Material Selection for Upstream Oil and Gas

Corrosion Awareness Day, 2026

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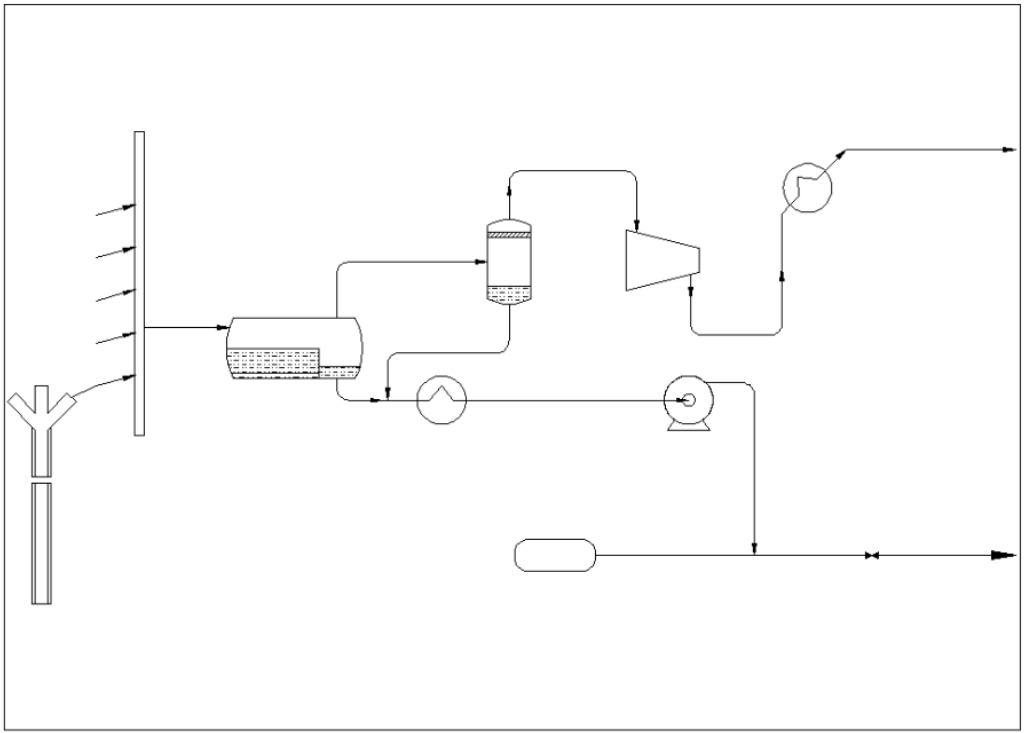
LR Offshore Technical Support Offshore

Outline

- Upstream Oil and gas processing
- Types of Corrosion
- Material Selection – Basic considerations
- Material Selection - Corrosion
- Material Selection - Mechanical
- Summary

Upstream Oil and Gas Processing



Simplified Process Flow Diagram of Oil and Gas separation

Well control equipment – e.g. alloy steel forging
AISI 4130 – 0.3%C, 1%Cr, 0.25% Mo
(quenched and tempered)

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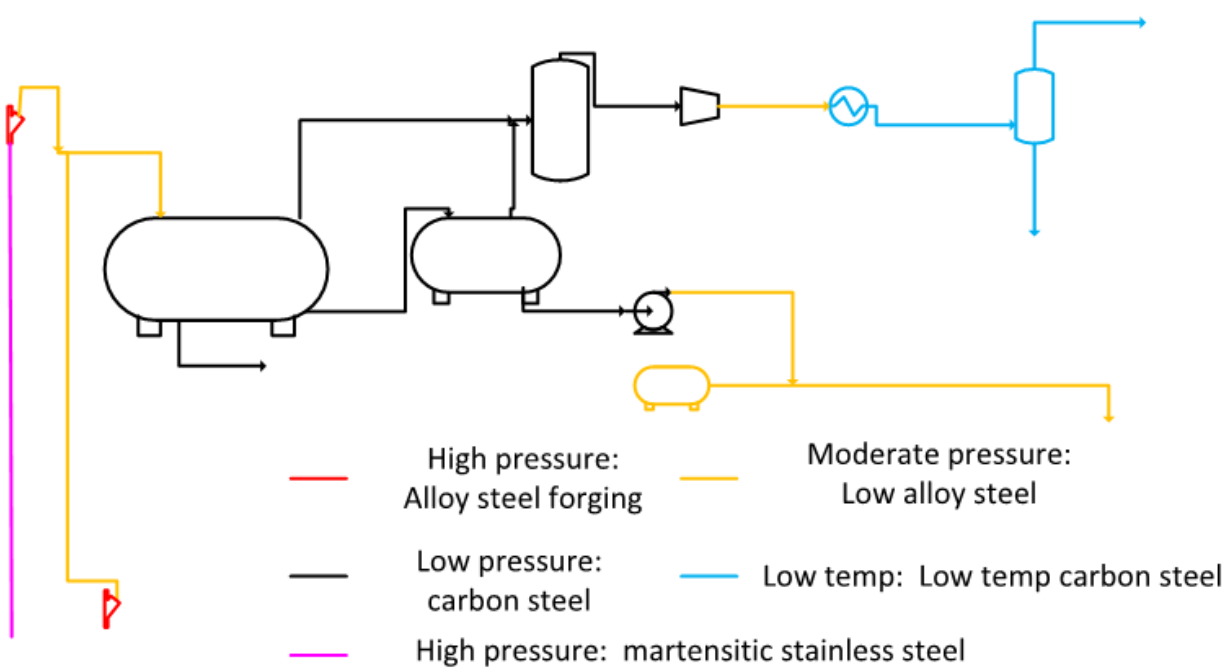


Simplified Material Selection Diagram for Oil and Gas separation showing

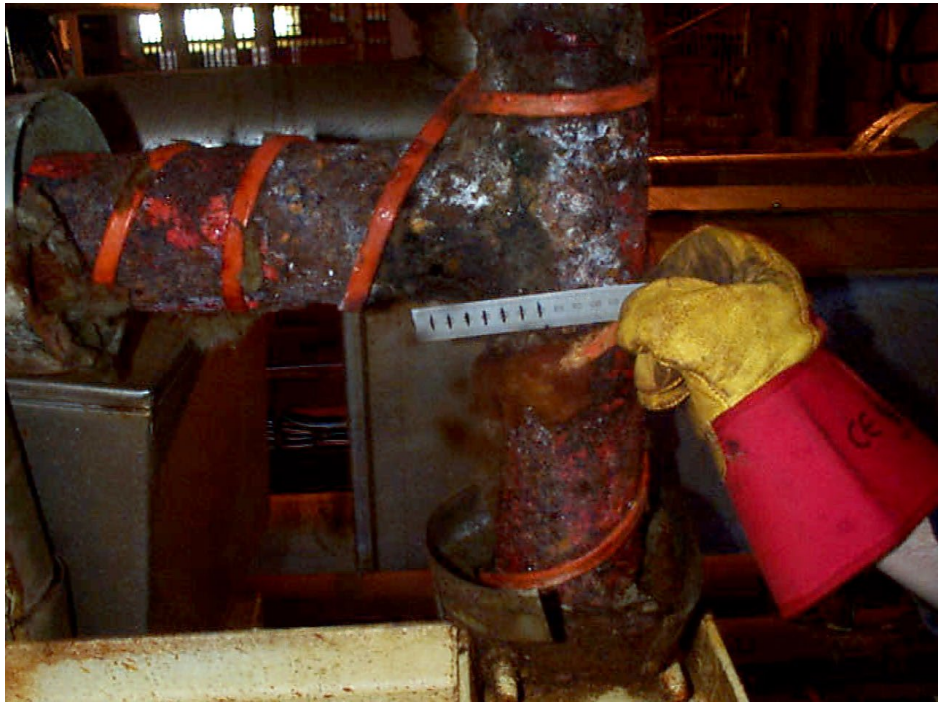
Types of Corrosion in Upstream Oil and Gas

- Carbonic acid corrosion
- Corrosion under insulation (CUI)
- Sour service (H_2S in water) cracking
- Galvanic corrosion
- Microbially-influenced corrosion (MIC)
- Oxygen corrosion
- Chloride stress corrosion cracking of stainless steels
- Erosion

Types of Corrosion – carbon and alloy steels

Flow-assisted general corrosion in an oil inlet header transporting oil, gas and produced water with dissolved CO_2

Types of Corrosion – carbon and alloy steels



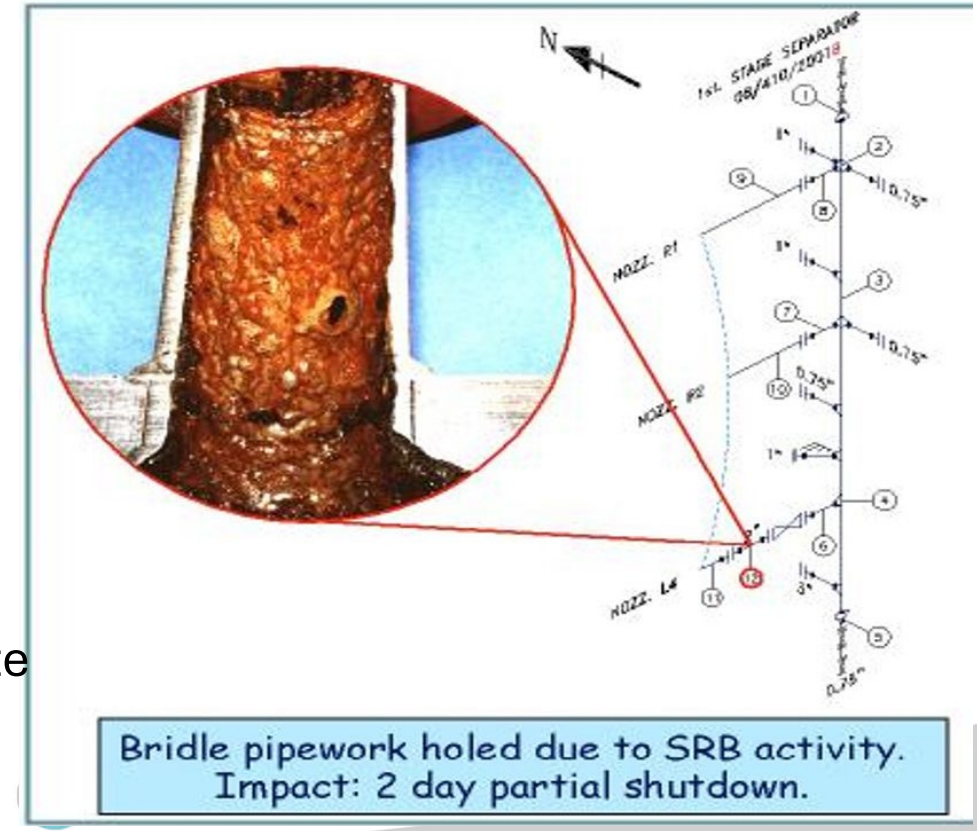
Corrosion under insulation of carbon steel

A gas leak caused a platform shutdown.
Radiographic inspection indicated extensive wall thinning. Insulation removal and close visual inspection revealed a pin-hole leak

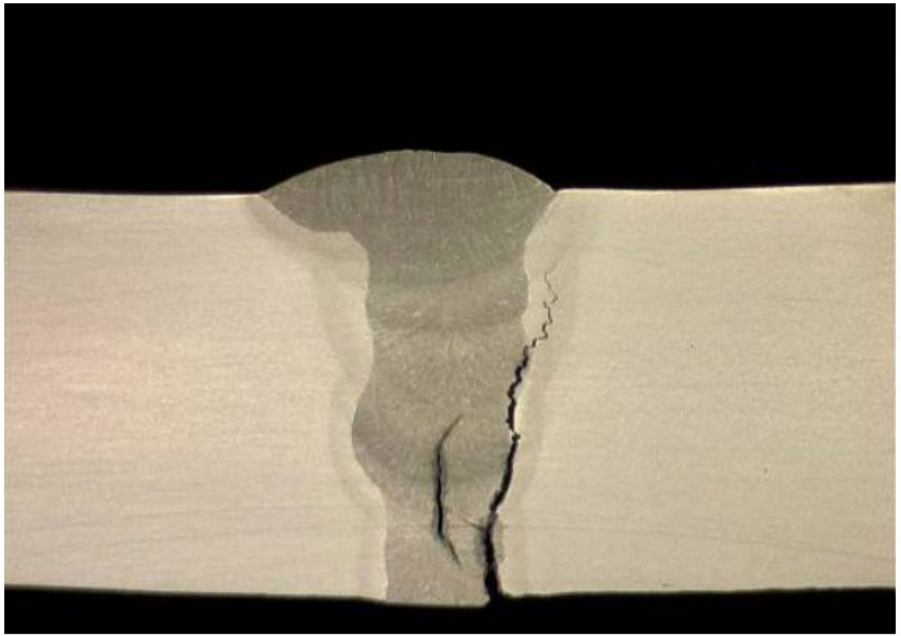
Types of Corrosion – carbon and alloy steels

MIC

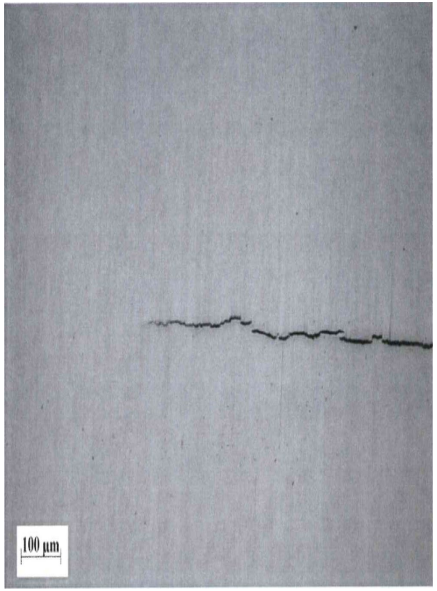
Stagnant conditions with sulphate and hydrocarbons



Sour service cracking – carbon and alloy steels



Sulphide stress cracking



Hydrogen induced cracking (HIC)

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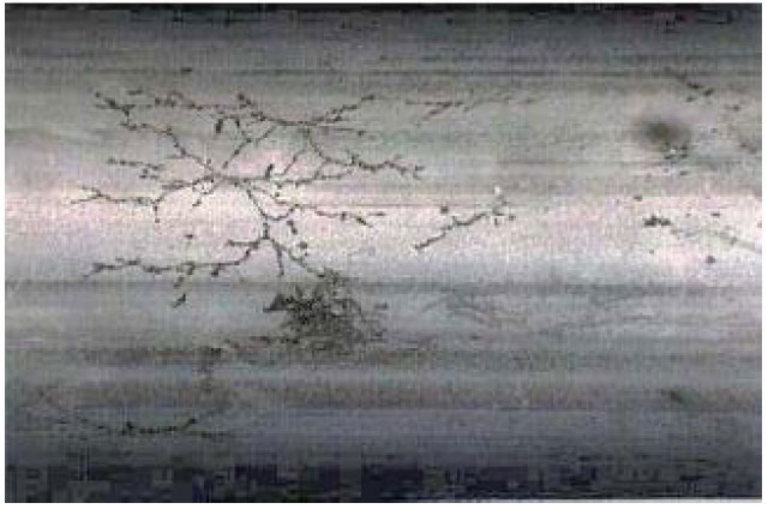
Types of Corrosion – Stainless steel



Chloride stress corrosion cracking

← Pitting corrosion in oxygenated seawater

Types of Corrosion – high temperature damage

Alloy 800H is used for the hottest parts of the flare tip assembly and 310 stainless steel can be used for exposure up to 650°C

Types of Corrosion in Upstream Oil and Gas

Seawater corrosion of carbon steel platform leg (no longer) protected by coating

Basic considerations

- Choice: Carbon steel or corrosion resistant alloys?
- Key influencing parameters:
  - Corrosivity
  - Flow rates
  - Chloride and hydrogen sulphide
- Mechanical properties
- Corrosion resistance
- Weldability
- Inspection, maintenance and repair
- Cost

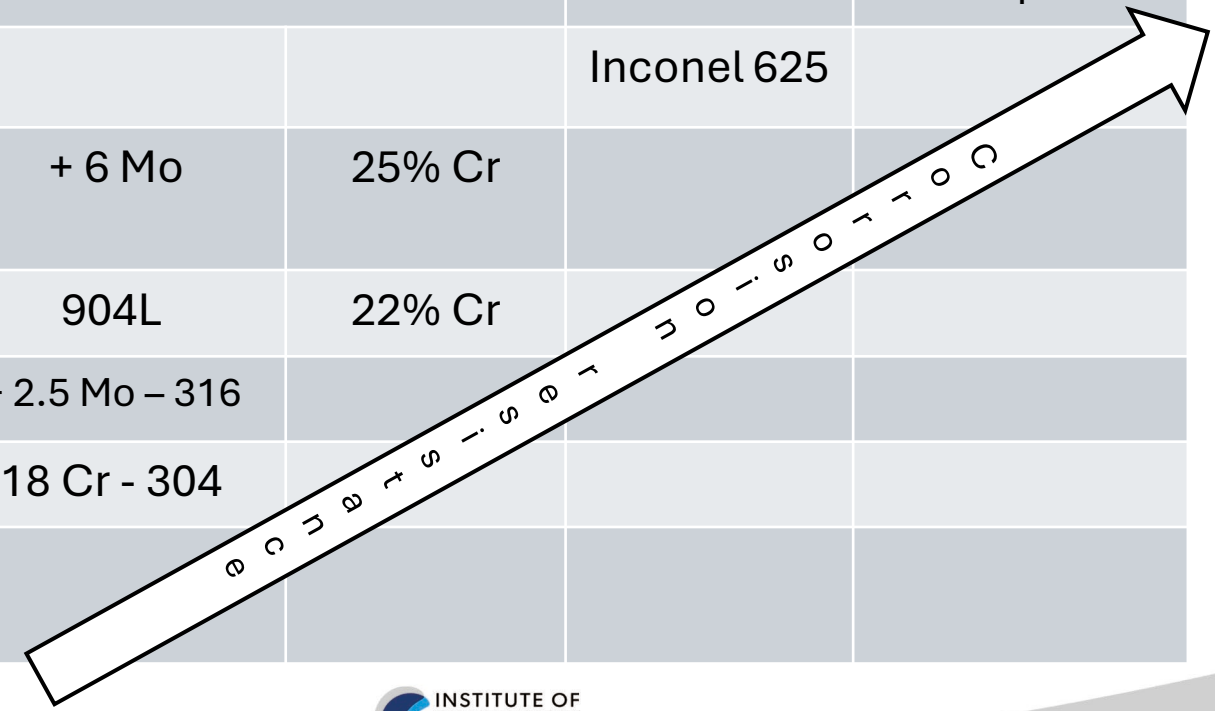
Basic choices and considerations

Carbon steel bars for mooring chain manufacture

Carbon steel clad with CRA

Corrosion resistant alloy (CRA) for tubes and a heat exchanger tube-sheet

Martensitic	Austenitic	Duplex	Ni alloys	Ti alloys
Stainless steels			Alloy 718	ASTM B265 Gr. 1
			Inconel 625	
	+ 6 Mo	25% Cr		
	904L	22% Cr		
	+ 2.5 Mo – 316			
	18 Cr - 304			
13 Cr – L-80				



Material selection reports - Corrosion

- Assessment inputs
- Corrosion threat identification
- Corrosion rate calculations
- Corrosion inhibitors
- Cracking in hydrogen H_2S environment

Material Selection – Corrosion Standards

- Norsok M-001 Materials Selection
- ISO 21457 Materials selection
- Norsok M-506 CO_2 Corrosion rate calculation model
- ISO 15156 Sour service
- Company standards

Typical material selection - Corrosion

NORSOK M-001:2025

Table 6 — Materials for production, process and produced water systems

Systems/equipment	Materials	Notes
Piping, valves, pumps and inline instruments	22Cr, 25Cr, 6Mo	a
Pressure vessels	22Cr, 25Cr	a
	CS/LAS with alloy 625, alloy 825, alloy 904 clad or weld overlay	
Vessel internals	316 SS, 22Cr, 25Cr	
Heat exchangers	22Cr, 25Cr, 6Mo, Ti gr. 2	b c

Notes:

[a] Carbon steel is an alternative for low corrosivity systems like dry gas and stabilised oil. See 6.2 for degradation mechanisms in stabilised oil.

[b] Titanium shall be used for the seawater side in heat exchangers.

[c] Due to formability, plates in titanium heat exchangers can be in Ti gr. 1.

Other important considerations

- Once the basics have been considered and materials have been selected, it is important to consider the following:
- Particular vulnerabilities & mitigations
- Materials heat treatment conditions
- Mechanical property specifications
- Quality control
- Manufacturer capabilities
- Welding
- Fabrication details

Summary – Materials selection

- Correct material selection is critical for project success
- Corrosion aspects are performed by Corrosion Engineers
- Other considerations are made with Materials Engineers
- Welding and fabrication considerations by Welding Engineers
- Standards and guidelines are used

Resources

- ISO 21457-2010: Petroleum, petrochemical and natural gas industries - Materials selection and corrosion control for oil and gas production systems
- Norsok M-001-2025: Materials Selection
- Norsok M-506 CO_2 Corrosion rate calculation model
- ISO 15156 Petroleum and natural gas industries – Materials for use in H_2S-containing environments in oil and gas production – Parts 1 to 3
- Norsok M-650: Qualification of manufacturers of special materials

Thank you for your attention

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