DME - 465

SPECIFICATIONS FOR CENTRIFUGAL WATER PUMPS

Materiel Branch
Directorate of Marine Engineering, Integrated Headquarters
Ministry of Defence (Navy),
New Delhi – 110 011

FEB - 2019

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11. The applicability of DME 465 is as follows:-

(a) All procurements by Shipyards for new construction ships (except Aircraft Carrier, Tankers and Submarines).

(b) All new procurements by Commands/ Material Organisations (as applicable).

(c) The specifications will not be applicable to any existing orders or any repeat orders for ongoing/ existing contracts.

Foreword

1. Centrifugal water pumps are vital equipment for most of the engineering systems onboard ships and submarines. It is a single major equipment group which handles variety of mediums like sea water, fresh water, feed water, chilled water etc. *IN* platforms are fitted with approximately 2,700 centrifugal water pumps of over 350 duty points. The current procedure of designing pumps to suit ship specific systems has led to proliferation of pump inventory between class of ships as well as within the same class of ship. Different models of pumps have also been observed to have been used for very minor differences in duty points. This has translated into huge inventory being maintained as OBS/ B&D spares and compounded the challenges on field regarding maintenance of pumps.

2. A need was, therefore, felt for rationalisation and standardisation of the duty points along with the type of pumps across platforms to reduce inventory management efforts and increase interchangeability across platforms/ systems. The exercise to standardise the centrifugal water pump was accordingly undertaken in consultation with Shipyards, Pump/ Motor manufacturers, Design and Production Directorates to rationalise the centrifugal water pump inventory.

3. With the given premise, Specification on 'Centrifugal Water Pump' (DME – 465) has been prepared by the Indian Navy towards standardization in 'type, orientation, motor ratings, base frame size, no. of SV mounts, material aspects and inspection test criteria' with an aim to enhance interchangeability, inventory reduction and quality compliance.

4. The comprehensive specification would serve as a guiding document to Design, Production and Procurement Directorates, pump manufacturers, inspection agencies, Shipyards and all other stakeholders related to manufacture and supply of centrifugal water pumps to Indian Navy. All stakeholders dealing with the design, selection, inspect and supply centrifugal water pump being inducted or retrofitted are required to comply with this Specification. Deviation to guidelines in this specification, if necessitated, would warrant advance and formal approval from IHQ MoD (N)/ DME.

5. Specifications promulgated in DME 465 take precedence over other specifications and any other documents quoted therein.

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New Delhi
26 Feb 2019

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CHAPTER – I

INTRODUCTION

1. **Pump**. A pump is a mechanical device which is used to lift working fluid (both gaseous and liquid) from low level to high level or to flow fluid from low pressure area to high pressure area or as a booster in a piping network system. Pumps come in a variety of sizes for a wide range of applications. They can be classified according to their basic operating principle as dynamic or positive displacement pumps. The dynamic pumps can be sub-classified as centrifugal and special effect pumps while the positive displacement pumps can be sub-classified as rotary or reciprocating pumps as shown in Fig 1.1.

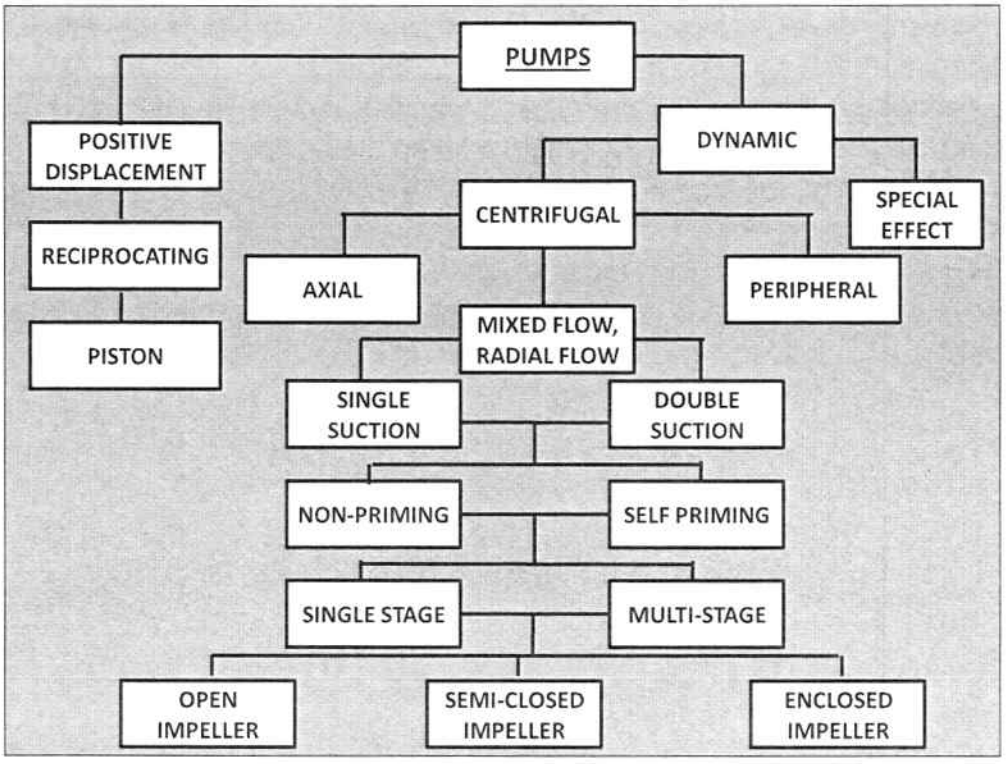


Fig 1.1 - Pump Classification

2. **Centrifugal Pump**. A centrifugal pump is of a relatively simple design with two main parts – the impeller and the diffuser. Impeller, which is the only moving part, is attached to a shaft and driven by a motor. Impellers and casings are made of bronze, polycarbonate, cast iron, stainless steel, NAB as well as other materials depending on end usage and working fluid. The diffuser (also called as volute) houses the impeller and captures and directs the water off the impeller as shown in Fig 1.2.

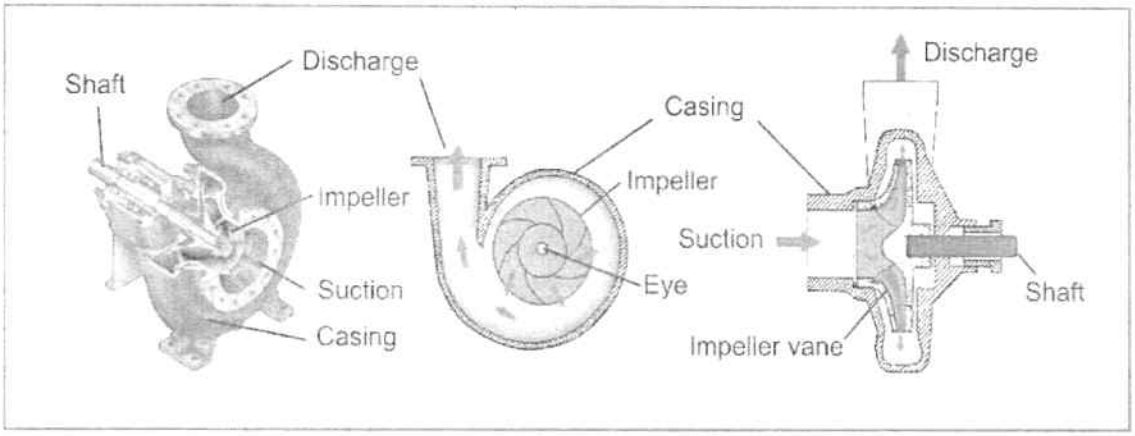


Fig 1.2 – Centrifugal Pump

3. **Working Principal of Centrifugal Pump**. The impeller is the rotating part that converts driver energy into the kinetic energy and volute or diffuser is the stationary part that converts the kinetic energy into pressure energy. The centrifugal force exerted on the liquid by the rotating impeller, moves the liquid away from the impeller eye and out along the impeller vanes to their extreme tip. The liquid is then forced against the inside walls of the volute and out through the discharge of the pump. The volute is designed such that it allows the liquid to expand which slows down the velocity of the fluid. As soon as the liquid slows down inside the volute, kinetic energy of the fluid is converted into pressure as governed by the Bernoulli's principle.

$$z_1 + \frac{v_1^2}{2 * g} + \frac{p_1}{\rho * g} = z_2 + \frac{v_2^2}{2 * g} + \frac{p_2}{\rho * g}$$

Equation 1 – Bernoulli's principle (in head form)

where,

z = elevation head from the datum (in metre)
v = velocity of the fluid (in m/s)
ρ = pressure of the fluid (in kg/ sq. cm)
g= acceleration due to gravity (in m/ sq. s)

4. This pressure then forces the liquid out of the pump discharge nozzle into outlet pipe lines. Further, continuous flow is maintained as the reduction of pressure occurring at pump inlet and impeller eye causes the liquid to be drawn into the pump. The increased kinetic energy is in turn converted to pressure by specially designed passageways that direct the flow to the discharge of the pump or to the next impeller in case of a multi-stage configuration.

5. **Pump Assembly.** The centrifugal pump is made of several primary components namely impeller, volute casing, shaft, bearing, mechanical seal etc. The general component-wise layout of a centrifugal pump are shown below as Fig 1.3

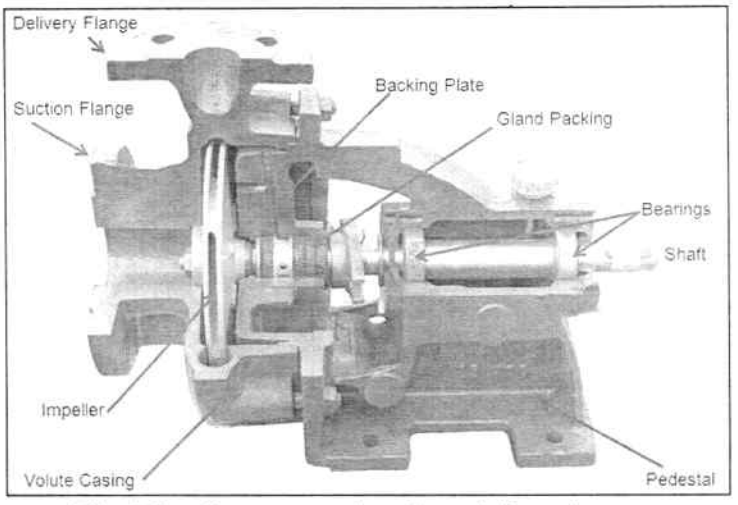


Fig 1.3 – Components of centrifugal pump

6. A centrifugal pump consists of casing, impeller, shaft, bearings and seals briefly elaborated below:-

(a) **Casing**. The pump's casing (Fig. 1.4) houses the whole assembly and forces the fluid to discharge from the pump and convert velocity into pressure. The casing is important to reduce friction losses. It supports the shaft bearings and takes the centrifugal forces of the rotating impeller and axial loads caused by pressure thrust imbalance. Most of all centrifugal pumps are of simple spiral casing and has to be carefully designed to avoid turbulences resulting in a decrease in efficiency. The shape of the casing is defined by several factors; these are profiles angles, diameter and width. Standard pump casings are made of cast iron, however, considering lesser resistant against cavitation, many pumps are made from more wear resistant materials like NAB, super duplex steel etc. Additionally, the casing material should have good damping properties to reduce vibrations.

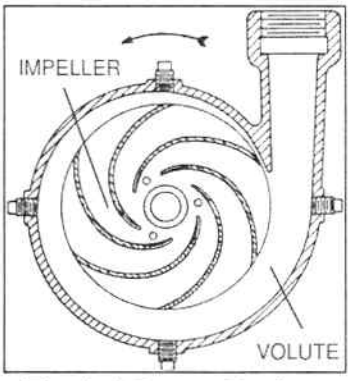


Fig 1.4 Pump Casing

(b) **Impeller**. The impeller is the essential part of a centrifugal pump. The performance of the pump depends on the impeller diameters and design. The pump's Total Dynamic Head (TDH) is basically defined by the impeller's inner

and outer diameter and the pump's capacity is defined by the width of the impeller vanes. In general, there are three possible types of impellers, open, enclosed and semi open impellers as shown in Fig 1.5, each suitable for a specific application. Impellers are made from various materials based on the application to ensure its long life.

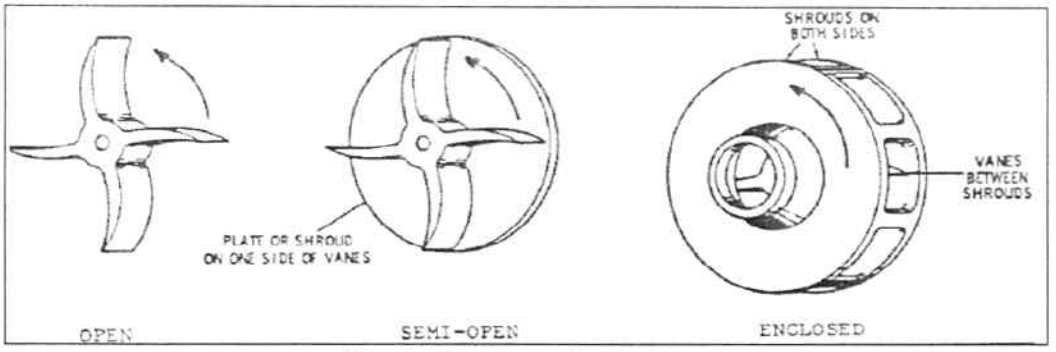


Fig 1.5 Types of Impeller

(c) **Shaft**. The shaft is the connection between impeller and drive unit which is in most cases an electric motor. It is mainly charged by a radial force caused by unbalanced pressure forces in the spiral casing and an axial force due to the pressure difference between front and backside of the impeller. The material of the shaft varies from carbon steel to ally steel based on the applications. There are several cranks to support the bearings and seals as shown in Fig 1.6. A high surface quality and small clearances are required, especially in the areas of the bearing's and mechanical seals to ensure right positioning of the shaft in the casing and ensure adequate life span. The correct positioning of the impeller on the shaft with required clearances within the casing is another important parameter. Additionally, in shaft design it is also important to avoid small radiuses at cranks to minimize stress in these areas which are susceptible for fatigue.

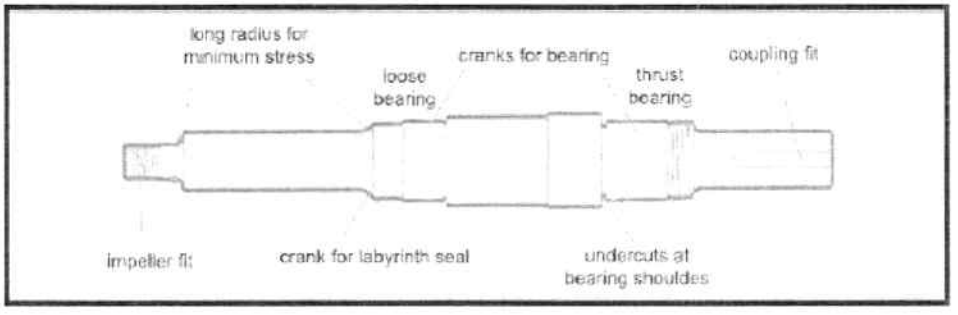


Fig 1.6 Pump Shaft

(d) **Bearings**. The bearings keep the shaft in place to ensure radial and axial clearance. The bearings lead radial and axial forces from the impeller into the casing. If the pump is operated at its Break Even Point (BEP), the bearing will only have to carry the rotating assembly's weight. Operation of a

pump beyond BEP leads to increased stresses, vibrations and decrease life span of pump. Therefore, correct selection of the bearing is important based on the forces generated by the pump with additional safety margin to cater for operation of pump beyond BEP. Further, the bearings are required to be adequately sealed to protect from external environment and operating fluids.

(e) **Sealing**. To protect the motors and bearings against ingress of fluid mechanical seals are fitted into the casing. A mechanical seal show in Fig.1.7 consists of primary and secondary sealing. In most cases the primary part, which is fitted to the casing, is made of a hard material like silicon carbide or tungsten carbide. The other, the rotating part of the primary seal is made of a soft material like carbon. Both parts are pressed against each other by a spring. The secondary sealing is not rotating relative to each other and provide a fluid barrier. The seal materials should be compatible to suit the application of the pump to ensure adequate seal lifespan.

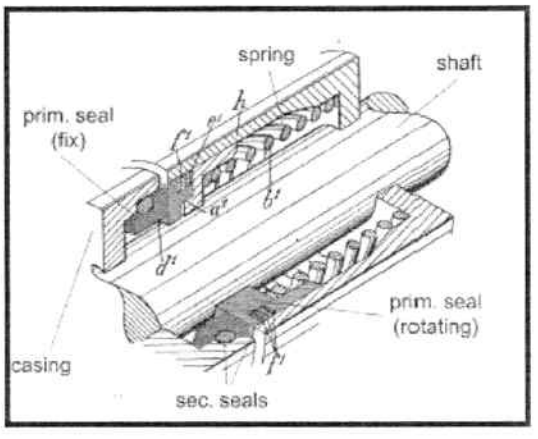


Fig 1.7 Mechanical Seal

6. **Pump Parameters**. There are several parameters on which the pump is designed and selected for a particular application. Some of the important parameters are enumerated below:-

(a) **Suction Lift (Negative)**. Suction lift exists when the source of fluid is below the center line of the pump. Thus the *Static Suction Lift* is the vertical distance in meter from the centerline of the pump to the free level of the fluid to be pumped.

(b) **Suction Head (Positive)**. Suction head exists when the source of supply is above the centerline of the pump. Thus the *Static Suction Head* is the vertical distance in meter from the centerline of the pump to the free level of the liquid to be pumped.

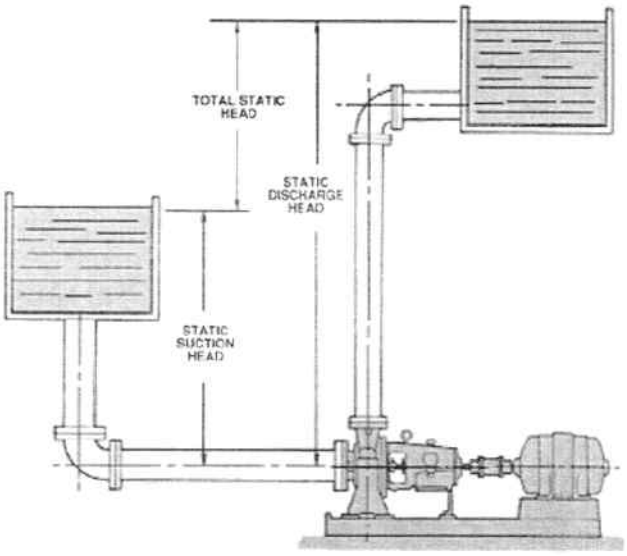


Fig. 1. 8 Suction Head in a pumping system where the pump is located below the suction tank

(c) **Static Discharge Head**. Static Discharge Head is the vertical distance in meter between the pump centerline and the point of free discharge or the surface of the liquid in the discharge tank.

(d) **Total Static Head**. Total Static Head is the vertical distance in meter between the free level of the source of supply and the point of free discharge or the free surface of the discharge liquid.

(e) **Friction Head (Hf)**. Friction Head (Hf) is the head required to overcome the resistance to flow in the pipe and fittings. It is dependent upon the size, condition and type of pipe, number and type of pipe fittings, flow rate, and nature of the liquid.

(f) **Velocity Head (Hv)**. Velocity Head (Hv) is the energy of a liquid as a result of its motion at some velocity V. It is the equivalent head in feet through which the water would have to fall to acquire the same velocity, or in other words, the head necessary to accelerate the water.

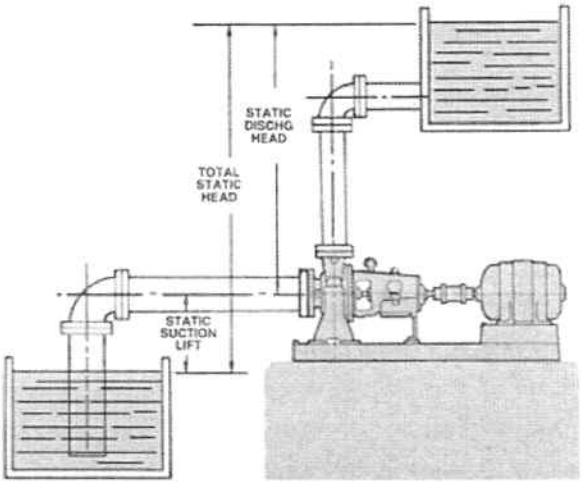


Fig. 1. 9 Suction Lift in a pumping system where the pump is located below the suction tank

(g) **Total Dynamic Head (TDH)**. Head in general is used to define energy supplied to a liquid by a pump and is expressed unit of length. In absence of any velocity it is equal to the height of a static column of fluid that is supported by the pressure in the point of datum. Total dynamic suction head (TDH) is the difference between total dynamic discharge head and total suction head **(Equation no. 2)**. Total head discharge (suction) head is practically the pressure read from a gauge at the discharge (suction) flange converted to length units and corrected to the pump centre line plus the velocity head at the point of the gauge. These two values represent the total amount of energy of the fluid at the discharge and suction flange of the pump. Mathematically it is the sum of static discharge (suction) head and velocity at the discharge (suction) flange minus total friction head in the discharge (suction) line. The difference of these values gives you the TDH which represents the energy added to the fluid. TDH does not depend on the delivered fluids density. A higher density only increases the pressure and therefore the required power at a constant flow rate.

$$TDH = hd - hs$$

$$TDH = (z_2 - z_1) + \frac{(p_2 - p_1)}{\rho * g} + \frac{(v_2^2 - v_1^2)}{2 * g}$$

Equation no. 2 – Total Dynamic Head

(h) **Flow Rate (Q)**. Flow rate is the volume of fluid passing through the pump per unit of time. It is calculated as area times fluid velocity (eqn.3). It depends on the impeller geometry and RPM. Impellers are optimized for highest outlet velocities multiplied by the useable impeller inlet area you will get the flow rate. An impeller is designed for a maximised flow rate at a specific speed depending on its diameter. This is called the point of best efficiency.

$$Q = A_1 * v_1 = A_2 * v_2$$

Abbreviations
Q – Flow rate
A- Area
v- Velocity

Equation no. 3 - Flow Rate

(j) **Net Positive Suction Head (NPSH)**. NPSH is defined as total suction head above the suction nozzle and corrected to datum, less the vapour pressure of the fluid converted into length units. It analyses energy condition on the suction side of the pump to determine whether the liquid will vaporise at the lowest pressure point of the pump. Vapour pressure is a characteristic fluid property increasing with increasing temperature. It indicates the pressure at which a fluid starts boiling, causing bubbles which move along the impeller surface to an area of higher pressure were they collapse rapidly and cause significant harm to it. By decreasing the pressure the temperature at which this happens also decreases. So if the pressure is low enough it is possible to see this effect even at surrounding temperature. This effect is known as cavitations and should necessarily be avoided. It is obvious that in order to pump a fluid in an effective way we have to keep it liquid. Therefore **NPSH required** ($NPSH_R$) is the total suction head required to prevent the fluid from vaporising at the lowest pressure point of the pump. $NPSH_R$ is a function of pump design as the pressure at the impeller decreases by accelerating the fluid along the impeller. There are also pressure losses due to shock and turbulences as the fluid strikes the impeller. To overcome all these pressure drops in the pump and maintain the fluid above vapour pressure a certain positive suction head is required. $NPSH_R$ varies with flow rate and speed within any particular pump. The **available NPSH ($NPSH_A$)** is a function of the system in which the pump operates. To avoid cavitations $NPSH_A$ must be bigger than $NPSH_R$. In practice the $NPSH_A$ can be determined by a gauge on the suction flange of the pump and the following formula (Equation no. 4). It is also common to add a certain safety value to the $NPSH_R$ to make sure that there is enough suction head to prevent the fluid from vaporising. In practice a safety value of 0.5m has turned out to be reasonable.

$$NPSH_A = \frac{\left(p_1 + p_e + \frac{v_1^2 * \rho}{2}\right) * p_v}{\rho * g} + \Delta z$$

$$NPSH_A = NPSH_R + 0.5\ m$$

Abbreviations
z - Potential Head
p - Pressure
v – Velocity
g - Acceleration due to gravity
ρ - Density

Equation no. 4 - Net Positive Suction Head (NPSH)

(k) **Specific Speed (N_s)**. Specific speed (N_s) is a non-dimensional design index used to classify pump impellers as to their type and proportions. It is defined as the speed in revolutions per minute at which a geometrically similar impeller would operate if it were of such a size as to deliver one gallon per

minute against one foot head. The understanding of this definition is of design engineering significance only, however, and specific speed should be thought of only as an index used to predict certain pump characteristics. As the specific speed increases, the ratio of the impeller outlet diameter, D2, to the inlet or eye diameter, D1, decreases. This ratio becomes 1.0 for a true axial flow impeller. Radial flow impellers develop head principally through centrifugal force. Low specific speed characterises a radial impeller and is increasing up to high specific speed at axial impellers. Impellers in between are known as Francis-vane and mixed-flow impeller (Fig.1.8). The following formula is used to determine specific speed:

$$Ns = \frac{N\sqrt{Q}}{H^{3/4}}$$

Equation no. 5 - Specific Speed (N_s)

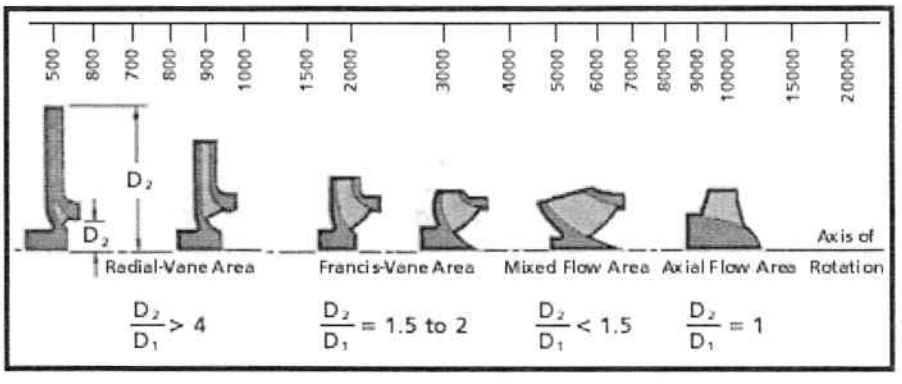


Fig. 1.8 - Values of Specific Speed, N_s & Impeller Design Vs Specific Speed

(I) **Power and Efficiency (P, η)**. The work performed by a pump is a function of TDH, flow rate and the specific gravity of the fluid. Pump input (P) or brake horse power (BHP) is the actual power delivered to the pump shaft. Pump output (P_{hydr}) or hydraulic horse power (WHP) is the energy delivered to the fluid per time unit (eqn.6). Due to mechanical and hydraulic losses in the pump, P_{hydr} is always smaller than P. Therefore efficiency is defined as P_{hydr} divided by P (eqn.7). The impeller geometry is optimized to provide highest flow rate at a certain speed at a given diameter at its point of best efficiency (BEP). If operating a pump off its (BEP), losses due to increasing turbulences and recirculation will increase and reduce efficiency. These effects are caused by a mismatch of the pump's design flow rate and the actual flow rate. The difference between inlet vane angle and approaching flow angle is increasing as moving away from the BEP as well as losses between impeller vane exit and the diffuser. Result of this is an increased flow between the impellers shrouds and the casing.

$$P_{hydr} = \rho * g * Q * TDH$$

$$\eta = \frac{P_{hydr}}{P} = \frac{\rho * g * Q * TDH}{P}$$

Equation no. 6 & 7 - Power and Efficiency (P, η)

7. **Affinity Laws**. The affinity laws expresses the mathematical relationship between the several variables involved in pump performance i.e effect on flow rate (Q) and head (H) by varying the pump RPM (N), diameter of pump impeller (D) and power rating (BHP) of the motor.

(a) For a constant velocity, the flow, head and BHP will change when the impeller diameter changes. With a change in the impeller diameter (called as trimming of an impeller), the affinity laws indicate:-

(i) The flow changes directly proportional to the change in diameter.

$$\frac{Q_I}{Q_{II}} = \frac{D_I}{D_{II}}$$

(ii) The head changes directly proportional with the square of the change in the impeller diameter.

$$\frac{H_I}{H_{II}} = (\frac{D_I}{D_{II}})2$$

(iii) The BHP changes directly proportional with the cube of the change in the impeller diameter.

$$\frac{BHP_I}{BHP_{II}} = (\frac{D_I}{D_{II}})3$$

(b) For a constant impeller diameter, the flow, head and BHP will change as per the affinity laws indicated below:-

(i) The flow changes directly proportional to the change in pump RPM.

$$\frac{Q_I}{Q_{II}} = \frac{N_I}{N_{II}}$$

(ii) The head changes directly proportional with the square of the change in pump RPM.

$$\frac{H_I}{H_{II}} = (\frac{N_I}{N_{II}})2$$

(iii) The BHP changes directly proportional with the cube of the change in pump RPM.

$$\frac{BHP_I}{BHP_{II}} = (\frac{N_I}{N_{II}})3$$

8. **Pump Performance Graphs**. The pump characteristics graph gives an insight into the performance of the pump under varying operating conditions. Once the pumps have been designed and manufactured, then pump performance characteristics can be indicated using these graphs.

(a) **Characteristics Curve**. This graph is plotted keeping the operating rpm as constant. This graph gives us the pump performance over a range of varying discharge rate and also helps us determine the optimal operating range. A sample graph is placed at Fig 1.11. The following correlations are observed from the graphs:-

(i) Head produced by pump decreases with increase in discharge rates.

(ii) Efficiency increases and peaks upto a certain discharge value followed by an efficiency drop.

(iii) The power input required also increases gradually with increase in discharge rates.

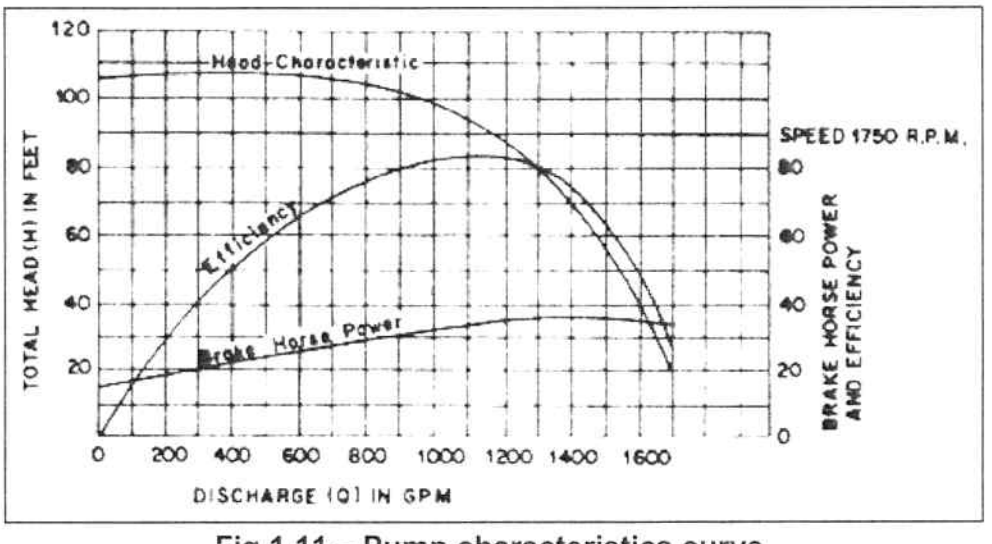


Fig 1.11 – Pump characteristics curve

(b) **Iso-Efficiency Graph**. This graph give a head-capacity variation for one speed and different impeller diameter or for different speed and one impeller diameter. The graphs are plotted between discharge rate and maximum head. Fig 1.12 (a) shows the variation in head with varying rpm keeping impeller diameter constant. Fig 1.12 (b) shows variation in head with varying impeller diameter which are mentioned at the right end of each curve.

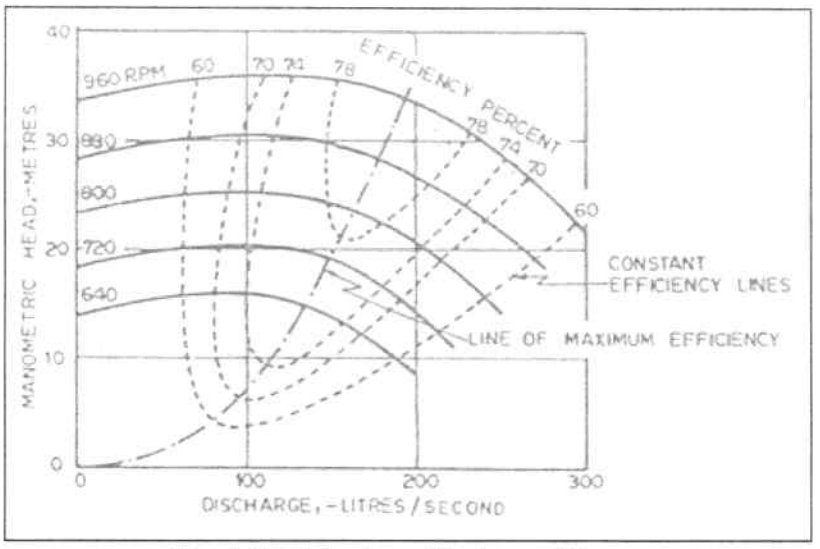


Fig 1.12 (a) – Isoefficiency Curve

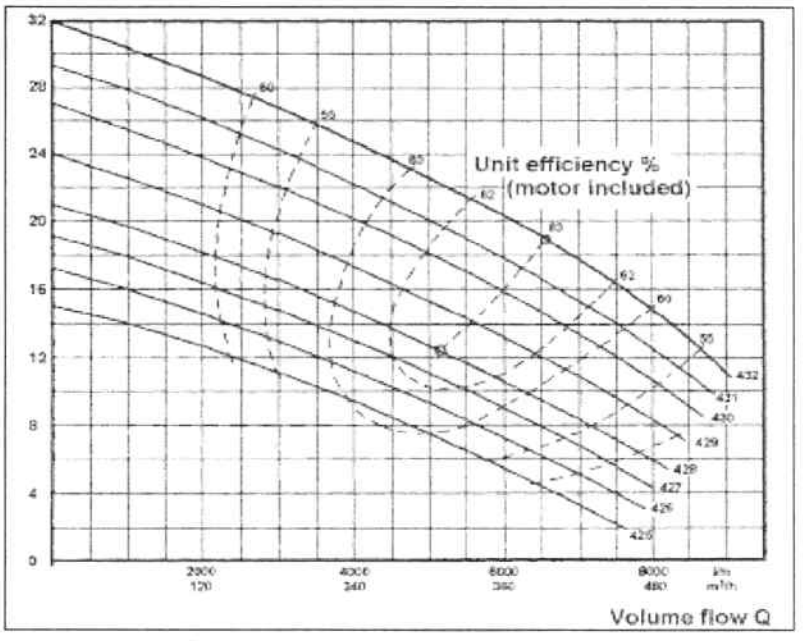


Fig 1.12 (b) – Efficiency Curve

9. **Pump selection**. Important selection parameters are required TDH, flow rate, $NPSH_A$, fluid and flexibility of the system. It is also important to know the fluid. Parameters like pH-value, viscosity, abrasives, fluid and surrounding temperature range as well as quantity, size and shape of solids. If we know that a centrifugal pump is the right pump for the application, we can go into detail searching for a

potential pump model. Most manufactures provide a pump selection software. But in general, to select a pump it is useful to plot the curve, characterising the system and the characteristic curve of a potential pump into the same diagram. The point of intersection of the two head curves indicates the operation point of the pump. ***Duty Point of a centrifugal pump is that point on the Flow and Head (HQ) curve where the pump curve intersects the system characteristics. The pump selected should have the best efficiency point of the pump as close to the duty point as possible. It is also possible to make predictions how the pump will behave when changing system parameters.*** This is reasonable in the case of a changing system or if there has been made a mistake during pump selection. So it is possible to change the impeller to the next larger size without changing the casing.

CHAPTER – II

GENERAL CONDITIONS & REQUIREMENTS

1. General conditions and requirements (GCR) for design, manufacture, execution, inspection, installation, trials and operation of the equipment are specified in the subsequent paragraphs. The GCRs are specified for every platform in SOTRs issued along with the RFP. The manufacturers of centrifugal water pump are required to ensure that the centrifugal water pump is suitably designed for promulgated GCRs.

2. **Applicable Standards**. The following documentation or their latest issues in effect is to form a part of this specification to the extent specified herein, except where a specific issue is indicated. In case of conflict between the contents of this document and the applicable portions of the referenced documents, the contents of this document shall take precedence.

(a)	NES 327	Pumps and Eductors
(b)	NES 1004	Requirement for design and testing of equipment to meet environmental standard
(c)	ISO 10816	Mechanical vibrations – Evaluation of machine vibration by measurements on non rotating parts
(d)	MIL-STD-167	Mechanical vibrations of Shipboard equipment.
(e)	MIL-STD 1474-E	Airborne borne Noise measurements and acceptance criteria of shipboard Equipment.
(f)	MIL-STD-740-2	Structure borne Noise measurements and acceptance criteria of shipboard Equipment.
(g)	*IN* Shock Policy	*IN* Shock Policy EG/5522/Policy dated 11 May 07 & EG/Policy/TSV/13/2016 dated 13 Dec 16
(h)	MIL-M-7298C	Technical Manuals
(j)	NES 747	Requirements for nickel aluminum bronze castings and ingots
(k)	NES 833 (Part 2)	NAB forgings
(l)	JSS 55555	Environmental Test methods for Electronic & Electrical Equipment.
(m)	MIL-STD-461 E/ F	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

(n)	ISO 12063 (1987)	Classification of Degree of Protection provided by enclosures of Electrical equipment.
(p)	INBR 312	NBCD Guidelines for new construction Ships
(q)	EED-Q-071 (R4)	Specifications of motor and starters for Naval Ships
(r)	NES 609	Guide to the determination of creepage and clearance distance for electro-technical equipments
(s)	NES 501	General requirements for the design of electrical equipment
(t)	NES 723	Electrical Tally/ Diagram Plate
(u)	DGS/EED/VI/1535/R6	Cable glands
(v)	DME 452	Preparation of Documents

3. Other standards such as IEC, VDI, DIN, BS, IS etc. shall be accepted subject to the *IN*'s approval, for which the supplier shall furnish adequate information along with the offer, to justify that these standards are equivalent or superior to the standards mentioned above. For such alternate standards, which are not normally published in English, the supplier shall also furnish a complete translation in English.

Environmental Conditions for Operation

4. The equipment to be offered for marine applications must achieve specified output and function smoothly under tropical conditions. It should be capable of operating at full specified performance at ambient temperature 0-55 deg C and relative humidity 30 to 100%, without any undue effect on maintenance or life. It should withstand air contamination through oil, salt and other contaminants associated with the marine environment. The equipment shall be designed to work as per IP ratings recommended for the pumps vide EED-Q-071 (R4).

5. The equipment is to be designed for continuous operation under the environmental conditions specified.

Ship Motion

6. The equipment is to remain mechanically secured and operate at its design performance when the ship is subjected to the action of the sea and weather in addition to the velocities and accelerations derived from deliberate maneuvers.

7. **Static Tilt of Equipment**. Equipment is to be designed to withstand the following shipboard angles of permanent heel and trim. The angles at which

equipment must remain capable of operation and survive without damage vary according to the type of ship and the orientation or function of the equipment. Following conditions to be considered:-

(a) Operate at design performance with a permanent tilt of 15 degrees in any direction.

(b) Survive, without leakage of fluids or other degradation, a permanent tilt of 30 degrees in any direction and be capable of design performance when conditions return to normal.

(c) All pumps upon which reliance is placed for damage control and fire fighting duties are to be capable of operating efficiently when the vessel is in a static damaged condition causing a heel of 30 degrees and a trim of 15 degrees.

8. Equipment in all ships is normally designed for un-stabilised conditions. Following are recommended for design purpose:-

(a) Roll : $\pm$ 30 deg

(b) Pitch : $\pm$ 15 deg

9. **Design Requirements**: The equipment is intended for use on Naval ships which requires the equipment to achieve high performance standards. In addition, the pumps should be of sound, rugged and of reliable design and construction. Space and weight constraints dictate that the equipment should be compact and light in weight, yet easy to maintain. Following are to be adhered to:-

(a) Consideration should be given during design to the handling of components and assemblies (including removal routes) when erecting, assembling and maintaining the pump package. Facilities should be provided, where necessary, for jacking bolt, extraction bolts, locating dowels, spigots and lifting eyes.

(b) Fabricated components should be stress relieved before machining.

(c) The forces and moments applied to pump connections should be agreed between the pump manufacturer and the system designer.

(d) Where provision of a drain connection is specified, complete emptying of the casing should be possible. Drains should be plugged or valved.

(e) Where provision of vent connection is specified, complete venting of the casing should be possible. Vents should be plugged or valved.

(f) Whenever specified, casing should be provided with a filling connection.

(g) Provision for zero discharge connection, wherever applicable.

(h) Pump should have the correct direction of rotation permanently indicated at a point that is clearly visible.

10. **Space Constraints**. Ease of operation and maintenance are to be ensured while designing the layout of system components. The manufacturer is to indicate the space requirement for operating the equipment as well as the maintenance envelope required to carry out maintenance onboard during normal operation and refit. Wherever the pump will be considered as replacement of an existing pump, the dimensions of the pump should meet the limitations of space availability due to the retro fitment.

11. **Operation.** The following to be ensured:-

(a) The equipment should be designed for unmanned continuous operation and should be provided with a robust control and monitoring system.

(b) The machinery space would be attended only for starting, stopping and routine checks only.

(c) The machinery to have provision for remote monitoring and control including switching on/ off and may have additional features, as specified in the order specifications like data logging, fault diagnosis and remote display of operating parameters at locations specified by the user.

12. **Supplier's Scope**. Scope of supply, applicable to the particular installation will be specified in the order specification. In general, scope of supply is broadly defined as follows:-

(a) Design the equipment in accordance with the specifications.

(b) Obtain *IN* approval of drawings prior to commencement of manufacture. Quality Assurance Document (QAD) available on www.dgqadefence.gov.in is required to be referred for preparation of drawings. Standard Quality Assurance Plan (SQAP) for centrifugal pump promulgated by DQA (WP) is required to be followed for manufacturing the centrifugal pump. In case there are deviations to SQAP promulgated by DQA(WP), *IN* approval is required to be taken for the QAP planned by the manufacturer.

(c) Manufacture the pumps as per approved design and drawings with strict adherence to SQAPs/ approved Quality Assurance Plan.

(d) Prove performance of the equipment as per approved Acceptance Test Procedure (ATP).

(e) Produce documentation on development, function and performance of the equipment.

(f) Paint, preserve, pack and transport the equipment to site as per approved procedures.

(g) Complete installation in the ship including power supply and control cabling as specified by the procurement agency.

(h) The scope of supply in all cases will include following (specific serials may be deleted wherever not applicable):-

(i) Pump complete with motor.
(ii) Starter.
(iii) Mounts.
(iv) Instrumentation with associated piping and isolating valves duly mounted on panel.
(v) Suction and discharge bellows.
(vi) Mating flanges.
(vii) Fasteners.
(viii) Expanders/ reducers.

13. The equipment on installation should be supportable for a minimum period of 25 years and is to be available for exploitation for an uninterrupted ops-cycle of 24-36 months.

CHAPTER – III

STANDARD CENTRIFUGAL WATER PUMP

1. Duty Point of a centrifugal pump is that point on the Flow and Head (HQ) curve where the pump curve intersects the system characteristics. The pump selected should have the best efficiency point of the pump as close to the duty point as possible. Centrifugal water pump requirements of duty point for various applications viz firemain, sea water, salvage, ballast, fresh water, feed water, bilge, AC sea water, AC chilled water, and Ref plant sea water applications in all future projects except Aircraft Carriers, Tankers and Submarines have been standardised. The Design/ Production Directorates including Shipyards are required to select the duty point of the centrifugal water pump for the concerned application from the standardized 28 duty points placed at **Appendix 'A'**. Therefore, the system design and locations of the centrifugal water pump onboard platforms are required to be undertaken keeping in mind these standardised duty points. The same will rationalise the centrifugal water pump inventory for both *IN* and pump manufacturers.

2. In order to facilitate interchangeability of pumps amongst platforms and pumps supplied by different OEMs, the under mentioned technical specifications for centrifugal water pump requirement for all future projects have been standardized:-

S.No.	Technical Specification	Standardised Specifications	Remarks
(a)	Type	All Pumps to be of Monobloc design	-
(b)	Orientation	Higher Duty –Vertical Lower Duty – Horizontal	Details for each Duty point indicated at **Appendix 'B'**
(c)	Suction and Discharge	All vertical pump to be Monobloc inline pump except Salvage pumps to be bottom suction side discharge and horizontal pumps to be centre suction and top discharge	
(d)	Motor Rating	Motor rating for each Duty point has been finalised	
(e)	No. of SV mounts	No. of SV mounts for each Duty point has been finalsed	
(f)	Base Plate Dimensions	Base plate dimensions for each Duty point has been finalised	

S.No.	Technical Specification	Standardised Specifications	Remarks
(g)	Location for SV mounts	Centre points for location of SV mounts on base plate	Indicative location details for SV mounts on base plate are placed at Appendix **Appendix 'C'**
(h)	Material	All centrifugal water pumps to be of NAB material	Details for various components of pump are placed at **Appendix 'D'**

3. All centrifugal water pump manufacturers are required to manufacture pumps iaw the above specifications, detailed specifications for each duty point is placed at **Appendix 'B'**. Further, the manufacturers are required to meet the standardized 28 duty points by minimum no. of pump models i.e using the same pump casing meet the duty point requirement by trimming of impellers or changes to motor RPM without affecting the efficiency drastically.

4. The indicative details for location of SV mounts on base plate for each duty point have been indicated in **Appendix 'C'** and selection of AKCC mounts is preferred. Additionally, all horizontal pumps are required to be supplied on the standardised base plate with a C channel welded on both the edges of the base plate along the longitudinal axis of the pump. Four SV mounts are required to be fitted on the C channel to facilitate installation onboard as shown in **Appendix 'C'**.

5. The material of the pump along with its internal components has also been standardized to avoid variations in material. *The same will be periodically reviewed post advancement in metallurgy and successful trials*. The details of the material for various components of the centrifugal pump are placed at **Appendix 'D'**.

6. All Design/Production Directorates, Shipyards and Pump manufacturers are required to select and induct centrifugal water pump on all platforms except Aircraft Carriers and Tankers based on the above standardized technical specifications for centrifugal water pumps. Deviation to guidelines in this specification, if necessitated, would warrant advance and formal approval from IHQ MoD (N)/ DME.

CHAPTER – IV

MAIN TECHNICAL REQUIREMENTS

1. The centrifugal water pumps are to be used for water applications onboard *IN* ships.

Pump Duty

2. The duty of the pump in a particular application will be selected by the system designer from the standardized 28 duty points. Following aspects should be considered while selecting the pump: -

(a) Operation in all environmental conditions as prescribed.

(b) Rated flow at rated head/ pressure.

(c) Flow and head/ pressure at specific duties.

(d) Requirement of self priming.

(e) Power requirement.

(f) Performance over specified range of speeds.

(g) Pump package vibration level

(h) Noise level of pump package.

(j) MTBF.

3. Duty of the pump should be defined with sufficient clarity in the procurement specifications so that the manufacturer is aware of the system requirement. The following information may be included in the procurement specifications: -

Ser	Parameter	Description
(a)	Type of fluid and its temperature range	To be specified
(b)	Qty	To be specified
(c)	Orientation required	To be specified as per type of pump mentioned at **Appendix 'B'**
(d)	Power supply	To be specified
(e)	Flow rate	To be specified as per standard ranges placed at **Appendix 'A'**

Ser	Parameter	Description
(f)	Discharge Head	To be specified as per standard ranges placed at **Appendix 'A'**
(g)	Suction lift	To be specified as per standard ranges placed at **Appendix 'A'**
(h)	Test pressures (i) Max operating Pressure (ii) For leak tightness (iii) For strength	 ___ mm (max) ___ mm (max) ___ mm (max)
(j)	Overall dimensions: (i) Height including motor (ii) Diameter (end to end including extensions) (iii) Length	To be specified in case of limitation
(k)	Material of the pump components	To be specified as per standard ranges placed at **Appendix 'D'**
(l)	Weight of the complete unit (without mounts)	To be specified in case of limitations
(m)	Axis arrangement	To be specified as per standard ranges placed at **Appendix 'A'**
(n)	Proposed shipping route (min. Door/ hatch size) (mm)	Door size to be specified Hatch size to be specified
(p)	Overall starter dimensions	To be specified in case of limitations
(q)	Ambient temperature	Capable of operating efficiently at ambient operating temperatures upto 55°C
(r)	Nominal bore of flanges (a) Suction flange (b) Discharge flange	(a) Suction flange: Pipe dia ____, PCD ___, OD ____. (b) Discharge flange: Pipe dia ____, PCD ___, OD ____. The dimensions of the flanges and fasteners are required to be iaw BS4504
(s)	Fasteners	The dimensions of the flanges and fasteners are required to be iaw BS4504
(t)	Mating Flanges	Requirement of Mating flanges for suction and discharge point if required may be included in scope of supply
(u)	Suction and Discharge Bellows	Dimensions of suction and discharge bellows to be specified

Ser	Parameter	Description
(v)	Expander and reducer	Requirement for expander and reducer if required may be included in scope of supply
(w)	Service life / running hours : (a) Service life up to pump repair (b) Total service life	 : Normally 4 years : Normally 25 years

Commercial Issues

4. In addition to the technical requirements of the pump, the procurement document may include commercial issues involved in the purchase and operation of the equipment. Some of these issues are as follows: -

(a) Through life contractual repair.

(b) Warranty and performance guarantees.

(c) Training requirements.

(d) Duration of spares availability.

(e) Transfer of intellectual property rights.

5. **Material**. The material of construction shall conform to the following specifications. The material and standard parts which are not specifically described, and which are necessary, shall meet the design and environmental specifications, and shall be used only after prior approval of *IN*. **All NAB castings should be subjected to Radiography with shrinkage level II**. The guide to material for various parts of a centrifugal water pump is placed at **Appendix 'D'**.

6. **Type of Pump for Selection**. All centrifugal water pumps for selection should follow the under mentioned criteria for selection:-

(a) All centrifugal water pumps to be vertical except Ref plant sea water pump, Bilge pump, Fresh water and Feed water pump to be horizontal.

(b) All vertical centrifugal water pumps are required to be inline pumps except salvage pump which are required to be bottom suction side discharge.

(c) All horizontal pumps to be centre suction and top discharge.

(d) Fresh water, feed water, bilge pump and ballast pump may have a priming unit based on requirement of the platform.

(e) All pump manufacturers to provide standard flanges and fasteners iaw BS 4504 for interchangeability.

7. **Scope of supply.** The scope of supply shall include the following items:-

(a) Pump complete.
(b) Electric motor.
(c) Companion flanges.
(d) Expander and reducer (as required).
(e) Bellows.
(f) Shock and vibration mounts.
(g) Gauge panel along with pressure gauges and isolating valves.
(h) Starter and control panel.
(j) Interface with IPMS if any.
(k) Special tools and test equipment for onboard maintenance.
(l) Complete drawings and technical documents.
(m) OBS and B&D spares.
(n) Training to *IN* crew.

Note: - The above list is only indicative. Any alterations and additions to the above list, which are considered necessary for satisfactory performance of the pump by the vendor, shall be included in the scope of supply.

8. **Safety Devices**. The system should have suitable safeties and alarms. Safety devices are to be fitted as necessary and the list is to be included in the offer. The details of interlocks (if any) shall also be specified in the offer.

9. **Hydraulic Design**. Cavitation i.e. the formation and sudden collapse of vapour cavities can occur whenever the local absolute pressure falls below the fluid vapour pressure. Cavitation causes deterioration in the pump performance and can cause noise and vibration. Cavitation should not occur at design duty of the pump. The selected speed of operation of pump, area of flow and the form of suction passages are to be designed with respect to the viscosity and vapor pressure of the pumped fluid to provide smooth flow to the impeller or rotor to avoid cavitation. Sudden changes in the cross sectional area for flow, and the direction of flow of fluid are to be avoided.

10. **Self Priming**. A pump may be required to be of the self priming type when machinery arrangement dictates that the pump/ impeller are above the fluid level. This requirement when applicable will be included in the order specification.

11. **Submersibility**. When it is specified that the pump and motor assemblies are to be capable of submergence, a flooding level of 05 meters above the pump seating is to be specified unless a greater flooding level is required. Under these

conditions, the pump is to be capable of starting and running for a period which will be specified in the order specification.

12. **Mechanical Design**. Pump casing is to be designed to withstand bending moments imposed by the fluid piping. Drain connections, where provided are to be at the lowest point of each pump casing. The direction of rotation of the pump is to be indicated on the pump casing. A provision for venting/ priming arrangement is to be provided on the pump.

13. **Seals**. Shafts are to be provided with mechanical seals of the face type. The design of the seal is to preclude ingress of oil or grease into the unit and permit replacement of mechanical seals with minimum amount of dismantling. The supplier is to indicate type and sealing materials in the offer.

14. Equipment, its components and piping will be arranged and installed to permit ready accessibility for operation, inspection and maintenance. The manufacturer shall furnish instruments that are needed for its proper operation and control. The head-discharge characteristics are to be stable throughout the whole of working range. Pumps are to incorporate suitable eyebolts for lifting gear to facilitate easy maintenance.

15. **Instrumentation**. The minimum essential instrument panel will include pressure gauges for suction and discharge in local position only. Failure of one or more of these gauges shall not make the equipment / system non-operational. Root connection of the gauge piping should be at the pressure source. Isolating cocks for the gauges to be suitable provided. Calibration of the gauge (scale) should be so selected that the maximum normal pressure will be approximately 75 percent of the full-scale range, and system-operating valves are in the two thirds of the scale range. Gauge piping will be connected with 08 mm OD copper tube. Instrument gauge board shall be 1/8 inch thick of steel.

16. The type and rating of the equipment and its components should be compatible with its service demands. Its size, weight and complexity should be held to a minimum, consistent with reliable and economical operation and maintenance.

CHAPTER – V

MISCELLANEOUS TECHNICAL REQUIREMENTS:

Maintenance Policy

1. The planned maintenance should be scheduled only after minimum operational time of 24 to 36 months between refits.

2. All maintenance and repair between overhauls will be carried out in-situ, onboard. The manufacturer shall forward the maintenance schedule, the planned maintenance intervals and procedure for carrying out the same.

3. **Interface Definition**. The manufacturer shall provide all information required for integration of the equipment onboard the ship including details of electrical supplies required for the pump motors and the Electric Control Panel etc.

Control and Monitoring.

4. Pump should be equipped with local instrumentation panel incorporating sufficient instrumentation to indicate the correct operation of the pump. The instrumentation panel should be easily observed from the local start/ stop/ emergency push button station.

5. The equipment should be designed for unmanned continuous operation and should be provided with a robust control and monitoring system. Each equipment is to be arranged for local starting and control in addition to remote/ automatic starting or control specified. Suitable provision for integration with IPMS may be provided.

6. The pump starter is to be located adjacent to the pump's local instrumentation so that operator is immediately aware of whether or not the pump has picked up suction.

7. Additionally, the machinery may require provision for data logging, fault diagnosis and remote display of operating parameters at locations specified by the user.

Reliability

8. Reliability shall be achieved by designing equipment to be robust and simple. The equipment is to be designed for minimum maintenance and for ease of such maintenance as and when required. Considering that all centrifugal pump has been standardized to monobloc pumps, the pump manufacturers are required to ensure

that the motor manufacturers use a robust bearing design to absorb axial and radial loads to reap the full benefits.

9. The manufacturer shall define the following reliability criteria for the pumps. The manufacturer shall state the source of the data and assumptions made in making reliability predictions.

(a) MTBD – Mean Time between Defects.
(b) MTBO – Mean Time between Overhauls.
(c) MTTR – Mean Time to Repair.
(d) Planned life.
(e) Life at maximum continuous rating.

Product Support

10. The supplier is to confirm product support for next 25 years for the equipment offered by them. In case the equipment is likely to be obsolete before 20 years, the supplier shall notify the Indian Navy with two years prior notice.

Painting

11. Marine Standard painting to be applied as applicable. The final colour at the time of delivery is to be RAL 7038 Epoxy Dark Admirality Grey iaw Indian Standard Congress ISC 632.

Instruction Plates

12. Instruction plate/ plates listing the starting/ stopping procedure and precautions in brief are to be prominently displayed on the equipment. The instruction plates are to be brass engraved. All gauges on the panels and the LCP should have tallies.

Isolating Valves

13. The pump will be fitted with isolating valves as required to provide isolation without the need for shutting down the system during maintenance. Gauges and monitoring equipment or devices will be arranged to permit ready vision or audibility within operating area of the equipment.

Packaging and Preservation.

14. Packaging, waterproofing, containerization and preservation considerations are to be iaw MIL-STD-2073-1E.

CHAPTER – VI

NOISE, SHOCK AND VIBRATION QUALIFICATION

1. **Introduction**. Design of the equipment, mounting system and connections / sub components, associated controls, panels should be undertaken to withstand specified shock loading without significant effect on performance and without any portion of the equipment coming adrift or creating a hazard to personnel or to other equipment. The installation and connections of the equipment shall account for the extreme displacements that may occur under shock conditions. Further, every reasonable and practical effort shall be made to minimize equipment noise and vibration through sub-assembly and component design. All parts of the equipment and accessories are to be designed to ensure resistance to fracture distortion or misalignment due to forces of vibration. Suitable flexible bellows and noise reduction clamps are to be used for all piping components within / associated with the equipment.

Shock Qualification.

2. All pumps and associated equipment installed in ships will be subjected to shock acceleration in service. Therefore all pumps should have an inherent degree of shock resistance.

3. The level of shock resistance the pump should have in any particular application will depend upon the type of ship, position of the pump in the ship etc. These details will be specified in the order specifications in accordance with BR 3021 and ***IN*** shock grade policy placed at **Appendix 'E'** for reference. Design shall be suitable to withstand shock loading without significant effect on performance and without any portion of the equipment coming adrift or creating a hazard to personnel or to other equipment.

Noise and Vibration.

4. **Mechanical Vibration**. Every reasonable and practical effort shall be made to reduce equipment noise through sub-assembly and component design. Unless otherwise specified in the relevant procurement specification, the mechanical vibration requirements for equipment shall be in accordance with MIL-STD-167 and ISO 10816 Part III.

5. **Structure Borne Noise**. The structure borne noise levels from the pump measured above the mounts nearest to the foundation must be less than the noise targets given by Navy. All noise and vibration values of equipment and mount

stiffness values need to be guaranteed and measured during Factory Acceptance Trials and should comply with the levels set out in **MIL-STD-740-2**.

6. **Air Borne Noise**. The air borne sound power level radiated by the auxiliary equipment should comply with the levels set out in **MIL-STD-1474 E**.

7. **Shock and Vibration (S & V) Mounts.** The S and V mounts are to be supplied along with the equipment indicating the following data: -

(a) Type.
(b) Quantity.
(c) Dynamic stiffness of mounts -1/3rd Octave band level 10Hz to 10 kHz.
(d) Transmissibility -1/3rd Octave band level (10Hz to 10 kHz).
(e) Footprint indicating position of mounts.
(f) Characteristic dimensions of the mounts.
(g) Rated load, deflection in 3 – axes and the natural frequency.
(h) Shock acceleration with and without the resilient mounts.

8. Vibration data, above and below the mounts (under the standard and optional mounting arrangements) is to be recorded as acceleration in dB reference $1e^{-5}$ m/ sec^2 (RMS). This data shall be in both 1/3 Octave band and narrow band spectra within a frequency range of 10 Hz to 10 kHz at 25%, 50%, 80% and 100% rated output, and supplied in graphical and digital format.

CHAPTER – VII

QUALITY ASSURANCE AND TESTING/ TRIALS

1. The design shall be such that weight and size are kept to the minimum possible extent, ensuring no compromise in reliability or significant deviation in the performance criteria. The manufacturer is to follow the quality assurance plan iaw the SQAPs promulgated by DQA(WP). Details of test equipment, test methods, preliminary qualification tests, etc are to be indicated in the offer. Shop floor tests and type tests (if required) are required to be conducted prior to dispatch of the pump by the supplier.

2. **Approval of Drawings**. All items are to be manufactured as per agreed/ approved Technical specification/ Purchase Order and drawings. The GA and installation drawings are to be submitted to *IN* for approval in quadruplicate upon placement of order prior commencement of manufacturing. Changes incorporated by *IN* will be binding on the supplier. All drawings, associated documentation and equipment list applicable must be in English language. The checking and approval of the drawings will not relieve the Supplier of the responsibility of ensuring that the design is sound, safe and strictly in accordance with the specification. Drawings are required to be prepared i.a.w. the QAD available on www.dgqadefence.gov.in

3. **SQAP for Centrifugal Pumps**. The **Standard Quality Assurance Plan (SQAPs)** promulgated by DQA (WP) and available on www.dgqadefence.gov.in. is required to be followed for manufacturing of all centrifugal water pumps. Any amendment to SQAPs shall be submitted for approval to DQA (WP) upon placement of order prior commencement of manufacturing. Changes incorporated by Navy will be binding on the supplier. Assembly and manufacturing is to commence thereafter as per approved drawings and SQAPs/ QAPs. SQAPs for centrifugal water pump is placed at **Appendix 'F'** for reference.

4. **Deviations**. Deviations from the approved drawings/ standards, if any, will render the affected parts liable to rejection. Customer's written approval is to be obtained before incorporation of any deviation into the equipment.

5. **Inspection and Testing/ Trials**. The equipment will be subject to stage inspection and final test and trials by the Naval Inspection Agencies as mutually agreed with the equipment manufacturers. All defects observed/ noticed during the Inspection/Testing are to be rectified before dispatch. After shop test the log book/ work test certificates etc as applicable will be made available along with the documents being supplied. Calibration certificates of all the gauges and instruments fitted on the equipment, sub-assemblies, associated auxiliaries and the instruments supplied loose, must be supplied

along with the main equipment. Following agencies will form the inspection, testing and trials team: -

Manufacturing inspection, testing/ trials	Reps of DQA(WP), New Delhi
FATs	Reps of DQA (WP) and Ordering Authority
Onboard acceptance trials	Reps of MTAA & ETMA of Indian Navy

6. The Supplier or his sub-contractor shall provide all necessary facilities for inspection including: -

(a) Instruments and apparatus.
(b) Access to QA Records.
(c) Access to premises.

Type Test.

7. The first of each type of equipment is to be type tested and each successive unit is to be production tested at the manufacturer's works. The aim of the type test is to: -

(a) Demonstrate to the satisfaction of the *IN* through the main contractor or Naval Inspector that the unit is in all respects suitable for its intended service and that it is able to perform its specified function.

(b) Establish the performance characteristic of the unit.

(c) Establish principal performance figures for checking production tests on later units.

8. **Proposals for Type Test**. The equipment manufacturer is to prepare the proposal for the type test that should include the following:-

(a) Date of commencement and completion of test.
(b) Delivery date of equipment.
(c) Place of test.
(d) List of tests and duration of each test.
(e) Estimates of performance.
(f) Details of each test including measures to be taken.
(g) Sketch of the test rig showing measurement points.
(h) Details of measuring equipment and standard of accuracy.

9. Type test shall comprise any or all of the following:-

(a) **Determination of physical data**.

(i) Assembled weight of the equipment dry and filled with working fluid.
(ii) Weight of individual assemblies.
(iii) Maintenance envelope.
(iv) Determination of centre of gravity, radius of gyration.

(b) **Wear**. Before a pump is type tested, a record is to be made by direct measurement of the relevant dimensions of wearing parts and clearances, unless these dimensions are available from the manufacturing records of the unit for comparison with the measured dimensions of the same components on completion of the endurance test.

(c) Operation of turning mechanism.

(d) **Safety tests**. All protection devices are to be tested to establish satisfactory operation.

(e) **Pressure test**. All physical retaining parts will be hydrostatically tested to the rated pressure for duration of five minutes. Also the entire pressure boundary on assembly of pump will be tested upto 1.5 times of working pressure for a minimum duration of three minutes.

(f) **Start/ stop test**. A minimum 30 start/ stops are to be carried out. Once the pump has been started, it should run for at least 15 minutes and then stopped.

(g) **Noise and vibration measurement**. Self induced noise and vibration levels at specified duty shall be measured. Air borne noise measured will not exceed the agreed value. Structure borne noise and vibration shall be measured above the mountings and vibration signature shall be recorded to form the bench marking data.

(h) **Shock test**. First of its kind pump will be physically shock tested at NSTL, Visakhapatnam to comply to *IN* Shock Grade 'A'. Alternatively, the shock calculations can also be submitted to NSTL, Visakhapatnam for approval, subject to approval from *IN* for not undertaking physical shock testing. The physically shock tested pump is to be yellow banded and handed over to *IN* for utilisation as training model. In case the equipment is required to be physically shock tested, requirement of yellow banding the equipment along with disposal (custodian) of the yellow banded equipment is to be

clearly brought out in the RFP. The same will assist in transferring of the yellow banded equipment to the concerned agency.

(j) **Inclined test**. Inclination test run will be carried out for duration of 30 mins at duty point in each direction of maximum inclination specified.

(k) **Endurance test**. One pump will be subjected to an endurance test for duration specified in the order specifications. The pump will be strip examined by the manufacturer after endurance test and all dimensions of the components are to be recorded.

(l) **Strip examination**. The pump will be stripped open post trials and all components will be inspected for wear. All dimensions, clearances are to be recorded with respect to specified limits and the wear down.

10. **Sub-contracts**. The Supplier may sub-contract portions of the work to other competent firms/ individuals as necessary. A list of proposed sub-contractors is to be submitted to the Customer for approval well in advance of sub-order tendering. Sub-contractors deemed unsuitable by the Customer shall not be approached. Copies of all sub contracts are to be provided to the Customer.

11. **Progress**. After placement of order, the Supplier is to submit a PERT chart for execution of the contract. This chart is to be mutually agreed to by the Supplier and *IN*. Thereafter, the Supplier shall render monthly progress reports to the Customer, briefly describing the progress of work on the order, including sub-orders.

12. **Performance test**. Each pump is to be tested for duration specified in the order specifications, to establish its performance over the full specified duty range to measure:

(a) Suction head.
(b) Discharge head vs. Output (at rated speed).
(c) Current, voltage, speed and power consumption.
(d) Efficiency.

CHAPTER – VIII

INSTALLATION & COMMISSIONING, SPARES AND DOCUMENTATION

1. Installation, trials, testing, tuning and commissioning of complete equipment is to be carried out on-board based on the scope of offer specified.

2. The manufacturer is required to provide the necessary representatives to assist in carrying out inspection and supervise the work that is done on the equipment, during the following phases: -

(a) On-board erection, alignment and connections.

(b) Setting to work.

(c) Harbour and sea trials (as required).

On Board Trials

3. On successful completion of trials at manufacturer's premises (FATs), the equipment is to be installed on board the ship and tested. All documentation related to setting to work, testing/ tuning, operation, maintenance, and logistic requirements (including tools) is to be provided and a mutually agreed program for their supply is to be made.

Spares

4. The On-board spares, Base and Depot spares and test equipment are to be recommended by the supplier. Such recommendations are to be commensurate with the reliability of critical components and component use in the system. Special tools and test equipment is to be supplied for onboard maintenance.

5. **Installation and Commissioning Spares**. The OEM shall supply one set of Installation and Commissioning spares required for setting to work and commissioning of the Equipment along with main equipment. The spares list should normally include one complete set of consumables and instrumentation spares.

6. **On Board Spares (OBS)**. OBS, special tools and special list equipment, which will be supplied with the main equipment, are to be included in the scope of supply and accordingly quoted for. The PIL shall be comprehensive and no part of the pump shall be left out. All parts will be introduced into the Navy's Inventory List (INCAT). The range and scale of OBS shall be so proposed that independent repairs

are possible by the ship's crew at sea by part replacement. The OBS and tools should include following (but not limited to): -

(a) All spares required for exploitation up to 2 years. The indicative list of OBS (not limited to) required to be supplied by the manufacturer is placed at **Appendix 'G'**. The indicative list of OBS is for a set of six pumps fitted onboard a ship. In case OBS is being procured for more/ less number of pumps fitted onboard, the numbers are to be accordingly scaled.

(b) One set of important assemblies to effect "repair by replacement".

(c) One set of general-purpose maintenance tools and test kits along with each plant.

(d) One set of special tools required for dis-assembling / assembling of components of effect "repair by replacement" / inspection of components.

7. **Five-year Base and Depot Spares / Comprehensive Part Lists**. Base spares recommendation is to cover maintenance/ overhaul requirements for 5 years including two refits. Itemised cost of B&D spares with validity of 2 years is to be forwarded with the main offer. The offer should include the following: -

(a) All spares required for 5 years exploitation. The mandatory list of B&D (not limited to) required to be supplied by the manufacturer is placed at **Appendix 'G'**. The indicative list of B&D is for three ship set with six pumps fitted onboard each ship. In case B&D is being procured for more / less number of pumps fitted onboard or ship set, the numbers are to be accordingly scaled..

(b) All consumables required for 5 years including two refits.

Drawings and Document along with the Equipment

8. All associated documentation, drawing and equipment list applicable must be in English language. All drawings and documents shall contain dimensions in scale and other parameters in metric units (SI Units). The drawing and documentation shall be complete to permit installation, operation and testing of equipment on board.

9. The extent and scope of technical drawings and documents shall be prepared and supplied to include (but not limited to) the following: -

(a) **Drawings**.

(i) Dimensional outline drawings (in metric units), of all major assemblies showing principal dimensions to establish the extent of space required in all direction for installation, operation and maintenance. Drawings are required to be prepared i.a.w. the QAD available on www.dgqadefence.gov.in.

(ii) As fitted drawings with description and part numbers of each major component and sub-assembly.

(iii) Assembly drawings of all individually mounted units.

(iv) Position and dimension of all mechanical interfaces.

(v) Mounting arrangement of each individual sub assembly.

(vi) Wiring diagram and connection diagram for all junction boxes and control panels.

(vii) Detailed definition of all terminal points and interfaces.

(b) **Documentation**. The vendor shall submit the technical proposal, including the following documents: -

(i) Operational Manual.
(ii) Repair Manual.
(iii) Instrumentation list.
(iv) Seating design and mounting details of control panel.
(v) Proposed inspection plan.
(vi) Indicative maintenance envelope for main tasks.
(vii) Tools required for installation, commissioning and maintenance.
(viii) Proposed two year on board spares and tools.
(ix) Proposed five year base and depot spares and tools holdings.
(x) Maintenance Manual showing periodicity of Maintenance and routines.
(xi) Part Identification List.

10. All associated documentation, drawing and equipment list applicable must be in English language. All drawings and documents shall contain dimensions in scale and other parameters in metric units (SI Units). The drawing and documentation shall be complete to permit installation, operation and testing of equipment on board.

CHAPTER – IX

MOTORS AND STARTERS

1. **Technical Specifications**. The motors shall be capable of developing specified rated output at extreme environmental conditions, ambient temperature, voltage and frequency. Motors and control panels will be as EED-Q-071 (R4) and Def Stan 02-532 & 536. Motor Run –Up –Time is not to exceed 8 Sec. While developing the rated output at such extreme conditions, the temperature rise of the motor shall be maximum 10 deg C higher than the permitted temperature rise at nominal voltage, frequency and temperature. The motors are to be manufactured for satisfactory performance under the following conditions and input supply characteristics/ specifications:-

(a) Rated voltage - 415V or 380V, 50Hz, 3 Phase (As per Ship's power supply)

(b) No of phases - 3 (Three) 3 wire supply system

(c) Voltage Tolerance

(i)	Steady state	- ± 0.5% at all load.
(ii)	Voltage range	- -15% to + 10%
(iii)	Recovery time	- 01 second.

(d) Frequency

(i) Nominal frequency	- 50 Hz
(ii) Constant load tolerance	- ± 0.5 Hz or ± 1.0%
(iii) Load range tolerance	- ±1 Hz or ± 2.0%
(iv) Transient	- ± 2.5 %
(v) Time of recovery	- 2 Sec to within 1% of transient
(vi) Frequency range	- +/- 3%

(e) Cooling - Air Cooled

(f) Enclosure - IP 56-Motors installed below deck
IP 57-Motors installed on weather deck
IP 58-Submersible motors upto 10 mtrs.
IP 68- Submerged beyond 10 mtrs.

(g) Frequency at rated load - 50 Hz

(h) Power factor - 0.7 lagging upto 5 KW
0.8 lagging above 5 KW

(j)	Rating	-	Continuous rating.
(k)	Efficiency	-	Motor should conform to efficiency class Eff -2(improved efficiency) mentioned at table 1 to 4 of IS 12615: 2004
(l)	Insulation	-	Class 'F' or above

2. **Environmental Conditions**. The design of the Motor should cater for the most adverse of the environmental and ambient conditions. The AC Motor and control equipment shall conform to the following specification:-

(a)	Ambient temperature	:	0 to 55° C
(b)	Relative Humidity	:	30-100% at 35° C.
(c)	Ship Motion	:	List : 30° Roll : ± 30° Pitch : ± 15°

3. **Shock and Vibration Requirement**. Motors are to be designed to withstand their full shock levels without allowing for the protection afforded by shock mountings. In general, the shaft deflection under designed shock and acceleration shall not exceed the air-gap dimension. Motors shall be capable of withstanding forced vibrations within the range of 5 to 33 Hz for major warships and 7 to 300 Hz for minor warships and other naval ships/crafts built in accordance with classified society's rules and regulations. Precautions must be taken against vibration excited by any attached driving or driven machinery having reciprocating parts. The fixing position for shock vibration mountings are to be such that the height of the machine center of gravity above the plane of fixing does not exceed one half of the minimum span of the mountings.

4. **Motor Protection**. All motors are to be provided with a means of protection from voltage variation of -15% to + 10% and overloads. The motor thermal protection system is to be designed to trip the motor when the winding has reached the maximum safe temperature of the insulation. The motor thermal protection system must detect the occurrence of maximum temperature by means of Positive Temperature Coefficient Thermistors (PTCT). The PTCTs provided in each phase of the windings shall be connected in series and only one pair of leads shall be brought out to separate terminals in the motor terminal box. The PTCT leads are to be taped to the stator leads for support.

5. **Starting Current**. The value of starting current shall not exceed 6 to 7 times the full load current for motors of capacities up to 75 kW and 4 to 5 times full load

current for motors of capacities above 75 kW. These values are applicable to direct on line starting only. No positive tolerance is allowable on starting current. For Star-Delta/Reactive type starters, the starting current for motors with star-delta starters should not be more than 3 times of rated current. In order to limit the starting current, DOL starters shall be used for motors upto 10 KW rating.

6. **Over-Speed**. All motors are to be designed to withstand, without excessive noise and vibration or damage, unloaded operation for a period of 15 minutes at a speed 15% in excess of the highest synchronous speed, i.e. the speed corresponding to the specified frequency plus the frequency tolerance of the supply.

Starter

7. **Design and Performance**. The individual components of the starters should conform to the relevant IEC and IS applicable for respective products. The manufacturers of starters / control panels for ship based applications should be ISO 9001 and ISO 14001 certified organisations manufacturing majority of the starters components like contactors, MCCBs/MPCBs, intelligent motor protection unit, relays etc. However, in addition to the basic standards, typical samples of assembled starters will also have to clear various Type /Routine tests as per this specifications and environmental tests as per JSS – 55555. The starter system should consist of motor starter with following associated components: -

(a) Main incomer switch-disconnector fuse/MCCB of SCPD unit for isolation purpose.

(b) HRC fuses for motor, cable & switchgear protection against short circuit.

(c) Line contactor for physical isolation (ON/OFF either from local or from remote) under operation of protection system.

(d) Intelligent microprocessor based Motor Protection Unit for Comprehensive protection.

(e) Ultra fast acting semiconductor fuses for thyristor protection (applicable to thyristor based soft starters).

(f) By-pass contactor for by-passing the controller during normal run condition (to improve the life of the thyristors).

(g) Types of starters to be provided for pump applications are as follows:-

(i) Upto 5 kW – DOL

(ii) 5-15 kW – Star/ Delta Starter.
(iii) Above 15 kW – Soft Starter.

Starter Protection

8. Starters for all motors of upto 15 kW rating should be incorporated with microprocessor based intelligent device called Microprocessor Protection Unit (MPU). Motors above 15 kW capacity are to be fitted with soft starters. Thermistor Input Protection is to be as per clause 0616(f) of EED-Q-071 (R4), Issue-1, Mar 07. The MPUs should be able to clearly distinguish between starting/running condition of the motor. The following protections from the above should be available at the time of motor starting & running:-

(a) Earth Fault.
(b) Overload.
(c) Short circuit.
(d) Too many start.
(e) Stalling.
(f) Single phase.
(g) Start Time out.
(h) Internal error.
(j) Start inhibit.

9. Following protections should be available only during running condition of the motor:-

(a) Voltage Unbalance.
(b) Undercurrent.
(c) Over Load.
(d) Over current.
(e) Under voltage.

10. **Internal Wiring**. LFH (Limited Fire Hazard) cables are only to be used for internal wiring.

11. **Routine Tests**. Following routine tests are to be carried out on the motor: -

(a) No-Load.
(b) Over Speed.
(c) Winding Resistance.
(d) With stand Voltage Test (High voltage test).
(e) Standard Withstand Voltage Test
(f) Insulation Resistance.

12. **Acceptance Tests**. Acceptance test which are required to be carried out are as follows:-

(a) Noise level test.
(b) Enclosure effectiveness tests.
(c) Environment withstand tests.
(d) Vibration tests.
(e) Shock or impact tests.
(f) Bearing health check at No Load conditions.

13. **Noise Level Test**. The overall sound power level in decibels must not exceed 90 db even at 20% over speed. In a sound proof non-reverberant room the sound level recorded by sound-level meter shall not exceed this level at a distance of one meter from the motor.

14. **Enclosure Effectiveness Tests**. These tests are to be carried out in accordance with IS 4691. All motors except 'water proof' motors are to be tested for IP 56 protection, water proof motors are to be tested for IP 57 protection. Motors submersed upto 10 mtrs. Are to be tested for IP 58 and those submersed beyond 10 mtr. to be tested for IP 68.

15. **Environmental Tests**. These tests are to be carried out as per Joint Service Specification JSS 55555. One motor from each range is to be subjected to these tests and other frame size in the range shall be accepted on the basis of certification from DWP/ DGI. The proto type motors and starters will be subjected to environmental tests as per table given below:-

Sl	Test	Specification	Test Condition/ Severity
(a)	Vibration	JSS 55555 – Test 28	5 – 33 Hz
(b)	High Temperature	JSS 55555 – Test 17	55 deg C for 16 Hrs. Procedure 5, Test Condition 'G'
(c)	Damp heat	JSS 55555 – Test 10	40 deg C – 95 deg C RH for 16 Hrs
(d)	Drip proof	JSS 55555 – Test 11	Vertical Water drip 1 m height for 15 min
(e)	Mould growth	JSS 55555 – Test 21	29 ° C 90 % RH mould growth chamber for 28 days
(f)	Bump	JSS 55555 – Test 5	1000 bumps – 40 G, 6 m/sec
(g)	Shock/Impact	JSS 55555- Test 24	As per laid down specifications
(h)	Inclination/Tilt	CL 3.12	As per laid down specifications
(j)	Ship Motion	NWS 1000, Pt1 Cap 1, Section 8	As per laid down specifications
(k)	EMI/EMC	MIL-STD 461 E	CE 01, CE-03 & RE-01

Sl	Test	Specification	Test Condition/ Severity
(l)	Performance/ Electrical	NES 629	Clauses 0401 to 0521
(m)	Environmental Stress Screening	DQAN policy 6630/Policy-17/DQAN/QA-11 dated 15 Mar 12 or any revised policies in vogue	For PCBs and Electronic components

16. **Test Results.** The test data obtained during performance tests of motors in factory premises be logged and following graphs be generated to evaluate the motor performance:-

(a) Torque Vs Speed.
(b) Current Vs Speed.
(c) Current Vs Time.
(d) Efficiency Vs Output.
(e) Power Factor Vs Output.

17. **Binding Drawings**. The following binding drawings in respect of motors and their control gear (starter) are to be submitted:-

(a) Overall dimensions of the equipment.
(b) Mounting arrangement.
(c) CG of the equipment.
(d) Winding and performance data sheet.
(e) Part identification list, indicating part No, Quantity makers name, specification no. etc.
(f) Sectional assembly drawings.
(g) Motor terminal box diagram.
(h) Terminal connection and circuit diagram.

18. **Documents**. One set of following documents are to be supplied along with the main equipment:-

(a) Equipment technical manual.
(b) Installation spécifications.
(c) CPL/PIL.
(d) As fitted drawings.

19. The documentation for the motor consisting of Handbook/ Part Identification lists and drawing should be so prepared that these fulfil the following three basic requirement:-

(a) Facilitates repair/ rewinding and over hauling of the motor by ship staff/dockyard technicians.

(b) Details of spares which may be required for carrying out onboard repairs/maintenance.

(c) Logistic management so as to enable the store authorities to identify and take procurement action of the spares/ equipment.

20. The documents which are required to be provided by the manufacturers are grouped as follows:-

(a) Winding and performance data sheet.
(b) Sectional assembly drawing.
(c) Part identification list.
(d) Dimension sheet.

21. **On Board Spares**. One set of Onboard Spares (OBS) sufficient for on board maintenance routines/ repairs/ defect rectification etc for a period of two years to be recommended by the supplier for approval. A set of approved OBS shall be supplied along with the main equipment.

22. **Base & Depot Spares**. The Base & Depot spares sufficient for 5 years of maintenance support of the system is to be recommended by the manufacturer. These are 5 years spares consisting of:-

(a) Stock quantities of on board spares.

(b) Spare parts estimated as requirement for over haul and maintenance tasks to be under taken in Dockyard and base repair organisation.

(c) Important sub assemblies expected to be required for occasional replacement during overhauls for repairs during break downs/ damage etc.

CHAPTER X

TRAINING

1. Complete training package for on board exploitation and maintenance (first second and third level Maintenance) along with tools and test kit to be offered. The manufacturer shall formulate and provide all necessary training dockets/ charts/ Computer Based Training Packages (CBT Packages) for ship's staff/ shore support personnel/ course participants for training.

2. The training sessions are required to cover the following (but not limited to):

(a) Familiarization on design, installation and operation, to be carried out in Equipment manufacturer's workshop during production of the first ship set.

(b) Instruction on Operation and Maintenance to be carried out at a location as indicated by Navy as mutually decided with the firm for crew operators and base maintainers.

(c) Training on control systems operation and maintenance.

CHAPTER – XI

SCOPE OF THE OFFER

1. The offer should be complete with all relevant details as sought by the procurement agency. The following information is to be submitted in the initial offer/ tender enquiry: - (**Any offer not submitted in accordance with the requirement is liable to be rejected)**

(a) Technical specifications of the pump and assemblies/ sub-assemblies.

(b) GA drawing of the pump indicating overall dimensions with maintenance envelope.

(c) Seating and installation particulars including feet drawings.

(d) Details of motor and control panel including type test certificates if held.

(e) List of OBS and B&D with itemized cost.

(f) Delivery period from date of placement of order.

(g) Scope of supply, installation and commissioning with price break up.

(h) Demarcation between scope of supply/ work between firm and that of Navy.

(j) Time schedule for trial and commissioning.

(k) Clause/ para wise compliance matrix. Deviations from the requirements be specified by submitting as deviation list.

(l) Proposed quality inspection plan iaw SQAP.

APPENDIX 'A'

LIST OF STANDARD DUTY POINTS FOR CENTRIFUGAL WATER PUMPs

S. No	Application	Duty Point		
		Flow Rate (TPH)	Disch. Head (MWC)	Suction Head (MWC)
1	Salvage Pumps	310	15	Flooded (5MWC)
2		200	20	Flooded (5MWC)
3		150	20	Flooded (5MWC)
4	Fire Pumps	150	80	Flooded (5MWC)
5		100	80	Flooded (5MWC)
6		80	80	Flooded (5MWC)
7		60	80	Flooded (5MWC)
8	Chilled Water Pumps	160	60	Flooded (5MWC)
9		110	60	Flooded (5MWC)
10		80	60	Flooded (5MWC)
11		60	60	Flooded (5MWC)
12		40	60	Flooded (5MWC)
13	Sea water application on viz, Sea water cooling pump, AC & Ref. Sea water pump, Ballast Pump (may be self priming if required on case to case basis)	250	30	Flooded (5MWC)
13A		250	30	Self Priming (5MWC)
14		200	30	Flooded (5MWC)
14A		200	30	Self Priming (5MWC)
15		160	30	Flooded (5MWC)
15A		160	30	Self Priming (5MWC)
16		125	30	Flooded (5MWC)
17		110	30	Flooded (5MWC)
18		80	30	Flooded (5MWC)
19		60	30	Flooded (5MWC)
20		40	30	Flooded (5MWC)
21		25	30	Flooded (5MWC)
22		15	30	Flooded (5MWC)
23	Ref Plant sea water Pump	7	30	Flooded (5MWC)
24	Bilge Pump	10	30	Self Priming (5MWC)
25		6	30	Self Priming (5MWC)
26	Fresh water and Feed water Pump	10	53	Self Priming (7MWC)
27		6	40	Self Priming (7MWC)
28		3	40	Self Priming (7MWC)

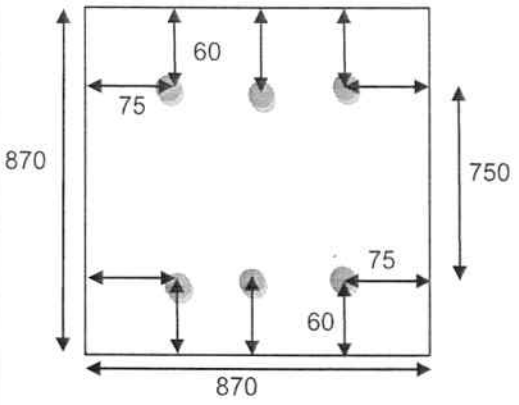
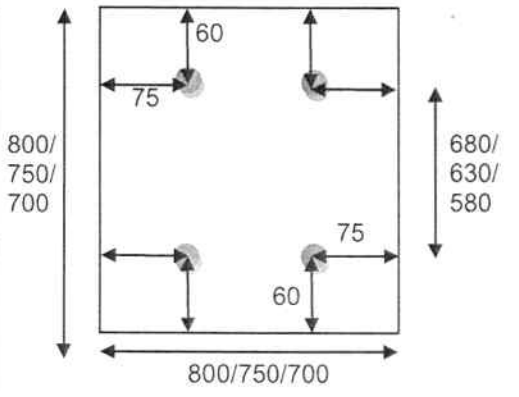
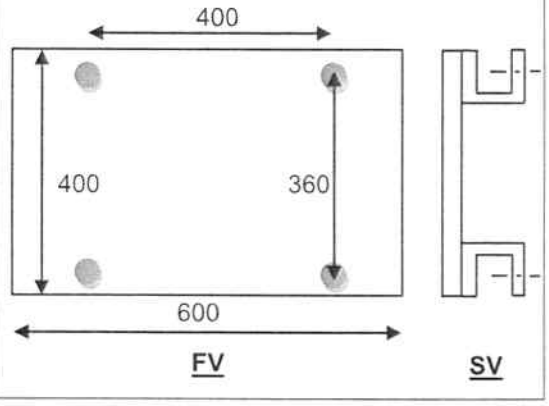
APPENDIX 'B'

DETAILS OF DUTY POINTS FOR CENTRIFUGAL WATER PUMPs

S. No.	Application	Duty Point			Orientation and Type of Pump	Recommended Motor Rating (KW)	Recommended L x B x H of complete assembly inclusive of motor and SV mounts (Meter)	Finalized Dimension of Base Plate L x B (Meter)	No. of SV Mounts
		Flow Rate (TPH)	Disch. Head (MWC)	Suction Head (MWC)					
1.	Salvage Pump	310	15	Flooded (5MWC)	Vertical, bottom suction side discharge Monoblock	22	0.75 X 0.75 X 1.6	0.75 X 0.75	4
2.		200	20			18.5	0.8 X 0.8 X 1.6	0.8 X 0.8	4
3.		150	20			18.5	0.8 X 0.8 X 1.6	0.8 X 0.8	4
4.	Fire Pump	150	80	Flooded (5MWC)	Vertical, Inline and Monoblock	60	0.87 X 0.87 X 1.6	0.87 X 0.87	6
5.		100	80			45	0.75 X 0.75 X 1.6	0.75 X 0.75	4
6.		80	80			37	0.75 X 0.75 X 1.7	0.75 X 0.75	4
7.		60	80			30	0.75 X 0.75 X 1.7	0.75 X 0.75	4
8.	Chilled Water Pump	160	60	Flooded (5MWC)	Vertical, Inline and Monoblock	45	0.75 X 0.75 X 1.7	0.75 X 0.75	4
9.		110	60			37	0.75 X 0.75 X 1.7	0.75 X 0.75	4
10.		80	60			30	0.75 X 0.75 X 1.7	0.75 X 0.75	4
11.		60	60			22	0.75 X 0.75 X 1.7	0.75 X 0.75	4
12.		40	60			18.5	0.7 X 0.7 X 1.7	0.7 X 0.7	4
13.	Sea water application viz, Sea water cooling, AC & Ref Sea water, Ballast Pump etc	250	30	Flooded (5MWC)	Vertical, Inline and Monoblock	37	0.75 X 0.75 X 1.6	0.75 X 0.75	4
13A.		250	30	Self Priming (5MWC)		37	0.75 X 0.75 X 1.6	0.75 X 0.75	
14.		200	30	Flooded (5MWC)		30	0.75 X 0.75 X 1.6	0.75 X 0.75	4
14A.		200	30	Self Priming (5MWC)		30	0.75 X 0.75 X 1.6	0.75 X 0.75	4
15.		160	30	Flooded (5MWC)		22	0.75 X 0.75 X 1.6	0.75 X 0.75	4
15A.		160	30	Self Priming (5MWC)		22	0.75 X 0.75 X 1.6	0.75 X 0.75	4
16.		125	30	Flooded (5MWC)		18.5	0.7 X 0.7 X 1.6	0.7 X 0.7	4
17.		110	30			18.5	0.7 X 0.7 X 1.6	0.7 X 0.7	4
18.		80	30			11	0.7 X 0.7 X 1.5	0.7 X 0.7	4
19.		60	30			9.3	0.7 X 0.7 X 1.3	0.7 X 0.7	4
20.		40	30			7.5	0.7 X 0.7 X 1.3	0.7 X 0.7	4
21.		25	30			5.5	0.7 X 0.7 X 1.2	0.7 X 0.7	4
22.		15	30			5.5	0.7 X 0.7 X 1.2	0.7 X 0.7	4
23.	Ref Plant sea water Pump	7	30	Flooded (5MWC)	Vertical, Inline and Monoblock	3.7	0.8 X 0.60 X 0.5	0.6 X 0.4	4
24.	Bilge Pump	10	30	Self Priming (5MWC)	Horizontal, centre suction top discharge, Monoblock	5.5	0.8 X 0.60 X 0.5	0.6 X 0.4	4
25.		6	30			3.7	0.8 X 0.60 X 0.5	0.6 X 0.4	4
26.	Fresh water and Feed water Pump	10	53	Self Priming (7MWC)		7.5	0.8 X 0.6 X 0.7	0.6 X 0.4	4
27.		6	40			5.5	0.8 X 0.6 X 0.7	0.6 X 0.4	4
28.		3	40			3.7	0.8 X 0.6 X 0.7	0.6 X 0.4	4

APPENDIX 'C'

INDICATIVE LOCATIONS OF SV MOUNTS ON BASE PLATE

Ser.	Size of Base Plates	Base Plate For Duty Points (TPH/MWC)	No. of SV Mounts	Location of SV Mounts
1.	870x870	150/80	06	
2.	800x800	200/20,150/20	04	
3.	750x750	310/15, 100/80, 80/80, 80/60, 160,60, 110/60, 80/60, 60/60, 250/30, 200/30, 160/30,	04	
4.	700x700	40/60, 125/30, 110/30, 80/30, 60/30, 40/30, 25/30, 15/30	04	
5.	800x500	7/30, 10/30, 6/30, 10/53, 6/40, 3/40	04	

Note: - All dimensions are in mm

APPENDIX 'D'

MATERIAL SPECIFICATIONS FOR COMPONENTS OF CENTRIFUGAL PUMPS

Centrifugal Pump Description	Pump Casing, Stuffing Box, Impeller, Wear rings	Base Plate	Shaft, Shaft Sleeve, Impeller Key	Fasteners
Fire Pump	NAB to DEF STAN 02-747 (NES 747)	MS	SS 316	IAW BS4504/ Material SS 316
Sea Water Pump (Ballast, Salvage, Aux cooling water, AC and Ref plant sea water Pump)				
Chilled Water Pump				
Bilge Pump (if centrifugal type)				
Fresh and Feed Water				

APPENDIX 'G'

INDICATIVE OBS AND B&D SPARES LIST FOR CENTRIFUGAL WATER PUMPS

Ser.	Description of Spares	OBS per Ship	B&D for three Ship Sets
1	Impeller	1	6
2	Impeller key	4	12
3	Wear Ring	2	6
4	Impeller nut	2	6
5	Impeller washer set	4	12
6	Adjusting Cam	1	3
7	Pump shaft and sleeve	1 set	3 set
8	Mechanical seal	6	12
9	Bearing set	2 set	6 set
10	Gasket and 'O' ring set	3 set	12 set
11	Instrumentation gauges/ transmitter	1 set	3 set
12	Fasteners	1set	6 set
13	Bellows (Discharge and suction)	2 set	6 set
14	Pressure gauge isolating valves	1 Set	4 Set
15	Pump Casing (casing and cover)	-	2 set
16	SV Mounts	-	2 set
17	Complete assembly of Pump inclusive of motor	-	2
18	Starter	-	2
19	Starter spares inclusive of fuses, push button, contactors, relays, lamps etc	2 set	6 set

Note: - The indicative list of OBS and B&D is for a set of six pumps fitted onboard a ship and three ship sets respectively. In case of more/ less number of pumps fitted onboard, the numbers are to be accordingly scaled.