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Materials Selection for Surface (Topsides) Equipment in Oil and Gas Production Facilities

Group Practice

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP Group Practice GP 36-15.

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1. Scope

- a. This GP specifies requirements for selection of materials for construction of surface (onshore and topsides) oil and gas production / injection equipment in E&P, including chemical and utility systems.

Equipment within the scope is essentially that comprising the topsides of offshore installations and that within the battery limits of onshore sites

- b. The following items are outside the scope of this GP:
 1. Drilling and completion equipment (see GN 36-003 and GN 36-013)
 2. Wellhead and Christmas tree equipment including choke valves
 3. Structural items and steel support fabrications
 4. Fabrication and associated QA/QC requirements (see 18- and 42-series ETPs)
 5. Subsea equipment (see GP 36-20)
 6. Flexible pipe (see GP 65-75)
 7. Pipelines, risers, pig traps (see 43-series and 65-series ETPs)
 8. Bulk storage tanks
 9. Protective coatings
 10. Thermal insulation
 11. Temporary equipment
 12. Steam plant and boilers (see GP 56-10)

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

BP

BPOUS RP 13-1-1	Crude Units
GIS 18-011	Welded Fabrication and Construction
GIS 18-013	Integral Cladding, Weld Overlay, and Limited Loose Lining of Pressure Vessels and Components
GIS 22-101	ISO 13705 Fired Heaters (API 560)
GIS 22-201	API 537 Flare Details
GIS 26-101	ISO 16812 Shell and Tube Exchangers (API 660)
GIS 26-103	ISO 13706 Air Cooled Heat Exchangers (API 661)
GIS 36-107	Integral Cladding, Weld Overlay, and Limited Loose Lining of Pressure Vessels and Components
GIS 43-316	Manufacture of CRA Clad or Lined Steel Pipe.
GIS 46-010	New Pressure Vessels



GN 06-001	Erosion Guidelines
GN 06-002	Corrosion Prediction Modelling
GN 06-005	Corrosion Protection of Bolting
GN 06-006	Corrosion Inhibition in E&P Facilities – Selection, Testing and Field Application
GN 18-003	Deposition of CRA Overlay in Small Diameter Tubulars and other Components.
GN 36-001	Requirements for Alloy 718 Equipment
GN 36-003	Non-metallic Materials Selection
GN 36-007	Compatibility Testing of Non-metallic Materials Within Subsea Chemical Delivery Systems
GN 36-013	Selecting Downhole Tubing and Casing Materials for Oil & Gas Production Wells
GN 36-016	Piping Materials Data Sheets
GP 06-14	Erosion Control
GP 06-20	Materials for Sour Service
GP 06-25	Design for the Prevention of CUI
GP 06-29	Corrosion Protection during Hydrotesting
GP 06-60	Painting of Metal Surfaces
GIS 06-601	Painting of Metal Surfaces
GP 06-63	Internal Coatings
GP 18-01	Welded Fabrication and Construction
GP 18-04	Manufacture of Duplex Stainless Steel Components
GP 22-20	API 537 Flare Details
EP GP 26-10	Heat Exchangers in the E&P Segment
GP 30-25	Field Instruments – General
GP 36-12	Amine Services
GP 36-20	Materials Selection and Specification for Subsea Equipment
GP 42-10	ASME B31.3 Piping Systems
GP 56-10	Boilers and Auxiliaries
GP 62-01	Valves
GP 65-75	Design of Unbonded Flexible Pipe Risers and Flowlines
GP 72-00	Design and Selection of Refractory Lining Systems

American Petroleum Institute (API)

API RP 6HP	Recommended Practice for High Pressure Wellhead and Christmas Tree Equipment (<i>Working Committee Draft</i>)
API Std 537	Flare Details for General Refinery and Petrochemical Service
API Std 560	Fired Heaters for General Refinery Service
API Std 660	Shell-and-tube Heat Exchangers for General Refinery Services
API Std 661	Air-Cooled Heat Exchangers for General Refinery Service

American Society for Testing and Materials (ASTM)

ASTM A 105	Carbon Steel Forgings for Piping Applications
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ASTM A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
ASTM A216	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A 217	Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High Temperature Service
ASTM A265	Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate.
ASTM A350	Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components.
ASTM A 351	Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts
ASTM A352	Standard Specification for Steel Castings, Ferritic and Martensitic for Pressure-Containing Parts Suitable for Low Temperature Service
ASTM A 395	Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A 494	Castings, Nickel and Nickel Alloy
ASTM A 744	Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
ASTM A 890	Castings, Iron-Chromium-Nickel-Molybdenum, Corrosion Resistant, Duplex (Austenitic/Ferritic) for General Application
ASTM B 164	Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B 348	Titanium and Titanium Alloy Bars and Billets

International Organisation for Standardisation (ISO)

ISO 15156	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production.
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NACE International

NACE MR0175	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production.
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Norsk Søkkel Konkurranseseposisjon (NORSOK) Norwegian standards association

NORSOK M-630	Materials Data Sheets for Piping
NORSOK M-001	Materials Selection

3. Terms and definitions

For the purposes of this GP, the following terms and definitions apply:

BP approval

Approval by the relevant BP Engineering or Technical Authority

Carbon steel

Weldable grades of carbon manganese steels suitable for pressure systems equipment.



Cladding

Metallurgically bonded corrosion resistant layer (e.g. as applied by roll bonding or fusion welding).

Coating

A material applied as a layer onto a substrate to provide corrosion protection.

High pressure/high temperature (HP/HT)

Equipment rated at or above 1034 bar and 121 °C per API RP 6HP.

Historically, BP considered pressures and temperatures above 690 bar and 82 °C to be HP/HT but this has evolved to the above-referenced industry recommended practice definition.

IIW Carbon Equivalent (CE)

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

Lining

Non-metallurgically bonded corrosion resistant layer.

Obturator

Part of the valve positioned in the flow stream to permit or block flow i.e. gate or ball.

Pressure boundary equipment

Equipment that comprises the main pressure-containing envelope, i.e. where failure would result in an uncontrolled loss of containment to the atmosphere.

PRE_w

Pitting resistance equivalent number ($PRE_w = \%Cr + 3.3 (\%Mo + 0.5 \%W) + 16 \times \%N$).

4. Symbols and abbreviations

For the purpose of this GP, the following symbols and abbreviations apply:

ABS	Acrylonitrile butadiene styrene
BHN	Brinell hardness number
CE	Carbon equivalent
CA	Corrosion allowance
CP	Cathodic protection
CRA	Corrosion resistant alloy
EA	Engineering authority
ENP	Electroless nickel plating
ERW	Electric resistance welded



GIS	Group instruction for supply
GP	Group practice
GRP	Glass fibre reinforced plastic
HAZ	Heat affected zone
HIC	Hydrogen induced cracking
HIP	Hot isostatic pressed
HP/HT	High pressure/high temperature
HRC	Rockwell hardness "C"
Hv	Vickers hardness number
LME	Liquid metal embrittlement
NDE	Nondestructive examination
PRE _w	Pitting resistance equivalent number
PVDF	Polyvinylidene fluoride
PWC	Preferential weld corrosion
PWHT	Postweld heat treatment
QA/QC	Quality assurance/quality control
RTJ	Ring type joint
SAW	Submerged arc welding
SCC	Stress corrosion cracking
SOHIC	Stress oriented HIC (hydrogen induced cracking).
SS	Stainless steel
SSC	Sulphide stress cracking
STP	Site technical practice
SWC	Stepwise cracking
UNS	Unified numbering system

5. Materials selection philosophy

- a. Projects shall produce a single materials selection philosophy that defines:

1. Design and operating conditions.

Evaluation of corrosivity normally includes:



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- *CO₂ -content*
- *H₂S-content*
- *Hg-content*
- *Content of oxygen and other oxidising agents*
- *Design and operating temperature and pressure*
- *pH including effects of organic acids*
- *Chloride/halide ion concentration*
- *Velocity, flow regime*
- *Sand or other solids production*
- *Micro-biological activity*
- *Condensing conditions*
- *Transient conditions e.g. shut-down and start-up*

A gas is normally considered 'dry' (i.e. no risk of free water) when the water dew point at the actual pressure is at least 10 °C lower than the actual operation temperature for the system. Materials for stagnant gas containment need particular attention.

2. Approach to materials selection.
3. Application of national and international materials specifications.
4. Compliance with regulations.
5. Requirements for materials and welding qualification testing.
6. Application of relevant GIS documents.

Project materials selection philosophy is normally developed during select and/or define stages.

- b. Construction materials for surface equipment shall be selected and specified to provide required levels of operational integrity, taking account of the following:
 1. Material availability in appropriate product forms
 2. Operations and maintenance strategy.
 3. Weldability
 4. Inspectability
 5. Project cost and schedule requirements.
 6. Complexity and novelty of equipment manufacture and fabrication.
 7. Internal and external in-service damage mechanisms for normal and transient conditions, including:
 - a) Corrosion (general and localised).
 - b) Environmentally assisted cracking.
 - c) Brittle fracture.
 - d) Erosion.
 - e) Fatigue and corrosion fatigue.
 - f) Hydrogen embrittlement.



8. Predicted changes in reservoir conditions over design life, e.g. souring.
 9. Effect of contact with well treating and completion chemicals.
 10. Operational criticality.
 11. Required life.
 12. Weight (for offshore).
- c. The application of carbon steels shall be maximised for pressure boundary equipment, consistent with the requirements of the relevant design codes to achieve an economic wall thickness for the design pressure and adequate fracture toughness at the minimum design temperature.
- d. Where the predicted internal corrosion on carbon steels exceeds 8mm for the design life, one of the following options shall be specified for acceptance by BP:
- Carbon steel with internal CRA cladding.
 - Solid CRA or non-metallic construction.
 - Carbon steel with internal coating in accordance with GP 06-63 may be used in particular cases.

An internal corrosion allowance limit of 3mm may be more desirable as a weight saving requirement for offshore topsides equipment.

- e. Surface facility equipment items, other than piping, shall not be designed to rely on upstream corrosion inhibition. Inhibition may be proposed for approval by BP where the required inhibitor performance and availability can be assured, taking account of geometry and layout, and where whole life costing indicates this is cost effective.

Corrosion inhibition is best suited to long, larger diameter piping runs of minimal complexity. Effective inhibition in branched fittings, dead legs and at locations of turbulence may be difficult to achieve. The application of inhibitors mandates the need for effective corrosion monitoring and inspection, the costs of which also need to be taken into account.

- f. Suitably qualified metallurgical, materials, welding, and corrosion specialists shall be involved in materials selection in projects. Complexity of some issues involved is such that this GP cannot always provide definitive recommendations.

Requirement for expert advice on materials issues will remain when deriving Site Technical Practices (STPs) from this GP.

- g. Non-metallic materials shall be selected in accordance with principles described in GN 36-003.

- h. Materials for surface (topsides) application shall be:

1. Covered by recognised standard or written material specification, subject to acceptance by BP.
2. Manufactured to qualified manufacturing procedure, subject to acceptance by BP.

- i. Standards and specifications for metallic materials shall include requirements for the following, as appropriate:

1. Melting, secondary refining and casting practice.
2. Chemical composition (heat and product).
3. Forging practice to produce fully wrought microstructure.

