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***TECHNICAL SPECIFICATION
FOR
DESIGN, SUPPLY AND ASSEMBLY
OF
FLOATING SYSTEM
AND
ASSOCIATED ANCHORING AND
MOORING
FOR
FLOATING SOLAR PV PROJECTS
ACROSS INDIA***

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INDIA**

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LIST OF ABBREVIATIONS USED

Acronym	Abbreviation
A&M	Anchoring and Mooring
AC	Alternating Current
AMC	Annual Maintenance Contract
ASTM	American Society for Testing and Materials
BHEL	Bharat Heavy Electricals Limited
BBU	Billing Break-up Unit
BOM	Bill of Material
BOQ	Bill of Quantity
BOS	Balance of System
CMCS	Centralized Monitoring and Control Room
DC	Direct Current
DSL	Dead Storage Level
EPC	Engineering, procurement and construction
F.O.S	Factor of Safety
FRL	Full Reservoir Level
FSP	Floating Solar Plant
FSPV	Floating Solar Photovoltaic
FQP	Field Quality Plan
GI	Galvanised Iron
GOI	Government of India
HDPE	High Density Polyethylene
HT	High Tension
HMPE	High Modulus Polyethylene (also UHMPE)
HSE	Health, Safety and Environment
HV	High Voltage
ICOG	Incoming and Outgoing



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INR	Indian Rupees
IFP	Inverter Floating Platform
ISO	International Organization for Standardization
JV	Joint Venture
kWh	kilowatt-hour
LA	Lightening Arrestor
LPSFP	Local Pooling Switchgear Floating Platform
MDDL	Minimum Draw down Level
MNRE	Ministry of New and Renewable Energy
MOU	Memorandum of Understanding
MSL	Mean Sea Level
MW	Megawatt
MQP	Material Quality Plan
Nos.	Numbers
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OHS	Occupational health & safety
PCC	Plain cement concrete
PCU	Power Conditioning Unit
PPE	Personal Protection Equipment
PV	Photo Voltaic
QAP	Quality Assurance Plan
RCC	Reinforced Cement Concrete
SCADA	Supervisory Control and Data Acquisition
SCB/SMB	String Combiner Box/ String Monitoring Box



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1.0 INTRODUCTION

This document describes the technical specification for the design and supply of HDPE floating system for forming the PV Module Island and for laying the DC and HT cables and associated Anchoring and Mooring systems for various floating solar projects to be executed by BHEL.

2.0 BRIEF SCOPE OF DESIGN, SUPPLY AND WORKS

2.1. DESIGN

- I. Design, Engineering and approval from End customer of complete PV Module Floatation platform along with complete floater accessories.
- II. Design of Floating system for laying DC and HT cables, SCB/SMBs, LA Mounting, Walkways etc.
- III. Design of Wave attenuation system/Floating Barriers and its anchoring & Mooring all along arrays as per design requirement based on wave study, as applicable.
- IV. Design of Suitable Anchoring and mooring System as per site specific conditions.

2.2. SUPPLY OF FLOATING SYSTEM

- I. Supply of PV floatation System along with all accessories and mandatory spares specified.
- II. Supply of Floating System for laying DC and HT cables along with all accessories
- III. Supply of Floaters for routing the DC Cables in the PV Module Array.
- IV. Floaters for mounting the SCBs/ SMBs, LA.
- V. Dedicated Walkway floaters for connecting the floating islands to land, if applicable.
- VI. Floaters and accessories required for Module cleaning system Installation
- VII. Supply of Wave attenuation system/Floating Barriers all along arrays as per design requirement based on wave study, as applicable.
- VIII. All anchoring system components and mooring accessories for complete Floating system along with AC & DC layouts.



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- IX. Items required for module to module connection & earthing like Cable Ties, Earthing Cable and necessary hardwares.
- X. The complete module mounting structure with all accessories and hardwares for mounting the finalized PV Module.

2.3.WORKS & SERVICES:

- I. Site Preparation Works, Assembly and Launching of floating platforms with Floaters, PV Modules and cable connection in between PV Modules.
- II. PV module string connections and earthing connections during assembly at shore.
- III. Assembly and Launching of floating platform for DC and HT Cable layout
- IV. Installation of Anchoring system for PV module floatation platform and DC & HT cable Layout.
- V. Mooring of PV module floatation platform and DC & HT cable Layout.
- VI. Anchoring & Mooring of wave Attenuation system/Floating Barriers, as applicable
- VII. Comprehensive O & M of complete Floating system & Wave Attenuation System, if applicable including anchoring & mooring for specified period defined in BOM/technical specification elsewhere.
- VIII. Comprehensive AMC of complete Floating system & Wave Attenuation System, if applicable including anchoring & mooring on yearly basis for specified period defined in BOM/technical specification.

Based on above scope of design, supply and works, a BOM will be prepared for providing quotations during project specific tendering. Detailed specification and scope elaborated in relevant section of the specification and its enclosures which are the integral part of the specification.

3.0PROJECT INFORMATION

Will be intimated at the time of inviting project specific tender.

4.0 SITE SPECIFIC DATA

Will be intimated at the time of inviting project specific tender.



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**5.0 MANDATORY TECHNICAL REQUIREMENTS/DOCUMENTS TO BE
SUBMITTED BY THE BIDDER ALONG WITH TECHNICAL BID**

- I. Bidder should be an OEM of Solar PV Floaters. A self-declaration along with details of manufacturing facilities to be submitted.
- II. Details and drawings of the HDPE floaters being offered to BHEL.
- III. Sample block layout of Minimum 5 MW AC (7 MW DC) including proposed DC cable, SMB, LA mounting arrangement on floaters.
- IV. Test results of the various test connected on the floaters indicated in clause 6.2.
- V. Bidder may indicate any patents filed for their floaters, if any.
- VI. Indicative MQP and FQP of the HDPE Floaters supply & Launching, Assembly works respectively.
- VII. Details of the parent technology provider/partner for HDPE Floaters, if any. Technical MOU/JV or other equivalent document for use of technology to be submitted.
- VIII. Tentative Source of raw material suppliers.
- IX. Details of base polymer grades used for HDPE Floaters.
- X. A self-declaration of Manufacturing plant capacity to be submitted.
- XI. Details of the moulds for respective floaters available with the bidder.
- XII. Vendor to mention the offered PV Module tilt as per his design.
- XIII. Vendor to specify mooring philosophy used like Taut/catenary.

6.0 TECHNICAL SPECIFICATIONS FOR FLOATING SYSTEM

6.1. GENERAL

The Floating system comprises of the Floating unit, Module support structure (if applicable), clamps/ connectors and associated hardware/ accessories for the Floating Solar PV system (FSPV).

6.2. CODES AND STANDARDS



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The floatation system must conform to the latest edition of any of the following IEC/ equivalent standards for floating system design qualification and type approval. The reports verified by third party NABL national or international accredited agency shall be submitted for approval to BHEL/End Customer.

CODES	Description
ASTM D1693-15 (or equivalent ISO Standards)	Standard Test Method for Environmental stress cracking of Ethylene plastics
ASTM D790, ISO 178	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics & Electrical Insulating Materials
ASTM D638, ISO 527	Standard Test Method for Tensile Properties of Plastics
ISO16770	Full Notch Creep Test (FNCT).
ASTM D2565, ISO 4892-2	Standard Practice for Xenon-Arc Exposure of Plastic intended for outdoor Applications
ASTM D4329, ISO 4892-3	Standard Practice for fluorescent ultraviolet (UV) lamp apparatus exposure of plastics
RoHS directive 2002/ 95/EC	Test for Restriction of Hazardous Substances

The test reports of HDPE Floaters conforming to above list of code and standards shall be submitted for review of BHEL/End Customer.

Note: BHEL reserves the right to conduct the sample testing of floaters in reputed labs of IITs/IISc etc. The test will be conducted jointly at the cost of bidder. In case results of tests conducted by BHEL have significant differences which can affect the strength & life of the floater, the floaters shall be rejected for further use.

6.3.FLOATING UNIT

The floatation units of module shall be modular and easily connected to each other. Once completely connected, the floating platform must be able to support the weight of PV module, module support structure, cables, SCBs/SMBs, LA, support railing (if applicable) etc. The floater system shall also be able to support the load of O&M personnel, electrical equipment as mentioned earlier in this document, Module washing system etc.

6.3.1. The floating units shall be standardized and designed for simple onsite installation.

6.3.2. The floating unit for PV Module mounting shall be prefabricated and modular in design with appropriate buoyancy to support the weight of at least one solar



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panel/equipment (as applicable) and additional minimum weight of 60 kg per unit. For other miscellaneous floats minimum buoyancy per sq. meter shall be 80 kg.

- 6.3.3. The floating unit design shall facilitate ease of assembly /disassembling, replacement of any module and enable future expansion or scaling.
- 6.3.4. The floatation unit should be manufactured from appropriate thermoplastic (virgin material) with UV stabilizer such that the life of floatation device shall be able to sustain for a period of minimum 25 years.
- 6.3.5. The material used in manufacturing shall withstand Environmental Stress Crack Resistance (ESCR) and have a combination of hardness and impact strength (ASTM D1693).
- 6.3.6. The material used for floatation device shall be chemically resistant to acid, lye, petrol and mineral oil and also partially resistant to benzene and non-detrimental to marine life.
- 6.3.7. To protect floating waterbody against deterioration of its water quality a material test certificate of floaters showing no appreciable change in water quality of the reservoir/water body for entire life of the project has to be submitted by the bidders during detailed engineering.
- 6.3.8. In order to increase longevity and prevent unexpected loss of buoyancy, the floating unit shall have an average material thickness of 3 mm with moisture retention of less than 5%. High load area shall have superior thickness to take the impact (Detailed design calculation to prove the adequacy of thickness at various points has to be submitted along with drawings at the time of drawing approval).
- 6.3.9. The floating unit material shall be designed to balance the thermal expansion so that PV Panel are not stretched due to effect of thermal expansion.
- 6.3.10. The complete floating system shall have at least 400 mm floating corridor along the periphery comprising of module floaters and/ or walkway floater to prevent water splash.
- 6.3.11. The design of the floating system shall incorporate appropriately sized walking platforms for regular maintenance and inspection. The walking platform shall be continuous with minimum width of 400 mm, excluding cable-laying arrangement. Dedicated walkway to be provided to avoid movement on cables.
- 6.3.12. Between walking platform maximum of four continuous rows of modules is allowed. Additional infrastructure required for accessing modules cables etc. during O&M shall be provided by the bidder or any other mechanized approach can be proposed



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by the technology solution provider to easy access to panels irrespective of rows / configuration.

- 6.3.13. Bidder to take into consideration load of all electrical equipment and accessories during the design of floatation platform. Details of typical Electrical equipment and accessories are as provided in specification.
- 6.3.14. For, String Combiner/monitoring Box (SCB/SMB) to be mounted on floaters, bidder to take into consideration the load of SCB during design of floaters and suitable supporting arrangement for mounting the SCB on Equipment floaters. Floaters, connection points/ears, connectors, supports etc. should be designed considering the load of the equipment to be mounted. Physical testing of floaters, connection points/ears, supports etc. has to be carried out on equipment floats. In vertical rows wherever SMBs are to be placed, dedicated additional walkway to be provided.
- 6.3.15. Floaters carrying cables should be designed to carry load of 1.5 times load of cable and other accessories with proper anchoring and mooring so as to withstand maximum load caused by wind, wave action, water level variation etc.
- 6.3.16. The bidder to populate the Array layout in the designated reservoir surface area. Also this Array population to cast minimum shadow (Shadow loss of the PV-Array limited to maximum 1%). This proposed Array layout has to be submitted to BHEL along with the technical documents for verification. The Array layout to include mandatory clearances for Inverter Rooms and other utilities. The shadow analysis of the array layout to be submitted to BHEL for approval.
- 6.3.17. Floating system should be designed to withstand the maximum wind speed of the location.
- 6.3.18. The floating units once assembled together should form an integrated structure. The relative alignment of the floating unit subsequent to complete installation shall not misalign the solar panels. The tilt of PV Panels should not get disoriented during lateral shift of the array.
- 6.3.19. The floating units shall be re-process able and recyclable at the end of its useful life.
- 6.3.20. The design life of the floating units should be 25 years.
- 6.3.21. Vendor to supply the Mandatory spares of each component of floating unit of detailed BOQ quantity of floating system including mooring accessories finalised after detailed engineering. The quantity of mandatory spares shall be intimated at the time of inviting project specific tender.



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- 6.3.22. The screw and nuts used for floater connection to have a sound locking arrangement to take care of the water flow. The positive locking arrangement to prevent any loosening of screw and nuts. This shall further prevent any loosening in the floater assembly.
- 6.3.23. Appropriate vapour escape vents should be provided for each floatation device.
- 6.3.24. The Caps of the floaters after interconnecting in assembly should be easily accessible for opening and removing of water in the event of breakage of cap due to thermal expansion or thread loss. There shall be no need to take out the floater from the assembly to remove water and replace the cap due to non-accessibility.
- 6.3.25. The PV modules shall be mounted in such a way that the clamping fixtures are easily accessible from top side in the assembled condition. There shall be no need to access from below the water for any removal/repair.
- 6.3.26. The Major screws of all HDPE bolts shall incorporate effective and durable additional fastener to prevent loosening over a period of time. This shall be way of Lock nuts, Split pins (only with solid Bolts)
- 6.3.27. Floats shall incorporate solid dummy ears at mid points on either side with thickness equal to regular connecting ears so as to enable drilling through them to fix Metallic strip, clamps or hardware for cable and tray supports, SCBs and for Water washing pipes.
- 6.3.28. Wherever Multi-tier floater arrangement is called for to support Cables or increase/decrease heights of mounted items, OEM shall design and provide Extra length solid HDPE/LDPE bolts with nuts and lock nuts for assembling 2 or three stacks of floaters.
- 6.3.29. Since all the mooring loads will be transferred from mooring line to floater ears through spreader bar, a mechanical destructive test will be done for ear load capacity for its tensile and shear strength. The report of the same to be submitted for review to BHEL before start of assembly of floaters at site.
- 6.3.30. All batches of floats to clearly carry Mould stamping showing Batch No. Month, Week of year of manufacture.
- 6.3.31. Strength adequacy of the floater (body, ears etc.) and connections to anchoring locations (Spreader bars) has to be established theoretically (CFD analysis or otherwise) with verification from reputed third party NABL accredited agency/ internationally accredited agency/ reputed institutions like IITs or NIOT, Chennai



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or Indian Register of Shipping (IR Class), Mumbai Etc. and submitted for BHEL/End Customer review.

6.3.32. The strength adequacy of the floaters and connections to anchoring locations (Spreader bars) has to be established by Physical tests also at NABL accredited laboratory. The test shall be witnessed by BHEL/End Customer.

6.4. MODULE MOUNTING STRUCTURE (MMS) (IF APPLICABLE)

6.4.1. The MMS shall be so as to allow easy replacement of any module by authorized personnel.

6.4.2. The MMS and associated hardware / fasteners, if used are metallic in nature, shall be non-corrosive, non-abrasive, without any sharp edges and suitable for site weather and marine conditions. The structures shall be made of anodised aluminium or SS with preferably HDPE coating over the structure. Any other suitable alloy material shall also be proposed subject to approval of BHEL.

6.4.3. All fasteners, nuts, bolts and other hardware shall be of Stainless steel – 304 or higher grade to suit the site conditions and to ensure a life of 25 years. However, for saline water SS316 to be used.

6.4.4. MMS shall be designed to withstand the extreme weather conditions in the area.

6.4.5. The modules shall be mounted at fixed tilt.

6.4.6. PV fixation system shall be of proven design and subjected to Mechanical test to withstand unit failure conditions under static and fatigue conditions for base wind speed. The results conforming to above test shall be submitted to BHEL on request.

6.4.7. The design calculations and strength verification reports for the MMS components shall be submitted for BHEL's approval.

7.0 ANCHORING AND MOORING SYSTEM

7.1. STANDARDS AND CODES

The Anchoring and Mooring system shall conform to the latest edition of any of the following standards guidelines as stipulated in table below for Anchoring and Mooring design qualification and type approval. The design reports verified by third party i.e. NABL, national or international accredited agency shall also be required for validation purpose.



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Standard/ Code	Description
DNVGL-RP-C205	Environmental conditions and environmental loads.
DNVGL-OS-E301	Position Mooring
DNVGL-OS-E302	Offshore Mooring Chain
DNVGL-OS-E303	Offshore Fibre Ropes
DNVGL-OS-E304	Offshore Mooring Steel Wire Ropes
ISO 19901-7	Station keeping systems for floating offshore structures and mobile offshore units
BV NR493 DT R03 E	Classification of Mooring Systems for Permanent Offshore Units
BV NI 605 DT R00 E	Geotechnical and Foundation Design, August 2014.
BV NR 578 DT R00 E	Rules for the Classification of Tension Leg Platforms (TLP), July 2012.
DNV-RP-E303	Geotechnical Design and Installation of Suction Anchors in Clay.
ISO 14713	Protection against corrosion of iron and steel structures
API-RP-2SK 3rd Edition	Design and Analysis of Station Keeping Systems for Floating Structures

7.2. TECHNICAL REQUIREMENTS OF ANCHORING & MOORING SYSTEM:

- 7.2.1. The anchoring and mooring system holds the floating platform in place and provides the mechanical stability it requires throughout its lifetime.
- 7.2.2. Water level variation and prevailing wind speed are the primary safety considerations for designing the floating solar plant. The mooring system thus needs to be designed such that it not only restricts lateral movement beyond the permissible limits of the platforms but also accommodates the water level variability.



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- 7.2.3. The design life of the Anchoring and Mooring system shall be 25 years.
- 7.2.4. The floating solar PV (FSPV) power plant should be at a minimum safe distance from the edge of the land surface. In case edge of land surface has a sloped edge then this distance of array from land edge to be calculated w.r.t to the position of floating island at minimum water level condition. However, the exact positioning can be finalized at the time of detailed engineering, after conducting bathymetric study.
- 7.2.5. The floating system comprising of floating unit, PV fixation system and associated anchoring system shall be designed as per base wind speed and able to withstand dynamic conditions as per IS 875-3.
- 7.2.6. The design of the mooring system shall permit minimal lateral movement of the plant in case of maximum wind loads (as per IS 875-3). The lateral excursion of the floating platform **not to exceed 2.5 meters** even at minimum water level. Anchoring design report for the project showing that the system could support the maximum wind load on site shall be submitted to BHEL.
- 7.2.7. Water variability: The mooring system should accommodate the fluctuations in water level of water body which will be intimated during project specific tendering. Further, the orientation of the plant needs to be maintained; hence, any fluctuations in water level shall allow minimal movement of the FSPV plant as per mooring system design.
- 7.2.8. The materials used in the anchoring and mooring system shall not contaminate the water and affect the aquatic ecosystem.
- 7.2.9. The materials used in the anchoring and mooring system shall have a design life of 25 years.
- 7.2.10. The design of complete system, including CFD modelling, comprising of Floating unit, MMS and anchoring system, shall be verified by suitable third party NABL accredited agency/ reputed institutions like IITs or NIOT, Chennai or Indian Register of Shipping (IR Class), Mumbai Etc. and submitted for BHEL/End Customer approval.
- 7.2.11. Detailed structural and stability calculations shall be submitted for BHEL approval.
- 7.2.12. The design calculations and strength verification reports for the mooring components shall be submitted for BHEL's approval.



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7.3. ANCHORING SYSTEM:

- 7.3.1. Anchoring of the floating Island can be through Concrete Block/Screw or Helical Piles/ Anchor Plates/ any advance anchoring system supported by design validation which will be most suited for site conditions. For anchoring design, applicable Codes and standards shall be followed.
- 7.3.2. In case the contractor wishes to adopt concrete pile foundation for anchoring system, Geo-tech. report shall also include the calculations, based on soil properties, for safe pile capacity under direct compression, lateral load and pull out as per IS:2911.
- 7.3.3. For single pile, Lateral load capacity shall be min. of the values obtained as per IS:2911 & Brom's method corresponding to free pile head. The report shall also include recommendations about type of pile, its depth and dia. to be used.
- 7.3.4. In case contractor wishes to use helical piles/ anchor plate the design, fabrication and installation shall conform to IBC (International building code). The contractor shall carry out field trials for initial load test on pile to verify the pile design to confirm the safe load carrying capacity under direct compression, Lateral load and Pull out. The min. of the two values (design value as per soil characteristics & field test results) shall be adopted.
- 7.3.5. The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area and as per the provisions of IS 2911 Part 4. However, minimum 5 nos. of piles shall be tested under each category of load.
- 7.3.6. The contractor shall submit detailed methodology for conducting the tests in line with IS: 2911 (Part 4)/ IBC for Engineer's approval before commencement of any test. For reference, the standard pile test procedures for compression & pull out and lateral load test to be submitted for approval. After completion of these tests the contractor shall compile the test results and submit the report in a proper format as specified in the BIS standard with recommendations/ conclusions for Engineer's approval. The pile work shall start only after approval of the final pile design duly verified/ confirmed with initial load test results.
- 7.3.7. If Bidder choose to provide helical pile/ anchor plate after due consideration to the above criteria, then following shall be adhered to by the bidder w.r.t Corrosion Protection.
- 7.3.8.** To avoid the corrosion in the steel section, due to continuous impact of water and air, or due to aggressive chemical environments, suitable anti-corrosive measures need



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to be considered. If Steel Section is proposed for anchoring, it shall be designed considering appropriate galvanization thickness (HDG) or other suitable material as per site corrosion category requirement.

7.4. ANCHORING & MOORING WORKS:

7.4.1. Complete anchoring and mooring works of Floating platforms and DC & HT Cable Layout as per approved design shall be in the scope of bidder.

7.4.2. All materials, consumables, tools, tackles and Infrastructure required for anchoring & mooring works shall be in the scope of bidder.

7.4.3. The boat, barges, cranes etc. required for anchoring and mooring works shall be arranged by bidder only.

7.4.4. In case of any dredging required for movement of barge or for safe installation of Arrays, anchoring and mooring works, dredging shall be done by bidder.

7.4.5. Anchoring shall be done in accordance with approved co-ordinates and reports of anchoring as per actual dropping shall be submitted on daily basis. In case any correction required in anchor position to be done immediately.

7.4.6. The mooring of arrays should have the positive locking of D-shackles to prevent its disengagement and eventually falling down in water in array movement.

8.0 ASSEMBLY OF FLOATERS AND PV MODULES

8.1. SITE PREPARATION WORKS:

8.1.1. PV Modules will be supplied by BHEL from BHEL Site Stores. Collecting the PV Modules from BHEL Site stores is in the scope of bidder. Temporary Storage of Solar PV Modules for assembly as per Module Manufacturer's recommendations is in the scope of the Floater vendor only. Any damage to the PV Modules after taking over by bidder from BHEL Stores and handing over of assembled array to BHEL back shall be responsibility of the bidder only. Bidder has to replace/replenish the PV module of same Make and Rating to BHEL in case of any damage happened till handover of assembled array to BHEL.



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8.1.2. The space for storage of floater & PV modules, working space for preparation of anchors, assembly area shall be prepared by bidder only.

8.1.3. Requisite no. of Ramped/slopped launching pads shall be constructed by the bidder.

8.2. ASSEMBLY WORKS

8.2.1. Installation of floating pontoons and modules as per approved assembly procedure. Transportation of PV Module from BHEL main Site store to bidder's store, unloading, storage of PV modules provided to bidder will be in bidder's scope. All other materials, consumables, tools, tackles and Infrastructure like boats, launching platforms required for Installation of Floaters shall be in the scope of bidder.

8.2.2. Bidder has to prepare required no of launch pads, as suitable for site conditions to install the floating platform in the required time duration.

8.2.3. Storage, security, construction power and movement of material shall be in bidder's scope.

8.2.4. Deputation of Safety personnel at site is mandatory during assembly works.

8.2.5. Transportation of materials viz floaters, PV modules etc. from storage area to assembly area will be done by bidder only.

8.2.6. Connection of anchoring ropes/chains to each floating island as per approved drawing.

8.2.7. BHEL will not provide any T & P for works at site. All has to be arranged by bidder only.

8.2.8. Bidder to do assembly (electrical works only) works under supervision of BHEL's BOS Subcontractor.

8.3. PRE-INSTALLATION CHECKS

The visual inspection shall include a check on the following items, where appropriate:

- ✓ Adequacy of working space, access, maintenance facilities, and drinking water.



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- ✓ Ensure only battery operated power tools while working on shore or water.
- ✓ Training on manufacturer instruction to be given to the all personnel involved in the module mounting
- ✓ Prior to Removal of module from the Module pallet ensure waste material to be collected and shift to scrap yard and finally to recycling agency.
- ✓ All the packing materials to be collected in waste bin or scrap yard.
- ✓ Ensure that Fire Extinguisher is always present and NO SMOKING signage should be displayed, as HDPE floats may get burnt easily and can cause huge fire.
- ✓ Ensure life buoy should be present at site.
- ✓ Ensure adequate number of life buoy shall always be present on the floating island for emergency situations
- ✓ Ensure the tug ropes are inspected before being used for pulling the assembled floating island to its designated location.
- ✓ Selection of equipment and protective measures appropriate to adverse environmental conditions.
- ✓ Presence of danger and warning signage.
- ✓ Display of appropriate drawing, instructions and other similar information.
- ✓ Ensure all Protective systems are in place.
- ✓ Ensure Appropriate PPEs (PVC hand Gloves, Safety Helmet, gum boots, waders, Life jacket etc.) to workmen.

8.4.SOLAR PANEL INSTALLATION:

- The floating assembly table should be free from any sharp edges and protruding nails to prevent person from any injury.
- Never scratch the parts of module with hand or any material.
- For taking the module from the pallet worker should be provided the specific training by the concerned engineer.
- For module handling hand gloves and goggles is must to avoid injuries due to sharp edges and frailness of the module.



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- At least Two persons are required for handling the PV module. Handling includes removal of module from pallet, carrying to structure by hand and fixing in the structure.
- Never carry a module on head.
- If any module damaged it should be immediately reported to the supervisor.
- Damaged module should be handled by wearing insulated hand gloves.
- Mounting in structure ensure tightening to be done by torque wrench.
- Module mounting should not be carried out during rainy condition.
- Supervision should be provided continuously throughout the activity.

8.5.FLOAT INTERCONNECTION:

- Training should be given by the site engineer on how to carry the assembled float to the shore.
- Support and end clamp should be fixed on module float on the table provided for assembly.
- Then module float should be brought to the assembly area.
- Then PV module to be brought by two workmen and fixed on module float.
- While doing interconnection of assembled floats workmen should take care of the biological hazards present near water (e.g. snakes).
- The shore surface should be made clear of any obstacles for easy pushing and avoid tripping of workmen over module.
- While pushing the assembled row into the water proper distribution of load should be equal, to avoid excess load on joints.
- Life jacket should be worn by all person when going on segment.
- Person with binocular should be present on shore for proper supervision.
- Before taking assembled segment into water sufficient drinking water should be on board, Life buoys to be placed at each corner.
- While pulling the segment inspection of rope should also be done.
- Training should be given to workmen before sending them to interconnect the segment with floating island.



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- Proper supervision should be done while interconnection.

8.6.ELECTRICAL CONNECTIONS PROCEDURE:

- **Series interconnection of SPV modules to form strings:**

During assembly, Bidder shall interconnect the SPV modules as follows:

- Each module is fitted integrally with a junction box having positive and negative polarity cables (4 or 6 sq.mm). Cable and connectors are part of Module supply.
- Positive cable of one module shall be connected to the negative cable of next module. The cables have MC4 type of connectors. One polarity cable has male type connector, while the other has female type connector.
- This way, 28 modules shall be connected in series. Each set of connections is called as a series string.

- **Earthing cable connections of solar PV modules:**

- All PV module earthing cable connections shall be completed by bidder during assembly. In 26/28 module string, each module frame shall be connected to adjacent module and modules of both ends shall have earthing cable with open connection, which shall be connected by BHEL to solar array earthing grid after launching of array in water.
- Bidder shall use min 2.5 sq.mm earthing copper cable (Yellow Green PVC sheathed) for connecting 28 modules in a row. The cable length between each module shall be 1.2 times of the distance between the earthing holes of PV modules.
- All the hardware (lugs, self-tapping screws etc.) of SS304grade shall be in bidder scope only. Vendor to take approval of GTP/MQP of earthing cable, cable length and hardware from BHEL before use in assembly.
- All PV Module cables shall be neatly tied above water with UV resistance ties.
- All above stated series connections and cable dressing of modules including module to module earthing should be done at shore.



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- While forming each row of the array of floaters, one must interconnect the module to module looping of DC Cables and use UV resistant cable ties on the hole provided on the supporting float or on the modules based on the available cabling length.
- Ensure to complete the module to module earthing looping during the connection of each row on the ground.
- Take care to ensure that the loose ends of the cables do not touch with water when floated out and also to ensure the cables are properly tied using UV resistant cable ties to ensure no cables touch the water surface.
- All tools & tackles required for Module and earthing connections are in the scope of bidder only. Requisite no. of tools required at site as per module assembly speed and Launching.

8.7. HANDOVER PROCEDURE OF ASSEMBLED ARRAY:

- Floater bidder shall complete the assembly of floater with PV Module for 100Kwp and post this BHEL's Electrical subcontractor will provide a demo of electrical connections in this assembled array. A joint protocol of demo with procedure shall be made after demo and the same shall be followed during assembly.
- After completing PV Module assembly, float connection and Electrical connection, as above, the assembly shall be checked by Electrical Sub-Contractor of BHEL before Launching for any discrepancy in electrical connection.
- The assembled Block shall be handed over to BHEL Electrical Sub contractor in water after completion of mooring of block. The joint handover protocol between Floater Vendor and BHEL's Electrical subcontractor shall be treated as assembly completion of block and used for payment of assembly.

8.8. INSTALLATION CHECKLIST:

- ✓ Check the connection of the injection nut with support piece on the connecting float, if applicable.



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- ✓ Check if the solar panel is aligned to the centre of each connecting float so as to have equal overhang on both sides.
- ✓ Check if aluminium clamps/PV Module Fasteners are tightened properly using the applicable hardware to the panel.
- ✓ Check if aluminium clamps/PV Module Fasteners are tightened properly using the applicable hardware with the float.
- ✓ Check that all interconnection ears are connected as per manual.
- ✓ Check the correct tightening of the applicable hardware at each interconnecting point.
- ✓ Check that if the anchoring / mooring spreader bars are connected as per design to the peripheral floats using interconnection ears.
- ✓ Check to ensure that the module to module looping of the DC cable and Earthing is done properly before pushing the floats into the water.
- ✓ Check to ensure the cables are sufficiently spaced above the water by use of cable ties to ensure no damages to the cable.
- ✓ Check the floats for any damages during assembly before pushing the arrangement into the water.

9.0 TYPICAL DETAILS OF EQUIPMENT, CABLES, LA ALONG WITH THEIR WEIGHTS FOR FLOATING SYSTEM DESIGN:

Following are the typical details of cables and other electrical system for an FSPV. However, actual details shall be provided during detailed engineering.

DC Power and HT cable details for floating SPV plant						
SL No	Description	Overall diameter (Max in mm)	Weight (Kg/m)	Bending radius 12D for LT and 20D for HT (Min in mm)	Route	Remarks
1	3.3kV, 1CX400 sq.mm XLPE	35	1.5	420	SCB to PCU	



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	Unarmoured AL cable					
2	3.3kV, 1CX400 sq.mm XLPE armoured AL cable	37	1.9	444	SCB to PCU	
3	33KV, 1CX150 sq.mm XLPE armoured Al cable	46	1.8	920	IFP to LPSFP	For trefoil formation 3 times the weight shall be considered
4	33KV, 1CX240 sq.mm XLPE armoured Al cable	51	2.3	1020	IFP to LPSFP	For trefoil formation 3 times the weight shall be considered
5	33KV, 1CX630 sq.mm XLPE armoured Al cable	64	4	1280	LPSFP to ground	For trefoil formation 3 times the weight shall be considered

9.1. Block shape may vary based on location of PCUs (on water /on land).

9.2. In case the PCUs are placed on water, the array sizing details no. of strings, no. of SMBs, type of Las, weight of SCB/SMBs, Height & Weight of LAs etc shall be provided based on PV Module Wattage during project specific tendering.

9.3. Floater should have additional clamping points for clamping HDPE pipes/FRP trays/ earthing strips etc other than four corners of the floater. Possibility of a clamping hole on module support member shall be explored for routing of 6 sq.mm cable below module using cable ties.



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10.0 WAVE ATTENUATION / REQUIREMENT OF FLOATING BARRIERS, AS APPLICABLE:

Detailed Wave study has to be carried out by the bidder and necessary wave attenuation methods to be provided for overall stability of the system.

The floating barrier is to be provided for restricting boats, debris, animals etc. Floating barrier can also be adopted to attenuate waves as per design requirement, if suited. The floating barrier should be manufactured from appropriate thermoplastic (virgin material) with UV stabilizer and environmentally friendly materials, such that the life of floatation device shall be able to sustain for a minimum period of 25 years. Materials shall be tested as per specifications given for PV floaters above in this document.

Innovative new product (floating water barrier) can be suggested by the bidder conforming to design, durability/ service life and environment friendly standards. Anchoring & mooring has to be provided at regular intervals as per detailed design considering design wind speed, water velocity, wave force etc.

Design of the floating barrier anchoring & mooring system shall be verified by suitable third party NABL accredited agency/reputed institutions like IITs or NIOT, Chennai or Indian Register of Shipping (IR Class), Mumbai and submitted for BHEL/End Customer's approval. The design life of the Anchoring system of floating barriers shall also be 25 years.

11.0 QUALITY ASSURANCE PLAN (QAP) & INSPECTION:

- 10.1. Detailed Material Quality Plan (MQP) for floater and its accessories shall be submitted within 7 days from the manufacturing clearance for BHEL/End Customer approval. A typical MQP for Floaters to be followed is attached for reference.
- 10.2. The floaters and all its accessories shall be inspected by an authorized representative of BHEL/End Customer/TPI at Manufacturer's/Supplier's premises before dispatch as per approved QAP (Quality Assurance Plan) of manufacturing. The items shall only be dispatched after issue of Material Dispatch Clearance Certificate (MDCC).
- 10.3. Bidder to raise inspection call 7 days in advance. The inspection call should contain BBU ref., QAP ref., internal test reports, RMTC etc. for review.
- 10.4. For Assembly and anchoring & mooring works, a detailed Field Quality Plan (FQP) shall be submitted within 7 days from the manufacturing clearance for BHEL/End Customer approval. The FQP shall detail out for all the works, equipment, services,



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quality practices and procedures etc in line with the requirement of the technical specifications to be followed by the Contractor at site. This FQP shall cover all the items / activities covered in the contract / schedule of items required, right from material procurement to completion of the work at site.

12.0 WARRANTY FOR FLOATING SYSTEM AND ANCHORING & MOORING:

A warranty period of 10 years from the date of successful completion of trial run of the project shall be provided for Floater units/ Floating platforms and associated accessories. Even though the warranty period envisaged for floater units and associated accessories is only 10 years, they shall be designed for a service life of minimum of 25 years from the date of successful completion of trial run of the project, considering ambient site conditions. As such, the design shall inherently ensure that there shall be no failure owing to crack, puncture, breakage etc. in the floaters and all associated accessories which affect the integrity of the whole system, for a minimum of 25 years from the date of successful completion of trial run.

The warranty of floating system as well as Anchoring & mooring system shall be provided by OEM only.

13.0 COMPREHENSIVE O & M OF FLOATING SYSTEM AND ITS ASSOCIATED ANCHORING & MOORING:

The bidder has to do Operation & maintenance of installed system for period specified in Project Information. Bidder has to depute sufficient no. of persons at site during O & M period as per project size requirement. Bidder to submit O & M manual for complete system which must include following (but not limited to):

- I. Periodic maintenance schedule for checking the floater condition, sign of crack/ damage, tightening of mooring ropes and any other maintenance needed to maintain healthiness of floating island. This includes replacement of faulty floaters used in the system.
- II. Bidder shall maintain a minimum stock of each component of floating system and its associated anchoring & mooring as O & M spare at site during complete O & M Period for maintenance of the system. Bidder to replenish the spares if consumed and maintain minimum stock at any time during O&M period. The minimum requirement is only indicative and any additional quantity as deemed required shall be maintained at site by the bidder.
- III. Schedule and methodology of checking of Anchoring and mooring components periodically for its wear and tear.



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IV. Schedule of preventive maintenance and checks.

O & M of floating and A & M works shall be done as per O & M manual approved by BHEL and a monthly report in appropriate format shall be submitted and accepted by BHEL for O & M payments.

14.0 COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT (AMC)

Bidder has to furnish AMC on yearly basis from the date of completion of O & M of the floating system for period specified in Project Information. Comprehensive AMC shall include all preventive maintenance and breakdown maintenance including replacement of any component to ensure that equipment is working satisfactorily as per design/system requirement. During AMC period, the OEM is required to respond within one working day through telecom or any electronic means. This AMC to include the following:

- I. Attending to and resolving any breakdown/fault of the floatation platform.
- II. Mandatory 1 half yearly visit (once in six months) to assess the floating platform for any failure or any sign which may lead to subsequent failure. Vendor to send the assessment report to BHEL/End customer through email.

In case of severe breakdown of the system, OEM has to send their representative within 72 hours. For the minor faults not hampering the generation, the OEM has to get the fault rectified within 7 working days. Failure from the OEM to adhere the activity and the time schedule may lead to BG encashment.
