MANUAL

FIREWATER PUMPS FOR OFFSHORE INSTALLATIONS

DEP 37.29.01.10-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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Shell International Exploration and Production B.V. (SIEP)
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The Hague, The Netherlands,

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They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for fire pumps in offshore installations.

This DEP is complementary to DEP 80.47.10.12-Gen. which is in a non-prescriptive “goal setting” format and gives a series of goals to assist in specifying and designing appropriate, fit-for-purpose water-based fire protection systems for offshore use. A key element in any firewater system are the firewater pumps.

DEP 80.47.10.12-Gen. states that the overall goal of a firewater pump system is to provide a reliable and secure supply of firewater to the firewater main system at the required pressures and flows for all the firewater-dependent equipment or systems on an installation. DEP 80.47.10.12-Gen. also lists the specific goals for the firewater pump system.

This DEP provides additional guidance on firewater pumps and their detailed specification which can assist in achieving the goals for the overall firewater system. It is, however, assumed that the pump type and pump configuration has been finalised using DEP 80.47.10.12-Gen. as guidance. The information and guidance provided is based on operating experience which may require modification to suit specific facility requirements.

This DEP shall be used in conjunction with data/requisition sheet DEP 31.29.02.93-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIEP and SIOP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in offshore installations which have water based fire protection sytems.

If national and/or local regulations exist in which some of the requirements may 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 as regards 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 with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

The **Principle** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. 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 word **should** indicates a recommendation.

1.4 ABBREVIATIONS

AFFF	Aqueous Film Forming Foam
BEB	Best Efficiency Point
GRP	Glass Reinforced Polyester
LAT	Lowest Astronomical Tide
NPSH	Net Positive Suction Head
VPI	Vapour Phase Inhibitor

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (9).

2. OPERATING PHILOSOPHY

The firewater pump operating philosophy will have an impact on the scope of supply and design of a firewater pump. The philosophy shall be developed in conjunction with the operating philosophy of the firewater system as a whole. It should also reflect the Fire and Explosion Strategy of the facility. Firewater system and pump operation, control and monitoring requirements are provided in DEP 80.47.10.12.-Gen. Application specific requirements will be detailed in the enquiry/order.

3. DESIGN AND MANUFACTURING

3.1 SCOPE AND RESPONSIBILITY

(1) Overall responsibility for the complete fire pump unit shall rest with the pump Manufacturer/Supplier.

(2) The fire pump unit shall include but not be limited to the following equipment:

- pump unit (bowl assembly);
- rising main (with lineshaft, if appropriate);
- anti-marine fouling system;
- overhead tank with hoses (if specified);
- prime mover (diesel engine or electric motor) complete, if specified, with starting equipment;
- power transmission (direct mechanical or indirect hydraulic);
- foam pump (if specified);
- piping, valves and ancillaries;
- baseframe;
- diesel day tank (if specified);
- fire pump controller.

Fire pump units shall be designed for uninterrupted operation at design conditions for 10 000 hours (except for scheduled oil changes), or intermittent duty (1 hour 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 required. Continuous operation for 10 000 hours is not intended, although the pump may be run continuously for long periods during the hook-up and commissioning phases. It is also recognised that the pump unit may be removed from service during the period for inspection and maintenance of, for example, the anti-marine fouling system.

Electric submersible pump units shall be designed for 35 000 hours continuous operation, with 2 000 stop-starts between overhauls.

Further guidance on design, operation, control, monitoring and testing is given in DEP 80.47.10.12-Gen.

3.2 PUMP UNIT

3.2.1 General

(1) The pump unit shall be a vertically mounted, radially split, multi-stage bowl assembly with mixed flow impellers. However, designs incorporating one or more immersed impellers, with further stages mounted at deck level, are an acceptable alternative. Electro-submersible type pumps are also acceptable where electric drive is specified.

(2) Pumps shall have a stable head/capacity curve rising continuously to shut-off. The head at shut-off for vertical mixed flow pumps shall be between 110% and 140% of the head at the rated capacity. 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. Refer to NFPA 20, clause 4.1.3.

Pumps shall be capable of at least a 5% head increase at rated conditions by installing a new impeller or impellers. Pumps shall have a non-overloading power/capacity characteristic unless otherwise approved by the Principal.

Pumps for parallel operation shall have a similar percentage head rise to shut-off. 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.

(3) The best efficiency point (BEP) should be close to the normal operating point, but in no case shall it be outside the limits of 80% - 115% of the rated flow.

(4) Engine-driven fire pumps (whether directly or indirectly driven) shall be designed to operate continuously at 105% of rated speed.

NOTE: NFPA 20, clause 8-2.4.2 requires that engines should be shutdown at a speed approximately 20% above rated engine speed.

(5) The reference point to be used for specifying the required delivery pressure shall be at the horizontal centre-line of the discharge flange at deck level and shall be referred to as the “deck level reference point”.

Given the pressure required at this 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. An allowance shall also 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. For pumps taking suction from the sea, the minimum operating level is the Lowest Astronomical Tide (LAT) level.

(6) Pump capacity shall include any cooling water requirements of the driver and transmission, and if specified any additional equipment to limit surface temperature.

(7) A coarse mesh strainer shall be located around the pump suction bell as defined in NFPA 20, clause. 4-3.4.1. The strainer shall have a free area of at least four times the area of the suction bell.

(8) 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.

(9) If the pump, driver or gearbox can be damaged by reverse rotation, a non-reverse ratchet or non-return (foot) valve shall be provided.

The ratchet shall be located in either the gearbox or motor, as appropriate. The design of the ratchet shall be submitted to the Principal for approval.

The foot valve shall be of the “non-slam” type and include a small-aperture by-pass to allow self-draining of the pump and rising main on shutdown. The rate of draining shall be sufficiently low to prevent impeller rotation.

(10) The impeller immersion depth shall be the greatest of the following:

1. Sufficient to ensure that the inlet to the first stage impeller is flooded 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).
2. Sufficient to provide the Net Positive Suction Head (NPSH) required by the pump plus a margin at LAT level with no wave trough allowance. The margin shall be 50% of the NPSH required by the pump at the inlet to the first stage impeller or 3.0 m, whichever is the greater.
3. An immersion depth specified on the data/requisition sheet.

NOTE: In calculating the immersion depth in accordance with 1 or 2 above, allowance shall be made for any draw-down in the caisson and 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.

(11) The Manufacturer/Supplier shall specify on the data sheet the net positive suction head (NPSH) required and minimum submergence when the pump is operated on water at the rated capacity and rated speed.

The NPSH required by the pump shall be sufficient to ensure that the head developed at the rated capacity does not fall-off by more than 5% during the specified life of the pump when operating continuously but in no case shall it be less than the NPSH which results in a 3% head loss of the first stage impeller at rated flow.

(12) All equipment shall be designed to permit rapid and economical maintenance. Major parts such as casing components and bearing housings shall be designed (shouldered, spigoted or doweled) to ensure accurate alignment on reassembly.

(13) Pumps shall be supplied with all special tools necessary to dismantle and assemble the unit. The Manufacturer/Supplier shall include a list of special tools in the proposal.

3.2.2 Pressure casing

(1) The thickness of the pressure casing shall be suitable for the maximum discharge pressure at the pumping temperatures plus an allowance for head increase (see 3.2.1(2)) with a 3.2 mm minimum corrosion allowance. The stress used in design for any given material shall not be greater than the values given in ASME VIII, Div. 1 for the same material. For cast materials, the factors specified in the code should be applied. Manufacturer's data report forms and stamping, as specified in the code, are not required.

(2) The maximum discharge pressure shall apply to all parts of the bowl assembly and rising main. Refer also to (3.3(2)).

(3) The bowl assembly casings shall have metal-to-metal fits or, if applicable, confined controlled-compression gaskets.

3.2.3 Bolting

(1) Bolting and studs shall comply with ISO 262.

(2) To facilitate dismantling and maintenance, internal and external bolting shall be fully resistant to corrosive attack by the fluid pumped. Bolting materials shall be specified in the proposal.

(3) Studded connections shall be furnished with studs installed. Blind stud holes should only be drilled deep enough to allow a preferred tap depth 1½ times the major diameter of the stud; the first 1½ threads at both ends of each stud shall be removed.

3.2.4 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. Pinning of impellers is not acceptable. Collets may be used with the Principal’s specific approval.

(3) Bowl assembly and line shafts shall be of ample size 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 properly finished throughout their length so that the shaft runout does not exceed the requirements of API 610, clause 5.2.2.3 and Table 5.1. Steps in shafts shall be machined with an internal radius of not less than 1.5 mm. Keys, keyways and fits shall conform to ISO R733.

(5) Renewable casing bushings shall be provided at all steady bearing points. The interstage pressure differential and character of the fluid handled (e.g. dirty or non-lubricating) should influence the need for corresponding shaft sleeves.

(6) The bowl assembly shaft shall be of one piece unless otherwise approved by the Principal (because of total shaft length or shipping restrictions). 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.

3.2.5 Wear-rings and bushings

(1) Renewable wear-rings shall be furnished in the casing. Impeller wear-rings are not required although provision for fitting during overhaul/refurbishment should be provided.

(2) Front and back wear-rings shall be furnished if required for axial balance; pumping vanes shall not be used to establish axial balance.

(3) Wear-ring material/hardness combination shall always be “non-galling” and where possible, wear-rings should be made of materials with known “non-galling” qualities e.g. Ni-resist cast iron.

(4) Renewable casing wear-rings shall be held in place by a press fit with locking pins or threaded dowels (axial or radial) or by flanged and screwed methods.

(5) Running clearances shall meet the requirements of API 610, clause 2.6.4, including the minimum running clearances provided in Table 2.2.

(6) Interstage bushings may have clearances to the Manufacturer’s standard, provided the clearances are stated in the proposal and are approved by the Principal.

Materials of steady bearings and/or interstage bushings shall be a “non-galling” combination.

3.2.6 Dynamics

(1) Actual critical speeds shall not encroach upon any specified operating speed ranges. The amplification factor shall not exceed eight while going through criticals. Amplification factors should be less than five.

(2) The separation margin (see Figure 1) of encroachment from all lateral modes (including rigid and bending) shall be at least (1) 20% over the maximum speed for rigid rotor systems, or (2) 25% below any operating speed and 25% above the maximum continuous speed for flexible-shaft rotor systems (see NFPA 20, clause 4-3.2.4).

(3) Torsional modes of the complete unit shall be at least 10% below any operating speed or at least 10% above the trip speed.

(4) The separation margin specified above is intended to prevent the overlapping of the critical response envelope into the operating speed range.

(5) Slow roll, start-up, and shutdown of the rotating equipment shall not cause any damage as critical speeds are passed.

(6) The calculations detailed in 1 and 2 below shall be provided by the Manufacturer/Supplier.

1. A lateral critical speed analysis to determine 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 3.2.6 (9)).

2. A torsional vibration analysis of the pump-driver system and a transient torsional vibration analysis for synchronous motor-driven systems. The Manufacturer/Supplier shall be responsible for the satisfactory performance of the system.

(7) All major rotating components, including impellers and couplings, should be dynamically balanced in accordance with ISO 1940, balance quality grade 6.3.

NOTE: The actual balance grade required to achieve the vibration performance defined in 3.2.6 (8) below should be confirmed by the Manufacturer/Supplier.

(8) 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. Vibration limits shall be in accordance with Figure 77 of the Hydraulics Institute Standard; 14th edition (p120). The Manufacturer/Supplier shall be required to review the structural drawings of the pump support and confirm that these vibration limits will not be exceeded during operation.

(9) A diesel-driven pump set may be required to operate at a reduced speed during platform hook-up and commissioning. The Manufacturer/Supplier shall advise the speed range(s) over which the pump shall not be operated. Pumps shall operate smoothly throughout the permitted speed range in reaching rated or other operating speed(s).

3.2.7 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 may develop while starting, stopping or operating at any capacity. Upthrust capability should preferable be catered for in the same manner (i.e. thrust bearing rated for double the maximum upthrust) but where upthrust only occurs as a transient during starting or stopping then a suitably rated secondary thrust arrangement may be supplied. The bearing should be the tilting pad type, but angular contact down and roller type ball bearings may be used in right-angle gearboxes if approved by the Principal. The maximum thrust load shall be determined using double the internal clearances.

(2) For motor-driven line-shaft type pumps the thrust bearing shall be housed in its own casing. For pumps driven through right-angle gearboxes the bearings may be housed in the top of the gearbox casings.

(3) Guide bushings that are suitably corrosion- and abrasion-resistant for the specified product and temperature shall be furnished at all steady bearing points in the pump unit (bowl assembly). In addition, 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 (Figure 2).

3.2.8 Pump materials

(1) Pump materials shall be as specified in DEP 80.47.10.12-Gen.

3.3 RISING MAIN/DISCHARGE HEAD

(1) The rising main shall be supplied in flanged sections of materials as specified in DEP 80.47.10.12-Gen. All sharp edges shall be removed from the flanges to avoid scuffing cables and pipes and, if required, the flanges should be scalloped to accept cables or flexible pipes. Cables and pipes shall be secured to the flanges with clamps made of Inconel 625.

(2) 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. If specified, the Manufacturer/Supplier shall submit the calculations made in determining the stress levels.

(3) The method of dismantling and reassembly of the rising main shall be considered and discussed with the Principal at an early design stage, so that the optimum section length can be established, lifting lugs added and handling/storage facilities defined.

(4) A minimum radial clearance of 50 mm 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. The minimum radial clearance shall be increased to 75 mm for pumps with a maximum diameter of 500 mm or more.

(5) Stabilising spiders should be provided to protect the pump, motor, cable and pipes while the rising main is being dismantled and re-assembled and while the pump is operating.

Typically, at least three spiders are provided but alternative proven arrangements may be offered by the Manufacturer/Supplier.

(6) The pump discharge shall terminate at a suitably rated ASME flange orientated as specified in the order/enquiry. The discharge shall be incorporated with the caisson-mating flange into a discharge head and may be cast or fabricated.

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.

Openings for nominal pipe sizes DN32, 65, 90, 125 and 175 shall not be used. Cast iron flanges shall be in accordance with ASME B16.1 and shall be fitted with full-face gaskets.

Copper alloy flanges shall be in accordance with ASME B16.24. Other flanges shall be in accordance with ASME B16.5.

For all flanges rated above 900 lb, the type of flange finish shall be agreed with the Principal.

The discharge head shall be capable of withstanding double the forces and moments in API 610 Section 2.4, in addition to internal pressure. These forces and moments are considered minimum loads and should be adjusted if the Manufacturer/Supplier has experimental or test data permitting higher values.

(7) The rising main shall be sized so that the flow velocity does not exceed 4.0 m/s at rated duty flow.

NOTE: This velocity applies to rising mains manufactured from the materials specified in DEP 80.47.10.12-Gen. Higher velocities are permissible if high alloy duplex stainless steel materials are used. However, evidence of satisfactory service shall be provided by the Manufacturer/Supplier including assurance that flow induced piping vibration will not be experienced.

(8) Bolting between sections of the rising main shall comply with (3.2.3(1)) and (3.2.3(2)).

(9) Pump sealing

The discharge head of vertical line-shaft pumps shall be provided with a stuffing box of proven design to seal against the pump discharge pressure.
Ample space shall be provided for replacement of the packing without removing or dismantling any part other than the gland and, if split, the seal cage.

Glands shall be designed so that the bolts cannot slip if the packing becomes loose. If split glands are used, the halves shall be bolted together. Eyebolts shall not be used for gland fasteners; instead, studs shall be screwed into the pump case.

The thrust bearing/gearbox support piece shall be provided with ample drainage, so that no liquid can collect around the stuffing box.

Stuffing boxes shall be of steel construction with a “non-galling” bushing or alternatively, solid Monel-type material.

3.4 PRIME MOVER

3.4.1 General

The fire pump shall be driven by a diesel engine or electric motor, as specified in the order/enquiry.

Driver power rating for electrically driven pumps shall exceed the maximum power demand at 100% speed by not less than 10%. Maximum power demand is the sum of:

- maximum pump absorbed power, including the 4% test tolerance defined in (Table 4) in (4.2.2);
- transmission losses (gearbox and line shaft losses or hydraulic system inefficiencies);
- auxiliary power take-off.

For diesel engine drives, the continuous rating of the engine shall not be less than the duty point absorbed power of the pump plus the 4% tolerance, plus transmission losses and auxiliary power take-off. The intermittent rating of the engine shall not be less than 105% of the maximum power demand as defined above for electric drives.

3.4.2 Diesel engines

(1) Diesel engines shall conform to NFPA 20, DEP 31.29.80.30-Gen. and the further requirements stated in this DEP.

(2) Flammable gas detectors, supplied by others, will be fitted in the diesel engine enclosure. Coincident high level operation of any two-gas detectors shall automatically isolate all electrical equipment that is not suitable for operation in a hazardous atmosphere. The necessary signal will be provided by the main platform fire and gas panel. Engine start-up and shutdown shall be in accordance with the requirements of DEP 80.47.10.12-Gen.

As the pump may be required to run under potentially hazardous conditions, no electrical generator shall be provided on the diesel engine. The batteries shall be charged from external supplies. Battery enclosures shall be in accordance with IEC 60529, IP65 standard.

The engine shall include an overspeed shutdown device (air intake shut-off) and a spark arrestor in the exhaust, as specified in DEP 31.29.80.30-Gen.

(3) The start system shall be by batteries (dual sets) with an additional hydraulic or pneumatic backup system.

(4) Diesel fuel will be gravity fed from a day tank either supplied by others or within the Manufacturer/Supplier's scope of supply, as specified in the order/enquiry.

The Manufacturer/Supplier shall state the maximum allowable elevation of the diesel day tank so as not to exceed the maximum permissible static pressure head. A minimum static head shall be maintained to ensure full flow rate through partially blocked filters.

(5) In the case of direct mechanical drive, the coupling between diesel engine and gearbox shall comply with NFPA 20 clause 4.5.1.4, ISO 10441 and the following requirements:

- Coupling to shaft junctures shall be capable of continuous operation at not less than 1.5 x maximum continuous torque developed by the driver.
- Couplings shall be designed to operate continuously with 125% of maximum steady state or transient axial displacement (whichever is the larger) occurring simultaneously with 125% of maximum angular misalignment and 125% of maximum parallel offset.
- The coupling shall not require continuous lubrication.
- It shall be possible to dismantle and remove the coupling without either gearbox or engine needing to be moved.

- It shall be possible to run the engine disconnected and an idling adapter shall be provided for this purpose if required.
- Coupling guards shall be made of one of the following spark-resisting materials:
  - Copper or copper based alloys (e.g. brass, bronze);
  - GRP.

  The guard shall be permanently fixed and sufficiently rigid to ensure that rubbing cannot result from deflection caused by normal body mass (90 kg) applied vertically or horizontally.
- For flexible metallic element couplings, the design shall be such that in the event of a flexible element failure drive is maintained.
- For rubber/elastomer element couplings, the following requirements shall apply:
  - The elastomeric or rubber composition shall be of the oil-resistant and anti-static type.
  - Metallic components, such as clamping rings, shall have radiused edges and corners where they come into contact with the flexible element(s).
  - When specified it may be required to incorporate a “back-up” facility in order to maintain drive for a limited period in the event of element failure.
- If the discharge head is mounted directly on the deck (not on an extended diesel engine base frame) a double-universal joint (Cardan) shaft shall be installed.

(6) The engine, governor, fuel control system and overspeed protection shall be designed so that external power sources are not required for their operation; that is, the engine shall be capable of starting, running and stopping when all platform power supplies have failed.

3.4.3 Electric motors

(1) The following requirements apply to electric motors other than submersible pump motors:

- electric motors shall be supplied in accordance with DEP 33.66.05.31-Gen.;
- overcurrent protection of electric motors that are required to remain operational in the event of fire shall be set at a minimum of 300% of the motor full load current in accordance with NFPA 20;
- electric motors and terminal boxes for fire pumps shall be waterproof, BASEEFA certified and suitable for use in Zone 1 areas. The ingress protection of the motor shall be at least IP 55 and the ingress protection of the terminal boxes shall be at least IP 65, in accordance with IEC 60529;
- the coupling and guards between motor and gearbox shall meet the same requirements as those for engine drives as detailed in (3.4.2 (5));

(2) Submersible electric motors shall meet the following requirements:

(a) The submersible motor shall be of the “wet” type, where the stator is flooded in coolant suitable for the environmental conditions; either oil or a water/glycol mixture. The motor winding insulation shall be ungraded. See (3.2.6 (7)) for balancing requirements.

(b) The motor assembly shall incorporate a tilting pad thrust bearing designed to carry double the expected maximum thrust that the pump may develop while starting, stopping or operating at any capacity. The upthrust bearing may be included in the pump unit (bowl assembly).

(c) The motor stator casing (wrap) and end caps shall be manufactured of aluminium bronze compatible with the pump unit. Other materials may be acceptable for the stator casing, subject to approval by the Principal.

(d) The submersible motor shaft shall be sealed with a mechanical seal to prevent the ingress of the pumped fluid. The seal shall have carbon against silicon carbide faces

with viton gaskets or bellows. The Manufacturer's standard method of sealing, if not a mechanical seal, should be offered as an alternative in the proposal.

To compensate for the pressure fluctuations within the motor during installation, operation and shutdown, the motor shall include a flexible diaphragm or, if specified in the order/enquiry, shall be pressurised from an overhead tank (see (h) below).

(e) A plate of 18 Cr-8Ni stainless steel or Monel-type material showing the direction of rotation shall be furnished, secured to the motor by stainless steel pins.

(f) The motor shall be supplied complete with one-piece power cable(s). For ease of handling a single three- or four-core cable is preferred to three or four individual phase cables. The Manufacturer/Supplier shall state his preference for cables in the proposal.

The cable(s) shall terminate at deck level in a flameproof junction box to IP56 suitable for mounting directly on the deck, with a support structure high enough to allow for the minimum bending radius of the incoming feeders into the bottom of the box. The junction box and support structure shall be supplied by the Manufacturer/Supplier and shall be coated with a paint system suitable for an open marine environment. The Manufacturer/Supplier shall submit details of the procedure, for review and approval, with the proposal. Details shall include surface preparation, paint materials/application/thicknesses and the Manufacturer's data sheets.

The cable length shall extend from the motor to deck level plus a further 5.0 m to reach the junction box. The final location of the box will be advised by the Principal.

(g) The power cable, motor pressurising/vent lines (if applicable) and the cable of hoses feeding the anti-fouling systems shall be clamped to scallops in the rising main flanges with clips of Inconel 625 type material.

(h) Overhead tank with hoses

1. If specified in the order/enquiry each pump shall be supplied with a stainless steel overhead tank for pressurising the submersible motor through flexible hoses. The tank shall be complete with a stand suitable for mounting directly on the deck.

2. Unless otherwise agreed each tank shall be complete with the following:

   - local gooseneck vent;
   - valved and flanged rain connection with blanking plate;
   - valved level gauge;
   - manway/inspection opening;
   - level switch for low tank level alarm;
   - filling connection for manual filling;
   - flanged connection for the motor pressurising hose;
   - flanged connection for the motor vent.

3. The overhead tank shall be provided with an earthing boss consisting of a 50 mm diameter x 50 mm long bar welded directly to the tank. A central hole tapped M10 x 30 mm deep shall be machined before welding into position with a 6 mm continuous fillet weld. The face of the boss shall be machined square. The thread and machined face shall be left unpainted.

4. The pressurising and vent piping shall be continuous flexible hose of reinforced construction. Each hose shall be clearly labelled "supply" or "vent". The hose materials shall be proposed by the Manufacturer/Supplier in the proposal and shall be subject to approval by the Principal. The hose length shall extend from motor to deck level, plus a further 5.0 m if required to reach the tank. In some installations the hoses which terminate at the caisson mating flange and the pressurising and vent connections to the tank will be stainless steel piping. The Manufacturer/Supplier shall liaise with the Principal at an early design stage to determine the pump and pressurising tank layout and length of piping required.

3.5 POWER TRANSMISSION

3.5.1 Direct mechanical drive (right-angle gearbox/line-shaft)

(1) Gearboxes shall be totally enclosed and comply with AGMA 6010-F97. Gearboxes shall be rated for the driver rated power with a service factor of not less than 1.5.

If the thrust bearing is incorporated in the gearbox, the appropriate requirements of (3.2.7) shall apply.

(2) It may not be possible to obtain a right-angle gearbox to match an engine's rated speed and required pump speed. Once an acceptable gear ratio has been agreed, the pump power demand with the engine running at rated speed shall be re-checked to ensure that the power margins described in (3.4.1) are still maintained.

(3) Line-shaft couplings shall be the sleeve type, keyed to the shaft and positively locked to prevent any part becoming loose in service. Screw-type couplings are not permitted.

(4) Precautions shall be taken to guarantee lubrication of upper sleeve bearings when the pump is started, unless the Manufacturer can offer an acceptable bearing proven to be suitable for short periods of dry running.

(5) The pump Manufacturer/Supplier shall advise the engine supplier of the torque required to start the line-shaft revolving. BS 5514-5 shall be complied with as regards responsibility for checking torsional vibration characteristics and stress.

(6) Adequate means of cooling the gearbox oil shall be provided. This can be either:

- internal cooling coil situated in the gearbox sump;
- external gearbox cooler.

Unless otherwise agreed, the cooling medium shall be sea water taken from the pump discharge. The cooling system shall be designed so that the maximum temperature of the oil to the bearings, under the most adverse environmental conditions, does not exceed 80 °C. A gearbox oil temperature indicator shall be provided.

For seawater cooling the materials in contact with the seawater shall be corrosion resistant and approved by the Principal.

3.5.2 Indirect hydraulic drive

(1) A moderate pressure hydraulic system, employing motor and pump of a simple rugged type with a minimum of working parts, such as a screw type, is preferred. Alternative types may be offered if the Manufacturer/Supplier can demonstrate satisfactory experience.

(2) The hydraulic system typically comprises a pump, hydraulic motor, filter, cooler, expansion tank, interconnecting pipework, hoses, valves, coffer-dam header tank and jockey pump. The jockey pump is electric motor driven and maintains a small continuous flow of hydraulic fluid through the system while the firepump is shut down. The design of the system should be in accordance with the Manufacturer's standard design provided satisfactory experience can be demonstrated.

(3) All items in contact with hydraulic fluid except the hydraulic pump/motor cases and tubing within them shall be fabricated from 316L stainless steel. Certain special hydraulic system components may be in carbon steel. The Manufacturer/Supplier shall supply full details in the proposal.

(4) If specified, or deemed necessary by the Manufacturer/Supplier, an electric, thermostatically controlled heater shall be located in the expansion tank. The surface heat flux shall not exceed 2.3 W/cm^2.

(5) The hydraulic fluid cooler shall use sea water as coolant, and use materials, design and fouling resistance equivalent to that of the engine cooling water heat exchanger described in (3.5.3).

(6) Hydraulic oil pipes and hoses shall be arranged to facilitate disassembly and avoid damage during installation. The Manufacturer/Supplier shall describe in his tender his

proposed method for obtaining a seal between all connecting pipes within the rising main. Any alternative piping methods shall be submitted to the Principal for approval and shall indicate clearly the method used for sealing joints and protecting against damage.

3.6 ANTI-MARINE FOULING SYSTEM

The pump shall be fitted with an anti-marine fouling system capable of preventing mussel, shellfish and algae growth on the pump and intake metalwork. Its design shall be such that the free area of the pump suction strainer is not reduced. The system shall be dismountable from the pump/motor unit to facilitate pump withdrawal if electric submersible pumps are used. Unless otherwise specified the system shall be of the ion exchange type.

NOTE: Experience has shown that the piping/tubing required for hypochlorite injection system is vulnerable to damage either from storm conditions if the piping is fitted on the outside of the caisson or during pump removal/replacement if the piping is fitted to the rising main.

The following requirements shall apply:

(1) The unit shall comprise, as a minimum requirement, the following items:

- electrode unit;
- transformer rectifier;
- armoured cable complete with spooling device;
- cable attachment brackets;
- junction box;
- commissioning spares; and
- any other equipment necessary to provide full protection from marine infestation using the platform electrical supply.

(2) The electrode unit shall consist of both aluminium and copper electrodes. The output of the auxiliary aluminium anodes shall give at least 4 µg/l of aluminium ions in solution and the copper anodes a minimum of 24 µg/l of cupric ions in solution. These levels shall be maintained throughout the pump's design flow range. At pump shutdown the current outputs shall be set to a nominal 25% of maximum to allow for eddy current losses and tidal flow. The Manufacturer/Supplier shall submit calculations to show that these levels of concentration can be maintained throughout the design life of the unit.

(3) The unit should be designed to last for at least five years of continuous use. The anodes shall be so sized that their average cross-sectional area at the end of this time shall not be less than 8 cm^2 and calculations to show this shall be included.

(4) The anode support frame shall be designed to attach to the pump intake or strainer depending upon the details of the order. The frame shall act as the cathode and shall be so insulated as to maintain a resistance of 10 000 Ω between all metal components throughout the lifetime of the unit.

(5) The transformer-rectifier control unit shall be fully self-contained and shall be free standing on anti-vibration mountings. All cabling shall be fire-resistant and the controller shall be of an approved type in accordance with NFPA 20 and enclosed to IEC 60529, IP65 standard.

(6) The control unit shall include the following equipment:

- ammeters and voltmeters for both anodes and cathodes;
- an hours-run meter for each electrode unit;
- independent manual current regulation for copper and aluminium circuits;
- positive and negative DC terminal identification;
- mains “on” indication;
- excess DC and DC failure alarms.

For electric submersible pumps a single piece armoured cable up to deck level plus a further 5.0 m (if required) shall be supplied, terminating in a separate junction box. Both the control unit and junction box shall be suitable for mounting directly on the deck with a support structure high enough to allow for the minimum bending radius of the incoming cables. The control unit and junction box shall be coated with an approved paint system suitable for an open marine environment.

3.7 FOAM PUMP

If specified in the order/enquiry each fire pump shall be supplied with its associated foam pump. This generally applies to centralised foam systems.

The pump should be of the positive displacement rather than centrifugal type. If centrifugal, the pump shall be supplied in accordance with DEP 31.29.02.30-Gen. Foam concentrate pumps may be directly coupled to the firewater pump driver or may be independently driven by electrical, diesel or water power according to the reliability and availability required. Foam concentrate pumps coupled to firewater pump drivers should not use a clutch or equivalent to separate the concentrate pump from the driver, but the concentrate pump coupling should be capable of being easily disconnected to permit uncoupled running for test purposes.

The foam pump shall be constructed of materials appropriate for the intended use and shall be suitably rated for the following service:

- the foam pump discharge pressure shall be at least 2 bar higher than the fire pump discharge pressure at all points on the firepump discharge curve;
- the foam pump flow rate shall be adequately sized to provide a nominal 1% Aqueous Film Forming Foams (AFFF) concentrate by volume into the firewater stream at all points on the fire pump discharge curve.

Should the foam pump be unable to meet the above design requirements, consideration may be given to limiting the foam pump design criteria to 0-110% of the fire pump rated flow, as defined in NFPA 20, subject to the approval of the Principal.

3.8 PIPING, VALVES AND ANCILLARIES

The Manufacturer/Supplier shall provide all piping, valves and ancillaries required to provide a fire pump package complete in itself. The package shall require the minimum of hook-up by the Principal.

Seawater pipework shall be in accordance with DEP 80.47.10.12-Gen.

An air valve shall be installed at the top of the riser. This shall be capable of venting air from the riser on pump start-up and allowing air into the riser on pump shutdown.

All Manufacturer/Supplier terminal points shall terminate with ASME flanges at the baseframe edge, unless otherwise agreed in writing by the Principal.

3.9 BASEFRAME

The complete fire pump package shall be either mounted on a single steel baseframe, or mounted on two base frames; one for the pump discharge head and gearbox (if fitted) and the other for the diesel engine and auxiliaries. The base frame arrangement shall be agreed between the Principal and the Manufacturer/Supplier.

3.10 NOISE LIMITS AND ACOUSTIC TREATMENT

3.10.1 General

All definitions, notations, measuring equipment, measuring procedures, test reporting, calculation methods and calculating procedures shall be in accordance with EEMUA 140 and EEMUA 141 or in accordance with a national standard approved by the Principal.

3.10.2 Noise limits

The noise generated by the overall package shall not exceed the limits stated on the equipment noise limitation sheet DEP 31.10.00.94-Gen.

Noise levels shall have an upper tolerance of + 0 dB.

The limits apply in the absence of reverberation and background noise from other sources and for all operating conditions between minimum flow and rated flow.

3.10.3 Noise abatement

If excessive equipment noise cannot be eliminated by low noise design, corrective measures should preferably take the form of acoustic insulation of pipes, gearboxes, etc. If noise hoods are proposed, prior approval must be obtained from the Principal regarding construction, materials and safety requirements. Noise control measures shall not interfere with or obstruct operations or routine maintenance activities.

3.10.4 Information to be submitted with the proposal

The Manufacturer/Supplier shall submit the guaranteed sound power levels and/or sound pressure levels of the equipment together with any other relevant information as requested in the equipment noise limitation sheet DEP 31.10.00.94-Gen.

The Manufacturer/Supplier shall also indicate which special silencing measures, if any, have been applied in order to obtain these levels.

3.11 FIRE PUMP CONTROLLER

3.11.1 General

(1) Controllers shall be of an approved type and shall be in accordance with NFPA 20. They shall be enclosed in a stainless steel cabinet with an ingress protection of at least IP65 in accordance with IEC 60529, and shall be fitted with an anti-condensation heater.

All relays shall be hermetically sealed and be suitable for 15 to 40 V (dc) (nominal 24 V (dc)) to ensure operation in the event of voltage dips during engine cranking.

In designing the controller, due consideration should be given to access for operation and maintenance, both internally and externally.

(2) The controller shall have the following features:

- annunciator panel with “first-up fault” features;
- AC/DC isolators;
- battery selector - manual start;
- start/stop button;
- automatic/manual test mode selector;
- battery chargers and controls;
- device to provide start attempts powered from each battery in turn;
- lamp test;
- two ammeters and selectable voltmeter, for the batteries;
- semaphore indicator to indicate that the electrics are isolated.

(3) The controller shall be designed to effect the operating philosophy described in DEP 80.47.10.12-Gen.

(4) Control and starter circuit isolators shall be provided. These may be located in the controller and should be suitable for use in a Zone 1 area.

(5) The controller design shall be such that when the engine is started manually, with the hydraulic starter, all engine monitoring channels function, and the overspeed protection device is operative.

3.11.2 Alarms

(1) Malfunctions to be monitored and annunciated as alarms on the controller should include but not necessarily be limited to:

Engine:
- low oil pressure;
- high oil temperature;
- low level in fuel tank;
- air intake valve closed;
- low hydraulic (or pneumatic) start pressure;
- high coolant temperature;
- low coolant temperature (indicates heater failure);
- low coolant level in make-up tank;
- overspeed;
- high exhaust gas temperature;
- fuel rack lever closed.

Electric motor:
- overload (high current);
- high winding temperature.

Gearbox:
- high oil temperature;
- low oil pressure (if a pressurised oil system is fitted);
- low oil level. Hydraulics driver system (if used);
- high differential pressure across filter;
- cofferdam level abnormal (indicates seal leakage);
- low temperature (indicates heater failure);

- jockey pump failed;
- low level in storage tank.

Controller:
- engine failed to start;
- battery volts low;
- battery charger failed;
- pump not available for remote start;
- pump on demand;
- pump running.

(2) The control system shall provide volt-free change-over contacts to annunciate the following parameters in the installation control centre and/or via telemetry, to another location:

"Unit Available" - i.e. fire pump package ready for automatic start and control system not in "manual" or "test" mode.

"Pump on Demand" - i.e. engine crank sequence operating.

"Pump Running" - i.e. normal start achieved and engine on load.

"Fault" - indicates that any one of the faults listed above has been signalled at the controller.

The controller shall accept signals (e.g. start, inhibit automatic start, isolate AC and DC power) from remote stations which are outside the Manufacturer/Supplier's scope of supply. The Manufacturer/Supplier shall be responsible for ensuring the compatibility of his equipment with the signals received. These signals may be of a "fleeting" nature. The data sheet will define the external signals to be accepted.

3.12 NAMEPLATE

Nameplates of 18Cr-8Ni stainless steel or Monel type material shall be furnished, securely attached by stainless steel pins to the discharge head and engine baseframe (if appropriate). Unless otherwise instructed in the inquiry/order, the nameplate(s) shall be stamped with the following information in the English language with the data in SI units:

- Principal's item number;
- Principal's name;
- Pump serial number;
- Casing hydrostatic test pressure (bar (ga));
- Capacity (m^3/h);
- Revolutions per minute;
- Pumping head (m);
- Pump and driver model number;
- Driver rated power (kW);
- Manufacturer of pump and driver;
- Project Tag Number;
- Year of manufacture.

In addition to being stamped on the nameplate, the pump serial number shall be plainly stamped on the bowl assembly. If other than unified screw threads are used on bolting, see (3.2.3(1)), this should be indicated on a separate stainless steel plate.

4. INSPECTION AND TESTING

4.1 INSPECTION

4.1.1 General

All equipment covered by this DEP shall be subject to inspection by the Principal at the Manufacturer/Supplier's works and at the works of any sub-supplier or sub-contractor.

The Principal shall therefore be permitted access to the equipment at all reasonable times.

4.1.2 Specific inspection

Certain tests and inspections shall be witnessed by the Principal and shall be considered "hold points" in the manufacture. These tests and inspections will be listed on the "Schedule of Essential Tests and Inspections" a specimen copy of which is attached as (Appendix 2) of this DEP.

4.2 TESTING

4.2.1 Hydrostatic test

Each pump casing (bowl) and section of rising main shall be hydrostatically tested with water to a minimum of 1.5 times the maximum allowable pressure.

This pressure is defined as the greatest discharge pressure at the specified pumping temperature for which the pump casings and rising main are designed.

Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when no casing or casing joint seepage or leaks are observed for a minimum of 30 minutes.

Any leakage shall be cause for rejection. Repairs shall be subject to prior approval of the Principal and shall be carried out in accordance with DEP 80.47.10.12-Gen. Repairs shall be subject to approval by the Principal's inspector before a second or subsequent test is commenced.

4.2.2 Performance test

(1) Unless otherwise specified, the Manufacturer shall operate the pump in the shop for a sufficient period to produce at least five points of complete test data, including head, capacity, and power. These five data points are subject to agreement between the Principal and the Manufacturer/Supplier but will normally be shutoff, minimum continuous stable flow, midway between minimum and rated flows, rated flow and 150% of rated flow. The pump shall be tested at the minimum immersion depth, as defined in (3.2.1(10)).

The pump may be shortened to suit the Manufacturer/Supplier's test facility. Appropriate corrections shall be made in the head produced due to the reduced length and friction losses.

(2) The Manufacturer shall maintain a complete detailed log of all final tests and shall prepare the required number of copies, including test curves and data, certified as to correctness. All running tests and mechanical checks shall be completed by the Manufacturer prior to the Principal's inspection.

(3) The test speed shall be within 5 % of the rated speed shown on the certified outline drawing. Test results shall be converted to the rated speed.

(4) The pump shall be driven by the contract driver.

(5) When operated at rated speed and rated capacity, pumps shall be within the tolerances, given in API 610 Table 4-2.

(6) If it is necessary to dismantle any pump after the shop test for the sole purpose of machining impellers to meet the tolerances on differential head, no performance retest will be required unless the reduction in diameter exceeds 5% of the original diameter.

However, a mechanical run test will be required. The diameter of the impeller at the shop test, together with the final diameter of the impeller, shall be recorded on a certified shop test curve sheet showing the operating characteristics on test and the calculated characteristic after the diameter of the impeller had been reduced.

If dismantling is necessitated because of some other correction, such as improvement of efficiency, NPSH, or mechanical operation, the initial test will not be acceptable and the final shop tests shall be run after such corrections are made.

4.2.3 NPSH test

(1) This test is optional and is only required if specified in the order/enquiry.

(2) NPSH required data shall be taken at the following four points: minimum continuous stable flow, midway between minimum and rated flows, rated flow, and 110% of rated flow. The NPSH test shall be in accordance with the test code of the Standards of the Hydraulic Institute.

(3) A vacuum tank suppression test is preferred.

The test-bed arrangement where the pump is installed above a suction pit in which the level can be lowered to approximately 10m below the pump, is also acceptable.

The Manufacturer shall state the method of NPSH testing (if specified) in the proposal.

(4) A drop in head of 3% at the first-stage shall indicate performance impairment. The total differential head should be divided by the number of stages to approximate first stage head.

4.2.4 Prime mover

Diesel engines shall be tested in accordance with DEP 31.29.80.30-Gen.

Electric motors shall be tested in accordance with DEP 33.66.05.31-Gen.

Submersible electric motors shall be tested in accordance with BS 4999-143, where applicable to submersible motors.

4.2.5 Controller

A full simulated operation test shall be carried out at the Manufacturer's works. All remote signals shall be simulated.

The details of this test shall be agreed with the Principal.

4.2.6 Complete fire pump set works performance test

Each complete fire pump set, i.e. firewater pump, prime mover, controller, foam pump and all ancillary items, shall be fully assembled, all utilities connected, and given a full-load, 8-hour performance test, at the Manufacturer's works. It is recognised that line-shaft pumps can probably only be tested at the Manufacturer's works with a short length of rising main and drive shaft. Details of all slave equipment to be used for tests shall be submitted in writing by the Manufacturer/Supplier to the Principal, and approval obtained before testing can commence. The test schedule shall include:

(1) Bring the engine to normal operating temperature.

(2) Operate the pump at a minimum of four points to obtain a characteristic curve at the rated speed. All conditions shall be stable at each test point.

(3) Operate the pump at duty point for four hours.

(4) Operate the pump at 150% duty point for two hours.

(5) The purpose of tests (3) and (4) is to verify the integrity of the complete fire pump package. At half-hourly intervals the following as a minimum shall be recorded:

- engine and pump speeds;
- engine and gearbox lube oil temperature to and from cooler;
- cooling medium temperatures (at inlet and outlet of all heat exchangers);
- vibration at points defined in (3.2.6 (10)), using an instrument complying with ISO 2954;
- lube oil pressures;
- fuel consumption;
- engine exhaust temperature;
- fire pump head and capacity.

The following measurements are for hydraulic drive pumps only:

- hydraulic oil temperatures to and from cooler;
- hydraulic oil pressure from each hydraulic pump;
- cofferdam liquid level.

Should this test reveal any faults or abnormal trends in equipment operation, the Principal reserves the right to instruct the Manufacturer/Supplier to carry out remedial work and repeat the extended test.

A manual hydraulic start shall be made with the engine cold, and with all electrical power isolated (AC and DC) prior to any other start-up. The set shall then be stopped manually whilst the electrical power is still isolated.

A second manual hydraulic start shall be made with the electrical power connected. With the engine running the following shall be demonstrated on the controller:

- engine run light comes on;
- engine monitoring channels function;
- overspeed system functions;
- emergency shutdown buttons;
- electric start lock-out system.

Hydraulic accumulator(s) capacity shall be checked by isolating the engine fuel system (to inhibit starting) and timing the cranking periods available.

The electric start system shall also be demonstrated along with the auto-switchover system.

5. PREPARATION FOR SHIPMENT AND STORAGE

5.1 GENERAL

When specified in the enquiry/order the Manufacturer/Supplier shall comply with the following:

(1) This section describes the procedure to be followed by Manufacturers/Suppliers to ensure the adequate preservation and protection of their mechanical equipment during transportation and storage prior to unpacking at the module fabrication yard, or any other manufacturing or fabricating facility that may be specified in the order/enquiry. Procedures for extended storage (cocooning) of mechanical equipment are not described in this DEP. If required, such procedures will be covered in a separate order/enquiry (or attachment thereto).

The procedures shall also be applied to equipment which is to be shipped directly to an offshore location; either during initial construction/hook-up, or as spare/replacement units during operational periods. Any additional preservation/protection requirements for sea transit or offshore storage shall be advised by the equipment Manufacturer/Supplier.

(2) Generally, mechanical equipment is supplied as part of a packaged unit which includes other types of equipment, instrument, electrical, valves and piping. Although this DEP provides minimum requirements for such components mounted in packaged units, any other standards, specifications or procedures listed in the order/enquiry which relate specifically to the preservation and protection of such components shall take precedence.

(3) Unless otherwise specified, the equipment will be installed on an offshore installation. Equipment preservation and protection shall be adequate to enable the equipment to be delivered without suffering damage or deterioration, stored at the module fabrication yard (or other place of storage that may be specified) for a period and then installed in a module (or in the open) during the construction phase. The probable storage period will be specified in the order/enquiry for the equipment and will extend from the time of despatch to the time of unpacking at the fabrication yard. If the storage period is not stated in the order/enquiry, a minimum period of 12 months shall be assumed. The construction will normally last for a 6-12 month period. Following construction the module containing the equipment will be transported by barge to the platform location for final installation, hook-up and process/utility commissioning.

(4) It is recognised that some or all of the preservation and protection applied to the equipment by the Manufacturer/Supplier will, of necessity, be removed at the fabrication yard during equipment installation and hook-up. If applicable, temporary preservation will then be applied to the equipment for the sea transit, installation and hook-up phases to ensure adequate protection up to the time of offshore process/utility commissioning.

Different preservation methods or deviations from the methods described here may be proposed by the Manufacturer/Supplier but shall only be used with the approval of the Principal.

(5) If the equipment packaging and protection remains unopened and undamaged, and is correctly handled in accordance with the Manufacturer/Supplier's markings and shipping instructions, then it shall remain the responsibility of the Manufacturer/Supplier that the equipment supplied remains in the same condition as when accepted by the Principal, ex-works.

If the Manufacturer/Supplier so wishes, this responsibility may be conditional on the Manufacturer/Supplier being allowed to inspect the equipment preservation/protection at intervals (to be agreed between the Manufacturer/Supplier and Principal) and on the Principal acting on any reasonable recommendations made by the Manufacturer/Supplier following such inspection visits. Such activities carried out under the Manufacturer/Supplier’s supervision or with the Manufacturer/Supplier’s approval, shall not relieve the Manufacturer/Supplier of his liabilities as described above.

(6) All items containing preservations and inhibitors shall have prominent warning labels or tags securely attached advising of procedures, cautions, toxicity of materials, hazards, necessity for removal prior to placing in service and any other salient cautioning factors.

When Vapour Phase Inhibitor (VPI) powders are used inside equipment, red tags shall be attached to the outside indicating the quantity of bags inside. All packaging materials and procedures should not be toxic and pose no other threat to the safety and hygiene of personnel.

(7) Any item of equipment protected internally with a desiccant shall be prominently labelled or tagged "WARNING - DESICCANT INSIDE". Desiccant shall be placed in a bag or other suitable container so as to prevent it dispersing inside the equipment during transit or installation. The drying of equipment prior to the application of preservative may be done by wiping dry or air drying. However, all inaccessible areas shall be air dried.

The Manufacturer/Supplier shall calculate the amount of desiccant required following the guidelines on the use of desiccants laid down in BS 1133 Section 19.

NOTE: Desiccant should not be used in combination with vapour phase inhibitors.

(8) Warning labels and tags shall be secured with stainless steel wire or rivets (as appropriate), in such a way that they will remain attached during transit and storage for 12 months under adverse conditions. Labels and tags shall preferably be of stainless steel, and lettering shall be a minimum of 10 mm high.

(9) Stress corrosion cracking can result when stainless steel equipment is in contact with salt water at temperatures greater than 50 ^{o}C. The residual stress in welded equipment can be sufficient to promote stress corrosion cracking. Extra precautions shall be taken when preserving stainless steel equipment which will be subjected to a saline environment, whether during operation, transit or installation.

5.2 MINIMUM PRESERVATION REQUIREMENTS FOR FIREWATER PUMPS

(1) All exposed shafts, machined and polished surfaces shall be thoroughly cleaned, coated with Preservative fluid and wrapped with heavy gauge plastic sheeting secured with tape. Where appropriate, shaft entries shall be wrapped with heavy duty tape, to prevent the ingress of dirt, dust and moisture.

(2) Alkaline solvents shall not be used to clean non-ferrous materials, especially aluminium, tin and zinc. Most alkaline cleaners are liable to attack paint. Alkaline solvents should be used with caution on highly polished surfaces as they may damage the surface and cause staining. Finger sweat on fine machined surfaces shall be removed with methanol.

5.2.1 Preservation procedure

5.2.1.1 General

In developing an overall preservation procedure the Manufacturer/Supplier should make reference to DEP 70.10.70.11-Gen.

5.2.1.2 Pumps

The bowl assembly discharge elbow and sections of rising main shall be drained and thoroughly dried, and be preserved with VPI powder or a desiccant.

5.2.1.3 Diesel engines

These shall be preserved in accordance with DEP 31.29.80.30-Gen.

5.2.1.4 Gear box

Gear boxes shall be preserved in accordance with DEP 70.10.70.11-Gen.

5.2.1.5 Flexible couplings

These shall be preserved in accordance with DEP 70.10.70.11-Gen.

5.2.1.6 Electric motors

These shall be preserved in accordance with DEP 70.10.70.11-Gen.

NOTE: It is essential to thoroughly flush out any preservative fluid before filling equipment with the service oils, as some preservative fluids, or other silicone-based fluids even in trace quantities, may cause serious deterioration of the service oil.

5.3 PRESERVATION OF ANCILLARIES AND ASSOCIATED EQUIPMENT

Control panels and instruments shall be sealed to ensure they are watertight. A suitable desiccant (e.g. silica gel) shall be placed inside and then they shall be shrink-wrapped with at least two layers of heavy duty film (0.2 mm thick). The faces of control panels and instruments shall be protected with plywood at least 6 mm thick. Electrical and instrument junction boxes (and other equipment) shall be sealed to ensure they are watertight, with a suitable desiccant (e.g. silica gel) placed inside.

Electrical wiring shall be terminated and adequately supported. No wires shall be left exposed.

NOTE: Desiccant must not be used in combination with vapour phase inhibitors.

5.4 TAGGING OF EQUIPMENT

(1) Before despatch, the Manufacturer/Supplier shall mark on, or securely attach to the equipment, a list of the specific oils, greases and rust preventatives used to protect the equipment. The list shall show Manufacturer and type number, the locations where each have been applied, method of removal and details of special precautions to be taken during periods of storage.

(2) Before despatch, the Manufacturer/Supplier shall mark on, or securely attach to the consignment, any special handling and/or storage instructions. These instructions shall include notification of any electrical, instrumentation or other components not suitable for long-term outdoor storage and any special handling instructions for catalysts and chemicals.

(3) Unless specified differently in the enquiry/order, each item of equipment or equipment package shall be tagged with a stainless steel tag secured to the equipment with stainless steel wire. The tag shall contain the following information in lettering of 10 mm height minimum:

- Name of Company;
- Project name and number;
- Principal's name (if different from company);
- Purchase order number;
- Principal's item number;
- Overall size and weight.

(4) The Manufacturer/Supplier shall comply with any additional and relevant tagging instructions in the order/enquiry.

5.5 PACKING FOR TRANSPORTATION AND STORAGE

(1) Whenever possible (if size permits) the equipment shall be boxed suitable for export. This shall require the equipment to be packed in stout wooden boxes with the lids securely fastened by nailing, screwing or strapping.

Certain large robust items of equipment and equipment packages may be shipped on wooden or steel pallets. The equipment shall be fastened to the pallets with strappings. Strapping shall comply with BS 1133 Section 15 or local equivalent if available and shall be stainless steel or plastic coated steel, of minimum width 12.5 mm thickness 0.27 mm. Stainless steel strapping shall be prevented from rubbing on the equipment.

Wooden boxes shall comply with BS 1133, Section 8 or local equivalent if available and any shipping regulations or other instructions included in the order/enquiry. The boxes shall be marked on at least two sides and top with the same information as listed in

(5.4(3)), together with the Principal's name and the delivery address.

Wooden containers shall be manufactured of flame-retardant timber. Steel boxes and reusable boxes are acceptable.

Consideration should be given to the further use of such boxes to provide protection for the equipment at the fabrication yard during the equipment installation and module construction phases.

All boxes shall contain a vapour barrier material.

A list of contents in a waterproof enclosure shall be attached to the outside of the box, or equipment if on a pallet, and a duplicate list enclosed with the contents.

For electric submersible pumps a steel transportation case shall be supplied as follows:

(i) Each electric submersible motor pump shall be supplied with a steel transportation box suitable for protecting the pump unit, motor and cable during transportation and storage, both onshore and offshore. The box shall be capable of supporting the pump unit both horizontally and vertically. The box will be used regularly, every time the unit is transported.

(ii) Cable reeling drums (one per cable) shall be supplied, to assist in the orderly handling of cables during installation and disassembly. Alternative arrangements where the cables are fed directly into the transportation case may be used, subject to approval by the Principal.

(2) All fragile items such as control panels, instruments and small piping/tubing shall be adequately supported and glass faces covered with polythene and plywood, which shall be at least 6.0 mm thick. Preservation of such items shall be as in (5.3).

(3) Whether boxed or strapped to pallets for shipment, the equipment shall be adequately supported so as to prevent damage during transit and lifting.

If required, any temporary supports should be of metal (not plastic or timber) unless, however, the use of metal would damage the item to be supported, in which case hard wood may be used. The outer skin of the insulation shall not be used for supporting surfaces, nor shall any temporary supports abut the insulation. If necessary the insulation (thermal or noise) should be stripped back and sealed.

(4) If it is necessary to remove any items from the equipment (or equipment package) for shipment, they shall be tagged, boxed and labelled in accordance with the requirements stated here for the equipment.

6. WEIGHT CONTROL

When specified in the enquiry/order the Manufacturer/Supplier shall comply with the following requirements.

6.1 INFORMATION WITH QUOTATION

A potential Manufacturer/Supplier shall provide as part of the quotation the estimated total installed operating weight of each pump set to be supplied, including all ancillaries and appurtenances regardless of whether they are supplied loose or installed on the unit. This estimate shall have an upward tolerance of 10% or 10 kg whichever is the greater.

Prior to placing an order a Manufacturer/Supplier may be required to guarantee his weight estimate with the above tolerance.

6.2 INFORMATION FOLLOWING AN ORDER

Within a period as specified in the requisition, the Manufacturer/Supplier shall supply the following information:

(1) The weight and position of the centre of mass of each pump unit:

- as intended to be shipped including packing, temporary shipping constraints, lifting
- equipment etc.;
- as installed including all ancillaries, appurtenances etc.;
- in operation, i.e. including the normal contents of process fluids, lubricants, etc.

(2) The weight of any ancillary or appurtenance to be shipped separately.

(3) The weight of any component or item included in a pump unit greater than 200 kg or 25% of the total weight of the pump unit whichever is the lesser (defined as a “major” component).

The above information shall be provided on a Weight/Centre-of-Mass Data Sheet, DEP 30.10.01.92-Gen.

6.3 WEIGHT CONTROL DURING MANUFACTURE

The Manufacturer/Supplier shall operate a weight control programme and shall notify the Principal at any time if information becomes available indicating that the weight of the complete pump unit or any major component differs from the data provided under (6.2) by more than 5 kg or 5% of the total weight whichever is the greater.

The Manufacturer/Supplier shall weigh all components or ancillaries as they are completed in his shops or received from sub-suppliers.

On completion of each complete pump unit, the Manufacturer/Supplier shall weigh it and again revise his initial estimates if necessary and re-issue the Weight/Centre-of-Mass Data Sheet certified final.

7. QUALITY ASSURANCE REQUIREMENTS

When specified in the enquiry/order, the Manufacturer/Supplier shall comply with the following requirements.

7.1 QUALITY ASSURANCE REQUIREMENTS

The Manufacturer/Supplier shall maintain a quality system which complies with ISO 9001, or an alternate standard if approved by the Principal.

The Manufacturer/Supplier shall submit, as part of his tender, a Quality Control Plan which addresses as a minimum the following (an acceptable format for such a plan is included as (Appendix 3):

- activity to be performed, i.e. all stages which effect or measure the quality of the product;
- all inspections and tests, contract review, process stages, procedure and operative qualifications;
- associated inspections and tests;
- procedure to be used;
- acceptance criteria required by the contract;
- actual acceptance criteria used;
- verifying document to be raised;
- hold and witness points.

8. DOCUMENTATION

8.1 TECHNICAL MANUALS

8.1.1 General

Technical manuals shall be provided and shall incorporate both Manufacturer/Supplier and sub-supplier data. Technical manuals shall be in accordance with BS 4884-1 and BS 4884-2, or instructions included in the enquiry/order. In addition, they shall meet the requirements of this DEP.

The Manufacturer/Supplier shall submit the Manual Index to the Principal before the Manual is issued for review and approval.

The Manual shall be divided into nine information categories (parts) as given below:

- Part 1 Leading particulars (including data sheets);
- Part 2 Installation;
- Part 3 Commissioning;
- Part 4 Operation;
- Part 5 Maintenance;
- Part 6 Parts data (including Spare Parts List and Interchangeability Record (SPIR) forms shown in (Appendix 5);
- Part 7 Drawings;
- Part 8 Lubrication;
- Part 9 Fault finding/correction procedures.

Within the parts of the Manual listed above, information shall be comprehensive and specific to the scope of supply with non-relevant information clearly edited out. Information required under Parts 6 to 9 is self-evident and no further requirements are stated here. However, for other parts, details are given below of the minimum information they shall contain.

8.1.2 Part 1 - Leading particulars (including data sheets)

This shall include all main characteristics of the equipment including sizes, weight, supply requirements, environmental and loading limitations, performance data, operating parameters, etc. Details of suppliers and agents in the country of intended operation of the fire pump shall be stated. A copy of the final issue of the appropriate equipment data sheets shall be included.

8.1.3 Part 2 - Installation

This shall contain sufficient information to enable correct initial installation. Contents shall include (as appropriate to the scope of supply):

- lifting, transportation, handling, unpacking and any special installation requirements;
- method of installation including alignment, mounting/support details and use of special support equipment or tools;
- ex-works preservation status including handling/disposal instructions for any fluids or compounds used for preservation or inhibition;
- details to enable connection of all utility services including any techniques required for certified intrinsically safe equipment.

8.1.4 Part 3 - Commissioning

This shall contain sufficient information to enable correct commissioning and recommissioning after major overhauls to be carried out. Contents shall include (as appropriate):

- procedures for preparation for initial operation including flushing, cleaning, lubrication, introduction of any medium, etc.;
- precommissioning checks;
- measures necessary to maintain equipment integrity between initial commissioning (which may be carried out onshore) and prior to initial operation;
- recommissioning checks and test procedures following shutdown.

8.1.5 Part 4 - Operation

This shall include sufficient data for operators not familiar with the equipment to functionally operate the equipment in a safe manner. Contents shall include:

- operating procedures for the various modes (manual/auto/remote) as applicable, and covering start-up, steady state running, shutdown, emergency shutdown and fault conditions. Procedures shall include operational limitations, precautions and method of operating control devices;
- diagrams identifying controls and adjustments.

8.1.6 Part 5 - Maintenance

This shall include sufficient planned, preventive and corrective maintenance data to support equipment maintenance in the workshop and the production of Principal's maintenance planning procedures. Contents shall include:

- maintenance schedules indicating recommended minimum and maximum periods for implementation of routine tests and preventive maintenance. Recommendations shall be based upon stated role of equipment and on the general requirement for most equipment to operate continuously for long periods;
- all routine maintenance and test procedures;
- corrective maintenance procedure, including equipment removal, dismantling, overhaul, assembly, replacement, repair, test and calibration. This information shall be supported by diagrams/drawings (in particular where removal/replacement procedures are complicated, with positive location of control points, adjustment points, test points, etc.);
- specified cleaning methods and materials;
- fits/clearances and tolerances (baseline and maximum);
- details of access/lifting requirements including weights of all components requiring mechanical lifting/handling facilities for removal and replacement;
- list of tools required for maintenance, both standard and special, and diagrams of test rigs to be used;
- safety precautions where necessary.

8.2 DATA SHEETS

Data sheets of approved form shall constitute the prime means of communicating details of the equipment between Principal and Manufacturer/Supplier. Unless otherwise agreed Shell Data Sheets shall be used.

The final issue of the data sheets, copies of which shall be included in the Technical Manual (see 8.1), shall accurately record details of the equipment as delivered.

8.3 OTHER DOCUMENTATION

Other documents, certificates, drawings and data shall be supplied by the Manufacturer/Supplier at the times and in the form and quantities as specified in the Documentation Requirements Schedule, a specimen of which in included as (Appendix 1).

9. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by the date, the latest edition of each publications hall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Data sheet for weight control	DEP 30.10.01.92-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Centrifugal pumps (amendments/supplements to API Std 610)	DEP 31.29.02.30-Gen.
Data/requisition sheet for centrifugal pumps	DEP 31.29.02.93-Gen.
Diesel fuelled compression ignition engines	DEP 31.29.80.30-Gen.
Electric motors: cage-induction and sychronous types	DEP 33.66.05.31-Gen.
The preservation of old and new equipment and piping standing idle	DEP 70.10.70.11-Gen.
Water-based fire protection systems for offshore facilities	DEP 80.47.10.12-Gen.

AMERICAN STANDARDS

ASME Boiler and Pressure Vessel code: Section VIII - Rules for construction of pressure vessels	ASME VIII
Cast iron pipe flanges and flanged fittings class 25, 125, 250 and 800	ASME B16.1
Pipe flanges and flanged fittings (steel)	ASME B16.5
Pipe flanges, bronze and flanged fittings	ASME B16.24

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York NY 10017
USA

Spur, helical, herringbone and bevel enclosed drives	AGMA 6010-F97

Issued by:
American Gear Manufacturers Association
1500 King St, Suite 201
Alexandria VA 22314
USA

Centrifugal pumps for petroleum, heavy duty chemical, and gas industry services	API 610

Issued by:
American Petroleum Institute
1220 L Street Northwest
Washington, DC 2005-4074
USA

Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps	Hydraulic Institute Standards

Issued by:
Hydraulic Institute (HI)
712 Lakewood Center North
14600 Detroit Avenue
Cleveland, Ohio 44107
USA

Installation of centrifugal fire pumps	NFPA 20:1996

Issued by:
National Fire Protection Association (NFPA)
470 Atlantic Avenue
Boston, Massachusetts, 02210
USA

BRITISH STANDARDS

Packaging code	
- Wooden containers	BS 1133 Section 8
- Tensional strapping	BS 1133 Section 15
- Use of desiccants in packaging	BS 1133 Section 19
Technical manuals:	
Part 1 - Content	BS 4884-1
Part 2 - Presentation	BS 4884-2
General requirements for rotating electrical machines:	
Part 143 - Specification for tests	BS 4999-143
Reciprocating internal combustion engines: Performance	
Part 5 - Torsional vibrations	BS 5514-5

Issued by:
British Standards Institute
389 Chiswick High Road
London
W4 4AL
UK

Noise procedure specification	EEMUA 140
Guide to the use of noise procedure specification	EEMUA 141

Issued by:
Engineering Equipment and materials Users Association (EEMUA)
14-15 Belgrave Square
London SW1X 8PS
UK

INTERNATIONAL STANDARDS

Classification of degrees of protection provided by enclosures	IEC 60529

Issued by:
Central Office of the IEC
3, Rue de Varembé
CH 1211 Geneva 20
Switzerland.

Copies can also be obtained from national standards organizations.

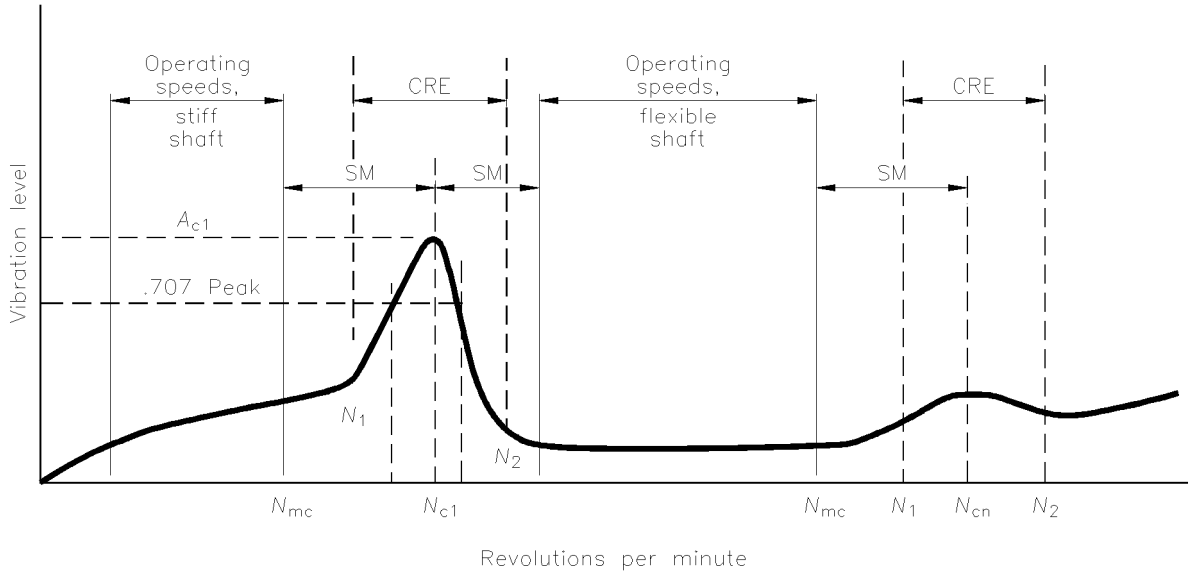
General purpose metric screw threads-selected sizes for screws, bolts and nuts	ISO 262
Mechanical vibration. Balance quality requirements for rigid motors	ISO 1940
Mechanical vibration of rotating and reciprocating machinery – requirements for instruments for measuring vibration severity	ISO 2954
Quality sytems – Model for quality assurance in design, development, production, installation and servicing	ISO 9001
Flexible couplings for power transmission – Special purpose applications	ISO 10441

Issued by:
International Organisation for Standardisation
1, Rue de Varembé
CH-1211 Geneva 20
Switzerland.

Copies can also be obtained from national standards organizations.

10. FIGURES

Figure 1 Rotor response plot

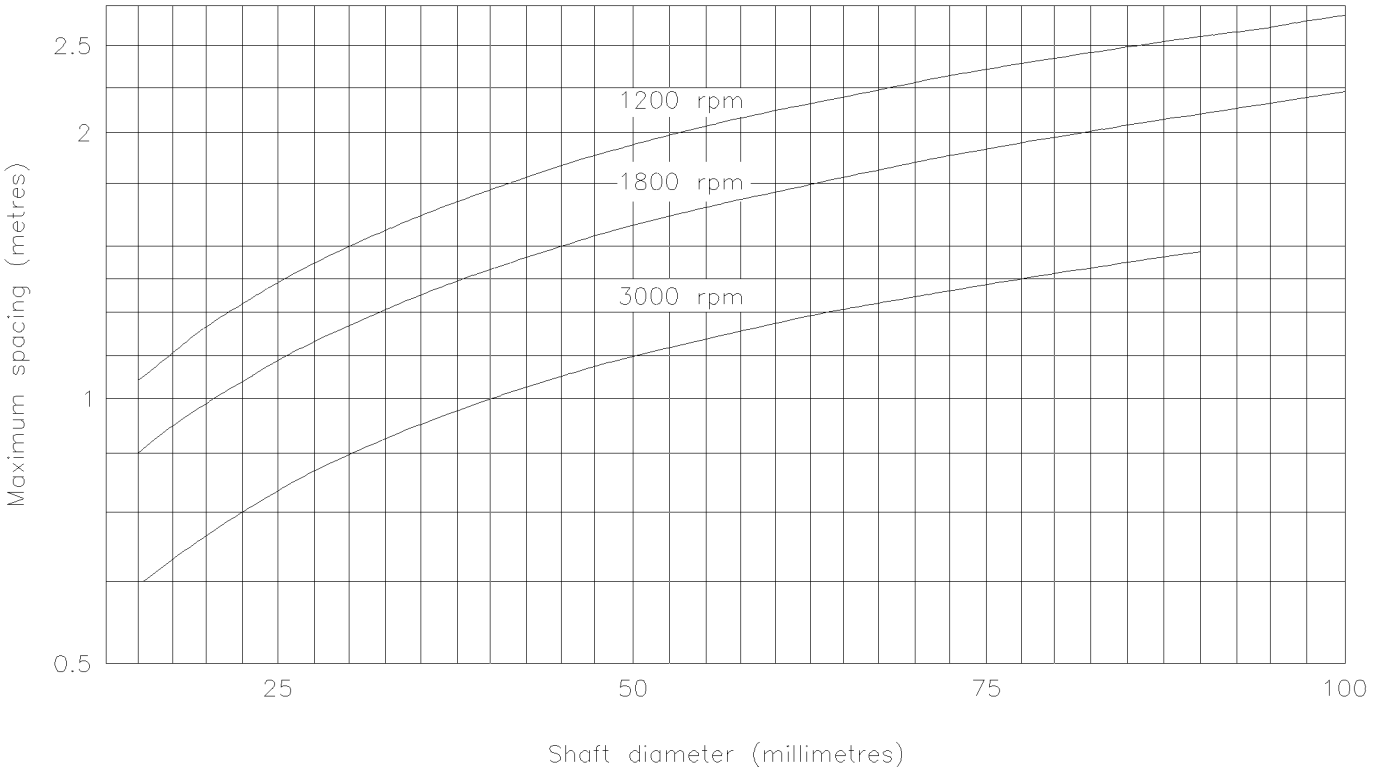


N_{c1} = rotor first critical, center frequency, cycles per minute.
N_{cn} = critical speed, nth.
N_{mc} = maximum continuous speed, 105 percent.
N_1 = initial (lesser) speed at .707 x peak amplitude (critical).
N_2 = final (greater) speed at .707 x peak amplitude (critical).

$N_2 - N_1$ = peak width at the half-power point.
AF = amplification factor
$N_2 - N_1$ = $N_{c1}/(N_2 - N_1)$
SM = separation margin.
CRE = critical response envelope.
A_{c1} = amplitude at N_{c1}
A_{cn} = amplitude at N_{cn}

NOTE: Curve shape is for illustration only and does not necessarily represent any actual rotor response plot.

Figure 2 Maximum spacing between shaft guide bushings



APPENDIX 1 DOCUMENTATION REQUIREMENTS SCHEDULE

DOCUMENTATION REQUIREMENTS

DOCUMENT CODE (NOTE 1)	DOCUMENT TITLE	APPROVAL BY PRINCIPAL'S INSPECTOR	APPROVAL OR REVIEW BY PRINCIPAL (NOTE 2)	INCLUDE IN TECHNICAL MANUAL (NOTE 3)
D01	CERTIFIED "AS BUILT" DRAWINGS	X	(X)	YES
	SHOWING ALL RUNNING CLEARANCES			
D03	OUTLINE ARRANGEMENT DRGS, SHOWING:		X	
	- ALL CUSTOMER CONNECTIONS			
	- FOUNDATIONS/SUPPORT LOADS			
	- ALLOWABLE NOZZLE LOADS (NOTE			
D04	ASSEMBLY DRAWINGS IDENTIFYING ALL		(X)	YES
	REPLACEABLE PARTS			
E03	MOTOR PERFORMANCE CURVES - IF APPLICABLE (NOTE 5)	X	(X)	YES
E06/07	PUMP PERFORMANCE CURVES (NOTE 6)	X	(X)	YES
E13	SPEED/TORQUE STARTING CHARACTERISTICS		(X)	YES
G05	WEIGHT/CENTRE OF MASS DATA SHEETS - INITIAL		(X)	-
	WEIGHT/CENTRE OF MASS DATA SHEETS - FINAL	X	(X)	
G06	EQUIPMENT DATA SHEETS -		(X)	
	EQUIPMENT DATA SHEETS -	X	(X)	YES
M09	TECHNICAL MANUAL (REFER SECTION 7)			
	- INITIAL DRAFT		X	
	- FINAL ISSUE		(X)	
P06	PRESERVATION AND PROTECTION PROCEDURE		X	YES
-	MATERIAL COMPLIANCE CERTIFICATES FOR BOWLS/	X	(X)	
	RAISING MAIN/SHAFTS/IMPELLERS			

X = COMPLETE VERIFICATION/CHECK
(X) = REVIEW ONLY

NOTES

1. DOCUMENT CODE TO APPEAR ON EACH DOCUMENT
2. DOCUMENTS REQUIRING APPROVAL OR REVIEW SHALL BE FORWARDED TO THE ADDRESS SHOWN ON THE DOCUMENT TRANSMITTAL SHEET
3. TECHNICAL MANUAL SHALL BE SUBMITTED TO THE PRINCIPAL
4. ARRANGEMENT TO INCLUDE DIESEL DRIVER, GEAR BOX, CONTROLLER
5. EFFICIENCY AND POWER FACTOR Vs LOAD AND SPEED/TORQUE AND CURRENT Vs SPEED/SAFE LOCKED ROTOR TIME CURVES. ALL AT 100% AND 80% VOLTAGE, AND 100% AND 80%
6. HEAD, EFFICIENCY POWER, MINIMUM FLOW AND WATER NPSH Vs CAPACITY

APPENDIX 2 SCHEDULE OF ESSENTIAL INSPECTIONS AND TESTS

SCHEDULE OF ESSENTIAL TESTS AND INSPECTIONS	Project : _____ Item : _____ Item/Tag No: _____						
	Manufacturer : _____ Manufacturer's Ref.No: _____						
	FIREWATER PUMP						
Description	**Execution of Test/Inspection**		**Certificate/Test Curve/Repot**			**Comments**	
	By	**Witnessed By**	**By**	**Reviewed by**	**In Manual**		
Hydrostatic Pressure Test	Manufacturer/Supplier	Inspector	Manufacturer/Supplier		Yes		
Performance Test	Manufacturer/Supplier	Inspector & Principal	Manufacturer/Supplier		Yes		
System Function Test	Manufacturer/Supplier	Inspector	Manufacturer/Supplier		Yes		
Complete Unit Test	Manufacturer/Supplier	Inspector & Principal	Manufacturer/Supplier		No		
NPSH Test	Manufacturer/Supplier	Refer to 4.2.3	Manufacturer/Supplier		Yes		
Material Test for Casing / Shaft / Impellers	Manufacturer/Supplier or Sub-Manufacturer/Supplier	-	Manufacturer/Supplier or Sub-Manufacturer/Supplier	Inspector	No		
Certificate of Compliance for Casing / Shaft / Impellers	-	-	Manufacturer/Supplier	Inspector	No	- Final issue of Data Sheets will signify Compliance	
Dynamic balanceing of impellers	Manufacturer/Supplier	Inspector	Manufacturer/Supplier	Principal	Yes		
Dimensional Check of Purchaser Interfaces	Manufacturer/Supplier	Inspector	-	-	No	- Inspection Release Note will signify Compliance	
Final Weight Check	Manufacturer/Supplier	Inspector	Manufacturer/Supplier	Principal	Yes		
Check of Preservation	Inspector	-	-	-	No	- Inspection Release Note will signify Compliance	

Revision	0	1	2	3	4
By					
Date					

APPENDIX 3 QUALITY CONTROL PLAN

QC Activity Sheet

QUALITY CONTROL PLAN

CLIENT / PROJECT/ LOCATION	DOCUMENT No.	PAGE OF / REVISION
SHELL		

CLIENT REFERENCE	DESCRIPTION	WORKS REFERENCE

REF No.	PROCESS DESCRIPTION OR QC ACTIVITY	QC PROC REF	ACCEPTANCE CRITERIA			VERIFYING DOCUMENT	INSPECTION			
			VENDOR REF	CLIENT REF	ACTUAL FIGS		IN HOUSE	CLIENT		C.A.
								Activity	Signature	