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Guidance on Industry Standard for Marine Loading Arms

GIS 38-300

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GIS 38-300. This Guidance on Industry Standard (GIS) is based on parts of heritage documents from the merged BP companies as follows:

BP

GS 138-3

Marine Loading Arms.

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1. Scope

This GIS provides guidance on industry standard for design and fabrication, inspection and testing, documentation, and installation of new steel articulated marine loading arms for liquid, liquefied gas and vapour services in petroleum and petrochemical installations.

This GIS may be used for assessment and modification of existing loading arms subject to review of limitations imposed by original design and subsequent amendments and present condition of relevant components.

Marine loading arms are vital items of terminal equipment. Their design involves many different engineering specialities, including stress analysis, materials, mechanical, electrical, hydraulic, and surge analysis. Apart from the fundamental product transfer duty, the design must account for the overall process system design, vessel details and behaviour, climatic effects, mooring practices, operating and emergency procedures, safety issues, and protection of both the environment and the assets.

For most services, the duty will require electro-hydraulic articulated marine loading arms capable of accommodating all relative ship movements within a defined envelope and safely separating under controlled conditions in an emergency without loss of product.

As loading arm technology continues to evolve, this GIS reflects the complexity of the equipment and the many lessons learned to date in its operation. With precision equipment of this nature, the achievement of minimum operating costs depends not only on meeting high quality specifications for design and manufacture but also on subsequent standards for maintenance. While this GIS assumes a satisfactory level of maintenance, design cautions are included to minimise the risks from potential shortcomings.

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.

American Institute of Steel Construction (AISC)

AISC S328	Specification for Structural Steel Buildings – Load and Resistance Design Factor.
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American Petroleum Institute (API)

API Spec 6D	Specification for Pipe Valves (Gate, Plug, Ball, and Check Valves).
API Spec 6FA	Specification for Fire Test for Valves.

American Society of Mechanical Engineers (ASME)

ASME	Boiler and Pressure Vessel Code – Section VIII, Rules for Construction of Pressure Vessels, Division 1.
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ASME	Boiler and Pressure Vessel Code – Section IX, Qualification Standard for Welding and Brazing Procedures.
ASME B-18	Bolting
ASME B 16.2	Gaskets, Flanged Fittings
ASME B16.5	Pipe Flanges and Flanged Fittings.
ASME B31.3	Chemical Plant and Petroleum Refinery Piping.

American Society for Testing and Materials (ASTM)

ASTM A105	Forgings, Carbon Steel, for Piping Components.
ASTM A106	Seamless Carbon Steel Pipe for High Temperature Service.
ASTM A181	Forgings, Carbon Steel, for General Purpose Piping.
ASTM A333	Seamless and Welded Steel Pipe for Low Temperature Service.

American Welding Society (AWS)

AWS D1.1	Structural Welding Code - Steel.
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BP Engineering Technical Practices (ETPs)

GP 6-60	Onshore and Offshore Paints and Coatings
GP 12-15	Wire and Cable
GP 12-20	Motors
GP 12-25	Earthing, Grounding
GP 12-30	Lighting and Small Power
GP 12-45	Electrical for Packaged Systems
GP 12-60	Hazardous Area Electrical Installations
GIS 12-101	IEC Low Voltage Switch Gear
GIS 12-151	IEC Low Voltage Power Cable
GIS 12-152	NEMA Low Voltage Power Cable
GIS 12-155	IEC Instrument and Control Cable
GIS 12-156	NEMA Instrument and Control Cable
GIS 12-201	IEC Low Voltage Induction Motors
GIS 12-202	NEMA Low Voltage Induction Motors
GP 18-01	General Requirements for Welded Fabrication
GP 30-70	Control and Instrumentation on Vendor Packaged Equipment
GP 36-10	Materials Selection
GIS 38-400	Hydraulic Power Systems
GP 60-50	General Issues – Equipment Packages
GIS 62-015	Gate, Globe, and Check Valves
GP 62-12	Ball Valves < NPS 20 in.
GP 62-13	Ball Valves > NPS 20 in.
GP 81-21	Codes for LNG Facilities

British Standards (BS)

BS 302	Stranded Steel Wire Ropes.
BS 1560	Circular Flanges for Pipes, Valves, and Fittings (Class Designated): Part 3: Section 3.1: Specification for Steel Flanges.
BS 4592	Industrial Type Metal Flooring, Walkways, and Stair Treads.



BS 5351	Specification for Steel Ball Valves for the Petroleum, Petrochemical, and Allied Industries.
PD 5500	Specification for Unfired Fusion Welded Pressure Vessels.
BS 5950	Structural Use of Steelwork in Building.
BS 6364	Specification for Valves for Cryogenic Service.
BS 6755	Testing of Valves: Part 1: Production Pressure Testing Requirements Part 2: Specification for Fire Type Testing Requirements.

International Organisation for Standardisation (ISO)

ISO 10497	Testing of Valves: Fire Type - Testing Requirements.
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National Electrical Manufacturers Association (NEMA)

Standards for Enclosures

Oil Companies International Marine Forum (OCIMF)

OCIMF 4	Design and Construction Specification for Marine Loading Arms.
OCIMF 28	Recommendations for Oil Tanker Manifolds and Associated Equipment.
OCIMF 29	Recommendations for Manifolds of Refrigerated Liquefied Gas Carriers for Cargoes from 0°C to -104°C.
OCIMF 30	Recommendations for Manifolds for Refrigerated Liquefied Natural Gas Carriers (LNG).

Occupational Safety and Health Administration (OSHA)

1910	Subpart "D" Walking, Working Surfaces.
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3. Definitions

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

bar

Except if referring to pressure differential, unit is stated either as gage pressure, bar (g), or absolute pressure, bar (abs). Gage pressure is measured from standard atmospheric pressure of 1.01325 bar (14.7 psi).

Cryogenic service

Cryogenic service is defined as product temperature below -80°C (-112°F).

4. Abbreviations

For the purpose of this GIS, the following abbreviations apply:

DL	Self Weight Load
DN	Nominal diameter
EL	Earthquake Load
ERC	Emergency Release Coupler



ERS	Emergency Release System
ESD	Emergency shutdown
FL	Fluid Weight Load
FMEA	Failure mode and effects analysis
HRC	High rupturing capacity
ID	Inside diameter
LCA	Design equivalent load
LCT	Test equivalent load
NPS	Nominal pipe size
OD	Outside diameter
PCA	Combined swivel design load
PCT	Test Load
PLD -	Design Pressure Load
PLT -	Test Pressure Load (1.5 x Design Pressure)
PTFE	Polytetrafluorethylene
QCDC	Quick connect/disconnect coupler
TL	Thermal Load
TLF	Test load factor
WL -	Design Wind Load
WL/EL	Either WL or EL

5. Design

5.1. General

- a. Design codes to be applied shall be as follows:
 1. Parts containing process fluids (cargo, vapour return, ballast, etc.) shall comply with ASME B31.3 and/or ASME Pressure Vessel Code, Section VIII, Division 1, and Section IX or BS PD 5500 as appropriate.
 2. Structural parts (which may include parts containing process fluids) shall comply with AISC codes, particularly AISC S328, or BS 5950.
 3. Hydraulic systems shall comply with BP GIS 38-400.
 4. Design shall apply applicable Oil Companies International Marine Forum recommendations (OCIMF) 4.



- b. Alternative designs may be proposed, provided that they can be shown to satisfaction of BP that required performance and function can be attained.
- c. Configuration of arms to meet operating envelope and simultaneous connection requirements shall be determined by Vendor. Vessel drift along and off jetty shall be assumed to occur simultaneously.
- d. Arms shall be fully balanced in all attitudes if empty.

This is common practice since it normally results in the least expensive design for both the loading arm and the foundation works. However, some existing loading arms may be balanced if full. Vendor may offer new designs to be balanced full if significant advantages can be demonstrated.

- e. Connection to vessel manifold shall be bolted, hydraulic quick connect/disconnect coupler (QCDC) or manual coupler as specified by BP in data sheets.
- f. Marine loading arms shall have hydraulically operated emergency release system (ERS).

The ERS is required to provide:

- *Reduced health hazards.*
- *Environmental protection.*
- *Asset protection (jetty equipment and vessel).*

For small diameters (not exceeding 150 mm (5.905 in)), and in very sheltered waters, consideration may be given to omission of the ERS and adoption of manual operation. This is only permissible for the transfer of wholly non-hazardous products, or very low risk products, and subject to a full quantified risk assessment to confirm the acceptability of the proposal.

- g. New loading arms with ERS shall be manoeuvred hydraulically.

Following an emergency release, the loading arm will be full of liquid, which even with a small diameter (150 mm (5.905 in)), is not easy to manoeuvre manually. Since hydraulic power is required to achieve the emergency functions (including raising of the arm), it is cost effective to provide hydraulic power for the additional normal manoeuvring functions. Furthermore, hydraulic is safer than manual manoeuvring when the loading arm is full of product.

- h. Inter-changeability of loading arm components should be provided for each bank of arms.
- i. If stowed, no portion of arm shall extend beyond jetty edge.

The geometry of the loading arm should provide adequate clearance between the edge of the jetty and the manifold end of the stowed loading arm. It should be recognised, however, that such a clearance may not afford complete protection during berthing or departure of a vessel.

- j. Swivel

1. Arm movements shall allow outboard arm triple swivel to be positioned on jetty or on elevated platform for maintenance.
2. Working area of 1 m (3.28 ft) minimum clear space around triple swivel shall be provided.
3. Maintenance and access facilities shall be required for apex and inner swivel.

- k. Clash checks on adjacent arms shall be performed by Vendor.

- l. Minimum clearances and locations for worst stowed, operating, and maintenance positions shall be stated by Vendor.



- m. Jetty layout drawings shall be reviewed by Vendor to establish clearances with new and existing equipment.

While the overall responsibility for clash checking may rest with the main contractor, it is important to ensure that Vendor is involved as soon as possible in developing layouts. Particular attention should be given to the location of the counterweights.

5.2. Operating envelope

- a. Typical operating envelope for single loading arm is shown in Figures 1 and 2. Envelope is based on location of ship's flange, tidal changes, ship's draft, and drift along and off jetty. Drift area (shaded) within operating envelope represents, in both plan and elevation, range of operating movements of ship's flange, which will not initiate an alarm.

It is recommended that BP establishes main operating envelope parameters prior to specification for enquiry or purchase as shown in Figures 3 and 4. These details should be entered on Data Sheets.

- b. Spacing
 - 1. Spacing between maximum reach and stage 3 alarm depends on vessel drift off rate and opening time for emergency release coupling (ERC).
 - 2. Spacing between stages 2 and 3 depends on vessel drift off rate and ERS valve(s) and emergency shutdown (ESD) valve(s) closure times.
 - 3. Stage 1 location is a compromise between having maximum sized drift area and earliest warning of a problem that may lead to shutdown.

Note that ESD valve(s) are not within the scope of supply for marine loading arms.

- c. Vessel drift off rate shall be 150 mm/s (5.905 in/s).

This rate is normal for open and exposed locations. A lower drift off rate may be agreed for protected or enclosed locations.

5.3. Stress analysis

- a. Stress and deflection analyses for loading arms in all arm conditions shall be submitted by Vendor.
- b. Allowable tensile stress
 - 1. Allowable tensile stress in loading arm shall be determined.
 - 2. Basic allowable stress shall be lower of either 0.29 x tensile strength or 0.49 x yield strength of material in annealed condition.
 - 3. Tensile and yield strength data shall be smaller of published range of values for relevant ambient and design temperatures.
- c. Pressure loads shall be based on design and test pressures stated by BP on data sheets.
- d. Fluid load shall be based on either:
 - 1. The specific gravity of seawater (1.03) for arms in general liquid service.
 - 2. Specific gravity of product for arms in liquefied gas or liquid chemical service and test medium used in factory acceptance tests.
- e. Wind load shall be based on design wind speed calculated for the most un-favourable wind direction.
- f. Wind pressures acting on the loading arm in the direction of the wind shall be calculated.
- g. Allowance for ice shall be:



1. For general services in cold climates where temperatures fall below freezing, self weight shall include allowance for 6 mm (.236 in) of ice (unless specified otherwise) on surfaces in any arm position.
2. For liquefied gas services, self weight and wind load shall include allowance of 25 mm (.984 in) of ice on all product lines.
3. Liquefied gas services in cold climates, shall have additional allowance of 6 mm (.236 in) of ice (unless specified otherwise) on surfaces in any arm position (ice specific gravity = 0.80).
- h. Earthquake loads, if specified, shall be considered to act on arm in stowed position, in directions parallel and perpendicular to jetty face.
- i. Thermal loads shall be based on maximum difference between ambient and product temperature, with consideration given to solar radiation, if applicable.
- j. For liquefied gas arms, temperature profiles assumed across fluid and structural members shall be stated by Vendor.
- k. Stress analysis shall be performed on integrally reinforced fluid members in both steady state and during rapid cool down.
- l. Stress intensification factors for elbows and pipe bends shall comply with ASME B31.3.
- m. Correction factors for flanged ends shall be restricted to arc angles of $\pi/2$ radians (90 degrees) or less and two flanges maximum. Swivel outer raceways and stiffening rings may be considered equivalent to flanges.
- n. Implications of strength reduction in weld areas shall be examined.
- o. Wire ropes shall comply with BS 302 and shall have minimum safety factor of 5 based on minimum breaking strength for all design conditions. Arm stress analysis shall take account of all rope loads, including pre-tensioning.
- p. Manifold
 1. Based on steel manifold in accordance with ASME B31.3, with Class 150 flanges.
 2. Manifold shall otherwise comply with appropriate OCIMF series of "Recommendations for Tanker Manifolds" in accordance with product carried. Other conditions, if required, will be defined by BP on data sheets.
- q. Loads transmitted to the ship's presentation flange under all circumstances shall be limited to specifics given in data sheets. In particular, if ERS is required, loads shall be determined with account taken for ERC components that remain attached to manifold in emergency disconnection.

Refer to OCIMF 28, 29, and 30 for guidelines.

5.4. Swivel joints

- a. Swivel joint assemblies shall permit repacking without dismantling major sections of arms. Triple swivel is the only exception.
- b. Swivel joints shall have ball or roller bearings.
- c. Triple swivel, support device, coupler, and valving shall be balanced such that outboard flange remains in vertical plane for all arm attitudes.
- d. Swivel joints shall also be designed with test load factors applied to combined swivel design load.
- e. If product temperature prevents use of lubricating grease, swivel joints shall have nitrogen purge system. Nitrogen shall circulate through each swivel joint and onto adjacent swivel



joint in series type system, with final controlled exhaust to atmosphere, unless stated otherwise.

- f. Swivel joints shall prevent water ingress, which is particularly important if swivel joint operating temperature would cause such water to freeze.
- g. Swivel joint seals for liquefied gas shall accommodate temporary vacuum conditions and reseal properly afterwards.

5.5. Emergency release system (ERS)

5.5.1. All services

- a. Emergency release system (ERS) shall consist of emergency release coupler (ERC) and associated isolating valve(s) mounted as low as practical on outboard arm. ERS selection shall be subject to BP approval.
- b. ERC shall be positioned in vertical section of triple swivel assembly to minimise forces at coupling faces during disconnection.
- c. QCDC shall not be used for ERC duty because emergency arm movements cause mechanical clashes, and operating time is generally excessive.

Ships manifolds to OCIMF recommendations have vertical presentation flanges, thus arm movements in an emergency disconnect using a QCDC would cause damage to the gasket and flange faces and possibly give rise to sparking.

- d. Isolating valves
 - 1. Isolating valves shall be ball type, with liner in case of hollow ball.
 - 2. Reduced bore valves are preferred (because of weight saving) if associated increase in pressure drop is acceptable.
 - 3. Butterfly valves may be acceptable for general liquid service.
 - 4. While isolating valves are usually part of an integral proprietary, ERC design, should comply with data sheets. Deviations shall be subject to BP approval.
 - 5. Valves shall comply with API Spec 6D and/or GIS 62-015.
- e. Valves shall be hydraulically actuated. Design closure time shall be 5 seconds, adjustable up to 15 seconds. Emergency release coupler (ERC) release time shall not exceed 2 seconds.

The ERS valve closure time may be set according to the results of a surge analysis (carried out by others), whether products are being loaded or off-loaded or both, and also whether loading arms are to accommodate surge pressures. The closure time and the drift off rate must be compatible with the spacing of the envelope stages. If offloading a vessel, consideration must be given to the negative surge effects on the loading arms and the downstream system if valves shut down in an emergency.

The release time is measured between receipt of the Stage 3 signal and complete opening of the coupling.

- f. Actuation of ERS
 - 1. On actuation of ERS, arm(s) shall automatically break clear by minimum of 2 m (6.56 ft) above ERC level in controlled manner, without risk to personnel and with arm(s) full or empty of product.
 - 2. It shall not be possible for arm(s) to fall onto manifold deck during or after completion of this operation.



3. Separation velocities for one arm and all arms, for both electro-hydraulic and pure hydraulic (accumulators) separation, shall be stated. Velocities shall be subject to BP approval.
- g. ERC shall be fully open and released before loading arm extends to maximum reach position at vessel drift off rate.
- h. ERC shall be operated by double acting hydraulic cylinder.
- i. In event of hydraulic or electric power failure, ERC shall remain securely closed.
- j. ERC release mechanism shall incorporate shear pin to protect against accidental manual activation.
- k. ERC and arm components remaining on ship after release shall not fall onto ship's deck or manifold service platform. Coupling components shall be restrained to prevent impact with adjacent arms.
- l. Unless specified otherwise, Vendor shall provide facilities, either separately or as part of riser, to support components normally attached to tanker manifold for routine testing of ERS.
- m. Strength of ERC shall be based on design equivalent load (LCA), which is maximum combination of design pressure, total axial load, bending moment, and shear acting at ERC for the most critical arm attitude and combination of loads on loading arm (refer to Tables 1 and 2). ERC shall also be designed with test load factors (TLF) applied to LCA.
- n. Testing of ERS components and system shall be possible without release of ERC. Testing devices shall not jeopardise system release if it is required.

This test checks the operation of the release cylinder and linkages without separation of the coupling. It should be performed prior to each loading operation.

- o. Aids shall be provided in design to ease and ensure proper reassembly of ERC after release.

5.5.2. General liquid service

- a. Unless specified otherwise, arms on general liquid service shall have single integral ball valve above ERC.
- b. Robust, offset trunnion type butterfly valves are acceptable in this service, provided they are leak tight under all operating conditions. Wafer type of mounting is not acceptable.

5.5.3. Liquefied gas and toxic service

- a. Arms on toxic or liquefied gas service shall have double ball valves, one provided on either side of ERC.
- b. Trapped volume between the valves shall be minimised to limit spillage on release.
- c. Mechanical links:
 1. Double ball valves shall be mechanically linked to ensure simultaneous closure.
 2. Valves shall be closed prior to ERC release.
 3. Link shall allow clean separation after ERC release.
- d. ERS shall ensure product line cannot separate before "piggy back" vapour return line where fitted.
- e. "Piggy back" vapour-return lines with spring loaded double check valves may be proposed.

