मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

इपोक्सी रेजिन प्रणाली द्वारा नई कंक्रीट को पुरानी कंक्रीट से जोडना

BONDING FRESH CONCRETE TO OLD CONCRETE BY EPOXY RESIN BONDING SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	28.02.25	REVISED & REISSUED	RIYA	VIKRAM	AS	MN
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Abbreviations:

ASTM	:	American Society for Testing & Materials

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1.0 SCOPE

1.1 This specification defines the material, constructional and other performance requirements for proper bonding of fresh concrete to old, hardened concrete by epoxy resin bonding system which is able to cure under humid conditions and bond to damp surfaces. Any special requirement as shown or noted on the drawings and directed by the Engineer-in-Charge shall govern over the provisions of this specification.

1.2 Actual working shall be carried out in accordance with this specification and recommendation of the manufacturer of the resin system to suit specific requirements for the particular site and other climatic conditions existing there. In case of any conflict, this specification shall govern.

2.0 MATERIALS

2.1 Epoxy resin system used for bonding fresh concrete to old hardened concrete shall consist of two components, viz. epoxy resin and hardener for combining immediately prior to use as per manufacturer's recommendations. Filler material shall be added, if required, as per manufacturer's specification. However, this shall be incorporated in any of the two components. The system shall cure under humid conditions and bond to damp surfaces.

2.2 The bonding material shall be compatible with the concrete to which it is to be applied and shall have the following minimum properties:

Compressive Yield Strength	55 N/mm^2 (7 days)
Tensile Strength	40 N/mm^2 (7 days)
Bond Strength	10 N/mm^2 (14 days)
Flexure Strength	35 N/mm^2 (7 days)
Shear Strength	10 N/mm^2 (7 days)
Pot Life	45 minutes
Full Cure	7 days at 20°C to 35°C
Overlaying Time (open time)	1 hour at 20°C to 35°C

2.3 The resin and hardener shall be mixed in the proportion as specified by the manufacturer. The preparation, mixing and application of the resin system shall strictly be in accordance with the manufacturer's recommendations.

2.4 Certificate of test results of all the materials from BIS/NABL recognised laboratories duly authenticated by the approved manufacturer(s) shall be submitted to Engineer-in-Charge and got approved by him in writing prior to commencement of work. In the event of failure to submit such test results from the manufacturer for any material, the contractor shall carry the tests from an approved laboratory and submit the test results including the name(s) of manufacturer(s) to the Engineer-in-Charge and get approved by him in writing prior to commencement of work. All tests shall be in accordance with ASTM C881M (Type V) in case of non-availability of any specific Indian Standard.

2.5 Pot life and open time

Pot life is the period during which the resin system after mixing retains sufficient workability for proper use and the resin system must be applied to the prepared concrete surface within this period.

The 'open time' is the maximum period of time allowable between application of resin system and pouring of fresh concrete. Exceeding the 'open time' shall result in considerably reduced adhesion. The adhesive shall be applied to the prepared substrata as soon as the components have been mixed and fresh concrete shall be poured immediately before adhesive begins to gel. The bonding of fresh concrete to old concrete shall not to be done if the temperature is below 10°C.

3.0 SPECIAL REQUIREMENT

3.1 All works covered by this specification shall be carried out by experienced and approved agency having sufficient knowledge in epoxy resin treatment works. Only skilled and experienced operators shall be employed for the purpose.

4.0 APPLICATION

4.1 Preparation of Concrete Surface

4.1.1 Grease, oil, algae and other foreign substances likely to impair good bonding shall be thoroughly removed from the surface by scrubbing or using detergent and washing with clean water. All loose and spalling concrete pieces shall be removed. The surface to be bonded shall be made thoroughly rough by chiselling, taking off the skin of concrete and sharp edges of aggregate shall be exposed. The surface shall be washed, wetted cleaned and dried with dry compressed air. Exposed reinforcement shall be thoroughly cleaned with sand paper and wire brushes to remove all dust and sticking mortar.

4.2 Mixing

4.2.1 The resin and hardener shall be thoroughly mixed in a mixer. The approved resin system shall be prepared strictly as per manufacturer's recommendations. It shall not contain lumps and shall have uniform colour. Filler material shall be added if so specified by the manufacturer. Hand mixing shall be allowed for small quantity with prior permission of the Engineer-in-Charge.

4.3 Method of Application

4.3.1 The resin system shall be applied by spraying to the prepared surface. Manual application by using stiff nylon bristle brush may also be allowed with prior permission of the Engineer-in-Charge. The manufacturer shall specify the method of application suitable for the specified work.

4.4 Coverage

4.4.1 A minimum of half kilogram per square metre (½ kg/m^2) or resin system shall be applied to prepared concrete surface. However, the covering capacity depends on the nature of surface over which the system is being applied and the contractor shall use additional quantity of the resin system as per the recommendation of the manufacturer.

4.5 Handling Precaution

4.5.1 Only skilled and experienced workers shall be entrusted with the application of epoxy system. The resin and hardener shall not be allowed to come into direct contact with the skin. Rubber or polythene gloves with cotton gloves underneath must be worn by the workers handling resin products. Parts of skin which have accidently come into contact with resin or hardener shall immediately be washed with lukewarm water and a mild soap. Special cleaning creams or chemical shall be kept readily available and used as recommended by the manufacturer.

4.6 Cleaning and Maintenance of Equipment

4.6.1 Tools and mixing equipment shall be cleaned immediately after use by using scrapers and other solvents (e.g. toluene, xylene or acetone) as recommended by the manufacturer.

5.0 APPROACH, WORKING PLATFORM & SCAFFOLDING

5.1 The contractor shall arrange all approaches, stairways, ladders, working platform etc. for carrying out the entire operation safely. The working area shall be neatly maintained and all facilities required by the Engineer-in-Charge for proper supervision of the work shall be provided by the contractor.

5.2 All precautionary measures required for the safety of the structure during the progress of operation and till the successful completion and handing over shall be the responsibility of contractor. He shall carry out all such measures as directed by Engineer-in-Charge.

6.0 PAYMENT (applicable to item rate tenders only)

6.1 Payment shall be made by weight of resin system actually used in the work.

6.2 The rate quoted shall be inclusive of all labour and materials required for the successful completion of the work including all cleaning operation before and after the work, preparation of the old, hardened concrete surface as specified, mixing, application of epoxy resin and other safety measures including their removal after completion, all plants and tools etc. complete. Rate shall also be inclusive of all tests required to check the specific properties of materials.

6.3 Any test specified and directed to establish the soundness and monolithicity of bonding of fresh concrete to old concrete actually executed shall be paid separately unless such tests fail to meet the requirements of this specification. In case of failure, no such payment shall be made and the contractor shall repair/ rectify or re-do the work as directed by Engineer-in-Charge at no extra cost to the owner.

6.4 Underground work like excavation, backfilling, removal of surplus earth, keeping the pit dry by pumping/ bailing out subsoil water shall be paid separately as per relevant item in the contract.

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STANDARD SPECIFICATION FOR EARTHWORK FOR UNDERGROUND PIPING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	14 03 19	REAFFIRMED AND ISSUED AS STANDARD SPECIFICATION	AVM	AJS	RS	RKT
3	23 05 11	REVISED AND ISSUED AS STD SPEC	ALOK	RKS	RBB	DM

Abbreviations:

IS	:	India Standard
RCC	:	Reinforced Cement Concrete
U/G	:	Underground

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1.0 SCOPE

This specification deals with earthwork in trenches and pits (for valves, manholes, catch pits etc.) for underground piping.

2.0 CODES & STANDARDS

IS: 783	Code of practice for laying of RCC pipes.
IS: 1200 (Part-I)	Method of measurement of building and civil engineering works.
IS: 3764	Excavation work – code of safety.
NOTE:-	Latest Edition of all Codes and Standards shall be followed.

3.0 MATERIAL

All workmanship and materials shall conform to the provisions of IS: 1200 (Part-1) and IS: 3764.

4.0 EARTHWORK IN EXCAVATION FOR TRENCHES / PITS FOR PIPELINES

4.1 Excavation

Plant, machinery and equipments for excavation shall be selected and deployed to provide optimum mechanization in excavation of trenches and pits. The selection for excavation and earth movement machinery etc. shall take into account type of materials to be excavated, method of excavation, prevailing weather conditions and type of transport to be used.

The excavation of area of cut shall be so timed that the bottom level is not exposed to the deteriorating influence of the weather for longer duration.

Excavation and earth moving equipment shall be deployed such that minimum damage is caused to the natural sub-soil structure of exposed formations.

The monitoring of soil deformations, ground water levels during and possibly after construction work shall be taken into consideration.

In the event, when excavation works are carried out in the vicinity of structures of any importance, the above monitoring shall be carried out within a distance, from the edge of the excavation of 5 to 15 times the excavation depth, depending upon the subsoil conditions and the stability of the neighboring structures.

4.2 Trenching work shall be carried out in all classes of soil including soft rock and excluding hard rock and shall be for all depths.

4.3 The trench shall be cut true to the line and level as per drawings.

4.4 If the trench is excavated below the required level than that indicated in the drawing, the extra depth shall be filled with concrete 1:5:10 or approved equivalent materials, as directed by the Engineer-in-Charge, at no extra cost to the owner.

4.5 In case of pressure piping, the trench shall be excavated generally as to provide a cover of 1000 mm or dia of pipe whichever is more. In case of gravity sewers/ pipes, the trench shall be excavated to conform to invert levels as per drawings. However in certain cases, the pipes may run at shallower levels or at deeper levels depending upon drawing, site condition etc.

No rebate for lesser excavations, nor extra payment due to deeper excavations, shall be admissible in those cases where pipeline laying rates are inclusive of earthwork items. The rates quoted shall be deemed to cover all works connected with trenching, whether trenches are with single pipeline or have multiple pipelines in common trenches including road cutting and making good the same.

4.6 The width of the trench shall be sufficient to give free working space of personnel, equipment, supports and ancillaries on each side of the pipe. The free working space shall conform to IS: 783. Generally it shall not be less than 150 mm on either side or 1/3 dia of outer diameter of the pipe, whichever is greater.

4.7 When pipelines are running parallel, whether the trenching shall be individual or common, shall be decided by the Engineer-in-Charge and such decision shall be final and binding on the contractor. No extra shall be payable for common excavations.

4.8 All earthwork involved in excavations of all types of manholes, catch pits, valve chambers, inspection chambers, chambers for instrumentation tapping etc., which are coming on the alignment of U/G piping or as defined by drawing as a part of U/G piping work, shall be paid extra under Earth work in excavation, back filling and removal of surplus earth etc. under relevant clauses of the SOR.

4.9 Aspects such as variations in the soil conditions and the geological structure, depth of excavation, the existence of ground water and surface water, the type and extent of excavation, the topography of site, the proximity of items such as roads, buildings and buried services, construction traffic and activities near the excavation eg. Stock piling shall be taken into account when determining whether the sides of excavation should be free standing, sloping or temporary supported.

Suitable drainage and / or dewatering system like Well Point method / Bore well method etc. shall be provided to prevent or limit ingress of surface or sub surface water into excavation.

Serviceable materials intended for reuse should be used as soon as possible after excavation otherwise they should be stock piled at a location beyond 1.5m from the top edge of the excavation or beyond a distance equal to the depth of the excavation whichever is higher at a location approved by the Engineer-in-charge. If excavated serviceable material is not possible to be stacked within the limits specified above, due to some constraint, it shall be stacked away at a location approved by Engineer-in-Charge and paid separately under relevant item.

Areas used for temporary stockpiling of excavated material shall be kept clean and orderly, with excavated material kept by the side of road to avoid traffic movement. Excavated areas shall be restored to their original condition before completion of works.

All types of shoring and strutting, wherever necessary, shall be adopted to with hold the face of earth or cutting in slope, as per site requirements and direction of Engineer-in-Charge. Supports shall be maintained such that the integrity of the sides of the excavation is not impaired.

4.10 Any obstacle encountered during excavation shall be reported immediately to the Engineer-in-Charge and shall be dealt with as instructed.

4.11 The contractor shall maintain all excavated trenches and pits, in a dry and trim condition.

4.12 Necessary barricading and protection of slopes against slips due to traffic movement shall be provided to the satisfaction of Engineer-in-Charge. Necessary warning flags and lights shall be provided to caution traffic in the areas where trenches and/ or pits are provided.

4.13 In case of road cutting, all road material i.e. metal etc., shall be taken out carefully and kept separately for reuse and road work shall be redone up to the original level, as it was prior to cutting the road, with the excavated road materials after laying and testing of the pipeline, within 10 days from the date of starting this work, at the cost of the contractor. The contractor shall provide suitable warning signs and barricades to prevent accidents.

Contractor shall also provide reasonable bye pass at his own cost when a road is cut for laying pipeline. Tankage dykes cut due to laying of the pipes, shall be redone conforming to the original specifications, by the Contractor at his own cost. Secondary dykes, to take care of any eventuality during construction, shall be provided by the Contractor at his own cost.

4.14 Dewatering shall be done in advance of the installation of the pipe to allow adequate inspection of padding of the bottom, if required. Dewatering shall be continued throughout during installation and backfilling.

The trench shall follow the gradient of pipeline as specified in the drawing. The contractor shall keep the trench in good condition, until the pipe is laid and tested. No extra claim shall be entertained due to its caving or setting down, either before or after the pipe is laid.

In case, pipe is lowered in caved trench and backfilled before being inspected by the Engineer-in-Charge, the Contractor shall re-excavate the trench for inspection and backfill it at his own cost.

5.0 BACKFILLING AND COMPACTION

Backfilling

Trenches shall be back filled with suitable materials which should be compacted to the same degree or better as the surrounding soils.

5.1 The soil used should be selected and approved by Engineer-in-Charge. Suitable material can be extracted from available excavated material. The soil should be free from rubbish, grass, organic matter, stones, building waste and Black Cotton Soil etc. It should be free from clods and hard lumps. In case good soil is not available from excavated material for back filling, trench shall be filled back with locally available coarse sand upto 30 cm. thick above the pipe and rest of trench shall be filled back with excavated soil upto required level.'

5.2 The filling should commence only after approval of Engineer-in-Charge is obtained and after the structures or pipes to be buried are tested and approved. Otherwise, if required, contractor shall uncover buried portion and refill at his own cost.

Temporary excavation supports should be removed as back filling and compaction proceeds, such that unacceptable movement of the supported ground does not occur.

Voids caused by extracted supports should be filled and compacted.

5.3 Filling should be done in layers. Each layer should be not more than 15 cm thick when loose and should be well rammed, with necessary watering, to obtain at least 90% of maximum laboratory dry density.

Compaction trials should be carried out on each soil type to be placed in backfill, in order to confirm the type of machine and number of passes required to obtain optimum compaction for given soil moisture contents. These trials should also be used to determine the variability of the proposed fill material for different weather conditions.

5.4 Care must be exercised to protect cables, pipes, joints, and other features from damage due to backfilling and consolidation.

5.5 Filling should extend up to the level of original ground surface or as per drawing or as directed by Engineer-in-Charge. The finished surface should be properly trimmed and dressed. The adjoining area should be cleaned and no heaps of surplus earth should be left out.

6.0 TRANSPORTATION OF SURPLUS EARTH

Unserviceable materials and serviceable materials not intended for re-use shall be removed from the work site and disposed off at a location as approved by Engineer-in-charge.

The surplus earth is generated due to pipe laying, valve chambers, and manhole construction etc. Surplus earth is also generated due to voids in the back filled volume of earth. The removal of surplus earth shall include excavation, loading, transportation, dumping, stacking or spreading, as per the directions of Engineer-in-charge.

7.0 PAYMENT

7.1 Unless specifically stated in the schedule of rates, no separate payment for earthwork in excavation, backfilling, transportation, dewatering etc. shall be admissible and the payment for the same is deemed to have been included in the relevant items of the contract.

7.2 In case payment for earthwork is specified separately in the Schedule of Rates, the payment shall be based on the actual quantity of excavation, backfilling and transportation done, taking into consideration the slopes authorised by the Engineer-in-Charge for excavation, volume of backfilling calculated on the basis of excavation reduced by the volume of pipes.

7.3 In cases where hard rock excavation is involved, the matter shall be referred to Engineer-in-Charge, before proceeding with the work.

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STANDARD SPECIFICATION FOR UNDERGROUND & ABOVE GROUND GALVANIZED STEEL PIPING (WATER SERVICES)

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6	27.10.2025	REVISED & ISSUED AS STD. SPEC.	PREETI	RKS	SKN	M.Nandi
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Abbreviations:

IS	Indian Standard
Kg/cm^2g	Kilogram per Square Centimeter Guage
MPa	Mega Pascal

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1.0 SCOPE

This specification covers the fabrication and erection of Galvanized Steel piping, both underground and above ground, including excavation, backfilling for the piping and testing.

2.0 CODES AND STANDARDS

IS: 554	Indian Standard- Dimensions for pipe threads where pressure tight joints are made on the threads- Dimensions, Tolerances and Designation
IS: 778	Indian Standard- Copper alloy gate, globe and check valves for water works purposes
IS: 1239 Part I	Indian Standard- Steel Tubes, Tubulars and other wrought steel fittings- Specification (Part 1 Steel Tubes)
IS: 1239 Part II	Indian Standard- Steel Tubes, Tubulars and other Steel fittings- Specification (Part 2 Steel pipe fittings)
-	Piping Material Specification (PMS)
-	Valve Material Specification (VMS)

NOTE: -Latest Edition of all Codes, Specifications and Standards shall be followed.

3.0 MATERIALS

a) All Galvanised piping shall conform to relevant piping material specification class.
b) All valves shall conform to relevant piping/ valve material specification class.
c) All fittings shall conform to relevant piping material specification class.

4.0 EARTHWORK IN EXCAVATION AND BACKFILLING ETC.

All earthwork for underground piping shall be governed by the provisions of EIL specification 6-65-0006,"Earthwork for underground piping", to the extent applicable.

5.0 JOINTING AND ERECTION OF SCREWED/ FLANGED GALVANIZED STEEL PIPING

5.1 Screw socket Joints

The screwed end of all pipes shall be thoroughly cleaned and painted with a mixture of Red and White Lead or Teflon before jointing. The joint shall be made by winding a few threads of hemp round the ends of tubes and then screwing them into sockets to the full depth of threads. Exposed threads shall be coated with approved anticorrosive paint. No pipe shall be bent / offset to save fittings. The offset in pipes shall be made only after the permission of the Engineer-in-Charge. If threaded end of pipe is damaged, the contractor shall cut the end with hacksaw and shall prepare new threads conforming to IS: 554, to required length.

All fittings shall be of Galvanised Steel. Fitting includes all couplings, elbows, tees, bends, unions, nipples, reducers, flanges with nuts, bolts, gaskets and rubber insertion and all other fittings to make a complete job.

5.2 Flanged Joints

Flanged joints shall be made by painting the faces of the flanges with red lead and bolting up evenly on all sides with compressed asbestos gasket as per piping material specification.

5.3 Valves

Flanged or screwed valves shall be installed in locations shown on the drawings as per specification for screwed or flanged joints.

6.0 JOINTING AND ERECTION OF WELDED GALVANIZED STEEL PIPING

Welded joints shall be made as per relevant piping specification(s).

7.0 FLUSHING & TESTING

Flushing and testing shall be as per specification no. 6-44-0013 (/job specification). Pipes or fittings which are found leaking shall be replaced/ redone, without extra payment.

8.0 PAYMENT

8.1 Payment shall be made on running meter basis of finished piping with fittings after testing etc. complete. No separate payment shall be made for earthwork in trenching and backfill, road cutting etc. Payment for valves and flanges etc. shall be made as per schedule of items on unit rate basis. The unions shall be provided at every 50 meter, unless otherwise stated in schedule of items / construction drawings. Rates shall include all incidental work such as transportation of all materials from Owner's store(s), custody, and fabrication and laying of underground piping.

8.2 The payment clause 8.1 is not applicable in case of LSTK Jobs.

भूमिगत सीवर प्रणाली के लिए मानक विनिर्देश (पूर्वनिर्मित प्रबलित सीमेन्ट कंक्रीट पाइप)

STANDARD SPECIFICATION FOR UNDERGROUND SEWER SYSTEM (PRE CAST RCC PIPES)

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Abbreviations:

IS	:	Indian Standard
Litres/km/hr/cm	:	Liters/ Kilometer/ Hours/ Centimeter
RCC	:	Reinforced Cement Concrete
mm	:	millimeter
cm	:	centimeter

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1.0 SCOPE

This specification covers the supply, laying, cutting, jointing and testing of Precast RCC pipes and related works.

2.0 CODES & STANDARDS

IS: 458 Pre Cast Concrete Pipes (with and without reinforcement- specification)

IS: 783 Code of practice for laying of Concrete Pipes

6-65-0006 Standard Specification for Earth Work for Under Ground Piping

NOTE:- Latest Edition of all Codes and Standards shall be followed.

3.0 MATERIALS

3.1 The pipes shall be centrifugal cast concrete pipes, socket and spigot type, with reinforcement conforming to IS: 458. The class of pipes shall be as specified on drawings. The pipes shall be accepted on the basis of Test Certificates from Manufacturers. Additional testing shall be done, if directed by Engineer-in Charge.

3.2 The surfaces and edges of the pipes shall be well defined and their ends shall be perpendicular to longitudinal axis

4.0 EARTHWORK

4.1 All earthwork involved in laying of RCC pipes and related works is deemed to have been included in the quoted rates for the laying of RCC pipes.

4.2 All earthwork shall be carried out as per specification No.6-65-0006 "Earthwork for underground piping ".

4.3 The bed of trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

4.4 If the trench bottom is extremely hard or rocky or loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade, by filling with selected fine earth or sand (fine murrum, if fine sand or soil is not available) and compacted, so as to provide smooth bedding for the pipe.

Where excavation requires blasting operations, it shall be ensured that no pipes are stacked in the vicinity and complete pipelines in the vicinity have already been covered before starting of blasting operation.

4.5 The trench shall be kept free from water. Shoring and strutting / timbering shall be done, wherever required. Excavation below water table shall be kept dry by dewatering the trenches, if required.

4.6 After excavation of the trench is completed, hollows shall be cut at the required position to receive the socket of the pipes and these hollows shall be of sufficient depth to ensure that the barrels of the pipes shall rest throughout their entire length on the solid ground and that sufficient spaces left for jointing the underside of the pipe joint. These hollows shall be refilled with sand after jointing the pipe.

5.0 LOWERING & LAYING

5.1 The pipes shall be lowered when the trench is ready and the bottom has been properly graded as per drawings.

5.2 Before lowering, the pipes shall be inspected carefully. Broken or cracked pipe shall be rejected. The inside of the pipe shall be cleaned off from sand, earth or any other matter.

5.3 The pipe shall be lowered carefully so as not to disturb the bed and sides of the trench. Heavy pipes shall be lowered with chain pulley blocks or crane.

5.4 Pipes shall be set according to line and grade. Prior to making joints, all surfaces shall be thoroughly cleaned and prepared as required, for the type of joint to be made. Pipe shall be carefully centered so that the complete sewer will have a smooth uniform invert.

5.5 In socket & spigot pipes, the socket end shall face the upstream direction.

5.6 Railway authorities or other appropriate authorities shall be consulted wherever the pipeline crosses a railway line, canal, etc.

5.7 Connection to existing sewer shall be done through a manhole.

5.8 The ends of the pipeline shall be kept sealed to prevent entry of any foreign materials. The seals shall be broken before / after the testing is done.

5.9 Wherever the joining material is cement, six or more lengths of pipe shall be laid in advance of each joint before it is finished.

5.10 In cases, where the natural foundation is inadequate, the pipes shall be laid either in concrete cradle supported on proper foundations or any other suitably designed structure. If concrete cradle bedding is used, the depth of concrete below the bottom of pipe shall be at least 1/4th of the internal diameter of the pipe subject to the min. of 100 mm and a maximum of 300 mm, the concrete shall extend by 150 mm on each side beyond the outside diameter of pipes. The pipes shall be laid in this concrete bedding before the concrete has set.

Pipes laid in trenches in earth shall be bedded evenly and firmly and as far as possible, up the haunches of the pipes, so as to safely transmit the load expected from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under and around the curve of the pipe from an even bed. Necessary provision shall be made for joints, wherever required.

6.0 JOINTING

6.1 Joint in the pipeline shall be of socket and spigot type and conforming to relevant Indian standards.

6.2 As per IS: 458, only flexible rubber ring joints shall be used for the joints in (a) all pressure pipes and (b) all non- pressure pipes except when used for road culverts/ cross drains. The pipe joints shall be capable of withstanding the same pressure as the pipe. Contractor shall provide pipes of socket and spigot type, meeting the above requirements.

6.3 As per IS: 458, joints in pipes of diameter up to 700 mm, shall be external flush type joint and shall be internal flush type for pipes of diameter more than 700 mm.

6.4 The groove in between the pipe ends is to be filled with jute, impregnated with bitumen and rolled in the form of gasket ring centrally around the pipe, to ensure uniform annular space between the collar and the pipe.

6.5 Cement mortar of proportion 1:2 shall be used for caulking the annular space. Care shall be taken to see that the bottom of the collar joint is also caulked properly.

6.6 The joint shall be finished at an angle of 45° and shall be kept wet for 10 days for curing.

7.0 TESTING

7.1 The pipeline shall be tested for water tightness of joints. The test shall be carried out from manhole. Pipe ends shall be closed and filled with water so that water level is up to the top of the manholes.

7.2 The line shall be kept full for 24 hours. Observations shall be taken at one hour interval and if leakage is within 2.5 liters/km/hr/cm of diameter of pipeline, it shall be deemed to have passed the test.

7.3 Engineer-in-Charge may at his own discretion, ask the contractor to test the laid pipe line in sections, in which case the contractor will do the same, as per the procedure to be decided by the Engineer-in-Charge, without any extra cost to Owner. The procedure adopted in such cases, however, will be to test the pipeline according to the criteria mentioned above.

7.4 In case joints are found to leak, they shall be repaired or redone and test shall be repeated until the joints are approved by Engineer-in-Charge.

The work shall have deemed to be rejected, in case any visual leakage observed from any of the joint. The contractor shall undertake repairing and testing of the joint without any extra cost to the owner.

7.5 After completion of the test, all temporary seals shall be removed, the test water shall be drained / pumped out and the line cleaned properly.

7.6 Before commissioning, the cleanliness of the pipeline shall be checked by following tests.

7.6.1 Torch & Mirror Test

In this method of testing, a torch will be held at one end of the pipeline inside a manhole and its image through the pipeline will be reflected and seen on a mirror held at the opposite end of the pipeline, inside the next manhole. Any obstruction / debris / major misalignment will not give a clear image, in which case the pipeline shall again be cleaned, rectified and the test redone.

7.6.2 Ring Test

In this method of testing, two steel / wooden rings of suitable thickness and design shall be fixed facing each other, at a distance of 2 feet or more. The block of rings shall be inserted from one end of the pipeline, inside manhole and pulled by a rope fixed to the block from the other end of the pipeline, inside the next manhole. The rings shall be of diameter 2"(inch) less than the inside diameter of pipe under testing. The rope used for pulling the ring block may be inserted in the pipeline by the contractor either during construction or afterwards by suitable means. Any obstruction/ debris/ major mis-alignment will prevent the ring to pass through the pipeline in which case the pipeline shall again be cleaned / rectified and the test redone.

The ring test shall be performed for the complete network of the sewer system, before the same is put in commission.

8.0 RESTORATION OF DAMAGED SURFACES AND CLEARING THE SITE

8.1 All pavements, structures, pipelines, cables, etc. removed, damaged or disturbed during the pipe laying work shall be restored to original conditions.

8.2 Surplus excavated soil or rubbish material shall be removed to a place, as directed by Engineer-in-Charge.

9.0 PAYMENT

9.1 Measurement of pipeline work for the purpose of payment shall be taken in running metre of the laid pipe measured along centre line, inclusive of joints. The rate quoted shall be inclusive of excavation, lowering, laying, jointing, connecting the pipe to manholes and grouting the pipe to manhole wall, testing, cleaning of pipelines, backfilling, commissioning and any other operation involved in the pipeline work.

9.2 The payment clause(s) as described in this standard specification shall not be referred/ applicable for LSTK Jobs.

जल–निस्सारण की नलसाजी व विनिर्माण हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR PLUMBING AND BUILDING DRAINAGE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	06.07.18	REAFFIRMED & ISSUED AS STD. SPEC.	LP	VG	RAJANJI SRIVASTAVA	R K TRIVEDI
3	23.08.12	REVISED & ISSUED AS STD. SPEC	JAY KUMAR	RC	RBB	DM

Abbreviations:

CI	Cast Iron
CM	Cement Mortar
CP	Chrome Plated
G.I.	Galvanised Iron
HCI	Heavy Cast Iron
IS	Indian Standard
Kg/sq.cm	Kilogram / Square Centimeter
LSTK	Lump Sum Trunkey
M.S.	Mild Steel
mm	Millimeter
P.C.C.	Plain Cement Concrete
Psi	Pound Per Square Inch
R.C.C.	Reinforced Cement Concrete

Structural Standards Committee:

Convenor: Mr. Rajanji Srivastava

Members:
Mr. Anurag Sinha
Mr. VK Panwar
Mr. Samir Das
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Charanjeet Singh (Projects)
Mr. Ravindra Kumar (Construction)

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1.0 SCOPE

1.1 This specification is intended to establish and define the materials and constructional requirements for plumbing & building drainage work.

1.2 All materials, fixtures and workmanship shall be in accordance with the relevant Indian Standard, Specifications and Codes of practices.

2.0 CODES & STANDARDS

IS: 269	Ordinary Portland cement, 33 grade
IS: 554	Dimensions for pipe threads where pressure-tight joints are made on threads
IS: 651	Salt-glazed stoneware pipes and fittings
IS: 778	Copper alloy gate, globe and check valves for water works purposes
IS: 782	Caulking lead
IS: 1239	Mild steel tubes, tubulars and other wrought steel fittings
IS: 1726	Cast iron manholes covers and frames
IS: 1729	Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories
IS: 1742	Code of practice for Building drainage
IS: 2065	Code of practice for water supply in Buildings
IS: 2470	Code of practice for installation of septic tanks
IS: 3486	Cast iron spigot and socket drain pipes
IS: 3950	Surface boxes for sluice valves
IS: 3989	Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories
IS: 5455	Cast iron steps for manholes

NOTE: - Latest Edition of all Codes and Standards shall be followed.

3.0 H.C.I. NAHNI TRAP (FLOOR TRAP)

Nahni trap shall be of heavy cast iron as per IS: 3989 with 100mm inlet and 80/ 100mm outlet with CP pressed steel grating. It shall be of self-cleaning design. Grating shall be of either hinged or screwed down type.

It shall be fixed in cement mortar 1:2, as directed by Engineer-in-Charge.

4.0 STONEWARE GULLY TRAP CHAMBER

The square mouth gully trap shall be of 100mm dia, conforming to IS: 651, of specified and/ or approved quality stoneware, complete with cast iron grating, and shall be got approved from Engineer-in-Charge. The size of CI frame and cover shall be of 300 x 300mm. It shall be properly fixed, as directed by the Engineer-in-Charge.

The size of the chamber shall be 300 x 300 x 675mm (internal). It shall be constructed of brick masonry walls, 125mm thick, in 1:4 cement mortar and M-20 concrete foundations. Inside & outside faces of the masonry walls shall be plastered with 1:3 cement mortar. The top of the chamber shall be provided with CI cover and frame.

5.0 VALVE CHAMBER, INSPECTION CHAMBER & MANHOLES

The size and type of construction of valve chamber, inspection chamber and manholes shall be as specified in the drawings or items.

6.0 C.I. SOIL / WASTE PIPES

CI pipes shall be socket and spigot of standard quality conforming to IS: 1729. The supply shall include all necessary accessories e.g. bends, Y- Junction, T- Junction, including plugs, shoes, cowls etc. complete.

CI soil / waste pipe below ground or floor shall be encased with 50mm thick PCC M20 Grade concrete.

The spigot of the pipe shall be placed fully resting inside the socket and hemp caulked home to leave space for lead depth as specified. Lead conforming to IS: 782 in molten state shall then be poured into the joint filling the same in one pouring. The lead shall be caulked by proper tools to make it even all round. Depths of lead in the joints from the top of the socket shall be 37mm for 150mm dia pipes, 25mm for 100 mm and 50mm dia pipes. All pipes shall be fixed 25mm clear of the wall with MS bat clamps or as approved by the Engineer – in Charge. All holes in walls and floors shall be made good by cement concrete M-15 grade and should be leak proof. All soil and waste pipes shall be tested for leakage by hydraulic test.

All CI pipes shall be painted with two coats of paint of approve make and shade over a coat of primer. Earthwork in excavation, backfilling and removal of surplus earth/ debris shall be considered as a part of the work. No separate payment shall be made for the same..

7.0 C.I. SOIL / WASTE VENT PIPES

CI pipes shall be standard quality conforming to IS: 1729. The supply shall include all necessary accessories e.g. bends, Y- Junction, T- Junction, including plugs, shoes, cowls etc. complete.

Jute yarn gasket of suitable diameter shall be used as required to support the spigot of the pipe at the proper grade and make truly concentric joints. Single piece of sufficient length shall be used to pass around the pipe and lap at the top and shall be thoroughly saturated in bitumen. This gasket shall be laid in the socket for lower third of the circumference of the joint and covered with cement mortar. The spigot of the pipe thoroughly cleaned with wet brush, inserted and carefully driven home after which a small amount of cement mortar (1:2) shall be inserted in the annular space around the entire circumference of pipe and solidly rammed into the joint with caulking tool. The joint shall then be completely filled with mortar and beveled off at angle of 45^0 with outside of the pipe. Cement used to join shall conform to IS: 269.

All holes in walls and floors shall be made good by cement concrete M-15 grade. All soil and waste pipes shall be tested for leakage by hydraulic test.

All CI pipes shall be painted with two coats of anticorrosive bituminous paint externally.

8.0 GI PIPES AND FITTINGS

All G.I. pipes and fittings shall conform to IS: 1239 and shall be of heavy grade for water supply system.

All screwed tubes and sockets shall have pipe threads in accordance with the requirements specified in IS: 554. Unless specified otherwise, pipes shall be supplied screwed with taper threads and sockets with parallel thread.

All fittings shall be malleable galvanised iron, approved by the Engineer-in-Charge. Fittings in G.I. line shall include all couplings, elbows, tees, bends, unions, nipples, reducers, flanges with nuts, bolts and rubber insertions, bushes and all other fittings to make a complete job.

Screwed G.I. pipes shall be jointed with screwed socket joints using screwed fittings. Care shall be taken to remove any burr from the end of the pipes after threading. White lead with a few strands of fine hemp shall be applied while tightening. Compounds containing red lead shall not be used.

All pipes above ground shall be fixed with G.I. holder bat clamps, clear off the wall, at 1.2 m centre to center. If the pipes are encased or embedded in wall, they shall be secured in position by iron hooks at 1.2 m centre to center. All visible pipes and clamps within and outside building shall be painted with two coats of white paint or aluminium paint as directed by the Engineer-in-Charge. No extra payment shall be made for clamps, hooks, cutting holes in walls, chasing and making good the same.

All underground pipes shall have a minimum earth cover of 600mm or as directed by the Engineer-in-Charge. No extra payment shall be made for excavation in trenches, backfilling the same and removal of surplus earth. Before any pipes are painted or covered up, they shall be tested to a test pressure equal to one and a half times the working pressure, as per job requirement (Minimum test pressure shall be $6Kg/Cm^2$ g) and the test pressure shall be maintained without loss for at least 30 minutes. Pipes or fittings which are found leaking shall be replaced and joints found leaking shall be redone, without extra payment.

9.0 GUN METAL VALVE

All full way and globe valves shall be of heavy gunmetal and tested at 300 psi and shall be approved by the Engineer-in-Charge. Valves shall conform to IS: 778. Size of valve chamber shall be as per item description. Construction of valve chamber shall be carried out as per clause 5.0 above. Valve chamber shall be provided & fixed with heavy duty C.I. surface box conforming to IS: 3950. The surface box shall be hinged pin open type & shall be fixed in the chamber slab. It shall have a hole for opening.

10.0 M.S. RUNGS/ C.I. STEPS

The rungs for pits, manholes and septic tanks etc. shall be made out of M.S. bars conforming to Indian Standard and to the shape and size as shown in drawings.

CI steps for manholes, if needed shall be as per IS: 5455

M.S. rungs shall be coated with 2 coats of approved bituminous paint.

11.0 SOAK PITS

All earthwork in excavation, brick work etc. shall conform to relevant I.S. standard.
The brickbats should preferably be slightly over burnt or thoroughly well burnt, deep red in colour with some proportion of deep blue or black veins. Spongy or vitrified material, as a result of excessive over burning, is useless and shall be rejected. Brickbats bigger than specified size shall be reduced to required size (40 to 50mm) before filling in soak pit and no extra payment shall be made for this. It shall be stacked at site as directed by Engineer-in-Charge. Soak pit & septic tank shall be connected with required piping.

12.0 SEPTIC TANK

Septic tanks shall be provided as per drawings and directions of Engineer-in-Charge. The sizes shall vary depending on the no. of users.

Alternatively, ready made RCC pipe septic tank, consisting of sewage receiving chamber, inspection door, vent pipe, inlet & outlet connections, manhole cover, C.I. steps etc. shall be used.

Design, testing & commissioning shall conform to IS: 2470 Part-I.

Access opening shall be provided for desludging & inspection.

The ventilating pipe shall be provided with pipe of at least 50mm dia extended 2 meters above the nearest working platform level.

In case where water table is shallow and soak pits are not recommended, upflow filters, as per drawings shall be provided.

13.0 PAYMENT

13.1 H.C.I. Nahni Trap (Floor Trap)

Payment shall be made per number basis. The rate shall include supplying and fixing Nahni trap, including cement mortar, cutting walls and floors and making good the same, providing and fixing chromium plated pressed steel grating etc. all complete.

13.2 Stoneware Gully Trap Chamber

Payment shall be made on per number basis. The rate shall include supplying and fixing of stoneware gully trap, CI grating, construction of masonry chamber, providing and fixing CI frame and cover, earthwork in excavation, foundation concrete, backfilling and removal of surplus earth up to a lead of 30m and labour and material etc. all complete.

13.3 Valve Chamber, Inspection Chamber & Manholes

Payment shall be made as per number basis including excavation, backfilling, removal of earth, construction of the valve chamber, inspection chamber and manhole, making connections of pipes through the walls including grouting, cost of M.S. rungs, cover slab, cost of CI cover and frame etc. as per specifications and directions of the Engineer-in-Charge.

The rate shall include breaking concrete or brick masonry work and making good the same with 1:4 cement mortar if necessary, finishing, painting, etc. as per directions of Engineer-in-Charge.

13.4 C.I. Soil / Waste Pipes

The payment shall be on running meter basis of pipes laid with fittings as required on site. The rate shall include supplying and fixing of pipes and necessary specials including cowl with hemp and lead, jointing & testing, bat clamps, fixtures, painting, cutting of walls, floor and making good the same and necessary scaffolding, encasing of pipes below ground or floor with 50mm thick PCC M20 concrete earth work in excavation, backfilling & removal of surplus earth etc. complete.

13.5 C.I. Soil / Waste Vent Pipes

The payment shall be on running meter basis of pipes laid. The rate shall include supplying and fixing pipes, jute gaskets dipped into bitumen and cement mortar and necessary specials including jointing with clamps, painting, cutting of walls, floor and making good the same, necessary scaffolding etc. complete.

13.6 GI Pipes and Fittings

Payment shall be made on running meter basis of actual pipeline laid. In addition to the sectional testing of water supply piping, the contractor shall test entire installation on completion of the job, to the entire satisfaction of the Engineer-in-Charge. No extra payment shall be made for testing. The contractor shall make his own arrangement for supply of water for testing, at his own cost. The rate for this item shall include supply and laying of G.I. pipes with necessary fittings, cutting of pipes to required lengths, threading, making holes in walls and floors and making good the same, jointing, painting, excavation and refilling including testing as directed by the Engineer-in-Charge.

13.7 Gun Metal Valve

The payment shall be made per number basis, including surface box. The rate shall include, supplying and fixing valve & surface box in position, as per drawings and directions of Engineer-in-Charge.

13.8 M.S. Rungs/ C.I. Steps

Payment for rungs shall be made on per number basis and the rate shall include supply, fixing, finishing the walls, painting etc. all complete.

13.9 Soak Pits

Payment of soak pit/ up flow filter shall be made per number basis. Rate quoted shall include brick masonry work, providing & filling brick bats, earthwork in excavation, backfilling, making inlet connection with pipe and connecting the same to septic tank etc. complete as shown in drawing.

13.10 Septic Tank

Payment of septic tank shall be made per number basis & rate shall include all accessories like inlet, outlet, vent pipe, manhole cover & C.I. steps, earthwork in excavation & backfilling, removal of surplus earth etc. all complete.

13.11 The above payment clauses are not applicable in case of LSTK Jobs

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STANDARD SPECIFICATION FOR

ACID RESISTING BRICK / TILE LINING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	16.08.21	REVISED & ISSUED AS STD. SPEC.	ADP	GYAS	ANURAG SINHA	SANJAY MAZUMDAR
5	06.07.18	REAFFIRMED & ISSUED AS STD. SPEC.	LP	VG	RAJANJI SRIVASTAVA	R K TRIVEDI
4	27.09.13	REVISED AND ISSUED AS STD. SPEC.	RB	RKS	RBB	DM

Abbreviations:

ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
IS	:	Indian Standard
LSTK	:	Lump Sum Trunkey
mm	:	Millimeter

Structural Standards Committee:

Convenor: Mr. Anurag Sinha

Members:
Mr. C. Damodaran
Mr. VK Panwar
Mr. Samir Das
Mr. Amitabh Kishore
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1.0 SCOPE

This specification covers the requirement of material and laying of Acid Resisting Brick/ tile lining for flooring on acid storage areas.

2.0 REFERENCES

2.1 Codes & Standards

IS 4457 Specification for ceramic unglazed vitreous acid resisting tile.
IS 4832 (Part-I) Chemical resistant mortar silicate type
IS 4832 (Part-II) Chemical resistant mortar Resin type
IS 4860 Acid resistant bricks
IS 9510 Specification for Bitumen Mastic, Acid resistant grade.

2.2 Specifications

ASTM D41-94 Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and waterproofing

Note: - Latest Edition of IS / codes and standards shall be followed

3.0 MATERIAL

3.1 Acid Resisting Bricks / Tiles

The Bricks shall conform to IS: 4860 – Class I quality. All bricks shall be dense, homogeneous and manufactured out of special raw material which shall have low lime, flint, sand and iron contents. These shall be specially fired and vitrified at high temperature to have qualities of low absorption. The size of the bricks shall normally be 230mm x 114mm x 64 mm or as per IS 4860. Ceramic unglazed Acid resisting tiles shall confirm to IS 4457. The size of Acid resisting tile shall be as per IS: 4457 or as defined in SOR.

3.2 Chemical Resistant Mortar

3.2.1 Silicate Mortar

It shall consist of selected potassium silicate solution and inert filter powder. Both mixed well to enable to set at ambient temperature. The mortar shall conform to IS 4832 (Part – I). The mixing proportion and other instructions for use shall be as specified standard manufacturers. Silicate mortar from standard manufacturers only shall be used. Contractor shall obtain approval from Engineer – in – charge prior to order and supply of the material. This type of Mortar is resistant to most acids except hydro-fluoric acid and concentrated ortho-phosphoric acid; they are not resistant to alkalies of any concentration or to boiling water or stream.

3.2.2 Resin Mortar

The furane and phenolic mortar for jointing consist of inert powder synthetic resin syrup. No water shall be used during mixing. This mortar shall conform to IS 4832 (Part – II). The mixing proportion and other instructions shall be as specified by standard manufacturers. Resin mortar from standard manufacturers only shall be used. Contractor shall obtain approval from Engineer – in – charge prior to order and supply of the material. This type of Mortar has a good resistance to non-oxidising mineral acids, and poor resistance to oxidising mineral acids. They are fairly resistant to inorganic alkalies and water.

3.3 Bitumen Primer

A bitumen primer is an asphalt based material thinned with petroleum solvent (conforming to ASTM D-41) should be applied over the surface. Primers from standard manufacturers only shall be used.

3.4 Bitumen Mastic

The bitumen mastic shall consist of a mixture of asphalt cement mineral filler, and mineral aggregate, which are acid alkali resistant. The composition, preparation and properties of the bitumen mastic shall be as per IS 9510 for resisting acid. The bitumen mastic shall be insoluble in Benzol and the matter soluble in diluted hydrochloric acid should not be more than five percent. "Prodorphalte" by Coromandal Prodorite or equivalent may be used.

4.0 LAYING

4.1 Surface Preparation

a) All damaged or questionable areas should be chipped out and replaced.
b) Adequate floor slope for good drainage is important.
c) Low spot should be avoided because finished floor will follow contour or sub floor.
d) Concrete should be dry, clean and well cured before application of membrane is started.

4.2 Primer Application

A bitumen primer should be applied over the prepared surface. It should be allowed to dry before applying the membrane material.

4.3 Membrane Application

Bitumen mastic is used to build up the membrane. It is heated to 120-205° C and applied to the primed surfaces. Multiple coat application should be made to thickness requirements. The thickness of the mastic layer shall be to suit the acid concentration and expected load or as specified by the Engineer-in-charge. Each coat should be inspected for blisters and pinholes. If present, they should be broken and before applying subsequent coats. Bitumen mastic should not be used as the membrane material where solvents are involved.

4.4 Reinforcement Application

Bitumen coated glass cloth can be used for membrane reinforcements at the corners, edges, walls, etc. depending on the requirements.

4.5 Application of Mortar and Bricks/Tile

There are two ways of lining Acid resisting linings:

4.5.1 When Bedding and Jointing Material are the same

A thin layer of about 3mm suitable resinous mortar is spread on the back of the acid resisting tiles and the tiles are pressed down on the bed. Suitable joint thickness of about 3mm should be maintained. Jointing is done with suitable resin mortar.

4.5.2 When Bedding and jointing material are different

A thin layer of about 6mm suitable silicate type mortar is spread on the back of the acid resisting tiles and the tiles are pressed down on the bed. Proper joint thickness of about 3mm

should be maintained and filled up with suitable resin type mortar. In case of pointing the joint thickness should be 6mm and depth of the pointing should be 19mm.

In this case, joints with silicate mortar should be acid cured with 20 to 25 percent hydrochloric acid or with 30 to 40 percent sulphuric acid before applying the resin type mortar. After acid curing, the free acid in the joints shall be cleaned with water and sufficient time should be allowed should be allowed for thorough drying. After curing resin mortar is used for filling up the joints.

5.0 GUARANTEE

The Vendor shall give material and performance guarantee for a period of minimum one year from the date of commissioning of the plant.

6.0 PAYMENT

6.1 Payment shall be on square meter basis of area covered.

6.2 The payment clause 6.1 is not applicable for LSTK Jobs.

पोर्टेबल प्रकार के अग्निशामक का मानक विनिर्देश

STANDARD SPECIFICATION FOR PORTABLE FIRE EXTINGUISHER

Rev. No	Date	Purpose	Prepared by	Checked by	Approved By: Standards Committee Convenor	Approved By: Standards Bureau Chairman
1	24.08.18	REVISED & ISSUED AS STD. SPEC.	GAURAV SINGH	GYAS	RS	RKT
0	19.08.10	ISSUED AS STANDARD SPECIFICATION	AS	RKS	RBB	ND

Abbreviations:

MS	MILD STEEL
IS	INDIAN STANDARD
PESO	PETROLEUM EXPLOSIVE SAFETY ORGANISATION

Structural Standards Committee

Convenor: Mr. Rajanji Srivastava

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1.0 SCOPE

This standard lays down requirements regarding material, shape, construction, method of operation, performance and tests of portable fire extinguisher of Carbon Dioxide type, Dry Chemical Powder type Fire Extinguisher.
The extinguisher shall be supplied along with respective extinguishing media duly charged.

2.0 CODES AND STANDARDS

IS: 5	Colours for ready mixed paints and enamels
IS: 2932	Enamel, synthetic, exterior; a) undercoating, b) finishing - specification
IS: 4308	Dry Chemical Powder for Fighting B and C Class Fires
IS: 4947	Specification for gas cartridges for use in fire extinguishers
IS: 14609	Dry Chemical Powder for Fighting A, B, C Class Fires
IS: 15222	Carbon dioxide as the extinguishing media for fire protection - Specification
IS: 15683	Portable Fire Extinguishers, Performance and Construction – Specification

Note: Latest Edition of all standard documents shall be followed

3.0 MATERIAL OF CONSTRUCTION & BASIC REQUIREMENT

3.1 CARBON DIOXIDE TYPE:-

3.1.1 Extinguisher shall be portable high pressure type with capacities 2 / 4.5 Kg as per requirement.
3.1.2 Requirement of performance, construction, and test shall comply with IS: 15683.
3.1.3 Carbon dioxide of 99.5% purity used as extinguishing media shall comply with IS: 15222 with maximum fill density shall not exceed 0.667Kg/l.
3.1.4 Extinguishers shall have concave base, material for extinguisher body shall be either steel conforming to IS: 7285 or aluminum confirming to IS: 4947 and discharge valve shall be of hand wheel / key / lever operated type conforming to IS: 3224

3.2 DRY CHEMICAL POWDER TYPE:

3.2.1 Extinguisher shall be portable low pressure Cartridge type with capacities 1 / 2 / 4 / 6 /per requirement based on fire rating.
3.2.2 Requirement of performance, construction, and test shall comply with IS: 15683.
3.2.3 Dry powder conforming to IS: 14609, I.S. 4308 and ~~or~~ IS: 4861 shall be used for charging the extinguishers.
3.2.4 Material for extinguisher body shall be carbon steel conforming IS: 513 with no vertical joints on the body. Discharge nozzle, valve assembly shall be SS-316 or brass confirming to IS: 6912.
3.2.5 Carbon di oxide gas cartridge shall be ISI marked as per IS: 4947

4.0 APPROVALS

Carbon di oxide extinguisher and valve shall have approval from PESO, Government of India, Nagpur.

5.0 COLOR & MARKING

The color of extinguisher bodies shall be Red conforming to shade no.536 or 538 of IS: 5. Paint shall conform to IS: 2932. Each extinguisher shall be clearly and permanently marked with the information specified in IS: 15683, along with IS certification mark and purchaser's name.

6.0 ACCESSORIES

Each extinguisher shall be supplied with MS bracket, screws and spanner as may be necessary. The details of the bracket shall be submitted with the offer.

7.0 INSPECTION

Owner's / EIL's authorized representative shall have access at all reasonable times to vendor's works where Extinguishers are being manufactured and/or tested. Vendor shall arrange for all tests and inspection facilities for checking material, design and fabrication, workmanship, finish, performance (operating performance and performance required for test fires), and testing as per IS: 15683.

8.0 INFORMATION REQUIRED FROM VENDOR

8.1 Following information shall be furnished by the vendor along with the supply of extinguisher:

- Instruction book(s) - Instruction book(s) for guidance of the user including both the operating and normal maintenance procedures shall be supplied. The book(s) shall include an itemized and illustrated part list/spare parts list giving reference number of all the wearing parts.
- Approval certificate from PESO as described in clause 4.

अग्निशमन के लिए नॉन पेरकोलेटिंग ले फलैट डिलेवरी नली हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR NON-PERCOLATING LAY FLAT DELIVERY HOSE FOR FIRE FIGHTING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved By	
5	27.05.24	REVISED & ISSUED AS STD. SPEC.	NS	AK	SKN	MN
4	26.06.18	REVISED & ISSUED AS STD. SPEC.	GAURAV SINGH	GYAS	RS	RKT
3	07.08.12	REVISED & ISSUED AS STD. SPEC.	JAY KUMAR	RC	RBB	DM
2	14.03.08	REVISED & ISSUED AS STD. SPEC.	GAURAV	RLT/ RKS	NK	VC
1	15.02.98	REVISED & ISSUED AS STD. SPEC.	RB	RB	MMK	A SONI
0	31.03.82	ISSUED AS STD. SPEC.	RB	-	HVR	RCPC

Abbreviations:

BIS	BUREAU OF INDIAN STANDARDS
IS	INDIAN STANDARD
mm	MILLIMETER

General Civil Standards Committee

Convenor: Mr. Samir Kumar Naskar

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Mr. Raj Kumar Singh
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Mr. Charanjit Singh (Projects)
Mr. Indrajit Neog (Construction)
Mr. Vikram Kumar Gupta (Structural)

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3.0 TYPES, REQUIREMENTS, TESTING, PACKING AND MARKING 4

4.0 MARKING 4

5.0 INSPECTION 4

1.0 SCOPE

1.1 This specification covers the general requirements for material, design, performance and test of non-percolating lay flat delivery hose for firefighting.

2.0 CODES AND STANDARDS

IS: 636 Non-Percolating Flexible Fire Fighting Delivery Hose.

Note: - Latest Edition of codes shall be followed

3.0 TYPES, REQUIREMENTS, TESTING, PACKING AND MARKING

3.1 Type 3 Hose shall be supplied conforming to IS 636.

3.2 The requirements of hose, working pressure, testing, its packing and marking shall comply to IS: 636.

3.3 The length of each hose shall be 15 m unless specified otherwise in the datasheet.

4.0 MARKING

4.1 Each hose shall be clearly marked with

a. Manufacturer's name or trademark.
b. Month and year of manufacture.
c. Type of the hose
d. Size of the hose
e. Length of the hose
f. BIS certification mark.

5.0 INSPECTION

Owner's / EIL's authorised representative shall have access at all reasonable times to vendor's works where Fire Fighting Delivery Hoses are being manufactured and / or tested. Vendor shall arrange for all tests and inspection facilities for checking material, design and construction, hydraulic performance, workmanship, finish and hydrostatic testing as per IS: 636. Any shortcoming pointed out shall be rectified to the satisfaction of the inspectors. All consumables for testing shall be arranged by the vendor at his own cost.

नॉरमल टाइप लैडिंग वाल्व के साथ स्थिर प्रकार की आग बुझाने वाली नलिका का मानक विनिर्देश

STANDARD SPECIFICATION FOR STAND POST TYPE FIRE HYDRANT WITH NORMAL TYPE LANDING VALVE

Rev. No	Date	Purpose	Prepared by	Checked by	Approved By: Standards Committee Convenor	Approved By: Standards Bureau Chairman
5	08.08.25	REVISED & ISSUED AS STD. SPEC.	NS	AK	SKN	MN
4	26.06.18	REVISED & ISSUED AS STD. SPEC.	GAURAV SINGH	GYAS	RS	RKT
3	23.05.11	REVISED AND ISSUED AS STD. SPEC.	ALOK	RKS	RBB	DM
2	22.12.05	REVISED & REISSUED AS STD. SPEC.	SKC	NK	VDS	VJN
1	15.02.98	REVISED & ISSUED AS STD. SPEC.	VEDA	SM	MMK	ASONI
0	31.03.82	ISSUED AS STD. SPEC.	RB	-	HVR	RCPC

Abbreviations:

ANSI	:	American National Standards Institute
IS	:	Indian Standard
PMS	:	Piping Material Specification
ASTM	:	American Society for Testing and Materials
Lpm	:	Liter per minute
NFPA	:	National Fire Protection Association
VMS	:	Valve Material Specification

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Mr. Inrajit Neog (Construction)
Mr. Vikram Gupta (Structural)

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ANNEXURE-I (SCOPE DRAWING FOR SUPPLY OF HYDRANTS).....7

1.0 SCOPE

This standard lays down the requirements of codes and standards, type, shape, dimensions, material and test for vertical stand post type fire hydrant (with or without pumper connection) to be installed on fire water main with Normal Type Landing Valves as per IS 5290. The Hydrant shall normally be supplied without pumper connection unless otherwise specifically mentioned in the Data sheet/ Material Requisition.

2.0 CODES AND STANDARDS

IS: 5290	Specification for Landing Valves
ANSI B16.5	Pipe Flanges and Flanged Fittings
ASTM A-105	Standard Specification for Carbon Steel Forgings for piping applications
NFPA 1963	Standard for Fire Hose Connections
6-52-0006	Standard specification for restriction orifice plates
7-52-0041	Orifice Plates and Flanges Dimensional Details

NOTE: - Latest Edition of all Codes and Standards shall be followed.

3.0 MATERIAL

The MOC of components shall be as the Data Sheet provided along with this specification in the Material Requisition.

4.0 DESCRIPTION

4.1 The hydrant shall be stand-post type which may of the following types (For details, refer Annexure-I)-

a. **Single Headed Hydrant –** The vertical post shall be of 75 mm diameter with one horizontal Landing Valve Single Outlet conforming to Normal Type landing valve as per Fig.1 of IS 5290 having flanged inlet and instantaneous female outlet as per Fig.2 of IS 5290. Refer Fig-A given in the Annexure-I

b. **2-Way Hydrant** - The vertical post shall be of 100 mm diameter with two horizontal hydrant arms, each of 75 mm diameter having independent Landing Valve Single Outlet conforming to Normal Type landing valve as per Fig.1 of IS 5290 having flanged inlet and instantaneous female outlet as per Fig.2 of IS 5290. Refer Fig-B given in the Annexure-I

c. **2-Way Hydrant with pumper connection** - The vertical post shall be of 150 mm diameter with two horizontal hydrant arms, each of 75 mm diameter having independent Landing Valve Single Outlet conforming to Normal Type landing valve as per Fig.1 of IS 5290 having flanged inlet and instantaneous female outlet as per Fig.2 of IS 5290. Also, one pumper connection, 4-inch outlet, non-threaded type fire department connection metal faced, without gasket as per NFPA 1963 with metallic blind cap with SS 304 chain. Refer Fig-C given in the Annexure-I

d. **4-Way Hydrant -** The vertical post shall be of 150 mm diameter with two horizontal hydrant arms, each of 100 mm diameter having 2 numbers of independent Landing Valve Single Outlet (on each am) conforming to Normal Type landing valve as per Fig.1 of IS

5290 having flanged inlet and instantaneous female outlet as per Fig.2 of IS 5290 on each arm. Refer Fig-D given in the Annexure-I

e. **4-Way Hydrant with pumper connection -** The vertical post shall be of 150 mm diameter with two horizontal hydrant arms, each of 100 mm diameter having 2 numbers of independent Landing Valve Single Outlet conforming to Normal Type landing valve as per Fig.1 of IS 5290 having flanged inlet and instantaneous female outlet as per Fig.2 of IS 5290 on each arm. Also, one pumper connection, 4-inch outlet, non-threaded type fire department connection metal faced, without gasket as per NFPA 1963 with metallic blind cap with SS 304 chain. Refer Fig-E given in the Annexure-I

4.2 Outlet of the landing valve shall be provided with instantaneous female coupling as per Fig.2 of IS 5290 with blind cap as per Fig.5 of IS 5290 along with SS304 chain.

4.3 Landing Valve Single Head Outlet conforming to IS: 5290 shall have rated flow of 900 lpm at 7 kg/cm2g

4.5 All flanges for landing valve connection shall have all dimensions conforming to ANSI.B.16.5, 150 lbs rating, Flat Face, Slip On type. Base flange of stand post shall be as per job specific Piping Material Class as mentioned in datasheet.

4.6 Job specific requirements, if any shall be as per Data Sheet enclosed in Bid/ Requisition document.

4.7 Refer Annexure-I for scope details for supply of Hydrants

5.0 RESTRICTION ORIFICE

5.1 Restriction Orifice (RO) may be provided in the landing valves as per requisition requirement.

5.2 The pressure conditions like Inlet pressure, design pressure and pressure drop in the RO shall be as per the table attached with the data sheet of Hydrant.

5.3 The flow through the RO shall be 900 lpm.

5.4 The MOC of the RO shall be SS 316.

5.5 Refer standard specifications 6-52-0006 and standard 7-52-041 for fabrication of Restriction orifice plate.

5.6 The type of RO plate shall be Concentric Square Edge type with single stage pressure reduction.

5.7 The line ID shall be 3” as per the PMS

6.0 WORKMANSHIP AND FINISH

All parts shall have good workmanship and finish. All warps and sharp edges shall be removed. The waterways shall have smooth finish.

7.0 TESTING

Each hydrant assembly shall be satisfactorily tested for water tightness, hydrostatic test and flow test as per IS 5290.

Hydrant assembly with Landing valves closed shall be satisfactorily tested and proved water tight, under a hydraulic pressure of 21.0 kg/cm². The pumper connection shall be kept closed during testing in case the same is provided on hydrant assembly.

8.0 PAINTING

The stand post and its arms shall be painted as specified in Job Specific Data Sheet attached with this specification.

9.0 MARKING

Each hydrant shall be clearly and permanently marked with the following:

a) Manufacturers name or trade mark.
b) Year & Month of Manufacture.
c) Batch Number
d) Purchaser name.
e) BIS certification marking on landing valve and couplings.

10.0 INSPECTION

Owner's / EIL's authorized representative or as mentioned in data sheet shall have access at all reasonable times to vendor's works where Stand Post Hydrants and Landing Valves are being manufactured and/or tested. Vendor shall arrange for all tests and inspection facilities for checking material, design and construction, hydraulic performance, workmanship, finish and hydrostatic testing. Any shortcoming pointed out shall be rectified to the satisfaction of the inspectors. All consumables i.e. water etc. shall be arranged by vendor at his own cost.

11.0 VENDOR's DRAWING AND DATA REQUIREMENT

Vendor shall furnish drawings for review, prior to fabrication of Hydrant assembly as per Vendor Data Requirement**.**

12.0 APPROVAL

Vendor shall furnish valid BIS certificate approval letter.

ANNEXURE-I

(SUPPLY SCOPE FOR FIRE HYDRANTS)

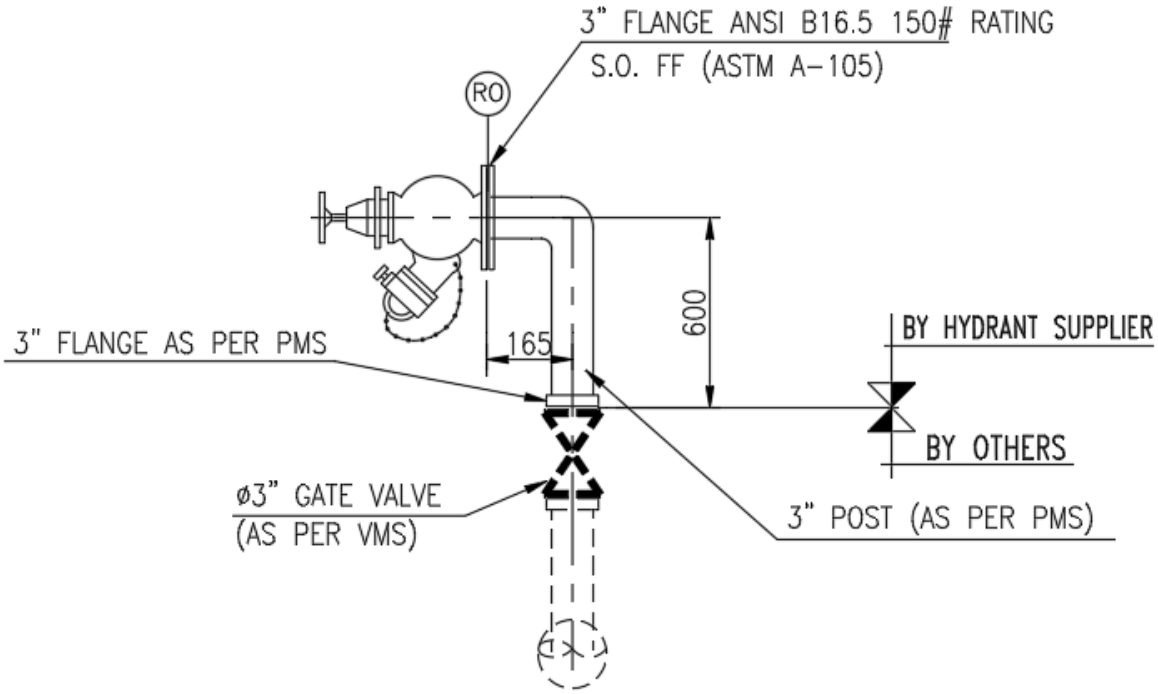

FIG A: SINGLE HEADED HYDRANT

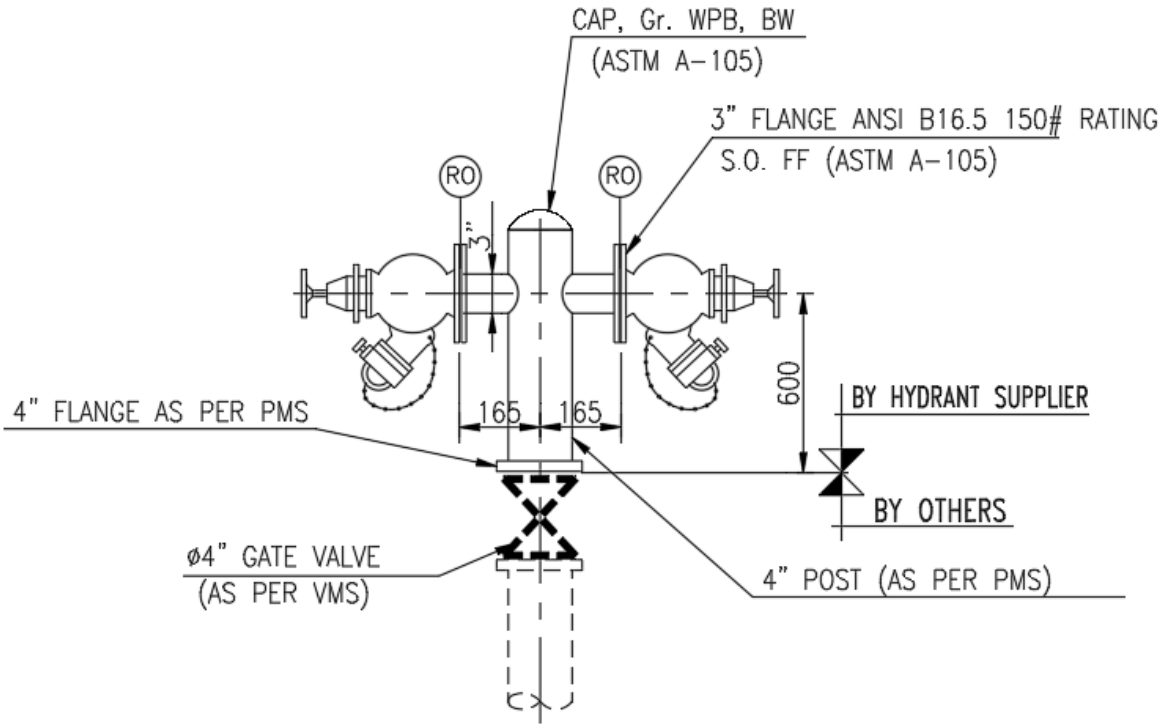

FIG B: 2-WAY HYDRANT

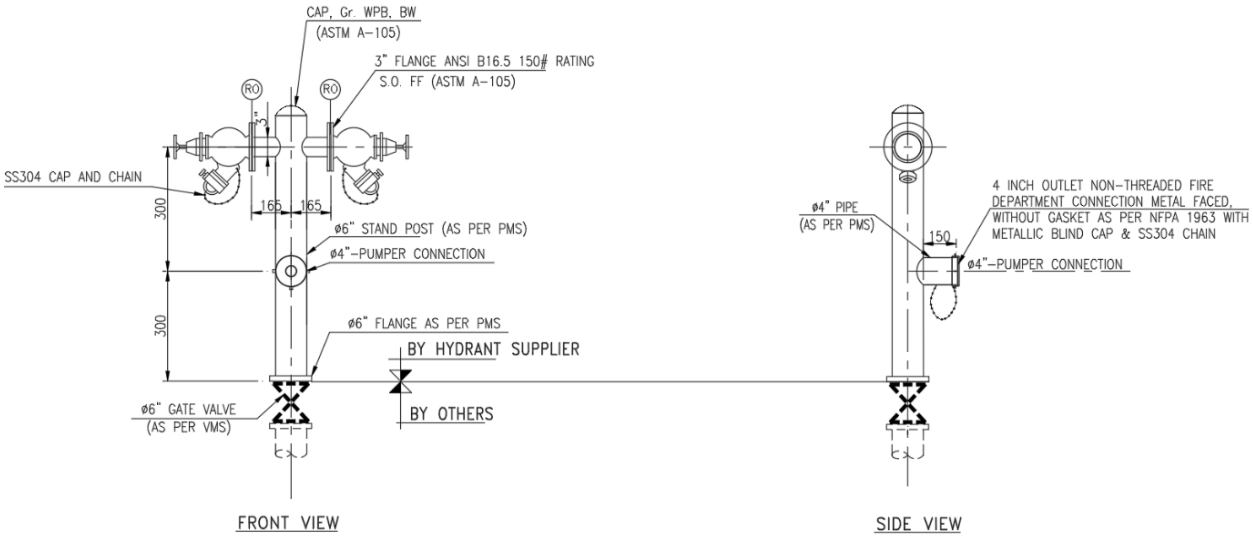

FIG C: 2-WAY HYDRANT WITH PUMPER CONNECTION

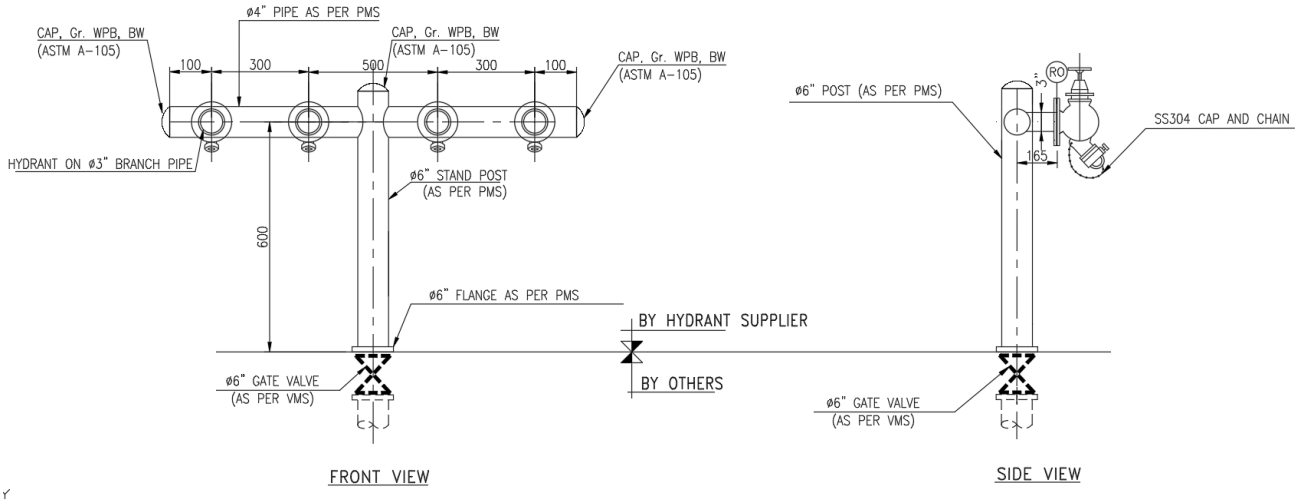

FIG D: 4-WAY HYDRANT

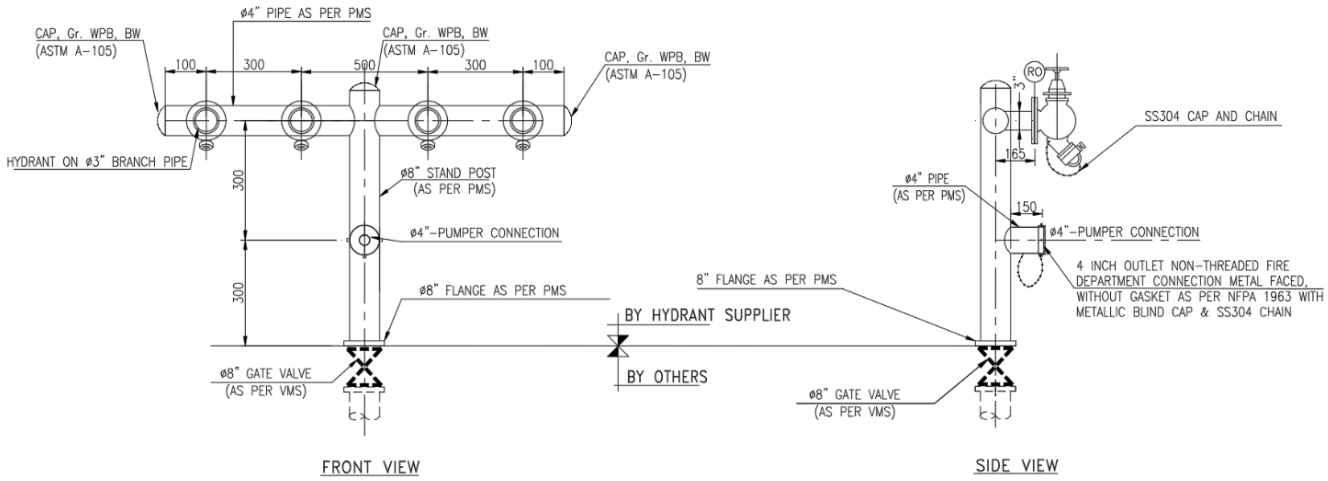

FIG E: 4-WAY HYDRANT WITH PUMPER CONNECTION

प्राथमिक सहायता होज रील के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR FIRST AID HOSE REEL

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved By	
5	27.10.25	REVISED & ISSUED AS STD. SPEC.	NKP	GYAS	SK NASKAR	M.NANDI
4	26.06.18	REVISED & ISSUED AS STD. SPEC.	GAURAV SINGH	GYAS	RS	RKT
3	23.05.11	REVISED & REISSUED AS STD. SPEC	ALOK	RKS	RBB	DM
2	12.01.06	REVISED & REISSUED AS STD. SPEC	SKC	NK	VDS	VJN
1	21.11.96	REVISED & ISSUED AS STD. SPEC	NK	PCS	MMK	A SONI
0	31.03.82	ISSUED AS STD. SPEC.	RB	KP	HVR	RCPC

ABBREVIATIONS:

IS : Indian Standard

General Civil Standards Committee

Convenor : Mr. Samir Kumar Naskar

Members:
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Dinesh Debbarma
Mr. Raj Kumar Singh
Mr. UC Pathak (Piping)
Mr. Charanjit Singh (Proj.)
Mr. Indrajit Neog (Const.)
Mr. Vikram Kumar Gupta (Structural)

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1.0 SCOPE

This specification covers the requirements regarding material, constructional details and test for Floor/Wall mounted First Aid Hose Reel, intended for installation within process units / buildings as emergency firefighting equipment.

Type _A -Wall mounting type to be used for mounting inside buildings on wet and dry riser. This can be directly mounted on the wall or custom-built cabinets for housing the hose -reel.

Type-B – Design shall be horizontal type hose reel-which can be mounted on custom built pedestals or in suitable position on fire engine.

2.0 CODES AND STANDARDS

IS : 884 First-Aid hose reel for fire-fighting.

NOTE: Latest Edition of all Codes and Standards shall be followed.

3.0 MATERIAL, CONSTRUCTION AND TEST

Material, Construction, tests and all other requirements shall conform to IS: 884, Type-A And Type B Hose Reel, except as mentioned in the Data Sheet of Hose Reel attached with Bids / Requisition.

4.0 SIZE

House reel tubing length shall be 30 m with internal bore 25 mm or as specified in data sheet.

5.0 HYDRAULIC PERFORMANCE

5.1 First Aid hose reel shall be capable of discharging not less than 44 lpm at the reel inlet pressure of 7 $kg/cm2_g$ +/- 0.1 $kg/cm2_g$ for 25mm size hose reel.

5.2 The horizontal range of water jet shall not be less than 6.0 m at the reel inlet pressure of 7 kg/cm2g.

6.0 MARKING

Each hose reel shall be clearly and permanently marked with the following information along with Purchaser's name.

a) Manufacturer's name or Trade Mark.
b) Year and month of Manufacture
c) Length and size of tube carried on hose reel.
d) Type of Reel.
e) BIS certification mark on house reel tubing
f) Batch number
g) Type of material.

7.0 INSPECTION AND TESTING

Owner's / EIL's authorized representative as mentioned in data sheet shall have access at all reasonable times to vendor's works where Hose Reels are being manufactured and/or tested. Vendor shall arrange for all tests and inspection facilities for checking material, design and construction, hydraulic performance, workmanship, finish and hydrostatic testing. Any shortcoming pointed out shall be rectified to the satisfaction of the inspectors. All consumables i.e. water etc. shall be arranged by vendor at his own cost.

8.0 VENDOR's DRAWING AND DATA REQUIREMENT

Vendor shall furnish drawings and data for review, prior to fabrication of Hydrant assembly as per Vendor Data Requirement.

9.0 APPROVAL

Vendor shall furnish valid BIS certificate.

सुरक्षा शॉवर एवं आई वॉश हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR SAFETY SHOWER AND EYE WASH

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved By	
5	17.08.21	REVISED AND ISSUED AS STANDARD SPECIFICATION	GAURAV SINGH	GYAS	Anurag Sinha	SM
4	11.01.19	REVISED AND ISSUED AS STANDARD SPECIFICATION	GAURAV SINGH	GYAS	RS	RKT
3	17.07.12	REAFFIRMED AND ISSUED AS STANDARD SPECIFICATION	JAY KUMAR	RC	RBB	DM
2	11.09.06	REAFFIRMED AND ISSUED AS STANDARD SPECIFICATION.	DCB	UCJ	VDS	VC
1	02.06.97	REAFFIRMED AND ISSUED AS STANDARD SPECIFICATION	AK	PCS	MMK	AS

Abbreviations:

GI	:	Galvanized Iron
IS	:	Indian Standard
Kg	:	Kilogram
LPM	:	Litre per minute
mm	:	Millimeter

Structural Standards Committee

Convener: Mr. Anurag Sinha

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1.0 SCOPE

This specification covers the general requirements regarding material, design, fabrication and acceptance tests for safety showers and Eye wash (combine unit).

2.0 CODES AND STANDARDS

IS: 1239	Mild steel tubes, tubular and other wrought steel fittings
IS: 10592	Specification for Industrial Emergency Shower, eye and face fountain and combination units.
Installation drawing	As per Vendor

3.0 DESIGN REQUIREMENT

3.1 It shall be as per IS : 10592.

3.2 The twin fountain head of eye wash unit shall give soft, controlled drenching of eye/face when the foot pedal is pressed.

3.3 Shower head should give uniform shower of water as soon as the chain/ pull rod is pulled.

3.4 Available inlet pressure shall not be less than 2.0 kg/cm^{2}g. In case available pressure is greater than 3.0 kg/cm^{2}g suitable Restriction Orifice shall be provided before safety shower and eye wash unit.

3.5 All steel parts shall be properly painted with 3 coats of anticorrosive paints.

3.6 Water supply pipe size shall be 40mm at inlet of combined equipment. Inlet connection shall generally be from top unless specified otherwise. Inlet connection shall be 1.5" flanged as per ASTM A105 (GALV.), 150FF.

3.7 Emergency shower head shall be capable of delivering a minimum of 76 lpm of water and each eye wash head shall be capable of delivering approximately 12 lpm.

4.0 MATERIAL OF CONSTRUCTION

Pipe	: GI heavy grade conforming to IS: 1239.
Pipe Fittings	: GI heavy grade conforming to IS: 1239 (II)/ CI conforming to IS:1879
Self closing Valve	: Gun Metal / Brass
Bowl for eyewash	: Stainless steel (SS 304)
Atomiser	: SS 304 with Copper head
Shower head	: C.P Brass or stainless steel(SS 304)
Foot Pedal	: M.S. with aluminium top
Spring	: M.S Galvanised
Pull chain	: M.S Galvanised

5.0 INSPECTION AND TESTING

a) The whole assembly shall be tested for its hydraulic performance as per the requirements of IS 10592

b) EIL/Owner's representative shall have access at all reasonable times to the manufacturer's work in which safety shower/its components are being manufactured and/or tested.

6.0 MARKING

Combined unit shall be marked with ISI certification mark and other marking requirement as per IS 10592

7.0 VENDOR DATA REQUIREMENTS

7.1 Vendor shall furnish drawings and data as per VENDOR drawing and data requirements for approval prior to manufacturing.

7.2 Original transparencies after incorporating the as built information shall be got signed by the inspection engineer before submitting to EIL/OWNER for records.

होज़ केबिनेट के लिए मानक विनिर्देशन

STANDARD SPECIFICATION FOR HOSE CABINET

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved By	
4	26.06.18	REVISED & ISSUED AS STD. SPEC.	GAURAV SINGH	GYAS	RS	RKT
3	21.01.2013	REAFFIRMED AND ISSUED AS STD. SPEC.	JAY KUMAR	RC	RBB	DM
2	26.12.07	REVISED AND REISSUED AS STD. SPEC.	GAURAV	PPC	NK	VC
1	20.06.97	REVISED AND REISSUED AS STD. SPEC.	NK	PCS	MMK	A.SONI
0	31.03.82	ISSUED AS STD. SPEC. RECOMPOSED IN AUG. 95	RB	-	HVR	-

Abbreviations:

BIS	Bureau of Indian Standards
GI	Galvanised Iron
IS	Indian Standard
MS	Mild Steel
mm	Millimeter

Structural Standards Committee

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Mr. Gyasuddin
Mr. Charanjit Singh (Proj.)
Mr. Ravindra Kumar (Const.)

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1.0 SCOPE

1.1 This specification covers the general requirements regarding the Design requirement, Material, Construction, Painting and Marking of Hose cabinet and fire fighting equipments contained in the cabinets.

1.2 The Hose cabinet shall be supplied along with all the fire fighting equipments contained in it.

2.0 CODES AND STANDARDS

IS: 5	Colors for Ready Mix Paints and Enamels
IS: 636	Non-Percolating flexible fire fighting delivery hose
IS: 903	Fire Hose Delivery Couplings, Branch Pipe, Nozzles and Nozzle Spanner
IS: 2871	Branch pipe, universal, for fire fighting purposes

NOTE: Latest Edition of all Codes and Standards shall be followed.

3.0 DESIGN REQUIREMENTS

3.1 Hose cabinet shall be of two types, Type-I and Type-II, to accommodate delivery hose and jet nozzle with branch pipe or universal branch pipe.

3.2 Type I Hose Cabinet

3.2.1 It shall be suitable to accommodate one Type B firefighting delivery hose (Reinforced rubber lined, non-Percolating with elastomeric outer coating applied as reinforcement conforming IS 636) of size 63 mm 15 meter long with ends couplings, one jet nozzle with branch pipe or one universal branch pipe.

3.2.2 It shall be capable of being mounted on wall. Necessary hangers and bracket for hose, nozzle and branch pipe or universal branch pipe shall be provided, with the cabinet.

3.2.3 It shall be provided with single panel glass door

3.3 Type II Hose Cabinet

3.3.1 It shall be suitable to accommodate two Type B firefighting delivery hoses (Reinforced rubber lined, non-Percolating with elastomeric outer coating applied as reinforcement conforming IS 636) of size 63 mm, 15 meter long with end couplings, one jet nozzles with branch pipe and one universal branch pipes.

3.3.2 It shall be of self-supporting type, suitable for outside installation. Necessary hangers and brackets for hose, nozzle and branch pipe or universal branch pipe shall be provided within the cabinet.

3.3.3 It hall be provided with double panel glass door.

3.4 Both the types shall be provided with handle type lock, a small recess to keep cabinet key under glass cover, a small hammer secured to the cabinet with a chain to break key glass cover.

4.0 MATERIAL

4.1 Cabinet shall be made of 18 gauge MS sheet suitably welded with single/double MS door frame glass covered. 3mm Glass with rubber gomet shall be securely fitted to the door frame in a standard manner.

4.2 Door shall be provided with standard handle Mortise type lock.

4.3 Hammer shall be of MS with GI chain.

4.4 Suitable size angle iron posts shall be provided to support type II cabinet.

4.5 Delivery hose shall be either of the following type

a) Type B Reinforced rubber lined hose to I.S. 636

4.6 End couplings, jet nozzle and branch pipe shall conform to I.S. 903.

4.7 Universal branch pipe shall conform to I.S. 2871.

5.0 PAINTING

The hose cabinet shall be painted with 3 coats of anticorrosive fire red paint conforming to shade no. 536 of IS: 5 from outside and white paint from inside. The paint shall conform to IS: 2932.

6.0 MARKING

6.1 Each cabinet shall be clearly and permanently marked with following.

a) The words Hose Cabinet-Type I or II
b) Instructions for use.

6.2 Each equipment in the cabinet shall be marked with BIS certification mark and purchaser's name.

7.0 TESTING

All equipments being supplied with Hose Cabinet shall be tested as per relevant IS test requirements.

8.0 INSPECTION

Owner's / EIL's authorised representative shall have access at all reasonable times to vendor's works where Hose Cabinets and equipments being supplied with Hose Cabinet, are being manufactured and/or tested. Vendor shall arrange for all tests and inspection facilities for checking material, design and construction, hydraulic performance, workmanship, finish and hydrostatic testing. Any shortcoming pointed out shall be rectified to the satisfaction of the inspectors.

9.0 VENDOR's DRAWING AND DATA REQUIREMENT

Vendor shall furnish drawings and data as per "Vendor's drawings and Data Requirements" for information and records.

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STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF PIPING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	28.03.25	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	MN
5	31.12.19	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	MI	RKT
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3	31.03.09	REVISED AND ISSUED AS STANDARD SPECIFICATION	RN	VKB	SC	ND
2	05.06.03	PMI REQT. INCLUDED AND ISSUED AS STANDARD SPECIFICATION	RN	DM	BN	SKG

Abbreviations:

A.S.	:	Alloy Steel
ASME	:	American Society of Mechanical Engineers
C.I.	:	Cast Iron
C.S.	:	Carbon Steel
IBR	:	Indian Boiler Regulations
LTCS	:	Low Temperature Carbon Steel
NACE	:	National Association of Corrosion Engineers
NB	:	Nominal Bore
NDT	:	Non Destructive Testing
P&ID	:	Piping and Instrumentation Diagram
PMI	:	Positive Material Identification
S.S.	:	Stainless Steel

Piping Standards Committee

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Ms. Sulakshana Hundekari (Piping)
Mr. Rameshwar Prasad (Piping)
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Mr. Rajesh Chitara (SMMS)
Dr. Sudip Paul (Structural)
Mr. Harsh Vardhan (Projects)
Mr. Pankaj Kumar Rai (Construction)
Mr. T. Kamalakannan (SCM-Inspection)

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1.0 SCOPE

This specification covers general requirements of fabrication and erection of above ground and trench piping systems at site. The specification covers the scope of work of Contractor, basis of work to be carried out by Contractor and standards, specifications and normal practice to be followed during fabrication and erection by the Contractor.

2.0 SCOPE OF WORK OF CONTRACTOR

Generally the scope of work of Contractor shall include the following:

2.1 Transportation of required piping materials (as described in Cl.2.1.1), pipe support (material as described in Cl. 2.3) and all other necessary piping materials from Owner's storage point or Contractor's storage point (in case of Contractor's scope of supply) to work site/shop including raising store requisitions for issue of materials in the prescribed format & maintaining an account of the materials received from Owner's stores.

2.1.1 Piping materials include the following but not limited to the same.

a. Pipes (All sizes and schedule)

b. Flanges (All sizes, types & Pressure ratings).

c. Fittings (All sizes, types and schedule)

d. Valves (All sizes, types and Ratings)

e. Gaskets (All sizes, types & Ratings)

f. Bolts, Nuts or M/C Bolts (All types)

g. Expansion Joint/Bellows (All types)

h. Specialty items like online filters, ejectors, sample coolers, steam traps, strainers, air traps, springs, silencers, snubbers, steam and condensate manifolds, injection nozzles, MOVs, sight glass, spray nozzles, integrated steam traps, hoses, hose couplings, etc.

i. Online instruments like control valve, orifice flange, rotameter, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, annubar, magnetic flow meter, ultrasonic flow meter, Coriolis mass flow meters, venturi PG/PT/ Flow transmitter, ejectors, static mixers, flame arrestors, thermal flow switches, pre-fabricated hook-ups etc.

j. Shut Down Valves with and without fire box.

2.2 Shop & field fabrication and erection of piping in accordance with documents listed under Cl.3.0 i.e. 'BASIS OF WORK' including erection of all piping materials enumerated above.

2.3 Fabrication and erection of pipe supports like shoe, saddle, guide, stops, anchors, clips, cradles, hangers, turn-buckles, supporting fixtures, bracket cantilevers, struts, tee-posts including erection of spring supports, sway braces, dummy pipes, corrosion pads/protection shields, low friction pads, clamps, special support, expansion bellows, steam and condensate manifolds supports etc. Corrosion Pads/Protection shields, stiffeners and stiffening rings, if not covered in the specifications/standards, shall be of the same material as of parent pipes.

2.4 Site fabrication of Piping items

Site fabrication of Piping items shall include but not be limited to the following

2.4.1 Fabrication of piping specials like special radius bends, reducers, mitres etc.

2.4.2 Fabrication of plain and threaded nipples from pipes as required during erection.

2.4.3 Fabrication of swage nipples as and when required.

2.4.4 Fabrication of odd angle elbow like 60°, 30° or any other angle from 90°/45° elbows as and when required.

2.4.5 Fabrication of flange, reducing flange, blind flange, spectacle blinds as and when required.

2.4.6 Fabrication of stub-in connection with or without reinforcement.

2.4.7 Grinding of edges of pipes, fittings, flanges etc. to match mating edges of uneven/different thickness wherever required.

2.4.8 Fabrication of circular pipe for steam rings, fire water lines, utility lines.

2.4.9 Threading of all small bore piping as per piping material specifications.

2.4.10 Drilling on blind flange for inserting / joining small bore lines.

2.4.11 Fabrication and welding of reinforcement pads at branch pipe locations wherever required.

2.4.12 Equipment nozzle reinforcement with pads, jacket & stiffeners wherever required.

2.4.13 Fabrication of injection nozzles as per details provided wherever required.

2.4.14 Fabrication of chain operation arrangement for valves, wherever required. All material required for this modification shall be supplied by Contractor.

2.4.15 Fabrication and erection in position of funnels required for OWS/ SS/ Condensate blow down system as per direction of Engineer-in-charge.

2.4.16 Grinding/ finishing of uneven surfaces/ joints after welding. Internal grinding of welds of orifice flanges to render smooth surface.

2.4.17 Tapping and drilling of holes in flanges, blind flanges etc. for making piping connections, providing jack screws in tapped and drilled holes, if required.

2.4.18 Providing bird screens at the outlet of lines open to atmosphere.

2.5 Modifications like providing additional cleats, extension of stem of valve, locking arrangement of valves etc. as and when required. Seal welding of plugs in orifice flange excess tappings, threaded drain plugs provided in valves as per direction of Engineer in charge.

2.6 Piping isometrics for main process/utility lines shall be provided to the Contractor for Units.

Preparation of miscellaneous small bore isometrics with bill of materials for process and utility lines (up to 1½" size) like instruments & pump flushing / cooling, sample connection, purging, pump casing vents & drains, pump base plate drains, control valve drains / vent to flare, instrument drains & vents, steam tracing (non-IBR) from steam supply stations up to

condensate recovery station, and lines specified as field routed within the Unit battery limit as and when required are in Contractor's scope of work. Approval for these isometrics prepared by the Contractor shall be taken from Engineer-in-charge before erection.

Small bore piping isometrics given by Owner shall be rechecked by Contractor before erection and installation.

2.7 Obtaining approval for drawings prepared by Contractor from statutory authority, if required. Contractor shall also arrange all necessary permits for hot work etc.

2.8 Spun concrete lining of the inside of pipes 3" NB & above including fittings and flanges as required in accordance with specification.

2.9 Rubber lining inside pipes, fittings, flanges as and when required, in accordance with specification.

2.10 Radiography, stress relieving, dye penetration, magnetic particle test etc. as required in specification.

2.11 Performing PMI using alloy analyzers as per 'Standard Specification for Positive Material Identification at Construction Sites, 6-82-0002'.

2.12 Casting of concrete pedestals and Fabrication and erection of small structures/ platforms for pipe supports and valve operation / attending some instruments, spectacle blinds etc., providing brackets, modification / extension of platforms, providing additional platforms / ladders for improving / providing accessibility.

2.13 Providing insert plates with anchor fasteners in concrete structures / paved floors. Cutting and repair of platform gratings around pipe openings and providing suitable members for support under the platform grating.

2.14 Making material reconciliation statement and return of Owner's supply left over materials to Owner's storage.

2.15 Flushing and testing of all piping systems as per standard specification for inspection, flushing and testing of piping systems (Specification No. 6-44-0013). The accessories required for blinding the line like flange, blind flange, gasket (all sizes, type and rating), stud-bolts, flexible hoses etc. are to be arranged by the Contractor. During flushing the discharged water / air shall be drained / routed as directed by the Engineer – In Charge.

2.16 Contractor shall prepare welding specifications for all weld joints where dissimilar welding will be performed, and obtain approval from EIL.

2.17 Contractor to ensure meeting all requirements for carrying out work in shutdown/running plant.

2.18 Pickling (as and when applicable) as per Job specification(s) for chemical cleaning of CS suction piping of compressors, SS Piping, Weldments etc, as applicable.

2.19 Chemical Cleaning/ Hydro jet cleaning as per marked-up P&IDs with supply of chemicals, consumables, DM water, equipments, boilers, coupons, tools & tackles and other testing equipments required for the same.

2.20 For Offsites, only Piping General Arrangement drawings shall be issued. Isometrics, if required, shall be prepared by the Contractor.

3.0 BASIS FOR WORK

3.1 The complete piping work shall be carried out in accordance with the following:

3.1.1 "Approved for Construction" drawings and sketches issued by EIL to the Contractor - Plans and/or Isometrics.

3.1.2 "Approved for Construction" drawings and sketches issued by Turn-key bidders to the Contractor - Plans and/or Isometrics.

3.1.3 Approved Process Licensor's standards and specifications.

3.1.4 Drawings, sketches and documents prepared by Contractor duly approved by Engineer-in-Charge (such as isometrics of small bore piping and offsite piping etc.).

3.1.6 EIL specifications/documents as below:

a. Process and Instrument Diagram.

b. Job Piping Materials Specification (****-6-44-0005). **** denotes job number.

c. Piping support, engineering standards.

d. Line list

e. Piping support indices (only in offsite), if supports are not shown in plan.

f. Job specification of Non-destructive Requirement of Piping (****-6-44-0016)

g. Job Welding Specification Charts for Piping Classes (****-6-77-0005)

h. Job Welding specification for fabrication of piping (****-6-77-0001).

i. Any other EIL or OTHER specifications attached with Piping Material Specification or special condition of contract (such as standard for cement lining of pipe, standard of jacketed piping, standard for steam tracing, Dimensional Tolerances etc.)

j. Standard specification for positive material identification (PMI) at construction sites, 6-82-0002

k. Standard Spec for application of torque & hydraulic bolt tension for flange joints (6-76-0002) and its addendum, if any.

3.1.7 Following codes, standards and regulations

a.	ASME B 31.3	:	Process Piping
b.	ASME Sec. VIII	:	Code for unfired pressure vessel.
c.	IBR Regulations		
d.	ASME Sec. IX	:	Qualification standard for welding and brazing procedures, welders, brazers and welding and brazing operators.

e. NACE Std. : Code for Sour Services material requirements MR-0175/MR0103/Job spec(NACE), as applicable

Note : All codes referred shall be latest edition, at the time of award of contract.

3.2 Deviations

Where a deviation from the "Basis of Work" and approved job procedure described above is required or where the basis of work does not cover a particular situation, the matter shall be brought to the notice of Engineer-in-Charge and the work carried out only after obtaining written approval from him in each case.

4.0 FABRICATION

4.1 Piping Material

Pipe, pipe fittings, flanges, valves, gaskets, studs bolts etc. used in a given piping system shall be strictly as per the "Piping Material Specification" for the "Pipe Class" specified for that system. To ensure the above requirement, all piping material supplied by the Owner / Contractor shall have proper identification marks as per relevant standards / EIL specifications / Licensors specification. Contractor shall provide identification marks on left over pipe lengths wherever marked up pipe lengths have been fabricated/erected. Material- traceability is to be maintained for A.S., S.S., NACE, LTCS, material for Hydrogen service and other exotic materials by way of transferring heat number, etc. (hard punching) as per approved procedure. This shall be in addition to colour coding for all piping materials to avoid mix-up.

For the purpose of common understanding the construction job procedure, to be submitted by the Contractor, shall include proposal for

- Maximizing prefabrication, inspection and testing at fabrication shop with minimum field joints.

- Positive material identification, handling, storage & preservation.

4.2 Dimensional Tolerances

Dimensional tolerances for piping fabrication shall be as per EIL Standard No. 7-44-0486. The Contractor shall be responsible for working to the dimensions shown on the drawings. However, the Contractor shall bear in mind that there may be variations between the dimensions shown in the drawing and those actually existing at site due to minor variations in the location of equipments, inserts, structures etc. Isometrics, if supplied may have the field welds marked on them. However, it is the responsibility of the Contractor to provide adequate number of field welds. Wherever errors / omissions/ mismatches occur in drawings and Bills of Materials it shall be the Contractor's responsibility to notify the Engineer-in-Charge prior to fabrication or erection.

4.3 IBR Piping

4.3.1 Contractor shall obtain approval for the piping systems falling under purview of IBR from the statutory Indian Boiler Regulations (IBR) authority of the state where the plant is situated. The Owner shall provide documentation for the IBR System. The Contractor shall carry out the fabrications, erection and testing of this piping as per requirements of Indian Boiler Regulations and to the entire satisfaction of the local Boiler Inspector. The Contractor shall also get the approval of IBR inspector for all fabrication and testing done by him at his own cost. All certificates of approval shall be in proper IBR forms.

4.3.2 IBR Package for residual, field routed and site modified steam lines shall be prepared by the Contractor. IBR approval for the same shall be in Contractor's scope, at his own cost.

4.4 Pipe Joints

The piping class of each line specifies the type of pipe joints to be adopted. In general, joining of lines 2" and above in process and utility piping shall be accomplished by butt-welds. Joining of lines 1-1/2" and below shall be by socket welding/butt welding/threaded joints as specified in "Piping Material Specifications". However, in piping 1-1/2" and below where socket welding/ threaded joints are specified butt - welds may be used with the approval of Engineer-in-Charge for pipe to pipe joining in long runs of piping. This is only applicable for non-galvanized piping without lining.

Flange joints shall be used at connections to Vessels, Equipment's, Valves and where required for ease of erection and maintenance as indicated in drawings.

4.5 Butt Welded and Socket Welded Piping

End preparation, alignment and fit-up of pipe pieces to be welded, welding, pre-heating, post-heating and heat treatment shall be as described in the Job welding specification (****-6-77-0005) and NDT specification (****-6-44-0016).

4.6 Screwed Piping

In general, Galvanized piping shall have threads as per IS:554 or ANSI B2.1 NPT as required to match threads on fittings, valves etc. All other piping shall have threads as per ANSI B2.1, tapered unless specified otherwise.

Threads shall be clean cut, without any burrs or stripping and the ends shall be reamed. Threading of pipes shall be done preferably after bending, forging or heat treating operations. If this is not possible, threads shall be gauge checked and chased after welding heat treatment etc.

During assembly of threaded joints, all threads of pipes and fittings shall be thoroughly cleaned of cuttings, dirt, oil or any other foreign matter. The male threads shall be coated with thread sealant and the joint tightened sufficiently for the threads to seize and give a leakproof joint. Threaded joints to be seal-welded shall be cleaned of all foreign matter, including sealant and made up to full thread engagement before seal welding.

It is the responsibility of the contractor to ensure leak proof joints and to maintain good workmanship handling or making threads during assembly.

4.7 Flange Connections

All flange facings shall be true and perpendicular to the axis of pipe to which they are attached. Flanged bolt holes shall straddle the normal centerlines unless different orientation is shown in the drawing.

Wherever jack screws are to be provided, drilling and tapping for the jack screws in the flange, shall be done as per EIL Standard before welding it to the pipe.

4.8 Branch Connections

Branch connections shall be as indicated in the piping material specifications. For end preparation, alignment, spacing, fit-up and welding of branch connections refer welding specifications. Templates shall be used wherever required to ensure accurate cutting and proper fit-up.

For all branch connections accomplished either by pipe to pipe connections or by using forged tees the rates quoted for piping shall be inclusive of this work.

Reinforcement pads shall be provided wherever indicated in drawings/ specifications etc. Reinforcement pads shall be pneumatically tested at 1.05 kg/cm2g with soap solution. This test shall be carried out before hydrostatic testing.

4.9 Bending

Bending shall be as per ASME B31.3 except that corrugated or creased bends shall not be used.

Cold bends for lines 1-1/2" and below, with a bend radius of 5 times the nominal diameter shall be used as required in place of elbows wherever allowed by piping specifications. Bending of pipes 2" and above may be required in some cases like that for headers around heaters, reactors etc.

The completed bend shall have a smooth surface, free from cracks, buckles, wrinkles, bulges, flat spots and other serious defects. They shall be true to dimensions. The flattening of a bend, as measured by the difference between the maximum and minimum diameters at any cross-section, shall not exceed 8% and 3% of the nominal outside diameter, for internal and external pressure respectively.

4.10 Forging and Forming

Forging and forming of small bore fittings, like reducing nipples for piping 1-1/2" and below, shall be as per ASME B 31.3.

4.11 Mitre Bends and Fabricated Reducers

The specific application of welded mitre bends and fabricated reducers shall be governed by the Piping Material Specifications. Reducers shall be fabricated as per directions of Engineer-in-Charge. The radiographic requirements shall be as per Material Specifications for process and utility systems and NDT Specification for steam piping under IBR, radiographic requirements of IBR shall be complied with.

4.12 Cutting and Trimming of Standard Fittings & Pipes

Components like pipes, elbows, couplings, half-couplings etc. shall be cut / trimmed / edge prepared wherever required to meet fabrication and erection requirements, as per drawings and instructions of Engineer-in-Charge. Nipples as required shall be prepared from straight length piping.

4.13 Galvanized Piping

Galvanized carbon steel piping shall be completely cold worked, so as not to damage galvanized surfaces. This piping involves only threaded joints and additional external threading on pipes may be required to be done as per requirement.

4.14 Jacketed Piping

The Jacketing shall be done in accordance with EIL Specification or Licensors specification as suggested in material specification or special condition of contract.

Pre-assembly of jacketed elements to the maximum extent possible shall be accomplished at shop by Contractor. Position of jump-over and nozzles on the jacket pipes, fittings etc. shall be marked according to pipe disposition and those shall be prefabricated to avoid damaging of inner pipe and obstruction of jacket space. However, valves, flow glasses, in line instruments or even fittings shall be supplied as jacketed.

4.15 Shop Fabrication / Prefabrication

The purpose of shop fabrication or pre-fabrication is to minimize work during erection to the extent possible. Piping spool, after fabrication, shall be stacked with proper identification marks, so as facilitate their withdrawal at any time during erection. During this period all flange (gasket contact faces) and threads shall be adequately fabricated by coating with removable rust preventive. Care shall also be taken to avoid any physical damage to flange faces and threads.

4.16 Miscellaneous

4.16.1 Contractor shall fabricate miscellaneous elements like flash pot, seal pot, sample cooler, supporting elements like turn-buckles, extension of spindles and interlocking arrangement of valves, operating platforms as required by Engineer-in-Charge.

4.16.2 Spun Concrete Lining

The work of inside spun concrete lining of pipes and specials of diameter 3" and above shall be done as per material specifications and special condition contract.

4.16.3 Fabrication of pipes from plate

Pipes shall be fabricated at site as and when required as per the specifications and the actual Piping Material Specification.

5.0 ERECTION

5.1 Cleaning of Piping before Erection

Before erection all pre-fabricated spool pieces, pipes, fittings etc. shall be cleaned inside and outside by suitable means. The cleaning process shall include removal of all foreign matter such as scale, sand, weld spatter chips etc. by wire brushes, cleaning tools etc. and blowing with compressed air/or flushing out with water. Special cleaning requirements for some services, if any, shall be as specified in the piping material specification or isometric or line list. S.S jacketed piping requiring pickling shall be pickled to remove oxidation and discolouring due to welding.

5.2 Piping Routing

No deviations from the piping route indicated in drawings shall be permitted without the consent of Engineer-in-Charge.

Pipe to pipe, pipe to structure / equipments distances / clearances as shown in the drawings shall be strictly followed as these clearances may be required for the free expansion of piping

/ equipment. No deviations from these clearances shall be permissible without the approval of Engineer-in-Charge.

In case of fouling of a line with other piping, structure, equipment etc. the matter shall be brought to the notice of Engineer-in-Charge and corrective action shall be taken as per his instructions.

5.3 Cold Pull

Wherever cold pull is specified, the Contractor shall maintain the necessary gap, as indicated in the drawing. Confirmation in writing shall be obtained by the Contractor from the Engineer-in-Charge, certifying that the gap between the pipes is as indicated in the drawing, before drawing the cold pull. Stress relieving shall be performed before removing the gadgets for cold pulling.

5.4 Slopes

Slopes specified for various lines in the drawings / P&ID shall be maintained by the Contractor. Corrective action shall be taken by the Contractor in consultation with Engineer-in-Charge wherever the Contractor is not able to maintain the specified slope.

5.5 Expansion Joints / Bellows

Installation of Expansion Joints/Bellows shall be as follows:

5.5.1 All Expansion joints / Bellows shall be installed in accordance with the specification and installation drawings, supplied to the Contractor.

5.5.2 a. Upon receipt, the Contractor shall remove the Expansion Joints/ Bellows from the case(s) and check for any damage occurred during transit.

b. The Contractor shall bring to the notice of the Engineer-in- Charge any damage done to the bellows / corrugations, hinges, tie-rods, flanges/ weld ends etc.

c. Each Expansion Joint / Bellow shall be blown free of dust / foreign matter with compressed air or cleaned with a piece of cloth.

5.5.3 a. For handling and installation of Expansion Joints, great care shall be taken while aligning. An Expansion Joints shall never be slinged from bellows corrugations/ external shrouds, tie / rods, angles.

b. An Expansion Joints / Bellow shall preferably be slinged from the end pipes / flanges or on the middle pipe.

5.5.4 a. All Expansion Joints shall be delivered to the Contractor at "Installation length", maintained by means of shipping rods, angles welded to the flanges or weld ends or by wooden or metallic stops.

b. Expansion Joints stop blocks shall be carefully removed after hydrostatic testing. Angles welded to the flanges or weld ends shall be trimmed by saw as per manufacturer's instructions and the flanges or weld ends shall be ground smooth.

5.5.5 a. The pipe ends in which the Expansion Joint is to be installed shall be perfectly aligned or shall have specified lateral deflection as noted on the relevant drawings.

b. The pipe ends / flanges shall be spaced at a distance specified in the drawings.

5.5.6 The Expansion Joint shall be placed between the mating pipe ends / flanges and shall be tack welded/bolted. The mating pipes shall again be checked for correct alignment.

5.5.7 Butt-welding shall be carried out at each end of the expansion joint. For flanged Expansion Joint, the mating flanges shall be bolted.

5.5.8 After the Expansion Joint is installed the Contractor shall ensure that the mating pipes and Expansion Joints are in correct alignment and that the pipes are well supported and guided.

5.5.9 The Expansion Joint shall not have any lateral deflection. The Contractor shall maintain parallelism of restraining rings or bellows convolutions.

5.5.10 Precautions

a. For carrying out welding, earthing lead shall not be attached with the Expansion Joint.

b. The Expansion bellow shall be protected from arc weld spot and welding spatter.

c. Hydrostatic Testing of the system having Expansion Joint shall be performed with shipping lugs in position. These lugs shall be removed after testing and certification is over.

5.6 Flange Connections

While fitting up mating flanges, care shall be exercised to properly align the pipes and to check the flanges for trueness, so that faces of the flanges can be pulled together, without inducing any stresses in the pipes and the equipment nozzles. Extra care shall be taken for flange connections to pumps, turbines, compressors, cold boxes, air coolers etc. The flange connections to these equipments shall be checked for misalignment, excessive gap etc. after the final alignment of the equipment is over. The joint shall be made up after obtaining approval of Engineer-in-Charge.

Hydraulic bolt tensioning & torque tensioning shall be performed on flange joints as per the requirements specified in "Standard Specification for application of Torque & Hydraulic Bolt Tension for flange joints," 6-76-0002 and its addendum, if any.

Temporary protective covers shall be retained on all flange connections of pumps, turbines, compressors and other similar equipments, until the piping is finally connected, so as to avoid any foreign material from entering these equipments.

The assembly of a flange joint shall be done in such a way that the gasket between these flange faces is uniformly compressed. To achieve this, the bolts shall be tightened in a proper sequence. All bolts shall extend completely through their nuts but not more than 1/4".

Steel to C.I. flange joints, if any, shall be made up with extreme care, tightening the bolts uniformly after bringing flange flush with gaskets with accurate pattern and lateral alignment.

5.7 Vents and Drains

High point vents and low point drains shall be provided as per the instructions of Engineer-in-Charge, even if these are not shown in the drawings. The details of vents and drains shall be as per piping material specifications / job standards.

5.8 Valves

Valves shall be installed with spindle / actuator orientation / position as shown in the layout drawings. In case of any difficulty in doing this or if the spindle orientation / position is not shown in the drawings, the Engineer-in-Charge shall be consulted and work done as per his instructions. Care shall be exercised to ensure that globe valves, check valves, and other uni-directional valves are installed with the "Flow direction arrow "on the valve body pointing in the correct direction. If the direction of the arrow is not marked on such valves, this shall be done in the presence of Engineer-in-Charge before installation.

Fabrication of stem extensions, locking arrangements, interlocking arrangements of valves (if called for) and change in orientation of spindles (if required as per site conditions) shall be carried out as per drawings/ instructions of Engineer-in-Charge.

5.9 Instruments

Installation of in-line instruments such as control valve, orifice flange, rotameter, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, annubar, magnetic flow meter, ultrasonic flow meter, Coriolis mass flow meters, venturi PG/PT/ Flow transmitter, ejectors, etc. and Shut Down Valves with fireboxes shall form a part of piping erection work.

Fabrication and erection of piping upto first block valve / nozzle / flange for installation of offline Instruments for measurement of level, pressure, temperature, flow etc. shall also form part of piping construction work. The limits of piping and instrumentation work will be shown in drawings / standards / specifications. Orientations / locations of take-offs for temperature, pressure, flow, level connections etc. shown in drawings shall be maintained.

Flushing and testing of piping systems which include instruments mentioned above and the precautions to be taken are covered in flushing, testing and inspection of piping (EIL Spec. 6-44-0013). Care shall be exercised and adequate precautions taken to avoid damage and entry foreign matter into instruments during transportation, installation, testing etc.

5.10 Line Mounted Equipments / Items

Installation of line mounted items like filters, strainers, steam traps, air traps, desuperheaters, ejectors, samples coolers, mixers, flame arrestors, sight glasses etc including their supporting arrangements shall form part of piping erection work.

5.11 Bolts and Nuts

The Contractor shall apply molycoat grease mixed with graphite powder (unless otherwise specified in piping classes) all bolts and nuts during storage, after erection and wherever flange connections are broken and made-up for any purpose whatsoever. The grease and graphite powder shall be supplied by the Contractor within the rates for piping work.

5.12 Pipe Supports

Pipe supports are designed and located to effectively sustain the weight and thermal effects of the piping system and to prevent its vibrations. Location and design of pipe supports will be shown in drawings for lines 2" NB & above. For lines 1½"NB & below Contractor shall locate and design pipe supports in line with EIL Stds. In case of IBR Lines 1½"NB & below only indicative supporting shall be provided & detailing of such supports is in Contractor's scope. Contractor shall obtain approval of Engineer - in - Charge on drawings prepared by Contractor, before erection. However, any extra supports desired by Engineer-in-Charge shall also be installed. Upon issue of drawings contractor to prepare BOM for support members in

contractor's scope for procurement action. Pipe shall be erected along with the primary support to the maximum extent to minimize works at height.

No pipe shoe / cradle shall be offset unless specifically shown in the drawings.

Hanger rods shall be installed inclined in a direction opposite to the direction in which the pipe move during expansion.

Piping (including small bore) shall not be supported directly from gratings of platforms including equipment platforms.

Preset pins of all spring supports shall be removed only after hydrostatic testing and insulation is over. Springs shall be checked for the range of movement and adjusted if necessary to obtain the correct positioning in cold condition. These shall be subsequently adjusted to hot setting in operating condition. The following points shall be checked after installation, with the Engineer-in-Charge and necessary confirmation in writing obtained certifying that:

- All restraints have been installed correctly.
- Clearances have been maintained as per support drawings.
- Insulation does not restrict thermal expansion.
- All temporary tack welds provided during erection have been fully removed.
- All welded supports have been fully welded.

5.13 Dismantling and Modifications

Dismantling/ modification of erected piping shall be carried out, if required for routing of lines as per revised Isometrics. All necessary clearances have to be taken by contractor from Engineer-in- charge.

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STANDARD SPECIFICATION FOR INSPECTION, FLUSHING AND TESTING OF PIPING SYSTEMS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
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2	05.06.03	PMI REQT. INCLUDED AND ISSUED AS STANDARD SPECIFICATION	RN	DM	BN	SKG

Abbreviations:

ASME	:	The American Society of Mechanical Engineers
IBR	:	Indian Boiler Regulations
PMI	:	Positive Material Identification
ppm	:	Parts per million
SS	:	Stainless Steel

Piping Standards Committee

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1.0 SCOPE

This specification covers the general requirements for inspection, flushing and testing of piping systems. However, testing of steam lines falling under IBR shall also be governed by Indian Boiler Regulations.

Flushing and testing of all piping systems shall be witnessed by the Engineer-In-Charge.

2.0 REFERENCES

ASME B31.3	:	Process Piping
IBR	:	Indian Boiler Regulations
6-82-0002	:	Standard Specification for Positive Material Identification (PMI) at Construction Sites

3.0 INSPECTION

During various stages and after completion of fabrication and erection, the piping system shall be inspected by the Engineer-In-Charge to ensure that:

- Proper piping material has been used.
- PMI has been performed as per EIL specification '6-82-0002'.
- Piping has been erected as per drawings and instructions of Engineer-In-Charge.
- All supports have been installed correctly.
- Test preparations mentioned in this specification have been carried out.

4.0 FLUSHING

Flushing of all lines shall be done before pressure testing.

Flushing shall be done by 'fresh potable water' or by 'dry compressed air wherever water flushing is not desirable to clean the pipe of all dirt, debris or loose foreign material.

Required pressure for water flushing shall meet the fire hydrant pressure or utility water pressure. For air flushing, the line/system shall be pressurized by compressed air at the required pressure which shall be 3.5kg/cm^{2}g maximum. The pressure shall then be released by quick opening of a valve, already in line or installed temporarily for this purpose. This procedure shall be repeated as many times as required till the inside of the pipe is fully cleaned.

In line instruments like control valves, orifice plates, rotameters, safety valves and other instruments like thermowells which may interfere with flushing shall not be included in flushing circuit.

The screens/meshes shall be removed from all permanent strainers before flushing. Screens/meshes shall be reinstalled after flushing but before testing.

During flushing temporary strainers shall be retained. These shall be removed, cleaned and reinstalled after flushing, but, before testing.

In case any equipment such as column, vessel, exchanger etc. form part of a piping circuit during flushing, this shall be done with the approval of Engineer-In-Charge. However, equipment thus included in the circuit shall be completely drained and dried with compressed air after flushing is completed.

During flushing discharged water/air shall be drained to the place directed by the Engineer-In-Charge. If necessary, proper temporary drainage shall be provided by the contractor.

Care shall be taken during flushing so as not to damage/spoil work of other agencies. Precautions shall also be taken to prevent entry of water/foreign matter into equipment, electric motors, instruments, electrical installations etc. in the vicinity of lines being flushed.

The contractor shall carry out all the activities required before, during and after the flushing operation, arising because of flushing requirements, such as but not limited to the following:

Dropping of valves, specials, distance pieces, inline instruments and any other piping part before flushing. The flanges to be disengaged for this purpose shall be envisaged by the contractor and approved by the Engineer-In-Charge. These flanges shall be provided with temporary gaskets at the time of flushing.

After flushing is completed and approved, the valve distance pieces, piping specials etc. shall be reinstalled by the contractor with permanent gaskets. However, flanges at equipment nozzles and other places where isolation is required during testing, only temporary gaskets shall be provided.

Records in triplicate shall be prepared and submitted by the contractor for each piping system for the flushing done in the proforma provided/approved by the Engineer-in-Charge.

5.0 PRESSURE TESTING

Pressure testing, in general shall be as per clause 345 of ASME B31.3, unless otherwise specified, herein. Lines carrying highly hazardous/poisonous fluids must have a sensitive leak test. For IBR lines, 'IBR Regulations' shall also be followed.

5.1 Extent of Testing

With the exclusion of instrumentation, piping systems fabricated or assembled in the field shall be tested irrespective of whether or not they have been pressure tested prior to site welding or fabrication.

To facilitate the testing of piping systems, vessels and other equipment may be included in the system with the prior approval of Engineer-In-Charge if the test pressure specified is equal to or less than that for the vessels and other equipment.

Pumps, compressors and other rotary equipment shall not be subjected to field test pressure.

Lines which are directly open to atmosphere such as vents, drains, safety valves discharge need not be tested, but all joints shall be visually inspected. Wherever necessary, such lines shall be tested by continuous flow of fluid to eliminate the possibility of blockage. However, such lines if provided with block valve shall be pressure tested up to the last block valve.

Seats of all valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Test pressure applied to valves shall not be greater than the manufacturer's recommendation nor less than that required by the applicable code. Where allowable seat pressure is less than test pressure, test shall be made through an open valve.

Instruments in the system to be tested shall be excluded from the test by isolation or removals, unless approved otherwise by the Engineer-In-Charge.

Restrictions which interfere with filling, venting, draining such as orifice plates etc. shall not be installed unless testing is complete.

Control valves shall not be included in the test system. Where bypasses are provided test shall be performed through the bypass and/or necessary spool shall be used in place of the control valve.

Pressure gauges which are part of the finished system, but cannot withstand test pressure shall not be installed until the system has been tested. Where piping systems to be tested are directly connected at the battery limits to piping for which the responsibility rests with other agencies, the piping to be tested shall be isolated from such piping by physical disconnection such as valve or blinds.

5.2 General Requirements / Test Preparation for Testing

Testing shall be carried out with permanent gaskets installed unless specified otherwise or instructed by the Engineer-in-Charge.

No pressure test shall be carried out against closed valve unless approved by the Engineer-in-Charge

The Engineer-in-Charge shall be notified in advance by the Contractor, of the testing sequence and programme, to enable him to be present for witnessing the test. The Contractor shall be fully responsible for making arrangements with the local boiler inspector to witness the tests for steam lines falling under IBR. IBR certificates for these tests shall be obtained in the relevant IBR forms and furnished to the Engineer-in-Charge.

Before testing, all piping shall be cleaned by flushing to make it free from dirt, loose scale, debris and other loose foreign materials.

All piping systems to be hydrostatically tested shall be vented at the high points and the systems purged of air before the test pressure is applied.

Wherever in the line any void exists due to any reasons, like absence of control valves, safety valves, check valves etc. it shall be filled with temporary spools.

All joints welded, screwed or flanged shall be left uninsulated and exposed for examination during the test. Before pressurizing the lines, each weld joint shall be cleaned by wire brush to free it from rust and any other foreign matter. All joints may be primed and painted prior to leak testing unless they are subject to sensitive leak test or testing with soap solution (e.g., reinforcement pads and lines to be pneumatically tested, etc.).

Where a system is to be isolated at a pair of companion flanges, a blank shall be inserted between the companion flanges. Minimum thickness of the blank shall be designed in accordance with applicable design code.

Open ends of piping system where blanks cannot be used, such as pumps, compressors, turbines or wherever equipment or pipe spools have been recovered or disconnected prior to hydrostatic testing, shall be blinded off by using standard blind flanges of same rating as the piping system being tested.

Pressure gauges used in testing shall be installed as close as possible to the lowest point in the piping system to be tested, to avoid overstressing of any of the lower portions of the system.

For longer lines and vertical lines, two or more pressure gauges shall be installed at locations decided by the Engineer-in-Charge.

For lines containing check valves any of the following alternatives shall be adopted for pressure testing:

- Whenever possible pressurize up-stream side of valve.
- Replace the valve by a temporary spool and reinstall the valve after testing.
- Provide blind on valve flanges and test the upstream and downstream of the line separately and remove the blind after testing. At these flanges, temporary gaskets shall be provided during testing and shall be replaced by permanent gaskets subsequently.
- For check valves in lines 1½" and below flapper or seat shall be removed during testing (if possible). After completion of testing the flapper/seat shall be refitted.

Gas lines when hydrostatically tested shall be provided with additional temporary supports during testing as directed by the Engineer-in-Charge.

Piping which is spring or counter-weight supported shall be temporarily supported, where the weight of the fluid would overload the support. Retaining pins for spring supports shall be removed only after testing is completed and test fluid is completely drained.

When testing any piping system, air or steam of approximately 2 kg/ cm^2g may be used as preliminary test to detect missing gaskets etc. as this avoids the necessity of draining the line to make repairs. However, steam shall not be used for this purpose, if the steam temperature is more than the design temperature of the line.

For jacketed pipes testing of core pipes shall be done on individual pieces where the pipe is continuously jacketed, before it is jacketed. The outer jacket shall be tested separately as a system. For piping with discontinuous jacketing the core pipe and the jacket shall be tested as separate continuous systems.

5.3 Testing Media, Test Pressure and Test Pressure Gauges

5.3.1 Testing Media

In general all pressure tests shall be hydrostatic using iron free water, which is clean and free of silt. Test fluid temperature shall be min. 5 °C. Maximum chloride content in water for hydrostatic testing for SS piping shall be 15- 20 ppm.

Air shall be used for testing only if water would cause corrosion of the system or overloading of supports etc. in special cases as directed by Engineer-in-Charge.

If operating fluid in the line is much lighter than testing fluid, the additional weight of testing fluid may render piping supports (as designed) inadequate. This will call for additional temporary supports. The typical examples are flare and vapor lines. It is preferable that hydrostatic testing is avoided in such systems and instead pneumatic testing may be specified.

Where air/water tests are undesirable, substitute fluids such as gas oil, kerosene, methanol etc. shall be used as the testing medium, with due consideration to the hazards involved. These test fluids shall be specified in the line list given to the contractor.

5.3.2 Test Pressure

The hydrostatic/ pneumatic test pressure shall be as indicated in the line list or as per the instruction of Engineer-in-Charge.

The selection of the piping system for one individual test shall be based on the following:

- Test pressure required as per line list.
- Maximum allowable pressure for the material of construction of piping.

Depending upon the above requirements and based on construction progress, maximum length of piping shall be included in each test.

5.3.3 Test Pressure Gauge

All gauges used for field testing shall have suitable range so that the test pressure of various systems falls in 35% to 65% of gauge scale range. Pressure gage dial shall be minimum of 150 mm. Size of Bourdon shall not be less than 75% of nominal diameter of dial range. Gauge shall be of a good quality and in first class working condition.

Prior to the start of any test or periodically during the field test programme, all test gauges shall be calibrated using a standard dead weight gauge tester or other suitable approved testing apparatus. Any gauge showing an incorrect zero reading or error of more than ± 2% of full scale range shall be discarded. The Engineer-in-Charge shall check the accuracy of master pressure gauge used for calibration. Calibration certificate shall be furnished for the pressure gages.

5.4 Testing Procedure

5.4.1 Hydrostatic Test

All vents and other connections used as vents shall be left open while filling the line with test fluid for complete removal of air. In all lines for pressurizing and depressurizing the system, temporary isolation valves shall be provided if valved vents, drains do not exist in the system.

Pressure shall be applied only after the system / line is ready and approved by the Engineer-in-charge.

Pressure shall be applied by means of a suitable test pump or other pressure source which shall be isolated from the system as soon as test pressure is reached and stabilized in the system.

A pressure gauge shall be provided at the pump discharge for guidance in bringing the system to the required pressure.

The pump shall be attended constantly during the test by an authorized person. The pump shall be isolated from the system whenever the pump is to be left unattended.

Test pressure shall be maintained for a sufficient length of time not less than 10minutes. Test pressure shall be released only after physical checking of all the joints and attachments are completed, to permit thorough inspection of all joints and connections for leakage or signs of failure. Any joint found leaking during a pressure test shall be retested to the specified pressure after repair.

The pump and the piping system to be tested are to be provided with separate pressure indicating test gauges.

Care shall be taken to avoid increase in the pressure due to temperature variation during the test.

5.4.2 Pneumatic Test

When testing with air, pressure shall be supplied by means of a compressor. The compressor shall be portable type with a receiver, after cooler and oil separator.

Piping to be tested by air shall have joints covered with a soap and water solution so that the joints can be examined for leaks.

All other details shall be same as per hydrotesting procedure (specified above).

5.5 Completion of Testing

After the hydrostatic test has been completed, pressure shall be released by opening the vents, in a manner and at a rate so as not to endanger personnel or damage equipment.

All vents shall be opened before the system is to be drained and shall remain open till all draining is complete, so as to prevent formation of vacuum in the system. After draining, lines / systems shall be dried by air. In services like dry air, ethylene etc., small traces of water can cause problem. For such lines hot air drying is to be done after hydro-test.

After testing is completed the test blinds shall be removed and equipment / piping isolated during testing shall be connected using the specified gaskets, bolts and nuts. These connections shall be checked for tightness in subsequent pneumatic tests to be carried out by the contractor for complete loop / circuit including equipment (except rotary equipment).

Pressure test shall be considered complete only after approved by the Engineer-in-Charge. Defects, if any, noticed during testing shall be rectified immediately and retesting of the system/ line shall be done by the contractor at his cost.

5.6 Test Records

Records in triplicate shall be prepared and submitted by the contractor for each piping system, for the pressure test done in the proforma provided/approved by the Engineer-in-Charge. Records shall also be submitted for the PMI undertaken as per EIL Std. Specification No. 6-82-0002.

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STANDARD SPECIFICATION
FOR
CEMENT LINED PIPING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
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2	15.03.24	REVISED AND ISSUED AS STANDARD SPECIFICATION	PK	SH	GB	MN
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Abbreviations:

ANSI	:	American National Standards Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
AWWA	:	American Water Works Association
BS	:	British Standard
IS	:	Indian Standards
ISO	:	International Standards Organization
PMS	:	Piping Material Specification
SIS	:	Swedish Institute for Standards
SWG	:	Standard Wire Gauge

Piping Standards Committee

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1.0 SCOPE

This specification covers the minimum requirements of materials, mixing, application of cement lining, curing, inspection, repair, handling & transportation of piping system carrying sea-water, brackish water up to 70°C. The provisions of this specification are in addition to AWWA C205 and relevant piping material classes given in job PMS.

2.0 CODES & STANDARDS

ANSI / AWWA C205	:	Cement mortar protective lining and coating for steel water pipe-shop applied.
AWWA C602	:	Cement mortar lining of water pipelines in place.
ASME B31.3	:	Process Piping
ASTM C33	:	Standard Specification for Concrete Aggregates
ASTM A82	:	Specification for steel wire, plain, for concrete reinforcement
ASTM C150	:	Standard Specification for Portland Cement
ASTM A185	:	Specification for steel welded wire fabric, plain, for concrete reinforcement
ASTM C642	:	Standard Test Method for Density, Absorption and Voids in Hardened Concrete
BS 4232	:	British Standards institution- Surface Finish of Blast Cleaned Steel for Painting
IS 383	:	Specification for Coarse & fine aggregates from natural sources for Concrete
IS 456	:	Plain & reinforced Concrete- Code of practice
IS 4031	:	Methods of Physical Tests for Hydraulic cement
IS 6441	:	Methods of test for Autoclaved Cellular Concrete Products
IS 12330	:	Specification for Sulphate Resisting Portland Cement
ISO 8501-1 / SIS-055900	:	Preparation of Steel substrates before Application of Paints & Related Products

3.0 MATERIALS

3.1 Pipes & Piping Materials

Basic pipe fittings, flanges etc. shall be carbon steel and designed as per ASME B31.3 as per the relevant piping material classes given in job PMS for the project.

3.2 Cements

Cement used in mortar lining shall be sulphate resistant as per ASTM C150 type-II or Portland cement conforming to IS 12330. Cement shall be free of lumps.

3.3 Sand

Sand shall consist of inert granular material and the grains shall be strong, durable and uncoated. Sand shall be clean and free from injurious amounts of dust, clay, flaky particles, oil, alkali, mica and other deleterious substances. Sand shall conform to IS383 Grading zone III/ASTM C33.

3.4 Water

Water used for cement mortar mixing and curing shall be clean and free from injurious ingredients or organic matter, alkali, oil, acid, salt, sugar or other impurities and shall conform to IS456. Salt water shall not be used for mixing under any circumstances.

3.5 Reinforcement

Reinforcement shall consist of welded steel wire fabric. Wires shall conform to ASTM A-82. Steel wires shall be galvanised at finished size. Wire fabric manufactured in flat sheets to ASTM A-185 shall be 2"x4" maximum steel wire mesh, with wire 12 SWG (2.6 mm minimum) each way.

4.0 APPLICATION

4.1 Cement Mortar Mixing

Cement lining shall be done in field shop, which may be outside the refinery boundary. Suitable mechanical equipment capable of mixing mortar and doing the lining work to a reasonable degree of uniformity w.r.t. thickness, density and strength shall be employed. Mortar shall be mixed in batches.

Mortar shall be composed of cement, sand and water and mixed well in proper consistency to obtain a dense, homogeneous lining that shall adhere firmly to the pipe surface. Cement mortar for lining shall consist of one part cement to not more than three parts sand by weight. Water to cement ratio shall be between 0.3 and 0.4 by volume.

Trial mixes shall be made to arrive at mix to achieve the requirements specified in procedure qualification clause 6.0.

4.2 Surface Preparation & Primer Application

Pipes shall be welded in suitable length and immediately prior to lining, the surface shall be thoroughly cleaned from inside removing all grease, scale, rust etc. by blast cleaning to Sa2 or by power tool to St.3 as per ISO 8501-1/SIS-05 5900/BS 4232. Surface cleaning shall be followed by spray application of welding grade of Inorganic Zinc Silicate prefabrication primer from approved paint manufacturers with a dry film thickness of 25 microns at both the pipe ends up to 100 mm pipe length. The cement lining shall be done at least after 10 Hours drying of the prefabrication primer to avoid damage of the primer.

4.3 Application of Reinforcement

Pipes & fittings in sizes 26" and above shall be cement lined with reinforcement. Wire fabric reinforcement shall be applied to the interior of pipes and fittings

Reinforcement shall be placed in the pipe in such a way as to cover the whole pipe length or sections to be lined. The reinforcement shall terminate at a distance of approx. 50mm from the ends. The reinforcement then shall be suitably tack welded. There shall be an overlap of minimum 25mm at the longitudinal joint of the reinforcement.

For the pipe butt joints, reinforcement in the form of strip approx. 150mm wide shall be placed and tack welded.

There shall be an overlap of minimum 25mm between two reinforcement sections.

4.4 Lining Application

The lining shall be applied in one course for the pipe section. No unfinished surface shall remain exposed for more than 20 minutes. Mortar shall be handled so as to avoid any kind of segregation and excessive moisture loss. During mortar application pipe should be at ambient temperature. If pipe is hot due to such reasons as lying in the hot sun, then the pipe must be

cooled with the help of wet gunny bags prior to application of mortar. Lining shall be free of any sharp corners and edges and must be suitably contoured/ rounded prior to curing.

For the lining at the joints of two pipes, reinforcement shall be applied as per 4.3 above. Old lining shall be suitably hacked to make it rough before filling mortar. Prior to mortar filling cement slurry may be applied on the surface.

Straight sections of pipe shall be lined by using spinning method or a method known to provide equivalent results such as by a machine traveling through the pipe and distributing the freshly mixed mortar uniformly along the full section and long radius bends of the pipe. The lining machine shall be provided with attachments for mechanically trowelling the mortar. Both the application and trowelling of the mortar shall take place at the rear of the machine so that the freshly placed and trowelled mortar will not be damaged. The trowel attachment, the rate of travel of machine and the rate of discharge of mortar shall be such that the pressure applied to the lining will be uniform and produce a lining of uniform thickness with a smooth, finished surface.

Hand patching at the end of the pipe, for length not more than 100mm length, shall be permitted to rectify the thinning of linings.

Fittings and specials shall be centrifugally spray lined to the same standard as straight pipes or, if this is precluded by their shape, by hand patched so as to achieve comparable results.

The thickness of lining shall be as per Figure-01. However to accommodate the disc movement of Butterfly valves the cement lining of the mating flanged spools shall be suitably tapered keeping minimum 3mm lining thickness.

5.0 CURING

After lining, the pipes shall be marked with the date of lining, **sealed with plastic caps** and shall be cured by moist curing as per AWWA C-205. Moist curing shall start after 24 hours of completion of cement lining and shall be done by continuous wetting or ponding. Under no circumstances the lining shall be allowed to dry during curing period. Curing shall be carried out for a minimum **Period of 7 days. Caps shall not be removed during the curing in order to protect the lining from drying out.**

6.0 PROCEDURE QUALIFICATION:

Prior to the application of the shop cement lining the manufacturer shall perform procedure tests and qualify a working procedure to demonstrate that he is able to produce a lining system in accordance with design requirement. The constituents, mortar & finished pipe shall be tested. To establish the correct combination of sand & water, minimum of five samples shall be prepared. For each mix following shall be accurately checked and recorded:

For Individual Constituents

- Cement/admixture
- Sand
- Water
- Proportions & weights of respective materials.

For Cement Mortar Test Specimen

- Density
- Compressive Strength
- Water absorption

Test blocks of this material when subjected to testing as per IS 6441/ IS4031 shall exhibit compressive strength of not less than **316 kg/sq.cm**. after 28 days of curing and the density of cured lining shall not be less than 2300 kg/cu.m. Water absorption as per ASTM C642 shall not exceed 10% for the test specimen. Based on the test results a procedure shall be standardised for mixing of the materials.

Inspection personnel shall witness the mixing of materials and sample preparations for procedure qualification. Test results shall be correlated with sample no. and a standard procedure shall be evolved.

7.0 INSPECTION DURING PRODUCTION

The entire procedure of applying cement-mortar lining shall be subjected to continuous inspection by Owner or their authorised representative. However, such inspection shall not relieve the contractor of the responsibility of meeting the specifications. The job shall be subjected to inspection at the following stages:

i) After surface preparation and prior to application of lining.
ii) After the application of reinforcement if any.
iii) After application
iv) After curing

Any lining not applied in accordance with this standard or not as per required thickness shall be subjected to rejection and replaced/repaired at the expense of the contractor.

The inspector shall have free access to all areas and facilities concerned, and the contractor shall furnish all reasonable assistance.

The inspection of lining in pipe up to 24" dia shall be made from both ends of the lined pipe segment by using strong lights and/or mirrors. The inspection shall be done before the lining has attained its initial set. For pipes 26" & above, a manual, visual inspection of the lined pipe interior shall be made. Defects in cement-mortar lining include, but are not limited to, sand pockets, voids, over sanded areas, honey comb, excessively cracked, drummy areas, areas of lining thinner than specified, and areas of unsatisfactory surface finish.

The surface of lining shall be smooth and free from irregularities, cracks up to 0.8mm wide and not over 300mm in length are acceptable. Trough to crest height shall not exceed 1.0mm.

8.0 REPAIR OF LINING

8.1 For pipes up to 24" dia, the defective lining shall be removed in total from the pipe segment before the initial setting. The pipe segment shall then be relined in full compliance with the specifications.

8.2 For pipes above 24", small defective areas shall be repaired by manual removal of the defective lining and by hand reapplication of mortar lining. Defective areas encompassing the full dia of the pipe shall be replaced by machine wherever practical.

8.3 A pipe that has been exposed by spilling or cracking of the lining shall be cleaned thoroughly free from debris.

8.4 When an epoxy pipe-joining compound is to be used for the repair, the surface shall be dry and dust free and a coating of the compound shall be applied with a small trowel or spatula. When the cement mortar mix is to be used, the surfaces shall be dust free and moistened with clean fresh water. Immediately after moistening the cement-mortar mix shall be applied using a small trowel. If necessary a brush can be used for "feathering in" the surface edges of the repair.

8.5 Where cement-mortar is used for the repair, the adjacent lining shall be coated far enough back to cover any visible cracks and shall be maintained in a moist condition for three days using a wet hessian sack or similar means. Alternatively, if the line can be filled, it shall be put into use after the initial set has taken place.

9.0 PIPE JOINTING

Pipe joints both for above ground and underground piping up to sizes **48"** shall be done by collars in general and by flanged fittings in specific cases wherever requirement arises for ease of fabrication, inspection and maintenance as per drawings. **Joints for sizes above 48" shall be butt weld.**

9.1 Jointing Methods:

9.1.1 Pipes, which have been cement-mortar lined shall not be butt welded together in the normal way as the mortar adjacent to the weld will be damaged by heat.

9.1.2 For pipe size upto**48"** diameter a uniformly applied layer of epoxy cement approx 1.6mm thick, shall be applied to both ends of the cement lining (and OD of the pipe and ID of the sleeve). Initial setting of epoxy cement must take place before the sleeve welding.

9.1.3 Pipe OD and sleeve ID shall be coated with **concrete joint coating – Two component solvent free Epoxy resin**. The sleeve welds should be located at 90 deg. clear of any longitudinal pipe weld.

9.1.4 Sleeves shall be welded using electrodes of dia less than 5mm. In the uphill technique care shall be taken that the lining, jointing and the coating are not damaged during welding (fit up and heat input).

9.1.5 The terminal ends shall be cut at right angles to the pipe axis and after completion of all welding out of roundness shall be within the limits specified by material code.

Pipes **above 48"**, shall be joined by butt welding and in-situ lining after welding. Refer Figure-01 for joint details.

10.0 FITTINGS & FLANGES

All fittings **up to 48" size** shall be generally collar joined with pipe. However flanged joints can be provided at critical locations for ease of fabrication, inspection and maintenance as per drawings. Flanges may be welded in field/shop prior to lining. Flange faces shall be free of cement lining. For detail refer Figure-02.

11.0 BRANCH CONNECTION

11.1 Branches in cement lined pipes shall be of minimum of 3" size. Stub in branch connections of size 3" onward shall be collar joined as per Figure-3A. However to meet specific requirement at critical locations for ease of fabrication, inspection and maintenance flanged joints may also be used as per Figure-3B.

11.2 Instruments branches for Temperature and Pressure instruments shall be as per figure-04 & 05. The 3" blind flange shall be drilled to suit inst./ vent/ drain size. The blind flange used for temperature connections shall be as per instruments standard. Blind flanges used shall be FRE lined on wetted parts (Refer Figures-05 & 06).

11.3 Vents and drains on cement lined piping shall be by 3" flanged stub with blind flange which is epoxy (FRE) lined on wetted parts. The blind flange shall be provided 3/4" tapped hole and 3/4" vent/ drain with valve & blind. Refer Figure-06 for details of vents & drains.

12.0 CUTTING METHODS OF CEMENT LINED PIPES

12.1 For cutting lined pipe, a slitter saw supported as necessary and containing a nylon bonded carborundum disc shall be used. Alternatively, a rigid pipe cutting machine using tungsten carbide tipped tools ground to the cutting angles.

12.2 On fusion welded steel pipes, the external weld shall be removed flush with, but not below, the face of the pipe for the width of the cutters, and if necessary for the complete width of the cutting machine.

12.3 The section to be removed and the adjacent pipe ends shall be suitably supported to avoid imposing any weight on the concrete lining when breaking through.

13.0 DAMAGE PROTECTION

13.1 Handling

Handling of lined pipe lengths shall be by means of nylon belts such that the pipes are supported 1/5 of their length from each end. Pipes shall not be lifted using hooks inserted in the pipe ends.

13.2 Transportation

13.2.1 Lined pipes being transported shall be adequately supported in a level horizontal position in order to minimize flexing and prevent induced bending and damage to the lining.

13.2.2 Pipes shall be protected from direct and indirect impact by means of suitable cushioning material.

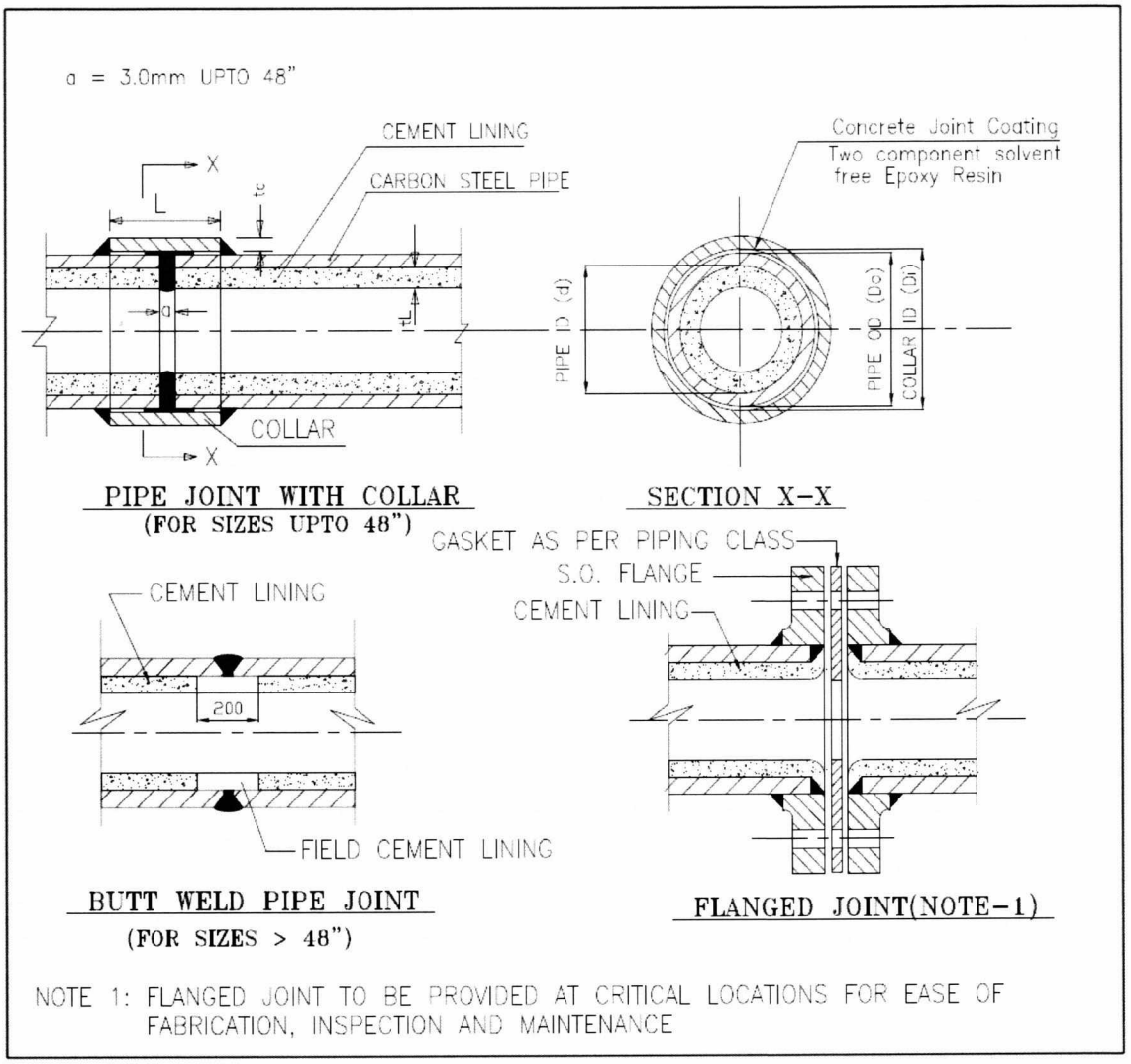
13.2.3 During transportation and storage pipe lengths shall have end caps or other suitable means of protection, with sufficient holes to permit air circulation, provided this does not cause drying out and cracking of the lining. Means shall be taken to ensure that the end protection remains securely fastened, especially during transportation.

13.2.4 Branch connections shall be suitably plugged or capped as described above

14.0 INSTALLATION

14.1 Care shall be taken when handling jointed lengths of pipes to ensure that induced bending and the possibility of damage to the lining is minimized.

14.2 During pipeline installation, when handling, lifting and laying pipe, the spacing of lifting points and supports shall be adequate to avoid induced bending.

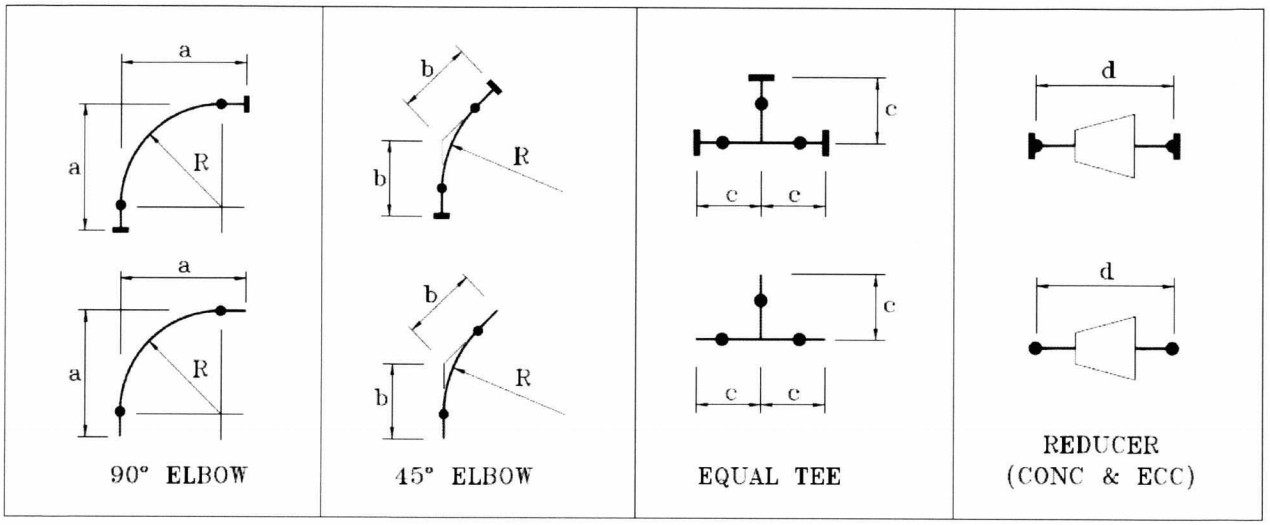


DETAILS OF COLLAR & THICKNESS OF CEMENT MORTAR LINING

PIPE NB (INCH)	PIPE OD (Do) (mm)	COLLAR ID (Di) (mm)	COLLAR LENGTH L (mm)	COLLAR THICK Tc (mm)	THICKNESS OF MORTAR LINING Tl (mm)	REMARKS
3"	88.97	95.00	150	6	6.0	Tolerance for sizes upto 48" +3.2/-1.6
4"	114.300	120.00	150	6	6.0	
6"	168.275	174.00	150	8	6.0	
8"	219.075	225.00	150	8	6.0	
10"	273.050	279.00	150	8	6.0	
12"	323.850	330.00	200	8	8.0	
14"	355.600	362.00	200	8	8.0	
16"	406.400	412.00	200	8	8.0	
18"	457.200	463.00	200	10	8.0	
20"	508.000	514.00	200	10	8.0	
24"	609.600	616.00	200	10	10.0	
26"	660.400	666.00	250	12	10.0	
28"	711.200	717.00	250	12	10.0	
30"	762.000	768.00	250	12	10.0	
32"	812.800	819.00	250	12	10.0	
36"	914.400	920.00	250	12	10.0	
40"	1016.000	1022.00	250	12	13.0	
42"	1066.800	1073.00	250	12	13.0	
44"	1117.600	1124.00	250	12	13.0	
48"	1219.200	1225.00	250	12	13.0	

Note : For Piping above 48", thickness of cement mortar lining shall be 13mm.

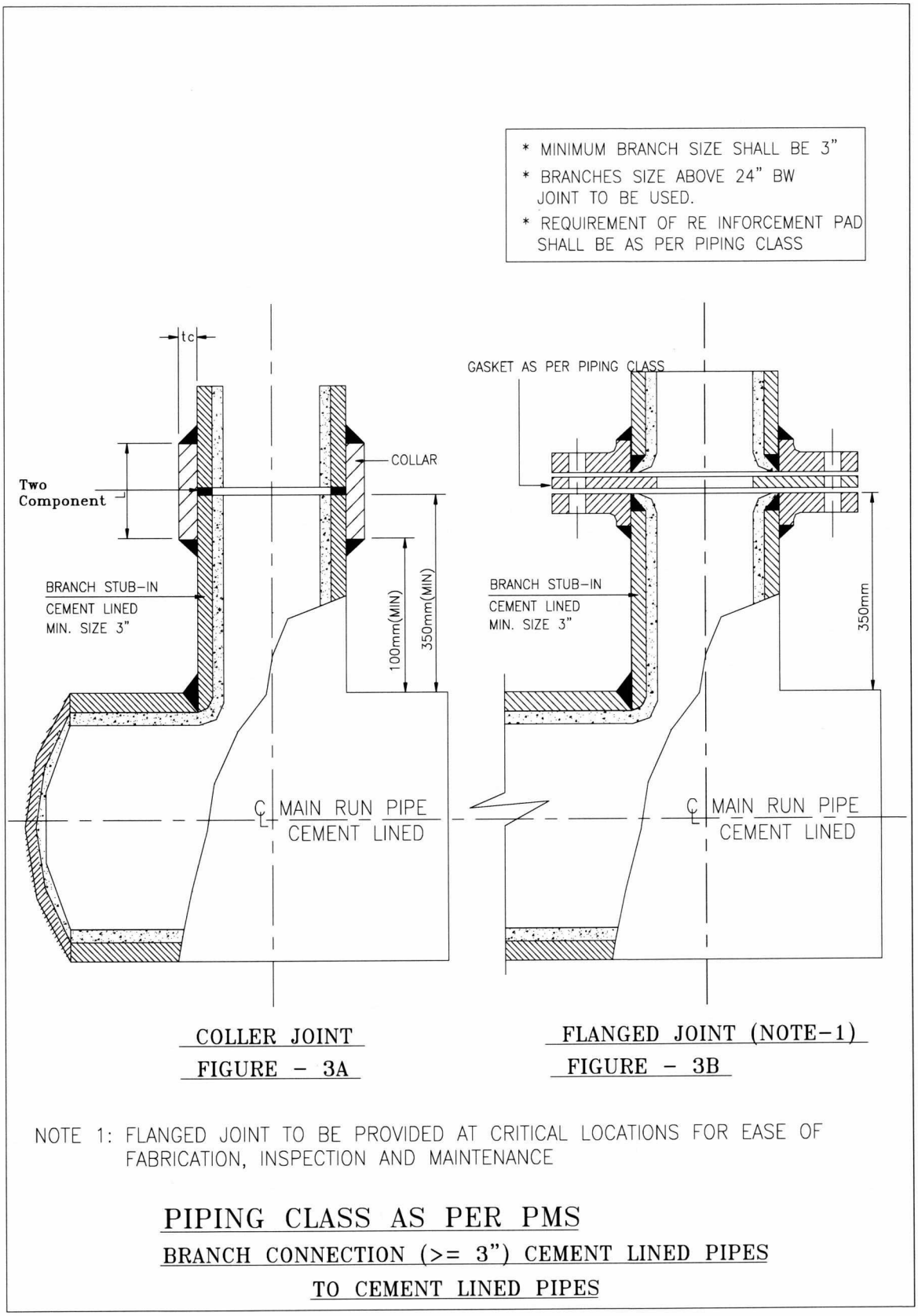
CEMENT LINED PIPES: JOINTS AND LINING THICKNESS (FIGURE-01)



NB (Inches)	a	b	c	d	R
	(All dimensions in mm)				
3"	264	201	236	389	114
4"	302	214	255	402	152
6"	379	245	293	440	229
8"	455	277	328	452	305
10"	531	309	366	478	381
12"	607	340	404	503	457
14"	683	372	430	630	533
16"	760	404	455	656	610
18"	836	436	493	681	686
20"	912	467	531	808	762
24"	1064	531	582	808	914
26"	1267	638	721	1010	1067
28"	1343	670	759	1010	1143
30"	1419	702	797	1010	1219
32"	1495	733	835	1010	1295
36"	1572	765	873	1010	1372
40"	1724	732	949	1010	1524
42"	1800	860	962	1010	1600
44"	1876	895	1013	1010	1676
46"	1953	927	1051	1111	1753
48"	2029	959	1089	1111	1829

NOTE
1. ALL FLANGES ARE 'SO' AS PER PIPING CLASS.
2. BASIC FITTING DIMENSIONS ARE AS PER ASTM B-16.9.
3. THIS TABLE DOES NOT COVER THE FABRICATED REDUCER AS PER EIL STD.
4. FOR FABRICATED FITTINGS OVERALL LENGTH SHALL BE CALCULATED AS FOLLOWS:
   LENGTH OF FABRICATED FITTINGS + SPOOL PIECE OF 150 MM UPTO 24": 200MM FOR 26"- 48".

CEMENT LINED PIPE FITTINGS (FIGURE-02)



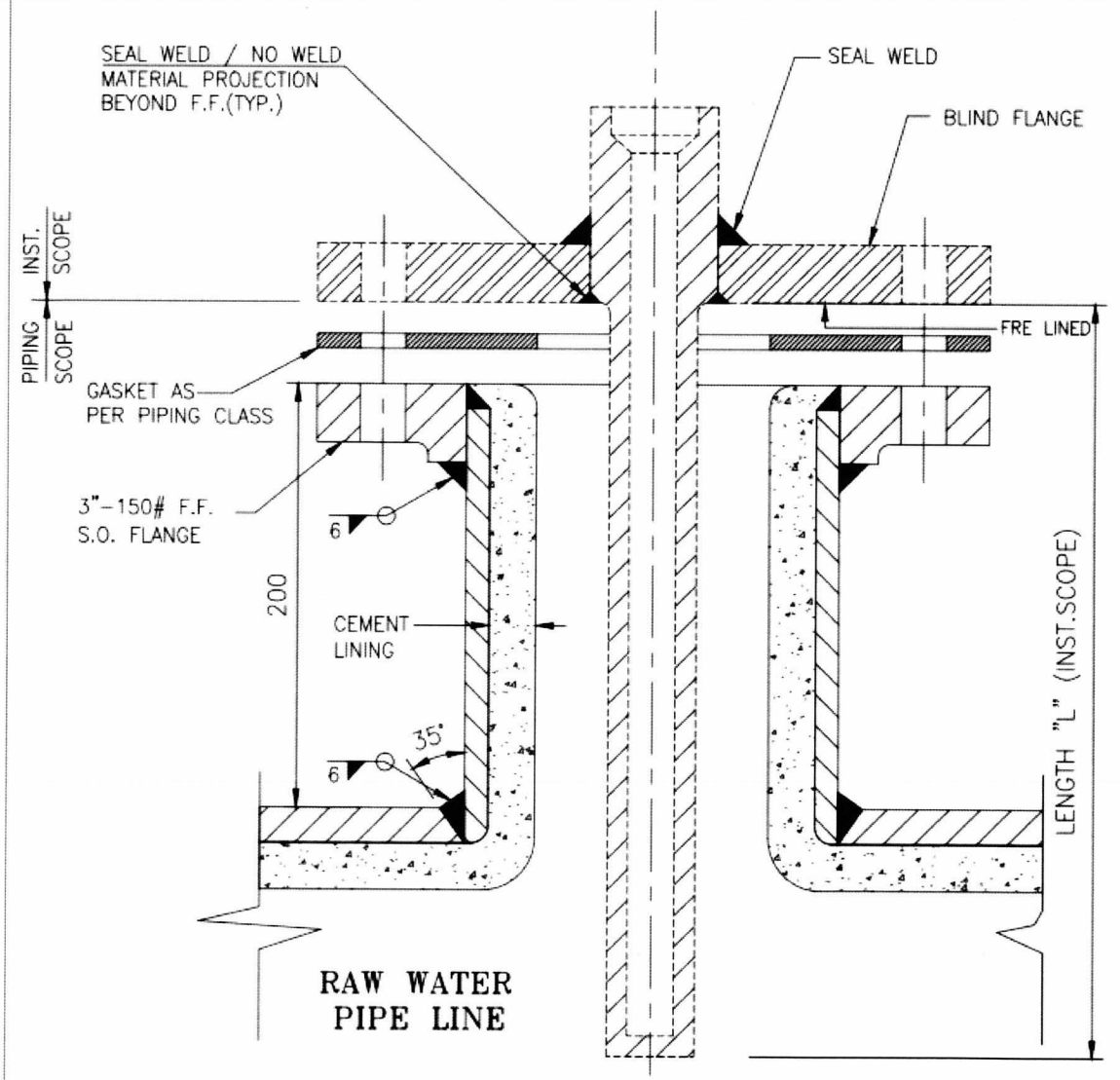
CEMENT LINED PIPE BRANCHES (FIGURE-03)

PIPE DIA.	FLANGED WELL "L" LENGTH
4"	250
6"	280
8"	280
10"	300
12"	300
14"	300
16"	350
18"	350
20" & ABOVE	400
VESSEL	AS REQD.

NOTES:-

1. ALL DIMENSIONS ARE IN mm, UNLESS OTHERWISE NOTED.

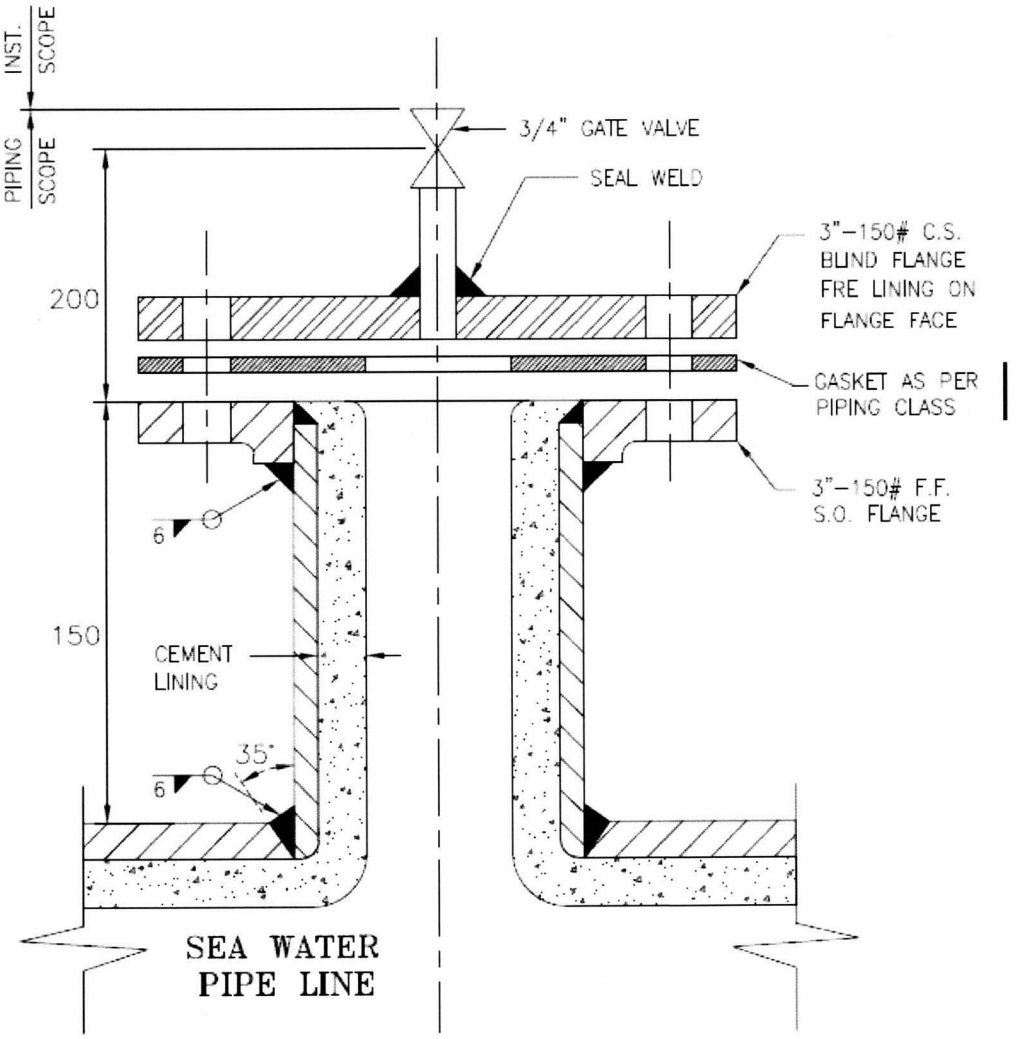
DETAIL OF INST. SCOPE ARE INDICATIVE ONLY AND SHALL BE AS PER INST. STD.



CEMENT LINED: BRANCH FOR THERMOWELLS (FIGURE-04)

NOTES:–

1. ALL DIMENSIONS ARE IN mm, UNLESS OTHERWISE NOTED.

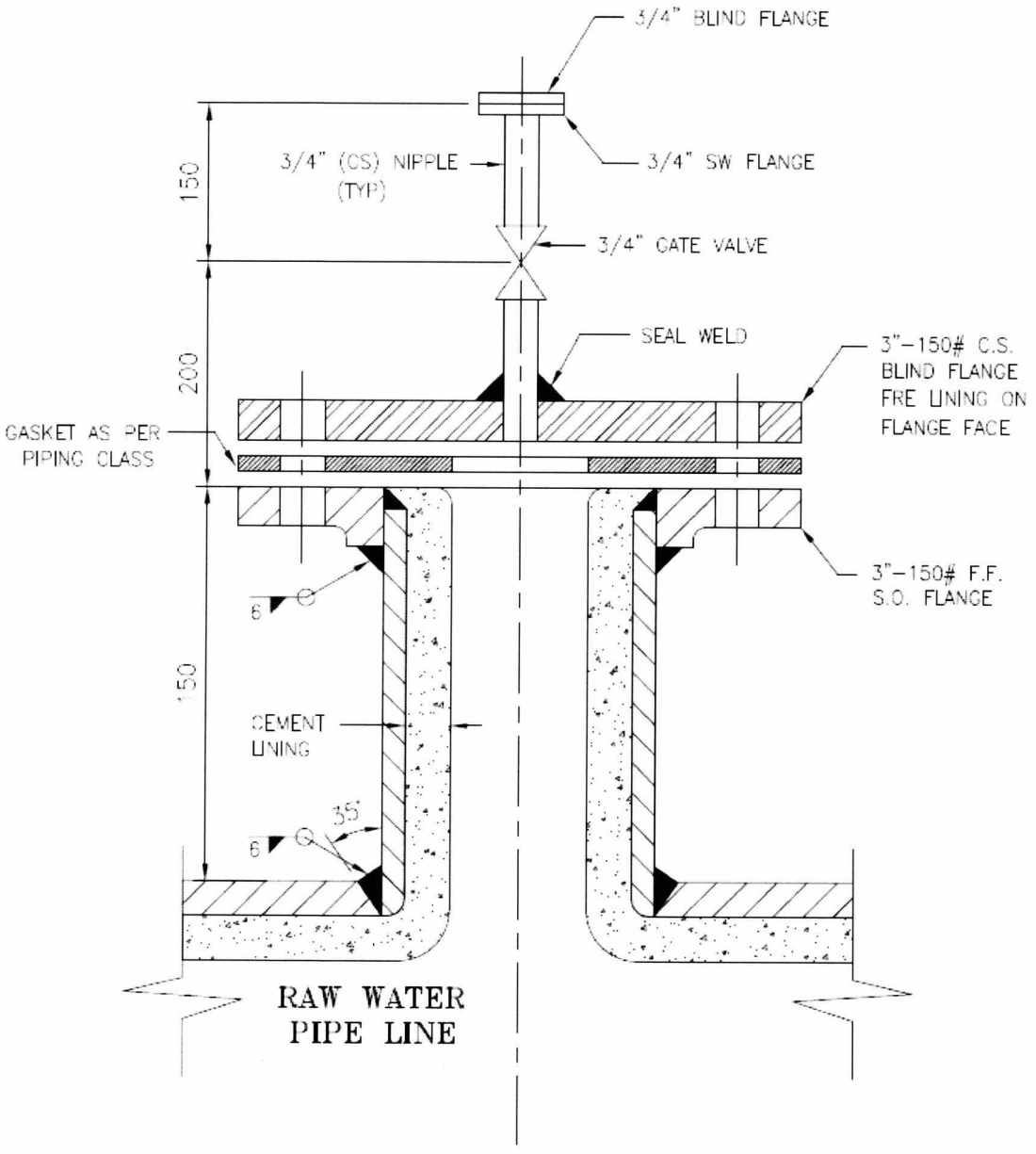


STD. FOR BRANCHES <3" AND PRESSURE INSTRUMENTS FOR PIPING CLASSES AS PER PMS

CEMENT LINED: BRANCH FOR PRESSURE CONNECTION (FIGURE-05)

NOTES:–

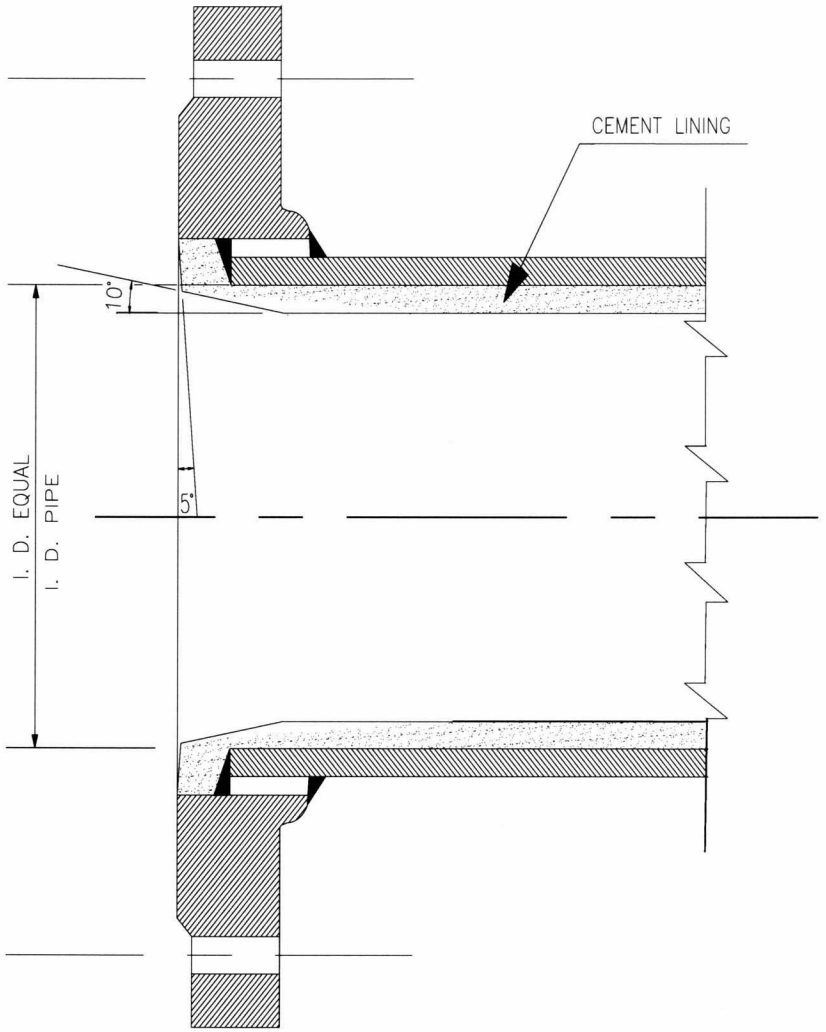
1. ALL DIMENSIONS ARE IN mm, UNLESS OTHERWISE NOTED.



STD. FOR BRANCHES < 3" AND VENT / DRAIN (3/4")

MATERIAL AS PER PMS

CEMENT LINED VENT AND DRAIN DETAILS (FIGURE-06)



TYPICAL DETAILS OF FLANGED
PIPE- TO-VALVE (BUTTERFLY) CONNECTION

CEMENT LINED DETAILS FLANGED ENDS (FIGURE-07)

अग्निरोधक लाइटिंग और पावर पैनलों के लिए विनिर्देश

SPECIFICATION FOR FLAMEPROOF LIGHTING AND POWER PANELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	22.03.21	REVISED AND ISSUED AS STANDARD SPECIFICATION	RKS	ANPS	PG	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	24.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
DGMS	Directorate General of Mines Safety
EIL	Engineers India Limited
ELCB	Earth Leakage Circuit Breaker
FRLS	Flame Retardant Low Smoke
GI	Galvanized Iron
IEC	International Electro-technical Commission
IP	Ingress Protection
IS	Indian Standards
LV	Low Voltage
MCB	Miniature Circuit Breaker
MR	Material Requisition
NABL	National Accreditation Board for Testing and Calibration Laboratories
PESO	Petroleum and Explosives Safety Organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
SPN	Single Phase and Neutral
SS	Stainless Steel
TPN	Three Phases and Neutral
XLPE	Cross Linked Poly Ethylene

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1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof Lighting and Power panels/ accessories suitable for installation in locations handling flammable liquids and gases / vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels
IS-12640	:	Residual current operated circuit breakers
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General requirements)
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d")
IS / IEC 60529	:	Degree of protection provided by enclosures (IP Code)
IS / IEC 60898	:	Electrical Accessories - circuit breakers for over protection for household and similar installations
IS / IEC 60947	:	LV switchgear and control gear.

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. The lighting and power panels shall be designed to operate under site conditions as specified in the data sheet. If not specifically mentioned therein, a design ambient temperature of 40° C and an altitude not exceeding 1000m above mean sea level shall be considered.

5.0 POWER SUPPLY

5.1 Lighting and power panels shall be suitable for 415V, 50Hz, TPN incoming power supply and outgoing circuits for 240V, SPN power supply.

5.2 For projects falling under the jurisdiction of DGMS, the following additional requirements shall apply:

5.2.1 The phase-to-phase voltage shall not exceed 125V (where electric lighting is used in underground mine)/ 250V (where electric lighting is used in open cast mine or surface of a mine), with the neutral or the mid-point of the lighting system connected with earth.

5.2.2 The panels shall have three phase, 3-wire system, without neutral.

5.2.3 Outgoing circuits shall be controlled by 2-pole MCBs. Earth leakage protection shall be provided for all outgoing circuits, which shall isolate both poles.

6.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals, as applicable, for the specified location, and marking as per IS/IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The enclosures of the lighting and power panels shall be made of cast light metal alloy, unless otherwise specified. The enclosures of the lighting and power panels intended for use in units handling sulphuric acid/ other corrosive materials shall be made of stainless steel grade SS-316L, if specified in MR/ Tender.

7.1.2 The panels shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel/ stainless steel minimum SS-304 (as specified in MR/ Tender). The canopy shall be suitable for providing protection against rain from top, back and two sides.

7.1.3 The lighting and power panels shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the panels shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flame proof Exd (Gas group IIA/IIB): Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof Exd (Gas group IIC): Light yellow shade 355 of IS-5/ RAL 1012.

All unpainted steel parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving elements, then these shall be greased with non-solidifying grease. However, in case of stainless steel lighting and power panels, finish shall be Electropolish/ Buffed/ equivalent finish.

7.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

7.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

7.1.7 All the non-current carrying metallic parts of the panel shall be inherently bonded together. Each lighting and power panel shall be provided with two earthing studs (bolt, nut with spring and plain washer) with lugs on the exterior of the panel enclosure suitable for termination of 10 mm dia GI wire rope. No screw type fixing arrangement shall be allowed.

7.1.8 Each outgoing feeder shall be provided with distinct terminals for phase, neutral and earth. The terminal block enclosures shall be adequately sized to properly terminate the cables by taking into account the required bending radii of cable cores and shall have the following minimum gland to terminal distances:

Conductor Size	Up to 2.5 mm^2	Above 2.5 mm^2 & Up to 10 mm^2	Above 10 mm^2 & Up to 35 mm^2	Above 35 mm^2 & Up to 95 mm^2
Gland to terminal distance	40 mm	60 mm	100 mm	150 mm

7.1.9 The panels shall be provided with suitably sized cable entries at the bottom/ sides, for incoming and outgoing cables. Panels shall be complete with double compression type nickel plated brass flameproof cable glands. Flameproof nickel plated brass sealing plugs shall be supplied, for plugging the unused cable entries. The quantity of sealing plugs shall be equal to 20% of the total number of outgoing cable entries.

7.1.10 The panels shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

7.1.11 A tag plate indicating Tag Number, engraved, 3 ply laminate fixed with screws, shall be provided on each lighting and power panel. Nameplates shall also be provided for each incoming and outgoing feeder. A separate nameplate shall be provided to indicate the name of manufacturer, testing agency, test certificate number, serial number, BIS license number, applicable gas group as per IS/IEC 60079, statutory agency (PESO) approval number and any additional marking required by statutory authority. The nameplates shall be Al anodized or SS-304 engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

7.2 Component Specification

7.2.1 Bus bars in the lighting and power panels shall be made of high conductivity copper, and shall be supported by non-hygroscopic insulators. Bus bars shall be colour coded for identification of phases and neutral.

7.2.2 The incomer shall have one no. 4 pole MCB isolator (without overload and short-circuit release) and one no. 4 pole ELCB (if specified in the MR/ Tender). ELCBs shall have a maximum sensitivity of 30mA.

7.2.3 The outgoing feeders shall be provided with double pole MCBs having overload and short-circuit releases. Further, separate 2 pole ELCBs with maximum sensitivity of 30mA shall be provided for outgoing feeders if specified in MR/ Tender.

7.2.4 All MCBs (except isolators) and ELCBs shall be with 10kA interrupting capacity.

7.2.5 The ELCB shall be hand reset type. Door mounted reset push button shall be provided for ELCB.

7.2.6 The operating knobs (ON/ OFF/ RESET) shall be provided with a suitable rack and pinion arrangement or cam type operating mechanism for operating them smoothly from outside.

7.3 Terminals & Wiring

7.3.1 The panels shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be

used. Tinned Copper lugs shall be provided for cable termination. Incoming and outgoing terminals shall be suitably segregated.

7.3.2 All internal wiring in lighting and power panels shall employ adequately sized, 660V/ 1100V grade, FRLS type, XLPE/ PVC insulated, Copper conductor wires, colour coded for phase, neutral and earth, with minimum conductor sizes as below:

Incomer : 16 mm²

Outgoing : 2.5 mm²

All terminations shall be with suitable lugs.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be submitted to the inspection agency, as per inspection and Test Plan no. 6-81-1008.

8.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test plan no. 6-81-1008.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

पैकेज उपस्कर के निम्न वोल्टेज वाले फ़िक्स किस्म के स्विच बोर्ड के लिए विनिर्देश

SPECIFICATION
FOR
LV SWITCHBOARD FIXED TYPE
FOR PACKAGE EQUIPMENT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	20.03.2025	REVISED AND REISSUED AS STANDARD SPECIFICATION	CA	SA	HK	MN
5	10.02.2021	REVISED AND REISSUED AS STANDARD SPECIFICATION	CA/RKS	SA	PG	SM
4	01.04.2016	REVISED AND REISSUED AS STANDARD SPECIFICATION	CA/RKS	SA	BRB	RN
3	03.02.2011	REVISED AND REISSUED AS STANDARD SPECIFICATION	DA	SG	UAP	DM
2	07.03.2005	REVISED AND REISSUED AS STANDARD SPECIFICATION	SSM	RR	AAN	SKG
1	19.11.2001	REVISED AND ISSUED AS STANDARD SPECIFICATION	SSM	AAN	VPS	GRR

Abbreviations:

A	Ampere
AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CPRI	Central Power Research Institute
CRCA	Cold Rolled Cold Annealed
CT	Current Transformer
CBCT	Core Balance Current Transformer
DC	Direct Current
DMPR	Digital Motor Protection Relay
DOL	Direct On Line
EIL	Engineers India Limited
ELR	Earth Leakage Relay
EPDM	Ethylene Propylene Diene Monomer
FRLS	Flame Retardant Low Smoke
HDPE	High-Density Polyethylene
HRC	High Rupture Capacity
Ics	Rated service short circuit current
Icu	Rated ultimate short circuit current
IEC	International Electrotechnical Commission
IP	Ingress Protection
IS	Indian Standard
kA	kilo Ampere
kW	kilo Watt
kWH	kilo Watt Hour
LED	Light Emitting Diode
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MFM	Multi-Function Meter
LV	Low Voltage
NO	Normally Open
NC	Normally Closed
PVC	Poly Vinyl Chloride
V	Volt
XLPE	Cross-linked polyethylene

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1.0 SCOPE

This specification covers the requirement of design, fabrication, testing, packing and supply of Low voltage fixed type switchboard in single front execution required for receipt, control and distribution of power to various low voltage consumers of the package equipment such as Air conditioning plant, Pressurisation plant, etc.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS unless otherwise specified.

IS : 1248	:	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories
IS : 2824	:	Method for determining the proof and the comparative tracking indices of solid insulating materials.
IS : 5082	:	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes.
IS : 5578	:	Guide for marking of insulated conductor.
IS : 11353	:	Guide for uniform system marking and identification of conductors and apparatus terminals.
IS : 13703	:	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC.
IS : 16227/ IEC: 61869	:	Instrument transformers
IS/IEC: 60255	:	Measuring Relays and Protection Equipment.
IS/IEC: 60269	:	Low-Voltage Fuses
IS/IEC: 60529	:	Degree of protection provided by enclosures (IP Code).
IS/IEC: 60947	:	Low Voltage Switchgear and control gear.
IS/IEC: 61439	:	Low voltage switchgear and control gear assemblies.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner/EIL in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one-year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The switchboards shall be suitable for installation and satisfactory operation in a pressurised room or in room with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The switchboards shall be designed to operate under specified site conditions. If not specifically mentioned, a design ambient temperature of 40° C and altitude not exceeding 1000 metres above mean sea level shall be considered.

4.3 All the equipments described in this specification are intended for continuous duty with the specified ratings under the specified ambient conditions unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 The switchboard shall be free standing, suitable for directly flush mounting with the wall, with complete front access for operation and maintenance. The switchboard shall be fixed type, in single front execution, assembled in single line up, metal enclosed, fully compartmentalised, totally segregated compartments for feeders, cables and bus bar, dust and vermin proof suitable for indoor installation with form of internal separation minimum "Form-3b" as per IS/IEC-61439, unless otherwise specified elsewhere. The switchboard shall be completely type tested for the following tests (Short circuit, Temperature rise, Degree of Protection, Impulse withstand etc), as per IS/IEC standards. The switchboard shall also be completely Design Verified as per IS/IEC 61439-1 and Design Verification Report shall be submitted for the same.

5.2 The switchboard enclosure shall be dust and vermin proof and shall provide a degree of protection not less than IP-41.

5.3 The switchgear shall be assembled out of vertical panels of uniform height not exceeding 2450 mm in a single line up. The maximum height of the operating handle/switches shall not exceed 1900 mm and the minimum height not below 300 mm.

5.4 The switchboard shall be designed to ensure maximum safety during operation, inspection, and connection of cables, relocation of outgoing circuits and maintenance with the bus bar system energised and without taking any special precautions. The switchgear shall permit maximum interchangeability. All identical equipments and corresponding parts shall be fully interchangeable.

5.5 It shall be possible to extend the switchboard, in either direction at a later date. End of bus bars shall be suitably drilled for this purpose. Panels at extreme end shall have openings, which shall be covered with plates screwed to the panel.

5.6 Adequate means shall be provided to prevent shorting of power and / or control terminals due to accidental dropping of maintenance tools etc. inside the switchboard. Checking and removal of components shall be possible without disturbing adjacent equipment/modules/feeders.

5.7 The frame, of individual vertical panels shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2mm (14SWG) CRCA except the doors and covers that may be made of 1.6mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

As an alternative to CRCA, Aluzinc/pre-galvanised sheet steel can also be provided for internal inter-panel partitions only as per vendor's standard manufacturing practices. However, all external surfaces shall be of CRCA with specified paint shade.

5.8 The switchboard shall be provided with integral base frame for each vertical panel. The switchboard integral base frame shall be suitable for tack welding.

5.9 All hardware shall be corrosion resistant. All joints and connections of the panel members shall be made of galvanised or zinc passivated cadmium plated high quality steel bolts, nuts and washers, secured against loosening.

5.10 All openings, covers and doors shall be provided with gaskets of Neoprene/HDPE/EPDM or equivalent around the perimeter to make the switchboard dust and vermin proof.

5.11 Suitable removable type eyebolts/ lifting hooks shall be provided for lifting of the panel/shipping section. These eyebolts/ lifting hooks, when removed shall not leave any opening in the panels.

5.12 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.13 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

5.14 The switchboard shall be suitable for top or bottom cable entry as mentioned in datasheet, and shall be provided with removable gland plates. The gland plate thickness shall be minimum 3mm. Non-magnetic cable gland plates shall be provided for termination of single core cables. The switchboard shall have a separate cable alley for each vertical panel with cable tying arrangement. The cable alley width shall be sufficient to accommodate the required number of cables. However, in any case it shall not be less than 200mm width. The cable alley shall be provided with a suitable hinged door. Required number of single compression nickel plated brass cable glands and tinned copper compression type lugs (for bolted terminals) for all power and control cables shall be included in the vendor's scope of supply.

5.15 The switch board shall comprise of incoming load break switch panel or air circuit breaker panel, outgoing switch fuse, switch fuse contactor feeders, MCCB feeders, motor starter feeders, control supply transformers, both power and auxiliary/control bus bars, cable termination compartment etc. All these shall be housed in independent compartments separated from each other by metallic barrier.

5.16 Main horizontal bus bars shall be provided at the bottom in separate compartment for switchboards with top cable entry and at the top for switchboards with bottom cable entry. Vertical bus bars required for connection between main bus bars and outgoing feeders shall be in separate vertical chamber. One set of vertical bus bars can be provided for feeding outgoing feeders in two panels on either side of the vertical bus bar.

5.17 All components including bus bars and cable termination shall be accessible only from the front side for repair and maintenance.

5.18 Each outgoing feeder shall be in multitier arrangement having minimum height of individual module as defined in switchboard data sheet. All feeders shall be of modular design with height in multiples of standard unit size.

5.19 All auxiliary devices for control, reset, indication, measurement and protection except the bimetallic relays shall be mounted on the front side of the respective compartment. Components requiring frequent inspection during operation shall be easily accessible. The design shall be such that all power ON/OFF or START / STOP and relay reset operations shall be performed without opening the panel door.

5.20 Each vertical panel shall be provided with space heater to prevent moisture condensation rated for 240V AC supply, provided with a switch, fuse or double pole MCB and thermostat having variable setting range of 30-70 °C. The panels shall be provided with suitable illuminating LED lamp with switch and fuse or MCB. Further, one number 240V AC, 6/ 16A, 5 Pin socket for owner's use shall be provided inside panels.

5.21 Main bus bars shall be of high conductivity electrolytic aluminium/ copper having uniform current rating throughout their length. Horizontal and vertical bus bars shall be sized depending upon the maximum expected current and to limit the specified maximum operating temperature at specified design ambient temperature.

5.22 The hot spot temperature of busbars, conductors including joints at design ambient temperature shall not exceed 130°C for Copper busbar and 120°C for Aluminium busbar. Temperature rise at all other locations shall be maintained in line with IS/IEC 61439.

5.23 Minimum clearance & creepage distances between live parts, between live parts/neutral to earth shall be as per IS/IEC 61439 for the selected material group and specified pollution degree.

5.24 Adequately sized auxiliary copper bus bars running horizontally in a separate enclosure / compartment shall be provided for space heaters, control supply and metering requirements. Necessary tee-off connections shall be used for distributing auxiliary supply to each vertical panel.

5.25 All horizontal and vertical bus bars shall be insulated with heat shrink PVC sleeves of 1100 V grade and removable shrouds shall be provided for joints. All bus bars shall be prominently marked with red, yellow and blue colour rings for easy phase identification at regular interval and at every power tap off point and designed to withstand specified short circuit currents for one second. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute.

5.26 Copper earth bus of minimum 30x6 mm^2 size for fault level upto 31.5 kA and minimum 50x6 mm^2 size for fault level upto and including 65 kA shall be provided throughout the length of the switchboard with provision for interconnection to earthing grid at two ends. All non-current carrying metallic parts of the mounted equipment shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.

5.27 Inside the switchboards, the wiring for power, control, signalling, protection and instrument circuits shall be done with FRLS, PVC/XLPE insulated copper conductors & BIS approved having 660/1100 V grade insulation.

5.28 For modules rated above 100 A, preferably copper strip connections shall be used. The controls connections shall be done with 660V grade PVC/XLPE insulated FRLS wires having stranded copper conductors. Minimum size of control wire shall be 1.5 mm^2 copper for circuits having fuse rating 10 A or less. For higher fuse rating control circuits, minimum 2.5 mm^2 copper conductor shall be used. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Transparent shrouds shall be used on outgoing power terminals.

5.29 Clamp type terminals shall be acceptable for wires upto 10 mm^2 size, for conductors larger than 10 mm^2, bolt type terminals with crimping lugs shall be provided. Each wire shall be terminated at a separate terminal. A minimum of 10% spare terminal shall be provided on each terminal block. Shorting links shall be provided for all CT terminals.

5.30 Components of similar modules of same sizes shall be identically located and wired. Control supply change over switch shall be provided in case the switchboard is with two bus-sections.

5.31 In open doors condition of compartment, all live parts or terminals of all door-mounted, internal components and bus contact openings shall be IP-2X protected.

5.32 Unless otherwise specified elsewhere, the switchboard assembly and components shall be suitable for use in pollution degree 3 environment as per IS/IEC.

6.0 EQUIPMENT / COMPONENTS SPECIFICATION

6.1 All circuit breaker shall be air break type. All switches shall be load break, heavy duty/motor duty, air break type with the operating handle mounted on the compartment door, complete with necessary interlock and defeat mechanism. All switches drives other than rotary switches shall be lockable in OFF position. Rating of switches for starter module shall meet the requirements of AC-23 duty as per IS/ IEC 60947 and minimum rating shall be as specified in job specification/data sheets.

6.2 The incomers & buscoupler shall be provided with 4 pole load break switch/breaker.

6.3 All contactor-controlled starter feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947. However, contactor-controlled motor feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947 considering energy efficient motors of IE-3/IE-4 type (as per job specification), unless otherwise specified elsewhere.

6.4 All fuses shall be non-deteriorating HRC cartridge link type, BIS approved. Power fuses shall be pressure fitted type and shall preferably have ribs on the contact blades to ensure good line contact. It shall be possible to handle fuses during off load conditions with full voltage available on the terminals. Wherever required fuse pullers shall be provided. The fuse base shall be so located in the modules to permit insertion of fuse pullers and removal of fuse links without any problem.

6.5 The contactors shall be air break type, equipped with three main contacts and provided with 1NO+1NC potential free spare auxiliary contacts wired to the terminal block for owner's use. The main contacts of contactor for motor starter module shall have AC-3 or AC-4 rating as per package requirements. Unless specified otherwise, the coil of the contactor shall be suitable for operation on 240 V, 1 Phase, AC supply.

6.6 Bimetal relays shall be provided for protecting the motor from thermal overload. Bimetal thermal overload relays shall be manually reset type with the reset push button provided on the cubical door. Bimetal relays shall be three elements, positive acting ambient temperature compensated type with adjustable setting range and built-in single phasing prevention feature, which operates even with 50% rated current at the time of single phasing.

6.7 MCCBs shall be provided with spring assisted quick make/ break manually operated trip free mechanism. `ON' and `OFF' position of the operating handle of MCCB shall be displayed and the operating handle shall be mounted on the door of the compartment. MCCB's as part of motor starter module shall be current limiting type and type tested for type-2 co-ordination as per IS/ IEC-60947 considering energy efficient motors of IE-3/ IE-4 type (as per job specification) unless otherwise specified elsewhere. MCCB shall be suitable for Ics=Icu=100%.

6.8 For MCCB feeders other than those provided with DMPR or any other numerical relay, MCCBs shall be provided with a tripping device with inverse time characteristic for over load protection and instantaneous characteristics for short circuit protection and earth fault protection.

6.9 Current transformers for metering shall have an accuracy class 1.0 and instrument security factor not greater than 5. Protective current transformers shall have an accuracy class 5P and an accuracy limit factor greater than 20.

6.10 All measuring AC instruments shall be moving iron, flush mounting type and of 72 x 72 mm square pattern instruments for incomer and outgoing feeders. The accuracy class for all instruments shall be 1.0 as per IS-1248. Ammeters for motor feeders shall have a non-linear compressed scale at the end to indicate motor starting current and red mark for the full load current. The KW/KWH meters shall be suitable to measure unbalanced loads on 3 phases 4-wire system. Test terminal block shall be provided for KWH meters.

6.11 Multifunction meters/ Digital meters shall be provided, if specified in job specifications/datasheets. All MFM/ digital meters shall be highly reliable, accurate and compact. MFM/ Digital meter data shall be saved in case of power failure. Communicable type MFM/ Digital meter shall be provided if specified in datasheet/ job specification.

6.12 Digital motor protection relay shall be provided, if specified in job specifications/datasheets. All DMPR relay shall have Multi-Protection features like Motor protection (Overload, Overcurrent, Earth leakage Protection, Ground fault, Stalled Rotor, Loss of load, Phase unbalance, Negative phase sequence, Reverse connection), overcurrent, undercurrent & under voltage protection.

6.13 DMPR shall also have display and following features shall be provided in display like type of fault, three phase current, power, voltage, power factor and motor load (%) etc.

6.14 CT ratio shall be settable in Digital MPR and communicable type DMPR shall be provided if specified in datasheet/ job specification.

6.15 CBCT with Earth Leakage Relay shall be provided if specified in job specifications/datasheets. ELR shall be manually hand reset type. In case hand reset feature is not available in the offered relay model, vendor to provide external hardware logic for manual hand resetting of the earth leakage relay.

6.16 All Control/selector switches shall be rotary back-connected types having a cam operated contact mechanism with knob type handle. Ammeter selector switch shall have make before break feature on its contacts. The selector switch shall generally have 4 positions, three for reading 3 phase currents and the fourth position for off. The voltmeter selector switch shall also have 4 positions. Three positions shall be used to measure phase-to-phase voltage and fourth shall be OFF position.

6.17 Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts.

6.18 MCB shall have minimum breaking capacity of 9kA unless otherwise specified. Positive ON/OFF indication shall be provided.

6.19 Indicating lamps shall be cluster LED type of minimum 8mm-diameter size. The following indicating colours shall be used.

Closed/on	:	Red
Open/off	:	Green
Fault trip	:	Amber
Control supply on	:	White

6.20 Push button colours shall be as follows:

Stop/open/emergency stop	:	Red
Start/close	:	Green
Reset/test	:	Yellow/Black/White

The 'Stop' push button shall be stayput type.

All motor starter feeders shall have Stop and Reset push buttons and On and Trip indication lamps.

6.21 A centrally located engraved nameplate shall be provided for the switchboard. Each module shall have engraved nameplate bearing data as per approved drawings. Nameplate or polyester adhesive stickers shall be provided for each equipment mounted on & inside the switchboard. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram. Special warning labels shall be provided on removable covers or doors giving access to cable terminals and bus bars.

Engraved nameplates shall preferably be of 3- ply (Black-White- Black) lamicoid sheets or anodised aluminium. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

7.2 For testing requirements refer Inspection & Test Plan No. 6-81-1012. Prior notice of minimum 4 weeks shall be given to EIL/owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

7.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1012.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special precaution notations such as Fragile, This side up, centre of gravity, weight, Owner's particulars, Purchase order number etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

औद्योगिक किस्म के नियंत्रण स्टेशन के लिए विनिर्देश

SPECIFICATION FOR INDUSTRIAL TYPE CONTROL STATIONS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	18.01.21	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	RSR	PG	SM
5	11.03.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	SV	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	JM	ANPS	UAP	DM
3	24.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian standards
CEA	Central Electricity Authority
CT	Current Transformer
DC	Direct Current
EIL	Engineers India Limited
FRLS	Flame Retardant Low Smoke
GI	Galvanised Iron
IEC	International Electrotechnical Commission
IP	Ingress Protection
IS	Indian Standards
LED	Light Emitting Diode
LV	Low Voltage
NC	Normally Closed
NO	Normally Open
PB	Push Button
PO	Purchase Order
PVC	Poly Vinyl Chloride
SMD	Surface Mount Device
SS	Stainless Steel
SWG	Standard Wire Gauge
VFD	Variable Frequency Drive
XLPE	Cross Linked Poly Ethylene

Electrical Standards Committee

Convenor: Mr. Parag Gupta

Members:
Mr. M.K. Sahu
Ms. Arvind NP Singh
Mr. Harish Kumar
Ms. Shalini Verma
Mr. Raman Sood
Mr. V.K. Jain
Ms. Shirali Aggarwal
Mr. Ayush Mathur (Projects)
Mr. Rajesh Sinha (Inspection)

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1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of industrial type control stations and accessories suitable for installation in non-hazardous/ safe outdoor areas.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS:

IS: 5	:	Colours for ready mixed paints and enamels.
IS: 1248	:	Direct acting indicating analogue measuring instruments and their accessories.
IS / IEC: 60529	:	Degrees of protection provided by enclosures (IP code).
IS / IEC: 60947	:	LV switchgear and control gear.

2.2 In case of imported equipment, IEC standards or equivalent standards shall be applicable, if these standards are equivalent or more stringent than the applicable Indian Standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 TECHNICAL REQUIREMENTS

5.1 Construction

5.1.1 The enclosures of the control stations shall be made of either sheet steel or cast light metal alloy, unless otherwise specified.

5.1.2 The control stations shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. Suitable canopy shall be provided for protection against rain from top, back and two sides. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel/ stainless steel minimum SS-304 (as specified in purchase specifications).

5.1.3 All control stations shall be suitable for 240V AC as well as for 110V/220V DC control supply.

5.1.4 The control stations shall be provided with gaskets made of non-inflammable and self-extinguishing material.

5.1.5 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as dark admiralty grey, shade 632 of IS-5/ RAL 7031. All unpainted parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving, then these shall be greased with grease which does not solidify.

5.1.6 All accessories like nuts, bolts, washers etc. and operating shaft of push buttons, switches etc. shall be made of stainless steel SS-304. Alternatively, nickel-plated brass material may be used for the operating shafts of push buttons, switches etc.

5.1.7 The control stations shall be provided with two earthing studs (minimum M10 bolt, nut with spring and plain washer) with lugs on the external surface of the enclosures suitable for termination of 8 SWG GI wire. No screw type fixing arrangement shall be allowed.

5.1.8 The control stations shall be provided with undrilled gland plate. However, double compression nickel-plated brass cable glands shall be supplied loose to suit the specified cable sizes. The cable termination chamber of the control station shall be large enough to provide a minimum space of 100 mm between top of the cable gland and bottom of the terminal block.

5.1.9 The control stations shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

5.1.10 A tag plate indicating Tag Number shall be provided on each control station. The tag plate shall be engraved, 3 ply laminate fixed with screws.

5.2 Component Specification

5.2.1 Push buttons for START/ OPEN and STOP/ CLOSE shall be of GREEN and RED colour respectively. Each push button shall have two NO and two NC contacts. The STOP push button shall be mushroom type with stay put feature and lockable in pressed position. Refer Sketch 1 for wiring and other details for various types of control stations

5.2.2 All selector switches shall have minimum two poles for each position. Each position of switch shall be indelibly marked on the control station. The configuration of selector switch shall be LOCAL-OFF-REMOTE.

5.2.3 All ammeters shall be of moving iron type having an accuracy class of 1.5 and suitable for 1 Ampere CT secondary. Minimum size of ammeter shall be either 72 mm x 72 mm or 65 mm diameter. 80% of the scale length shall cover 100% of the CT primary current uniformly and the balance 20% of the scale shall cover 100-800% of the CT primary. A red mark corresponding to the full load current of the motor shall be provided on the ammeter dial. The ammeter front glass shall be toughened.

5.2.4 Indicating lamp(s), wherever provided, shall be clustered LED type or SMD chip type LED with colour lens of minimum 25 mm diameter.

5.3 Terminals & Wiring

5.3.1 The control stations shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Each terminal for external cable connection shall be suitable for termination of 2.5 mm^2 (unless otherwise specified) stranded copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

5.3.2 All internal wiring shall employ 1.5 mm^2, 660V/ 1100V grade, FRLS type, XLPE/ PVC insulated copper conductor wires. All termination shall be with suitable lugs.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

6.2 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1014.

6.3 All equipment shall be subjected to various routine / acceptance tests as per Inspection and Test Plan no. 6-81-1014.

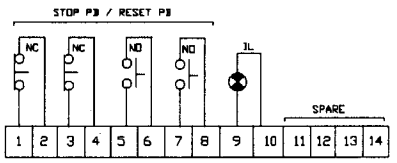
7.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

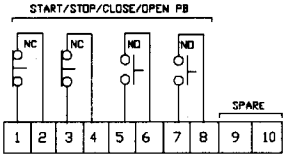
The equipment may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

SKETCH–1

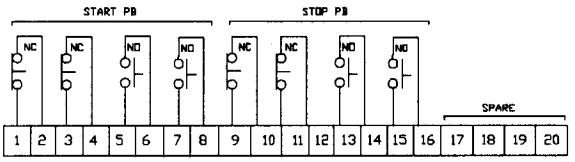
WIRING DETAILS OF CONTROL STATIONS



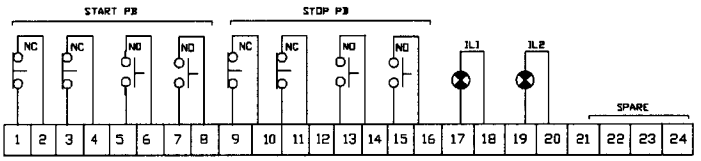
TYPE–A1 (STOP P.B. WITH LAMP)
OR
(RESET P.B. WITH LAMP)
(CABLE SIZE : 4Px2.5 Sq.mm)



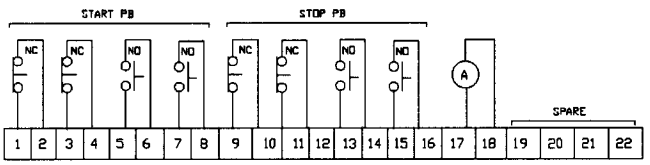
TYPE–A2
(START PB) OR (STOP PB) OR (CLOSE PB) OR (OPEN PB)
(CABLE SIZE : 2Px2.5 Sq.mm)



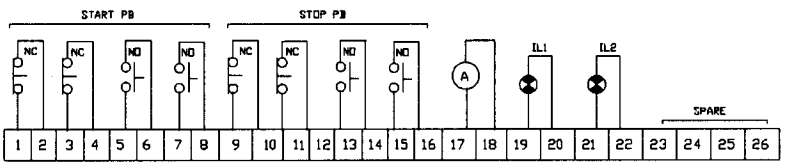
TYPE–B1 (WITH START & STOP PBs) OR (WITH CLOSE & OPEN PBs)
(CABLE SIZE : 4Px2.5 Sq.mm)



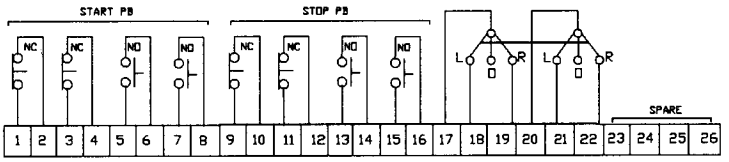
TYPE–B2 (WITH START & STOP PBs & INDICATION LAMPS)
OR
(WITH CLOSE & OPEN PBs & INDICATION LAMPS)
(CABLE SIZE : 6Px2.5 Sq.mm)



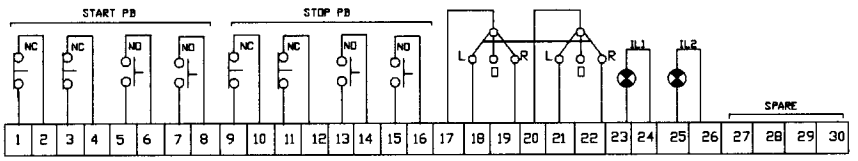
TYPE–C1 (WITH START & STOP PBs & AMMETER)
(CABLE SIZE : 4Px2.5 Sq.mm)



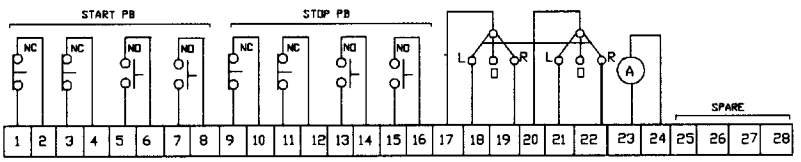
TYPE–C2 (WITH START & STOP PBs, AMMETER & INDICATION LAMPS)
(CABLE SIZE : 6Px2.5 Sq.mm)



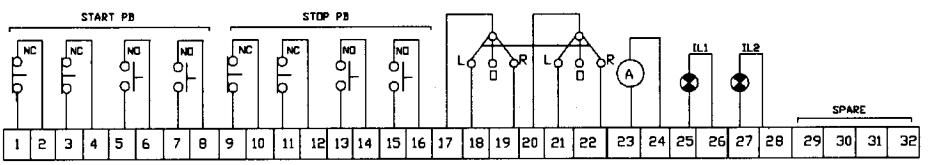
TYPE–D1 (WITH START & STOP PBs & L–O–R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm)



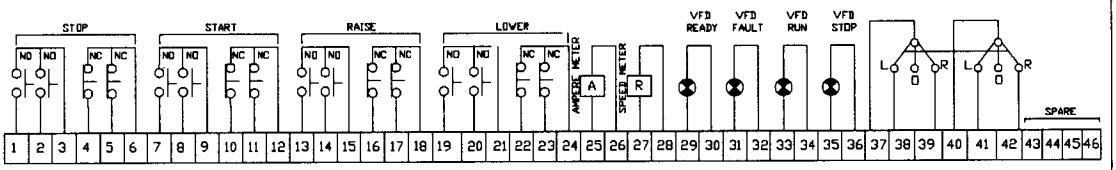
TYPE–D2 (WITH START & STOP PBs, L–O–R SELECTOR SWITCH & INDICATION LAMPS)
(CABLE SIZE : 12Px2.5 Sq.mm)



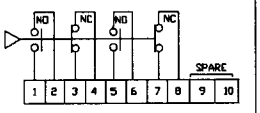
TYPE–E1 (WITH START & STOP PBs, AMMETER & L–O–R SELECTOR SWITCH)
(CABLE SIZE : 6Px2.5 Sq.mm)



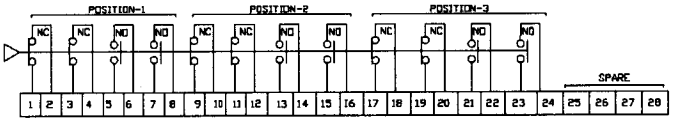
TYPE–E2 (WITH START & STOP PBs, AMMETER, L–O–R SELECTOR SWITCH & INDICATION LAMPS)
(CABLE SIZE : 12Px2.5 Sq.mm)



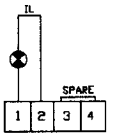
TYPE–F (WITH START & STOP PBs, RAISE & LOWER PBs, L–O–R SWITCH, AMPERE METER, SPEED METER & INDICATING LAMPS) (REFER NOTE–5,6,7)
(CABLE SIZE : 12Px2.5 Sq.mm)



TYPE–I1
SEL SWITCH (2POSITION)



TYPE–I2 SEL SWITCH (3POSITION)



TYPE–I3
(LAMP STATION)

GENERAL NOTES:

1. SHORTING LINKS SHALL BE PROVIDED BY VENDOR. REQUIREMENT SHALL BE INFORMED DURING VENDOR DRAWING REVIEW.
2. WIRING DETAILS SHALL BE READ IN CONJUNCTION WITH MR/TENDER.
3. CABLE SIZES AS INDICATED ABOVE ARE TENTATIVE AND MINIMUM. EXACT CABLE SIZES SHALL BE INFORMED DURING VENDOR DRAWING REVIEW. VENDOR TO PROVIDE REQUIRED SIZE OF CABLE TERMINATION CHAMBER WITH SUITABLE TERMINALS, CABLE ENTRIES, CABLE GLANDS AND LUGS. CONDUCTOR SIZE SHALL BE 2.5 SQ.MM, UNLESS OTHERWISE SPECIFIED.
4. AMMETER WHEREVER PROVIDED, SHALL BE ANALOGUE TYPE UNLESS OTHERWISE SPECIFIED. 4–20 MA TYPE SHALL BE PROVIDED IF DEFINED IN MR/TENDER.
5. FOR VFD CONTROL STATIONS, LAMP SUPPLY VOLTAGE SHALL BE SAME AS VFD CONTROL SUPPLY VOLTAGE.
6. FOR VFD CONTROL STATIONS, IF EXTERNAL SUPPLY IS REQUIRED FOR METERS, THEN SAME SHALL BE AS VFD CONTROL SUPPLY VOLTAGE.
7. METERS IN VFD CONTROL STATIONS SHALL BE SUITABLE FOR 4–20mA TRANSDUCER OUTPUTS AND SHALL BE CALIBRATED FOR THE ACTUAL MOTOR CURRENT. FOR VFD HAVING BYPASS FACILITY, METERS SHALL BE CAPABLE OF READING BYPASS MODE FULL LOAD AND STARTING CURRENTS AS WELL AS VFD MODE DRIVE CURRENT.
8. NUMBER AND COLOUR OF INDICATING LAMPS SHALL BE AS PER THE JOB SPECIFATION/TENDER.
9. CONTROL STATIONS TYPE "I" ARE TYPICALLY FOR INSTRUMENTATION USE.
10. ALL PUSH BUTTON AND CONTROL SWITCH CONTACTS SHALL BE RATED FOR MINIMUM 5A AT 240V(AC–15) AND 1A AT 220V/110V(DC–13) DUTY. CONTACT RATINGS FOR CONTROL STATIONS FOR INSTRUMENTATION USE SHALL BE AS PER INSTRUMENTATION REQUIREMENT.
11. THE EXACT DESCRIPTION OF PB'S WHETHER START/STOP OR OPEN/CLOSE SHALL BE INFORMED DURING VENDOR DRAWING REVIEW.
12. ALL L–O–R SELECTOR SWITCHES SHALL BE LOCKABLE IN OFF POSITION.

अग्निरोधक प्लगों, साकेटों तथा हैंडलैम्पों के लिए विनिर्देश

SPECIFICATION FOR FLAMEPROOF PLUGS, SOCKETS AND HAND LAMPS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	31.08.20	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AR	ANPS	SA	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	29.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

BIS	Bureau of Indian Standards
BS	British Standard
CEA	Central Electricity Authority
COB	Chip On Board
DGMS	Directorate General of Mines Safety
DOB	Driver On Board
ES	Edison Screw
FRLS	Flame Retardant Low Smoke
FRP	Fibre Reinforced Plastic
GI	Galvanised Iron
HRC	High Rupturing Capacity
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
IP	Ingress Protection
IS	Indian Standard
LED	Light Emitting Diode
LV	Low Voltage
NABL	National Accreditation Board for Testing and Calibration Laboratories
NEMA	National Electrical Manufacturers Association
PCB	Printed Circuit Board
PESO	Petroleum and Explosives Safety Organisation
PVC	Poly Vinyl Chloride
RCCB	Residual Current Circuit Breaker
SPN	Single Phase Neutral
SS	Stainless Steel
TPN	Three Phase Neutral
VDE	Verband der Elektrotechnik, Elektronik und Information stechnik

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1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof plugs, sockets, transformers, hand lamps and accessories suitable for installation in locations handling flammable liquids and gases/ vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels.
IS-10322	:	Luminaires
IS-13383	:	Photometry of luminaires - Method of measurement
IS-16101	:	General lighting – LEDs and LED modules – Terms and definitions.
IS-16102	:	Self-ballasted LED lamps for general lighting services.
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General Requirements).
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures “d”).
IS / IEC 60529	:	Degrees of protection provided by enclosures (IP Code).
IS / IEC 60947	:	LV switchgear and control gear.

National Lighting Code (NLC)-2010

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner’s/ EIL’s decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location and marking as per

IS/IEC 60079 or IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

6.0 TECHNICAL REQUIREMENTS

6.1 Construction

6.1.1 The enclosures of the plugs, sockets, transformers and hand lamps shall be made of cast light metal alloy.

6.1.2 The equipment shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. The sockets for fixed installation, i.e. 415 V three phase sockets and 240 V single phase sockets, shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanised sheet steel/ FRP/ stainless steel minimum SS-304 (as specified in purchase specifications). The canopy shall be suitable for providing protection against rain from top, back and two sides.

6.1.3 The enclosures shall be provided with gaskets for IP, if required by equipment certification. Gaskets, wherever provided, shall be made of non-inflammable and self-extinguishing material.

6.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flame proof (Gas group IIA/ IIB) : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof (Gas group IIC) : Light yellow shade 355 of IS-5/ RAL 1012

All unpainted steel parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving then these shall be greased. Grease, which does not solidify, shall be applied to flamepath.

6.1.5 Equipment shall be marked as per IS/IEC 60079.

6.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

6.1.7 All the non current carrying metallic parts of the equipment shall be inherently bonded together. The TPN sockets shall be provided with two earthing studs, with lugs on the exterior of the enclosure, suitable for termination of 10 mm dia. GI wire rope. Internal earth terminals shall be provided in each enclosure for all single phase plugs and sockets for connecting the earth core of the cables.

6.1.8 The terminal block enclosures shall be adequately sized to properly terminate the cables by taking into account the required bending radii of cable cores and shall have the following minimum gland to terminal distances:

Conductor Size	Up to 2.5 mm^2	Above 2.5 mm^2 & Up to 10 mm^2	Above 10 mm^2 & Up to 35 mm^2	Above 35 mm^2 & Up to 70 mm^2
Gland to terminal distance	35 mm	60 mm	100 mm	150 mm

6.1.9 The sockets shall be provided with 2 nos. suitably sized cable entries at the bottom for specified cable sizes and complete with 2 nos. flameproof double compression type nickel plated brass flameproof cable glands. The plugs shall be supplied with 1 no. suitably sized cable entry for specified cable size and complete with 1 no. double compression type nickel plated brass flameproof cable gland. Each socket shall be supplied with 1 no. flameproof nickel plated brass sealing plug, for plugging the unused cable entry.

6.1.10 The sockets shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

6.1.11 A tag plate indicating Tag Number shall be provided on each socket. A nameplate shall be provided to indicate the Name of Manufacturer, test certificate number, serial number, BIS license number, applicable gas group etc. as per IS/IEC 60079 and any additional marking required by statutory authority like approval no. etc. The nameplates shall be engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate. All tag plates shall be engraved, 3 ply laminate fixed with screws and name plate shall be Al anodized or SS-304 engraved or laser-marked and fixed with rivets.

6.2 Socket Outlets & Plugs

6.2.1 The sockets shall be provided with a switch and a mechanical interlock so as to break the electrical circuit before the plug is completely withdrawn and make the circuit after the plug is fully inserted.

6.2.2 In order to prevent accidental removal of plug from socket, the engagement and disengagement shall be by two separate and distinct movement and positions.

6.2.3 415V, 63A three phase flameproof plugs and socket meant for welding receptacle/ any other three phase auxiliary load, shall be provided with 4 pins (3P+E).

6.2.4 4 pin socket shall be provided with 63A, three pole heavy duty switch; whereas, 5 pin socket shall be provided with four pole (TPN) heavy duty switch. Heavy duty switch shall be suitable for AC duty rating as applicable.

6.2.5 Both 24V and 240V, 15A single phase flameproof plug and socket shall be provided with 3 pins (2P+E).

6.2.6 Provision shall be made so that it shall not be possible to insert 24V plug on to a 240V socket.

6.2.7 The sockets shall be provided with either a spring loaded hinged cover, or with a cap connected through metallic chain, to close the same when not in service.

6.2.8 Scraping earth connection shall be provided between the plug and socket. Earth pin of plug shall first engage with earth pin of switch socket.

6.2.9 The plug assembly shall be mechanically rugged, light and shall not unduly stress the socket or its own pins when fitted on to the socket. The diameter of the earth pin of the plug and socket shall be at least 1.1 times the diameter of the phase pins.

6.3 240V/ 24V Portable Transformer units

6.3.1 The 240V/ 24V portable transformer unit shall be supplied complete with 240V/ 24V transformer having a 24V socket on the secondary side and 5 meter length of 3x1.5 mm^2 copper conductor, PVC insulated, metal braided flexible cable, duly terminated in the transformer primary at one end and having 240V plug on the other end. The socket outlets and plugs shall meet the requirements of clause 6.2 above.

6.3.2 The 240V/ 24V transformer shall be designed for 30VA rating on continuous basis. Insulation Class shall be "B", as a minimum. Automatic protection employing earth leakage detection scheme with 30mA current sensitivity shall be provided to disconnect supply on occurrence of an earth fault. 30mA RCCB (preferable)/ HRC fuses shall be provided on primary and secondary side of the transformer. The transformer shall have an earthed screen between primary and secondary winding.

6.3.3 Suitable handle for carrying the transformer unit shall be provided.

6.3.4 Alternatively, 24V socket outlet (as per Cl. 2.5 above) shall be provided with a built-in 240V/24V 30VA transformer duly protected by HRC fuse in phase on primary side. In this case, a separate portable 240/24V transformer unit is not required.

6.4 24V Hand Lamp units

6.4.1 Each hand lamp unit shall be supplied complete with 15 meter length of 3x1.5 mm² copper conductor, PVC insulated, metal braided flexible cable, duly terminated in the hand lamp at one end and having 24V plug on the other end. The plug shall meet the requirements of clause 6.2 above.

6.4.2 The well glass provided shall be clear and toughened type. Hand lamp shall be provided with 10W, 24V AC LED lamp with ES27 cap having minimum output of 900 lumens. Alternatively, if specified in MR, it shall be with lens/ glass and 20W, 24V AC COB/ discrete LED with driver/ LED PCB with DOB having minimum output of 1800 lumens. The minimum output for 10W or 20W shall be guaranteed at 18V to 26V.

6.4.3 Hand lamp shall be provided with either galvanised steel or epoxy powder coated mild steel protective wire cage using minimum 3mm welded steel construction and having mesh dimension not exceeding 50mm x 50mm.

6.4.4 Suitable handle for carrying the hand lamp unit and a stand type guard suspension hook shall be provided.

6.5 Terminals & Wiring

6.5.1 All equipments shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. The terminals shall be suitable for termination of stranded conductors. Tinned copper lugs shall be provided for cable termination.

6.5.2 All internal wiring shall employ adequately sized, 660V grade, FRLS type, PVC insulated Copper conductor wires, colour coded for phase, neutral and earth, with minimum conductor sizes as below:

TPN Plugs and sockets:	16 mm²
SPN Plugs and sockets:	2.5 mm²

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works, under his care and expense.

7.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports applicable PESO/ DGMS approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

7.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1021.

7.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test Plan no. 6-81-1021.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity',

'Weight', 'Owner's particulars','PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

छत सौर फोटोवोल्टिक पावर प्रणाली के लिए विनिर्देश

SPECIFICATION FOR ROOFTOP SOLAR PHOTOVOLTAIC POWER SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	31.07.25	ISSUED AS STANDARD SPECIFICATION	SS/PK	RS	HK	MN
0	30.05.19	ISSUED AS STANDARD SPECIFICATION	DR/PB	PG	BRB	RKT

Abbreviations:

AC	Alternating Current	LAN	Local Area Network
ACDB	AC Distribution Board	LCD	Liquid Crystal Display
BIS	Bureau of Indian Standards	MCCB	Moulded Case Circuit Breaker
BS	British Standard	MC4	Multi-Contact with 4 mm dia. contacts pins
CEA	Central Electricity Authority	MNRE	Ministry of New & Renewable Energy
CPP	Captive power Plant	MOV	Metal Oxide Varistor
CRCA	Cold Rolled Cold Annealed	MPPT	Maximum Power Point Tracker
CT	Current Transformer	MS	Mild Steel
DC	Direct Current	NABL	National Accreditation Board for Testing and Calibration Laboratories
DG	Diesel Generator	NEMA	National Electrical Manufacturer's Association
EIL	Engineers India Limited	PCU	Power conditioning Unit
EMC	Electro Magnetic Compatibility	PIV	Peak Inverse Voltage
EMI	Electro Magnetic Interference	PV	Photo Voltaic
EPDM	Ethylene Propylene Diene Monomer	PVC	Poly Vinyl Chloride
EVA	Ethyl Vinyl Acetate	RFI	Radio Frequency Identification
FF	Fill Factor	SAT	Site Acceptance Test
FO	Fibre optic	SLD	Single Line Diagram
FRLS	Flame Retardant Low Smoke	SPD	Surge Protection Device
FRP	Fibre-Glass Reinforced Plastic	SPV	Solar Photo Voltaic
GI	Galvanised Iron	STC	Standard Test Conditions
GRP	Glass Reinforced Plastic	TPN	Three Phase Neutral
HMI	Human Machine Interface	UV	Ultra Violet
IEC	International Electro-technical Commission	V	Volt
IEEE	Institute of Electrical and Electronics Engineers	V_m	Maximum Power Voltage
IGBT	Insulated Gate Bipolar Transistor	VT	Voltage Transformer
I_m	Maximum Power Current	W_p	Watt peak
IP	Ingress Protection	XLPE	Cross Linked Poly Ethylene
IS	Indian Standards	EBXL	Electron beam cross-linked
JB	Junction Box		

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1.0 SCOPE

1.1 The intent of this specification is to define the functional and design requirements for Roof Top Solar Photo Voltaic (SPV) Power System installed on building roof top meant for generating electrical energy from solar energy. This specification also covers the requirements for selection, design, engineering, manufacture, testing at manufacturer's works, packing & dispatch, installation, testing and commissioning at site of the system.

1.2 The contractor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent & requirement of this specification and job specification/ datasheets. Contractor shall ensure that the design, product selection and installation are carried out as per good engineering practices, which shall also include the requirements of safety, reliability, ease of maintenance and operation.

1.3 Compliance with this specification and /or approval of any of the contractor's documents shall not relieve contractor of his responsibility towards the completeness and satisfactory operation of the Solar Photovoltaic Power system.

2.0 CODES AND STANDARDS

2.1 The equipment & system shall comply with the requirements of latest revision of IEC and relevant BIS and other Indian/ International standards as applicable including the following:

a)	IEC 62446:	Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection.
b)	IEC 61215 / IS 14286:	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
c)	IS/ IEC 61701:	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
d)	IEC 61853-1/ IS 16170-1:	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
e)	IEC 61730-1, 2:	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part 2: Requirements for esting
f)	IS/ IEC 60947:	Low-voltage switchgear and control gear
g)	IEC 62759-1:	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units
h)	IEC 62109-1, 2:	Safety of power converters for use in photovoltaic power systems Safety compliance (Protection degree IP 65 for outdoor mounting, IP 31 for indoor mounting)
i)	IS/ IEC 61683:	Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency
j)	IEC 62891-2020:	Procedure for measuring overall efficiency (including static and dynamic MPPT efficiency) of grid connected PV inverter.
k)	IS16169-2019:	Test procedure of islanding prevention measures for utility connected PV inverters.
l)	IEC 60255-27:	Measuring relays and protection equipment - Part 27: Product safety requirements
m)	IEC 60068-2 (1,2,14,27,30 & 64):	Environmental Testing of PV System – Power Conditioners and Inverters
n)	IEC 61000- 2,3,5:	Electromagnetic Interference (EMI), and Electromagnetic

		Compatibility (EMC) testing of PV Inverters (as applicable)
o)	IEC 62093 & IEC 60068-2:	Design Qualification Environmental Testing.
p)	IS 17293-2020:	Electric cables for photovoltaic systems for rated voltage 1500 V d.c.
q)	IS/IEC 60947- 1, 2, 3; EN 50521:	General requirements for connectors- safety
r)	IEC 60269-6:	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
s)	IEC 62208 & IEC 60529:	General Requirements for Junction Boxes/ Enclosures.
t)	IEC 62124:	PV Standalone system design verification
u)	IEC 60364-7-712:	Electrical installation of buildings Requirements for SPV power supply systems
v)	IEC 61643-11:2011 / IS 15086-5:	Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
w)	IEEE 519	Recommended practices and requirements for harmonics control in electrical power systems
x)	NBC-2016:	National Building Code of India
y)	NEC (SP-30:2023):	Nation Electric Code of India
z)	IS 16221 (Part 1): 2016	Safety of power converters for use in photovoltaic power systems: Part 1 General requirements.
aa)	IS16221 (Part 2): 2015:	Safety of power converters for use in photovoltaic power systems: Part 2 Particular requirements for inverters
bb)	IS16664 :2018/IEC 62716: 2013:	PV module ammonia (NH3) corrosion testing
cc)	IS 9000 (Part 12)/IEC 60068-2-668:	PV modules testing for dust and sand exposure based on for high dust/sand geographical sites
dd)	IS/IEC-62305(All parts):	Protection against lightning.
ee)	IS/IEC 60529- 1989:	Degrees of protection provided by enclosures (IP Code).
ff)	IS 17210 (Part 1)/IEC 62804-1:	Test Methods for the Detection of Potential-Induced Degradation –Crystalline Silicon PV modules.
gg)	IS 7098 (Part 1) - 1988:	Cross linked polyethylene (XLPE) insulated PVC sheathed cables: Part 1 For working voltage up to and including 1100 V.
hh)	IS 694/IS 1554 (Part 1 and 2):	PVC insulated unsheathed and sheathed cables cords with rigid and flexible conductor for rated voltages up to and including 1100 V.
ii)	IS/IEC 61439-2:	Low voltage switch gear and control gear assemblies: Part 2 Power switch gear and control gear assemblies.
jj)	IEC 62561-7.	Lightning protection system components (LPSC) – Requirements for earthing enhancing compounds.

2.2 Any other regulations laid down by the Central, State or ocal Authorities from time to time shall also be referred.

2.3 In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.4 The equipment and system shall comply with the National Solar Mission guidelines of India and MNRE guidelines & specifications.

2.5 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.6 In case Indian standards are not available for any equipment, standards issued by IEC/BS/ /IEEE/ or equivalent agency shall be applicable.

2.7 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The SPV system shall be suitable for installation and satisfactory operation on the rooftop of buildings located in a tropical, humid and corrosive atmosphere.

4.2 All the equipment shall be suitable for the site conditions specified in the enquiry document/ data sheets. If not specifically mentioned therein, a design ambient of 40°C, an altitude not exceeding 1000m above mean sea level and maximum wind velocity as mentioned in datasheet/ job specification shall be considered.

4.3 All equipment of the system are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 SYSTEM DESIGN REQUIREMENTS

5.1 The equipment and materials shall be designed for the following grid power supply conditions unless otherwise mentioned:

a) Grid Supply (at the point of interconnection)

i)	Voltage	: 415 V AC ± 10%
ii)	Frequency	: 50 Hz ± 3%
iii)	Maximum Fault Level (for 1 second)	: Refer data sheet
iv)	System Neutral Earthing	: Solidly earthed (unless otherwise specified)
v)	No. of Phases	: TPN

b) SPV System Voltages

i)	PV module voltage/ array voltage	: To be decided by the Contractor
ii)	Power Conditioning Unit input voltage	: To be decided by the Contractor
iii)	DC voltage	: To be decided by the Contractor
iv)	Power Conditioning Unit output voltage	: 415 V TPN, 50Hz

5.2 System Description & Power Evacuation

The main intent of grid connected PV solar system shall be to convert solar energy to generate electricity. The electricity generated shall be directly connected to the power system at 415V. The solar system shall be photovoltaic based in which arrays of photovoltaic (PV) modules shall be installed on building roof top under clear sky, shade free, tilted towards south at an optimum inclination. Contractor shall perform the analysis for finalizing the location, direction & inclination angle of the PV arrays.

The PV arrays shall convert solar energy and generate DC electricity, which shall be collected using array junction box and/ or main junction box and finally fed into power conditioning unit (PCU). The PCU shall convert DC power to three phase AC power at 415V voltage and shall be hooked up to 415V power supply system of substation/ building electrical system/ plant electrical system/ grid (Grid/DG/ CPP etc.) after automatic synchronization. In case of solar PV system out of synchronization due to grid/ plant electrical supply failure, or due to low/ high grid voltage, the PV system shall get disconnected from the grid. Once the healthy grid supply is available, PV system shall again automatically synchronize with grid supply and would feed energy/power into electrical system.

5.3 Major Items & Components of the SPV system

The Grid connected Solar Rooftop Photo Voltaic (SPV) system consists of SPV array, Module Mounting Structure, Power conditioning Unit (PCU) having Maximum Power Point Tracker (MPPT) and controls & protections, interconnecting cables and junction boxes etc. PV arrays shall be mounted on suitable structures. Grid Connected SPV system shall be without battery and shall be designed with necessary features to supplement grid power during day time.

Solar PV system shall consist of following equipment/ components as minimum. Any other equipment / component required for completeness & operation of the system shall be provided by contractor:

a) Solar PV Modules/Panels, Crystalline type

b) Grid Connected/ On-grid Power Conditioning Unit with MPPT units

c) Mounting Structures

d) AC Distribution board

e) Junction Boxes

f) Data Acquisition and monitoring system including weather monitoring instruments

g) Cables, Pipes, conduits, accessories, glands, lugs etc.

h) Earthing, Lightning, over voltage & Surge Protection

i) Fuses/ Switches/ Circuit breakers/ Connectors

5.4 Design / Selection Criteria of the System

a) The quantity of solar modules, W_p rating of each solar module, number of PCU and AC output rating of PCU shall be decided by contractor considering the total capacity of the SPV system required as per the Job specification.

b) Contractor shall ensure proper system designing that would include consideration of accurate solar irradiation data, resulting in the correct sizing of equipment for the solar power system and get the same approved from the EIL/ Owner. Proper design and component sizing procedures as per acceptable standards shall be adopted. Contractor shall provide the detailed energy generation calculation (daily/ monthly /yearly) and other analysis reports with the help of internationally accepted software (e.g. PVSyst) during detailed engineering.

c) All PV Modules shall be of same make and rating and shall have identical characteristics.

d) The solar PV modules shall be tilted towards south. The tilt angle shall be fixed based on the availability of maximum annual solar insolation (kWh/m^2-day) at particular tilt based on optimum inclination analysis.

e) Full rated PCU shall be provided i.e. overloading capacity available in the PCU shall not be used to meet the peak rating of power evacuation from PV System. PCU rating shall be finalized considering poorly ventilated non air conditioned room/ outdoor installation as per the job specification.

f) PV Array Configuration

The solar Array shall be configured in multiple no. of sub-arrays, providing optimum DC power to suitable number of sub arrays. Contractor shall furnish the design indicating configuration of PCU and respective sub arrays. While ensuring full compatibility between PV array and PCU, contractor shall consider the following aspects and the calculations shall be submitted for review:

i. The number of PV modules per string in an array shall be decided such that MPPT DC voltage range is not violated under site condition. All strings shall be identical w.r.t. number of modules and their ratings & characteristics. For achieving identical strings, if more number of PV modules are required, the same shall be provided.

ii. The peak-power point voltage and the peak-power point current of any module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.

iii. As far as possible, all PCU shall be of identical ratings. All PCUs shall be of same make. Grid Connected String inverter with MPPT shall be provided. For a solar PV system, the AC combined wattage of all inverters shall not be less than the rated DC capacity of the PV plant at STC. For a solar PV system, smaller rating of multiple inverters can be provided and AC output from all inverters shall be fed to ACDB of that system. One feeder from ACDB shall evacuate power to 415V switchboard in substation/ building electrical system.

iv. The maximum open circuit voltage of the arrays shall not violate the maximum DC voltage that the PCU can accept under minimum site temperature.

v. Contractor shall suitably decide series parallel combination of PV modules, DC voltage for array, DC input voltage of PCU etc. Contractor shall finalize suitable scheme for solar power evacuation ensuring grid connectivity at 415 V. However, string output voltage/ DC array voltage/ PCU input voltage shall be highest possible DC voltage considering the optimum energy generation as per the PCU MPPT range.

vi. The array output shall be well within the input voltage range of the inverter so that inverter works in MPPT range for most of the solar insolation range.

vii. The automatic synchronization facility of solar power and grid power shall be provided at PCU only. PCU shall adjust voltage & frequency levels to suit the grid supply. Synchronization at any other location in the system is not acceptable.

g) The complete solar system layout shall be developed by contractor indicating all modules, mounting structures, PCU, JBs etc. The solar system including mounting structures shall

have required walkways at intervals for movement of personnel for operation & maintenance.

6.0 EQUIPMENT SPECIFICATIONS

Equipment and material shall conform to the following specifications as well as site & system conditions defined elsewhere in the enquiry document. The equipment shall be manufactured in accordance with current Indian/ International Standards. In absence of specification for any equipment/ system, the specification shall be developed by contractor and shall be approved by the EIL/ Owner. All similar materials and removable parts shall be uniform and interchangeable with one another.

6.1 Solar Photo Voltaic Modules

a) Solar PV module array shall consist of high efficiency Solar Modules utilizing Mono Crystalline Silicon PERC solar PV cells. Individual Solar module rating shall not be less than 600Wp at standard test conditions. Preference shall be given to bigger Solar PV module (≥ 600 Wp).

b) Mono Crystalline silicon PV modules design qualification and type approval shall comply with IS 14286 (Part 1/Sec 1).Thin film PV modules design qualification and type approval shall comply with IS 14286 (Part 1/Sec 1),IS 14286 (Part 1/Sec 2), IS 14286 (Part 1/Sec 3) and IS 14286 (Part 1/Sec 4) outlines procedures for sampling, marking and testing of thin-film PV modules, such as amorphous silicon, cadmium telluride (CdTe),copper indium gallium selenide (CIGS), micro-morph and other thin film technologies.

c) All materials used shall be having a proven track record of reliable and stable operation in external outdoor applications.

d) Module rating is considered under standard test conditions (STC), however, solar modules shall be designed to operate and perform in relative humidity up to 100% with temperatures between -10°C & +65°C and withstand gust as per the wind zone of the location from back side of the panel. The Geological data of site shall be referred for design to get optimum generation.

e) Bypass diodes shall be used to prevent PV modules from being reverse biased and consequent hot spot heating. These shall be normally installed in the junction box or embedded in PV module encapsulation.

Bypass diodes installed external to PV module or Junction Box shall comply with following requirements:

i) Voltage rating min. 2 × VOC MOD of the protected module;

ii) Current rating of min. 1.4 × ISC MOD of the protected module;

iii) Installed according to module manufacturer's recommendations;

iv) Installed such that no live parts are exposed; and

v) Protected from degradation due to environmental factors.

f) The PV modules shall be suitable for highly corrosive atmosphere throughout their lifetime.

g) PV modules must qualify as per relevant IS/IEC standards (test reports/ certificate from IEC/NABL accredited laboratory shall be furnished). Additionally the performance of PV modules at STC conditions must be tested and approved by one of the IEC / NABL Accredited Testing Laboratories including Solar Energy Centre of MNRE. Qualification certificate from IEC/NABL accredited laboratory as per relevant standard for PV modules shall be accompanied with the STC report/ certificate.

h) Class A (safety class II) modules shall be used for general applications where PV system voltage exceeds DVC-A limit of 50Vd.c.

i) Weatherproof DC rated connector and a cable as a part of the module shall be provided for making connections easier & secure and not allowing for any loose connections.

j) Modules shall be resistant to water, abrasion, hail impact, humidity and other environment factor for the worst site conditions/ situations.

k) Each module shall have low iron tempered glass front for strength and superior light transmission. It shall have tough multi-layered polymer back sheet for environment protection against moisture and provide high voltage electrical insulation. Transmitivity of glass shall not be less than 91%.

l) The fill factor of modules shall not be less than 0.72.

m) The rated output of any module shall have maximum tolerance of ±3%.

n) Module efficiency of SPV module shall not be less than 20% at STC.

o) Each PV module must have a RF identification tag (RFID). The following information must be mentioned in the RFID used on each module. This can be inside or outside the laminate, but must be able to withstand harsh environmental conditions.

i. Name of the manufacturer of PV Module

ii. Name of the Manufacturer of Solar cells

iii. Month and year of the manufacture (separately for solar cells and module)

iv. Country of origin (separately for solar cells and module)

v. I-V curve for the module

vi. Peak Wattage, Im, Vm and FF for the module

vii. Unique Serial No. and Model No of the module

viii. Date and year of obtaining IEC PV module qualification certificate

ix. Name of the test lab issuing IEC certificate

x. Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

p) The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof cover with captive screws and cable gland entry points or may be of sealed type and shall be IP-65 rated designed for long outdoor operation in harsh environment.

q) I-V curves at STC for modules shall be furnished.

6.2 Power Conditioning Unit

a) Power Conditioning Unit shall convert DC power generated by SPV array into 3 phase 415V, 50 Hz AC power to be connected to grid/ plant electrical system. It also provides necessary protections for grid synchronization and data logging & monitoring. The DC energy produced shall be utilized to maximum and supplied to the DC bus for inverting to AC voltage with the help of power Conditioning Unit using its Maximum Power Point Tracking (MPPT) which shall be part of the PCU. MPPT shall extract maximum energy from solar. MPPT voltage range shall be selected for wider voltage range and MPPT shall be of very high efficiency as per the applicable codes.

i. The PCU shall have protections such as, over current, short circuit, earth fault, over temperature, internal protection arrangement against any sustained fault etc.

ii. The PCU shall be designed for continuous reliable power supply, minimize the risk of short circuit and shall ensure human & operational safety.

iii. The PCU shall have built in metering and data logging arrangement for monitoring plant performance.

iv. The PCU shall be designed to be completely compatible with the SPV array voltage. Minimum open circuit DC voltage suitability for PCU shall be 1000V DC.

v. MPPT controller, inverter and associated control and protection devices etc. shall be integrated into the PCU.

vi. The PCU shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.

b) The PCU shall automatically turn on and turn off successively as the available solar irradiation varies over the day. The PCU shall have all necessary synchronization equipment installed and shall be able to synchronize independently and automatically/ phase lock with grid power supply to attain synchronization.

c) The 3 phase Grid connected PCU shall incorporate latest technological advances to provide highly reliable and efficient energy conversion from DC to AC. The PCU shall incorporate system design which uses multiple power stakes which work in tandem. Both AC & DC lines shall have suitable fuses/ contactors/MCCB to allow safe start up & shut down of the system. Fuses used in the DC circuit should be DC rated. The PCU shall be complete with all protection, metering, alarm, annunciation, indications as required.

d) The power conditioning unit shall be three phase static solid state type with integrated system comprising static inverter, controller, input & output contactors, line filters, EMC filters and protection devices and all other equipment/ accessories required for completeness of the system whether specifically mentioned herein or not, but necessary for completeness and satisfactory performance of the system.

e) The inverter shall be efficient with IGBT based reliable design. The control system shall be of highest reliability based on microprocessor / Digital signal Processor design.

f) The PCU manufacturer shall be responsible for design, engineering and manufacturing of the complete PCU system to fully meet the intent and requirements of this specification and enclosed data sheets. Selection, sizing and suitability of all equipment and components used for PCU system shall be PCU manufacturer's responsibility.

g) All breakers/ contactors shall be adequately rated for continuous rating as well as breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All DC input isolating device shall be double pole type.

h) All electronic power devices including transistors (IGBT), diodes etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device. All other electrical components such as transformers, reactors, breakers, contactors, switches, bus bars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall be subjected to PIV greater than 50% of its rated value.

i) PCU shall have user friendly LED/ LCD display & keypad for system control, programming, monitoring, change set points and for viewing on line parameters such as DC power input, DC input voltage, DC current, AC power output, AC voltage (all the 3 phases and line) and AC current (all the 3 phases and line), cumulative output energy in KWH, power factor, frequency, PCU operating state status, various fault conditions etc.

j) PCU performance parameters:

i. The total harmonic distortion and individual harmonics level shall be less than 3% for both voltage and current harmonics.

ii. DC ripple content shall be less than 3%.

iii. Safety from grid power failure including under-voltage, overvoltage or any other fault conditions.

iv. The efficiency of the PCU shall be minimum 96%. The PCU shall be transformer less design.

v. PCU shall have internal protection arrangement against any sustained fault in the feeder line & against lightning strikes in the feeder line.

vi. PCU shall have required protection arrangement against earth leakage faults.

vii. DC output side shall have suitable DC rated contactor/ MCCB/ other protection devices for protection & isolation. AC output side shall have suitable AC rated 4 pole TPN switch/breaker with protection devices for isolation purposes.

viii. The minimum indications through LEDs/ LCD display shall be as follows:

- Inverter ON
- Grid ON
- Grid/ Inverter under voltage / over voltage
- Inverter over-load
- Inverter over temperature
- Earth fault

k) PCU shall be able to withstand an unbalanced Grid/ Electrical system conforming to relevant IEC/ IS standard.

l) PCU shall have communication facility and all the data related to metering, operating status, faults etc. shall be hooked up to Data monitoring system.

m) PCU Operational Requirements:

i. The PCU inverter shall be designed such that it follows grid voltage & frequency and shall operate without any problem for normal fluctuations of grid voltage & frequency. The PCU shall be suitable for synchronizing with grid supply voltage variation range of +12.5%, -20% and frequency variation range ±3%. PCU inverter shall follow grid frequency up to ±3Hz of the normal output frequency.

ii. The PCU shall be provided with auto wake up feature such that PCU inverter shall be able to wake up when the available power from the PV array is more than the total loss of the inverter system. As the available power from the PV array changes with weather condition, the wake up algorithm shall be adaptive in nature.

iii. The PCU shall be able to synchronize AC output with the grid power supply and shall close output contactor/ breaker when the synchronization parameters (voltage difference, frequency difference and phase angle difference) are complied.

iv. The power control scheme of the PCU shall follow the maximum output from the PV array determined by the level of solar radiation on the DC side and shall employ maximum power point tracking (MPPT) control capable of constantly obtaining the maximum energy from the array according to the quantity of solar radiation and temperature.

v. As the PCU shall be operating in parallel with the grid power supply, it shall be capable of interrupting line-line fault currents and line-to earth fault currents.

vi. The PCU shall have following modes of operation:

- Standby mode – The PCU shall operate in this mode when PV array does not have enough power capacity to maintain PCU inverter losses or PCU has responded to a fault condition and fault condition has been cleared. In this mode PCU shall remain idle, disconnected from PV array as well as from grid. The

inverter shall remain in this mode until PV array voltage exceeds wake up value and enter into system wake up test mode.

- Wake up test mode – After PV array voltage exceeds wake up value, the PCU control system shall continuously monitor PV array voltage for certain duration before making transition to power tracking mode. If the PV array voltage drops below wake up value during test duration, PCU shall enter into standby mode.
- Power tracking mode – This shall be main operating mode of the PCU under normal operating condition. In this mode maximum power point tracking algorithm shall be functional which shall extract maximum power from PV array under varied conditions of solar irradiance and temperature.
- Sleep mode – Whenever PCU output power drops below certain threshold limit, PCU enters into sleep mode and wait for certain duration. Within this duration if PCU output power exceeds threshold limit, PCU re-enters into power tracking mode, otherwise PCU goes into standby mode.
- Shutdown mode – The PCU shall operate in this mode whenever fault conditions will be responded. The PCU shall disconnect itself from PV array as well as from grid.

n) PCU Protective functions

i. The PCU shall be provided with anti-islanding control and protection such that in case of grid supply failure, PCU shall stop exporting power to the grid/ power system.

ii. The PCU shall be able to sense the following situations and accordingly shutdown & disconnect itself from the grid as well as from PV array:

- Grid power supply over voltage & under voltage,
- Grid power supply over frequency & under frequency.
- AC over current & earth fault
- Protection against islanding.
- Loss of any phase of the grid power supply.
- DC bus overvoltage & under voltage
- DC bus over current & earth fault
- Device over temperature/ system temperature rise, heat sink over temperature
- Short circuit
- Array earth fault detection

iii. The PCU shall sense reverse polarity of DC connection, provide warning and shall remain in standby mode.

iv. The PCU shall be provided with surge arrester (metal oxide varistor) both at AC and DC side to protect the system from lightning & switching surges.

v. Cooling system shall include adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled PCU, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the PCU panels for these fans. In case, redundant cooling fan is not possible to be mounted, same shall be supplied loose. Fans shall be equipped with monitoring facilities to provide an alarm/ indication in the event of fan failure.

vi. A suitably sized earth bus shall be provided at the bottom of the panels with provision for earth connection at both ends to main earth grid. The minimum size of earth bus shall be 25 x 3 mm² Copper (or equivalent Aluminium). All potential free metallic parts of various equipments shall be earthed suitably to ensure safety.

o) Maximum noise level from PCU at 1 meter distance, under rated load condition with all normal cooling fans shall not exceed 75 dBA.

p) The PCU shall be housed in sheet steel panel. The panel shall be fabricated from structural / CRCA sheet steel. The panel shall be free standing floor mounted or wall mounted type as per job specification/data sheet, fitted with suitable lovers for ventilation and cooling fans as required. Dust tight gaskets shall be provided. The enclosure shall provide minimum IP-31 degree of protection for indoor panel and IP-65 for outdoor panel. Canopy shall be provided for outdoor PCU.

q) The PCU shall be located indoor or outdoor as specified in the job specification/data sheet.

r) The PCU/ inverter should have been tested from the MNRE approved test centers / NABL/ BIS/ IEC accredited testing – calibration laboratories. In case of imported PCU, these should have been approved by international test houses.

s) The minimum requirements for the design and manufacture of PCE/Inverters for safety like protection against electric shock, energy, fire, mechanical and other hazards shall comply with IS 16221 (Part 2).Procedure for measuring efficiency of PV system PCE shall comply with IS/IEC 61683.Procedure for measuring overall efficiency (including static and dynamic MPPT efficiency) of grid connected PV inverter shall comply with IEC 62891.Test procedure of islanding prevention measures for utility connected PV inverters shall comply with IS 16169.Environmental testing of PCE/inverters shall comply with relevant parts of IS 9000 series as given in IS 16221(Part 2).EMC/EMI testing of PV inverters shall comply with relevant parts of IS 14700 series as given in IS 16221 (Part 2).

6.3 ACDB (AC Distribution Board)

a) The AC power output of all the inverters shall be fed into the ACDBs (one or multiple number of ACDBs as per requirement and job specification/ SLD).

b) ACDB shall be floor mounted or wall mounted type as specified in the job specification/ data sheet and compartmentalized. The minimum IP-31 degree of protection shall be provided for indoor ACDB and IP-65 for outdoor ACDB. Canopy shall be provided for outdoor ACDB.

c) ACDB shall have required number of feeders for connecting with all the inverters in the SPV system plus 10% additional spare feeders (minimum of 1 no. of each type and rating). All inverters of the PV system shall be connected to ACDB of that system i.e., AC power generated from all inverters shall be combined in ACDBs and combined power from each ACDB shall be fed to the substation / building switchboard.

d) All incoming feeders (from PCU) and outgoing feeder (to substation / building switchboard) shall be provided with MCCB. The MCCB shall be microprocessor based with over-current, short circuit & earth fault protection with shunt trip facility. MCCBs shall be 4 pole type.

e) Outgoing feeder feeding the substation / building switchboard shall have analogue ammeter, voltmeter and integrated Digital Multi-function Meter which includes energy meter. The Digital Multi-function meter including energy meter shall have communication facility and same shall be hooked up to data monitoring system. Digital Multi-function meter along with CT/VT shall be of accuracy class 0.5.

f) Fault level of ACDB shall be same as that of 415V switchboard in substation/ building electrical system at which the power is to be integrated.

g) Continuous current Rating of the ACDB shall be as per maximum installed capacity of the PV system (AC inverter maximum ratings or DC installed power KWp whichever is higher) and 10% higher/ spare rating.

h) The ACDB shall be located indoor or outdoor as specified in the job specification/data sheet

6.4 **Junction Box (AJB/ MJB/ DCJB)**

a) PV array and PV string combiner boxes shall comply with IS/IEC 60529 for degree of protection and complete assembly shall comply to IS/IEC 61439-2, shall be of thermo-plastic/Polycarbonate/FRP material, minimum IP 65 compliant, and UV resistant when exposed to outdoor environment. PV array and PV string combiner boxes shall be minimum IP 54 compliant when exposed to indoor environment.

b) The terminals shall be connected to bus-bar arrangement of proper sizes as required. The junction boxes shall have suitable cable entries fitted with cable glands/ lugs/MC4 connectors of appropriate sizes for both incoming and outgoing cables. All wires/cables must be terminated through cable lugs/ suitable PV system DC connectors. Suitable markings shall be provided on the bus-bars for easy identification and cable ferrules shall be fitted at the cable termination points for identification

c) The junction boxes shall be suitable for solar PV system application and also applicable IS/ IEC codes and MNRE recommendations/ requirement.

d) Copper bus bars/terminal blocks housed in the junction box shall be with suitable termination threads conforming to IP65 standard and door/cover with EPDM rubber gasket to prevent water entry. Provision of earthing shall be provided in junction boxes.

e) The Array Junction Box shall have high quality suitable capacity metal oxide varistors (MOVs) / SPDs. The Array Junction box shall also have suitable surge protection. The Junction Boxes shall have suitable arrangement for the following.

i. Provide arrangement for disconnection for each of the groups.

ii. Combine groups of modules into independent charging sub-arrays that shall be wired into the controller.

iii. Provide a test point for each sub-group for quick fault location

iv. To provide group array isolation.

v. The current carrying ratings of the junction boxes shall be suitable with adequate safety factor to inter connect the solar PV array.

f) As far as possible, JBs shall be placed at 1.5 meters height or above for ease of accessibility.

6.5 **Data Acquisition and Plant Monitoring System**

a) The Data Acquisition & Monitoring System shall cover the complete solar PV system. One set of weather monitoring instruments shall be provided unless otherwise specified. The data monitoring system & data loggers of the PV system shall be suitable for integration with weather monitoring instruments.

b) The data acquisition, monitoring & data logging system shall provide facility for plant monitoring, fault analysis, time & date stamped system data logs for analysis with suitable laptop/ desk top computer and shall allow visualization, monitoring, commissioning and service of the SPV system. Metering and instrumentation for display of systems parameters and status indication shall be provided. The data monitoring system/ data-logger shall have the provision of interface of complete data through MODBUS TCP/IP protocol with RJ45 port or any other protocol as defined in Job Specification/ datasheet. Data monitoring software for data analysis shall be provided.

c) The data acquisition, monitoring & logging system shall be either web based or interconnected with the owner's substation automation system as defined in the job specification/ data sheet.

d) For web based system, it shall be possible to access the data logger with any standard web browser and relevant software/hardware required shall be supplied by contractor for monitoring & data downloading. In addition to web portal, it shall be possible to retrieve

data directly from data acquisition & monitoring system. Complete data of monitoring system as per this specification including all inverters, weather monitoring systems, Digital Multi-function meter in ACDBs etc. shall be accessible and downloadable from the data monitoring software via internet/ web access in laptop / desktop computer with required authentication.

e) For substation automation interconnected system, the SPV data monitoring system/ data-loggers shall be connected to the owner's Data Concentrator / Ethernet Switches or Owner's SCADA or ECS RTU located in the substation as mentioned in the Job Specification/ data sheet. In this regard all necessary provisions shall be considered in the data monitoring & data logger system by contractor. Complete data related to data monitoring system including all inverters, weather monitoring systems, Digital Multi-function meters (including energy meter) in ACDBs etc. shall be available in the substation data concentrator /HMI. Cables for interconnection up to data concentrator/ Ethernet switches shall be provided by the contractor.

f) Weather Monitoring Instruments as per the following shall be provided:

i. Solar Irradiance: An integrating Pyranometer / Solar cell based irradiation sensor (along with calibration certificate) shall be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with the data logging system.

ii. Temperature: RTD type thermometer and Temperature probes for recording the Solar panel temperature, module back surface temperature and ambient temperature shall be provided complete with readouts integrated with the data logging system.

iii. Anemometer: For wind speed measurement, anemometer shall be provided (along with calibration certificate) complete with readouts integrated with the data logging system.

g) The following parameters shall be accessible via the operating interface display in real time for solar power system:

i. DC power input

ii. DC Input Voltage

iii. DC Input Current

iv. AC Voltage

v. AC Output current

vi. AC Output Power

vii. Power factor

viii. Time Active

ix. Time disabled

x. Time Idle

xi. Power produced

xii. Operating modes

xiii. Inverter status

xiv. Fault indications

xv. Protective function limits i.e. AC Over voltage, AC Under voltage, Over frequency, Under frequency, Earth fault, PV starting voltage, PV stopping voltage etc.

xvi. Data from weather monitoring instruments –Solar irradiance daily & per month based on instantaneous irradiance readings (kWh/m2/month), Daily and monthly average ambient temperature based on instantaneous temperature readings near array field, Module back surface temperature, Wind speed at the level of array plane

xvii. Solar Energy generation data from all Digital Multi-function meter (energy meter) in ACDBs.

h) All major parameters on the digital bus and logging facility (the current values, previous values for up to a month and the average values) shall be available for energy auditing through the internal microprocessor and should be read on the digital front panel.

i) PV array energy production: Digital Multi-function meter shall log the actual values of AC voltage, Current & Energy generated by the PV system. Digital Multi-function meter shall be connected with data logger of the PV system to have interface of complete data through MODBUS TCP/IP protocol with RJ45 port or any other protocol as defined in Job Specification/ datasheet. Guaranteed energy productions values shall be measured in digital Multi-function meter (Energy meter) mounted on ACDBs. Hence, the historical & instantaneous data of Digital Multi-function meter shall be available at data logger & monitoring system.

j) DC String/Array monitoring and AC output monitoring shall be provided as part of the inverter and/or string/array combiner box or separately.

k) String and array DC Voltage, Current and Power, Inverter AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency shall be monitored as a minimum.

l) All instantaneous data shall be shown on the computer screen.

m) Software shall be provided for USB download and analysis of DC and AC parametric data for the system.

n) If specified in the job specification/data sheet, complete SCADA system including server, software etc. for centralized monitoring system shall also be provided for storage, download and analysis of cumulative data of various solar systems and the data of the solar radiation & temperature monitoring system.

o) Simultaneous monitoring of DC and AC electrical voltage, current, power, energy and other data of the system for correlation with solar and environment data shall be provided.

p) The data acquisition & monitoring software shall also be installed by contractor in owner's laptop/desk top computer during testing and commissioning of PV system at site. One set of original software in CDs/DVDs/removable media shall be also provided by contractor which shall be handed over to owner after commissioning of the system.

q) The system data shall be secured from all any kind of breach. All data loggers shall be suitable to be connected with any local laptop for data monitoring and downloading of data shall be possible with a laptop.

6.6 Cables

All power, control, signal, communication, LAN, Fibre Optic (FO) cable, DC cables as required for the SPV system shall be provided by the Contractor. Further AC Power and control cables from PCU to ACDB and from ACDB to substation / building Electrical system MV switchboard for power supply hook up shall be provided by Contractor.

a) Cable Design Criteria

i. Sizes of cables between string interconnections, array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum. The cables shall be as per relevant IS codes and shall be insulated with a special grade XLPE/ XLPO compound formulated for outdoor use.

ii. The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2%.

iii. The total voltage drop on the AC cable segments from the solar inverter to the ACDB shall not exceed 0.5% for PV systems located nearby to the ACDB where ACDB is located in the same building. The total voltage drop on the cable segments from the solar inverter to the ACDB shall not exceed 2.0% for PV systems located away from the ACDB where ACDB is not located in the same building.

iv. Cable sizing document shall be submitted by contractor for review to EIL/ Owner based on the voltage drop, other sizing criteria as per the requirement. The final cable sizes shall be decided during detailed engineering based on the approved cable sizing document. Contractor to ensure that all equipments shall be suitable for termination of the required cable sizes.

b) DC Cables & Connectors

i. All solar PV d.c. cabling shall comply with IS 17293. This standard applies to low smoke halogen-free, flame retardant, UV resistant, flexible, tinned-copper conductor, single-core, double insulated power cables with electron beam cross-linked (EBXL) insulation and sheath, for use at the d.c. side of photovoltaic systems, with a nominal d.c. voltage up to 1.5 kV between conductors and between conductor and earth and temperature rating of – 40 °Cto + 90 °C.

ii. It is recommended to use cable as per IS 17293, UV stabilized single core flexible copper conductor cables for solar PV d.c. cabling. Multi-core cables shall not be used.

iii. Use of aluminum conductor d.c. cables requires larger diameter, calls for due precautions in cable termination, and poses higher potential risk of loose termination, d.c.arcing and fires as compared to use of copper conductor d.c. cables.

iv. Minimum DC cable size shall be 4.0 sq. mm copper.

v. Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors and couplers.

c) AC Cables

i. All indoor a.c. Cabling shall comply with atleast FRLSH grade as per IS 694/IS 1554 (Part1and2) standards as appropriate. Use of copper conductors is recommended up to 25 mm2 size.

ii. All outdoor a.c. cabling shall comply with IS 7098 (Part 1), IS 7098 (Part 2) and IS 7098 (Part 3). Use of copper conductors is recommended up to 25 mm2 size.

iii. Underground a.c. cables shall be armoured preferably with copper conductor. Aluminum conductor a.c. cables of suitably larger diameter may be used with extra care and precaution following recommended cable termination practices.

6.7 Module/ Array Mounting Structure

a) Unless otherwise specified, mounting structures shall be made of hot dipped galvanized mild steel (MS).

b) The mounting structures shall be designed to sustain wind loading applicable as per the wind zone & also as per wind speed mentioned elsewhere. The entire structure including array shall be earthed to an independent earth pit with redundant paths. Mounting structures shall be with fixed tilt.

c) Each structure shall have angle of inclination as per site conditions to take maximum insolation for annual energy output. The array structure shall be so designed that it will occupy minimum space without sacrificing the SPV panels output and allows easy replacement.

d) Suitable fastening arrangement such as grouting and calming shall be provided to secure the installation against the specific wind speed.

e) Each Panel frame structure shall be so fabricated as to be fixed on the floor of roof top. The height of the frame shall be so decided to avoid shadows from building structure subject to minimum 500 mm above rooftop level unless otherwise specified.

f) The Contractor shall specify installation details of the PV modules and the support structures with appropriate diagrams and drawings. Such details shall include, but not limited to the following;

i. Determination of true south at the site

ii. Array tilt angle to the horizontal, with permitted tolerance

iii. Details with drawings for fixing the modules

iv. Details with drawings of fixing the junction/terminal boxes

v. Structure installation details and drawings

vi. Inter-panel/Inter-row distances with allowed tolerances

vii. Safety precautions to be taken

The array structure shall support SPV modules at a given orientation and shall absorb & transfer the mechanical loads to the rooftop columns properly. While deciding civil foundation & structure required for the SPV system, the load bearing capacity of roof shall be considered by contractor.

7.0 CABLING, EARTHING & LIGHTNING / SURGE PROTECTION

7.1 Cabling System

Cabling system shall conform to the following requirements: -

a) Within building area, the cables shall be laid in GI cable trays. Further in case cable trenches are available in the SPV system cable routes, power and control cables can be laid in cable trenches also.

b) GI cable trays, conduits, pipes, sleeves, cable accessories, cable lugs, ferrules etc. for cable laying shall be provided.

c) Above ground cables shall be well supported on cable trays and suitably protected against mechanical damage.

d) Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer.

e) Signal cables e.g. communication, LAN and data highway cables etc. shall preferably not be laid in the same trench/ tray along with electrical cables. FO cables if any shall be laid in the HDPE pipe conduit.

f) Cable/wires shall be routed in GI cable trays and shall be suitably tagged & marked with ferule or by other means so that the cables are easily identified. On routes where cables are few, cables & conduit pipes can be directly clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm.

g) Top most cable trays and vertical cable trays shall be provided with GI sheet covers.

7.2 Earthing System

a) The earthing for array and power system shall be provided as per provisions of IS -3043, and CEA guidelines. The earthing system shall comprise of equipment earthing connections, main earthing grid along with suitably located earth plates to provide multiple earth connections and earth electrodes in test pits. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.

b) Each Array structure of the SPV shall be earthed. The entire structure including array shall be earthed to an independent earth pit with redundant paths.

c) The system neutral, current & potential transformer secondary neutral, metallic non-current carrying parts of all electrical equipment i.e. PV arrays, mounting structures, JBs, PCU, ACDB and cable shields & armour shall be earthed.

d) The complete earthing system shall be mechanically & electrically connected to provide independent return to earth. All the electrical equipment operating above 250 V shall have two separate and distinct connections to earth grid.

e) All non-current carrying metal parts shall be earthed with two separate and distinct earth conductors to the nearest earth grid. All earth connections shall be visible for inspection.

f) The resistance values of the earthing system shall not exceed 1 ohm.

g) The d.c. earthing conductor should be rated for 1.56 times the maximum short circuit current of the PVstring/sub-array/array (25 percent design safety factor and 25 percent irradiance factor);

h) Min. 6 mm2 copper conductor, outdoor rated (IS 7098) cable for PV module frame interconnections;

i) Min. 6 mm2 copper conductor, outdoor rated (IS 7098) cable for module frame to MMS connection;

j) Min. 50 mm2 copper conductor or 50 mm2 copper coated steel conductor, or 25 × 3 mm GI strip for MMS to MET connection

k) Min. 50 mm2 copper conductor or 50 mm2 copper coated steel conductor, or 25 × 3 mm GI strip for SCB/AJB/Inverter chassis to MET connection; and

l) Min. 50 mm2 copper conductor or 50 mm2 copper coated steel conductor, or 25 × 3 mm GI strip for Lightning Protection earth electrode.

m) In soil with resistivity higher than 3 000 Ωm, the use of type B earth electrodes or earthing enhancing compounds is recommended in IS/IEC 62305. Earth enhancing compounds shall comply with IEC 62561-7.

7.3 Lightning & Over Voltage/ Surge Protection

a) The SPV system shall be provided with lightning and over voltage/ surge protection connected to earth pits. The source of over voltage can be due to lightning / atmospheric disturbance and/or switching surge. The main aim of over voltage protection shall be to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components. The entire space occupying the SPV array shall be suitably protected against lightning by deploying required number of lightning arrestors. Necessary concrete foundation for holding the lightning conductor in position shall be provided after giving due consideration to maximum wind speed and maintenance requirement at site.

b) The Lightning conductor shall be earthed through flats and connected to earth pits as per applicable Indian Standards. Each Lightning arrestor shall be fitted with individual earth pit as required.

c) Lightning protection shall comply to IS/IEC 62305. Connection components shall comply with IEC 62561-1. All LA air termination, down conductors, earthing conductors and earth electrodes shall comply with IEC 62561(Part 1 and 2).the value of 5 ohms as earth resistance shall be ensured. The protection against induced high voltages shall be provided by the use of Metal oxide varistors (MOVs) with suitable earthing such that induced transients find an alternate route to earth.

d) The lightning protection of Solar PV system shall also comply to the requirement of NBC 2016.

e) Air Terminals may be installed at physical distance from PV mounting structures or mounted directly on the PV module structure at strategic locations to bring the complete area under zone of protection. The height of vertical air terminals shall be calculated such that there is no or minimum influence of shadow on the PV modules (as per NBC 2016). The quantities of vertical air terminals shall be determined such as to bring the entire PV installation under protection zone.

f) Surge Protection

The internal surge protection shall consist of three MOV type surge arrestors connected from +ve and –ve terminals to earth (via Y arrangement) suitable for higher withstand of the continuous PV-DC voltage during earth fault condition.

8.0 ENERGY METERS:

Gross/Net/ Energy Meter/TOD (Time of Day) Energy Meter shall be provided as per Job Specification in Line with State Electricity Board/ Regulatory Commission requirements.

9.0 SHOP INSPECTION & TESTING

a) All electrical equipment including PV modules, PCU, JBs, data logging system, cables, material etc. shall be thoroughly inspected and tested at the manufacturer's works in accordance with approved inspection & test plans. Contractor shall prepare and furnish the inspection & test plans for EIL/owner approval. The type test certificates for the equipment shall be available; in case of non-availability of type test certificates, fresh testing of the equipment in accordance with applicable codes & standards shall be done. All routine & acceptance test as per the applicable standards shall be conducted on the equipment.

EIL/ Owner may

10.0 SHOP INSPECTION & TESTING

a) All electrical equipment including PV modules, PCU, JBs, data logging system, cables, material etc. shall be thoroughly inspected and tested at the manufacturer's works in accordance with approved inspection & test plans. Contractor shall prepare and furnish the inspection & test plans for EIL/owner approval. The type test certificates for the equipment shall be available; in case of non-availability of type test certificates, fresh testing of the equipment in accordance with applicable codes & standards shall be done. All routine & acceptance test as per the applicable standards shall be conducted on the equipment.

b) EIL/ Owner may witness all factory tests. EIL/ Owner shall have entry and access at any time to all parts of manufacturer's facilities associated with manufacturing and testing of the system.

c) Contractor shall invite EIL/ Owner well in advance of the date at which the system is ready for testing.

d) Before dispatch of equipment from manufacturers work, Contractor shall prepare inspection report for individual equipment and same shall be submitted along with test certificates for EIL/Owner review and release note.

11.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as `Fragile', `This side up', `Center of gravity', `Weight',

Owner's particulars, Purchase order number etc., shall be clearly marked on the package together with other details as per Purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature. In order to prevent movement of equipment within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover and supplied along with the shipment.

12.0 FIELD INSPECTION, TESTING & COMMISSIONING

a) Site inspection, testing and commissioning of electrical installation shall be carried out as per EIL Standard Specification no. 6-51-0087.

b) All the equipment installed by the Contractor shall be tested and commissioned.

c) Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the Contractor shall carry out the rectification.

d) The Contractor shall carry out all the field tests as enumerated in the technical specification & technical documents which may be furnished to him during execution of the work.

e) Before the SPV system is made live, the Contractor shall carry out suitable tests to establish to the satisfaction of Engineer-in-Charge/Owner that the installation of equipment, wiring and connections have been correctly done and are in good working condition and that it will operate as intended.

f) All field tests shall be conducted in the presence of Owner/Engineer-in-Charge or his authorized representative unless he waives this requirement in writing. All testing equipment necessary to carry out the tests at site shall be arranged by the Contractor. The tests shall be recorded on approved Performa and certified records of the tests shall be submitted to Owner/Engineer-in-Charge.

g) After the completion of all tests and rectification of all defects pointed out during final inspection, system start-up trial would be commenced. Any defects noticed during the start-up trial relating to the equipment supplied and work carried out by the Contractor, will be rectified by the Contractor.

12.2 Site Acceptance Test (SAT)

a) Contractor shall prepare SAT documentation covering power distribution system in the plant & system functional testing and submit it for EIL/Owner review and approval. Site Acceptance Test shall be done based on the stipulation in the approved SAT document. Once the test is successfully performed, the temporary acceptance of the system shall be given. Only then the system would be ready for test run.

b) Contractor shall offer fully functional system for SAT when he has successfully commissioned all equipment, carried out all pre SAT and submitted the reports.

13.0 WARRANTY

13.1 The mechanical structures, electrical works & equipments including power conditioners/ inverters/ maximum power point tracker units/ distribution boards/ digital meters/ switchgear etc. and overall workmanship of the grid connected solar photovoltaic plant shall be warranted against any manufacturing/ design/ installation defects during the warranty period.

13.2 Contractor shall be fully responsible in respect of proper design, manufacture, quality workmanship and operation of all the equipment, accessories etc. supplied by the Contractor for the warranty period.

13.3 It shall be obligatory on the part of Contractor to modify and/or replace any equipment/component free of cost in case any malfunction is revealed even during on line operation after taking over within the warranty period.

13.4 **Performance Warranty:**

The predicted electrical degradation of power generated not exceeding 20% of the minimum rated power over the 25 year period and not more than 10% after ten years period of the full rated original output.

छोटे एम.वी. वैरीएबल फ्रीक्वेन्सी ड्राईव सिस्टम के लिए विनिर्देश

SPECIFICATION FOR SMALL MV VARIABLE FREQUENCY DRIVE SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	06 11 19	REVISED AND ISSUED AS STANDARD SPECIFICATION	MKM	HK	SA	RKT
1	20 08 14	REVISED AND ISSUED AS STANDARD SPECIFICATION	MK/SA	HK	BRB	SC
0	24 04 09	ISSUED AS STANDARD SPECIFICATION	AM	SG	JMS	ND

Abbreviations:

AC	:	Alternating Current
AFE	:	Active Front End
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CBCT	:	Core Balance Current Transformer
CEA	:	Central Electricity Authority
CFL	:	Compact Fluorescent Lamp
CRCA	:	Cold Rolled Cold Annealed
DC	:	Direct Current
DCS	:	Distributed Control System
DOL	:	Direct On Line
ELR	:	Earth Leakage Relay
EM	:	Electromagnetic
EMC	:	Electromagnetic Compatibility
FLC	:	Full Load Current
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IGBT	:	Insulated Gate Bipolar Transistor
I/O	:	Input/Output
IP	:	Ingress Protection
IS	:	Indian Standard
LCS	:	Local Control Station
LCP	:	Local Control Panel
LED	:	Light Emitting Diode
MCB	:	Miniature Circuit Breaker
MCCB	:	Moulded Case Circuit Breaker
MTBF	:	Mean Time Between Failure
NEMA	:	National Electrical Manufacturer's Association
PCC	:	Point of Common Coupling
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
r.m.s	:	Root Mean Square
THD	:	Total Harmonic Distortion
VDE	:	Verband Deutscher Electrotechniker
VFD	:	Variable Frequency Drive

Electrical Standards Committee

Convener : Ms. Sumita Anand

Members : Mr. Parag Gupta
Mr. M.K.Sahu
Ms. ANP Singh
Mr. Harish Kumar
Ms. Shalini Verma
Mr. Raman Sood
Ms. Shirali Aggarwal
Mr. Rajesh Sinha (Inspection)
Ms. N.P. Guha (Projects)

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1.0 SCOPE

The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Medium Voltage, AC Variable Frequency Drive (VFD) System for small ratings of air coolers and non critical applications (typically upto 55kW motor ratings). The VFD system shall be complete with Squirrel Cage Induction motor as specified in data sheet, Converter, DC link/AC line reactor with associated auxiliaries, filters(if required) and field mounted local motor control panel.

The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets.

This specification applies to drives connected to line voltage up to 1000 V, AC.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the latest editions of the following standards unless specified otherwise:

IS: 4411 Code of designation of semi-conducting devices

IS: 5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits

IS: 5469 Code of practice for the use of semiconductor Junction Devices

IS: 8789 Values of Performance characteristics for Three Phase induction motor

IS: 12615 Line Operated Three Phase a.c. Motors (IE CODE) - Efficiency Classes and Performance Specification

IS: 14901 Semi-conductor devices- Discrete devices & Integrated Circuits

IS: 15880 Three Phase Cage Induction motors when fed from IGBT Converters- Application Guide

IS 16724 / IEC 60079-14 Explosive Atmospheres — Electrical Installations Design, Selection and Erection

IEC 60068-2-60 Environmental testing: Tests -Flowing mixed gas corrosion test

IS/IEC 60079-0 Explosive atmospheres: Equipment - General requirements

IS/IEC: 60947 Low Voltage Switchgear and Controlgear

IEC: 60146 Semiconductor Convertors general requirements and line commutated convertors.

IEC 60721-3-3 Classification of environmental conditions: Classification of groups of environmental parameters and their severities - Stationary use at weather protected locations

IS/IEC 61439-0 Low-Voltage Switchgear and Controlgear Assemblies- Guidance to Specifying Assemblies

IS/IEC 61439-1 Low-voltage switchgear and control gear assemblies- General Rules

IS/IEC 61439-2 Low Voltage Switch Gear and Controlgear Assemblies- Power Switch Gear and Control Gear Assemblies

IEC 61800-2 Adjustable speed electrical power drive systems: General requirements - Rating specifications for low voltage adjustable speed A.C. power drive Systems

IEC 61800-3 Adjustable speed electrical power drive systems: EMC requirements and specific test methods

IEC 61800-5 Adjustable speed electrical power drive systems: Safety requirements - Electrical, Thermal, Energy and Functional.

IEC 61800-8 Adjustable speed electrical power drive systems: Specification of voltage on the power interface

IEC TS 60034-25 Rotating Electrical machines, AC electrical machines used in power drive systems – Application guide.

IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical Power Systems

ANI/ ISA-S71.04 Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants

ASTM B845 Standard Guide for Mixed Flowing Gas (MFG) Tests for Electrical Contacts

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 SITE CONDITIONS

3.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 40^{o}C and an altitude not exceeding 1000 metres above mean sea level shall be considered.

3.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurised room, as specified in data sheet.

3.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/ spares to enable the end user to place order for spares and services.

4.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification and attached data sheets.

4.5 VFD panels shall be sourced from the OEM of VFDs. VFD Panels from system groups / channel partners shall not be accepted.

5.0 TECHNICAL REQUIREMENTS

5.1 Performance Requirement

5.1.1 The system shall be energy efficient, and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 The VFD system shall be designed to deliver the motor input current (FLC) and torque for the complete speed torque characteristics of the load. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit. Necessary design in the VFD shall be considered to avoid / minimise drop in the output voltage of VFD. VFD sizing shall be done taking care of following:

- Input supply variation of +/-10% and frequency variation of +/- 3%.
- Steady state voltage drop across the AC drive including associated choke and internal / external filters on input & output side.
- Steady state voltage drops of 3% across cable from VFD to motor.

VFD sizing calculation shall be submitted by vendor for review/approval by Owner/EIL. Sizing for choke / filters shall be also provided for review / approval by Owner.

5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as specified in the data sheet:

a) Variable torque changing as a function of speed i.e. Speed squared
b) Constant torque over a specific speed range
c) Constant power over a specific speed range where the torque decreases when speed increases
d) Any other as specified in data sheet

5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 unless otherwise specified with speed set accuracy of ±1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.6 The dv/dt limits & V_{peak} shall be as per IEC-61800-2 & 60034-25 & same shall be considered in the design of motor.

5.1.7 The controller output overload capacity shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.

5.1.8 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in set point within a time limit up to 60 seconds.

5.1.9 The integrator action of the set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustment by the distributed control system shall be considered as 10 seconds.

5.1.10 Drive shall trip in case the speed exceeds 105% of the maximum operational speed and / or reduces to 95% of the minimum operational speed for more than 10 seconds.

5.1.11 Maximum noise level from the drive at 1 meter distance, under rated load with all normal cooling fans operating shall not exceed 75 dB(A).

5.1.12 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start-up adjustments and troubleshooting.

5.1.13 Harmonics shall be restricted within maximum allowable levels of current and voltage distortion as per recommendation of latest edition of IEEE519. To verify compliance to IEEE519 at switchboard level the necessary data related to switchboard like min. short circuit current (kA) , Load current , other linear and non linear loads connected to the switchboard and the working / standby configuration of the connected loads shall be provided by owner. Using the above required data the harmonics shall be analyzed and suitable mitigation solution shall be provided by vendor by providing suitable filters in VFD, 6/12 pulse VFD, AFE VFD etc.

5.1.14 VFD shall be provided with Auto-Reacceleration feature with facility of enabling/disabling this feature at site.

5.1.15 Vendor to provide suitable voltmeter at VFD output side (after filter) so that final output voltage at VFD end i.e. after taking into account voltage drop within VFD is available.

5.1.16 VFD System shall be designed to comply with EMC requirements as per IEC 61800-3 for conductive and radiated emission. Type test report for EMC compliance for VFD Panel shall be submitted by vendor. For longer cable lengths, requisite mitigation measures including providing suitable filters in VFD panels shall be provided by vendor to comply with EMC requirements. Design and construction of VFD shall also comply to safety requirements specified in IEC 61800-5.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips upto 20% of nominal (e.g. in case of a large motor start up connected to the same bus as VFD), shall not cause the control system to stop functioning and shall not trip the drive system

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2

seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of re-synchronizing onto running motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached standard specification for Medium Voltage Induction Motors.

5.2.5 The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed regulated corresponding to 4-20 mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

a) With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated / Digital potentiometer shall be provided as a speed set point device.

b) With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

c) Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, operator shall be able to start and speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above. (For local control station, also refer Cl. 5.5.6 below).

5.2.8 The required provision for the interface with PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/Data Highway Plus/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.

5.2.9 Temperature controller in VFD shall receive signal from thermistor provided in the motor. Contact of the same from temperature controller shall be used in Start Permissive.

5.3 Panel Construction

5.3.1 Each VFD system shall preferably be housed in separate stand alone panel fabricated using Galvanised steel or any other material complying with EMC requirements & unpainted from inside. The sheet steel used for the panel shall be of minimum 2 mm thickness except the doors & covers which will be of minimum 1.5mm thickness. Alternatively common panel(s) for several VFD systems can be considered, provided suitable barrier for full height are provided between different VFD module for safety, operation and maintenance.

The VFD panel(s) shall be suitable for indoor installation, if not otherwise specified. The panel(s) shall be free standing with degree of protection as min. IP-41 & type test report shall be submitted for the same. The maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.2 Each VFD module shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors, filters, output isolating device (for VFD with By-pass), control circuit, control accessories, indication and annunciation etc.

5.3.3 Main isolating device shall function as a manual disconnect and shall be an AC thermal-magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.

5.3.4 Bolted undrilled gland plate shall be provided at bottom with single compression type cable gland. Clamp type terminals shall be used for connection of all wires up to 10 mm^2 and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum clearance between gland plate to cable termination point for power cable termination shall be 300mm clear.

5.3.5 Bus bars shall be of electrolytic copper/aluminium, colour coded. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided. The type/material of construction for all name plates shall be preferably anodized aluminum or 3-ply (Black-White-Black) lamicoid sheets. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.3.6 All the power and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating. All components mounted on DIN RAIL shall be provided with end clamps except for components mounted firmly on base plates using screws.

5.3.7 Each panel shall be provided with LED type illuminating lamp with MCB & door limit switch for lamp control. 5/15A, 240V power socket with switch shall be provided. Each panel shall have space heater with variable setting thermostat. Dual pole MCB shall be provided for isolation and protection of utility components.

5.3.8 Copper earth bus of min. 30X6 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.

5.3.9 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.

5.3.10 All the control wiring shall be enclosed in plastic channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, flame retardant, low smoke, copper conductor wire. 1.5 mm^2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm^2 size for control fuse rating above 16 A for electrical circuits and 0.5 mm^2 for electronic circuits.

5.3.11 All electronic modules and components shall be accessible from front of panel only. Modular plug-in/draw-out assemblies for both the system control electronic equipment and power electronic equipments shall be used.

5.3.12 Suitable removable type hooks shall be provided for lifting the panel(s).

5.3.13 Conformal coating shall be done for all PCB, electronic equipments as per min. Class 3C2 (Harsh environment) of IEC 60721-3-3. Alternatively, it shall comply with ANSI/ ISA S71.04 class G3 or IEC 60068-2-60 for mixed flow gas test or ASTM B845.

5.3.14 Spare terminals of all the devices viz. relays, transducers, Digital/Analog I/O Boards etc. shall be wired upto panel terminal strip.

5.3.15 VFD Panel including insulator supports, conductors etc. shall be designed to withstand specified short circuit currents for a period of min. 1 sec. Short circuit type test report alongwith busbar sizing calculations shall be submitted by vendor. For small rated VFD protected with incoming SFU/MCCB feeders having fault current limiting features, prospective short circuit current shall be considered.

5.4 Cooling

Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

a) The motor shall be converter grade motor suitable for operation with a solid state power supply consisting of an adjustable frequency inverter for speed control and shall comply to IS 16724, IEC-60034-25 and relevant part of IS/IEC-60079.

b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c) The motor shall be designed to operate continuously at any speed over the range (1-100%) of rated speed or as specified in data sheet.

d) Motor shall be provided with thermistor type temperature detector.

e) The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.

f) Motor shall be designed suitable to deliver the torque required for complete speed torque characteristics of the load considering the voltage available at the motor terminals after taking into account supply voltage tolerances, voltage drop within VFD panel and voltage drop within cable as specified in cl. no. 5.1.2.

g) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in line voltage, frequency and starting current limitations as specified in data sheet.

h) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid state power supply.

i) The motor insulation shall be designed to accept the applied voltage wave form, within the V_{peak} and dv/dt limits as per IEC-61800-2 and 60034-25.

j) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

k) Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning. Insulated bearing (Non Drive End) shall be provided irrespective of motor frame size.

l) Motor for hazardous area application shall have valid type test certificate issued by recognized independent test house certifying that motor is suitable for converter duty application. Corresponding statutory approval (e.g. PESO/DGMC etc.) as applicable for the specified location shall also be furnished for the hazardous area motor.

5 5.2 **Power Converter**

a) The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter.

b) Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

c) All power converter devices shall include co-ordination by peak voltage protecting snubber networks and di/dt and dv/dt networks.

d) The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range.

e) All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.

f) The power converter circuit shall be designed so that motor can be powered at its full name plate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

g) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

h) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

i) All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I^2t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

5.5.3 **DC Link / AC line Reactor (if required as per vendor standard design)**

a) Smoothing reactors for the DC link shall be provided if required as per standard design of vendor. AC line reactors, if provided as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.

b) The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.

c) Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.4 **Output Filter**

VFD output current waveform shall be inherently sinusoidal at all speeds. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after a loss of AC voltage.

The VFD system shall inherently protect motor from high voltage dv/dt stress & Vpeak , independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.5 **Bypass Feature**

5.5.5.1 Output contactor or Load Break Switch shall be provided for isolation between the output of Controller and the motor for VFD systems with Bypass feature.

5.5.5.2 Bypass feature shall be provided, if specified in the data sheet along with VFD-Bypass selector switch. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:-

- Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & upto 55kW unless otherwise specified in the data sheet. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds.

- Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors/ breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.6 **Local Control Station**

The local control station shall conform to the attached standard specification(s).

Meters in the local control station for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

Vendor to ensure that suitably sized canopy shall be provide by vendor for outdoor LCS which will cover LCS from all 3 sides and protect the LCS from rain water in all directions.

Auxiliary AC power supply for LCP/LCS shall be derived by vendor.

LCS shall be provided with 20% spare terminals.

5.6 Protection, Control, Metering and Indication / Annunciation

5.6.1 The manufacturer shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor based system.

5.6.3 **Operator Control Panel**

Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for Run/Stop, Local/Remote, Increase/Decrease, menu navigation and parameter select/save. All parameter names, fault messages, warnings and other information shall be displayed in Complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics.

5.6.4 **Protective Features**

The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:

i) Under / Over voltage protection
ii) Phase loss, phase reversal protection
iii) Programmable Over current protection
iv) Inverter Fault protection
v) Over frequency /Over speed protection of motor
vi) Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm. Suitable sensors as required for same shall be provided)
vii) Over temperature protection of equipment
viii) Complete motor protection
ix) System Earth fault Protection

5.6.5 **Alarms**

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system etc.

5.6.6 **Controls**

The controls shall be provided as a part of the Operator Control Panel as per clause 5.6.3 above.

5.6.7 **Indications**

The following indications shall be provided as a part of the Operator Control panel.

i) Motor running
ii) Motor stopped
iii) VFD System Fault
iv) System ready to start
v) AC mains ON
vi) Motor over speed
vii) Drive 'ON'
viii) Motor zero speed
ix) Remote breaker trip

Potential free contacts of items i) - vii) shall be wired separately for indications in DCS system.

5.6.8 **Metering**

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

i) Input AC voltage
ii) Input AC frequency
iii) Input AC Current
iv) Output voltage
v) Output current VFD / Bypass
vi) Output frequency
vii) Drive thermal state
viii) Motor speed
ix) Motor energy meter
x) Run hour meter

Necessary dual type transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS under both VFD and Bypass mode of operation.

5.6.9 **Annunciations**

Potential free contacts shall be provided for following annunciation and shall be wired up to terminal block for owner's use for remote monitoring:

i) Drive fault

All drive internal faults will be annunciated as drive fault.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system.

5.8 Control Circuit

Control supply for devices external to VFD module i.e contactors control, indicating lamps, digital meters (Ammeter, Voltmeter, Speedometer) etc. shall operate on 240V control supply

derived from single-phase control supply transformer, with switch-fuse provided in primary and MCB in secondary, located inside the drive controller.

One No. 110V DC /110V AC/ 230V AC UPS Supply for each VFD panel shall be provided by owner for VFD control logic. Power supply at any other voltage shall be derived by vendor. Conversion of this 110V DC / 110V AC / 230V AC supply to any other voltage level or to AC/DC power supply shall be take care by vendor by providing suitable converter/inverter module inside VFD panel.

240V AC space heater supply for panel and motor space heater shall be provided from external source by owner.

5.9 Reliability Features

i) The expected life time of the VFD shall be minimum 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

ii) The controller design shall incorporate the following reliability features:
- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.10 Maintenance Features

The controller design shall incorporate the following maintenance features:
- Modular construction
- Printed circuit boards shall be plug connected.
- All components shall be easily accessible from the front of the enclosure.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be RAL-7032, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the VFD shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of EIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 Complete VFD system (as defined in Cl.1.0 above) shall be offered for test & inspection as per EIL Std. ITP 6-81-1038. In case combined testing requirement is mentioned in PR/Data sheet, testing shall be carried out on Complete VFD with Job motor as per EIL Std. ITP 6-81-1038. For hazardous area application, requirements specified in cl. no. 5.5.1.l) above shall also be complied.

6.4. String Test with Driven Equipment

If a string test with driven equipment is required, this will be mentioned in the data sheet of the driven equipment.

7.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

मध्यम एवं उच्च वोल्टेज केबल एवं असेसरिज के लिए विनिर्देश

SPECIFICATION FOR MEDIUM AND HIGH VOLTAGE CABLES & ACCESSORIES

Rev. No	Date	Purpose	Prepared by	Checked by	StandardsCommitteeConvenor Approved by	Standards Bureau Chairman
9	30/06/22	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	RSR	MKS	SM
8	20/01/17	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	BRB	RN
7	01/04/16	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	BRB	RN
6	11/04/11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM

Abbreviations:

ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CEA	:	Central Electricity Authority
DGMS	:	Director General of Mines and Safety
EIL	:	Engineers India Limited
EPR	:	Ethylene Propylene Rubber
FR	:	Flame Retardant
FRLS	:	Flame Retardant Low Smoke
FS	:	Fire Survival
ICEA	:	Insulated Cable Engineers Association
IEC	:	International Electro technical Commission
IEEE	:	The Institute of Electrical & Electronic Engineers
IS	:	Indian Standards
LF	:	Low Frequency
NEMA	:	National Electrical Manufacturers Association
PE	:	Polyethylene
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
UV	:	Ultra Violet
XLPE	:	Cross linked Polyethylene

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1.0 SCOPE

This specification along with data sheets covers requirements for design, manufacture, testing at works and supply of Fire survival Medium voltage cables and Flame Retardant Low Smoke Medium & High Voltage cables and cable jointing / terminating accessories for medium and high voltage systems.

2.0 STANDARDS

2.1 The cables and cables jointing & terminating accessories shall comply with the latest edition of the following standards as applicable:

IS: 209	:	Specification for zinc.
IS: 1554 Part-1	:	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V (including amendment no. 1, 2, 3, 4 & 5)
IS:1554 Part-2	:	Specification for PVC insulated (heavy duty) electric cables for working voltages from 3.3 kV up to and including 11 kV (including amendment no. 1, 2, 3 & 4)
IS: 3961(Pt-6)	:	Recommended current rating for cables: Part- 6 Cross-linked Polylene insulated PVC sheathed cables
IS: 3961(Pt-7)	:	Recommended current ratings for cables part 7 cross-linked insulated thermoplastic sheathed cables
IS: 3975	:	Mild steel wires, strips and tapes for armouring of cables.
IS: 5831	:	PVC insulation and sheath of electric cables.
IS: 6380	:	Specification for elastomeric insulation and sheath of electric cables.
IS: 7098 Part-1	:	Cross linked polyethylene insulated PVC sheathed cables for working voltage upto and including 1100V (including amendment no. 1,2,3,4 & 5)
IS: 7098 Part-2	:	Cross linked polyethylene insulated thermoplastics sheathed cables for working voltages from 3.3 kV up to and including 33 kV (including amendment no. 1 & 2)
IS: 8130	:	Conductors for insulated electric cables and flexible cords.
IS: 10418	:	Drums for electric cables.
IS:10462 (Pt-1)	:	Fictitious calculation method for determination of dimensions of protective coverings of cables: Part - I Elastomeric and thermo-plastic insulated cables.
IS: 10810	:	Methods of test for cables: - Part 41: Mass of zinc coating on steel armour - Part 58: Oxygen index test - Part-61: Flame retardant test - Part-62: Fire resistance test for bunched cables. - Part-63: Measurement of Smoke density of Electric cables under fire conditions
IS: 13573 (Pt-1):		Cable accessories for extruded power cables - part 1 for working voltages for 1.1 kv upto and including 3.3kV (E) - test methods and test requirements
IS: 13573 (Pt-2):		Cable accessories for extruded power cables - part 2 for working voltages for 3.3kV (UE) upto and including 33kV (E) - test requirements
IS: 13573 (Pt-3):		Cable accessories for extruded power cables - part 3 for working voltages for 3.3kV (UE) upto and including 33kV (E) - test methods
IS: 16269	:	Recommended short circuit ratings of electric cables with rated voltage from 1.1kV to 220kV

IEC: 60331-21	:	Tests for electric cables under fire conditions circuit integrity – Procedures and requirements – Cables of rated voltage up and including 0.6/1.0kV.
IEC: 60332-1	:	Test of the fire behaviour on single core or single cable (flame retardancy)
IEC: 60332-3	:	Tests of the fire behaviour on bunched cables (reduced flame propagation)
IEC-60754-1	:	Test on gases evolved during combustion of materials from cables, Determination of the amount of halogen acid gas content
IEC: 61034	:	Measurement of smoke density of cables burning under defined condition
NEMA-WC53	:	Standard test methods for extruded dielectric power, control, instrumentation and portable cables for test.
IEEE-383	:	Standard for qualifying electrical cables and splices for nuclear facilities
ASTM-G-154	:	Standard practice for operating fluorescent light apparatus for UV exposure of non metallic materials.
ASTM-D-2863	:	Measurement of minimum oxygen concentration to support candle like combustion of plastics
BS: 7846	:	Electric cables- 600/1000V armoured fire resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.

2.2 The cables and accessories shall also conform to the provisions of CEA Regulations and other statutory regulations, as applicable.

2.3 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However, Owner's decision in this regard will be final and binding.

3.0 GENERAL CONSTRUCTION

3.1 The cables shall be suitable for laying in trays, trenches, ducts, and conduits and for underground-buried installation with uncontrolled backfill and possibility of flooding by water and chemicals.

3.2 Outer sheath of all cables shall be black in colour and the minimum value of oxygen index shall be 29% at 27 ± 2 ° C. In addition suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack. However, for earthing cables; colour of outer sheath shall be green.

3.3 All cables covered in this specification shall be Flame Retardant Low Smoke (FRLS) or Fire Survival (FS). The outer sheath of FRLS cables shall possess flame propagation properties meeting requirements as per IS-10810 (Part-62) category AF. FRLS cable shall be identified by indenting, embossing or printing the appropriate legend i.e. 'FRLS, Category – C2' throughout the cable length. FRLS properties shall be as per IS:10810 Part 61 & 62, IEC-60332 Part 1 & Part 3, IEEE-383, IEC-61034, IEC-60754 Part 1, ASTM-D-2863.

3.4 Sequential marking of the length of the cable in metres shall be provided on the outer sheath at every one metre. The embossing/engraving shall be legible and indelible.

3.5 The overall diameter of the cables shall be strictly as per the values declared by the manufacturer in the technical information subject to a maximum tolerance of ±2 mm up to overall diameter of 60mm and ±3mm for beyond 60mm.

3.6 PVC/ Rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand metre length. In addition, ends of the cables shall be properly sealed with caps to avoid ingress of water during transportation and storage.

3.7 The joints in armour wire/strips shall be made by brazing or welding and any surface irregularities shall be removed. A joint in any wire/strip shall be at least 300mm. from the nearest joint in any wire/strip in the complete cable.

3.8 The cables meant to be used in mining area under the jurisdiction of DGMS shall satisfy the following

(a) "DGMS CERTIFIED" to be embossed at outer sheath at regular interval.

(b) Cables to be used in Mines shall have copper conductor only.

(c) The resistance of armour shall not exceed that of the conductor as specified in IS-8130 by more than 33%. To satisfy this, substitution of galvanised steel wire/strip in armouring by the required number of tinned copper wires/strips is permissible.

(d) For mining cables, the size and type of armour shall be such that the combined conductance of armour shall be equivalent to 75 percent of the conductance of the largest conductor of the cable.

3.9 Medium Voltage Cables

3.9.1 All power/control cables for use on medium voltage systems shall be heavy-duty type, 650/1100V grade with aluminium/ copper conductor (as mentioned in datasheet / Material requisition), XLPE insulated, inner-sheathed, armoured/ unarmoured and overall PVC sheathed. XLPE insulated cables shall meet the requirement specified in IS-7098 (Part-1).

3.9.2 The conductors shall be stranded for all sizes of MV power cable. Conductors of nominal area less than 16 mm^2 shall be circular only. Conductors of nominal area 16 mm^2 and above may be circular or shaped as per IS 8130. Cables with reduced neutral conductor shall have sizes as per Table- 2 of IS 7098 (Part-1).

3.9.3 The core insulation shall be with XLPE compound applied over the conductor by extrusion. It shall conform to the properties given in Table-1 of IS: 7098 (Part-1).

3.9.4 The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of Type ST-2 PVC compound as per IS: 5831. The minimum thickness of inner sheath shall be as per Table-5 of IS: 7098 (Part-1). Single core cables shall have no inner sheath.

3.9.5 All cables shall be provided with armour except those specifically specified as unarmoured. For single core cables intended for use on AC system, the armouring shall be of non-magnetic material. For multicore cables, the armour shall be by single round galvanised steel wires where the calculated diameter below armouring does not exceed 13 mm and by galvanised steel strips where this dimension is greater than 13 mm. Requirement and methods of tests for armour material and uniformity of galvanisation shall be considered as per IS - 3975 and IS - 10810 (Part 41). The dimensions of armour shall be considered as per method (b) of Table-6 of IS - 7098 (Part -1). For single core cables, the armour shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter for cable having calculated diameter under armour upto 55 mm. In case of calculated diameter under armour is more than 55 mm. Table-6 of IS: 7098 (Part-1) shall be followed for dimension of armour.

3.9.6 The outer sheath for the cables shall be applied by extrusion and shall be formulated for lower smoke and shall be of PVC compound conforming to the requirements of type ST-2

compound as per IS: 5831. The minimum and average thickness of outer sheath for unarmoured cables and minimum thickness of outer sheath for armoured cables shall be as per Table-8 of IS: 7098 (Part -1).

3.9.7 For XLPE insulated cables, it shall be possible to continuously operate the cable at a maximum conductor temperature of 90°C under full load condition and 250°C under short-circuit condition.

3.9.8 The fire survival cables shall meet the following additional requirements :

i) The insulation shall be of EPR or equivalent material with glass mica tape below or above insulation.

ii) The cables shall meet requirement of circuit integrity test for a minimum period of 3 hours at maximum temperature of 950° C.

3.10 High Voltage Cables

3.10.1 Power cables from 3.3kV and up to and including 33kV systems shall be Aluminium/ Copper conductor, XLPE insulated, sheathed, armoured/ unarmoured and overall PVC sheathed.

3.10.2 The conductors shall be stranded and compacted circular for all cables.

3.10.3 All cables rated 3.8/ 6.6kV and above shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi conducting screen.

3.10.4 The core insulation shall be with cross linked polyethylene insulating compound dry cured, applied by extrusion. It shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. It shall conform to the properties given in Table-1 of IS: 7098 (Part-2).

3.10.5 The insulation screen shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic copper screen. The copper screen for all the three cores together shall be capable of carrying the single line to ground fault current value and the duration specified in the data sheet. For single core cable, copper screen provided shall be capable of carrying the single line to ground fault current value and the duration specified in the data sheet. For screen sizing, final temperature shall be considered as 200°C under adiabatic condition as per IS: 16269.

3.10.6 The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.

3.10.7 The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST 2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness. The minimum thickness of inner sheath shall be as per Table-5 of IS: 7098 (Part-2). In case of single core cables, there shall be extruded inner sheath between insulation metallic screen and armouring.

3.10.8 All cables shall be provided with armour except those specifically specified as unarmoured. For single core cables intended for use on AC system, the armouring shall be of non-magnetic material. For multicore cables, the armour shall be by galvanised steel strips. Requirement and methods of tests for armour material and uniformity of galvanisation shall be as per IS-3975 and IS -10810 (Part 41). The dimensions of armour shall be as per method (ii) of Table-6 of IS -7098 (Part -2). For single core cables, the armour shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter for cable having calculated diameter under armour

upto 55 mm. In case of calculated diameter under armour is more than 55 mm. Table-6 of IS: 7098 (Part-2) shall be followed.

3.10.9 The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of Type ST 2 compound of IS: 5831. The minimum and average thickness of outer sheath for unarmoured cables and minimum thickness of outer sheath for armoured cables shall be as per Table-7 of IS: 7098 (Part-2).

3.10.10 The thickness of the insulation, inner sheath shall be governed by values given in Table-4 and Table-5 of IS: 7098 (Part -2).

4.0 CABLE ACCESSORIES

4.1 The termination and straight through jointing kits for use on the systems shall be suitable for the type of cables offered as per this specification and shall meet requirements of IS 13573.

4.2 The accessories shall be supplied in kit form. Each component of the kit shall carry the manufacturer's mark of origin.

4.3 The kit shall include all stress grading, insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.

4.4 The contents of the accessories kit including all consumable shall be suitable for storage without deterioration at a temperature of 45° C, with shelf life extending to more than 5 years.

4.5 Terminating Kits

The terminating kits shall be suitable for termination of the cables to an indoor switchgear or to a weatherproof cable box of an outdoor mounted transformer/ motor. For outdoor terminations, weather shields/ sealing ends and any other accessories required shall also form part of the kit. The terminating kits shall be from one of the makes/ types mentioned in the data sheet.

4.6 Jointing Kits

The straight through jointing kits shall be suitable for installation on overhead trays, concrete lined trenches, and ducts and for underground burial with uncontrolled backfill and possibility of flooding by water and chemicals. These shall have protection against any mechanical damage and suitably designed to be protected against rodent and termite attack. The inner sheath similar to that provided for cables shall be provided as part of straight through joint. The jointing kits shall be from one of the makes/ types mentioned in the data sheet.

5.0 INSPECTION, TESTING AND ACCEPTANCE

The cables shall be tested and inspected at the manufacturer's works. Manufacturer shall furnish all necessary information concerning the raw material supply to EIL/ Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality. For HV cables, the vendor shall give at least 2 weeks advance notice to the purchaser, regarding the date of testing to enable purchaser's representative to witness the tests.

5.1 Cables

5.1.1 After completion of manufacture of cables and prior to despatch, the cables shall be subjected to type, routine, acceptance and special tests as detailed below. The test reports for all cables shall be got approved from the Engineer before despatch of the cables.

5.1.2 All routine tests, acceptance tests, type tests and additional type tests for improved fire performance shall be carried out as listed in IS: 7098 (Part-1 & Part-2) on XLPE insulated cables.

5.1.3 The test requirements for PVC sheath of cables shall be as per latest revision of IS: 5831.

5.1.4 Test for Resistance to Ultra Violet Radiation: This test shall be carried out as per ASTM-G-53 or ASTM-G-154 on outer sheath. The retention value of tensile strength and ultimate elongation after the test shall be minimum 60 % of tensile strength and ultimate elongation before the test. Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by EIL before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognised test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided outer sheath remains same.

5.1.5 Acceptance tests as per IS-7098 (Part-1 & Part-2) and the following special tests to be performed on the cables as per sampling plan for all cables. However these tests are required to be witnessed by EIL/ Owner for HV cables.

a. Accelerated water absorption test for insulation as per NEMA-WC-53 (for XLPE/ EPR insulated cables). Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by EIL before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided type of insulation remains same.

b. Oxygen Index Test: The test shall be carried out as per IS-10810 (Part 58). Sampling to be done for every offered lot/size as per sampling plan.

c. Flammability Test: The test shall be carried out on finished cable as per IS-10810 (Part 61 & 62). Sampling for these tests is to be done randomly once for each order, provided outer sheath remains same. The acceptance criteria for tests conducted shall be as under:

Part-61-The cable meets the requirement if there is no visible damage on the test specimen within 300 mm from its upper end

Part-62-The maximum extent of the charred portion measured on the test sample should not have reached a height exceeding 2.5 m above the bottom edge of the burner at the front of the ladder.

d. Test for rodent and termite repulsion property shall be done by analysing the property by chemical method.

5.1.6 Following tests shall be carried out to prove FRLS property of the cable.

a. Critical oxygen index as per ASTM-D-2863 i.e. Determination of % of oxygen required for combustion at room temperature of FRLS sheath which shall remain as 29% (min.)

b. Temperature index as per ASTM-D-2863 i.e. to determine at what temperature normal oxygen content of 21% in air will support combustion of FRLS sheath which shall remain as 250°C.

c. Halogen acid gas emission as per IEC-60754 Part 1 i.e. to determine the % of release of hydrochloric acid gas from the FRLS sheath under fire which shall be 20% (max.)

d. Smoke Density Test shall be as per ASTM D - 2843 and Smoke Density Rating of FRLS Sheath shall be 60% (max.).

5.1.7 The test for circuit integrity for fire survival cables shall be carried out as per IEC-60331 (Part-21).

5.2 Cable Accessories

Type tests should have been carried out to prove the general qualities and design of a given type of termination/ jointing system as per IS-13573. The type test certificates from independent testing laboratory shall be submitted before despatch.

6.0 PACKING AND DESPATCH

6.1 Cables shall be despatched in non-returnable steel drums of suitable barrel diameter, securely packed, with the take-off end fully protected against mechanical damage. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit or storage.

6.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, voltage grade of cable, length of cable in metres, drum no., cable code, BIS certification mark, gross weight etc. shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

6.3 Cables shall be supplied in drum lengths as follows:

6.3.1 **MV Cables**

-	Multicore Power cables upto 50 mm^2	:	2000 m
-	Multicore Power cables from 70 mm^2 up to 500 mm^2	:	1000 m
-	Single Core Power cables upto 630 mm^2	:	1000 m

6.3.2 **HV Power Cables Upto 11kV Grade**

-	Three Core cables upto 400 mm^2	:	750 m
-	Single Core cables upto 400 mm^2	:	1000 m
-	Single Core cables above 400 mm^2 and upto 1000 mm^2	:	750 m

6.3.3 **HV Power Cables Above 11kV Grade and upto 33kV Grade**

-	Three Core cables upto 300 mm^2 grade	:	500 m
-	Single Core cables upto 400 mm^2	:	1000 m
-	Single Core cables above 400 mm^2 and upto 1000 mm^2	:	500 m

However exact drum lengths shall be finalised during order execution. A tolerance of ± 3 % shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to (-2%) to (+0%).

संचार, अग्नि चेतावनी और कंट्रोल पेयर्ड केबल के लिये विनिर्देश

SPECIFICATION FOR COMMUNICATION, FIRE ALARM AND CONTROL PAIRED CABLES

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	07/04/21	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	PG	SM
6	01/04/16	REVISED AND ISSUED AS STANDARD SPECIFICATION	RG	MKS	BRB	RN
5	27/04/11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
4	25/04/08	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
3	21/03/03	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	SKG

Abbreviations:

ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CEA	:	Central Electricity Authority
DGMS	:	Director General of Mines and Safety
DOT	:	Department of Telecommunications (Government of India)
EIL	:	Engineers India Limited
EPR	:	Ethylene Propylene Rubber
FR	:	Flame Retardant
FRLS	:	Flame Retardant Low Smoke
FS	:	Fire Survival
IEC	:	International Electro technical Commission
IEEE	:	The Institute of Electrical & Electronics Engineers
IS	:	Indian Standards
LF	:	Low Frequency
PE	:	Polyethylene
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
UV	:	Ultra Violet
XLPE	:	Cross Linked Poly Ethylene

Electrical Standards Committee

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1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture and supply of Flame Retardant Low Smoke type and Fire Survival type paired PVC sheathed control cables and cables for use in plant communication & fire alarm systems and jelly filled telecommunication cables.

2.0 CODES AND STANDARDS

The equipment shall comply with the requirements of the latest revision of the following standards:

2.1 BIS and other Standards

ASTM-D-883	:	Standard terminology relating to plastics.
ASTM-D-2863	:	Measurement of minimum oxygen concentration to support candle like combustion of plastics.
ASTM-G-154	:	Standard practice for operating fluorescent light apparatus for UV exposure of non-metallic materials.
ASTM-D-924	:	Standard test method for dissipation factor (or power factor) and relative permittivity (dielectric constant) of electric insulating liquids.
BS-6234	:	Specification for polyethylene insulation and sheath of electric cables.
IS-694	:	Polyvinyl Chloride Insulated Unsheathed and Sheathed Cables/cords With Rigid and--Flexible Conductor for Rated Voltages--Up to and Including 450/750V.
IS-1554 (Part-1)	:	PVC insulated (heavy duty) electric cables: Part 1 for working voltages up to and including 1100V.
IS-3975	:	Mild steel wires, formed wires and tapes for armouring of cables.
IS-5831	:	PVC insulation and sheath of electric cable.
IS-6380	:	Elastomeric insulation and sheath of electric cables.
IS-7098 (Part-1)	:	Cross Linked polyethylene insulated PVC sheathed cables: For working voltage up to and including 1100 V.
IS-8130	:	Conductors for insulated cables and flexible cords.
IS-9938	:	Recommended colours for PVC insulation for LF wires and cables.
IS-9968	:	Elastomer insulated cables: Part 1 For working voltages upto and including 1100 V.
IS-10418	:	Drums for electric cables.
IS-10462 (Part 1)	:	Fictitious calculation method for determination of dimensions of protective coverings of cables (Part-1: Elastomeric and thermoplastic insulated cables).
IS-10810	:	Methods of Test for Cables: - Part 41: Mass of zinc coating on steel armour. - Part 58: Oxygen index test. - Part-61: Flame retardant test. - Part-62: Fire resistance test for bunched cables. - Part-63: Measurement of Smoke density of Electric cables under fire conditions.
IS-12444	:	Continuously cast and rolled electrolytic copper wire rods for electrical conductors.
IEC: 60331-21	:	Tests for electric cables under fire conditions circuit integrity – Procedures and requirements – Cables of rated voltage up and including 0.6/1.0kV.
IEC: 60332-1	:	Test of the fire behavior on single core or single cable (flame retardancy).

IEC-60332-3	:	Tests of the fire behavior on bunched cables (reduced flame propagation).
IEC-61034	:	Measurement of smoke density of cables burning under defined condition.

2.2 **DOT Standards**

GR/WIR-06/03	:	Specification for cable - switchboard (Screened and Unscreened) - Generic requirements.
GR/CUG-01/03	:	Specification for solid polythene insulated fully filled, polythene sheathed underground telecom cables.

2.3 In case of imported cables, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.4 The cables shall also conform to the provisions of the CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.5 In case Indian standards are not available for any material, standards issued by IEC or equivalent agency shall be applicable.

2.6 In case of any contradictions between various referred standard/specification/data sheet and statutory regulations, the most stringent one shall govern and decision of owner/EIL in this regard will be final and binding.

3.0 GENERAL CONSTRUCTION

3.1 Cables shall be suitable for installation in following conditions:

i. Above ground in open-air locations (trays/ ducts) in tropical, humid and corrosive atmosphere prevalent in refineries/ petrochemical plants with severe weathering and exposure to solar radiation.

ii. Directly buried in underground trenches, conduits with uncontrolled back-fill and possibility of flooding by water and chemicals.

iii. Design ambient air temperature of 40°C/ ground temperature of 30°C.

3.2 The joints in armour wire/strips shall be made by brazing or welding and any surface irregularities shall be removed. A joint in any wire/strip shall be at least 300mm from the nearest joint in any wire/strip in the complete cable.

3.3 The cable meant to be used in mining area under jurisdiction of DGMS shall satisfy the following:

a. "DGMS CERTIFIED" to be embossed at outer sheath at regular interval.
b. The resistance of armour shall not exceed that of the conductor as specified in IS: 8130 by more than 33%. To satisfy this, substitution of galvanized steel wire/strip in armouring by the required number of tinned copper wires/strips is permissible.
c. For mining cables, the size and type of armour shall be such that the combined conductance of armour shall be equivalent to 75% of the conductance of the largest conductor of the cable.

4.0 TECHNICAL REQUIREMENTS FOR NON JELLY FILLED CABLES

4.1 The control cable shall be heavy duty type, 650/1100V grade with copper conductor, XLPE insulated, twisted pair, individual pair screened/shielded, overall screened/shielded, inner sheathed, armoured and PVC overall outer sheathed.

4.2 Non jelly filled communication and fire alarm cables shall in general conform to the requirements of DOT specification GR/WIR-06/03.

4.3 **Conductors**

4.3.1 The size of conductor shall be as per job requirements/data sheets.

4.3.2 The conductors shall consist of annealed, high conductivity copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/WIR-06/03.

4.3.3 The conductor shall be stranded for the control cables and shall be solid for fire alarm and communication cables.

4.4 **Insulation**

4.4.1 For fire alarm and communication cable, the core insulation shall be with PVC compound applied over the conductor by extrusion.

4.4.2 For control cable, the core insulation shall be with Cross Linked Poly Ethylene (XLPE) compound cured, applied over the conductor by extrusion. It shall be free from voids and shall conform to the properties given in Table-1 of IS: 7098 (Part-1).

4.4.3 PVC Insulation shall meet the following requirements:

Conductor Diameter (Area)	Type of Insulation	Thickness of Insulation (Minimum)
Up to 0.5mm ($0.2mm^2$)	Type-A as per IS-5831	0.18 mm
Above 0.5mm ($0.2mm^2$) & up to 0.71mm (0.4mm2)		0.26 mm
Above 0.71mm ($0.4mm^2$) & up to 0.9mm (0.63mm2)		0.31 mm
Above 0.9mm ($0.63mm^2$) & up to 1.12mm ($1mm^2$)		0.39 mm
Above 1.12mm ($1mm^2$) & up to 1.38mm ($1.5mm^2$)		0.58 mm
1.78mm ($2.5mm^2$)		0.71 mm

4.4.4 The nominal thickness of XLPE insulation for $1.5mm^2$ and $2.5mm^2$ conductor size control cables shall be 0.7mm in line with Table-3 of IS: 7098 (Part-1).

4.4.5 The colour used for insulation shall conform as nearly as practicable to the standard colours as per IS-9938. The wire insulation shall have colours in accordance with Table-2 of DOT specification GR/WIR-06/03. The applied colour shall neither have deleterious effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.

4.4.6 For single pair cables, the colour shall be incorporated in the insulation.

4.4.7 For multi pair cables, cores shall have uniform pattern of continuous spiral (Pitch not exceeding 25mm) to facilitate easy identification. This may be done by the application of one or more coloured strips on a base colour or by direct extrusion.

4.4.8 Alternately, colouring may consist of concentric coloured rings or dots or dashes on the base colour. The coloured rings, dots or dashes shall have a width of not less than 1.0mm and shall be repeated along the length of the insulation at an interval not less than 15mm and not more than 25mm.

4.4.9 The dots or dashes shall be applied on diametrically opposite sides of the insulation, so that all colours are visible when the insulation is viewed from any side.

4.4.10 In addition to colouring, control cables shall also be identified with prominent and indelible Alpha Numeric numerals on the outer surface of the insulation/ screen. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50mm between two consecutive numbers.

4.5 **Twisting**

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 80mm.

4.6 **Core Formation**

The core formation shall conform to Cl. 6.0 of DOT specification no. GR/WIR-06/03.

4.7 **Screen/ Shield**

4.7.1 The control cables shall be provided with individual pair screen/shield and also overall screen/shield. Fire alarm and communication cables shall be provided with overall screen/shield. The screen/shield shall be of aluminium tape with minimum thickness of 0.04mm. The overlap shall be minimum 3mm for cables up to 50 pair & minimum 6mm for cables above 50 Pair. The screen/shield shall be backed by an outer protective layer of 0.13mm PVC tape or other non-hygroscopic material lapped applied longitudinally or helically with overlap.

4.7.2 The cables shall be provided with a drain wire. Drain wire shall have a minimum cross-section of 0.5mm^2, shall be composed of multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the overall screen/shield. The drain wire resistance including screen shall not exceed 30 ohm/km.

4.8 **Ripcord**

A non-metallic ripcord of suitable quality shall be laid longitudinally under the inner sheath & overall screen/shield. The ripcord when pulled shall cut through the sheath and strip the core.

4.9 **Inner Sheath**

4.9.1 An extruded inner sheath of type ST1 PVC, as per IS-5831, with minimum thickness as per Table-4 of IS-1554 (Part-1) shall be provided for PVC insulated cable. For XLPE insulated cable, an extruded inner sheath of type ST2 PVC, as per IS-5831, with minimum thickness as per Table-5 of IS-7098 (Part-1) shall be provided. It shall be applied over the laid up core, by extrusion to fit closely on it.

4.9.2 The inner sheath shall be as circular as possible. It shall be possible to remove the inner sheath without damage to the insulation.

4.9.3 When one or more layers of non-hygroscopic tape is helically applied over the laid up cores, as a binder, the thickness of such tape(s) shall not be construed as a part of the inner sheath.

4.10 **Armour**

4.10.1 The cables shall be provided with armouring, made of hot dip galvanized steel wire /strip over the inner sheath.

4.10.2 The armour shall be by means of 1.4mm thick round wires for cables with under armour diameter up to 13mm. For cables with an under armour diameter above 13mm, the armour shall be of flat steel strip with thickness as per IS-1554 (Part-1) or IS-7098 (Part-1), as applicable.

4.11 **Outer Sheath**

4.11.1 The cables shall be provided with an extruded PVC sheath for external protection. The PVC shall be type ST1 PVC, as per IS-5831 for PVC insulated cable and type ST2 PVC, for XLPE insulated cable.

4.11.2 All cables covered in this specification shall be flame retardant low smoke (FRLS). The outer sheath shall be with oxygen index minimum 29% at 27$\pm$2^{0}C and shall possess flame propagation properties meeting requirements as per IS: 10810 (Part-62) category AF. FRLS cables shall be identified by indenting, embossing or printing an appropriate legend i.e. 'FRLS, Category – C2' throughout the cable length. FRLS properties shall be as per IS: 10810 Part 61 & 62, IEC-60332 Part 1 & Part-3, IEEE-383, IEC-61034, IEC-60754 Part-1, ASTM-D-2863.

4.11.3 In addition, suitable chemicals shall be added to the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

4.11.4 The thickness of outer sheath shall be as per IS-7098 (Part 1) for XLPE insulated cable and as per IS-1554 (Part-1) for PVC insulated cable.

4.11.5 The outer sheath shall fit tightly on the armour and shall be applied in such a manner that no undue residual strain is left in the material.

4.11.6 The outer sheath shall be red in colour for cables to be used for fire alarm system, grey in colour for cables to be used for telephone & communication system and black in colour for control cables.

4.11.7 Sequential marking of the length of the cable, in meters, shall be provided on the outer sheath at every one meter. The marking shall be legible and indelible by suitable method.

4.11.8 The overall diameter of the cables shall be strictly as per the values declared in the data sheet, subject to a maximum tolerance of $\pm$2mm.

4.11.9 The fire survival cables (if specified in specification/ data sheet) shall meet the following additional requirements:

i) The insulation shall be of EPR or Silicone rubber or equivalent material with glass mica tape below or above insulation.

ii) The cables shall meet requirement of circuit integrity test for a minimum period of 3 hours at maximum temperature of 950^0 C.

iii) Vendor shall have the test certificate for circuit integrity test as per IEC: 60331-21.

4.12 **Cable Capacitance**

4.12.1 The core to core capacitance of the cables shall not exceed 100nF/km at 1kHz.

4.12.2 The core to screen capacitance for the screened cables shall not exceed 250nF/km at 1kHz.

5.0 TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES

5.1 Jelly filled telecom cables shall in general conform to the requirements of DOT specification GR/CUG-01/03.

5.2 **Conductors**

5.2.1 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/CUG-01/03.

5.3 **Insulation**

5.3.1 Each conductor shall be insulated with insulating grade PE conforming to Cl. 4.0 of DOT specification GR/CUG-01/03.

5.4 **Twisting**

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 150mm.

5.5 **Core Formation**

The core formation shall conform to Cl. 6.0 of DOT specification GR/CUG-01/03.

5.6 **Filling Compound**

5.6.1 The cable core shall be filled with a suitable stable water resistant compound, which shall be compatible with the insulation, binders and tapes used in the cable.

5.6.2 It shall be homogeneous and uniformly mixed material containing an anti-oxidant.

5.6.3 The compound shall not obscure the identification of the colour of the insulation of the conductors.

5.6.4 It shall not contain dirt, metallic particles or other foreign matter.

5.6.5 The compound shall be readily removable from the insulated conductors by wiping.

5.6.6 It shall be free from any unpleasant odour and shall have no toxic or dermatic hazards.

5.6.7 The flash point of the compound shall not be less than 200°C.

5.6.8 The volume resistivity measured at 100°C shall not be less than 10^{10} ohm-cm.

5.6.9 The permittivity at 1 MHz tested as per ASTM D-924 shall not be greater than 2.3 at 20°C.

5.7 **Core Wrapping**

At least one closed helical or longitudinal application of a non-hygroscopic and non-wicking polyester tape or tape of any other suitable material shall be provided over the cable core.

5.8 **Screen/ Shield**

5.8.1 The cables used for telephone system shall be provided with overall screen/shield. The screen/ shield shall be of aluminium tape with minimum thickness of 0.2mm. The overlap shall be minimum 3mm for cables having maximum diameter over inner sheath < 30mm & minimum 6mm for cables having maximum diameter over inner sheath ≥ 30mm. The screen/shield shall be coated with 0.05 mm nominal thickness polythene/copolymer on both sides. The thickness of the composite tape shall be 0.3mm ± 15%.

5.8.2 The aluminium tape shall be electrically continuous throughout the length of the cable.

5.9 **Inner Sheath**

5.9.1 The inner sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.9.2 The inner sheath shall be of polythene conforming to type 03C or H03C of BS 6234 and shall contain a suitable antioxidant system. The material shall be virgin as per ASTM D-883 and meet the requirements of Cl. 10.1 of DOT specification no. GR/CUG-01/03.

5.9.3 The thickness of inner sheath shall conform to Table-6 of DOT specification no. GR/CUG-01/03.

5.9.4 The maximum diameter over inner sheath shall conform to Table-7 of DOT specification no. GR/CUG-01/03.

5.10 **Armour**

5.10.1 The cables shall be provided with bedding and armour over the inner sheath.

5.10.2 The bedding shall consist of two close helical lappings of polythene or polypropylene tape. Each tape shall be applied with a minimum of 5% overlap.

5.10.3 The armour shall be made of hot dip galvanized steel tape of thickness as per Table-8 of DOT specification GR/CUG-01/03.

5.11 **Outer Sheath**

5.11.1 The external protection shall consist of a polythene sheath conforming to the material specification defined in Clause 5.9 above.

5.11.2 The thickness of outer sheath shall conform to Table-9 of DOT specification GR/CUG-01/03.

5.11.3 The outer sheath shall be as circular as possible and free from pinholes and other defects.

5.11.4 Colour of outer sheath shall be grey.

5.11.5 The maximum diameter over outer sheath shall conform to Table-7 of DOT specification GR/CUG-01/03.

5.12 **Cable Capacitance**

The average mutual capacitance of the pairs measured at 800 to 1000Hz shall be 52 ± 3 nF/km. However, the mutual capacitance of individual pairs shall be within the limits of 52 ± 4.5 nF/km.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected to examination, testing and approval by EIL/ Owner. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality.

6.2 The following acceptance tests shall be conducted on the completed jelly filled cables as per the test procedures given in DOT specification GR/CUG-01/03 and this specification:

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.
ii. Measurement of thickness of insulation, inner sheath, screen, armour & outer sheath.
iii. Measurement of resistance of conductor.
iv. Measurement of resistance unbalance.
v. Continuity check & measurement of resistance of Poly-al tape.
vi. Colour coding.
vii. Conductor continuity test.
viii. Mutual capacitance test.
ix. Capacitance unbalance test.
x. Cross talk test.
xi. Attenuation test.
xii. Insulation resistance test.
xiii. Dielectric strength test.
xiv. Drip test.
xv. Armour galvanization test.
xvi. Conductor annealing test.
xvii. Measurement of drum length.

6.3 Following tests shall be carried out to prove FRLS property of the cable:

a. Critical oxygen index as per ASTM-D-2863 i.e. Determination of % of oxygen required for combustion at room temperature of FRLS sheath which shall remain as 29% (min.)

b. Temperature index as per ASTM-D-2863 i.e. To determine at what temperature normal oxygen content of 21% in air will support combustion of FRLS sheath which shall remain as 250°C.

c. Halogen acid gas emission as per IEC-60754 Part 1 i.e. To determine the % of release of hydrochloric acid gas from the FRLS sheath under fire which shall be 20% (max.)

d. Smoke Density Test shall be as per ASTM- D - 2843 and Smoke Density Rating of FRLS Sheath shall be 60% (max.).

6.4 The test for circuit integrity for fire survival cables shall be carried out as per IEC-60331 (Part-21).

6.5 The following tests shall be conducted on the completed non jelly filled cables as per the test procedures given in DOT specification GR/WIR-06/03 and this specification:

6.5.1 **Acceptance tests**

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.
ii. Measurement of thickness of insulation, inner sheath, screen, armour & outer sheath.
iii. Measurement of resistance of conductor.
iv. Colour coding.
v. Conductor continuity test.

vi. Mutual capacitance test.
vii. Capacitance unbalance test.
viii. Insulation resistance test.
ix. High voltage test.
x. Armour galvanization test.
xi. Conductor annealing test.
xii. Measurement of drum length.

6.5.2 **Special Tests**

The non-jelly filled cables shall also be subjected to following special tests:

i. Oxygen index test as per IS-10810 (Part 58).
ii. Flammability test on finished cable as per IS-10810 (Part 61 & 62).
iii. Test for rodent and termite repulsion property shall be done by analyzing the property by chemical method.

The special test shall be conducted on one sample from each lot. The sample will be selected by the inspector.

7.0 PACKING AND DESPATCH

7.1 Cables shall be dispatched in non-returnable steel drums of suitable barrel diameter, securely packed, with the take-off end fully protected against mechanical damage.

7.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, 'Owner's particulars', 'P.O. numbers' etc., shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

7.3 The drum lengths for cables shall be as below:

a.	Upto 6 pairs	: 2000 meter
b.	Above 6 pairs & upto 10-pair, upto 0.9 mm dia	: 2000 meter
c.	Above 6-pairs & upto 10 pairs, above 0.9 mm dia	: 1000 meter
d.	Above 10 pairs & upto 50 pairs	: 1000 meter
e.	Above 50 pairs & upto 100 pairs	: 500 meters
f.	Above 100 pairs	: As per job requirement (subject to max. length of 500 meters)

7.4 A tolerance of ± 3% shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to -2% to +0% only.

7.5 For non-jelly filled cable, PVC/ rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables shall be properly sealed, with caps, to avoid ingress of moisture/ water during transit and storage.

7.6 For jelly filled telephone cables, the ends of the cable shall be sealed by thermo shrinkable end caps of adequate wall thickness. Alternately ends may be sealed by enclosing them in rubber or PVC caps of wall thickness not less than 1.8mm. The caps shall be secured to the outer sheath with hose clips or ties or black adhesive tape or heat shrinkable sleeves.

7.7 The cables may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains and high ambient temperature.

संकटमय क्षेत्रों में लाइटिंग फिक्सचरों एवं जंक्शन बक्सों के लिए विनिर्देश

SPECIFICATION FOR HAZARDOUS AREA LIGHT FIXTURES AND JUNCTION BOXES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.12.20	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/RKS	ANPS	PG	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	27.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CRI	Colour Rendering Index
DC	Direct Current
DGCA	Director General Civil Aviation
EIL	Engineers India Limited
FRLS	Flame Retardant Low Smoke
IEC	International Electrotechnical Commission
IES	Illuminating Engineering Society
IP	Ingress Protection
IS	Indian Standard
LED	Light Emitting Diode
MR	Material Requisition
NABL	National Accreditation Board for Testing and Calibration Laboratories
PESO	Petroleum and Explosives Safety Organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
SPD	Surge Protection Device
SPN	Single Phase Neutral
SS	Stainless Steel
XLPE	Cross Linked Poly Ethylene

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1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of LED lighting fixtures, complete with LED lamp and driver, junction boxes and accessories suitable for installation in locations handling flammable liquids and gases/ vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels
IS-10322	:	Luminaires
IS-13383	:	Photometry of luminaires - Method of measurement
IS 15885 (Part 2/ Sec 13)	:	Safety of lamp control gear-Part-2 Particular requirements-Section 13 d.c. or a.c. supplied electronic control gear for LED modules
IS-16101	:	General lighting – LEDs and LED modules – Terms and Definitions
IS-16102	:	Self-ballasted LED lamps for general lighting services
IS-16107	:	Luminaires performance
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General requirements)
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d")
IS / IEC 60079-7	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Increased Safety "e")
IS / IEC 60079-15	:	Electrical apparatus for explosive gas atmospheres Construction, test & marking of type of protection "n"
IS / IEC 60529	:	Degrees of protection provided by enclosures (IP Code).

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries,

petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 POWER SUPPLY

All AC lighting fixtures/ junction boxes shall be suitable for 240V ± 10%, SPN, 50Hz ± 3% power supply and all DC lighting fixtures/ junction boxes shall be suitable for 110/ 220V ± 10% power supply.

6.0 CERTIFICATION

The equipment shall have test certificates issued by NABL-approved/ Central Government labs in India/ IECEx-approved/ equivalent labs. All equipment (indigenous & imported) shall also have valid statutory approvals, as applicable, for the specified location, and marking as per IS/IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid BIS license.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The enclosures of the lighting fixtures and junction boxes shall be of cast light metal alloy.

7.1.2 All equipment shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection.

7.1.3 The enclosures shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flameproof Exd (Gas group IIA/IIB) and AC supply: Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flameproof Exd (Gas group IIC) and AC Supply : Light yellow shade 355 of IS-5/ RAL 1012
- Non-sparking ExnR/ Increased safety Exec and AC Supply : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- DC lighting fixtures : Bright red shade 538 of IS-5/ RAL 3003

All unpainted parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving elements then these shall be greased with non-solidifying grease.

7.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

7.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

7.1.7 All equipments on single phase supply shall be provided with an independent earth terminal with lug inside the enclosure for terminating the third (earth) core of the cable and shall have facility for looping.

7.1.8 A nameplate shall be provided to indicate the details of testing agency, name of manufacturer, test certificate number, statutory approval agency (PESO), serial number, BIS license number, applicable gas group etc. and any additional marking required by statutory authority like approval no. etc. The nameplates shall be Al anodized or SS-304 engraved type or laser-

marked and permanently fixed/ fixed with rivets on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

7.2 Lighting Fixtures

7.2.1 Glass used for all types of lighting fixtures shall be clear and suitable for use under conditions involving exceptional risk of mechanical damage. Glass shall be toughened type.

7.2.2 All well/ bowl glass fixtures shall be provided with Stainless Steel SS-304 protective wire cage using minimum 5mm welded steel construction and having mesh dimension not exceeding 50mm x 50 mm. The mounting bolts of SS-304 required for physically connecting the hazardous area well/ bowl glass lighting fixtures (bracket/ ceiling mounted type) to the respective mounting bracket shall be supplied by Vendor along with the fixtures.

7.2.3 The fixing parts of the enclosure, which are to be opened for replacement of lamp, shall be so fastened that they can be unfastened only with special tools.

7.2.4 The lighting fixtures in Zone-2 area shall be Ex nR type, unless otherwise specified in the MR/ Tender.

7.2.5 For LED fixture, integral junction box shall be provided with 3 nos. cable entries for loop-in, loop-out and associated wiring to fixture. Alternatively, lighting fixtures shall be provided with 2 nos. threaded entries and 2 nos. hazardous area double compression nickel plated brass cable glands, and internal wiring shall be provided for driver and lamp. The glands shall be suitable for the specified cable size. 20% of the fixtures shall be supplied with 1 no. nickel plated brass plug for sealing the unused entry.

7.2.6 The top of all well/ bowl glass lighting fixtures shall be identically drilled/ threaded to facilitate installation on pole/ column or ceiling.

7.2.7 The flood lighting fixtures shall be supplied with adjustable mounting arrangement both in horizontal and vertical plane.

7.2.8 The aviation warning lighting fixtures shall have cluster LED lamps of Type C, medium intensity (as per DGCA civil aviation statutory regulations) and of red colour, fixed (not flashing), 2000cd, unless otherwise specified.

7.2.9 All lighting fixtures shall be provided with suitable mirror-polished aluminum internal reflector of suitable thickness to ensure adequate mechanical strength.

7.2.10 Lighting fixtures shall be tested for resistance to impact in line with IS/ IEC 60079-0. Impact test certificates shall be furnished by vendor.

7.2.11 All LED fixtures shall be supplied complete with lamp and driver. LED driver shall be suitable for surge protection of minimum 4 kV surge. However, for flood lights, aviation warning lights, and lighting fixtures with wattage higher than 90W, LED driver shall be suitable for surge protection of minimum 10 kV surge. An additional fail safe SPD may be provided, as required, to achieve 10 kV surge protection. LED driver shall comply with the requirement of IS 15885-2-13. Fixture lifetime (L70) shall be greater than 50000 hours at ambient temperature of 40°C.

7.2.12 LED type lighting fixtures shall fulfill the following requirements:

a. Minimum power factor shall be 0.95.

b. LED lighting fixture luminous efficacy shall be minimum 100 lumen per watt.

c. LED lighting fixture beam angle shall be 120°/ 90° depending upon fixture location and mounting height.

d. The CRI for LED lighting fixtures shall be greater than 80 for indoor fixture and greater than 70 for outdoor fixture.

e. The colour temperature of white colour LED shall be from 5700K to 6500K, unless otherwise specified.

f. Polar curves/ photometric drawings shall be submitted by vendor for the offered lighting fixtures.

g. LED lamps and drivers shall be provided with minimum 5 years warranty period, unless specified otherwise in the MR/ Tender. Driver shall have valid BIS certification and the same shall be furnished during drawing review stage.

h. The LED light fixtures, should be tested for luminous lux level as per IES-LM-79. Wherever wire guard is provided, testing shall be done with wire guard. Type test certificates for LM-79 for all fixtures shall be from an NABL-accredited/ IECEx-certified/ equivalent lab.

i. The LEDs used in the lighting fixtures should be tested for the service life as per IES-LM-80. Type test certificates shall be furnished in compliance to same.

7.3 Junction Boxes

The junction boxes shall be of flameproof or non-sparking type construction as mentioned in the MR/ Datasheet. All junction boxes for looping of single phase lighting circuits using cables up to 6mm^2 shall be minimum 125mm diameter in size. Each junction box shall be complete with requisite number of cable entries and double compression flameproof nickel plated brass cable glands to suit the specified cable size.

7.4 Terminals & Wiring

7.4.1 The fixtures and junction boxes shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. The terminals for external cable termination shall be suitable for 2.5mm^2 solid Copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

7.4.2 All internal wiring shall employ 1.5mm^2, 660/ 1100 V grade, FRLS type, XLPE/ PVC insulated Copper conductor wires, colour coded for phase, neutral and earth. All termination shall be with suitable lugs.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1061.

8.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test Plan no. 6-81-1061.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before

being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight',' Owner's particulars', 'PO nos.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

ऊर्जा दक्ष निम्न वोल्टेज प्रेरण मोटरों के लिए विनिर्देश

SPECIFICATION FOR ENERGY EFFICIENT LOW VOLTAGE INDUCTION MOTORS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	15.09.25	REVISED & ISSUED AS STANDARD SPECIFICATION	SS/RKR	ST	HK	MN
2	11.10.19	REVISED & ISSUED AS STANDARD SPECIFICATION	RKR	VKJ	SA	RKT
1	12.08.14	REVISED & ISSUED AS STANDARD SPECIFICATION	SS/SHIRALI	VKJ	BRB	SC
0	20.04.09	ISSUED AS STANDARD SPECIFICATION	SD	BRB	JMS	ND

Abbreviations:

AL	:	Aluminium
BIS	:	Bureau of Indian Standards
BS	:	British Standards
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mines and Fuel Research
CPRI	:	Central power research institute
CT	:	Current Transformer
CU	:	Copper
DGMS	:	Directorate General of Mines Safety
DOL	:	Direct On Line
EIL	:	Engineers India Limited
ERTL	:	Electronics Regional test laboratory
EU	:	European Union
FM	:	Factory Mutual
FRP	:	Fiber Reinforced Plastic
IEC	:	International Electro-technical Commission
IEEE	:	Institute of Electrical & Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
JEC	:	Japanese Electro-technical Committee
KLPL	:	Karandikar laboratories Pvt. Ltd.
LCIE	:	Laboratoire Central des Industries Electriques
NEMA	:	National Electrical Manufacturers Association
PESO	:	Petroleum and Explosive Safety Organisation
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
RPM	:	Revolutions per Minute
UL	:	Underwriter's Laboratories
VFD	:	Variable Frequency Drive
VDE	:	Verband Deutscher Elektrotechniker

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1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of energy efficient-High efficiency (IE2/IE3/IE4 as specified in data sheet) three phase medium voltage squirrel cage induction motors.

2.0 CODES AND STANDARDS

2.1 The squirrel cage induction motors and their components shall comply with the latest editions of following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

IS - 5	:	Colours for ready mixed paints and enamels.
IS - 1076	:	Preferred numbers.
IS - 1231	:	Dimensions and output series of foot mounted induction motors-frame numbers 56 to 315 L.
IS - 1271	:	Electrical insulation- Thermal evaluation and designation.
IS - 2223	:	Dimensions of flange mounted AC Induction motors.
IS - 2253	:	Designation for types of construction and mounting arrangement of rotating electrical machines.
IS - 2254	:	Dimensions of vertical shaft motors for pumps.
IS - 4029	:	Guide for testing three phase induction motors.
IS - 6362	:	Designation of methods of cooling of rotating electrical machines.
IS - 8223	:	Dimensions and output series for rotating electrical machines.
IS - 8789	:	Values of Performance Characteristics for Three-Phase Squirrel Cage Induction Motors with Degree of Protection IP-2X.
IS - 9283	:	Motors for submersible pump sets.
IS - 12065	:	Permissible limits of noise level for rotating electrical machines.
IS - 12075	:	Mechanical vibration of rotating Electrical Machines with shaft heights 56 mm and higher - measurement, evaluation and limits of vibration severity.
IS – 12615	:	Line Operated Three Phase a.c. Motors (IE CODE) "Efficiency Classes and Performance Specification"
IS - 13529	:	Guide on effects of unbalanced voltages on the performance of three phase cage induction motors.
IS - 13555	:	Guide for selection and application of three phase induction motors for different types of driven equipment.
IS - 14568	:	Dimensions and output series for rotating electrical machines, frame numbers 355 to 1000 and flange numbers 1180 to 2360.
IS / IEC60079-0:		Electrical apparatus for explosive gas atmospheres (General requirements)
IS/IEC-60079-1:		Explosive Atmospheres-Equipment protection by flame proof enclosures "d".
IS/IEC60079-2	:	Explosive protection by pressurized enclosure "p".
IS/IEC60079-7	:	Explosive Atmospheres-Equipment protection by increased safety – "e".
IS/ IEC: 60529	:	Degree of protection provided by enclosures (IP Code)
IS/IEC-60034/ IS 15999	:	Rotating Electrical machines
IS/IEC 61241:		Electrical apparatus for use in the presence of combustible dust
IS/IEC 60072-1:		Dimensions and output services for operating electrical machines Part-1 : Frame number 56-400 and flange number 55 to 1080

2.2 In case of imported motors, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian Standards.

2.3 The motors shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian Standards are not available, standards issued by IEC/ BS/ VDE/ IEEE/ JEC/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to ensure the end user for placement of order for spares and services.

4.0 OPERATING CONDITIONS

4.1 Ambient Conditions

Motors shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in refineries, petrochemical, fertilizer and metallurgical plants. Service conditions shall be as specified in the motor data sheet. If not specifically mentioned therein, a design ambient temperature of 40 ° C and an altitude not exceeding 1000 meters above mean sea level shall be taken into consideration.

4.2 Frequency and Voltage Variations

Unless otherwise agreed, motors shall be designed for continuous operation at rated output under the following conditions:

a) The terminal voltage differing from its rated value by not more than ± 10 % or
b) The frequency differing from its rated value by not more the ± 5 % or
c) Combined variation — The sum of absolute percent variations of (a) and (b) not exceeding 10 percent.

4.3 Starting

a) Motors shall be designed for direct-on-line starting or other method of starting as specified in datasheet.
b) Motors shall be designed for re-acceleration under full load after a momentary loss of voltage with the residual voltage being 100% and is in phase opposition to the applied voltage.
c) Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. In addition, Locked Rotor withstand time under hot conditions at 75% & 100% voltages, shall be minimum 1.4 times the starting time at the corresponding voltage.

d) Unless otherwise specified, all motors shall be suitable for starting under specified load conditions with 75 % of the rated voltage at the motor terminals.

e) Motors shall be designed to allow the minimum number of consecutive starts indicated in Table below:

Starts	Min. no. of consecutive starts
No. of consecutive start-ups with initial temp. of the motor at ambient level (cold)	3
No. of consecutive start-ups with initial temp. of the motor at full load operating level (hot).	2

4.4 Direction of Rotation

Motors shall be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. Directional arrow should be manufactured from corrosion resistant material. When a motor is provided with bi-directional fans, a double-headed arrow should be provided.

Normally, clockwise rotation is desired as observed from the driving (coupling) end, when the terminals UVW are connected to a power supply giving a terminal phase sequence in the order UVW. Counter-clockwise rotation of the motor shall be obtained by connecting the power supply to terminals so that the phase sequence corresponds to the reversed alphabetical sequence of the terminal letters. Ample space shall be provided at the terminal box for interchanging any two external leads for obtaining the reverse phase sequence.

5.0 PERFORMANCE

5.1 Motors shall be rated for continuous duty (S_1), unless otherwise specified.

5.2 Unless specified, the starting current (as % rated current) shall be as per IS 12615, subject to IS tolerance

5.3 In particular cases, when the starting current is to be limited, care shall be taken such that the design values of torque meets the load requirement while at the same time complying to clause 4.3 above of this specification. Unless otherwise specified the minimum pull-up torque of motors, at rated voltage & frequency shall be minimum 50% of the rated full load torque.

5.4 In particular cases, when the starting with reduced voltage is specified, care shall be taken such that the design values of torque meets the load requirement while at the same time complying to clause 4.3 above of this specification.

5.5 Starting torque and minimum torque of the motor shall be compatible with the speed torque curve of the driven equipment under specified starting and operating conditions.

In case where characteristics of driven equipment are not available while selecting the motor, minimum starting torque shall be 110% of rated value for motors up to 75 kW and shall be 90% of rated value for motors above 75 kW.

5.6 The breakdown torque at the rated voltage shall be not less than 175% of the rated load torque with no negative tolerance. Unless otherwise agreed, the breakdown torque shall not exceed 350% of the rated load torque.

In case of motors driving equipment with pulsating loads (e.g. reciprocating compressors, crushers, ball mills) the minimum value of pull out torque at 75% of the rated voltage shall be more than the peak value of pulsating torque and the current pulsation shall be limited to 40%.

5.7 Motors fed by variable frequency drive shall additionally meet the following requirements

a) The motor shall be converter grade motor suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control and shall comply to IS 16724, IEC-60034-25 and relevant part of IS/IEC-60079.

b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c) The motor shall be designed to operate continuously at any speed over the range (1-100%) of rated speed or as specified in data sheet.

d) Motor shall be provided with thermistor type temperature detector.

e) The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.

f) Motor shall be designed suitable to deliver the torque required for complete speed torque characteristics of the load considering the voltage available at the motor terminals after taking into account supply voltage tolerances, voltage drop within VFD panel and voltage drop within cable as specified in VFD specification.

g) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in line voltage, frequency and starting current limitations as specified in data sheet.

h) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid state power supply.

i) The motor insulation shall be designed to accept the applied voltage wave form, within the Vpeak and dv/dt limits as per IEC-61800-2 and 60034-25.

j) The motor vendor shall also coordinate with driven equipment vendor & VFD vendor and obtain requisite details for motor design.

k) Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning. Insulated bearing (Non-Drive End) shall be provided irrespective of motor frame size.

l) Motor for hazardous area application shall have valid type test certificate issued by recognized independent test house certifying that motor is suitable for converter duty application. Corresponding statutory approval (e.g. PESO/DGMS etc.) as applicable for the specified location shall also be furnished for the hazardous area motor.

m) The motors shall be suitable for the current wave forms produced by the power supply including harmonics generated by the drive. The necessary coordination by motor manufacturers with drive manufacturers regarding harmonics generated by VFD shall be taken care and incorporated in motor design suitably.

n) The motors shall be designed to operate continuously at any speed over the range as per process requirement with minimum range as 10–100% of rated speed or as specified in data sheet. The characteristics shall be based on the application – in terms of constant torque / variable torque as per the driven equipment. Additional cooling fan shall be provided if required to limit the temperature rise to specified limits, alternatively option of applying suitable de-rating may be considered.

o) The motors shall withstand torque pulsation resulting from harmonics generated by the solid state power supply.

p) The motors required to be transferred to DOL bypass mode shall be rated for specified variations in line voltage and frequency.

5.8 The minimum values for performance characteristics of these motors shall be as given in the tables 1, 2 & 3 of IS 12615 for IE2/IE3/IE4 motors, subjected to tolerance as per IS/IEC. Motors operated by frequency converters may have higher losses as compared to line (sinusoidal) power supply due to the harmonic voltage content. These motors must be tested on sinusoidal supply and efficiency must meet the declared efficiency class (which should not be lower than IE 2 class).

6.0 CONSTRUCTIONAL DETAILS

6.1 Windings

6.1.1 Unless otherwise specified, motors shall be provided with class `B' insulation as a minimum. In case of motors with class 'F' insulation, the permissible temperature rise above the specified ambient temperature shall be limited to those specified in the applicable Indian standards for class `B' insulation.

6.1.2 The winding shall be tropicalised. The windings shall preferably be vacuum impregnated. Alternately the windings shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmospheres.

6.1.3 Windings shall be adequately braced to prevent any relative movement during operation. In this respect, particular care shall be taken for the stator windings for direct-on-line starting squirrel cage motors. Insulation shall be provided between coils of different phases that lie together. Core laminations must be capable of withstanding burnout for rewind at 350 ºC without damage or loosening.

6.1.4 In case of motors driving equipment with pulsating loads, special care shall be taken for the joints of rotor bars and end rings to avoid premature failures due to induced fatigue stresses.

6.1.5 The windings shall be connected in delta. However, for motors rated 2.2 kW and below, star connection may be accepted. In case of motors with star-delta starting, the motor windings shall be fully insulated for delta connection.

6.1.6 The ends of the windings shall be brought out into a terminal box. These shall be terminated by means of terminals mounted on an insulating base made of non-hygroscopic and non-flammable material.

6.1.7 All motors shall be provided with six terminals and suitable links to connect them in star or in delta except for motors rated up to and including 2.2 kW which may be accepted with three terminals.

6.2 Terminal Box and Cable Entries

6.2.1 Unless otherwise agreed, the terminal box shall be located on the right hand side as viewed from the driving (coupling) end. The terminal box shall have side cable entry from non-driving end. However, as a special case, terminal box located on top may also be accepted, particularly for hazardous area motors, in case manufacturer has only top mounted terminal box design which is duly tested/certified & approved by corresponding agency as mentioned in clause 11.0 below for installation in hazardous area. The terminal box design shall allow rotation in steps of 90°C to facilitate cable entry from any direction at site.

6.2.2 Terminal box cover shall be provided with handles to facilitate easy removal. However, for terminal box covers weighing less than 5 kg., terminal box covers without handles can be accepted.

6.2.3 The terminal box shall be provided entries for suitable cable glands corresponding to the size of the specified cable. Crimp type tinned Copper lugs and nickel-plated brass (or aluminum if specifically required), double compression type cable glands shall be supplied along with the motors for the specified cable sizes for power and space heater cables.

6.2.4 For flameproof motors, terminal box can be also provided in increased safety 'Exe' execution.

6.2.5 The terminals, cable lugs, terminal box, cable entries and cable glands shall be suitable for the minimum cables sizes as specified below for 2 pole, 4 pole or 6 pole motors:

Motor rating up to and including	Size of phase conductor (mm^2)
2.2 kW and below	2.5 cu
3.7 kW	6 cu
5.5 kW	10 cu
7.5 kW	16 cu
9.3 kW	16 cu
11.0 kW	16 cu
15.0 kW	50 Al.
18.5 kW	70 Al
22.0 kW	70 Al
30.0 kW	95 Al
37.0 kW	120 Al
45.0 kW	150 Al
55.0 kW	240 Al
75.0 kW	2x95 Al
90.0 kW	2x120 Al
110.0 kW	2x240 Al
125.0 kW/132 kW	2x240 Al
160.0 kW	2x240 Al

NOTE: - Exact cable size for the motor shall be informed during vendor drawing review. Vendor to provide required size of the terminal box.

6.2.6 Cable sizes for motors having synchronous speeds 750 RPM and below shall be as agreed between the purchaser and manufacturer.

6.3 Motor Casing and Type of Enclosure

6.3.1 The minimum degree of motor enclosures including terminal boxes and bearing housing shall be IP-55 as per IS/IEC.

6.3.2 Motors for outdoor use shall be suitable for installation and satisfactory operation without any protective shelter or canopy. Motor casing shall be provided with a suitable drain for removal of condensed moisture except in case of flameproof motors (Type Ex d/Ex de).

6.3.3 All internal and external metallic parts, which may come into contact with cooling air, shall be of corrosion resistant material or appropriately treated to resist the corrosive agents, which may be present in the atmosphere. Screws and bolts shall be of rust proof material or protected against corrosion.

6.3.4 Unless otherwise agreed, motors shall have standard frame sizes (min.) for various output ratings as stipulated in IS/IEC.

6.4 Bearing and Lubrication

6.4.1 Motors shall have grease lubricated ball or roller bearings. In all cases, the bearings shall be chosen to provide a minimum L-10 rating life of 5 years, (40, 000 hours) at rated operating conditions
(The L-10 rating life is the number of hours at constant speed that 90% of a group of identical bearings will complete or exceed before the first evidence of failure).

6.4.2 The bearings shall be adequate to absorb axial thrust produced by the motor itself or due to shaft expansion. Motors designed to handle external thrust from the driven equipment shall be supplied with a thrust bearing at the non-driving end.

6.4.3 In cases such as pumps for hot liquids where the driven equipment operates at high temperatures, bearings shall be cooled by a shaft-mounted fan. This shall ensure efficient ventilation of the bearing and disperse the heat transmitted from the driven equipment by conduction or convection.

6.4.4 Bearings shall be capable of grease injection from outside without removal of covers with motors in the running conditions. The bearing boxes shall be provided with necessary features to prevent loss of grease or entry of dust / moisture e.g. labyrinth seal/ oil seal/ V seal. Where grease nipples are provided, these shall be associated, where necessary, with appropriately located relief devices, which ensure passage of grease through the bearings.

6.4.5 Pre-lubricated sealed bearings may be considered provided a full guarantee is given for 4 to 5 years of trouble-free service without the necessity of re-lubrication.

6.5 Cooling System

All motors shall be self ventilated, fan cooled. Fans shall be corrosion resistant or appropriately protected. They shall be suitable for motor rotation in either direction without affecting the performance of the motor. If this is not possible for large outputs, it shall be possible to reverse the fan without affecting the balancing of the motor.

For motors operating in hazardous area, the fans shall be of an anti-static non-sparking material.

6.6 Rotor

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and long service life for the bearings. Die cast aluminum rotors for motors in hazardous areas may be accepted provided the same are type tested and approved by competent authorities.

6.7 Shaft Extension

Motors shall be provided with a single shaft extension with key-way and full key. Motor shaft shall be sized to withstand 10 times the rated design torque.

6.8 Lifting Hooks

All motors weighing more than 30 kg. shall be provided with lifting hooks of adequate capacity.

6.9 Earth Terminals

Two earth terminals located preferably on diametrically opposite sides shall be provided for each motor. Necessary nuts and spring washers shall be provided for earth connection.

7.0 MISCELLANEOUS ACCESSORIES

7.1 Anti-Condensation Heaters

All motors rated 30 kW and above shall be provided with 240 V anti-condensation heaters, sized and located so as to prevent condensation of moisture during shutdown periods.

For motors with heaters installed in hazardous atmospheres (Zone - 1 or Zone - 2), such heaters shall conform to the provisions of applicable Indian Standards and temperature classification specified in the motor data sheet.

The heater leads shall be brought out, preferably, to a separate terminal box which shall be of the same specification and grade of protection as the main terminal box.

A warning label with indelible red inscription shall be provided on the motor to indicate that the heater supply shall be isolated before carrying out any work on the motor.

7.2 Name Plates

In addition to the motor rating plate, a separate number plate for motor tag number shall be fixed in a readily visible position. This number shall be as per the motor data sheets. Nameplates and tag plates shall be of stainless steel material. Name plate shall include details as specified in IS 15999 Part 1 / IEC 60034 Part 1.

8.0 CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 120 % of the synchronous speed. For flexible rotors this shall be between 60 % and 80 % of the synchronous speed; the second actual critical speed shall be above 120 % of the synchronous speed.

9.0 PAINTING

All metal surfaces shall undergo manufacturer's standard cleaning /painting cycle. After preparation of the under surface, the equipment shall be painted with two coats of epoxy based final paint. Color shade of final paint shall be 632 of IS: 5/ RAL-7031. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then these shall be greased.

10.0 INSPECTION AND TESTING

10.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner, if specified / agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine / acceptance tests shall be carried out at manufacturer's works under his care and expense.

10.2 Type test certificates from CIMFR or equivalent test house, applicable PESO/ DGMS approval certificates, BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The certificates and BIS license must be valid at the time of dispatch.

10.3 Test certificates of bought out components shall be shown to the inspection agency on demand during inspection.

10.4 Combined testing of LV motors along with their associated VFDs shall be carried out as a unit. During this testing, temperature rise and harmonics levels shall be measured to ensure they are within the permissible limits as per applicable standards. This test may not be required in case same make / type / rating of motor & VFD as a unit has been already tested and copy of test certificate is available which will be furnished for EIL/Owner's reference.

10.5 All equipments shall be subjected to various routine / acceptance tests as per Inspection & Test plan no. 6-81-1064.

11.0 CERTIFICATION

A copy of valid BIS license shall be furnished for energy efficient motors as per IS 12615.

All hazardous area equipment shall have hazardous area test certificates and approvals as per following:

For Indigenous manufactured hazardous area equipment:
For all electrical items manufactured in India, the testing shall be carried out & test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished as per IS/IEC 60079-1.

Alternatively, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

For Imported hazardous area equipment:
For all electrical items manufactured outside India, test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished as per IS/IEC 60079-1.

As an alternative option-1 to this, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

As an alternative option-2 to this, EU Type Examination Certificate, which is applicable for manufacturers having manufacturing locations in countries covered under the European Union, valid copy of Production Quality Assessment / Assurance Notification shall be furnished.

All equipment i.e. Indigenous & imported, shall also have valid statutory approvals, as applicable for the specified location and marking as per IS/IEC 60079 and as required by statutory authorities.
For installations in India, PESO approval letter shall be provided.

12.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to the finish. Crates/cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO Nos.' etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

विद्युत उपकरणों के लिए स्थापना विनिर्देश

SPECIFICATION FOR ELECTRICAL EQUIPMENT INSTALLATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	13 08 19	REVISED & ISSUED AS SPECIFICATION	RM	RS	SA	RKT
4	21 05 14	REAFFIRMED & ISSUED AS SPECIFICATION	FA	SA	BRB	SC
3	25 04 08	REVISED & ISSUED AS SPECIFICATION	RKS	SSM	JMS	VC
2	28 02 03	REVISED & ISSUED AS SPECIFICATION	HKM	RSG	VPS	SKG
1	26 08 97	REVISED & ISSUED AS STANDARD SPECIFICATION	RR	VPS	SG	AS

Abbreviations:

AC	:	Alternating Current
ACDB	:	AC Distribution Board
AL	:	Aluminium
BIS	:	Bureau of Indian Standards
CCoE	:	Chief Controller of Explosives
CD	:	Compact Disc
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mining and Fuel Research
CT	:	Current Transformer
CTC	:	Carbon Tetrachloride
CU	:	Copper
DC	:	Direct Current
DCDB	:	DC Distribution Board
DGMS	:	Directorate General of Mines and Safety
Ex(d)	:	Flameproof
FRP	:	Fibre Reinforced Plastic
HV	:	High Voltage
IR	:	Insulation Resistance
IS	:	India Standard
LV	:	Low Voltage
HMI	:	Human Machine Interface
MV	:	Medium Voltage
OISD	:	Oil Industry Safety Directorate
OSR	:	Oil Surge Relay
OTI	:	Oil Temperature Indicator
PF	:	Power Factor
PI	:	Polarisation index
PRV	:	Pressure relief Valve
PT	:	Potential Transformer
SLD	:	Single Line Diagram
UPS	:	Uninterrupted Power Supply
VRLA	:	Valve Regulated Lead Acid
WTI	:	Winding Temperature Indicator
PESO	:	Petroleum and Explosives Safety Organization

Electrical Standards Committee

Convenor: Ms. Sumita Anand

Members: Mr. Parag Gupta
Mr. M.K. Sahu
Ms. ANP Singh
Mr. Harish Kumar
Ms. Shalini Verma
Mr. Raman Sood
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Ms. N.P. Guha (Projects)
Mr. Rajesh Sinha (Inspection)

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1.0 SCOPE

This specification defines the requirements for the installation, field inspection, testing and commissioning of electrical equipment, forming part of electrical power distribution and utilisation system, including Communication and Fire alarm system.

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workmanlike manner in conformity with this specification, EIL Installation Standards, layout drawings and to the following specifications/ codes of practice of Bureau of Indian Standards and OISD standards.

SP-30 (BIS)	National Electrical Code.
IS:7816	Guide for testing Insulation resistance of rotating machines.
IS:10028 (Part-2)	Code of practice for selection, Installation and maintenance of transformers; Part 2 : Installation.
OISD 137	Inspection of Electrical Equipment.
OISD 147	Inspection and safe practices during electrical installations

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations.
b. Regulations laid down by CEA/Electrical Inspectorate.
c. Regulations laid down by PESO/DGMS (as applicable).
d. The petroleum rules (Ministry of Industry Government of India).
e. Any other regulations laid down by central/state/local authorities and Insurance agencies.

3.0 INSTALLATION OF EQUIPMENT

Prior to start of installation of the electrical equipment, Contractor shall verify that equipment and complete materials have been received. Handling, shifting to required site location, installation, testing and commissioning of all electrical equipment shall be done by contractor with utmost care. Manufacturer's instructions and the requirements given in their technical manuals shall be strictly adhered. The substation/switchgear room wherein the equipment shall be installed shall be kept clean, dry and free from all debris. Panel floor cutouts not in immediate use shall be suitably covered to avoid any mishap. When handling the switchboard panels, care shall be taken to observe the correct lifting arrangements and to make sure that slings are attached to the manufacturer's designated lifting points,where applicable. No parts shall be subjected to undue strains or sudden stresses which could cause damage to the equipment.

The lifting position mark indicated on packing casing shall be adhered to strictly, for keeping it in required vertical position.

Contractor shall check and report to the Engineer-in-charge about any damaged item and / or missing component for getting the same replaced as per specifications. During installation, all accessories and loose items shall also be inspected by the contractor before their assembly/mounting.

Manufacturer checklist, manual for erection and installation and any specific requirement for equipment handling, installation and commissioning shall be strictly adhered to.

3.1 Switchboards and Bus Ducts

3.1.1 The term switchboard here includes all HV / MV/ LV switchboard panels, motor control centers, power and lighting distribution boards, UPS panels, ACDB, Battery charger panels, DCDB etc.

The switchboard panels shall be handled with care, avoiding any impact to the equipment. Dragging of the panels directly on floor shall be avoided. Roller bars may be used for shifting of panels. Use of a crane and trailer shall be made for handling of equipment. The switchboard panels shall be properly supported on the truck or trailer by means of ropes to avoid any chance of tilting. The switchboards shall be lifted after ensuring that panel supports, nuts and bolts are all intact and tightened. While lifting the panels in packed conditions, utmost care shall be taken to avoid any damage to insulators, bushings, metering and protective equipment and if specified in the tender document tyre mounted hydraulic trolley shall be used.

The panels shall be preferably kept inside the packing cases till foundations are ready. Proper rain/sun/dust protection shall be ensured till switchboards are installed.

3.1.2 The switchboard panels shall be installed on prepared foundations or floor cutouts. Steel base channels shall be welded to inserts provided in floor slab. Cross members shall be provided at the junctions of each shipping section and other places as required.. It shall be ensured that the base plate level of HV switchboard shall match with the finished floor level.

The foundation pockets and the grouted bolts shall be cured for a minimum period of 48 hours. Proper level of base frames shall be maintained throughout and shall be checked with water level/spirit level. Steel Shims shall be provided below base frame wherever required.

3.1.3 The switchboard panels shall be taken out from the packed cases and shifted one by one to their proper place. All the panels shall be assembled, aligned and leveled. Alignment of panels shall be checked in both longitudinal and lateral directions. It shall be ensured that panel to panel coupling bolts, bus bar links etc. fit properly without any strain on any part. No new holes for jointing of the panels other than those recommended by the vendor shall be drilled. No gaps shall be left between the panels. Gap if any found between panels shall be suitably sealed using sealing compound or T-profile. The lifting, racking in and out operation of the breaker and all other motions shall be free from any obstruction.

The panels shall be checked for correct vertical position using Plumb line and spirit levels. The switchboard panels shall be tack welded at suitable intervals to base channel.

After erection of switchboard panels, all uncovered portions of floor cutouts shall be covered with 6 mm thick removable chequered plates finished with floor level. The design of the chequered plates shall be such that the maximum allowable deflection is L/200 (where L is the span of the chequered plates in meters) for a live load of 500 kg./sq. meters.

Additional stiffer shall be provided at the bottom if required. Suitable lifting arrangements shall be provided for chequered plates. The chequered plates shall be painted with a coat of red oxide zinc chromate primer after proper surface preparation as per specifications. Where specified, panels' cutouts provided for future use shall be filled with lean concrete.

3.1.4 After completion of Installation of switchboards, all the cubicles, switchboard components such as switches, starters, CT and PT chambers, bus bar chamber shall be cleaned and checked for tightness of all the components.

Vacuum circuit breakers shall be checked for integrity of bottle seals. All loosely supplied items shall be fitted up. Bus bar sections or links shall be inserted and where specified, of high

voltage equipment shall be insulated. Interconnection wiring between shipping sections shall be done by contractor.

All the wiring connections shall also be checked. Contact resistance of all bus bar joints and contactors shall be checked. Insulator shall be checked for any damage. All the starters, switches, contacts shall be cleaned with CTC where required.

All the moving parts shall be checked for easy and free movement. Hinges of panel doors shall be lubricated to give free and noise less movement. All openings shall be kept completely closed to avoid ingress of any foreign particles inside the panel.

Functional scheme verification of individual feeder shall be carried out and minor wiring modifications in the panel wiring, if required shall be done as per the directions of Engineer-in-charge. Special attention shall be paid to CT circuits' polarity, wiring continuity and correctness in the protection as well as measurement circuits. Auto transfer scheme shall be simulated and verified. During the course of scheme verification tests, defective components if any shall be taken out, after bringing to the notice of Engineer-in-charge. The same shall be replaced by component supplied by owner.

3.1.5 Where switchboard is damp or having a low IR value due to damaged insulators/ bushings/any other insulated parts, or any other reason, the entire switchboard shall be dried-up according to the instruction of the Engineer-in-charge for the IR value to improve to a safe level for commissioning. Care shall be taken to protect the surrounding insulation from direct local heating during the drying up process.

3.1.6 All the metering instruments, protective relays and other relays and contactors shall be tested as per manufacturer's recommendations and according to the instructions of the Engineer-in-charge. Protection relays shall be inserted and connected and settings adjusted as required by the Engineer- in- charge

3.1.7 All moving parts, of closing/tripping mechanism, racking in and racking out mechanism, spouts and shutter closing mechanism shall be checked for proper operation. All the auxiliary contacts of breaker shall be checked-up, cleaned and contact pressure measured.

3.1.8 All the control wiring, PTs, bushings, bus bars, other live parts of switchgear, incoming and outgoing cables shall be meggered.

3.1.9 Electrical simulation tests shall be carried out for all the protective, alarm and annunciation relays and external interfaces to ascertain proper functioning.

3.1.10 Safety insulation mats of approved make and of required voltage grade shall be provided in the sub-station.

3.1.11 **Pre-Commissioning Check List**

Before commissioning any switchboard, following points shall be checked and ensured for safe energising of the switchboard:

i. That the installation of equipment to be commissioned is complete in all respects with its auxiliaries and all other mounting including earthing. Openings in floor within and outside panels have been sealed off. All cover and door gaskets are intact to make the enclosure vermin proof.

ii. That all the metering instruments have been checked and found in working order. Indicating lamps are healthy and are in correct position. All power and control fuses are of proper rating.

iii. That the polarity test and ratio test of all the PTs and CTs is complete and phase sequence of CTs conforms to the correct vector group connections. Wiring continuity and correctness are ensured in the protection and measurement circuits. Polarity of D.C. supply for all the circuits is correct.

iv. That the high voltage tests of incoming and outgoing cables have been conducted and results are satisfactory.

v. That all the protective relays including both conventional and microprocessor based numerical relays and thermal overload relays/electronic motor protection relays have been tested for secondary injection tests. (Primary injection tests shall be carried out for differential protection, Restricted Earth fault protection at full / reduced current to ensure correctness of complete wiring). Relay settings, status indications, fault annunciations, data logging and display of switchboard SLDs shall be verified from HMI in case the same is provided.

vi. That IR Value has been recorded for bus bars, circuit breaker, incoming and outgoing cables, control wiring and potential transformers. Where required joint resistance of bus bars have been recorded and found to be satisfactory. All the surroundings and panels have been cleaned and temporary earth leads have been removed.

vii. Following tests shall be ensured for all CTs

- Insulation resistance test
- Ratio test through primary injection
- Polarity test
- Knee point voltage for class PS CTs

viii. Following tests shall be ensured for all PTs

- Insulation resistance test
- Ratio test through primary injection
- Polarity test

ix. Following tests shall be ensured for all breakers

- Insulation resistance test
- Breaker closing, opening sequence using 3 pole timers
- High voltage test both in open and close condition for HV breaker
- Contact resistance of all three poles using 100A DC Kit

x. Following tests shall be ensured for all meters

- Calibration of meters
- Functional verification and settings

xi. Following tests shall be ensured for all relays

- Secondary injection test
- Relay settings
- Timing check with timers
- Any other test recommend by the supplier

xii. Following tests shall be ensured for all bus bars

- Tightness of all nuts/bolts using Torque wrench
- IR value
- Contact resistance using 100A DC Kit
- Cleaning of bus bar chamber using vacuum cleaner
- Conducting jelly shall be applied on AL/CU joints as per manufacturer's recommendations
- HV test in case of HV switchboard

xiii Following tests/Checks shall also be performed on the switchboards

- Functional verification of individual feeders including all spare feeders
- Simulation test for under voltage tripping of related feeders such as motor feeder, capacitor feeders etc
- Verification of control supply schemes
- Stability test for all differential protections
- Simulation test for bus auto/manual change over scheme, fast bus transfer scheme
- Checks for all panel illuminations, indicating lamps, sockets
- All upstream and down stream interlocks

3.1.12 Bus Ducts

The bus ducts as per issued drawings will be supplied in parts and all the parts shall be assembled and the bus bar connections shall be made at site. The insulators in bus ducts shall be inspected for any possible damage during transit and the defective ones shall be replaced. The insulators shall be cleaned. Contact surface of bus bars, bus bar bolts and nuts shall be thoroughly cleaned. Petroleum jelly shall then be applied and bolted connection made. The bus duct enclosure shall be checked for earth continuity and then earthed at two places. The bus duct shall be properly supported between switchgear and transformer. The opening in the wall where the bus duct enters the switchgear room shall be completely sealed to avoid rain water entry. Expansion joints, flexible connections etc. supplied by the manufacturer of the bus duct shall be properly connected. The bus duct levelling shall be checked with spirit level and pendulum weight.

The sandwiched busducts shall be stacked vertically for installation such that each phase and neutral busbar of each sandwich busduct are vertically aligned in a line. This arrangement would allow for shorting of busbars across sandwich busducts before connecting to switchboard.

Pre-commissioning check list

Before commissioning any bus duct, following points shall be checked and ensured for safe energising of the bus ducts

- All joints are tightened using torque trench
- Cleaning of bus duct chamber with vacuums cleaner
- Silica gel breather shall be connected if supplied. If required, silica gel shall be reactivated as per the instruction of engineer in charge.
- Space heater circuit shall be checked and tripping through thermostat shall be ensured
- Contact resistance shall be measured for all phases/neutral using 100A DC kit
- High voltage test in case of HV bus ducts

3.2 Transformers

Transformers on receipt at site shall be unloaded by means of crane or lifting devices of adequate capacity. All lifting lugs shall be used to avoid unbalanced lifting and undue stresses on lugs. Lifting lugs if any provided for partial lifting (e.g. for active part, conservator) etc. shall not be used for lifting complete transformer. Parts other than those identified for lifting of the transformer shall not be used for lifting. While slinging, care shall be taken to avoid slings touching other parts.

3.2.1 Before lifting transformer, it shall be ensured that all cover bolts are tightened fully. In case when it is necessary to use jacks for lifting, projections provided for the purposes of jacking shall be used. Lifting jacks shall not be used under the valves or radiator tubes. For transporting transformers from stores to site, the transformers shall be loaded on a suitable capacity truck or trailer. The transformers shall be properly supported by steel ropes and stoppers on the trailer to avoid tilting of the transformers in transit due to jerks and vibrations. At no instance, the transformer shall be kept on bare ground. Where it is not possible to unload the transformer directly on a foundation, it shall be unloaded on a properly built wooden sleeper platform. A transformer shall never be left without putting stoppers to the wheels.

3.2.2 Transformers shall be examined, for any sign of damage in transit. Particular attention shall be given to the following in this regard.

i. Dents on tank wall or cooling tubes, radiators
ii. Damage to protruding parts like valves, sight glass etc.
iii. Loosening of bolts due to vibration in transit.
iv. Cracked or broken bushings.
v. Oil leakage particularly along welds.

If anything adverse is noted, the same shall be brought to the notice of Engineer- in- charge.

3.2.3 Contractor shall examine the transformer base, oil pit, fire walls and foundations made by the civil contractor. It shall be ensured that oil spills can not propagate along cable trenches. Any discrepancy noted will be brought to the notice of Engineer- in- charge. Transformers shall be placed on channels or rails over concrete foundations. The transformers shall be levelled, aligned and checked for free movement on the channels or rails. Stoppers shall be provided to the transformers immediately to prevent any movement. Normally transformers upto 1000 kVA rating shall be received duly fitted with radiator tubes, conservator tanks, valves, wheels and other accessories. While the transformers of above 1000 kVA rating may be supplied with loose accessories. All the accessories like radiators, cooling fans, valves, conservator tanks, explosion vent pipe, bushings and other devices which are supplied in different packages shall be checked for any transit damage and cleaned thoroughly before fixing on the transformer. All loosely supplied parts shall be assembled as per manufacturer's instruction manuals/ drawings and documents. All the connections for CTs bushings and other wiring shall be checked for tightness and correctness before replacing the lid or tightening all the bolts. Gravels shall be filled in the transformer bay, soak pit as per requirement.

3.2.4 **Topping of transformer with oil**

Before topping up with oil, transformer shall be fitted with all accessories such as valves, gauges, thermometers etc. Oil samples shall be taken from each drum and tested for determination of dielectric strength. Any sign of leakage of the barrel or of its having been opened shall be recorded and reported. It is necessary to filter the oil before the transformers are filled. It shall be ensured in oil filling operation that no air pockets are left in the tank and that no dust or moisture enters the oil. All air vents shall be opened. Oil shall be filled through a streamline oil filter using metal hose. To prevent aeration of the oil, the transformer tank shall be filled through the bottom drain valve. In a transformer with conservator tank, the rate of oil flow shall be reduced when the level is almost upto the bottom of the main cover to prevent internal pressure from rupturing the pressure relief-pipe diaphragm. Sufficient time shall be allowed for the oil to permeate the transformers and also for the locked -up air bubbles to escape. Any air accumulation in the buchholz relay shall be released.

3.2.5 **Transformer Oil**

i. Sample of oil from transformer shall be taken from both top and bottom of the tank. In case of oil filled cable box with a separate conservator, separate oil samples shall be taken from cable box.

ii. **Testing of Oil**
For dielectric test, the oil shall be tested as described in IS: 335. The oil shall also be tested for acidity in accordance with the methods prescribed.

iii. Dissolved Gas analysis (DGA) of transformer oil sample may be carried out at site as per IS-9434.

3.2.6 Drying out of the transformers, if required, shall be carried out and record maintained in accordance with IS: 10028. Normally a streamline filter shall be used for drying-up. IR value versus time of both windings along with OTI/WTI and filtrations machine temperature curve for IR value Vs time shall also be plotted and recorded during the drying-up process.

Precautions when drying

i. The maximum sustained temperature to which transformer oil may be subjected shall be limited to 80^0 C.

ii. The transformer shall be carefully monitored throughout the drying out process and all observations shall be carefully recorded.

iii. Drying out shall be continued so that the insulation resistance as prescribed in the standard code of practice is attained and the value remains constant for more than 12 hours. However, a minimum number of cycles shall be done for each transformer as found necessary by the Engineer-in-charge. Generally a Megger reading of 2 megohms / kV at 60^0 C temperature with a 5 kV Megger may be a rough indication for stopping the dehydration.

3.2.7 The following work on transformers shall be performed by the contractor if specifically called for:

i. Before finally commissioning the transformer it may sometimes be desired to run it for a few hours on short-circuit, applying a low voltage, approximately equal to the impedance voltage of the transformer. During this process, regular readings of the insulation resistance of the winding to earth and winding to winding and temperature against time shall be recorded.

ii. Testing of radiator tubes for any leakage and rectifying these by welding / brazing.

3.2.8 **Pre-commissioning Check List**

Before commissioning of any transformer, the following points shall be checked for safe energisation of the transformer:

i. All the accessories have been fixed properly and transformer body and neutral are properly earthed. The transformer dehydration is over and results are satisfactory and approved by the Engineer-in-charge. In case transformers are idle for more than one month after dehydration, transformer oil has been given at least two circulations.

ii. Oil level, in the transformer conservator tank and all the bushings is upto the marked point and the oil has been tested for dielectric strength and acidity.

iii. Silicagel is in reactivated condition. The breather pipe is clear from any blocking and contains oil upto the proper level.

iv. The explosion vent diaphragm does not have any dents. Accumulation of any oil and air had been released.

v. Operation of off-load and on-load tap changers on all the tap positions is satisfactory. The mechanical parts of the on-load tap changer are lubricated. Motor IR value has been taken and found satisfactory. Tap position mechanical indicator on the transformer and tap position indication meter on the control panel are reading the same tap positions. Tap changer limit switches are operating satisfactorily on the maximum and minimum tap positions. On-load tap changer contact pressure and resistance is as per manufacturers recommendations. Oil level of tap changer tank is upto the required level and oil has been tested for dielectric strength. The tap setting on which the off load tap switch is locked shall be recorded. Generally the off-load tap switch shall be kept on nominal tap.

vi. Buchholz relay (of main tank as well as that of oil filled cable box, as applicable) has been tested and checked up for any friction in the movement, and floats are free. All the other protective relays, alarm and annunciation relays have been tested.

vii. Metering equipment has been tested and polarity test of PT's and transformer winding is satisfactory. Phase sequence and connections have been checked for proper vector group.

viii. Ratio test and winding resistance on all the tap positions is satisfactory.

ix. Gaps of arcing horns for the bushings where provided are in order and earth connections for the surge diverters have been checked.

x. Winding and oil temperature thermometer pockets contain oil and the winding and oil temperature settings on dial gauges are in order.

xi. Transformers fitted with fans for forced air cooling have been checked up for starting and stopping of the fans both in manual and auto mode and air-displacement has been verified.

xii. Simulation tests for all external interface connection alarm, annunciation and trip circuits have been checked and are in order.

xiii. Insulation resistance of all the control circuits and IR value of the transformer windings and all the incoming and outgoing cables have been checked.

xiv. Valves in the cooling system and valve between the buchholz relay and the conservator tank are in open position.

xv. Setting of all the protective relays is at the desired value and DC Trip supply is healthy.

xvi. Magnetic, current and magnetic balance test have been conducted

xvii Simulation test for WTI,OTI,PRV (of main tank as well as that of oil filled cable box, as applicable), OSR

xviii Settings of WTI/OTI as per the instruction of the manufacturer

xix Earth resistance value for the neutral earthing

xx Before charging, it is ensured that water sprinker system, if provided, is installed and is operational.

xxi In case the fire protection system of transformer is by Nitrogen injection system, testing of this system is ensured.

xxii In case of power transformer rated 50MVA and above, SFRA (sweep frequency response analysis) has been conducted at site.

xxiii tan delta test of transformer has been conducted for 50 MVA and above transformer.

3.2.9 **Observations after Commissioning**

After switching on the transformer the following points shall be observed and recorded.

i. The inrush magnetizing current and no-load current.
ii. Alarm, if any, or if any relay flag has operated.
iii. Voltage and current on all the three phases.
iv. Transformer hum or abnormal noise.
v. Circulation of oil and leakages.
vi. Record current, voltage, cooling air temperature, winding temperature and oil temperature readings, hourly for 24 hours.
vii. Cable end boxes for any over-heating.

3.3. HV and MV MOTORS

3.3.1 All the motors generally would be erected by the mechanical contractor.

3.3.2 Electrical contractor shall keep the motor space heater energised as per the directions of Engineer-in-charge. Electrical contractor shall measure the insulation resistance of motor windings and PI in case of HV motors. Insulation resistance of the motors shall be measured between the winding of the machine and its frame by means of a 500 / 1000 V Meggar in case of 415 V motors. A minimum value of 1 megohm for 415 V motors shall be considered a safe value. In case of lower I.R. Value, the insulation value shall be improved by any of the following methods as directed by the Engineer-in-charge.

i. Blowing hot air from external source.
ii. Putting the motor in oven.
iii. Placing heaters or lamps around and inside after making suitable guarding and covering arrangements so as to conserve the heat.

In case the insulation is low, the following method of drying has to be adopted, after consultation with Engineer-in-charge. During drying the temperature rise of winding shall not exceed the permissible value for the class of insulation used.

i. By locking the motor so that it can not rotate and then applying such a low voltage to the stator terminals so as to pass full load current in the stator keeping the stator winding temperature below 90^0 C . In this case a close watch shall be kept for any possible overheating and I.R. Values vs. temperature shall be plotted and heating continued till I.R. value becomes steady.

ii. By blasting hot air from external source, Maximum temperature of winding while drying shall be 70^0 C to 80^0 C (thermometer) or 90^0 C to 95^0 C by resistance method. Heating shall be done slowly first till steady temperature of winding is reached after 4 to 5 hours, and for large machines after 10 hours. A record has to be kept for drying process, with half an hour readings and, till steady temperature is reached. In case it is essential, the drying process can be supplemented by blower.

3.3.3 It shall be ensured that the motor leads are correctly connected in the terminal box, as indicated in the 'Name Plate'. The covers of all terminal boxes shall be properly fixed, the gaskets intact. The control circuit shall be tested for proper functioning as per circuit diagram.

3.3.4 In case of synchronous machines, slip rings and brush gear shall be polished and brushes shall be fixed in their holders with clearance and pressure as recommended by the manufacturers.

3.3.5 Before commissioning, the ventilation and cooling system of the motor must be inspected. In case of motor with forced ventilation the air inlet shall be examined to ensure that it is free from moisture and any foreign material. It shall also be ensured that recommended flow and pressure of air is available to produce the required cooling effect.

3.3.6 The motor control gear shall also be carefully examined, the over-load settings may be reduced or time lags bypassed from protective gear to ensure rapid tripping of switchgear in event of faults. The direction of rotation of a new motor especially of large capacity, and phase sequence of supply shall be kept in view while joining and connecting to the motor terminals

3.3.7 Finally the motor shall be started on no-load after decoupling, and shall be allowed to run for a minimum period of 4 hours, or for a time as instructed by Engineer-in-charge. Attention shall be given to the proper running of the bearings, vibration or unusual noises if any. Voltage, starting current, no load current, stator winding and bearing temperature shall be recorded after every 1 hour during this test. Direction of rotation shall be checked and recorded. Normally the motors run in clockwise direction as viewed from the driving end with reference to the phase sequence R, Y, B.

3.3.8 After switching off the motor, the insulation resistance of the motor shall be recorded under hot and cold conditions.

3.3.9 If the no load test run is found satisfactory, the motor shall be allowed to run for 8 hours and all readings shall be recorded.

3.3.10 The following work on motors, may be performed by the contractor if specifically called for.

i. The proper level of bearing oil has to be checked. The condition of grease in bearings shall be checked and in case it is necessary, complete replacement of bearing with specified grade of grease after proper cleaning of the bearing shall have to be done. Wherever external greasing facility exists, the condition of grease may be checked by pumping some new grease of specified grade at start. If the grease coming out is deteriorated grease shall be replaced.

ii. All the motors, motor exciter set and induction generators directly coupled or coupled through reduction gears shall be checked for abnormal vibration, if any Large rated HV motors with journal type bearings are liable to get damaged from shock, rough handling during transit. Any minor defect in a race or roller may give rise to considerable amount of vibration and noise. Contractor shall check and bring to the attention of Engineer-in-charge any defect noticed in this regard.

iii. Due care shall be taken to avoid any damage to bearing insulation wherever provided.

3.4. Batteries/Battery charger

Battery (Lead acid, Nickel Cadmium or VRLA type as specified) shall be erected on stands and insulators supplied by the manufacturer of the batteries. The installation shall be done as per the layout drawings and manufacturer's instructions. Electrolyte if required / as applicable shall be filled as per manufacturer's instructions. Interrow connections shall be made with the leads supplied by the manufacturer. Functional check shall be done on the battery charger including battery charging and discharging, recharging as per the recommendation of the manufacturer.

3.5. Neutral Earthing Resistor

The neutral earthing resistor shall be inspected for any damage to the resistor grid and other components. The resistor shall be levelled and installed. All covers etc. shall be checked for

tightness to ensure that the enclosure of the resistor is dust, vermin and weatherproof. Earthing conductors shall be taken from the out end terminal of the resistor, for connection to earth electrodes and to the main grid. Check such as IR, operation of space heater, earth resistance shall be done before the commissioning.

3.6 Welding Receptacles

The welding receptacles shall be erected on steel/concrete structures as per the drawings. In isolated places a separate support shall be fabricated and installed.

3.7 Push Button/Control Stations

The push buttons / control stations shall be installed near to the motors to be controlled. Individual channel supports shall be installed as per EIL standard. If control stations for hazardous areas are to be supplied by contractor, these shall be of Ex (d) type, tested by CIMFR and approved by PESO or other applicable certifying authorities. All outdoor push buttons / control stations shall preferably have integral canopies for additional weather protection. The canopy shall be made of 2 mm thick galvanized sheet steel or FRP where these are not integral with the equipment.

3.8 Gang operated Isolators/outdoor Disconnectors

The isolators shall be transported to site in the dismantled condition. All the insulators may be also supplied loose. The contractor shall inspect, clean, assemble and install the isolator on the base structure previously fabricated, erected and levelled by him. The operating mechanism shall be installed on the structure and connected to the isolator poles. The operating mechanism shall be tested by slowly bringing the isolator to the closed position and carrying out the necessary adjustment as per the manufacturer's instructions. The earthing switches, frames and operating handle etc. shall be earthed.

3.9 Contractor shall provide the following items in substation, as per CEA Regulations.

3.9.1 Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires and fire extinguisher (carbon dioxide, dry chemical extinguisher etc.) suitable for dealing with electric fires shall be conspicuously marked and kept.

3.9.2 First aid boxes containing ointments and medicines for immediate treatment of injuries (As prescribed by Indian Red Cross Society or equivalent).

3.9.3 Instructions of restoration of persons suffering from electric shock in English, Hindi and local language of the district shall be affixed in a conspicuous place.

3.9.4 Danger boards (HV, MV) shall be provided on transformer bay gate, switchboards, entrance to switchgear room and at other places as required by Engineer-in-charge.

3.10 The Communication system and Fire alarm system panels and equipment shall be installed complying to manufacturer's instructions. The location of field station (call back station unit, break glass unit, telephone set etc.) shown on the drawing are indicative. The exact location shall be decided at site by contractor in consultation with Engineer-in-charge. Correct type of equipment with regard to hazardous protection as specified on drawing shall be adhered to by contractor, for installation.

4.0 EQUIPMENT COMMISSIONING

4.1 Field inspection, testing and commissioning of the complete electrical installation shall be carried out as per EIL specification no. 6-51-0087.

After the equipment is installed properly in accordance with drawings and specifications, contractor shall carry out all pre-commissioning checks and tests as per EIL format in the presence of Engineer-in-charge and test readings shall be recorded and furnished to EIL in triplicate.

4.2 All equipment layout drawings shall be marked by the Contractor for "AS BUILT STATUS" and two sets of hard copies shall be submitted to EIL.

5.0 LIST OF CONSTRUCTION EQUIPMENT

The contractor shall have all necessary construction equipment, tools and tackles and testing instruments to carry out the erection works and to commission the system as specified. These shall include but not be limited to the following, and these shall be brought to site by contractor before the start of work.

5.1 Equipment

i. Portable grinder.
ii. Portable welding machine.
iii Portable gas cutting / welding set.
iv. Pipe threading machine.
v. Pipe bending machine (hydraulic).
vi. Portable drill machine suitable to take up drilling for different sizes as per requirement.
vii Dewatering pump sets (diesel driven).
viii. Power Hacksaw.
ix. Conduit dye set.
x. Hydraulic crimping machine with round/hexagonal dye set.
xi. Hand crimping tool.
xii. Portable electric blowers, vacuum cleaners.
xiii. Miscellaneous items such as slings, pulleys, tarpaulins, wooden sleepers, ladders. etc. as required.
xiv. Safety belts, safety goggles, and gloves.
xv. Separate tool kit for each Electrician.
xvi. Hydraulic/Hand held grease gun

5.2 Test Instruments

i. Insulation tester 1000 V hand driven.
ii. Insulation tester 2500 V motor/hand driven.
iii. Insulation tester 5000 V motor/hand driven
iv. Phase sequence indicator.
v. Earth Resistance tester.
vi. Single phase variac
vii. 3 phase variac of adequate capacity.
viii. Secondary and primary injection testing kit.
ix. Multimeter, both analogue and digital
x. Portable Ammeters, Wattmeters, P.F. meters.

xi. Portable Voltmeters.
xii. Clip on meters of different ranges.
xiii. Tacho-meter.
xiv. Kelvins double bridge for measurement of very low resistance.
xv. D.C. high -pot test kit.
xvi. A.C. high -pot test kit.
xvii. Oil filtration machine of adequate capacity.
xviii. Lux Meter to measure illumination levels.
xix. Breaker timing 3 pole kit
xx. Timers
xxi. 100A DC milli volt drop (Contact resistance) kit
xxii. Vibration measuring Instrument
xxiii. Thermo meters

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SPECIFICATION
FOR
CABLE INSTALLATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	24.01.24	REVISED AND ISSUED AS STANDARD SPECIFICATION	DKC	RS	MKS	MN
5	26.02.18	REVISED AND ISSUED AS STANDARD SPECIFICATION	DC/RM	RS	BRB	RN
4	21.11.13	REVISED AND ISSUED AS SPECIFICATION	FA	SA	UAP/JMS	SC
3	25.04.08	REVISED AND ISSUED AS SPECIFICATION	RKS	SSM	JMS	VC
2	28.02.03	REVISED and ISSUED AS SPECIFICATION	HKM	RSG	VPS	SKG
1	04.08.97	REVISED and ISSUED AS STANDARD SPECIFICATION	RR	VPS	SG	AS

Abbreviations:

BIS	:	Bureau of Indian Standards
BS	:	British Standards
CCOE	:	Chief Controller of Explosives
CD	:	Compact Disc
CEA	:	Central Electricity Authority
CIMFR	:	Central Institute of Mining and Fuel Research
DC	:	Direct Current
DGFASLI	:	Directorate General Factory Advice Service & Labour Institutes
DGMS	:	Directorate General of Mines and Safety
EHV	:	Extra high voltage
ET	:	Electrical Thread
FGL	:	Finished Ground Level
FLP	:	Flame Proof
FRP	:	Fibre Reinforced Plastic
GI	:	Galvanized Iron
HV	:	High Voltage
IS	:	Indian Standards
ISMC	:	Indian Standard Medium Channel
MS	:	Mild Steel
OISD	:	Oil Industry Safety Directorate
PVC	:	Poly Vinyl Chloride
RCC	:	Reinforced Concrete Cement
SWG	:	Standard Wire Gauge
FO	:	Fibre Optic

Electrical Standards Committee

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Mr. Rajesh Sinha (Inspection)
Ms. Shalini Verma (PEM)

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1.0 SCOPE

This specification defines the requirements for supply of materials, wherever applicable, installation, testing and commissioning of cable installation.

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, EIL installation standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD standards listed below :

SP:30 (BIS)	Special Publication - National Electrical Code.
IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating.
IS:10810(Part 43)	Method of Test for cables ; Part 43 Insulation resistance.
IS:10810(Part45)	Method of Test for cables ; Part 45 High voltage test.
OISD RP- 147	Inspection and safe practice during electrical installation
OISD 173	Fire prevention and protection system for electrical installation

2.2 In addition to the above it shall be ensured that the installation conforms to the requirements of the following as applicable:

a. CEA Regulations

b. Regulations laid down by CEA/Electrical Inspectorate.

c. Regulations laid down by CCOE/DGMS/DGFASLI (as applicable).

d. The petroleum rules (Ministry of Industry, Government of India)(As applicable)

e. Any other regulations laid down by central/state/local authorities and insurance agencies

3.0 MATERIAL SPECIFICATIONS

All materials and hard wares to be supplied by the contractor shall be new, unused and of best quality and shall conform to the latest specifications of Bureau of Indian Standards.

3.1 Cable Trays

These shall be ladder type trays either prefabricated hot dip galvanised sheet steel trays or site fabricated angle iron painted trays or FRP trays as specified in job specification.

3.1.1 Pre-fabricated hot dipped galvanised trays

The cable trays shall comply with the requirements specified in EIL installation standard enclosed with the specification/Tender.

3.1.2 Site fabricated angle iron trays

Angle iron cable trays shall be fabricated from standard rolled angle iron sections of size 75x75x8 for runners for supporting spans limited to 3000 mm. Cross support shall be 25 x 6

mm MS flat for tray width upto 500 mm and 32 x 6 mm flat for tray of more than 500 mm wide and spacing between two cross supports shall not exceed 250 mm.

3.1.3 Vertical supports for both the prefabricated and site fabricated type trays shall be fabricated out of ISMC 100 and horizontal supports shall be with 65 x 65 x 6 mm angle iron sections.

Outer most tier of all vertical cable trays shall be covered with GI sheet for protection against physical damage to cables. Bottom most cable tray shall also be provided with GI sheet from the bottom side for the protection of the cables from the hydrocarbon pipes located below. GI Covers also shall be provided for the top most cable trays located outdoors.

Cable racks and trays shall be covered by removable top covers on upper most tiers allowing adequate ventilation in following cases where:

- Mechanical damage of cables is likely to occur during maintenance in the plant.
- Oil or spillage of chemicals can be expected.
- Protection from exposure to sun is required.

GI cover sheet shall allow adequate ventilation to the cables and shall be in standard length of 3000 mm, flanged on both sides for fixing on cable tray.

3.1.4 **FRP type cable trays**

The cable trays shall comply with the requirements specified in EIL standard specification and installation standard enclosed with the specification/Tender

3.2 Cable Glands

Cable glands shall be of nickel plated brass unless otherwise specified. The single compression type cable glands shall be used for indoor panels/equipment (e.g. substation, control room etc). The cable glands for outdoor terminations shall be weather protected, double compression type. Cable glands forming a part of relevant FLP enclosure shall be FLP type, tested by CIMFR or any other recognized independent testing laboratory and approved by CCoE/DGMS or any other statutory authority as applicable. Indigenous FLP glands shall have valid BIS license as per the requirements of statutory authorities. All cable glands shall comply with the requirements given in IS/IEC-60079 Part 0.

Entry thread of cable gland shall be compatible to the entry thread provided in the equipment (BS, ET, NPT, PG as applicable). If required, suitable reducers/adopters shall be used.

3.3 Connectors

Terminations of cables with stranded conductor shall be made with crimped type tinned copper solder less lugs which shall be suitable for the cable size mentioned in cable schedule.

Cable lug material shall be selected based on the applicable as under. For HV cable terminations, heavy duty, long barrel, crimping type lugs shall be supplied. Sector shaped/ circular barrel lugs shall be provided for making connections for cables having sector shaped/ circular geometry of conductors respectively.

Copper conductor cable & copper bus bar/ terminals	Tinned copper
Copper conductor cable & Aluminium bus bar/ terminals	Bi-metallic (Copper barrel with Aluminium palm)
Aluminium conductor cable & Copper bus bar/terminals	Bi-metallic (Aluminium barrel with tinned Copper palm)
Aluminium conductor cable & Aluminium bus bar/ terminals	Aluminium

3.4 Ferrules

Ferrules shall be of approved type and of size to suit core size mentioned and shall be employed to designate the various cores of control/signal cable by the terminal numbers to which the cores are connected, for ease of identification. Ferrule shall be printed type.

4.0 CABLE LAYING

4.1 General

Cable installation shall include power, control, lighting, fire alarm, telephone and communication cables. These shall be laid in trenches/ cable trays /Duct as detailed in the cable layout drawings. Cable routing given on the cable layout drawings shall be checked in the field so as to avoid interference with structures, heat sources, drains, piping, air-conditioning duct etc. Any change in routing shall be done to suit the field conditions wherever deemed necessary, after obtaining approval of Engineer-in-charge.

4.1.1 EHV, High voltage, medium voltage power and control cables shall be separated from each other by adequate spacing or by running through independent pipes, trenches or cables trays, as shown on layout drawings/installation standards. Details of cable routes and cable spacing not shown in detail on these drawing shall be determined by the contractor and approved by the engineer- In-charge.

The individual cable fixing clamps and spacers for laying of single core cables shall be of non-magnetic material. As a general practice, the metallic sheath, screen and armour of single core cables shall be earthed at one point to keep the same at earth potential unless otherwise stated. The continuity of armour and semiconductor screen shall be broken at each joint. Single core cables, when laid in trefoil formation shall be braced by suitable clamps at a distance, not exceeding 3 meters along the cable routing.

If straight through joints are required to be provided on single core cables, armour shall be broken at joints as per manufacturer's recommendations. For single core cables, armour shall be earthed at one end for the cable run length as per manufacturer's recommendation. The armour & screen of EHV cables shall be earthed at one end/both end and surge voltage limiters shall be installed at the straight through joints as specified in job specification/data sheet.

The Telephone, Communication and Fire alarm cables shall run on instrument trays/ducts/ trenches in the units. Wherever these are not available, cables shall be taken in a separate trench/tray with a minimum spacing of 300 mm from power and control cables

Telephone, fire alarm and plant communication cables shall be directly buried in road berm area, (unless otherwise specified in cable layout drawings). These cables shall cross power cables preferably at right angles. Street lighting cables shall be laid on the other side of road berm area.

Above ground FO cable shall be laid in HDPE ducts and shall run in cable trays of control cables, underground FO cables shall be laid in HDPE duct above layer of control cables & shall be protected with sand & bricks.

Fire barriers shall be deployed at locations where cable enter/exit the substation above ground or/and cable enter/exit between cable cellar to switchgear room through cutouts. Fire barriers shall be as per job specification.

At every 30 meter distances cable tray shall be painted with tray numbers as per cable layout drawings for identification purpose.

The earth continuity of cable trays shall be maintained by providing bonding jumpers as per earthing schedule while changing the level of cable trays.

4.1.2 The lengths indicated in the cables schedule are only approximate. The contractor shall ascertain the exact length of cable for a particular feeder by measuring at site. All cable routes shall be carefully measured .Before the start of cable laying, the contractor shall prepare cable drum schedule and get that approved by Engineer-in-charge to minimize/avoid straight through joints and then the cables cut to the required lengths, leaving sufficient lengths for the terminations of the cable at both ends. The various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. Extra loop length shall be given for feeder cables where required as per the directions of Engineer-in-charge to meet contingencies

Cables shall be laid in directly buried trench or in RCC trench (underground trench) or in cable tray along pipe sleepers or in over head trays as shown on cable layout drawings. RCC covers of trenches shall be effectively sealed to avoid ingress of chemicals and oils.

Overhead trays shall be installed 2700 mm (minimum) above grade level and 300mm above FGL in case cable trays are installed along with pipe sleepers. At road crossings overhead trays shall be installed at 7000 mm (minimum) above grade level or cables shall be routed through cable tray culvert/ Electrical road crossings as per layout drawings.

Sufficient care shall be taken while laying cables to avoid formation of twist, sharp bend etc. in order to avoid mechanical injuries to cables. Rollers shall be used for pulling of cables.

Cable installation shall provide minimum cable bending radii as recommended by cable manufacturer.

4.1.3 Cables shall be neatly arranged in the trenches / trays in such a manner that criss-crossing is avoided and final take off to the motor / switchgear is facilitated. Arrangement of cables within the trenches / trays shall be in line with cable layout drawings. Cable routing between cable trench and equipment/motors shall be taken through GI pipe sleeves of adequate size or branch cable trench as indicated in cable layout drawing. Pipe sleeves shall be laid at an angle of maximum 45 to the trench wall. Bending radii of pipes shall not be less than 12D. It is to be ensured that both the ends of GI pipe sleeves shall be sealed with approved weather proof sealing plastic compound after cabling. In places where it is not possible, cables shall be laid in smaller branch trenches. Different rows of cable trays in cable cellar below the cutout shall be so fixed such that the trays don't obstruct cable entry to the panels.

4.1.4 All cables shall be identified close to their termination point by cable tag numbers as per cable schedule. Cable tag numbers shall be punched on stainless steel straps (2mm thick, 20 mm wide and of enough length) securely fastened to the cable and wrapped around it.

Each underground cable shall be provided with cable tags of stainless steel straps securely fastened every 30 m of its underground length with at least one tag at each end before the cable

enters/leaves the ground. In unpaved areas, cable trenches shall be identified by means of cable markers as per installation drawing. These cable markers shall be placed at location of changes in the direction of cables and at intervals of not more than 30 m and also at cable straight through joint locations. Cable route markers shall extend 600mm above ground.

4.1.5 All temporary ends of cables must be protected against dirt and moisture to prevent damage to the insulation. For this purpose, ends of cables shall be covered with an approved PVC end cap or rubber insulating tape.

4.1.6 Each row of cables shall be laid in place and before covering with sand. All wall openings/pipe sleeves shall be effectively sealed after installation of cables to avoid seepage of water inside building/lined trench. Every cable shall be given an insulation test in presence of Engineer-in-charge/Owner before filling the cable trench with sand Any cable which is found defective shall be replaced.

4.1.7 Where cables pass through foundation walls, the necessary openings shall be provided in advance for the same by another agency. However, should it become necessary to cut holes in

existing structures for example floor slab etc., the electrical contractor shall determine their location and obtain approval of the Engineer-in-charge before carrying out the same.

4.1.8 Cables for road crossings shall be taken through ERC (Electrical Road Crossing)/cable duct as shown in the cable layout drawings and sleeves/ducts shall be effectively sealed thereafter.

At road crossing and other places where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not slack and get damaged by pipe ends.

4.1.9 Wherever cable trench crosses storm water, waste water channel/drain, cables shall be taken through PVC/RCC pipes. Where cables are required to cross drains of depth more than 1200 mm, cables shall be taken over the drain on cable trays supported suitably using ISMC 150/200 sections.

4.1.10 Ends of cables leaving trench shall be coiled and capped and provided with protective cover till such time the final termination to the equipment is completed.

4.2 Cables Laid Direct in Ground

Cables shall be laid underground in excavated cable trenches where specified in cable layout drawings. Trenches shall be of sufficient depth and width for accommodation of all cables. Cables shall be properly spaced as per installation standards. Maximum number of cable layers in trench shall be preferably limited to 6 layers.

Minimum depth of directly buried cable trench shall be 750 mm for medium voltage and 900 mm for HV Cables. The depth and the width of the trench shall vary depending upon the number of layers of cables as per EIL installation Standards.

Cables shall be laid in buried trenches at depth as shown in the cable layout drawings. It is to be ensured by the contractor that the bottom of buried trenches shall be cleared of all rocks, stones and sharp objects before cables are placed. The trench bottom shall be filled with a layer of sand or stone dust. This sand /stone dust shall be leveled and cables laid over it. These cables shall be covered with 150 mm of sand on top of the largest diameter cable and sand shall be lightly compacted. A flat protective covering of 75 mm thick second class red bricks or concrete tiles as per specification shall then be laid and the remainder of the trench shall be filled back - filled with natural soil, rammed and leveled.