

DEP SPECIFICATION

FIREWATER PUMPS FOR OFFSHORE INSTALLATIONS

DEP 37.29.01.10-Gen.

February 2017

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for main firewater pumps for offshore installations.

This DEP is intended to be used in conjunction with NFPA 20 (but is not an overlay to NFPA 20).

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the number dated February 2015; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to offshore oil and gas production. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

Definitions for terms/phrases (e.g., Maximum Discharge Pressures), Pressure Casing, MAWP, etc. are as defined in ISO 13709/API 610 and NFPA 20, unless noted otherwise.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Deck Level Reference Point	The reference point to be used for specifying the required delivery pressure at the horizontal centre-line of the discharge flange at deck level.

1.3.3 Abbreviations

Term	Definition
AFFF	Aqueous Film Forming Foam
BEP	Best Efficiency Point
GRP	Glass reinforced polyester/plastic
LAT	Lowest Astronomical Tide
MAWP	Maximum Allowable Working Pressure
NPSH	Net Positive Suction Head
NPSHR	Net Positive Suction Head Required
VPI	Vapour Phase Inhibitor

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2015. The changes followed a requirements quality review and were not a technical update. The following are the main, non-editorial changes.

Section/Clause	Change
All	Restructured and clarified requirements, enforced use of shall/should/may for normative statements and separation of requirements.
2.2.8	Move requirements previously embedded in note in Table 2.2.8 up to the body of the section.
2.4.2, item 3	Restructured and reworded SHALL [PS] requirement for clarity.
2.4.2, item 9	Restructured and reworded SHALL [PS] requirement for clarity, including separating from shall statements.
2.4.2, item 10	Restructured and reworded SHALL [PS] requirement for clarity.
2.4.2, item 11	Restructured and reworded SHALL [PS] requirement for clarity.
2.4.2, item 12	Restructured and reworded SHALL [PS] requirement for clarity.
2.5.2	Relocated commentary text into the Informative.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. DESIGN AND MANUFACTURING

2.1 GENERAL

1. Overall responsibility for the complete fire pump unit shall rest with the pump Manufacturer/Supplier.
2. The scope of supply shall be as specified within the data sheets and project requisition.
3. All fire pump units shall be designed for uninterrupted operation at design conditions for 10,000 h (except for scheduled oil changes), or intermittent duty (1 h per week for 10 years) whichever is considered more onerous.

This requirement relates to the quality of the pump design, i.e., a rugged, durable unit is desired. Continuous operation for 10,000 h is not intended, although the pump can be run continuously for long periods during the hook-up and commissioning phases. The pump unit can be removed from service during the period for inspection and maintenance of, for example, the anti-marine fouling system.

4. The electric motor driver shall be suitable for at least 1,000 start-stops between overhauls.
5. Electric submersible pump units shall be designed for 35,000 h continuous operation, with 2,000 stop-starts between overhauls.



2.2 PUMP UNIT

2.2.1 General

1. The pump configuration shall be as specified on the data sheet.
2. The pump unit should be a vertically mounted, radially split, multi-stage bowl assembly with mixed flow impellers.
3. Designs incorporating one or more immersed impellers, with further stages mounted at deck level, may be provided as an alternative.
Typically this would mean a two pump arrangement - a low pressure vertical lift pump with a horizontal booster pump mounted at deck level.
4. If an electrical drive is specified, an electro-submersible type pump may be provided in lieu of a line shaft pump.
5. Pumps shall have a stable head/capacity curve rising continuously to shut-off.
6. The head at shut-off for vertical mixed flow pumps shall be between 110% and 140% of the head at the rated capacity.
7. Pumps shall provide not less than 150% of the rated capacity at a total head of not less than 65% of the head at the rated capacity.
8. Pumps shall be capable of at least a 5% head increase at rated conditions by installing a new impeller or impellers.
9. Pumps shall have a non-overloading power/capacity characteristic unless otherwise approved by the Principal.
10. Pumps for parallel operation shall have a similar percentage head rise to shut-off.
 - a. Parallel operation shall be assumed when so stated on the data/requisition sheet or whenever two or more identical pumps are ordered or enquired for at the same time.
11. Rated operating point shall be within the range of 80% – 115% of the Best Efficiency Point (BEP).
12. Engine-driven fire pumps (whether directly or indirectly driven) shall be designed to operate continuously at 105% of rated speed.
13. Semi-open impellers shall not be used without the approval of the Principal.
14. The reference point to be used for specifying the required delivery pressure should be at the horizontal centre-line of the discharge flange at deck level, referred to as the “deck level reference point”.
15. Given the pressure required at the deck level reference point and details of elevations the pump Manufacturer shall estimate losses in the riser pipe and determine the total differential head required, assuming the pumped fluid is at the minimum operating level and allowing for wave motion and “draw-down” in the caisson.
 - a. An allowance shall be made for the pressure drop around the anti-fouling device and through the suction strainer, assuming that the free area of the strainer has been reduced by 50% by fouling.
 - b. For pumps taking suction from the sea, the minimum operating level shall be the Lowest Astronomical Tide (LAT) level.
16. In addition to required fire water capacity, pump capacity should also include any cooling water requirements of the driver and transmission and, if specified, for any additional equipment to limit surface temperature.
17. A coarse mesh strainer shall be located around the pump suction bell as defined in NFPA 20, section 7.3.4.2.

18. All fasteners on any rotating part and all fasteners on static parts of the pump inside the caisson (including the rising main) shall be positively locked against becoming loose in service.
19. A non-reverse ratchet or non-return valve shall be provided to prevent reverse rotation of the pump.
20. The ratchet should be located in either the gearbox or motor, as appropriate.
21. The design of the ratchet shall be subject to approval by the Principal.
22. Submersible motor driven pumps shall have a non-slam, non-return valve located immediately above the pump unit.
 - a. The valve should include a small aperture by-pass to allow self-draining of the pump and rising main on shutdown.
 - b. The rate of draining should be sufficiently low to prevent impeller rotation.
23. A non-return foot valve shall not be used.
24. The impeller immersion depth shall be the greatest of the following:
 - a. the depth sufficient to ensure that the inlet to the first stage impeller meets the minimum submergence requirements as specified by the Manufacturer at the Lowest Astronomical Tide (LAT) level and allowing for the 100-year wave trough depth (assuming the wave trough depth from LAT is one-third of the total wave height from trough to apex);
 - b. the depth sufficient to provide the (NPSH) required by the pump at LAT level with no wave through allowance, plus a margin equal to or greater than the following:
 - i. 50% of the NPSH required by the pump at the inlet to the first stage impeller, or
 - ii. 3.0 m (10 ft.) at the rated point.
 - c. an immersion depth specified on the data/requisition sheet.
25. The Manufacturer/Supplier shall specify on the data sheet the (NPSH) required and minimum submergence when the pump is operated on water at the rated capacity and rated speed.
26. The NPSH required by the pump shall be less than the NPSH available by at least 1.0 m (3 ft.) throughout the operating range of the pump.
27. While deciding NPSH margin or submergence depth, consideration should be given for increase in NPSHR over specified life of the pump due to degradation caused by wear and fouling.
28. All equipment should be designed to permit rapid and economical maintenance.
29. Major parts such as casing components and bearing housings shall be designed (shouldered, spigoted or doweled) to ensure accurate alignment on reassembly.
30. Pumps shall be supplied with all special tools necessary to dismantle and assemble the unit.
 - a. The Manufacturer/Supplier shall include a list of special tools in the proposal.

2.2.2 Pressure casing

1. The thickness of the pressure casing shall be suitable for the maximum allowable discharge pressure at the pumping temperatures plus an allowance for head increase [see (2.2.1 item 8) with a 3.2 mm (1/8 in) minimum corrosion allowance, as applicable].
2. The allowable stress used in design for any given material shall not be greater than the values given in ASME Section II, Part D for the same material.
 - a. For cast materials, the factors specified in the code shall be applied.

The Manufacturer's data report forms and stamping, as specified in the code, are not required.
3. The maximum discharge pressure shall apply to all parts of the bowl assembly and rising main.

Refer also to (2.3).
4. The bowl assembly casings shall have metal-to-metal register fits, O-ring fits or, if applicable, confined controlled-compression gaskets.
5. Pumps shall be provided with eyebolts or lugs to facilitate lifting.

2.2.3 Bolting

1. Bolting and studs shall comply with ISO 262/ANSI B16.5.
2. To facilitate dismantling and maintenance, internal and external bolting shall be fully resistant to corrosive attack by the fluid pumped.
3. Bolting materials shall be specified in the proposal.
4. Studded connections shall be furnished with studs installed.
5. Blind stud holes should only be drilled deep enough to allow a preferred tap depth 1½ times the major diameter of the stud.
6. The first 1½ threads at both ends of each stud shall be removed.

2.2.4 Rotating elements

1. Impellers shall be single-piece castings with solid hubs.
2. Impellers shall be secured to the pump shaft and retained against circumferential movement by keying.
 - a. Impellers shall not be pinned.
 - b. Use of collets shall be subject to approval by the Principal.
3. Bowl assembly and line shafts shall be designed to transmit the maximum torque required under any specified operating conditions, and to withstand continuously all stresses resulting from supported weights, thrusts and starting, including across-the-line motor starting.
4. Shafts shall be machined and finished throughout their length so that the shaft runout and fits are in accordance with ISO 13709.
5. Renewable casing bushings and shaft sleeves shall be provided at all steady bearing points.
6. The bowl assembly shaft shall be of one piece unless otherwise approved by the Principal (because of total shaft length or shipping restrictions).
7. The line shaft inside the rising main (if applicable) shall be in sections of length determined by critical speed criteria and headroom available for dismantling the rising main.

2.2.5 Wear-rings and bushings

1. Renewable wear-rings shall be furnished in the casing.
2. If impeller wear-rings are provided, provision should be made for fitting them during overhaul/refurbishment.
3. Installation of renewable wear rings shall comply with ISO 13709, section 6.7.3.
4. Wear-ring material/hardness combination and materials of steady bearings and/or interstage bushings shall have a difference of 50 BHN to be considered "non-galling" unless both the stationary and the rotating wear surfaces have Brinell hardness numbers of at least 400.
5. Where possible, wear-rings should be made of materials with known non-galling qualities.
6. Wear surfaces coated with DLD or HVOF may be used to meet non-galling requirement and to keep the design clearances at normal level.
7. Running clearances and bushings shall meet the requirements of ISO 13709 unless otherwise approved by the Principal.

2.2.6 Dynamics

1. Actual critical speeds shall not encroach upon any specified operating speed ranges.
2. The amplification factor shall not exceed eight while going through criticals.
Preference will be given to designs with amplification factors of less than five.
3. The separation margin (see Appendix A, Figure 1) of encroachment from all lateral modes (including rigid and bending) shall be at least one of the following:
 - a. 20% over the maximum speed for rigid rotor systems, or
 - b. 25% below any operating speed and 25% above the maximum continuous speed for flexible-shaft rotor systems.*The separation margin specified is intended to prevent the overlapping of the critical response envelope into the operating speed range.*
4. Torsional modes of the complete unit shall be at least 10% below any operating speed or at least 10% above the trip speed.
5. Slow roll, start-up, and shutdown of the rotating equipment shall not cause any damage as critical speeds are passed.
6. The following calculations shall be provided by the Manufacturer/Supplier:
 - a. A lateral critical speed analysis to verify that the critical speeds of the driver and gear box (if applicable) and the critical speeds of the pump are suitable for any specified operating speed range. (refer to the data/requisition sheets and the last paragraph of this section).
 - b. A torsional vibration analysis of the pump-driver system and a transient torsional vibration analysis for synchronous motor-driven systems.
7. The Manufacturer/Supplier shall be responsible for the satisfactory performance of the system.
8. All major rotating components, including impellers and couplings, shall be dynamically balanced in accordance with ISO 1940, to balance quality grade 2.5.
9. Non universal joint couplings may be balanced to grade 6.3 if approved by the Principal.
10. Balancing requirement and acceptance criteria for universal coupling shall be mutually agreed between the Manufacturer/Supplier and the Principal.

11. The actual balance grade required to achieve the vibration performance should be confirmed by the Manufacturer/Supplier.
12. During the works test of the complete pump set, vibration readings shall be taken on the top flange of the driver or gearbox mount on lineshaft pumps with rigid couplings, and next to the top pump bearing on lineshaft pumps with flexible couplings.
13. During the shop test, vibration limits for motor driven units shall meet the requirements of ISO 13709.
14. Vibration limits for engine driven units or hydraulically driven units shall meet the requirements of ISO 13709, section 8.3.4.4.2.
15. The Manufacturer/Supplier shall review the structural drawings of the pump support and confirm that these vibration limits will not be exceeded during operation.
16. FEA of the support structure and pump assembly should be performed to predict the vibration at site.
17. If review of the structural drawings and/or FEA reveals that shop vibration limits, as specified in (2.2.6, item 13), cannot be achieved at site then the Vendor should suggest structural modifications, if any, to improve the dynamic behaviour of the structure-pump assembly.
18. If the efforts to improve the predicted dynamic behaviour of the structure-pump assembly does not result in acceptable predicted vibration at site then the vibration acceptance criteria for site testing/operation shall be mutually agreed between the Vendor/Packager and the Principal.
 - a. Relevant part of ISO 10816 may be used as reference to arrive at a mutually acceptable vibration limit.

FEA, if applicable, may be outsourced to a third party.
19. The Manufacturer/Supplier shall advise the speed range(s) over which the pump is not to be operated.

A diesel-driven pump set may operate at a reduced speed during platform hook-up and commissioning.
20. Pumps shall operate without exceeding the amplification factor (see 2.2.6 item 2) throughout the following:
 - a. allowable speed range;
 - b. while reaching rated speed, or
 - c. while reaching any other operating speed(s).

2.2.7 Bearings and bushings

1. For line-shaft type pumps, either motor or diesel driven, the Manufacturer/Supplier shall supply an oil-lubricated thrust bearing designed to carry double the maximum down thrust that might develop while starting, stopping or operating at any capacity.
 - a. Upthrust capability should be catered for in the same manner (i.e., thrust bearing rated for double the maximum upthrust).
2. Where upthrust only occurs as a transient during starting or stopping, a suitably rated secondary thrust arrangement may be supplied.
3. Designs resulting in up thrust in normal operating condition shall subject to approval by the Principal.
 - a. The bearing shall be selected per ISO 13709 (table 10).
 - b. The maximum thrust load shall be determined using double the internal pump clearances.
4. Right angle gearboxes shall have hydrodynamic thrust bearings.
 - a. Rolling element bearings may be used if approved by the Principal.
5. For motor-driven line-shaft type pumps, the thrust bearing shall be housed in its own casing.
6. For pumps driven through right-angle gearboxes, the bearings may be housed in the top of the gearbox casings.
7. Guide bushings that are corrosion- and abrasion-resistant for the sea water and temperature shall be furnished at all steady bearing points in the pump unit (bowl assembly).
 - a. For line-shaft driven pumps the guide spiders in the rising main shall be provided with bushings.

A guide for the maximum spacing between shaft guide bushings is provided in (Appendix A, Figure 2).
8. The line-shaft bearings shall be either product lubricated or externally lubricated.
 - a. Product lubricated line-shaft bearings shall be suitable for lubrication by means of sea water including some sand particles.
 - b. A bearing retainer shall be provided to support column and shaft alignment.

2.2.8 Pump materials

1. Materials should be as specified in Table 2.2.8.

Table 2.2.8 provides a cost effective material selection considering environmental conditions. Option 1 is the lowest cost acceptable material selection if it suits the environmental conditions.
2. Alternative materials may be used subject to approval by the Principal.
3. Evidence of satisfactory service for any alternatives suggested by the Manufacturer/Supplier shall be provided by the Manufacturer/Supplier.
4. KMonel shall not be specified/used for Gulf of Mexico (GOM) due to pitting issues.
5. Use of composite materials shall be subject to approval by the Principal.

The selection of materials for the rising main/column pipe and caisson is not intended to be restrictive.
6. Detailed material specifications including wear-ring hardness shall be provided by the Manufacturer/Supplier in the proposal, and subject to approval by the Principal.

Table 2.2.8 Recommended Material Selection

Component	Recommended Material Options (Lower to Higher Cost)			
	Option-1 (316 SS)	Option-2 (Ni-AL-BRZ)	Option-3 (Duplex)	Option-4 (Super Duplex)
Casing/Bowls/Wear ring	CF8M 316 SS	Ni-AL-Bronze CA958	Duplex Alloy CD4MCuN ASTM A890 Grade 1B	Alloy 2507 (UNS S32750) ASTM A890 Grade 5A
Impellers	CF8M 316 SS	Ni-AL Bronze CA958	Duplex Alloy CD4MCuN ASTM A890 Grade 1B	Alloy 2507 (UNS S32750) ASTM A890 Grade 5A
Rising Main/Column/Disch. Head/Caisson	316 SS	Ni-AL Bronze	Duplex Alloy 2205 (UNS S32305/S31803)	Alloy 2507 (UNS S32750)
Shafting	316 SS or Nitronic 50	Nitronic 50 Monel K500	Duplex Alloy 2205 (UNS S32305/S31803)	Alloy 2507 (UNS S32750)
Bearing	Bronze, Rubber or Bronze backed Rubber	Bronze, Rubber or Bronze backed Rubber	Bronze, Rubber, Bronze backed Rubber or Hardfacing on metal shell	Bronze, Rubber, Bronze backed Rubber or Hardfacing on metal shell
Bolting	316 SS	KMonel / Nitronic 50	Duplex Alloy 2205 (UNS S32305/S31803)	2507 (UNS S32750)
Keys/Collets	316 SS	KMonel or Nitronic 50	Duplex Alloy 2205 (UNS S32305/S31803)	2507 (UNS S32750)
Strainer and Anti Fouling Mounting	316 SS	KMonel / Nitronic 50	Duplex Alloy 2205 (UNS S32305/S31803)	2507 (UNS S32750)

Table : Material option selection guide

Parameter	Option-1 (316 SS)	Option-2 (Ni-AL-BRZ)	Option-3 (Duplex)	Option-4 (Super Duplex)
Pitting/Crevice/General Corrosion	1	4	4	5
Stress Corrosion	1	5	4	5
Erosion/Cavitation	3	1	4	5
Marine Fouling	1	4	1	1
Pollution/Sulfides in seawater	1	1	4	5
Warmer Ambient Temp	2	5	3	4
Galvanic	3	2	4	5
Overall Score	12	22	24	30

7. Materials, casting factors and the quality of any welding shall be equal to that required by ASME Section VIII, Div 1.

The Manufacturer's data report forms specified in the code are not required.

8. Minor parts not identified (nuts, gaskets, washers, keys and so forth) shall have corrosion resistance equal to that of specified parts in the same environment.
9. Castings shall meet the acceptance criteria as defined within section 8.2.2.7, Table 15 - "Materials Inspection Standards" of ISO 13709.
- a. The surfaces of castings shall be cleaned by sandblasting, shot-blasting, pickling or any other standard method.
 - b. All mould parting fins and remains of gates and risers shall be chipped, filed or ground flush.
10. The use of chaplets in castings should be kept to a minimum.
11. Chaplets shall be clean and corrosion free (plating permitted) and of a composition compatible with the casting.
12. The leaks and defects in pressure casing (as defined in ISO 13709) castings shall not be repaired by peening or burning-in, or by the use of plastic or cement compounds.
13. Repair by welding or plugging shall be undertaken only when permitted by the material specification and then only in accordance with the procedures detailed below.

Repair by welding

14. Weldable grades of castings may be repaired by welding if all of the following are met:
- a. approval by the Principal before any major weld repair is carried out;
 - b. all repairs meet the inspection requirements and acceptance standards for the original material;
 - c. for steel castings, the repair welding procedure and the repair welder's qualifications are both in accordance with ASTM A 488 and approved by the Principal;
 - d. the total quantity of weld metal deposited is less than 10% of the mass of the casting;
 - e. after weld repair, castings are suitably heat-treated if this is specified in the relevant material specification;
 - f. details of all weld repairs and of the heat treatment, where applicable, are recorded.
15. The definition of a major weld repair shall be taken as either a removal of more than 50% of wall thickness for material options 1 and 2 and 20% of the wall thickness for material options 3 and 4, or a length of more than 150 mm (6 in) in one or more directions, or a total surface area of all repairs exceeding 20% of the total casting surface area, whichever is the smallest.
16. All necessary repairs not covered by ASTM shall be subject to approval by the Principal.
- a. Details of all repairs shall be recorded and reported to the Principal.
 - b. Principal shall be informed of the need for plugging before any repair is carried out.
17. There shall be no fully enclosed cored voids in castings, including voids closed by plugging.

2.2.9 Couplings and Guards

1. Couplings and guards shall be in accordance with NFPA 20.
2. Coupling material shall be stainless steel unless otherwise specified on the data sheet.

2.3 RISING MAIN/DISCHARGE HEAD

1. The rising main shall be supplied in flanged sections of materials to facilitate installation.
2. All sharp edges shall be removed from the flanges to avoid scuffing cables and pipes.
3. The flanges should be scalloped to accept cables or flexible pipes.
4. Cables and pipes shall be secured to the flanges with clamps made of Inconel 625.
5. The rising main and flanges shall be designed to maintain mechanically imposed stresses within the limits of the material yield strength.

The stresses are imposed in supporting the rising main, pump/motor unit, water column and anti-marine fouling unit, in addition to the discharge pressure of the pump.

6. If specified, the Manufacturer/Supplier shall submit the calculations made in determining the stress levels.
7. The method of dismantling and reassembly of the rising main should be considered and discussed with the Principal at an early design stage, so that mutually acceptable section length can be established, lifting lugs added and handling/storage facilities defined.
8. A minimum radial clearance of 50 mm (2 in) shall be maintained all round the maximum diameter of the pump/rising main assembly.

This clearance is intended to assist installation/removal of the assembly, and allow for caisson and rising main deflections under wave loading and marine growth.

- a. The minimum radial clearance shall be increased to 75 mm (3 in) for pumps with a maximum diameter of 500 mm (20 in) or more.
9. A minimum of three stabilising spiders shall be provided to protect the pump, motor, cable and pipes (as applicable) while the rising main is being dismantled and re-assembled and while the pump is operating.
 - a. One stabilising spider shall be located at the pump unit, and the remainder equi-spaced up the rising main.
 - b. The quantity and location of spiders shall be subject to approval by the Principal.
 10. The pump discharge shall terminate at a suitably rated ASME flange orientated as specified in the order/enquiry.
 11. The discharge shall be incorporated with the caisson-mating flange into a discharge head.
 - a. The discharge head shall be cast or fabricated.
 12. Unless specified in the order/enquiry, the Manufacturer/Supplier shall liaise with the Principal at an early project design stage on the caisson mating flange design details.
 13. Openings for nominal pipe sizes DN 32 (NPS 1 ¼), DN 65 (NPS 2 ½), DN 90 (NPS 3 ½), DN 125 (NPS 5) and DN 175 (NPS 7) shall not be used.
 14. Cast iron flanges shall be in accordance with ASME B16.1 and fitted with full-face gaskets.
 15. Copper alloy flanges shall be in accordance with ASME B16.24.
 - a. Other flanges shall be in accordance with ASME B16.5.