| EMPLOYER<br>Mount Row Terminals FZE | PMC<br>Summit Engineering FZC | EPC CONTRACTOR<br>Hiap Seng Engineering Limited FZC |
|---|---|---|

**PROJECT: Mount Row Terminal Expansion, Fujairah**

| JOB NO: 251109 | DOCUMENT TYPE:<br>SPECIFICATION | Page 1 of 30 |
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| Date: 27-04-2026 | DOCUMENT NO:<br>MRT-ENG-MEC-SPE-0003 | Rev-B |

# SPECIFICATION FOR POSITIVE DISPLACEMENT PUMPS

| Rev No. | Date | Description | Prepared by | Checked by | Approved by |
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## Table of contents


1. PROJECT BACKGROUND AND INTRODUCTION: ..... 4
1.1 Project Location ..... 4
1.2 Units ..... 5
1.3 Definitions ..... 5
1.4 Abbreviations ..... 6
1.5 Proposed Facility ..... 7
2. SCOPE ..... 9
3. CONFLICT AND DEVIATION ..... 9
4. CROSS REFERENCE ..... 9
5. APPLICABLE CODES AND STANDARDS ..... 9
6. SITE DATA ..... 11
7. PRECEDENCE ..... 11
8. SCOPE OF SUPPLY ..... 11
9. VENDOR EXPERIENCE ..... 12
10. DESIGN ..... 12
10.1 General ..... 12
10.2 Pump Casing ..... 15
10.3 Screw Rotor ..... 16
10.4 Shafts and Shaft Sleeves ..... 16
10.5 Vibration ..... 17
10.6 Flanges ..... 17
10.7 Gears (For Gear Pump) ..... 17
10.8 Mechanical Seals and Bearings ..... 18
10.9 Stuffing Boxes for Conventional Packing ..... 18
10.10 Couplings and Coupling Guard ..... 19
10.11 Bearings ..... 19
10.12 Piping ..... 20
10.12.1 Cooling Water ..... 20
10.12.2 Seal Flushing ..... 20
10.13 Hot Oil Jacketing ..... 21
10.14 Auxiliary Connections ..... 21
10.15 Base Plate ..... 21
10.16 Electric Drive / Power ..... 22
11. MATERIALS ..... 22
12. NAMEPLATES AND ROTATION ARROWS ..... 23

13. INSPECTION AND TESTING ..... 23
13.1 General ..... 23
13.2 Hydrostatic Tests ..... 25
13.3 Performance Test ..... 25
14. PACKAGING STORAGE AND SHIPMENT ..... 27
15. SPECIAL TOOLS AND SPARE PARTS ..... 27
16. PAINTING ..... 28
17. DOCUMENT REQUIRED ..... 28
18. INSTALLATION ..... 29
19. COMMISSIONING & SITE ACCEPTANCE TEST ..... 29
20. GUARANTEES ..... 30

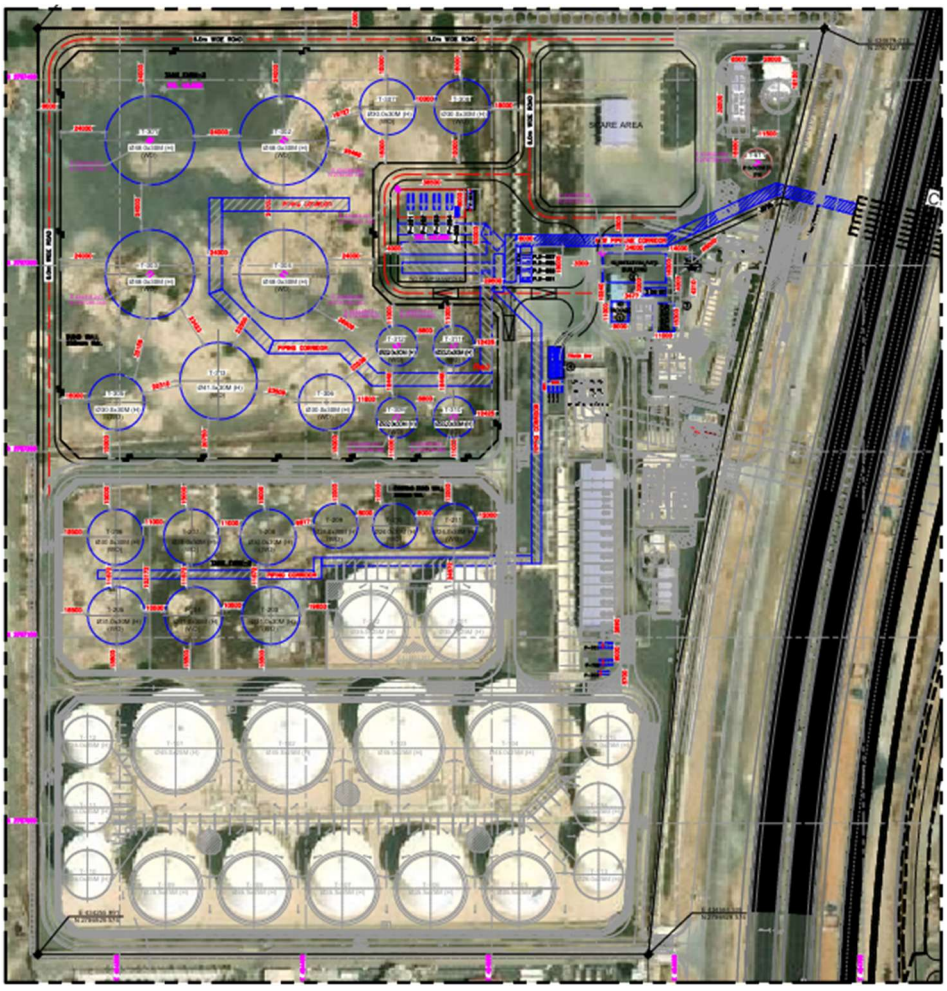
## 1. PROJECT BACKGROUND AND INTRODUCTION:

Mount Row Terminals FZE is planning to increase the storage capacity of its petroleum product storage Terminal located on the western side of Port of Fujairah and intends to utilize the Port of Fujairah Matrix Manifold facilities. The Terminal is planned to have an increased capacity of around 560,425 cubic meters. Twenty-Two (22) atmospheric product storage tanks will be constructed in conformance to applicable local and international regulations as part of the project.

Hiap Seng Engineering LTD FZC, has been appointed by the Employer "Mount Row Terminals FZE" as the EPC Contractor and Summit Engineering FZC as the PMC of the project scope.

### 1.1 Project Location

The project is located in the emirate of Fujairah in UAE. To the West of Fujairah – KhorFakkan highway.



*Aerial Photo of Project Site*

### 1.2 Units

| Parameter | Unit | Abbreviation |
|---|---|---|
| Temperature | degree Celsius | ° C |
| Pressure | Bar (absolute) | bara |
| | Bar (gauge) | barg |
| Length | Kilometers | km |
| | Meter | m |
| Flowrate | Cubic meter per hour | $m^3/hr$ |
| Density | Kilograms per Cubic meter | $kg/m^3$ |
| Level | Percentage or Millimeters | % or mm |
| Velocity | Meter per second | m/s |
| Viscosity | Centistokes | cSt |
| | Centipoise | cP |
| Weight / Mass | Kilogram | kg |
| Pipe size | Inches | in or “ |
| Capacity | Cubic meter | $m^3$ |

### 1.3 Definitions

| Term | Definition |
|---|---|
| Employer | Mount Row terminals FZE |
| PMC | Summit Engineering FZC |
| EPC Contractor | Hiap Seng Engineering Limited FZC |
| Shall | Statutory/Project mandatory provisions |
| Should | Contextually recommended provisions |

### 1.4 Abbreviations

| Abbreviation | Description |
|---|---|
| AGMA | American Gear Manufacturers Association |
| AISI | American Iron and Steel Institute |
| ANSI | American National Standard Institute. |
| API | American Petroleum Institute. |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| BEP | Best Efficiency Point |
| BPVC | Boiler and Pressure Vessel Code |
| CS | Carbon Steel |
| dBA | Decibel A-weighing |
| EN | European Standard |
| EU | European Committee for Standardization |
| FAT | Factory Acceptance Test |
| HI | Hydraulic Institute |
| Hz | Hertz |
| ISO | International Organization for Standardization |
| IEC | International Electrotechnical Commission |
| ITP | Inspection and Test Plan |
| MDMT | Minimum Design Metal Temperature |
| MOC | Material of Construction |
| MR | Material Requisition |
| MTC | Material Test certificate |
| NDT | Non-Destructive Examination |
| NPS | Nominal Pipe Size |
| NPSH | Net Positive Suction Head |
| NPSHA | Net Positive Suction Head Available |
| NPSHR | Net Positive Suction Head Required |

| | |
|---|---|
| PQR | Procedure Qualification Record |
| RMS | Root means square value. |
| SAT | Site Acceptance Test |
| SEM | Side Entry Mixer |
| WPS | Welding Procedure Specification |

### 1.5 Proposed Facility

As part of expansion scope, nine (9) number of tanks in Tank farm 2 and thirteen (13) number of tanks in tank farm 3 tanks will be designed to store White Oil products. Tank farm 1 and two (2) tanks in tank farm 2 are already existing and operational in the terminal. The storage tank details for tank farms 2 and 3 are tabulated as below:

| Tank Farm | Tank Tag No. | Product | Diameter (m) | Height (m) | Type | Geometrical Capacity (m3) |
|---|---|---|---|---|---|---|
| Tank Farm 2 | T-201 (Existing) | BO | 35.5 | 25 | Cone Roof | 24,745 |
| | T-202 (Existing) | BO | 35.5 | 25 | Cone Roof | 24,745 |
| | T-203 | WO | 31 | 30 | Al. Dome + Al. IFR | 22,643 |
| | T-204 | WO | 31 | 30 | Al. Dome + Al. IFR | 22,643 |
| | T-205 | WO | 31 | 30 | Al. Dome + Al. IFR | 22,643 |
| | T-206 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-207 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-208 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-209 | WO | 24 | 30 | Al. Dome + Al. IFR | 13,572 |
| | T-210 | WO | 24 | 30 | Al. Dome + Al. IFR | 13,572 |
| | T-211 | WO | 24 | 30 | Al. Dome + Al. IFR | 13,572 |
| Tank Farm 3 | T-301 | WO | 48 | 30 | Al. Dome + Al. IFR | 54,287 |
| | T-302 | WO | 48 | 30 | Al. Dome + Al. IFR | 54,287 |
| | T-303 | WO | 48 | 30 | Al. Dome + Al. IFR | 54,287 |
| | T-304 | WO | 48 | 30 | Al. Dome + Al. IFR | 54,287 |
| | T-305 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-306 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-307 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-308 | WO | 30 | 30 | Al. Dome + Al. IFR | 21,206 |
| | T-309 | WO | 22 | 30 | Al. Dome + Al. IFR | 11,404 |
| | T-310 | WO | 22 | 30 | Al. Dome + Al. IFR | 11,404 |
| | T-311 | WO | 22 | 30 | Al. Dome + Al. IFR | 11,404 |
| | T-312 | WO | 22 | 30 | Al. Dome + Al. IFR | 11,404 |
| | T-313 | WO | 41.5 | 30 | Al. Dome + Al. IFR | 40,580 |

Note: White Oil – WO, Black Oil – BO, Al. Dome – Aluminum Dome Roof, Al. IFR – Aluminum Internal Floating Roof

The following major Terminal operations will be considered in project design.

- Ship loading operations
- Ship unloading operations
- Inter tank transfer
- Stripping
- Additive truck unloading

The Port of Fujairah facility is designed to handle both loading and unloading of ships between jetty and tank Terminal. Marine Loading Arms (MLAs) are installed at the jetty for connection to product ships. The MLA is also linked to the Communal Pipeline Systems of POF, which connects to the Matrix Manifold Area before being linked to customer pipelines connecting to tanks. Mount Row User Motor Operated DBB Valves (MOVs) will be considered in the MM2 Manifold Area for dock lines going to Berth facilitating the transfer operation between Terminal and POF.

| Pump Tag No. | Capacity (m3/hr) | Service | Type | Configuration | Operations |
|---|---|---|---|---|---|
| P-201 to P-204 | 3000 | White Oil | Centrifugal with VFD | 3 working + 1 standby | Ship loading / Inter-tank transfer |
| P-205 | 750 | White Oil | Positive Displacement with VFD | - | Stripping |
| P-701, P-702 | 3000 | Black Oil / Fuel Oil | Positive Displacement with VFD | 1 working + 1 standby | Ship loading / Inter-tank transfer |
| P-703 | 1000 | Black Oil / Fuel Oil | Positive Displacement with VFD | - | Stripping |
| P-601, P-602 | 75 | Additive products | Positive Displacement | 1 working + 1 standby | Truck unloading |

Pipelines connecting the Terminal to Port of Fujairah MM-2 are to be designed to ASME B31.4 and will be used for both ship loading and ship unloading operations. Bi-directional PLRs are considered at the Terminal and MM-2 side for facilitating the pigging operations. One (1) nitrogen pipeline from terminal to POF is considered to facilitate supply of nitrogen to PLRs during pigging from POF towards terminal. The pipelines envisaged between Terminal and POF MM2 are listed as follows:

| Sr. No. | Service | Pipelines |
|---|---|---|
| 1 | Black Oil / Fuel Oil | 1 x 36” |
| 2 | White Oil | 3 x 28” |
| 3 | Nitrogen | 1 x 8” |

## 2. SCOPE

This specification covers the minimum requirement for design, detailed engineering, manufacturing, packing & forwarding, supply, installation, and commissioning of Positive Displacement pumps for transfer of petroleum products at Mount Row Terminals FZE, Fujairah.

Positive displacement - rotary pumps shall be designed and supplied in accordance with this specification, API STD 676 Fourth Edition, data sheets and other referred documents in the Material Requisition.

In case no specific requirement is provided or reference made in this specification for specific items or components, Contractor/vendor shall adhere to internationally accepted good engineering practices and the same shall be notified to the Employer/Employer's Representative for Approval.

## 3. CONFLICT AND DEVIATION

Vendor is responsible for the review of this specification and other documents attached or mentioned elsewhere in this document / MR and shall highlight any deviation, alteration or modification required during the bidding stage itself and the same shall be notified to the Employer/Employer's Representative for Approval.

## 4. CROSS REFERENCE

This specification shall be read in conjunction with equipment datasheets, technical specifications, employer requirement and other relevant documents attached with the Material Requisition.

## 5. APPLICABLE CODES AND STANDARDS

Codes, Standards and Specifications referred to herein form part of the requirements of this Specification in the manner and to the extent specified. The principal code / Standard to which the pump must be designed, manufactured and tested shall be as specified in the project specific data sheets.

Unless otherwise specified, the date of edition or revision of the reference codes, standards or specifications shall be the latest.

| **Local Regulations** | |
|---|---|
| - | UAE Fire and Life Safety Code of Practice |
| - | Port Rules for Top-side Facility Operations (POF) |
| **American Gear Manufacturers Association (AGMA)** | |
| AGMA 514.02 | Load Classification and Service Factors for Flexible Couplings |
| AGMA 6010-E88 | Standard for Spur, Helical, Herringbone and Spiral Bevel Gears |

| | |
|---|---|
| **American Petroleum Institute (API)** | |
| API 676 | Positive Displacement pump for petroleum, petrochemical and natural gas indust |
| API 614 | Lubrication, Shaft-sealing, and Oil-control Systems and Auxiliaries |
| API 661 | Petroleum, Petrochemical, and Natural Gas Industries Air-cooled Heat Exchangers |
| API 671 | Special purpose coupling for petroleum, chemical and gas industry services. |
| API 677 | General Purpose Gear Units for Refinery Services |
| API 682 | Shaft Sealing Systems for Centrifugal and Rotary Pumps |
| **American Society of Mechanical Engineers (ASME)** | |
| ASME B16.20 | Metallic Gaskets for Pipe Flanges |
| ASME B16.21 | Non-metallic Flat Gaskets for Pipe Flanges |
| ASME B16.5 | Steel Pipe Flanges and Flanged Fittings |
| ASME B16.47 | Large Diameter Steel Flanges |
| ASME B18.2.1 | Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws |
| ASME B18.2.2 | Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts |
| ASME B31.3 | Process Piping |
| ASME B 4.1 | Preferred Limits and Fits for Cylindrical Parts |
| ASME B46.1 | Surface Texture (Surface Roughness, Waviness and Lay) |
| ASME BPVC Sec II | Materials |
| ASME BPVC Sec V | Non-Destructive Examination (NDT) |
| ASME BPVC Sec VIII | Rules for construction of pressure Vessels |
| ASME BPVC Sec IX | Welding, Brazing and Fusing Qualification |
| ASME PTC 8.2 | Performance Test Codes – Centrifugal Pumps |
| **European Committee for Standardization (EN)** | |
| BSEN 10204 | Types of Inspection Documents - Metallic Products |

| | |
|---|---|
| **Hydraulic Institute Standard for Centrifugal Pumps (HI).** | |
| **International Electrotechnical Commission (IEC).** | |
| IEC 60529 | Degree of protection provided by the enclosure (IP code) |
| IEC 60034 | Rotating electrical machines |
| **International Organization for standardization (ISO)** | |
| ISO 7-1 | Pipe threads where pressure tight joints are made on threads, Part 1: Dimensions, tolerance and designation |
| ISO 281 | Rolling Bearings- Dynamic load and rating life. |

| | |
|---|---|
| ISO 21940 | Mechanical Vibration. Rotor balancing. |
| ISO 14691 | Petroleum, Petrochemical and Natural Gas Industries -Flexible Couplings for Mechanical Power Transmission -General - Purpose Applications |

## 6. SITE DATA

For Site Data, refer datasheet MRT-ENG-GEN-DSS-0001.

## 7. PRECEDENCE

Any case of apparent conflict between the requirements of this specification and any other relevant documents shall be notified to the Employer / Employer's representative. However, most stringent of requirements shall prevail. The following order of precedence shall apply:

1. Local statutory regulations
2. Data Sheets.
3. This specification.
4. Project Specifications.
5. Other referenced documents.

## 8. SCOPE OF SUPPLY

Pump Vendor shall have unit responsibility and shall ensure that all sub-vendors comply with the project requirements and reference documents.

The Vendors scope of supply shall include but is not limited to all necessary equipment as described herein after making a complete and operable unit. Each package shall be complete with but not limited to the following major equipment and requirements. The equipment shall be supplied in assembled condition on the baseplate, ready for installation.

- Pump
- Driver
- Relief Valves
- Variable Speed Drivers
- Coupling & Coupling Guard
- Bearing
- Mechanical seal and Plan
- Condition monitoring instruments wired to the Junction boxes mounted on the Skid.
- Dampers
- Lubrication System
- Piping within the skid
- Base Plate

- Foundation Bolts
- Companion Flange (for nonstandard connections) with gasket and bolts.
- Earthing lugs
- First fill of oil & lubricants
- Lifting lugs on baseplate.
- Any other material / accessories required as per specification / data sheet/MR/ Code requirements.
- Documentation
- Special tools if required
- Spare parts as per Material Requisition

## 9. VENDOR EXPERIENCE

Contractor shall ensure that the Pumps and related accessories are procured from the reputed vendor, and it shall be from vendor's established product range. Prototypes shall not be offered by the vendor and shall not be selected by the contractor. Equipment shall be purchased from the vendor who can furnish the documented evidence of experience of similar nature with units successfully operating in similar conditions.

The vendor for the equipment shall be an established manufacturer having adequate engineering, manufacturing & testing facilities.

All equipment and components offered shall have previous operating experience and shall have been used in comparable service.

Vendor submitted sufficient design data to verify that the design will withstand the design, operating and environmental conditions.

Vendor shall provide the reference list covering at least two (2) similar installations.

The equipment proposed as references shall have operated satisfactorily for more than 2 years.

A general reference list with all types of models and operating conditions is unacceptable unless similar examples are clearly indicated.

## 10. DESIGN

### 10.1 General

I. The detailed design and Engineering of the equipment shall be the total responsibility of the Vendor. Design data provided in this specification and in the data, sheets is preliminary and is not intended to cover complete details. Vendor shall submit detailed design calculations (if applicable), filled in data sheets, performance curve, specifications, and drawings for the Employer / Employer's Representative approval.

ii. The equipment shall be designed to withstand Process, Mechanical and Environmental conditions specified in the Design Basis, Data Sheets, this Specifications and other Project documents attached with the

MR.

iii. All Electrical Equipment's and Components shall be designed in accordance to the Electrical Engineering Discipline documents attached with the Material Requisition. Motor rating shall be 110% of the maximum pump absorbed power.

iv. The equipment shall be designed for a minimum service life of 30 years.

v. The unit shall consist of the rotary screw type (PD) pump coupled to its driver, including drain valve and flange for connection with the piping flanges. Special attention shall be made to the selection of the type of bearing, mechanical seal and pump material to be used.

vi. Pumps shall be designed to provide minimum slip and maximum volumetric efficiency. All equipment shall be designed to run safely to the trip speed and relief valve set pressure plus 10%.

vii. All equipment, particularly mechanical seals, shall be designed to permit rapid and economical maintenance. Major parts shall be designed and manufactured to ensure accurate alignment on reassembly.

viii. Instrumentation for condition monitoring is typically indicated in the P&ID. Vendor shall propose adequate instrumentation for condition monitoring of the pumping unit including the Driver and other Accessories.

ix. Pump design shall ensure operational safety, reliability, consistent performance and low operating cost. Short term dry run operation should be possible.

x. Rotary screw type pumps shall be provided with a replaceable casing liner, Vendor shall indicate the hardness values for the casing, liner and screw in its proposal.

xi. As a minimum, carbon steel (CS) or material specified in the datasheet shall be used for pressure containing parts, cast iron shall not be used until specified or approved by the Purchaser.

xii. Pump performance curve and power curve for different viscosities shall be submitted for Purchaser review and approval. Rotary pumps efficiency as function of viscosity shall be submitted.

xiii. Pump and driver shall be mounted on a common base plate.

xiv. Tapped holes in pressure parts shall be held to a minimum. Sufficient metal in addition to the metal allowance for corrosion shall be left around and below the bottom of drilled and tapped holes in pressure section of casings to prevent leakage.

xv. Stationary and moving pumping elements shall be designed and fabricated to prevent galling. Rotating parts shall be properly aligned. Internal loads shall be fully supported by the use of such means as hydraulic balance, bearings or bushings.

xvi. Rotors and shafts shall be stiff enough to prevent contact between the rotor bodies and casing and between gear timed rotor bodies at the most unfavourable specified conditions, including 110 percent of the

relief valve set pressure.

xvii. Unless otherwise specified, Vendor shall recommend the pump speed for the specified service, considering factors as NPSH, maximum fluid viscosity, allowable solids and abrasive content and sizes and wear allowance for required service.

xviii. Pump shall be provided with the external relief valve for safety operation.

xix. Inlet and outlet connections shall be flanged and its orientation shall be determined and finalized by the Purchaser. The inlet connection shall be designed for the same pressure as the outlet connection to permit testing under the required full test pressure.

xx. Pump performance curve and power curve for different viscosities shall be submitted for Purchaser review and approval. Rotary pumps efficiency as function of viscosity shall be submitted.

xxi. Pump shall be designed so that the sound levels do not exceed 85 dBA at 1m distance from the pump while operating at specified conditions.

xxii. Pumps shall be suitable for continuous duty unless otherwise specified in the data sheets.

xxiii. Difference between net positive suction head available (NPSHA / NPIPA) and required (NPSHR / NPIPR) shall not be less than 1m.

xxiv. Asbestos and asbestos filling material shall not be used in any application. Copper shall be prohibited.

xxv. Pumps including auxiliary systems shall be securely mounted and supported to avoid damage during shipment, storage, operation and maintenance. Adequate measures shall be taken for safe storage of the pumps and its ancillaries.

xxvi. The equipment shall be provided with adequate fully certified lifting points and all necessary lifting arrangements like spreader beams to enable single point lifts.

xxvii. Lifting lugs shall be provided at the balancing point of the equipment assembly for maneuvering the assembly into position. Separate lifting lug shall be provided for the electric motor and other major accessories. Lifting provision shall be provided for all components more than 25kg.

xxviii. The complete assembly of pump, motor, transmission and accessories shall be suitable for hazardous area application and it shall be suitable for operation in marine environment. Motor shall have Ingress Protection of minimum IP 66 and ATEX Certified EExd for Hazardous area installations.

xxix. Vendor shall provide earthing lug to make the equipment electrically continuous.

xxx. Pump, motor and its auxiliaries shall be suitable for outdoor (without shelter) installation and operation considering the local conditions as outlined in the data sheets and other project documents.

xxxi. Pump, driver and accessories shall be designed so that the maximum allowable sound levels are not exceeded while operating at specified conditions. Allowable sound level shall be 85dB or below.

xxxii. Mean time between major overhauls i.e. seals replacement, bearings etc. shall be minimum three (3) years, and Vendor shall include the provisions in design to achieve this requirement.

xxxiii. Pump Supplier shall furnish all necessary load data (static / dynamic) for the design of pump foundations. Pump Supplier shall also furnish the general arrangement of base frame with locations of anchor bolts.

xxxiv. Pump supplier shall furnish the details / specification of recommended grout.

xxxv. SI units shall be used for data sheets, drawings and provided manuals.

xxxv. All field equipment (detectors, proximiters, probes with matching extension cables, etc.) shall be according to the rotating Vendor's standard field installation and shall be supplied by the rotating equipment Vendor. However, all sensors shall be compatible with MMS. Rotating equipment Vendor and MMS Vendor shall coordinate with each other to ensure all sensors/transducers are compatible with MMS.
Relay outputs shall operate in a fail-safe normally energized mode with contacts closed. The MMS system shall de-energize the relay and trip the machine via the ESD system.

xxxvi. Rotating equipment Vendor shall supply the junction boxes suitable for a hazardous area complying with signal segregation requirements.

## 10.2 Pump Casing

Pressure casing shall be sufficiently thick to withstand the maximum discharge pressure at pumping temperature and hydrostatic test pressure at ambient temperature. All casings shall have a minimum 3mm corrosion allowance. Pressure containing components shall be manufactured in accordance with the ASME code, Section VIII, Division-1. The manufacturers' data report forms and stamping specified in the ASME Code are not required.

The design stress, temperature restrictions and other requirements for materials shall confirm the limitations in the ASME code, Section VIII, Division 1 for similar material.

Maximum allowable working pressure of the casing shall be as per the requirement of API 676.

Casing vent connections shall be provided unless the pump is self-venting, drain connections shall be provided, and gauge connection shall also be provided. Vent and drain connections shall be valved and piped to the edge of base plate. All connections between casing and valve shall be welded on hydrocarbon service. Vent and casing drain connections shall be 15NB and 25 NB respectively.

Connections other than those covered by ASME B16.5 require Purchaser approval. Making parts, for nonstandard

flanges, shall be furnished by the vendor; mating parts include companion flanges, gaskets, studs, bolts, nuts or washers.

Pumps shall be provided with suitable appurtenances, such as eyebolts, lugs or jackscrews. The casing shall be supported by feet beneath the casing or any other suitable support between the casing and base plate.

Pumps shall be provided with external relief valve unless otherwise specified in the data sheet. Relief valve shall be able to handle 100% rated capacity when fully open and to limit accumulation pressure to 10% of set pressure.

If heating is required as per data sheet pump shall be provided with jacket for stuffing box / mechanical seal and casing. If jacket is not feasible, heating coil may be offered with coil inlet and outlet having flanged connections and suitably located to prevent Vapour lock. Coil shall be designed suitable for specified maximum pressure and temperature of heating medium. Jackets, if specified in data sheets, shall be suitable for the maximum working pressure specified for jacketing medium.

### 10.3 Screw Rotor

Vendor shall design, fabricate and supply screws required to meet the operational requirement. Screws provided shall be compatible with the black oil and white oil being handled. If required, screws shall be coated with material to enhance wear resistance and reduce abrasion.

Rotor / screws shall be provided with the timing gear. Timing gears shall be designed as per AGMA 6010 with a minimum service factor of 1.5.

Timing gear and roller bearings should be externally mounted. Lubrication for timing gear and bearing shall be provided.

Calculation for maximum allowable rotor deflection (Twin screw Pump) under the worst operating condition shall be calculated and submitted for Purchaser review.

Elastomer/ flexible material used in the pump construction shall be compatible with the handled fluid and is able to meet the operating and local environmental conditions.

Complete rotor assembly shall be dynamically balanced at rated speed.

The hardness of pump gears / rotors shall be a minimum of BHN 200, and the difference in hardness between one another shall be at least BHN 50.

### 10.4 Shafts and Shaft Sleeves

The shaft shall be of ample size to transmit the rated driver power and designed to withstand operation for the entire head-capacity range of the pump.

Replaceable shaft sleeves are required for all pumps. Shaft sleeves shall be securely locked to the shaft and sealed at one end. When the size of the pump makes the use of shaft sleeve impractical, the shaft shall be made of a wear and corrosion resistant material.

Shafts shall be machined and total indictor run out shall not be more than 25 um.

Shaft material shall be clearly indicated by the vendor in the relevant data sheet and is subject to acceptance by the Purchaser.

### 10.5 Vibration

Peak-to-peak vibration limits shall apply to pumps with anti-friction bearings and sleeve bearings. The limits shall cover vibration during shop and field tests at rated speed and throughout the full operating capacity.

Vibration and temperature instruments for continuous monitoring shall be provided for pumps with power rating higher than 75 kW.

Pump vibration (including driver) at the test bench and site shall be within allowable range as specified in the code.

The pump rotor system shall be designed such that all critical speeds are outside the operating speed range. The first critical speed shall be at least 20% above the maximum continuous operating speed. Lateral and torsional critical speed analysis shall be performed and submitted for review in accordance with API 676 requirements.

### 10.6 Flanges

Openings for nozzles and other pressure-casing connections shall be standard pipe sizes in accordance with ASME B16.5. Openings of DN 32, 65, 90, 125, 175, and 225 (NPS 1 1/4, 2 1/2, 3 1/2, 5, 7, and 9) shall not be used.

Flanges shall conform to the requirements of ASME B16.5 for sizes up to and including 24” NB and ASME B16.47 Series A for sizes 26” NB through 60” NB.

Cast iron flanges are not acceptable.

If the pump manufacturer’s standard design offers a flange thickness and diameter greater than necessary for the specified rating, the heavier flange may be furnished, but it shall be faced and drilled as specified. Flange bolt holes shall straddle the centerlines. Non-standard flanges shall not be supplied.

### 10.7 Gears (For Gear Pump)

Vendor shall design, fabricate and supply gears in accordance with API 677 latest edition and shall meet the operational requirement. Gears provided shall be compatible with the black oil and white oil being handled.

Gears shall be coated with material to enhance wear resistance and reduce abrasion.

Gears shall be designed to ensure smooth pulseless discharge flow.

Selected gears shall preferably be herringboning type, as they provide better operation for viscous fluids.

Vendor can propose alternative gear design with basis of selection.

Gears shall be optimized and designed to have small radial and axial clearances, reduction in slip and high volumetric efficiency.

### 10.8 Mechanical Seals and Bearings

Mechanical seals design, type, arrangement and material shall be as per the latest edition of API 682. Seal manufacturers shall recommend a suitable seal based on seal selection criteria as outlined in the API 682 Annexure A. In case if seal manufacturer has their own procedure for seal selection, then the same shall be submitted for review and approval by the Employer.

Vendors shall consider the hazard class of fluid being handled. Toxicity, flammability, and reactivity of each fluid shall be identified. Careful consideration shall be given to the selection of seal type and seal material. Vendor shall ensure its compatibility with the fluid being handled.

Seal face material combination shall be carefully selected based on the nature of fluid, its viscosity and presence of any abrasive material in the pumping fluid.

Material to be used for sealing face elements, secondary sealing element, springs; bellows (if used) shall be submitted for Purchaser review and approval.

Seal flushing plan shall be carefully selected and shall be submitted for review and approval.

Seal end plates shall be of Stainless-Steel material. Seal end plates shall be retained by a minimum of four stud bolts.

Seal flush piping shall be of 18 Cr-8 Ni stainless steel materials.

Pumps with rotor/screws mounted between the bearings shall be furnished with cartridge type mechanical seals.

Seal flushing systems, including all accessories and instruments such as transmitters, orifices gauges and valves, shall be furnished by the pump manufacturer. They shall be fully assembled and installed on the pumps. Piping shall be thoroughly cleaned before connecting to a pump. Piping on vertical pumps, except in-line pumps, may be separately boxed for shipment.

Heat exchangers used for cooling mechanical seal flushing streams (if required) shall have 15NB minimum size tubing for the process liquid. The tube material shall be seamless fabrication. Material for the product side shall be 18 Cr-8Ni stainless steel or as specified. The material shall be compatible with the product handled by the pump as specified in the data sheet.

### 10.9 Stuffing Boxes for Conventional Packing

Packing rings shall not be considered flammable, corrosive or toxic liquids.

### 10.10 Couplings and Coupling Guard

Couplings shall be designed, manufactured and supplied by the supplier. Coupling for the motor power rating of more than 500 kW shall be designed in accordance with API 671 latest edition.

Type of couplings shall be as specified in pump data sheet.

The pump manufacturer shall mount the pump half-coupling. Gear and driver half couplings shall be furnished and mounted by the pump manufacturer unless otherwise specified.

Coupling shall be spacer type flexible element. Spacer shall be retained if the flexible element ruptures Coupling guard shall be rigid to withstand deflection and prevent rubbing of parts.

Couplings shall be dynamically balanced when the size-speed relationship is such that balancing is recommended by the coupling manufacturer.

Non sparking removable coupling guards are required. They shall be sufficiently rigid to avoid contact with the coupling or shaft due to body contact.

Manufacturers shall furnish the coupling cross sectional drawing, installation procedure and shall complete the coupling data in the pump data sheet.

### 10.11 Bearings

Antifriction bearing (Radial & axial) or hydrodynamic bearing shall be proposed depending upon the load conditions.

Radial bearings shall be the standard available design (ball, roller, sleeve or pivoted shoe) unless otherwise specified by the Purchaser or recommended by the in the code / standard.

Anti-friction bearings shall be the standard type and selected to give three years (25,000 hrs) minimum (AFBMA) rating life with continuous and not less than 16,000 hrs at maximum axial and radial loads and rated speed. The rating life is the number of hours at constant speed that 90% of a group of identical bearings will complete or exceed before the first evidence of failure.

Vendor shall furnish the factors such as bearing speed limit, bearing life (L10) requirements, lubrication practices, load carrying capability etc in the proposal.

For high radial load applications, cylindrical roller bearings is suggested as a minimum. Vendor may propose, alternative type for better service in their proposal. For application with combination of high radial & axial loads, taper roller bearings shall be considered as an option.

Lubrication for thrust and radial bearings shall be by means of oil. Grease lubrication is not recommended. Bearing housing shall be provided by means of constant level oiler.

Bearing housing shall be equipped with the following

- Constant level oiler
- Level sight glass
- A drainable sight-glass

The up-thrust and down-thrust values for vertical pumps shall be the maximum forces expected at any point on the full curve.

Vendor shall confirm the requirement of a complete lube oil system. If required, the same shall preferably be as per API 614.

### 10.12 Piping

Piping shall terminate with a flanged connection. Piping shall be in accordance with ANSI B31.3, flanges and flanged fittings in accordance with ANSI B16.5. Tapped openings and piping threads shall conform to ASMEB1.1 and B2.1.

Auxiliary piping system and accessories shall be supplied fully cleaned, pressure tested, assembled and installed on the pump or within the confines of the base plate.

Single utility supply / return connection shall be provided at skid end. Further distribution and connection within skid shall be done by vendor including safety valve if necessary. Connections at skid edges shall be flanged, valve and blinded. Interconnecting piping between Pump and lube oil system if applicable shall be supplied by Vendor.

Piping and equipment shall be designed and arranged for easy dismantling and maintenance.

Nozzle load and moments shall be provided.

A thread sealant lubricant shall be used on the pipe threads of all connections to ensure the threads are vapor tight. PTFE tapes shall not to be used in the seal flush system. Plugged holes shall be provided at proper locations to drain the oil which may get collected in the stool due to improper functioning of gear box, oil seal, etc.

#### 10.12.1 Cooling Water

In general, external cooling medium will not be available.

#### 10.12.2Seal Flushing

Systems shall be arranged for easy disassembly to permit maintenance and cleaning and shall be properly supported to prevent vibration and damage. The temperature and pressure rating of the system shall not be less than the pump causing maximum discharge pressure at the maximum pumping temperature.

All flushing system components shall be stainless-steel material.

18Cr-8Ni stainless steel tubing shall be used for flushing fluids to mechanical seals. The minimum size of tubing shall be 15NB. The minimum tubing wall thickness for 15NB and 20NB sizes shall be 1.65mm (0.065 inch). Tubing fittings shall be 18 Cr-8Ni stainless steel.

Seal flushing systems, including all accessories and instruments such as transmitters, orifices, gauges and valves, shall be furnished by the pump manufacturer. They shall be fully assembled and installed on the pumps. Piping shall be thoroughly cleaned before connecting to a pump. Piping on vertical pumps, except in-line pumps, may be separately boxed for shipment.

### 10.13 Hot Oil Jacketing

If specified in the data sheet, hot oil jacketing shall be provided for heating medium as specified in the data sheet. Flanged hot oil inlet and outlet (one each) connections will be provided near the pump end of the unit. Size shall be furnished by the supplier in the Proposal.

### 10.14 Auxiliary Connections

Tapped openings and threads shall conform to ASME B1.1 and B2.1. Auxiliary piping connections that are supplied but not piped shall be plugged with solid plugs.

### 10.15 Base Plate

The package comprises the pump, driver and all accessories that shall be supplied as a package assembled on a common rigid skid frame fabricated in steel.

The skid frame shall be designed to support the pump and to ensure enough rigidity to maintain the correct alignment of the driver.

To make handling easier, lifting lugs shall be provided at the four ends of base frame.

All horizontal pumps shall be furnished with sturdy drain rim or drain pan-type base plates with a raised lip. They shall extend the full length and width of the pumps and driver unit and shall be fully machined to receive pump and driver.

Connections for drain shall be tapped 25 NB in the raised lip at the pump side and shall be located to effect complete drainage. The pan or upper surface of the base plate shall be sloped at least 10 mm per meter toward the drain.

Transverse and axial positioning jackscrews shall be provided for drive train components which have a mass greater than 100 kg (220 lb.) to facilitate transverse horizontal and longitudinal adjustments.

Minimum two 100-mm grout holes shall be provided on each base plate. They shall be positioned to allow grouting with all the components in place and have vents to promote even grout distribution. Grout holes shall have raised lips to prevent liquid accumulating on the exposed grout.

The centerlines of pump shafts shall be sufficiently high above base plates for correct installation of all auxiliary piping connections such as pump drains, steam turbine inlet end drain and leak off connections.

The base frame shall be provided with an adequate number of anchor bolt holes. The anchor bolts shall be designed and supplied by the pump manufacturer.

All vertical in-line pumps shall have a flat-bottomed casing.

Sufficient numbers (minimum two, diagonally opposed) of lugs shall be provided at suitable location of the base plate for connection to the external earthing grid via earthing cables.

### 10.16 Electric Drive / Power

Motor shall be air cooled (TEFC - Totally Enclosed Fan Cooled) with a method of cooling IC 411 or IC 611 (TEAAC) in accordance with IEC 60034-6. The motor shall be designed, manufactured, and certified for operation in hazardous areas in accordance with IEC 60079.

Vendor shall indicate the driver type, rating and speed based on the duty under consideration, and the site and utility conditions as specified in the data sheets.

Driver shall be sized to meet the maximum specified operating condition (including all losses). Gear losses and transmission losses shall be added to the pump power consumption before the driver rating factors are applied.

The motors shall be rated to cover all possible variations in demand, imposed by the specified operating conditions. Driver rating shall be at least 10% more than the power absorbed at the pressure when relief valve is fully open. This shall be inclusive of all losses (gear box, coupling etc.).

Drivers shall be selected from the approved vendor list and approved by the Purchaser.

Pump and motor shall be assembled and aligned on a common base plate.

## 11. MATERIALS

Vendor is responsible for selection of suitable material for manufacturing the Pumps and accessories. Materials of construction selected by the vendor shall be compatible with all the products specified in the data sheet. As a minimum, carbon steel (CS) shall be used for pressure containing parts. Cast iron shall not be used unless specified or approved by the Purchaser.

Material shall be identified in the proposal with their applicable ASTM, AISI, ASME or SAE numbers including the material grade. Manufacturer material specification giving physical properties, chemical composition and test requirement shall be included in the proposal.

Material for the mechanical seal i.e. hard face, soft face and flexible element shall be in accordance with API 682. Material selected for pump shall be compatible with the fluid handled as per pump data sheet.

Casings shall be sound, free from shrinkage holes, blowholes, scale, blisters and other defects. Surfaces shall be cleaned by the pump manufacturer's standard methods. All casting burrs shall be filed or ground flush with the surface of the casting.

Leaks and defects in pressure casings must not be repaired by plastic or cement compounds. When casting repairs are authorized by the Purchaser, repair welding shall be according to the applicable ASTM / ASME specifications. Welding repairs shall be with welding rod having the same chemical composition as the parent material and is subject to approval by Employer / Employer`s representative.

Vendor shall provide the material hardness values (Brinell) in the data sheet. Hardness values shall be provided for all major components i.e. shaft, impeller etc.

Material test certificates shall be provided for the Employer / Employer's representative review and approval.

## 12. NAMEPLATES AND ROTATION ARROWS

A corrosion-resistant nameplate shall be permanently attached at an easily accessible point on each Pump. Nameplates and rotation arrows shall be of Austenitic Stainless steel or of nickel-copper alloy (Monel®16 or its equivalent).

The nameplate shall be stamped with the following information, as minimum

- Manufacturer Name
- Manufacturer Reference Number and Pump Serial Number
- Tag Number
- Type of Pump
- Pump Model
- Year of Manufacture
- Purchase Order No.
- Rated Capacity
- Rated Head
- NPSHR
- Specific Gravity of Fluid
- Weight.
- Maximum allowable working pressure and hydrostatic pressure
- Rated Speed and Critical Speed in RPM
- Driver rating.

Each Pump shall be provided with a cast-in or permanently attached arrow indicating the direction of rotation.

## 13. INSPECTION AND TESTING

### 13.1 General

Vendor shall prepare and submit the inspection test plan and test procedures for the Employer / Employer's Representative approval. Contractor/Vendor shall submit the quality assurance plan before commencement of fabrication. Acceptance criteria shall be mutually agreed by all parties. Approved QA procedures shall form the

basis for equipment inspection. Test shall be witnessed by the Employer/ Employer's representative.

Vendor shall furnish the acceptance criteria for FAT and SAT as per international codes and standards, for the review and approval of Employer/Employer's Representative. FAT will be witnessed by Employer / Employer's Representative.

Material certificates per BS EN 10204 Type 3.2 or equivalent shall be provided for pressure containing parts. Certificates of compliance in accordance with BS EN 10204, Type 3.1 shall be provided for other parts.

For each weld, the following documents shall be submitted to Employer for review:

- Procedure Qualification Record (PQR) as per ASME Sec IX.
- Welding Procedure Specification (WPS) including repair procedures as per ASME Section IX.
- Welder Qualification Record (WQR) as per ASME Sec IX
- Welding map with reference for identification of welds, welder and parts to be welded. Full details shall be included (weld design, sizes, materials, pre-heat and post heat treatments, etc.).

Non-destructive examinations shall be carried out according to agreed QA plan and approved ITP. All results must be certified by the Employer / Employer's Representative.

Other requirements are as follows.

- Casting surface shall be sand blasted before any examination. All casting shall be free from voids, tears, cracks and any other defects.
- NDE procedure and acceptance shall be according to ASME BPVC Section V / relevant standard requirements. It includes dye penetrant inspection, magnetic particle inspection, ultrasonic test, radiography test, impact testing etc.
- The magnetic particle method shall be used for superficial examinations as per ASME BPVC Section V if the material is ferromagnetic and the surface is accessible. It shall be wet method. The method of drying powder shall not be used.
- The liquid penetrant method shall be used for superficial examinations as per ASME BPVC Section V if the material is nonmagnetic or inaccessible for a magnetic particle examination.

Each pressure casing shall be hydrostatically tested with water at 16 0C or above. The minimum test pressure shall be 1.5 times the maximum allowable casing working pressure. Test certificates are required for all components and systems subjected to hydrotest.

Cooling water jackets shall be hydrostatically tested at a pressure of 1.5 time's maximum cooling water system design pressure.

Hydrostatic tests shall be maintained for a minimum duration of 30 minutes. Only clean and fresh water of pH

between 6 & 8 shall be used for hydrostatic testing. All water used for testing shall be chloride free.

Employer / Employer's representative reserves the right to visit vendor's manufacturing and testing facility to witness various tests.

Final assembly records and running clearances shall be submitted.

Equipment may be subject to rejection even after delivery, if it does not comply with the performance guarantees, inspection certificates and reports submitted by the Vendor/contractor at the time of manufacturing and shop testing.

Rejected equipment shall be repaired / replaced by the contractor/Vendor.

The procedure and acceptance criteria for the various non-destructive examinations shall be as per ASME BPVC Section V- Non-Destructive Examination.

### 13.2 Hydrostatic Tests

Each pressure casing shall be hydrostatically tested with water at 16oC or above. The minimum test pressure shall be 1.5 times the maximum allowable casing working pressure with temperature correction.

Cooling water jackets shall be hydrostatically tested at a pressure of 1.5 times maximum cooling water system design pressure.

Auxiliary piping shall be hydrostatically tested with water at 16oC or above. The minimum test pressure shall be 1.5 times the design pressure of the auxiliary piping or 8.0 Barg, whichever is greater.

The chloride content of liquids used to test austenitic stainless-steel materials shall not exceed 50 ppm (ppm by mass).

All hydrostatic tests shall be maintained for a minimum of 30 minutes, or as per requirements, whichever is stringent.

### 13.3 Performance Test

All equipment shall be subjected to factory acceptance test (FAT) as per the approved testing procedure. Test report shall be submitted to the Employer after completion and acceptance of performance test. Each Pump shall be performance tested at vendor's facility with job motor and at rated speed.

Pumps employing VFD for speed control shall be tested at pump vendor's facility with pump, job motor and job VFD.

No negative tolerance is permitted on specified rated capacity and discharge pressure during performance testing. Positive tolerance is not permitted on NPSHR.

During performance test vibration shall be measured at every test point except shut off. FFT shall be performed and detailed vibration report with spectra shall be submitted with the final performance test

report.

NPSH test shall be performed. Tests can be conducted simultaneously with the performance test.

Four-hour mechanical run test shall be performed after the stabilization of bearing oil temperature.

Noise shall be measured during performance test at every test point, and it shall be within the allowable range of 85dBa at 1m anywhere from the equipment.

Performance tests shall be conducted in accordance with Section 3.6 of the Hydraulic Institute pump standards. The manufacturer shall operate the pump in their shop for sufficient period to obtain complete test data, including speed, discharge pressure, suction pressure, power, capacity, external relief valve full flow at set pressure and its resultant accumulation pressure.

Performance test shall be with the pumping fluid. In case, testing with pumping fluid is not feasible, vendor shall furnish correction curve for correlating test data obtained with test fluid to the performance required with pumping fluid to the Purchaser, prior to test.

Unless otherwise mutually agreed upon, the test speed for all pumps shall be the rated speed.

The certified test curve shall be corrected to actual speed of the job driver.

No negative tolerance is permitted on specified rated capacity and discharge pressure during performance testing. Positive tolerance is not permitted on NPSHR at rated capacity.

Test tolerance shall be within the limit specified in API 676 latest edition Table 5.

**a) Mechanical Run Test**

The pump shall be mechanically run for four hours at the rated flow with pumping fluid and job motor. During Mechanical Run Test, vibration shall be measured on the bearing and on the base plate for the capacity range of + 10% of rated capacity. On the test bed the vibration amplitude shall not exceed 75 microns.

Pumps shall be dismantled after the Mechanical Run Test to check for wear / damage to all parts.

The contract shaft seals and bearings shall be used in the machine for the mechanical running test. During testing all parts of the pump including bearings shall operate without excessive heating, vibration or display of other unfavorable characteristics. If after shop test any modifications to the pump parts are required, the test shall be repeated. A retest is also required when modification to non-internal components may affect pump performance.

**b) NPSH Test**

The pump shall be tested for NPSH as per API STD 676 fourth edition. At rated speed and with NPSHA equal to quoted NPSHR, the pump capacity shall be within three percent of the non-cavitating capacity.

The pump shall not be run while cavitating.

**c) High Discharge Pressure Test**

The pump shall be operated at the Pressure Limiting Valve set pressure at the maximum rated pump speed and a fluid viscosity agreed to by the vendor and the Engineer to confirm that the pump does not seize under these conditions. A single data point will be collected.

**d) Acceptance Test**

Factory and field acceptance tests shall be carried out and certificates furnished. Factory acceptance test reports in originals shall be made available at site prior to erection of the pumps.

## 14. PACKAGING STORAGE AND SHIPMENT

Packaging and shipment procedure shall be submitted to Employer for review and approval. It shall also include the storage instructions at site. Preparation for shipment shall be made after all the testing and inspection of the equipment has been completed and the equipment has been approved by the Employer/Employer`s representative.

The storage procedure for short term and long-term preservation, including both at warehouse and at installed positions, shall be provided considering the local site conditions and if any special measure is required for the onsite storage, it shall be conveyed to the Employer in due time.

Vendors shall pack all goods to be suitable for sea transportation such as open deck cargo and at least 6-month storage at site.

The procedure shall specify the cleaning and drying methods, the application of preservative material, protective wrapping any disassembly required for shipping and removal of any protective items installed for shipping purposes.

Machined surfaces shall be anti-corrosion protection as well as against mechanical shock by efficient means and they shall be easily removable after transport.

All flanged openings shall be protected with steel plate covers or wood covers to provide adequate protection and shall be attached by proper bolting or by means of some straps.

## 15. SPECIAL TOOLS AND SPARE PARTS

Vendor shall prepare a list of spare parts and special tools required for erection, pre- commissioning, commissioning, and start up and two year’s operation.

Contractor shall submit the recommended spare parts for the Employer’s Representative approval and recommendation.

The contractor shall ensure the in-time supply of recommended spare parts.

1. Erection, pre-commissioning and Commissioning spares shall be part of vendor base scope of Supply.
2. Supply of 2 years' operating spare parts including 1 mechanical seal is required.
3. Special tools required for Installation, maintenance and operation if required and recommended by vendor shall be included in vendor base scope.

## 16. PAINTING

Before shipping any equipment, all un-machined surfaces shall be treated and painted in accordance with the approved project painting specification MRT-ENG-MEC-SPE-0010.

Alternatively, vendors may propose a paint system suitable for marine and process plant environmental conditions.

Painting specifications shall be submitted to Employer / Employer's representative for review and approval prior to painting activities.

## 17. DOCUMENT REQUIRED

All documents/drawings of contractor, sub-contractor, supplier and sub supplier shall be in English. Two soft copies (on separate discs) and two hard copies of all the final documents shall be provided for record.

All drawings and documents shall show the name of the vendor (supplier), name of project, Employer, main contractor, EPC Contractor and Employer's representative.

1. Dimensional general arrangement drawing of Pump, driver and all accessories.
2. Cross sectional drawings of Pump, motors, bearings, couplings, mechanical seals and all accessories with bill of materials.
3. Primary and secondary seal flushing plan schematics, bill of material and installation drawings
4. Electrical and instrumentation schematics, wiring diagrams, list of connections and bills of materials.
5. Allowable piping forces and moments, dynamic and vibration loads
6. Inspection and test procedure
7. Manufacturing Procedure
8. Painting Procedure
9. NDE Procedures
10. Radiography Procedure
11. Repair Procedures (if applicable)
12. PQR, WPS and WQR
13. Material certifications
14. Stage Inspection Reports, NDE reports

15. Weld Map
16. Radiographic Film & Report

17. Certified hydrostatic test data
18. PSV Calculation and Datasheet.
19. Performance curves
20. Performance test and Mechanical Run test reports
21. Rotor balancing report and coupling balancing certificate
22. Noise data sheets
23. Installation, operation and maintenance manuals.
24. Preservation, packaging and shipping procedures
25. Lubrication requirement and lube oil data sheets.
26. Specification of Grout
27. Commissioning spare parts and two years operational spare parts.
28. Packing List
29. MRB (Including As Built Documents)
30. Painting Specifications
31. Painting test certificates

## 18. INSTALLATION

Installation of the pumps will be done by the EPC contractor in accordance to the approved specifications and manufacturer's recommendations. Installation of Pumps & accessories, including alignment of the pump and driver coupling shall be done in the presence of Employer's and the Vendor's representative. Vendors scope of service includes deputing suitable experienced, with pumps of similar capacity, and qualified Engineers for supervising the erection.

## 19. COMMISSIONING & SITE ACCEPTANCE TEST

Commissioning of the pumps followed by Site Acceptance Test shall be done by the EPC contractor/ Employer in accordance to the approved commissioning procedures, pump operation manual and manufacturers recommendations, SAT Procedure etc. Commissioning shall be done only after clearance of the commissioning checklist for the pumps, related pipe work, electrical and instrumentation works. It will be the responsibility of the Contractor to ensure availability of operation manuals, as-built drawings, commissioning spares and consumables, commissioning engineer and Vendor's representative at the site for commissioning of the pumps and Site Acceptance Test. Vendors scope of service includes deputing suitable experienced and qualified Engineers for supervising the commissioning activities and Performing SAT.

## 20. GUARANTEES

Pumps and all accessories shall be guaranteed to operate continuously and satisfactorily maintain all the functions under the whole range of operating and climatic conditions.

Vendors shall guarantee the equipment and its accessories against defective material, design and workmanship for a period of 1 year after commissioning of facility.