OPEN TENDER TECHNICAL SPECIFICATION

FOR
THE PROJECT

SOLAR MULTI-EFFECT DESALINATION SYSTEM

SPONSORED BY
MINISTRY OF EARTH SCIENCES, GOVERNMENT OF INDIA, NEW DELHI

INDEX

1. PROJECT INFORMATION

1.1 LOCATION

The Solar based stand alone Sea Water Desalination System (Solar LTF – MED) shall be installed at Vivekananda Kendra, Kanyakumari district of Tamil Nadu. The nearest Railway station is Kanyakumari and Airport is Trivandrum located at a distance of approximately 2kms& 90 kms respectively from Project site.

1.2 INTENT OF PROJECT

The intent of Solar LTF-MED system is to produce Potable water from Sea Water. It is envisaged to be accomplished by utilizing the hot water produced by solar thermal collectors.Hot water shall be used to produce low pressure saturated steam which in turn, shall be used in Multi-Effect Desalination system to produce desalinated water from sea water.

1.3 PLANT INPUT & OUTPUT DATA

S. No	Description			Unit	Parameter
i	Capacity (8 hr Operation)			Tons/Day	10
ii	Quality of Output Water	Desalinated Water	TDS	ppm	5
		Potable Water	TDS	ppm	150
			pH	-	6.5-8.5
iii	Quality of Inlet of Sea Water	TDS		ppm	33,000 – 35,000
		pH		-	8.2
		Temperature		°C	30

2. SCOPE OF WORK:

The Scope of Work consists of detailed process and mechanical design of Evaporators & its subsystems, making the assembly and internal fabrication drawings of each effect and subsystems, preparation of training and maintenance documents.

Also includes procurement of raw materials, fabrication of Flash Chamber, Evaporators, Condenser and sub system, design and procurement of piping, electrical, instrumentation, delivery of all the equipments at site including all Bought out items, installation and commissioning of Solar photo voltaic power generation system with adequate storage, solar thermal collectors with adequate storage system and Solar LTF-MED Desalination unit. Final performance testing.

3. SCOPE OF SUPPLY:

Scope of supply consists of manufacturing items includes Flash chamber, evaporator, condenser, Piping, etc., as required.

All bought items such as Solar Thermal Panels, Solar PV Panels, Solar pumps and Re-mineralization, Sea water intake and outlet sub systems etc., as required.

4. PROCESS DESCRIPTION:

The plant being driven by solar energy, the design of the entire plant is dictated by the availability of solar heat from solar panels during the sun shine hours. The advantage of the technology is mainly from the use of renewable energy.

The proposed concept of desalination involves both flashing and evaporation, initially vapor is produced by flashing the hot water in the flash chamber from solar system at around 62°C and this vapor becomes the heat input to the multi stage evaporator to produce an equal quantity of steam. The flashed vapor condenses inside the tubes of the evaporator while the vapor generated in the first effect feeds the successive effects and finally condenses in a condenser where the final product water is collected. The quality of product water achieved by this process is high that it can be utilized for potable needs after re mineralization.

All the equipment should be designed according to the required rated flow, capacity, pressure and temperature as per the process requirement.

Evaporation of seawater in each effect occurs by the exchange of the latent heat through the heat transfer surface between condensing vapor inside the tubes and evaporating brine outside tubes. Horizontal tube film type of evaporators is used for each effect. Steam introduced into the first, highest temperature effect is condensed inside the tubes and the heat thereby released produces a nearly equal amount of vapor to be evaporated from the feed water on the outside of tubes. The vapor produced in the first effect is in turn, condensed in the second effect, again evaporating a portion of the seawater feed, The process is repeated up to the last (n^{th}) effect. The n^{th} effect vapor is condensed in a Final condenser by transferring heat to seawater.

Incoming raw seawater flows through the tube of the Final condenser. Most of the heated raw water existing from the Final condenser tubes becomes feed water to the evaporating effects with the remainder is discharged. The feed water is introduced into the 1^{st}, 2^{nd}, 3^{rd} … n^{th} effects as shown in the Process Flow Diagram. The feed water in each effect is sprayed over the outside of the horizontal evaporator tube bundle parallel to remaining effects. As the feed flows down through successive rows of tubes, a portion of it evaporates in each effect. The vapor produced passes through demisters that disengage any entrained brine droplets. Then, the vapor is transferred to the tubes of the next effect. The distilled water produced from plant will be sent to re-mineralization unit. Typical process diagram is attached in pdf file. Schematic layout of the plant is shown in Fig.1 with sea water well and potable water storage tank.

5. MAIN COMPONENTS

The major plant components/equipments comprise mainly the following

S. No	Main Components / Equipments	Unit	Quantity
5.1	Flash Chamber	no.	1
5.2	Evaporator	no.	1
5.3	Final Condenser	no.	1
5.4	Vacuum Systems	no.	1
5.5	Solar Thermal Panels	Lot	1
5.6	Solar PV System	Lot	1
5.7	Water Ejector	no.	1
5.8	Re-mineralization System	no.	1
5.9	Process Piping Materials	Lot	1
5.10	Process Pumps	nos.	5

5.1 FLASH CHAMBER: The warm water from the solar thermal collectors enters the flash chamber which is at a pressure lower than the saturated vapor pressure of the warm feed water. A portion of the warm water vaporizes and the water cools by giving away the heat for vaporization. The decrease in temperature after flashing is called the flash range and that reduction in temperature is generally compensated from the waste heat source.

5.2 EVAPORATOR: The evaporator is a simple shell and tube heat exchanger where the vapor from flash chamber is fed into the tubes and the saline / brackish water is sprayed over the tubes. The construction and process is very similar to the evaporator of MED desalination system. The sprayed water is heated and evaporation begins when the temperature corresponding to saturation pressure maintained in the evaporator is reached. The vapor production in the effect is slightly lesser than the quantity of vapor produced in the flash chamber. The quantity of spraying is based on the experience and optimization of scaling factor.

The heat transfer tubes used are of aluminum alloy and fixed using Ethylene Poly-Die-Mono (EPDM) rubber grommets Food Grade (FG) for simple and easy maintenance. The vapor generated in the evaporator is condensed in a condenser.

The MED Evaporators consists of many effects. Each evaporator will be individually with interconnecting pipes. As all the evaporators are operating at Vacuum conditions, reinforcements, stiffeners should be provided on the evaporator shell in order to endure the load during pneumatic tests and during operation. The evaporator shells of all effects should be made of Duplex Material.

The bottom of each effect should be provided with a manhole in each effect for maintenance and inspection. The Manhole covers on evaporator shell should be hinged for easy opening and should be accessible from platforms and ladders around the unit. The cover should be kept in easily accessible locations. Observation windows on the shell should be provided in each effect to observe spray pattern inside the shell. The Seawater feed spray nozzles shall be constructed of SS 316L materials. These will be designed for ease of removal in case of blockage. The nozzle design and their location on distribution header should ensure uniform flow distribution over the tube bundles to avoid areas of low flow or drying out and consequential scale formation on the tube surfaces. Demisters required for maintaining purity of the product should be made by SS 316 L mesh mats with minimum 75mm thickness. They shall be arranged in conveniently sized inter changeable sections to permit ease of handling, maintenance, and replacement through access door. Access platform, walkways, handrails, and access stairs shall be permanently installed for access to all important sections of the plant for maintenance and inspection wherever necessary. The design of shell be in accordance with ASME / HEI / TEMA standard.

EVAPORATOR TUBE BUNDLE: The Evaporator design shall be as per TEMA standards or design approved by the engineer user's department. The tube bundle in each effect shall be horizontal and fixed to Duplex tube plates by Grommet. Mock testing of rubber grommets for arriving at the leak rate should be conducted before installation in the evaporators. Such testing will be witnessed by engineers from user department. Suitable support plates of compatible material are to be provided. Provisions for easy removal and replacement of tubes through bolted and manhole covers without any cutting should be planned. Evaporator tube shall be of Al alloy. Suitable fouling factors should be used in the design of the heat transfer surface in the MED plant. Some of the tubes shall be used for cooling the non condensable gases. All interconnecting ducts and pipe work should have sufficient flexibility to allow thermal expansion without imposing excessive loading on associated plant and pumps. Flexible bellow / couplings should be used wherever applicable and shall be designed to withstand both pressure and vacuum condition. The cross sectional view of a typical effect showing tube bundle arrangement.

Tubes inside the shell can be arranged either in central tube or side tube arrangement. The actual tube arrangement can be chosen depending upon the ease of fabrication, accessibility of tubes and demisters and manhole placing. Mechanical design should be based on the arrangement chosen. For similarity all the effects shall be of same dimension and arrangement. The detailed engineering drawings of all the evaporators and equipments with all the dimensions are to be made by the supplier. The drawings are to be approved by the users executive engineer before taking up for the fabrication job by the supplier. Tentative dimensions & specifications evaporator shell and tube bundle (Al alloy) are as follows:

Each evaporator should have adequate heat exchanging surfaces. The requested heat surface shall be accommodated in shells with required necessary diameter total length not exceeding the comfortable access to the tube sheets. In this size, comfortable access to the internals should be considered for inspection and maintenance.

INTERCONNECTION BETWEEN STAGES: All effects will be placed in a common shell. Vapor in the every effect should be transferred to the next effect through vapor box. Condensate collected at the end of tube bundle is siphoned to the next effect via U pipe. Some of the bottom tubes of the next effect are utilized to transfer condensate to the next effect. Concentrated seawater(brine) is also transferred to the next effect via U siphon. The siphoning vertical length (U length) for Brine and distillate transfer to next effect should be more than the operating pressure difference between stages.

5.3 FINAL CONDENSER: A simple heat exchanger with condensing steam on the shell side and cooling water on the tube side. The condenser is made of stainless steel shell and titanium tubes fixed with tube expansion. The cooling water enters the tubes of the condenser and the exit water is split into two streams one feeding the evaporator and the other is rejected back. The total product water is collected out from the condenser as distillate.

The Final condenser shall be of shell & tube type heat exchanger. Tubes for condenser will be of Ti Gr.2 with required wall thickness as per process. The water boxes, tube plates and tube support plates shall made of Duplex. Shell shall be made of Duplex. The design of condenser should be done in accordance of TEMA C. Galvanic coupling between dissimilar metal should be avoided. The tube side design flow rate of seawater should be in line with the Process requirement. Shell side condensing vapor design load should compensate the working condition. Final condenser shell (SS 316 L) and tube bundle (Ti Gr.2) Final condenser coolant sea water flow rate should be designed as per the process requirement. The final condenser should have adequate heat exchanging surface and size of tubes corresponds to the same. The number of passes shall be as necessary to ensure the acceptable process water flow velocity.

5.4 VACUUM SYSTEM: A single stage water jet ejector forms the vacuum system for the entire system. This shall be capable of extracting all the non-condensible gases (NCG) from feed water, air in-leakage and carbon dioxide released in evaporation, together with associated vapor and discharging to atmosphere. Non-condensible gases will be transferred by cascade venting to the lowest pressure part (up to final condenser) and then by extraction to the ejector. The ejector is driven by water at required pressure which is the motive water flow for the ejectors and the NCG are sucked through the ejector secondary stream and discharged along with reject.

5.5 SOLAR THERMAL PANELS: The plant being driven by thermal energy, the design/capacity of the entire plant is dictated by the availability of solar heat as hot water from solar panels in the day hours. The advantage of the technology is mainly from the use of waste or renewable energy. Motive steam for the MED System is flashed from the hot water in the Flash chamber under Vacuum condition. This Hot Water is produced from the Solar Thermal Panels utilizing the Energy of Solar heat. The initial inlet water for Solar Thermal Panel is from a DM Tank. After once the system starts circulation the Water is circulated continuously between Solar Thermal Panels and Flash Chamber. The required Flashing Temperature of Water for Flash Chamber is attained in the Thermal Panels and there will be a Temperature drop in the Flash Chamber again this circulated to Thermal Panels for raise in Temperature. The approximate Flash range will be from 55 ^{o}C to 62 ^{o}C

5.6 SOLAR PV SYSTEM: The total plant is Stand alone system, Total power required for the plant is achieved by using Solar Photo Voltaic System. The major power consumptions of the System is for Pumps, I&C Items. The minimum Power requirement will be 25 kW (e)

5.7 WATER EJECTOR: This equipment is used for creating system Vacuum as required

5.8 REMINERALIZATION SYSTEM: Since thermal desalination process produces high purity distillate of about 5 ppm, it is essential that the distillate is converted to potable quality by injection of minerals. This system consists of a dosing pump with diluted solutions of salts containing sodium bicarbonate and calcium chloride to achieve TDS levels of 150-300 ppm as recommended by WHO standards.

5.9 PROCESS PIPING / INSTRUMENTS MATERIALS: Supply of process pipes and valves and laying them are under the scope of the supplier. Process piping for seawater and brine services will be of SS 316 L and of suitable pressure ratings. Suitable sensors insertion points are to be kept on the piping for sensing the required parameters. Suitable valves are to be provided wherever needed. Suitable Non Return Valves are to be provided wherever necessary.

5.10 PROCESS PUMPS:

- 1×100% Seawater Feed Pump with motor, 110% flow rate
- 1×100% Water Ejector Pump with motor, 110% flow rate
- 1×100% Brine Recirculation Pump with motor, 110% flow rate
- 1×100% Distillate Pump with motor, 110% flow rate
- 1×100% Solar Recirculation Pump with motor, 110% flow rate

Unless otherwise specified, all pumps should be designed for 110% of duty capacity, at the required duty head. The pumps will be installed to have an adequate NPSH to prevent cavitations and trouble free operation. The NPSH available value will have the 0.5m higher than NPSH required value at design capacity. All electric motors should have a sufficient horsepower so that they shall not be overloaded at any condition. All motors will be of the totally enclosed fan cooled type. All the pumps supplied by the supplier shall be tested as per requisite standards. Performance testing and inspection will be carried out by user's engineer before dispatch from the supplier. All the pumps to be provided with variable frequency drive to enable to start at soft start.

6. INSPECTION / TESTING / ACCEPTANCE TESTS

i. IIT reserves the right to inspect, or to have their authorized representative inspect the Solar LTF-MED at any time during their fabrication to ensure their compliance with the specification.

ii. The supplier conducts the following tests that are performed at the factory.

- Visual Inspection
- Overall dimensional inspection
- Leak test
- Pressure test
- Weight of each piece of the equipment

iii. The necessary tapping to be provided on tube side as well as on shell side for fixing gauges (Pressure, Temperature and Flow).

7. DRAWING & DOCUMENTS

The following Set of documents shall be supplied along with equipment:

- Bought out items Data Sheet
- Raw material test certificate for metallic components (shell, dish ends, tubes, tube sheets, baffle plates etc) under section 3
- Factory Acceptance Test Certificate Operation / Maintenance Manual Parts Catalog.
- As Built Drawings for the entire Assembly and non-assembly procedure.
- Handling procedure.

8. PERFORMANCE GUARANTEE

The Solar LTF-MED shall be guaranteed for material, workmanship and satisfactory performance at site, on line for a minimum period of Twelve (12) months from the date of commissioning.

9. OVERALL PROCESS SPECIFICATION

S. NO	OVERALL DESIGN PARAMETERS	UNIT	DATA
1	Plant Capacity / Production	m^3/day	10
2	Operating Hours / Day	hrs.	8
3	No. Effects (Minimum)	nos.	4
4	Feed Water entry to Condenser	kg/h	27,000
5	Makeup seawater as feed	˚C	32
6	Seawater Spray – Flow rate	kg/h	6,800
7	Product Salinity (TDS)	ppm	5
8	Feed Water Salinity	ppm	33,000 – 35,000
9	Feed Water Temperature	˚C	25 to 30
10	Evaporator Temperature (1st Effect)	˚C	55.4
12	Evaporator Temperature (Last Effect)	˚C	46.7
13	Brine Discharge Flow Rate	kg/h	1800
14	Gain Output Ratio (GOR)		3.5 (min)

Note: *All the technical parameters are indicative value, Bidder has to design and specify in their offer*.

10. TECHNICAL DATA-SHEETS

S. NO	DESCRIPTION	REMARKS
A	**FLASH CHAMBER**	
1	Material of Construction	SS 316L
2	Design Pressure	Vacuum
3	Design Temperature	65 °C
4	Shell Size (mm) – OD x Thick x Length	1400 (min) x ** x **
B	**EVAPORATOR**	
1	Material of Construction (Sea Water side/ Steam side)	Duplex/ SS 316 L
2	Design Pressure	Vacuum
3	Design Temperature	55.4 °C
4	Shell Size (mm) – OD x Thk x Length	1400 (min) x ** x **
5	Tube Material	Aluminum Alloy
6	Tube Size (mm) – OD x Thk x Length – For 1 Effect	25.4 x ** x 1400(min)
7	No. of Effects (minimum)	4 nos.
8	Tube to Tube Sheet Connection	Grommet
9	Grommet – Material / Size	EPDM (F.G) / **
10	Tube arrangements	Triangular Pitch
11	Heat transfer area in Sq. M	380

** - Bidder to specify in their offer

Note: *All the technical parameters are indicative value, Bidder has to design and specify in their offer*.

C	**CONDENSER**	
1	Material of Construction (Sea Water side/ Steam side)	Duplex/ SS 316 L
2	Design Pressure	Vacuum – 0.09 bar(a)
3	Design Temperature	**
4	Size (mm) –ID x Thk x Length	800 (min) x ** x 1800 (min)
5	Tube Material	Ti Grade 2
6	Heat Transfer Area	90 m^2
7	Tube Size (mm) – OD x Thk x Length	17.4 x ** x 1400 (min)
8	Type of Pass	Double Pass
9	Tube to Tube Sheet Connection	Expansion
10	Tube arrangement	Triangular Pitch

** - Bidder to specify in their offer

Note: *All the technical parameters are indicative value, Bidder has to design and specify in their offer.*

D	PUMPS					
S. NO	**DESCRIPTION**	**SEA WATER**	**WATER EJECTOR**	**BRINE CIRCULATION**	**DISTILLATE**	**SOLAR RECIRCULATION**
1	**GENERAL**					
	MAKE	Grundfos / Equivalent	Grundfos / Equivalent	Grundfos / Equivalent	Grundfos / Equivalent	Grundfos / Equivalent
	TYPE	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	DUTY	110	110	110	110	110
	SUCTION PRESSURE [bar(a)]	0.40	0.40	0.30	0.30	0.35
	DISCHARGE PRESSURE [bar(a)]	2.5	5.0	3.0	3.0	6.0
2	**PROCESS PARAMETERS**					
	FLUID	Sea water	Sea water	Sea water	Distilled water	Distilled water
	FLOW (CuM/h)	27	24	5.5	1.6	30.6
	TEMPERATURE (°C)	32	37-39	44-46	43	55-62
3	**MATERIAL OF CONSTRUCTION**					
	CASING	SS 316L	SS 316L	SB 265	SB 265	SS 316L
	IMPELLER	SS 316L	SS 316L	SB 265	SB 265	SS 316L
4	**MOTOR**					
	MAKE	Grundfos / Equivalent	Grundfos / Equivalent	Grundfos / Equivalent	Grundfos / Equivalent	Grundfos / Equivalent
	RATED POWER (kW)	4	7.5	1.1	0.55	7.5
	DUTY (%)	110	110	110	110	110
	VARIABLE FREQUENCY DRIVE	Danfoss/ ABB or Equivalent	Danfoss/ ABB or Equivalent	Danfoss/ ABB or Equivalent	Danfoss/ ABB or Equivalent	Danfoss/ ABB or Equivalent

** - Bidder to specify in their offer

Note: *All the technical parameters are indicative value, Bidder has to design and specify in their offe*r.

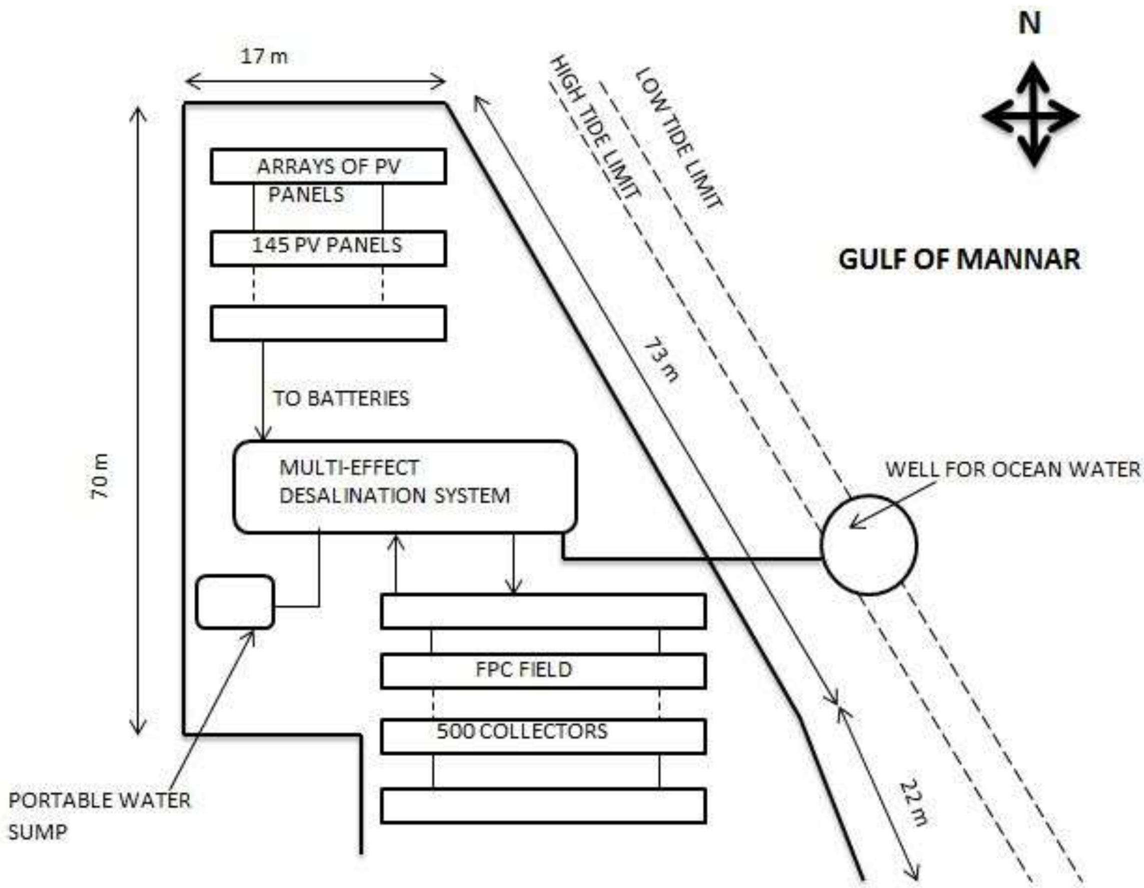

Fig.1 Schematic Layout of MED plant at site

11. Experience of the bidder

The bidder should have designed/engineered, manufactured/ erected and commissioned atleast one multi-effect distillation coupled with 5 TPH steam generation system coupled with solar thermal water heating system.

12. TECHNICAL DATA-SHEETS – BIDDER TO FILL

S. NO	DESCRIPTION	REMARKS
A	**FLASH CHAMBER**	
1	Material of Construction	SS 316L
2	Design Pressure	**
3	Design Temperature	**
4	Shell Size (mm) – OD x Thick x Length	** x ** x **
B	**EVAPORATOR**	
1	Material of Construction (Sea Water side/ Steam side)	Duplex/ SS 316 L
2	Design Pressure	**
3	Design Temperature	**
4	Shell Size (mm) – OD x Thk x Length	** x ** x **
5	Tube Material	Aluminum Alloy
6	No. of Tubes	**
7	Tube Size (mm) – OD x Thk x Length – For 1 Effect	** x ** x **
8	No. of Effects (minimum)	** no
9	Tube to Tube Sheet Connection	Grommet
10	Grommet – Material / Size	EPDM (F.G) / **
11	Tube arrangements	Triangular Pitch
12	Heat transfer area in Sq. M	**

** - Bidder to specify in their offer

C	**CONDENSER**	
1	Material of Construction (Sea Water side/ Steam side)	Duplex/ SS 316 L
2	Design Pressure	**
3	Design Temperature	**
4	Size (mm) –ID x Thk x Length	** x ** x **
5	Tube Material	Ti Grade 2
6	Heat Transfer Area	**
7	No. of Tubes	**
8	Tube Size (mm) – OD x Thk x Length	** x ** x **
9	Type of Pass	Double Pass
10	Tube to Tube Sheet Connection	Expansion
11	Tube arrangement	Triangular Pitch

** - Bidder to specify in their offer

D	PUMPS					
S. NO	DESCRIPTION	SEA WATER	WATER EJECTOR	BRINE CIRCULATION	DISTILLATE	SOLAR RECIRCULATION
1	GENERAL					
	MAKE	**	**	**	**	**
	TYPE	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
	DUTY	110	110	110	110	110
	SUCTION PRESSURE [bar(a)]	**	**	**	**	**
	DISCHARGE PRESSURE [bar(a)]	**	**	**	**	**
2	PROCESS PARAMETERS					
	FLUID	Sea water	Sea water	Sea water	Distilled water	Distilled water
	FLOW (CuM/h)	27	24	5.5	1.6	30.6
	TEMPERATURE (°C)	32	**	**	**	**
3	MATERIAL OF CONSTRUCTION					
	CASING	SS 316L	SS 316L	SB 265	SB 265	SS 316L
	IMPELLER	SS 316L	SS 316L	SB 265	SB 265	SS 316L
4	MOTOR					
	MAKE	**	**	**	**	**
	RATED POWER (kW)	**	**	**	**	**
	DUTY (%)	**	**	**	**	**
	VARIABLE FREQUENCY DRIVE	**	**	**	**	**

** - Bidder to specify in their offer