperature range ~ 280-500ºC)
  - ✓ intermetallic phases embrittlement in the temperature range ~ 600-900ºC



MICROSTRUCTURE:

- Ferrite/austenite balance (aprox. 50%/50%)
- Precipitation: sigma, chi,nitrides, carbides…

Materials Characteristics:
Solid solution Nickel-based alloys

MAIN CHARACTERISTICS:

- Excellent resistance to high temperature corrosion in many environments
- They also form a thin and adherent protective oxide layer
- High strength over a wide range of temperatures.
- Nickel-based alloys can be used to approximately 0.75 times their melting point.

MICROSTRUCTURE:

- Grain size according to ASTM E112
- Precipitation: carbides, sigma…

Process Technology

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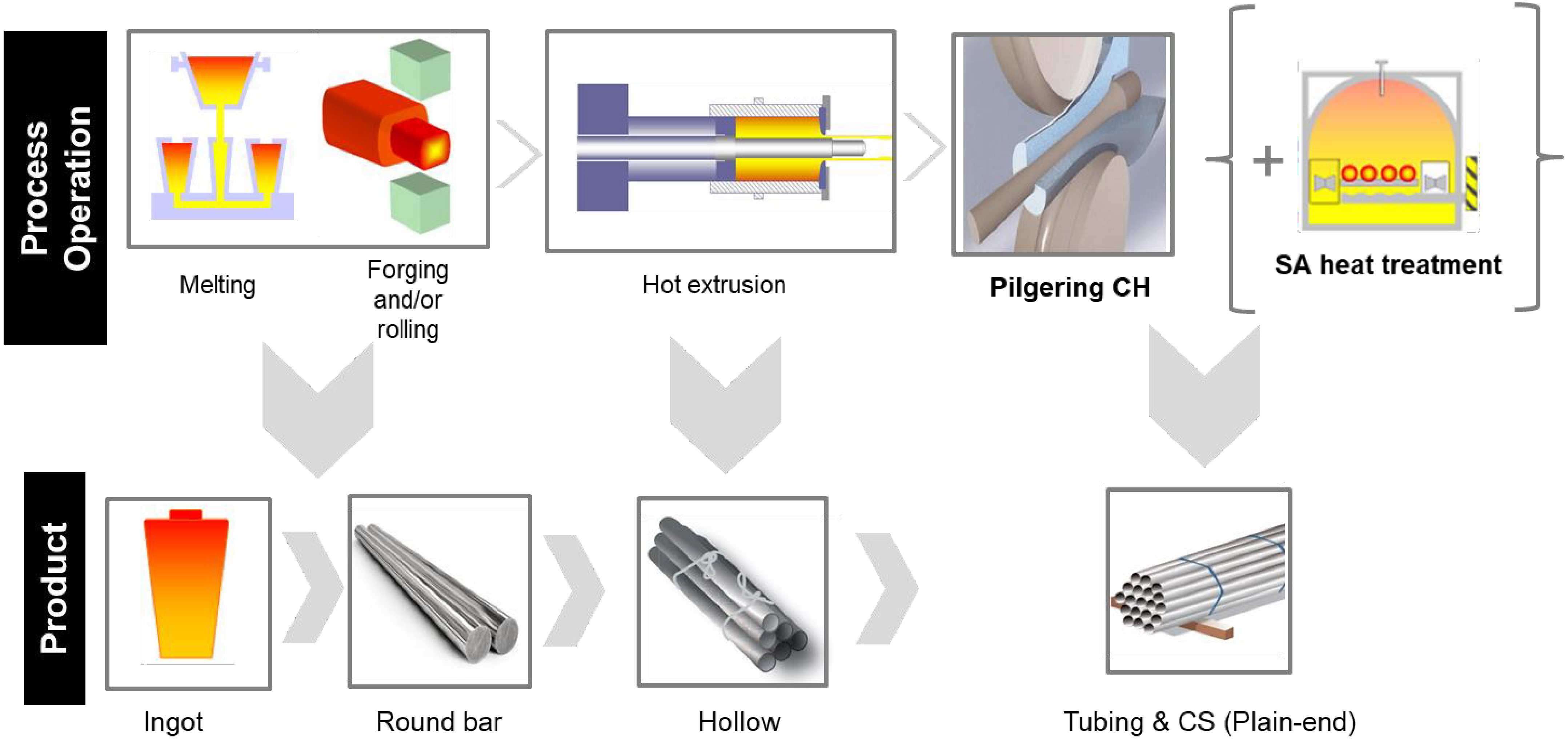
Production process, Route up to 7 5/8"



How to get the best outcome for your CCS Project…

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How to get the best outcome for your CCS Project

- Work with experts with deep technical knowledge to understand your requirements from the beginning
- Support throughout the FEED and FID stages
- Material selection is key- **CRA is your CCS Ally**
- Local technical and commercial support throughout the project

Thank You
Q&A

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