TANGEDCO
UDANGUDI STPP STAGE I
2 X 660 MW

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER
(TOTAL 2 BOOKS)

Specification No. : PE-TS-435-165-N011 (REV. 01)

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA - 201301

COOLING TOWER TECHNICAL SPECIFICATION COMPRISE 2 BOOKS:

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5.0.0 SITE CONDITION

5.1.0 Location and existing Infrastructure

The plant location details are as follows:

Country	:	India
State	:	Tamil Nadu
Administrative district	:	Thoothukudi
Next big cities to site	:	Thoothukudi (approx.45 kms from site)
Road access	:	East Coast Road – State high way (176)
Nearest Railway Station	:	Thiruchendur (approx.12 kms from site)
Nearest Airport	:	Vagaikulam (approx.60 kms from site)
Nearest Harbour	:	Tuticorin (approx.45 kms from site)

The proposed power project will be located at Udangudi in Tamil Nadu. The proposed power project site is located at about 45km South of Thoothukudi. The proposed marine facilities for the power project will be built on the coast adjoining the power project. The site is accessible by well developed roads.

The town of Tuticorin has all infrastructural facilities and has number of Industries. Tuticorin is well connected by both state highways, National highways and has direct rail link with State Capital Chennai.

5.1.1 Soil Profile

A Preliminary soil investigation report and topographical survey has been carried out by Owner. The results are furnished in a separate annexure.

The Detailed geotechnical Investigation and Setting out survey will be performed by the EPC contractor, and will be the basis for the detailed engineering for the project. The geotechnical report shall contain recommendations for foundation design during detailed engineering.

5.1.2 Seismic intensity

Seismic Intensity	:	As per IS : 1893 Latest
Zone	:	II
Intensity	:	As per IS:1893-Latest

5.1.3 Tide Levels

The recorded tide levels with respect to the Chart Datum (CD) near the identified intake point are as follows:

Mean high water-Spring	CD + 0.99 m
Mean high Water-Neap	CD + 0.71 m
Mean low Water-Neap	CD + 0.55 m
Mean low water-Spring	CD + 0.29m
Mean sea level	CD + 0.64 m
Highest High Tide Level	CD+ 1.026 m
Lowest Low Tide Level	CD + 0.110 m

5.2.0 Meteorological conditions

Ambient Air Temperature

Maximum dry bulb temperature	:	41℃
Minimum dry bulb temperature	:	17℃

Relative humidity

Mean Maximum humidity (Summer)	:	84%
Mean Minimum humidity (Summer)	:	62%
Maximum humidity (Monsoon)	:	97%
Minimum humidity (Monsoon)	:	45%

Rainfall

Annual rainfall (Maximum)	:	718.2 mm
Annual Rain fall (Minimum)	:	384.1 mm
Twenty four (24) Hour max	:	138.2 mm

High Flood Level

High Flood Level for site	:	RL 2.450 m

Wind

Mean Wind Speed (max)	:	20.6 km/h
Wind direction	:	North, North East, North West, East

The details given are arbitrary and may vary. The contractor should collect the actual data from the Meteorological Department pertaining to the site location and design the plant accordingly.

Meteorological data corresponding to Tuticorin observatory station shall be adopted. These data can be collected from Regional Meteorological Centre, India Meteorological Dept, 50, College Road, Chennai – 600 006.

5.3.0 Design Requirements related to site conditions

5.3.1 Design Ambient Data

Rainfall data:

The maximum rainfall in a year to be considered for design is 718.2 mm. 24 hours maximum to be considered is 138.2 mm. Area drainage study as required is in Contractor's scope of work.

Wind data

Wind loads to be considered for design of structures shall be based on the design wind speeds arrived at based on IS : 875 (Part -3) – Latest Edition. The parameters for calculation of design wind speed as per IS : 875 (Part -3) – Latest Edition are elaborated under Volume II, Section 5 of Detailed Technical Specification - Civil.

5.3.2 Seismic Data

Seismic loads to be considered for design of structures shall be as per as per IS : 1893. Seismic design criteria are elaborated under Volume - II, Section 5 of Detailed Technical Specification- Civil.

1.00	**INTENT OF SPECIFICATION:**
1.01	This specification is intended to cover the vetting of thermal design undertaken by BHEL Consultant, manufacture, assembly, inspection and testing at manufacturer's and/or his sub-contractors works, proper packing, delivery at site, transportation, unloading/handling at site, storage at site, site fabrication, site painting, erection including all civil works/ testing/ commissioning at site and performance testing of Natural draft type cooling tower for 2X660MW UDANGUDI STPP STG I including complete Electrical, C&I and Civil Works as specified and as necessary. This specification is for Two (2) nos. Natural Draft Counter flow Cooling Towers for 2X660MW UDANGUDI STPP STG I. BHEL intends to get this NDCT's package executed by qualified contractors on an item rate basis. BHEL has done the thermal sizing of the NDCTs through its design Consultant and the same is approved by the owner. The owner approved thermal design is enclosed at Section IA along with the General Arrangement Drawing. The Cement, Structural and reinforced Steels for Cooling tower are excluded from Bidder's scope as they shall be free issue by BHEL. Terms and conditions for free issue items being given along with NIT. The NDCT contractor is required to own the owner approved thermal design and GA drawing such that the responsibility of cooling tower performance shall remain with the bidder in all manners. Any questions or clarifications regarding thermal design may be sought by the NDCT contractor to satisfy himself of its veracity. The tentative quantities for thermo-hydraulic components (Fills and distribution system) listed for S.Nos. 24 and 25 of BOQ as per BHEL's Design are indicated in Annexure-1 of section IA and the same is calculated based on the area inside the NDCT at respective levels shown in the GA drawing. If found necessary ''the NDCT contractor may suggest modifications to the thermo-hydraulic components (listed at S. Nos. 24 and 25 in the BOQ) with technical reasoning/analysis/calculations to justify the measures to improve the thermal performance of the NDCT which will be guaranteed by the bidder''. And as such the responsibility of cooling tower performance shall remain with the bidder in all manners. While suggesting justifiable reasons for changes as above the NDCT contractor shall abide by the following constraints. Also, the NDCT contractor shall guarantee the NDCT performance considering these constraints that are inviolable. 1) Civil Design of NDCT Shell, Shell Profile and Shell dimensions at various heights 2) Foundation of NDCT 3) Air Inlet Height 4) Basin & Internal Structure Column-Beam Grid Dimensions and Elevations 5) Water Distribution Ducts 6) Layout of CW Hot water inlet header to Cooling Tower 7) Height and Diameter of NDCT. Once the changes with justifiable reasons/analyses/calculations provided by the NDCT Contractor are accepted by BHEL/Consultant and duly incorporated, the NDCT contractor will vet the final thermal design & GA of NDCT and furnish the Performance guarantee. The thermal design and GA vetted by the NDCT contractor shall be furnished to Customer for approval. The NDCT contractor shall vet the thermal design as above within two weeks of award of contract, for further approval by BHEL/customer. The GA drawing already approved by owner may be required to be approved again depending on changes to the thermo-hydraulic components, if any and therefore the NDCT contractor shall furnish the relevant modifications agreed to by BHEL/Consultant to these items (only) keeping the other dimensions frozen for further approval from BHEL/Customer. The complete design and engineering of NDCT shall remain in the scope of BHEL's Consultant.

All Mechanical/Electrical/C&I drawings prepared by BHEL Consultant will be reviewed by the NDCT contractor before submission to customer for approval.

The NDCT contractor is required to estimate the “lump sum” cost of the thermo-hydraulic components based on his modified arrangement (if any) or as per Annexure-A. This lump sum cost shall be added to the cost of other BOQ items quoted by the NDCT contractor on item-rate basis to arrive at the total cost of evaluation.

No change in the quantities and cost of thermo-hydraulic components shall be allowed during execution due to any reason whatsoever from that quoted during tender stage.

SECTION - I

SPECIFIC TECHNICAL REQUIREMENTS

SUB-SECTION IA - Specific Technical Requirements (Mech.)
SUB-SECTION IB - Specific Technical Requirements (Electrical)
SUB-SECTION IC - Specific Technical Requirements (C & I)
SUB-SECTION ID – Datasheet-A

SUB-SECTION – IA

SPECIFIC TECHNICAL REQUIREMENTS (MECHANICAL)

1.00.00	**DELETED.**
2.00.00	**SCOPE OF EQUIPMENTS & WORKS UNDER THIS SPECIFICATION:**
2.01.01	**Scope (Mechanical):**
	a) Incoming hot water piping, including vertical run, Motorized Butterfly valves on hot water risers. Terminal point for hot water pipe shall be as per enclosed NDCT GA Drg. Welding at terminal point shall be in bidder's scope. Bidder shall also supply a Pressure Gauge & Temperature Gauge at the terminal point. Any reducer/ expander required at the terminal point shall also be in the bidder's scope. b) Tower fills & fill supports, drifts eliminators, including all supporting structures, fastening arrangements & accessories. c) Screens, along with handling arrangement and guides embedded in concrete shall be provided at the outlet of cold water channel. d) Sluice/ stop log gate with handling arrangement and guides in each of the cold water outlet channel connection from the cold water basin. e) Manually operated chain pulley blocks, together with the monorails and supporting frames for the handling of screen and gates. f) Knife-edge gate valve/sluice valve in each de-sludge connection and also De-sludge piping up to the disposal point at local storm water drain channels. g) Pipe spools to be embedded in sludge pit walls and terminated with flanged end at suitable distance from outer face of respective wall. h) Water Distribution system consisting of Pipes. Hangers & pipe supports & anchoring arrangement for all piping coming under the scope of supply. i) Two (2) Nos. (1+1) sludge pumps (submersible type) complete with electric motors, non-return valve, isolation valve, piping supports, hangers etc. for cold-water basin drainage. The bidder shall terminate pump discharge pipe work into Discharge Header of CW Blowdown pump at a distance of approx. 300 M from sludge pit. j) Counter flanges, bolts, nuts & gaskets for all piping connections in the scope of bidders and also at terminals.
2.01.02	**Scope (Electrical):**
	a) Complete electrical equipment as per specification/ details indicated in Section IIA shall be in bidders' scope. b) The scope of power & control cables & special cables shall be as per section IIA (electrical). c) Base plate, foundation plates, anchor bolts, sleeves, inserts in concrete work for electrical and mechanical equipment & accessories.
2.01.03	**Scope (C & I):**
	a) Removable type Pitot Tube at each hot water inlet- piping header to measure the flow (during performance Guarantee test only). The Pitot Tube shall be left with customer after the completion of the test . b) One no. Pressure Gauge and One no. Temp Gauge at Hot Water pipe header at T.P.

	c) One no. of Anemometer for measurement of wind velocity. d) One no. of Psychrometer. e) Local Control Panel for Sump/Sludge Pumps (Submersible type). f) Level switches for sump/pit level high/normal/low/very low interlocks. g) Actuator for Motorized BFV at inlet of hot water pipes.
2.01.04	**Scope (Civil):**
	a) Complete civil works as detailed in Book 2 of 2 (Civil Specification) including excavation, shoring, dewatering, backfilling, concrete work including shuttering, sand filling, disposal of surplus soil outside plant boundary, formwork including automatic climb form, laser beam survey instruments, fabrication, galvanizing and erection of steel structures and inserts, finishing anchor bolts, RCC sump/duct, laying and testing of hot water pipe line, water proofing, providing PVC water stops and joint fillers, drainage and other ancillary items connected with cooling towers. All faces of concrete structures and steel structures coming directly in contact with water shall be coated with corrosion resistant coating system as approved. The surfaces that would include are inner face of hyperbolic shell, raker column faces, inner faces of cold water basin, fill support structures, hot water distribution ducts & channels, cold water channel etc. The scope of this work shall consist of , but not limited to, the construction of reinforced concrete double curvature hyperbolic shell, ring beams, foundations (including Piling, if required), cold water basins with partition walls, hot water ducts, drain sumps, external drain chamber with associated pipe work, cold water channels with sluice gate up to the terminal point as specified elsewhere, hoists and monorails, primary and secondary hot water distribution troughs, fill support system including columns and beams, drift eliminators, testing of cold water basin for water tightness, external stairs, sludge pit for each basin section, all other staircases/ladders as required, doors and their frames, walkways, platforms, steel fitting, fixture, inserts, including fabrication, hand railing, providing protective measures in concrete and steel materials against effect of water and other chemicals on the completed structure etc. b) Supply & application of painting at site including lettering on the outer wall of the cooling tower as per customer requirement.
2.01.05	The following are also included in bidder's scope: a) One set of special tools & tackles required for maintenance of equipment & accessories in the cooling towers. b) Various drawings, datasheets, calculations, test reports/ certificates, operation & maintenance manuals including "As built drawings" etc. as specified & as necessary. c) Supply of first fill of lubricants for all equipments under this package including second fill/ replenishments as necessary during & after commissioning till handing over of the plant. d) Supply of commissioning spares on as required basis. e) Scope of services shall include but not limited to erection/ testing/ commissioning/ trial run/ performance testing & handing over of cooling towers. Transportation of equipments, material to site, local clearance, storage at site etc. & supply of all labor including supervision personnel, materials, erection tools & tackles etc. as necessary for expeditious execution of works etc. are also included in bidder's scope. It shall be the responsibility of the bidder to arrange all T & P required for the execution of complete job including erection & civil works.
3.00.00	**Equipment & Services to be provided by Purchaser:**
	a. Supply and erection of incoming hot water piping up to bidder's terminal point.

	b. Supply & erection of sludge discharge piping beyond the bidder's terminal point, if applicable. c. Cold-water outlet channels for cooling tower beyond the bidder's terminal point. d. For Electrical, C&I and Civil works, refer Sections IB/IIB, IC/IIC and Book 2 of 2 respectively enclosed herein.
4.00.00	The cooling tower shall comply with standard technical specifications of cooling towers enclosed in section -'II'. In the event of any conflict between Section -'II' & section 'I', the section 'I' shall prevail. In case of any contradiction in different clauses/parts of Section-I or any other clause of specification, the most stringent requirement shall prevail.
5.00.00	DELETED
6.00.00	DELETED
7.00.00	DELETED
8.00.00	**PERFORMANCE TESTING AT SITE**
8.01.00	**Scope:**
	To ascertain the fulfillment of guarantees after completion of erection and commissioning of the cooling tower, contractor shall carry out performance test at site of CT in presence of employer / purchaser at site.
8.02.00	**Codes:**
	The following codes and standards shall be applicable for conducting test unless otherwise modified or supplemented by the enclosed procedure and mutually agreed to between Owner, BHEL and bidder. a) Code ATC-105: Acceptance test code for water cooling towers. (latest Version). b) BS-4485: Specification for Water Cooling Tower. c) BS-1042: Methods for the measurement of fluid flow in pipes. d) BS-3435: Measurement of electrical power and energy in acceptance testing. e) ASME 19.5: Supplements on instruments and apparatus.
8.03.00	**Conductance of tests:**
	Performance testing of cooling tower shall be done to demonstrate the guaranteed cooling water temperature at rated duty point. The cold-water temperature as specified in the specification shall be guaranteed by the bidder for the design conditions of CW flow, range, ambient WBT as specified
8.03.01	The bidder shall submit cooling tower performance test procedure as per ATC 105 for approval & conduct the test as per the approved procedure, in the event of order.
8.03.02	The bidder shall be given permission to inspect the Cooling Tower in advance and ready it for the test.
8.03.03	**Cooling Tower performance shall be tested jointly by Contractor in presence of BHEL and Owner. All the representatives shall jointly record data of test**. a) The responsibility for conducting the test will be with the bidder. b) **All test instruments required for the PG test will be provided by contractor and meets the stipulations of the CTI ATC 105.** c) Calibration of instruments to be used in the test shall be carried out by an approved independent agency. Calibration of instruments should be carried out previous to, but not more than six months before the test. The calibration certificate of the instruments should be valid for the period of test. d) List of instruments to be arranged by the bidder along with the calibration certificates of the

	instruments to be used and psychometric charts and tables should be submitted to owner for approval.
8.03.04	PG test shall be carried out by the bidder after completion of the cooling tower and at a time when the atmospheric conditions are within limits of deviation from the design conditions as specified in this section preferably in the period from May to September.
8.03.05	Performance test shall be carried out based on ambient WBT. The performance curves of the towers showing variation in performance with change in ambient wet bulb temperature, cooling range, relative humidity water loading of the tower etc, required to ascertain the performance of the tower shall be furnished to the successful bidder. Performance curves applicable to 90%, 100% and 110% of the design water flow rate shall be furnished to the successful bidder.
8.03.06	The guaranteed performance of the equipments shall be demonstrated by the bidder after evaluating the P.G. test should the result of the test deviate from the guaranteed values the bidder shall be given an opportunity to modify/rectify/replace the fills and other materials associated with the performance of tower as required to enable it to meet the guarantees. In such cases the PG test shall be repeated within one month from the date on which the equipment is ready for retest and cost of modification, including labour, materials and cost of additional testing shall be borne by the Bidder. The chance for repeat testing will be given only twice during the contract period. All the modifications carried out by the bidder in the Cooling Tower to meet the contractual requirements shall be carried out free of cost to the Owner in other towers (if applicable for the package).
8.03.07	In case the test cold water temperature as determined from the PG test is higher than the predicated value (based on the performance curves). Purchaser reserves the right to accept all the towers after assessing the LD/ Penalty for performance as specified in cl no- 11.00.00.
9.00.00	The makes of all the equipments under this specification shall be subject to purchaser's approval in the event of order.
10.00.00	It is mandatory for the bidder's to furnish along with the bid the deviations if any, whether major or minor in the '**Schedule of Deviations**' only. In the absence of the deviations listed in the '**Schedule of Deviations**', the offer shall be deemed to be in full conformity with the specification not withstanding anything else stated elsewhere in the offer, data sheets etc. **The hidden deviations or stated/ implied deviations in the offer shall not be acceptable and binding on the purchaser**.
11.00.00	**PENALTY FOR PERFORMANCE:**
	Bidder is responsible for workmanship & material supplied for the cooling tower. a) Performance testing of cooling tower shall be done to demonstrate the guaranteed cooling water temperature at rated duty point. The cold-water temperature as specified in the specification shall be guaranteed by bidder for the design conditions of CW flow, range, ambient WBT as specified. In case the test cold-water temperature as determined from the PG test is higher than the predicted value. Owner reserves the right to reject/replace the fills and other materials associated with the performance of the tower. In the event of acceptance by purchaser, penalty of 5% of contract value shall be deducted. b) The successful bidder shall demonstrate the above guarantees during performance testing at site. The purchaser is, however, not bound to accept the equipment and reserves the right to out rightly reject it if the actual values exceed beyond the plant design limits.
12.00.00	**INSPECTION AND TESTING:**
	Purchaser/ Customer or their authorized representatives shall have the right to inspect at any stage of manufacture & construction, all materials, components & workmanship & testing of material. The

	bidder shall provide all facilities for inspection & testing without any extra cost to the purchaser/ Consultant.
12.01.00	The contractor/ manufacturer shall conduct the following minimum specific tests to ensure that the equipment shall conform to the requirements of this section and in full compliance with the requirements spelt out in applicable codes and standards.
12.02.00	Material identification and testing of regulating valve assemblies, screen assemblies, all supporting structural assemblies, fills, all nuts and bolts, sluice valves, nozzles and all other applicable components constituting each cooling tower.
12.03.00	Hydrostatic testing of hot water distribution piping regulating valves and all other pressure parts at a pressure and duration as spelt out in this specification.
12.04.00	Visual, dimensional checking of all components of each cooling tower.
12.05.00	Material testing of all components, hydrostatic testing of all pressure parts at a pressure and duration in compliance with this specification, static and dynamic balancing tests of all rotating components such as pump shaft, line shaft, impeller etc. and complete performance testing as minimum for each sludge pump in each cooling tower.
12.06.00	Tests for hoists, chain pulley blocks and all other lifting tackle shall be carried out as per relevant Indian/ equivalent international standards.
12.07.00	Any other tests deemed necessary for safe, reliable and satisfactory operation of the equipment.
13.00.00	**QUALITY PLAN:**
13.01.00	The inspection & testing of the cooling towers & its various components shall be as per quality plans approved by the purchaser/ Customer. Bidder shall submit the quality plans based on the guidelines given in specification & quality plans enclosed herein. The customer hold points of BHEL/ Customer/Customer nominated agency shall be marked in the QP at the contract stage, in the event of order & inspection/ testing shall be carried out as per same apart from various test certificates/ inspection records etc. Following standard QP are enclosed for bidder's guidance: • Cooling tower • Pipes, fittings & pipe work • BF Valves • Chain Pulley Blocks • Gate/ Globe Valves • Submersible Pumps
13.02.00	The quality plans for various electrical, C&I and Civil works are enclosed in respective sections for bidder's compliance.
13.03.00	For equipments not covered above, bidder shall submit QP's for same on the basis of similar guidelines & submit for approval in the event of order.
14.00.00	DELETED
15.00.00	**DRAWINGS, CURVES AND INFORMATION REQUIRED: DELETED**
16.00.00	**Successful bidder in the event of award of contract shall furnish the drawings/ documents for all temporary structures, all erection methodologies, bought items or self-manufactured and/or fabricated items.**

SECTION-B: MECHANICAL WORKS

1.0 GENERAL

The scope of Mechanical works and testing requirements are covered in this section. The specification gives a broad outline of the scope of work and services to be provided by the contractor and it is not the intent of this specification to cover all the granular details of the package. It shall be the responsibility of the contractor to provide all the necessary materials, works and services required to complete the project in all respects, even if the same are not explicitly mentioned in this specification.

All the detailed fabrication drawings shall be prepared by the contractor and got approved by the Engineer-in-Charge. All the latest revisions of relevant Indian and International standards are applicable in this contract.

1.1 MEASUREMENT & PAYMENT

For payment of work done under this section, the actual quantity erected in the NDCT as measured and approved by the Engineer-in-Charge shall be considered for payment. The quantities lost towards wastage, etc., shall be to the contractor's account and no bills toward wastages, etc. shall be entertained.

2.0 FILL

Fills are of PVC Splash type. Fills should be supported in Duplex SS grids with PP Clips in such a manner that movement in both horizontal & vertical directions are arrested. Additional Duplex SS or PP tie wire should also be used to ensure that the fills do not fall off position due to failure of clipping arrangement.

The fills should not sag with all the working, scaling and temperature loads envisaged, including the induced vibrations.

The fill shape, size and configuration shown in the GA drawing enclosed with this specification must be followed without deviation. No changes in these aspects will be permitted.

3.0 HOT WATER DISTRIBUTION SYSTEM

Hot water should flow into the RCC Primary Ducts through corrosion protected MS Riser pipes that enter the NDCTs through the air inlet as shown in the enclosed GA drawing. It is preferred that the water discharges into the duct from the bottom.

A RCC Secondary Duct shall receive hot water from the Primary Duct for distribution into specific segments as per design.

The lateral distribution pipes embedded in the Primary and Secondary Ducts are fitted with down-spray type nozzles, which spray water uniformly over the fill. Spray pattern over the fill should be

circular or square, but solid in either case to ensure equal and uniform distribution of water over the fill without resulting in dry spots at all plant loads.

The complete water distribution system should be rigidly secured to the supporting structure as shown in the drawings.

3.1 PRIMARY DUCT

Primary duct is designed as a RCC channel with cast in-situ slab on top (i.e. closed on top). Each primary duct has 2 Nos. of 1000 mm (W) x 1000 mm (B) x 1000 mm (D) min. open surge shafts cum manholes with rungs to access duct bottom. Each primary duct also has a 100 NB drain plug with dummy nut.

The primary duct also acts as a walk way across the tower. Hence, handrails are provided on both sides along the duct.

3.2 SECONDARY DUCT

A Secondary duct is required to distribute hot water over small segments of the circular area which cannot be catered to by the Primary duct. This duct too is designed as a RCC channel but with a cast-in-situ slab on top.

The secondary duct too acts as a walk way. Hence, handrails are provided on both sides along the duct.

3.3 LATERAL PIPES

Lateral pipes are of GRP material or as shown in the drawings. The pipes should be with Spigot ends so that couplers for jointing are avoided to the extent possible. Reducers, End plugs, etc. needed for the operation of the distribution system and as shown in the drawings shall be provided by the contractor. All the accessories shall be of the same rating as of the pipe (Class 3 to IS: 4985).

Lateral pipes shall have pre-fabricated holes at desired intervals (as shown in the drawing) for fixing of nozzles. No drilling will be permitted in pipes after these are installed/embedded in HW ducts.

Maximum diametrical tolerance of (+) 1 mm is allowed for the holes. And alignment of holes shall be within + 10 mm tolerance limit. Hence, it is suggested that the contractor make a suitable jig arrangement at ground level to achieve this requirement.

Nozzles should be fixed to the lateral pipes by bolting and tying with Polypropylene (PP) straps as shown in the drawings. In case of additional fastening with PP straps, the straps shall be capable of taking a minimum load of 30 Kg. Necessary accessories for fastening shall be of same material as of the strap. Bolts shall be of Duplex SS material.

Pipe joints shall be rendered leak proof by proper application of adhesive (supplied by manufacturer) as shown in the drawings.

Alignment of lateral pipes shall be within the tolerance limits specified above for the pre-fabricated holes. All the nozzles shall be aligned to the direction of gravity. The levels of the pipes and nozzles shall be maintained to result in uniform distribution.

3.4 NOZZLES

The nozzles shall be of down-spray type in PP construction. The spray pattern shall be either circular or square with a minimum diameter of 900 mm.

The contractor shall offer a nozzle that achieves the spray pattern and diameter specified at a static head shown in thermal design calculations. The final choice of the nozzle shall be subject to acceptance by the Engineer-in-Charge.

The tolerance on nozzle opening size for discharge shall be limited to ±1% of that shown in the drawings. Contractor shall demonstrate the performance at 80%, 100% and 120% water loads at nozzle vendor premises using a properly designed test rig. The contractor shall submit testing facility details along with test procedure for review and acceptance before under taking the performance test and procurement or supply of nozzles.

Owner reserves the right to witness the nozzle testing at vendor works. Contractor shall submit the nozzle performance curves to the Owner for review and final acceptance of the proposed nozzle type to achieve the performance envisaged in designs and drawings.

In case of any deficiency is found in nozzle performance at a later stage, the Contractor shall provide additional nozzles or nozzles of a better type without any additional cost to the Owner to meet the design requirements.

In case nozzles comprise of two or more parts, assembly of the same shall be either by threaded connection or Duplex SS bolting. The Contractor shall submit a sketch/drawing of the nozzle and its fixing arrangement, including two sample pieces along with his offer.

3.5 HOT WATER PIPING

The MS hot water riser piping shall be connected to the Owner's hot water header pipe at the Terminal Point as shown in the drawing. The end connection shall be of welded type. If the terminal points of owner's header pipes are not ready, all the open ends of the pipes shall be covered with polythene sheets to prevent corrosion.

Steel pipes shall be made either by ERW/SAW methods. Steel pipes shall conform to IS: 1239 (Medium grade) and IS: 3589 (Fe 410 grade) as the case may be. Steel plates for pipes shall conform to IS: 2062. For pipe sizes up to 300 NB, seamless long radius elbows shall be used unless otherwise specified. For pipe sizes above 300 NB, mitre bends shall be used.

The Contractor shall provide the necessary civil & structural works, if required for all the independent foundations, thrust blocks, etc supporting the hot water pipe. Painting shall be as specified elsewhere in these documents.

3.5.1 Butterfly Valves

Butterfly Valves shall be electrically operated Double flanged type meeting the requirements of AWWA C – 504 or BS: 5155. Necessary cabling for actuators and limit switches, etc shall be provided by the Contractor up to a common Junction Box located near the Staircase.

POD (Proof of Design) Test	: AWWA C – 504
Operating Fluid	: Water at 45 to 50 deg. C
Design Pressure	: 5.7 Kg./Sq.cm
Max. Differential Pressure	: 5.7 Kg./Sq.cm.
Head loss coefficient	: Max. 0.25
Body & Disc	: Cast Iron to IS: 210 Grade FG 260 or Fabricated steel to IS:2062 / IS:2002 with Rubber or Ebonite Lining
Shaft	: Duplex SS
Bearing type	: Self-lubricated type
Disc seat	: EPDM
Body Seat	: Duplex SS
Internal Hardware	: Duplex SS
External Hardware	: SS 316L
Wetted Fasteners	: Duplex SS
other Fasteners	: SS 316L
Gland Packing	: Teflon
Gaskets, Rings, etc.	: Nitrile Rubber
Accessories	: 2 Nos. of 2NO + 2NC Limit Switches 'OPEN' & 'CLOSE' or as per Actuator data sheet enclosed with Electrical Specifications

All the butterfly valves shall be complete with graduated position indicator, arrow indicating the flow direction, actuators, limit switches, etc. The valves shall be suitable for erection in any position (Horizontal / Vertical, etc.). The operating mechanism shall be mounted directly on or supported from valve body. Actuator specifications shall be as specified elsewhere in this document.

All the butterfly valves shall be provided with hand wheel. Butterfly valves of size 350 NB and above shall be provided with reduction gear units. Valves shall close in clockwise direction. The hand controls shall be dimensioned to guarantee an easy manoeuvre under most severe conditions. The hand controls shall be provided with locking systems to avoid the disk assuming a not desired

position during operation. The pulling force required on the hand wheel-rim shall not exceed 30 Kg. when operating the valve under full flow and operating pressure, in case of failure of actuator. The reduction units shall be watertight, complete with lubrication and position indicator.

3.5.1.1 Flanges

For valves designed as per AWWA C-504, flanges shall conform to ANSI B16.1 Class 150 for CI valves and AWWA C-207 Class D for fabricated steel valves. The counter flanges shall conform to AWWA C-207 Class D.

For valves designed as per BS: 5155 the flanges shall be as per BS: 4504. All the flanges shall be of slip-on and flat-face type. Flanges shall be fabricated from steel plates conforming to IS: 2062.

3.5.2 Ball Valves:

Ball valves are envisaged mainly for flow measurement ports. These valves shall conform to IS: 9890 and are of threaded type.

Pattern and Construction : Full bore in single piece

Nominal size : 150 NB

Design pressure : 6 kg/sq.cm

Material of construction : Duplex SS

3.5.3 Sluice Gate (if applicable)

The sluice gate shall be of circular opening conforming to IS: 3042 Class – 1, with rising spindle. The materials of construction of the gates shall be as follows:

Frame and Door : SS 316L

Face, seat rings, trim and Spindle Nut : SS 316L

Spindles, bolts and nuts : SS 316L

Each sluice gate shall be furnished complete with extension spindle through extra-strong pipe of required length connected to the floor-stand through stem coupling. The floor-stand shall be provided on concrete floor of the drain box. Each gate shall be furnished with bell-bottom base and shall 815 mm high, provided with an indicator and open/close positions clearly marked on the stand. The floor-stand shall be furnished with 450 mm diameter hand wheel and wheel-stem coupling to suit the sluice extension pipe.

3.5.4 Miscellaneous

Each hot water header shall have 3 Nos. of 150 NB, 200 mm long MS stubs internally and externally coated with Corrocoat or Polyurea or Glass Flakes. The stubs can have threaded or flanged ends (depending on valve ends) for measurement of water flow with Pitot tube. The location of these stubs shall be at a location on the header piping where at least a straight length of 10D on upstream side and 5D on downstream side is available.

Each stub shall be fitted with 150 NB Ball Valve in Duplex SS for isolation purpose. All necessary bolts, washers, nuts shall be of Duplex SS.

Each hot water header shall have one number stub for pressure gauge with isolation valve and one thermowel for temperature measurement.

3.6 CONSTRUCTION FEATURES OF M.S. PIPING:

3.6.1 End Preparation, Cutting, etc.

For steel pipes, end preparation for butt-welding shall be done by machining/flame cutting. Socket weld preparation shall be saw/machine cut. All the welding electrodes and other requirements for welding, including any special material, shall be arranged by the contractor.

For tees, laterals, mitre bends and other irregular details, template shall be used for accurate cutting.

3.6.2 General Instructions for Piping Construction

While erecting the field run pipes, the contractor shall check the accessibility of valves, instrument tapping points and maintain minimum head room requirement and other necessary clearances from the adjoining work areas. Irrespective of whether mentioned in the drawings or not, all pipelines shall be given proper slope towards the drain point.

3.6.3 Welding:

a. Before welding the ends shall be cleaned by wire-brushing, filing or grinding.
b. Welding of piping shall be done by certified welders. Welders' qualification shall be as required by ASME Section-IX. Welding at any joint should be completed in one go.
c. Welding under this specification shall be done by a process approved by the Engineer-in-Charge.
d. Automatic or semi-automatic welding shall be done only with the specific approval of the Engineer-in-Charge.
e. As far as possible welding shall be carried out in flat position. In case that is not possible, welding shall be done in a position as close as to the flat position as possible.
f. Downward technique is not allowed in the welding of pipes in horizontal position, unless permitted by the Engineer-in-Charge.
g. Combination of welding processes or usage of electrode of different classes or 'makes' in a particular joint shall be done after the welding procedure has been duly qualified and approved by the Engineer-in-Charge.

h. Welding carried out in ambient temperature of 50°C or below shall be heat-treated.

3.6.4 Alignment & Spacing

a. The pipes joined by welding shall be aligned correctly within the existing tolerance on diameters, wall thickness & out of roundness, which shall be preserved during welding. All flange facings shall be true and perpendicular to the axis of the pipe with bolt holes being off centre, unless different orientations are shown in drawing to match some equipment connections.
b. Components to be welded shall be aligned and spaced.
c. Root opening shall be 1 mm to 2 mm for wall thickness of 2.4 mm or under and for all thicknesses in oxy-acetylene welding. For 2.4 mm and above, root opening shall be 2 mm to 3 mm.
d. Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form a part of final welding these shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.
e. Electrode size for tack welding shall be selected depending upon the root opening.
f. Tack welding should be equally spaced as follows:

For 65 NB pipe and smaller	: 2 tacks
For 80 NB to 300 NB pipe	: 4 tacks
For 350 NB & larger pipes	: 6 tacks

3.6.5 Welding Technique

a. Root pass shall be made with respective electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.
b. Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxy-acetylene welding is recommended.
c. The route pass of butt-joints shall be so as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.
d. Each pass shall be cleared to be made free of slag before the next pass is deposited.
e. In case of deviation from the welding process and electrodes as specified, the contractor shall seek the approval of Engineer-in-Charge before implementing the change.
f. On completion of each run, craters, weld irregularities, slag, etc. shall be removed by grinding or chipping.
g. During the process of welding, all movements, shocks, vibrations or stresses shall be carefully avoided in order to prevent weld cracks.
h. Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG (3.25 mm). At least two passes shall be made on socket weld.

4.0 BASIN

Basin is divided into two equal parts by a diametrical partition wall. Each NDCT basin compartment shall be provided with a cold water outlet and a drain sump at the opposite ends. A peripheral drain shall be provided with a minimum floor slope of 1:400 towards the drain sump for easy cleaning of the basin. The basin floor itself, in turn will be provided with a slope of 1:500 towards the peripheral drain.

Sludge will be removed using portable pumps, which shall be supplied by the contractor. The Contractor shall make all provisions such as platforms with handrails, discharge piping up to terminal point, etc. for smooth operation of these pumps. Rungs shall be provided up to the bottom of sump in each compartment for maintenance of valves and pumps.

5.0 COLD WATER CHANNEL

Cold water outlet near cooling tower is partitioned into two parts. Each part of cold water outlet shall have Screens and Stop Log Gates as shown in the drawings. Guide frames of Screens and Gates shall be interchangeable.

To obtain proper alignment of the guide channels, a bigger slot will be left in the concrete and after fixing the channels in position the grouting of these channels will be done by secondary grout/concrete so that fixtures do not get disturbed.

Monorails with push trolleys, chain pulley blocks and hooks shall be provided for handling of gates and screens,. The structural arrangement required for the monorails shall also be provided by the contractor as per the approved drawings.

A walkway with handrails shall be provided across the outlet for easy operation of gates and screens. Both the compartments of cold water outlet shall be combined into a gravity channel at the end of the partition wall as shown in the drawings. The combined cold water outlet shall be covered with RCC cast-in-situ slab up to terminal point. Termination of cold water outlet shall be done with PVC water stopper.

5.1 SCREEN

Mesh	: SS 316 L
Mesh Size	: 10 mm x 10 mm to IS: 2405, Part 1
Supporting Frame	: SS316 L
Guide Frame (Embedded in Concrete)	: SS 316 L
Trash Tray	: SS316 L
Fasteners	: SS 316 L

Screens shall freely move inside the structural framework embedded in the concrete walls of the open channel. Screens provided in the outlet channel shall have a trash tray incorporated on the

upstream side of the bottom edge of the screen to catch any debris falling down the screen during removal.

5.2 STOP LOG GATE

Standard	: IS: 5620
Guide frame (Embedded in Concrete)	: SS 316L
Gate (including supporting frame)	: SS 316L
Slide plates of gate	: SS 316L
Slide Seal	: EPDM Musical note to IS: 11855
Bottom Seal	: EPDM to IS: 11855
Painting	: Specified elsewhere
Fasteners	: SS 316L

Slide gate constructed in hot double-dip galvanized structural steel sections shall be furnished as per the drawings to be given during execution. The gate shall move freely inside a structural framework embedded in the concrete walls of the open channel. The gates shall have a continuous bearing under compression all around the opening ensuring no leakage.

6.0 ACCESS

6.1 STAIR CASE

All stair cases shall be 'Dog Legged'. The minimum clear width of the stairways and platforms shall be 1000 mm. Minimum clear headroom of 2.5 m shall be maintained over platforms and walkways.

6.2 ACCESS DOORS

The doors shall be of single leaf – double skin type and of 2.1 m (H) x 1.2 m (W) size fabricated from min. 6 mm thick FRP sheet in ribbed construction.

6.3 CAGE LADDER

The cage ladder shall conform to IS: 3696. The ladders shall be min. 600 mm wide and made of hot double dip galvanized 75 mm x 6 mm thick flats with 20 mm diameter rungs at 300 mm centres with stays at every 1.75 m connected to the wall. The ladder shall be provided with a hot double dip galvanized MS cage consisting of 50 mm x 6 mm straps at 800 mm centres with min. five (5) Nos. 50

mm x 6 mm vertical cage flats throughout the complete length of the ladders. Intermediate landing platforms with handrails, as required and/or as shown in the drawings shall be provided.

6.4 WALKWAYS

Walkways shall be min. 1000 mm wide and shall have min. 2.1 m headroom, unless otherwise specified. All walkways shall have safety handrail of min. 1.2 m height on both sides.

6.5 RUNGS

SS 316 rungs of 12 mm diameter shall be embedded in CW Channel RCC wall. Each rung shall be 450 mm wide x 150 mm beyond the wall face unless otherwise specified.

7.0 MATERIAL HANDLING FACILITIES

7.1 AT TOP OF SHELL

During maintenance of the tower, to lift the materials like lighting poles, aviation lights, welding machine etc., from ground to the top of the tower, material handling provision to be made at the top of the tower. MSHDG plates of size 300 x 300 x 20 mm shall be embedded in the wall, flush with the outside concrete surface at 1 m C/C on the shell circumference at the top most platform level. Each plate shall have four tapped holes with nuts welded to the back of each hole (for having extra-long thread engagement) for fixing bolts later. The drilled and tapped holes and nuts shall be suitable for 20 mm diameter bolts. Care shall be taken to prevent entry of concrete into the nut and tapped holes. This arrangement is to support a swivelling lifting arm to hoist a load of 1000 kg.

7.1.1 PORTABLE ROTATING TYPE LIFTING ARM

Lifting arms including swivelling brackets, pins, etc. complete shall be provided along with 250 mm diameter CS pulleys. It shall be possible to easily erect/dismantle this arrangement as and when required. All structural steel sections, brackets and inserts such as bolts, nuts, plates, etc., shall be of MS hot dip galvanized.

7.2 FOR SCREEN AND SLIDE GATE IN COLD WATER CHANNEL

Monorail beam at sufficient height shall be provided. A hand operated chain pulley block with traveling trolley of capacity not less than 125% weight of slide gate shall be provided. All other accessories for this system shall also be designed for the same load. Monorails shall be extended outside the cold water channel to lift/lower the equipment from/to the ground level.

Life	: Not less than 20 years
All parts	: SS 316L or better
Chain pulley blocks	: IS: 3832, Class 2 duty
Hand operating chain	: SS 316L
Load Chain	: SS 316L

Hook	: IS: 7847
MOC of hook	: High tensile steel and heat treated or better as per Clause 7.1 (b) of IS: 3815 suitable for highly corrosive environment
Wire ropes/slings	: IS: 2266

8.0 HARDWARE

All the hardware immersed in water or in direct contact with water/water spray shall be of Duplex SS, unless otherwise specified. The hardware not in contact with water or moisture shall be of SS 316L, unless otherwise specified. However, all hardware for handrails and cage ladders, etc external to the tower shall be of hot double dip galvanized MS.

10.0 TESTS:

The contractor shall submit detailed QAPs for approval. Typical QAPs are given elsewhere in this document.

10.1 FILL

10.1.1 Material Test

For plastic fills and drift eliminators impact tests shall be done as per ASTM-D-256 and flammability tests as per ASTM-D-635. Density and Vicat softening tests shall also be done. The contractor shall submit test certificates from approved third party laboratories for approval by the owner. All tests on Fills & Drift Eliminators shall conform to CTI STD-136.

10.1.1.1 UV Test for Plastic fills

UV test shall be done as per ISO-4892. Impact test shall be done before and after UV test. Test certificate from approved third party laboratories shall be submitted for approval by the owner.

10.1.2 Dimensional Test & Load Test on Fill

Dimensional accuracy and material thickness will be checked randomly at site. Load Test shall be done on a mock fill assembly. Both the tests will be done in presence of Engineer-in-Charge.

10.2 BUTTERFLY VALVES

Butterfly valves shall meet the proof of Design test and Disc strength test confirm to AWWA-C-504. Seat leak test shall be done in both directions. In case of fabricated valves, UV test on plates 20 mm or above thickness for body, disc and shaft shall be done. Radiography test on 100% butt welds and 10% DPT on fillet welds shall be done in presence of Engineer-in-Charge.

10.3 GATE/BALL VALVES

Material test, DPT for 100% butt welds and 10% fillet welds, assembly fit up and hydraulic test shall be done and certificates of same to be submitted for approval.

10.4 SLIDE/STOP LOG GATE

Material and DPT for 100% butt welds and 10% fillet welds shall be done and certificates of the same shall be submitted for approval. Assembly fit up, Dimensional accuracy and Leak tight test shall be done at site.

10.5 CHAIN PULLEY BLOCKS

Test certificates of material and DTP shall be submitted for approval. Full load test and 25% overload test shall be carried out with all motions and safety features at site.

10.6 HOT WATER PIPES

Certificates of material and welder qualification shall be submitted for approval. Assembly fit up, dimensional accuracy, DPT and NDT (if required) shall be done at site.

10.7 SCREENS

Certificates of material and DPT shall be submitted for approval. Assembly fit-up test and dimensional accuracy shall be done at site.

11.0 VENDORS LIST

S. No	DESCRIPTION	VENDORS
1.	Testing Agency for Fills & D/E	Shriram Labs, New Delhi / CIPET, CHENNAI
2.	Butterfly Valves	AUDCO / FOURESS / KEYSTONE / IL / INTER VALVE/ KIRLOSKAR / DYNAMIC
3.	Structural Steel	SAIL / TATA / JINDAL / VIZAG STEEL
4.	PVC Pipes	SUPREME / FINOLEX / PRINCE
5.	Push Trolley, Chain Pulley Block, Hook & Chain	WMI / INDEF
6.	Red Oxide Zinc Chromate Primer	'APCOMIN' OF ASIAN PAINTS / BISON UNIVERSAL OF BRITISH

		PAINTS / '3100' OF JANSON & NICHOLSON / SYNTHETIC ZINC CHROMATE OF SHALIMAR PAINTS
7.	Epoxy Primer	HINDUSTAN CIBA GEIGY / Dr. BECK & Co / CHEM.E.LEEK
8.	Epoxy Paint	HINDUSTAN CIBA GEIGY / Dr. BECK & Co / CHEM.E.LEEK
9.	Aviation Obstruction Lights	BINOY / INSTAPOWER / AVAIDS
10.	PVC Fills & D/Es	CONTRACTOR'S OWN MAKE / MM AQUA
11.	SS Weld / FRP Mesh	CONTRACTOR'S OWN MAKE / WIRE NETTING INDUSTRIES / JEETMUL JAICHANDLAL / NBC Weld Mesh
12.	Nozzles	CONTRACTOR'S OWN MAKE / VULQUA
13.	GRP Pipes	EPP Composites / Fibre Tech Composites / BSF FRP Industries / Other Reputed

This vendor list is tentative and shall be subject to CUSTOMER approval during detailed engineering.

SECTION-C: ELECTRICAL & INSTRUMENTATION

1.0 AVIATION OBSTRUCTION LIGHTING SYSTEM (AOLS)

The aviation obstruction lights shall meet the recommendations of ICAO and all the requirement of Director General of Civil Aviation, India and FAA guidelines in general.

Aviation lights shall be fixed on the top of NDCTs. Type of fixtures shall be as listed below.

Tower height	Type of Light	Description
<= 150m	Type B, Medium Intensity	Red flashing light with directional intensity of 2000cd ± 25%. Flash frequency shall be in the range of 20 to 60 per minute
> 150m	Type A, High Intensity	White flashing light with directional intensity of 200000cd ± 25%. Flash frequency shall be in the range of 40 to 60 per minute

The number of fixtures shall be as given under.

Top diameter	No. of fixtures
<=20 ft	3
20 ft < >= 100ft	4
100 ft < >= 200ft	6
> 200 ft	8

All flashing lights shall flash simultaneously. Low and Medium intensity lights, if applicable should be operated only in night times. High intensity lights should be operated in day time with full intensity (2,00,000 Cd), during twilight times with 20,000 Cd and in night times operates with 2,000Cd intensity. Installation and setting angles for high intensity lights shall conform to table no.6.2 of ICAO / FAA guidelines.

1.1 AVIATION OBSTRUCTION LIGHTS (AOL)

Each AOL fixture shall have 100% standby light i.e. twin type. In case of failure of any operating light, the standby should be activated automatically with auto changeover facility giving hooter feedback. AOL shall be LED type conforming to IP-65 grade protection class. High intensity lights shall have

intensity step changers. The control panel for the AOLs shall be mounted near the main distribution board under the staircase.

1.2 Photoelectric light detectors shall be furnished and installed near NDCTs to monitor the north sky. The detector shall cause the control unit to energize the aviation lighting system with the north sky illuminance. The lighting system may be energized during short periods of decreasing illumination due to abrupt periods of shadow during daylight hours, but shall not be de-energized as the result of short periods of increasing illumination levels due to lighting flashes or stray light sources when overall illumination level is such that the system is operating.

1.3 Temporary warning lights shall be installed during construction and these shall be located above the top most point of the obstruction and shall be shifted as construction progresses. These lights need to be installed only after the level of obstruction is greater than 50 m above ground. Temporary warning lights shall be of four fixtures each with not less than 10 candelas of red light. Power for operation of the temporary lights shall be obtained from the construction power system. Electrical circuits and cables for these lights shall be furnished, installed and maintained by the Contractor during the construction / erection period. These lights shall be operated right from sunset to sunrise.

1.4 The contractor shall provide hand railing around the beacon platforms, if applicable for attending to any maintenance work.

1.5 The AOLs shall be adequately secured to the handrails / parapet wall of the top platform against wind forces.

1.6 All cables shall be supplied and fixed as per relevant IS codes, clamped at intervals of 1000 mm by the side of the ladder. The cables shall be PVC insulated and PVC sheathed / armoured copper conductor of 650/1100V grade heavy duty conforming to IS: 1554 Part – I (latest revision). The cable shall be subject to Owner's approval.

1.7 The contractor shall install weatherproof terminal boxes with cable glands on top of the NDCTs at a location close to the AOLs. Suitable pull boxes shall be provided at convenient locations.

1.8 There will be two incomers – one main and the other stand-by. Automatic changeover facility with manual option shall be provided in case of failure of main incomer. Standby incomer will be disconnected once the main incomer is restored with suitable delay. A 0-30 second delay timer should be provided to prevent change over taking place for very short-term failure. A16 ampere or higher rating circuit for AOLs shall be provided. The aviation warning lights shall be controlled by photoelectric cell facing north sky through contractor. Auto manual operation selector switch shall be provided for 'ON' and 'OFF' operations. A wall mounted, sheet steel enclosed type Distribution Board (DB) shall be supplied and installed at the ground level for below the staircase. It shall have arrangement to receive Owner's PVC cable (size to be intimated later) and shall have an isolating switch and separate switch fuse circuits for feeding the aviation lights. The DB shall be outdoor type dust and vermin proof and shall have a sheet steel thickness of not less than 2 mm and shall have a proper gasket with removable gland plates at top and bottom. The DB shall also house the automatic switching arrangement described above. The board shall be dead front type; all equipment shall be mounted on auxiliary door. The DB shall be provided with two separate and distinct Grounding terminals. The cables and cabling between distribution board, flashing control unit and AOL fixtures shall be in Contractor's scope.

1.9 Lighting fixtures, conduits, junction boxes, etc., shall be properly earthed using GI wire of 14 SWG. Earth wire will run along the entire length of the cable between the fixtures and DB where it will be connected to the earth.

1.10 Contractor's scope includes supply, installation, commissioning and maintenance of the complete AOL system and its cabling until the NDCTs are taken over by the Owner. The scope shall also include the associated civil works.

1.11 AOL system shall be test operated by the Contractor for not less than 12 months from the date of trial commissioning. Equipment and work that fails during the test period shall be repaired or replaced at the option of the Engineer-in-Charge. Upon any failure in this system during the test period, a new test period of 12 months will be required after repair or replacement of the equipment that has failed.

1.12 POWER RECEPTACLES

32A TPNE industrial type switch-socket outlet(s) shall be provided on the top peripheral platform and on landing platforms, if applicable as specified elsewhere.

2.0 EARTHING AND LIGHTNING PROTECTION

The Contractor's scope of supply for lightning protection includes complete system required as per IS: 2309 from air termination rods to earth mat and electrodes, whether specifically mentioned herein or not.

Grounding system shall confirm to IS: 3043. Each air terminator shall be connected to individual earth-pits through individual down conductors and earth conductors. Apart from the above, a coronal band and an earth mat shall be provided for each NDCT. Depending on the number of earth pits, four shall have test links and two shall have pigtails for connecting to main plant earth grid. All structures and equipment (even the one which are not supplied by the contractor but are in the cooling tower area) shall be connected by minimum two parallel conductors to nearest down/earth conductors.

2.1 Material of Construction

Material of conductors used above Ground level shall be of GI with zinc deposition of minimum 900 gm/m^2. All buried conductors are of MS round bars of min. 40 mm diameter.

a.	Air terminator	: 2 m long, 20 dia. Copper rod with pointed tip
b.	Coronal Band	: 75 x 10 thk GI flat
c.	Down Conductor	: 75 x 10 thk GI flat
d.	Earth Conductor	: 40 dia MS rod
e.	Earth Mat	: 40 dia MS rod
f.	Earth Electrode	: 3 m long, 40 dia MS rod
g.	Grounding for Columns & Structures	: 50 x 6 thk. GI flat
h.	Handrails & Steel structures	: 40 x 3 thk. GI flat

i. Grounding for Distribution boards & Control Panels, etc. : 40 x 3 thk. GI flat
j. & Grounding for Power outlets Lighting Fixtures : 14 SWG GI wire

2.2 AIR TERMINATOR

Tip of air terminator shall be pointed and at least 1.2 m above top of cooling tower. Air terminator shall be clamped with heavy-duty GI clamps at a minimum of 3 points to the structure. Air terminators shall be connected to down conductor and coronal band by use of pressure type fittings.

2.3 CORONAL BAND

Cooling tower shall have a coronal band connecting all air terminators provided at the top of the cooling tower. It shall be clamped to structure at 1000 C/C intervals all around.

2.4 DOWN CONDUCTOR

Down conductors shall be connected to Air terminators via the Coronal band at the top of the cooling tower and to the earth conductor at 300 mm above FGL through a test point at 1.2 m above grade. These conductors shall be continuous as far as possible. Intermediate breaks if any, shall be welded to form continuous circuit from top to bottom. Lapping of down conductor by bolting is not acceptable. These conductors shall be embedded in the outer surface of the concrete shell and diagonal columns with a minimum cover of 50 mm. These shall come out of the shell at the top of the cooling tower and at the ring beam level.

Ladders shall be electrically connected to the down conductors at top, middle and bottom by bolted connections.

2.4. TEST LINK

Test link shall be of 50 x 6 thk GI flat with electroplated bolts, nuts and washers. Test link shall be installed in a GI box fixed on the outside surface of the raker column.

2.5 EARTH CONDUCTOR

Earth Conductor shall be connected to down conductor, earth mat and earth pit by welding. Earth conductor shall be taken through approx. 1.3 m long, 100 NB AC pipe filled with PCC (1:3:6).

2.6 EARTH MAT

Cooling tower shall have a circular earth mat of diameter at least 12 m more than the cooling tower sill diameter and laid at 1000 mm below the ground. All the joints shall be of welded type.

2.7 EARTH PIT

Earth Pit shall be constructed as per IS: 3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 600 mm. Earth Pits shall be treated with salt and charcoal, in case average resistance of soil is more than 20 ohm-meters.

2.8 CLAMPS & ANCHORS:

All connections, clamps, anchors, etc. of the lightning protection system shall be made of GI fittings. All joints, unless otherwise specified shall be clamped or bolted (min. 2 Nos. of bolts) to form high pressure contact for a connection of adequate current carrying capacity and mechanical strength.

2.9 VERTICAL AND HORIZONTAL REINFORCING BARS

All vertical reinforcing bars at the top and the bottom portion of the cooling tower shall be electrically connected to the nearest horizontal reinforcing bar and these bars shall in turn be connected to the down conductors. At locations where vertical reinforcing bar is spliced, each of the spliced bar shall be electrically connected to at least one horizontal reinforcing bar which in turn shall be electrically connected to the down conductor. These electrical connections shall be made by winding tightly with not less than five (5) wrapped turns of 14 SWG GI wire.

2.10 TEMPORARY LIGHTNING PROTECTION

Temporary arrangement for lightning protection during construction shall be maintained by connecting the reinforcement bars to two Grounding conductors of minimum size 50 x 6 thk. Temporary protection shall be provided even after the completion of the tower till such time that the permanent air termination rods and various conductors, etc. are installed.

3.0 INSTRUMENTATION
3.1 PRIMARY INSTRUMENTS

a. Thermowel

Thermowel shall be of one piece solid bore type in SS 316 and of step-less tapered design as per ASME PTC 19.3.

b. Temperature Gauge

Range : 0^{o} C – 50^{o} C (linear 270^{o} arc in metric units)

Accuracy : + 1% of span

Dial size : 150 mm

Sensing element : Mercury in steel with SS Bulb and Capillary

Body material : Die-cast aluminium

Protection : IP55

Zero / Span adjustment : Required

Accessories : SS Thermowel

c. Pressure Gauge

Range : 0 – 5 kg/sq.cm (linear 270^{o} arc in metric units)

Accuracy : + 1% of span

Dial size : 150 mm

Sensing element : Bourdon/Diaphragm/Bellow of SS 316

Body material : Die-cast aluminium

Protection : IP55

Zero / Span adjustment : Required

Accessories : Blow out disc, Siphon, Snubber, Pulsation Dampener, Isolation Valve

3.2 SECONDARY INSTRUMENTS

RTD

Range : 0^{o} C – 50^{o} C

Characteristic : Linear with temperature (within + ½ % of top range value)

Type : Metal sheathed, ceramic packed

Standard : DIN 43670

No. of Elements : Duplex – 4 wire

Housing : IP 55 / Die-cast Aluminium

Calibration and accuracy: As per Class A of DIN 43760

Accessories : Spring loaded for positive contact with the well

SCHEDULE – II: PROCEDURE FOR PERFORMANCE TEST

The Contractor is required to comply with the Thermal Design Calculations, GA Drawing and Design Basis Report enclosed with this specification and stand guarantee for thermal performance of the NDCTs as per the specification requirements.

Once the construction and erection works are completed by the Contractor, he shall undertake trial commissioning of the NDCTs after notifying the Owner/Purchaser. The Owner shall provide the necessary water flow / heat load to the NDCTs for trial commissioning.

After successful trial commissioning to the satisfaction of the Owner/Purchaser, the Contractor shall carry out Performance Guarantee Test on the NDCTs as per the schedule agreed to demonstrate the thermal performance during conditions close to the design.

1.0 SCOPE AND PURPOSE

1.1 Scope

This Performance Test Procedure covers the determination of the water-cooling capacity of the Natural Draught Cooling Tower.

1.2 Purpose

This note gives an outline of procedure for the performance test. For full details, the tender documents and other associated documents as well as codes mentioned below may be referred.

1.3 Flexibility

It is recognized that the data limitations specified throughout this test procedure represent ideal conditions, which are not available most of the times the tests are performed. In such cases actual conditions may be used provided written consent is obtained from the official representative of the manufacturer and the Engineer-in-Charge.

1.4 Scope of Test

Acceptance test shall cover the determination of the thermal capability and verification of the guarantee parameters of the cooling tower constructed for the project.

1.5 Conduct of the Test

a. Test shall be conducted by accredited representatives of the Contractor in the presence of the Owner/Purchaser. The Contractor shall be given permission to inspect the tower in advance. Owner's/Purchaser's representatives shall witness all phases of the test and record the data jointly with the Contractor.

b. The responsibility for conducting the test will be with the Contractor.

c. All instruments required for the Performance test and their calibration as per codes will be the responsibility of the Contractor.

d. Calibration of the test instruments will be carried out by an approved independent Govt. agency. The calibration of the equipment should not be older than six months before the test and should be valid at the time of the test.

e. Performance curves

Performance curves for 80%, 90%, 100%, 110% and 120% of design water flow are enclosed. The performance of cooling tower during the test shall be compared with the performance possible/expected on the basis of these curves.

1.6 Codes

The performance test will be generally as per CTI Code ATC-105 or BS4485 Part-II. The following checks should be done before the test.

a. Water distribution system shall be essentially clear and free of foreign materials, which may impede the normal water flow. All the nozzles should be in place and clean so that the water distribution is good and as per design.
b. Fill shall be essentially free of foreign materials such as oil, tar, scale, silt or algae.
c. Water level in cold-water basin shall be as close as possible to normal operating level and should be maintained substantially constant.
d. Make up water and blow down should be stopped during the test period. In case it is not possible to stop the make-up water, the correction for the same will be applied as per code.

2.0 CONDITIONS OF THE TEST

Every effort should be made to conduct the test when the conditions are very close to the design. At the time of the test, the tower shall be in good operating condition. During the test, steady state and calm conditions shall prevail for the various parameters involved. Tentatively, the duration of the test shall be 4 hours. During this period, to avoid uncertainties introduced by make-up water and purge water, these will be shut off and the duration modified accordingly to maintain the concentrations of dissolved solids, etc. The station power load should be maintained at its near maximum.

The design parameters of the cooling tower are as follows:

Parameter	Unit	Design Point	Performance Range
Circulating water flow rate	m^3/hr		±20%
Cooling Range	^oC		±20%
Ambient Wet-bulb Temp.	^oC		±8.5
Ambient Relative Humidity	%		40% to 100%
Re-cooled Water Temp.	^oC		To be checked with the Performance Curves
Wind Velocity	km/hr		0 to 5

3.0 VARIATION IN THE RANGE OF PARAMETERS

During the test, the water-flow, range and heat load shall not vary by more than 5%, and shall generally remain within the limits specified in the table above.

The total dissolved solids in circulating water shall remain within design limits. Instantaneous air temperature readings may fluctuate, but variation in averages during the test period shall not exceed the following:

a. Wet bulb temperature : 1°C
b. Dry bulb temperature : 2.5°C

4.0 INSTRUMENTS FOR MEASUREMENT

All the Instruments to be used shall be calibrated.

a. Water flow: The circulating water flow should be measured using a Pitot Tube - Manometer assembly. The flow through the tower should be measured in the hot water header/riser(s) based on

the provisions made by taking either two traverses at 90° if sufficient straight length is available or three traverses at 120° if adequate straight length is not available.

b. Hot Water Temp: The hot water temperatures should be measured by using RTDs with 0.05°C least count. The measurement should be done in the hot water header / riser based on the provisions made.

c. Cold Water Temp: The cold water temperature should be measured by using RTDs with 0.05°C least count. The measurement should be done in the cold-water outlet.

d. Relative Humidity: The Relative Humidity should be derived from the measurement of wet bulb and dry bulb temperatures.

Wet Bulb Temperature (WBT): WBT should be measured using a Mechanically Aspirated Psychrometer with its bulb continuously kept wet by a wick. The air velocity over the temperature sensitive element should be maintained between 3 and 5.4 meters/sec. The thermometers for wet bulb and dry bulb shall be Mercury in glass type with a least count of 0.05°C. The measurement of WBT should be made at about 1.5 to 2.0 m above the sill level and between 15 and 100 meters to wind ward of the tower and equally spread along a line substantially bracketing the flow to the tower.

Readings should be taken at about 5 minute intervals consecutively at various stations. Both the temperatures should be measured in the shade.

The ambient wind velocity should be measured using a rotating cup / vane type anemometer. Calibration of the instrument before the test is necessary. Measurement should be made in an open and unobstructed location upwind of the tower and beyond the influence of inlet air approach velocity.

Location may be selected within 30 m of and to the windward direction of the tower at a point 1.5 to 2 m above the basin curb elevation. This location shall be subject to mutual agreement. Care shall be taken that the wind velocities and direction recorded are the true reflection of the conditions affecting the tower. Wind direction should be recorded with the help of the compass and the tower orientation.

5.0 PROCEDURE FOR THE PERFORMANCE TEST

Tentatively, the test should be conducted for a 4 hour duration and out of this, an hour will be selected which is considered to be of most stable conditions (The test may be terminated earlier in case it is found that the conditions are quite stable for at least one hour duration before the 4 hour period). The average readings will be taken at 10 min. intervals.

The hour when the conditions are most stable shall be considered for the test readings. The measurement tolerance shall be as per codes. As already mentioned the make-up water and purge water will be stopped during the test to avoid uncertainties. However if it is not possible to stop the make-up and purge water, suitable correction shall be applied as per CTI / BS codes.

6.0 FREQUENCY OF OBSERVATIONS

Readings shall be taken at the regular intervals and recorded in the units and to the number of significant digits as shown in the following table:

Measurement	Unit	Min. nos. per hour	Record to nearest
WBT	°C	12	0.1
CWT	°C	12	0.1
HWT	°C	12	0.1
Wind Velocity	km/hr	6	0.1
Water Flow	m^3/hr	3	1

One full Pitot tube traverse readings will be taken prior to conducting the actual test. During the test a minimum of three centre point readings will be taken to verify the flow.

7.0 COMPUTATION OF THE RESULTS

7.1 Computation of Water Flow

The water flow of each diameter traversed shall be determined separately by graphical integration method. The curves shall be plotted with radius against velocity on millimetre graph paper on large scale (not less than 1:5) to minimize computational error. The water flow calculation shall be as per formulae given in CTI Code ATC-105.

The average flow through all the diameters is the calculated flow through the pipe.

7.2 Calculations of the Tower Performance

7.2.1 Determination of predicted cold water temperature

The predicted cold-water temperatures (CWTs) shall be read from the performance curves for 80% to 120% of the rated flow (as the case may be) at the test wet-bulb temperature with range and relative humidity as varying parameters. A first cross-plot is drawn at each of the flow rates and a set of curves are drawn between predicted CWT and relative humidity with range as a parameter.

Scribe the test RH on the above cross-plot to read various predicted CWTs at different ranges for each of the water flow rates. Draw a second plot with between predicted CWTs and different ranges for each of the water flow rates.

Scribe the test range on the above cross-plot to read various predicted CWTs for each of the water flow rates. Draw a third cross-plot between predicted CWTs and water flow rates at the test WBT, range and relative humidity.

Enter the test CWT on the above cross-plot to read the predicted water flow rate.

7.2.2 Determination of Tower Capability

Tower capability should be calculated using the following formula, which is as per ATC-105:

$$\text{Capability} = \frac{\text{Test Water Flow Rate (measured using the Pitot Tube)}}{\text{Predicted Water Flow Rate (determined from the cross-plots)}}$$

7.2.3 Deviation in Guaranteed CWT

The tower capability calculated as above shall be used for determining the deviation in design CWT as per the procedure given in Appendix-M of CTI Code ATC-105.

The allowable tolerance in design CWT shall be subtracted from the above deviation determined as per ATC-105 to arrive at the deviation in guaranteed CWT.

7.2.3 Acceptance Criteria

If the deviation in guaranteed CWT equals zero (after subtracting the allowable tolerance), the tower is deemed to have met the guaranteed conditions.

7.3 Accuracy

To account for the errors in measurements, a tolerance of 0.3°C shall be allowed while determining the deviation in guaranteed CWT as above.

8.0 ARRANGEMENTS TO BE MADE AT SITE

a. By OWNER / PURCHASER

The plant heat load will be maintained as per steady state conditions explained above within the permissible limits of variation.

The circulating water flow, HWT and the dissolved solids concentration will be within the permissible range of variations.

The Condenser, Turbine and the Water Treatment System, if applicable will be maintained in clean condition to ensure that thermal parameters stay within the permissible limits of cooling tower testing.

b. By CONTARCTOR

A working platform shall be erected on each hot water riser or a pit provided across the header (buried), as the case may be, to facilitate flow measurement using pitot tube.

Pitot stubs shall be connected to the HW piping (riser or header, as applicable) along with isolation valves to facilitate insertion of pitot tube for flow measurement.

All the necessary measuring instruments, props, scaffolding, necessary manpower, etc. shall be arranged by the Contractor for the purpose of PG testing.

All such instruments and other appurtenances shall be taken back by the Contractor after successful PG testing of the cooling towers.

SUB-SECTION – IB

SPECIFIC TECHNICAL REQUIREMENTS (ELECTRICAL)

	TITLE: **ELECTRICAL EQUIPMENT SPECIFICATION FOR** **NATURAL DRAFT COOLING TOWER** **UDANGUDI STPP STAGE-I (2x660 MW)**	SPECIFICATION NO. VOLUME NO. : **II-B** SECTION: **C** REV NO. : **00** DATE: 09.05.2018 SHEET: 1 OF 1

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Total Sheet including cover & content sheet = 191

The requirements mentioned in Section-C / Data Sheets-A of section D shall prevail and govern in case of conflict between the same and the corresponding requirements mentioned in the descriptive portion in Section-D.

SECTION-C

(ELECTRICAL PORTION)

1.0 EQUIPMENT & SERVICES TO BE PROVIDED BY BIDDER:

a) Services and equipment as per "Electrical Scope between BHEL and Vendor".

b) Any item/work either supply of equipment or erection material which have not been specifically mentioned but are necessary to complete the work for trouble free and efficient operation of the plant shall be deemed to be included within the scope of this specification. The same shall be provided by the bidder without any extra charge.

c) Supply of mandatory spares as specified in the specifications of mechanical equipments.

d) Electrical load requirement for Natural draft cooling Tower.

e) All equipment shall be suitable for the power supply fault levels and other climatic conditions mentioned in the enclosed project information.

f) Bidder to furnish list of makes for each equipment at contract stage, which shall be subject to customer/BHEL approval without any commercial and delivery implications to BHEL

g) Various drawings, data sheets as per required format, Quality plans, calculations, test reports, test certificates, operation and maintenance manuals etc shall be furnished as specified at contract stage. All documents shall be subject to customer/BHEL approval without any commercial implication to BHEL.

h) Motor shall meet minimum requirement of motor specification.

i) Vendor to clearly indicate equipment locations and local routing lengths in their cable listing furnished to BHEL.

j) Cable BOQ worked out based on routing of cable listing provided by the vendor for " both end equipment in vendor's scope"shall be binding to the vendor with +10 % margin to take care of slight variation in routing length & wastages.

k) Cabling, earthing & lightning protection shall meet minimum requirement of cabling, earthing & lightning protection specification.

2.0 EQUIPMENT & SERVICES TO BE PROVIDED BY PURCHASER FOR ELECTRICAL & TERMINAL POINTS:

Refer "Electrical Scope between BHEL and Vendor".

3.0 DOCUMENTS TO BE SUBMITTED ALONG WITH BID

3.1 The electrical specification without any deviation from the technical/quality assurance requirements stipulated shall be deemed to be complied by the bidder in case bidder furnishes the overall compliance of package technical specification in the form of compliance certificate/No deviation certificate.

3.2 No technical submittal such as copies of data sheets, drawings, write-up, quality plans, type test certificates, technical literature, etc, is required during tender stage. Any such submission even if made, shall not be considered as part of offer.

PACKAGE: COOLING TOWER (NATURAL DRAFT) Annexure-I
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT SECTION-C
PROJECT: UDANGUDI STPP STAGE-I (2x660 MW)

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
1	415V MCC	BHEL	BHEL	240 V AC (supply feeder)/415 V AC (3 PHASE 4 WIRE) supply shall be provided by BHEL based on load data provided by vendor at contract stage for all equipment supplied by vendor as part of contract. Any other voltage level (AC/DC) required will be derived by the vendor.
2	Local Push Button Station (for motors)	BHEL	BHEL	Located near the motor.
3	Power cables, control cables and screened control cables for a) both end equipment in BHEL's scope b) both end equipment in vendor's scope c) one end equipment in vendor's scope	 BHEL BHEL BHEL	 BHEL Vendor BHEL	1. For 3.b) & c): Sizes of cables required shall be informed by vendor at contract stage (based on inputs provided by BHEL) in the form of cable listing. Finalisation of cable sizes shall be done by BHEL. Vendor shall provide lugs & glands accordingly. 2. Termination at BHEL equipment terminals by BHEL. 3. Termination at Vendor equipment terminals by Vendor.
4	Junction box for control & instrumentation cable	Vendor	Vendor	Number of Junction Boxes shall be sufficient and positioned in the field to minimize local cabling (max 10-12 mtrs) and trunk cable.
5	Any special type of cable like compensating, co-axial, prefab, MICC, fibre Optic cables etc.	Vendor	Vendor	Refer scope/ C&I portion of specification for scope of fibre Optic cables if used between PLC/ microprocessor & DCS.
6	Cabling material (Cable trays, accessories & cable tray supporting system)	Vendor	Vendor	1. Layout details between vendors supplied equipment & installation dwgs by vendor. 2. BHEL will provide cable trench/cable racks/cable pedestals along with cabling material up to the terminal point approx. 10 m away from cooling tower. Further cabling (supply and E&C) shall be in vendor's scope.
7	Cable glands ,lugs, and bimetallic strip for equipment supplied by Vendor	Vendor	Vendor	1. Double compression Ni-Cr plated brass cable glands 2. Solder less crimping type heavy duty tinned copper lugs for power and control cables.
8	Equipment grounding (including electronic earthing) & lightning protection	Vendor	Vendor	Material and sizes shall be as per specification and subject to BHEL approval during detailed engineering stage. Refer note no. 4 for electronic earthing.
9	Below grade grounding	BHEL	Vendor	MS Rod material shall be provided by BHEL. All other materials/ consumables are in vendor's scope.
10	LV Motors with base plate and foundation hardware	Vendor	Vendor	Makes shall be subject to customer/ BHEL approval at contract stage.

PACKAGE: COOLING TOWER (NATURAL DRAFT) Annexure-I
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT SECTION-C

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
11	Lighting System	Vendor	Vendor	In addition to other lighting system items, vendor shall consider aviation lights & their control as per statutory requirement and Lighting panels (LP) & timer control as per requirement. Further wires, any other material required for lighting system shall also be considered by vendor in their scope. BHEL will provide the power supply along with LDB at one location near Cooling Tower for feeding cooling tower vendor LPs/other lighting loads. Further distribution including material is in vendor scope.
12	Aviation Lighting	Vendor	Vendor	
13	Any other equipment/ material/ service required for completeness of system based on system offered by the vendor (to ensure trouble free and efficient operation of the system).	Vendor	Vendor	
14	Engineering activities during detailed engineering stage, including those listed below: a. Electrical load data submission in PEM format b. Electrical equipment GA drawings and layout drawings c. Cable trench/ tray layout drawings d. Control & Instrumentation cable schedules showing routing details [including electronic earthing cable & cables supplied by PEM for CT equipment]. e. Grounding and lightning protection system layouts f. Cable termination/ interconnection details (diagram)/ Cable block diagram	Vendor	--	1. Documentation shall be submitted as per project schedule for BHEL/ customer approval. 2. Vendor shall be responsible for necessary coordination with BHEL for required engineering interfacing during contract stage. 3. Any approval required from electrical inspection authority for electrical equipment shall be arranged by vendor.

NOTES:

PACKAGE: COOLING TOWER (NATURAL DRAFT) Annexure-I

SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT SECTION-C

1. Make of all electrical equipment/ items supplied shall be reputed make & shall be subject to approval of BHEL/customer after award of contract without any commercial implication.
2. All QPs shall be subject to approval of BHEL/customer after award of contract without any commercial implication.
3. In case the requirement of Junction Box arises on account of Power Cable size mis-match due to vendor engineering at later stage, vendor shall supply the Junction Box for suitable termination.
4. Vendor shall indicate location of Electronic Earth pit in their civil assignment drawing.

LOAD TITLE	RATING (KW / A)		UNIT (U)/STN (S)	Nos.		VOLTAGE CODE*	FEEDER CODE**	EMER. LOAD (Y)	CONT.(C)/ INTT.(I)	STARTING TIME >5 SEC (Y)	LOCATION	BOARD NO.	CABLE		BLOCK CABLE DRG. No.	CONTROL CODE	REMARKS	LOAD No.	VERIFICATION FROM MOTOR DATASHEET (Y/N)	KKS NO
	NAME PLATE	MAX. CONT. DEMAND (MCR)		RUNNING	STANDBY								SIZE CODE	NOs						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

ANNEXURE-II

NOTES:
1. COLUMN 1 TO 12 & 18 SHALL BE FILLED BY THE REQUISITIONER (ORIGINATING AGENCY); REMAINING COLUMNS ARE TO BE FILLED UP BY PEM (ELECTRICAL)/ CUSTOMER
2. ABBREVIATIONS : * VOLTAGE CODE (7):- (ac) A=11 KV, B=6.6 KV, C=3.3 KV, D=415 V, E=240 V (1 PH), F=110 V (cc): G=220 V, H=110 V, J=48 V, K=+24V, L=-24 V
: ** FEEDER CODE (8):- U=UNIDIRECTIONAL STARTER, B=BI-DIRECTIONAL STARTER, S=SUPPLY FEEDER, D=SUPPLY FEEDER (CONTACTER CONTROLLED)

LOAD DATA (ELECTRICAL)	JOB NO.	435	ORIGINATING AGENCY		PEM (ELECTRICAL)	
	PROJECT TITLE	2X660 MW UDANGUDI STPP	NAME		DATA FILLED UP ON	
	SYSTEM	NATURAL DRAFT COOLING TOWER	SIGN.		DATA ENTERED ON	
	DEPTT. / SECTION	ELECTRICAL	SHEET 1 OF 1	REV. 00	DE'S SIGN. & DATE	

CABLE SCHEDULE FORMAT

ANNEXURE III

UNITCABLENO	FROM	TO	PURPOSE	CABLE SCOPE (BHEL PEM/ VENDOR)	REMARKS	CABLESIZE	PATHCABLENO	TENTATIVE CABLE LENGTH

Explanatory notes for filling up cable list for routing through WinPath, the cable routing program (developed by Corporate R&D) being used in PEM.

1. For the purpose of clarity, it may please be noted that the information given in regard to the cables to be routed through WinPath as per the system elaborated below is called "Cable List", while the term "Cable Schedule" applies to the cable list with routing information added after routing has been carried out.

2. The cable list shall be entered as an MS Excel file in the format as per enclosed template EXT_CAB_SCH_FORMAT.XLS. No blank lines, special characters, header, footer, lines, etc. shall be introduced in the file. No changes shall be made in the title line (first line) of the template.

3. The field properties shall be as under:
    a. UNITCABLENO: A/N, up to sixteen (16) characters; each cable shall have its own unique, unduplicated cable number. In case this rule is violated, the cable cannot be taken up for routing.
    b. FROM: A/N, up to sixty (60) characters; the "From" end equipment/ device description and location to be specified here. Information in excess of 60 characters will be truncated after 60 characters.
    c. TO: A/N, up to sixty (60) characters; the "To" end equipment/ device description and location to be specified here. Information in excess of 60 characters will be truncated after 60 characters.
    d. PURPOSE: A/N, up to sixty (60) characters; the purpose (i.e. power cable/ indication/ measurement, etc.) to be specified here. Information in excess of 60 characters will be truncated after 60 characters.
    e. REMARKS: A/N, up to forty (40) characters; Any information pertinent to routing to be specified here (e.g., cable number of the cable redundant to the cable number being entered). Information in excess of 40 characters will be truncated after 40 characters.
    f. CABLESIZE: A/N, 7 characters exactly as per the codes indicated below shall be specified here. The program cannot route cables described in any other way/ format.
    g. PATHCABLENO: Field reserved for utilization by the program. User shall not enter any information here.

4. One list shall be prepared for each system/ equipment (i.e., separate and unique cable lists shall be prepared for each system).

5. The cables shall be described as per the scheme listed below:

Explanatory notes for filling up cable list for routing through WinPath, the cable routing program (developed by Corporate R&D) being used in PEM.

A	NN	A	NNN
|	|	|	|
Cable Voltage Code (see B below)	No. of cores (e.g. 01,03,3H, 07)	Cable code (See C below)	Cable size (e.g. 035,185,2.5, 0.5)

please refer below examples:

i) 3C x 120 sq. mm. (1.1kV) PVC FRLS, Unarmoured Aluminium cable, the voltage code shall be D03G120
ii) 3C x 2.5 sq. mm. (1.1kV) PVC FRLS, Unarmoured Copper cable, the voltage code shall be D03C2.5
iii) 3.5C x 120 sq. mm. (1.1kV) PVC non-FRLS, Armoured Aluminium cable, the voltage code shall be D3HF120

(A) SYSTEM VOLTAGE CODES:

(ac) A = 11KV, B = 6.6KV, C = 3.3KV, D = 415V, E = 240V, F = 110V
(dc) G = 220V, H = 110V, J = 48V, K = +24V, L = -24V

(B) CABLE VOLTAGE CODES:

A = 11KV (Power cables)
B = 6.6KV (Power cables)
C = 3.3KV (Power cables)
D = 1.1KV (LV & DC system power & control cables)
E = 0.6KV (0.5 sq. mm. Control cables)

(C) CABLE CODES

PVC Copper

A = Armoured FRLS	B = Armoured Non-FRLS
C = unarmoured FRLS	D = Unarmoured Non-FRLS

Explanatory notes for filling up cable list for routing through WinPath, the cable routing program (developed by Corporate R&D) being used in PEM.

PVC Aluminium

E = Armoured FRLS	F = Armoured Non-FRLS
G = unarmoured FRLS	H = Unarmoured Non-FRLS

XLPE Copper

J = Armoured FRLS	K = Armoured Non-FRLS
L = unarmoured FRLS	M = Unarmoured Non-FRLS

XLPE Aluminium

N = Armoured FRLS	P = Armoured Non-FRLS
Q = unarmoured FRLS	R = Unarmoured Non-FRLS

S = FIRE SURVIVAL CABLES
T = TOUGH RUBBER SHEATH
U = OVERALL SCREENED
V = PAIRED OVERALL SCREENED
W = PAIRED INDIVIDUAL SCREENED
Y = COMPENSATING CABLES
I = PRE-FABRICATED CABLES
Z = JELLY FILLED CABLES

6. Once a cable list has been given to PEM for routing, any subsequent changes required in the cable list (which may be in the form of addition of cables, deletion of cables, change of type or size of cable, etc.) must be informed as specific changes (as a separate file MS Excel of the same format as the original file) to the cable list given earlier if the cable list has been routed and cable schedule generated. The routing status of the cable list shall be got confirmed from PEM by the agency that has prepared the cable list before the changes are intimated. In case PEM confirms that the cable list in question has not been taken up for routing, and the revised cable list is acceptable,

the same may be sent. Since cable routing through the program involves adding each cable list to the project cable schedule database, the original cable schedule shall not be furnished to PEM with revisions incorporated within.

7. For any assistance or clarifications, please contact mailto:praveendutta@bhelpem.co.in

SECTION–3.16: MOTORS

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of HT motors, LT Motors and DC motors.

2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and /or supplemented by this specification.

a)	IS: 325	Three phase induction motors
b)	IS: 12615	Energy efficient induction motors
c)	IS: 900	Code of practice for installation and maintenance of induction motors
d)	IS: 996	Single-phase AC induction motor for general purpose
e)	IS: 1231	Dimensions of three-phase foot-mounted induction motors
f)	IS: 2223	Dimensions of flange mounted AC induction motors
g)	IS: 4029	Guide for testing three-phase induction motors
h)	IS: 8789	Values of performance characteristics for three-phase induction motors
i)	IS: 13555	Guide for selection and application of 3-phase AC induction motors for different types of driven equipment
j)	IS: 5571	Guide for selection of electrical equipment for hazardous areas
k)	IS: 12065	Permissible limits of noise level for rotating electrical machines
l)	IS: 12075	Mechanical vibration of rotating electrical machines
m)	IS 60034-5	Degree of protection provided by Integral design of rotating electrical machines
n)	IS 60034-8	Terminal marking and direction of rotation
o)	IS 60079-1	Equipment protection by flame proof enclosure
p)	IS 60034-1	Rotating electrical machines.
q)	IS 60079	Explosive atmospheres
r)	IS/IEC 60529	Degrees of protection provided by enclosures (IP code)
s)	IEC 60034	Rotating electrical machines.
t)	IS 3177	Code of practice for Design, Manufacture, Erection and testing of Cranes and Hoists

3.0.0 TECHNICAL REQUIREMENTS

3.1.0 Design ambient temperature

Motors shall be suitable for an ambient temperature of 50 degree C and relative humidity of 95% and shall deliver the rated output without exceeding its guaranteed temperature limits.

3.2.0 Supply voltage

Motors rated up to and including 415 V are termed as LT motors and the motors rated higher than 415 V are termed as HT motors.

Motors shall be capable of delivering the rated output under following voltage and frequency variations without exceeding its guaranteed temperature limits.

- Frequency variation : (+) 3% and (-) 5%
- Voltage variation for LT motors : (±) 10%
- Voltage variation for HT motors : (±) 6%
- Combined variation of voltage and frequency : 10% (absolute sum)

All the motors shall be so designed that maximum inrush currents, locked rotor torque and pullout torque developed at extreme voltage and frequency variations do not endanger the motor and the driven equipment.

3.3.0 System Parameters

Sl. No.	Description	11 kV and 6.6 kV System	LT System
1.	Voltage level	6.6 kV : Above 200 kW and upto 2000 kW 11 kV: Above 2000 kW	240 V : up to 0.2 kW 415 V: >0.2 kW and up to 200 kW.
2.	System earthing	Earthed through resistance, limiting earth fault current to 300 Amps	415 V system solidly grounded.
3.	Fault withstand rating of motor terminal box (Breaker operated)	50 kA for 0.2 sec for 11 kV and 31.5 kA for 0.2 sec for 6.6 kV	415 V system : 50/65 kA for 0.2 second

3.4.0 Type

AC Motors shall be squirrel cage induction type unless otherwise it is specified.

3.5.0 Duty

- All AC motors shall be squirrel cage three phase/single phase induction motors. All the motor shall be designed for bi-directional rotation.
- All the motors shall be rated for S1 duty for continuous operation. Motors of crane and hoist application shall be intermittent duty.
- DC motor shall generally be of shunt wound type rated for 220 V DC.
- Motors shall be suitable for installation in hot, humid and tropical atmosphere and polluted at places with coal ash and or fly ash.
- The motors shall be suitable for bus transfer schemes provided on the 11 kV/6.6 kV/415 V systems without any injurious effect on its life.

3.6.0 Design margin

Whenever the basis for motor rating are not specified in the corresponding mechanical specification section maximum continuous motor rating shall be atleast 10% above the maximum load derived of the driven equipment under entire operating range including voltage & frequency variation.

The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating; pull up, breakdown and full load torques are available for the intended service.

Service shall be considered as 1.0 only.

3.7.0 Method of Starting

- All the motors shall be suitable for direct on-line starting on full load. Where variable voltage and variable frequency (VVFD) operation is envisaged through VVFD drives, motors shall be specially designed for such application.
- LT motors rated up to 125 kW shall be controlled through MPCB/MCCB and contactor. LT motors rated more than 125 kW shall be controlled through air circuit breaker.
- HT Motors shall be controlled through vacuum circuit breaker.

3.8.0 Efficiency

All the duty motors shall be energy efficient type. For HT and LT motors, it shall be IE3 class as per IS 12615. For VFD controlled HT and LT motors, it shall be IE2 class as per IS 12615.

3.9.0 Temperature rise

- Winding Insulation shall be Class F.
- Temperature rise of air cooled motors shall not exceed 70°C over air temperature of 50°C by resistance method, while delivering its maximum rated output.
- Temperature rise of water cooled motors shall not exceed 80°C over inlet cooling water temperature by resistance method, while delivering its maximum rated output.

3.10.0 Starting voltage

a) Motors shall be capable of starting and accelerating the load at following starting voltage, with direct on-line starting, without exceeding specified winding temperatures.

- HT Motors (up to 1000 kW) : 85% of rated voltage
- HT Motors (> 1000 kW up to 4000 kW) : 80% of rated voltage
- HT Motors (> 4000 kW) : 75% of rated voltage
- LT motors : 80% of rated voltage

b) During fast changeover of power supply source, vector difference between the motor residual voltage and the incoming supply voltage shall be about 150% of the rated voltage and the motors shall withstand voltage stress and torque stress developed during that time, which may last for a period of one (1) second.

c) The motor shall be capable of operating at full load at a supply voltage of 75% of the rated voltage for 5 minutes.

3.11.0 No. of Starts

Continuous duty motors shall be suitable for the following starting requirements under the specified conditions of load, torque and inertia.

- No. of consecutive hot starts shall be 2 (with initial temperature of the motor at full load operating level).
- No. of consecutive cold starts shall be 3 (with initial temperature of the motor at ambient temperature).
- For conveyor motors, no. of consecutive hot starts shall be 3 (with initial temperature of the motor at full load operating level).

3.12.0 Starting current

- Locked rotor current of HT motors for applications other than listed below shall be limited to 600% of the full load current, and is subject to IS tolerance.
- For energy efficient LT motors, locked rotor current shall be as per IS: 12615.
- Locked rotor current of the VFD controlled AC motors shall be limited to 300% of the full load current, and is subject to IS tolerance.
- Locked rotor current of the BFP motors shall be limited to 450% of the full load current of the motor, and is subject to IS tolerance.

3.13.0 Locked rotor withstand time

- The locked rotor withstand time for HT motors under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage specified above by atleast three seconds or 15% of the accelerating time whichever is greater. Provision of speed switch shall be avoided to the extent possible. In case the speed switch is required, it shall be indicated by the bidder in his offer
- For the LT motors having starting time up to 20 seconds at minimum permissible voltage, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 seconds more than the starting time.
- For the motors having starting time more than 20 seconds and up to 45 seconds at minimum permissible voltage, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 seconds more than the starting time.
- For motors having starting time more than 45 seconds at minimum permissible voltage, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.
- When a speed switch is mounted on the motor shaft, the same shall remain closed for speeds lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% over speed in either direction of rotation.

3.14.0 Torque Requirements

- Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor full load torque.
- Pull out torque at rated voltage shall not be less than 205% of full load torque.
- Motors subjected to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at 125% of rated speed in reverse direction.

3.15.0 Enclosure

a) Motors shall have IP 55 degree of protection.

b) For hazardous location, the enclosure of motors shall following have flame proof construction conforming to applicable standard.
   - Fuel oil area Group – IIB
   - Hydrogen generation plant area : Group – IIC)

3.16.0 Cooling

- LT motors shall be totally enclosed fan cooled (TEFC), type IC411. The cooling shall be effected by self-driven bi-directional centrifugal fan protected by fan cover.
- HT motors can be totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or closed air circuit air cooled (CACA-IC6A1A1) type.
- Motors rated >3000 kW can be closed air circuit water cooled (CACW).
- Motors with CACA/CACW heat exchangers shall have dial type thermometer with adjustable alarm contacts to indicate the following:

  -Hot and cold air temperatures of the closed air circuit for CACA motors.

  -Hot and cold, air and water temperatures for CACW motors.
- The Alarm switch contact rating shall be minimum 0.5 A at 220 V DC and 10 A at 230 V AC.

3.17.0 Winding

- Winding shall be class F insulation with temperature limited to class B. Insulation shall be Non-hygroscopic, oil resistant, and flame resistant. Winding, fittings and hardware shall be corrosion resistant. Winding shall be tropicalized and suitably varnished, baked and treated for operating satisfactorily in humid and corrosive atmosphere.
- For the VFD operated drives, insulation shall be designed to take care of stresses due to high DV/DT. Motors shall be wound with dual coated winding wires and impregnated with VPI process. Further for such application, insulated bearings shall be provided to avoid circulating current caused by shaft induced voltages.
- Space heaters rated for 240 V AC, 50 Hz supply shall be provided for motors rated 30 kW and above to maintain windings in dry condition when motor is standstill.
- For HT motors, insulation shall be Vacuum Impregnated (VPI).
- HT motors shall withstand one minute power frequency voltage test or 1.2/50 micro sec lightning impulse Voltage wave of 4U+5 kV (U=Line voltage in kV) test on main insulation as per IEC 600034-15. The coil inter-turn insulation shall withstand steep front impulse withstand voltage as per IEC 600034-15.
- For HT motors, 12 nos. simplex or 6 nos. duplex RTDs (two per phase), each having D.C. resistance of 100 ohms at 0℃, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the ETD's shall be platinum.

3.18.0 Bearings

- Motor shall be provided with antifriction bearings, unless sleeve bearings are required by the motor application. Bearings shall be provided with seals to prevent leakage of lubricant or entrance of foreign matters like dirt, water etc. into the bearing area.
- Sleeve bearings shall be split type, ring oiled with permanently aligned, close running shaft sleeves. Grease lubricated bearings shall be pre-lubricated and shall have provisions for in-service positive lubrication with grease nipple and relief holes. For sleeve bearings, the bearing housing shall be preferably in end shield itself.
- Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if anti-friction bearings can take vertical thrust, thrust and guide bearings are not required.

- Lubricant shall not deteriorate under all service conditions. The lubricants shall be limited to normally available types. For motors rated 30 kW and above re-lubrication facility shall be provided.
- For motor with forced lubrication, a shaft driven oil pump shall be provided along with an electrical auxiliary pump. Alternatively, two motor driven pumps may be provided, one working and one standby. All necessary auxiliaries and accessories shall be provided to complete the system. A pressure gauge and pressure switch for low oil pressure warning and to start the standby oil pump automatically shall also be provided. A motor driven jacking oil pump may be provided, for heavy shaft loads.
- Flow switches shall be provided for monitoring oil flow of forced lubrication bearings, if used. Alarm switch contact rating shall be minimum 0.5 A at 220 V DC and 10 A at 230 V AC.
- For bearing temperature measurement, duplex RTDs shall be provided for each bearing and shall be wired up to the terminal box.
- Each bearing shall be provided with dial type thermometer.
- For all VFD operated motors shall have insulated bearings to prevent flow of shaft currents.
- For motors rated above 1000 KW having shaft length more than 1.5 M shall have insulated bearings to prevent flow of shaft currents.
- All the motors rated <15 kW shall be provided with sealed ZZ bearings.
- Lub oil pressure transmitters shall be provided to DCS for remote monitoring. Lub oil pressure very low trip to HT equipment shall be 2 out of 3 logic.

3.19.0 Terminal Boxes

- Separate terminal boxes of IP 55 degree of protection shall be provided for stator leads. For single core cables, gland plate shall be non-magnetic material. Terminal box of HT motors shall be capable of being turned 360° in steps of 180°. Terminal box of LT motors shall be capable of being turned 360° in steps of 90°. The terminal boxes shall be split type with removable cover with access to connections.
- Terminals for motors shall be stud type, thoroughly insulated from the frame. The terminals shall be clearly identified by phase markings, with corresponding direction of rotation marked on the non-driving end of the motor.
- The terminal box shall be capable of withstanding maximum system fault current for 0.2 sec for all breaker operated motors and shall be provided with explosion vent.
- For contactor operated LT motors, the terminal box shall be capable of withstanding the fault current for 0.2 sec minimum and operating time of MPCB/MCCB.
- Removable gland plates of thickness not less than 2.5 mm sheet steel or 3 mm aluminium (for single core cables) shall be provided for cable boxes.
- Cable spreader box shall be provided for larger cable sizes.
- Cable boxes of HT motors shall be phase segregated type. The terminals of three phases shall be segregated by barriers of metal or fiber glass. For HT motors, cable box design shall be suitable for accommodating cable termination kits.
- Separate terminal box for space heaters shall be provided.
- A separate terminal box of IP 55 degree of protection shall be provided for temperature detectors.
- Motors rated >1000 kW shall be provided with neutral current transformers of PS class on each phase for differential protection in neutral side terminal box. The three phases shall be connected to form the star point after passing through the CTs. The CT details shall be

finalized during detail engineering. Neutral terminal box shall have IP 55 degree of protection.

- The secondary leads of CT shall be wired to separate auxiliary terminal box of IP 55 degree of protection
- All the accessory terminal boxes shall be located on the same side of the main (power) terminal box.
- For LT motors, terminal box shall be located on top, unless otherwise specified.

3.20.0 Earthing Terminals

The frame of each motor shall be provided with two separate and distinct grounding pads complete with tapped hole, GI bolts and washer. The terminal box shall have a separate grounding terminal.

3.21.0 Noise and Vibration

- Motors shall be selected with low noise levels in accordance with IS 12065.
- The peak amplitude of the vibration shall also be within the specified limits of IS: 12075.
- All HT motors shall be provided with vibration pads for mounting vibration detectors.

3.22.0 Name Plates

Motor shall have stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / IS: 12615 and shall also have 'BEE' marking.

In addition to the minimum information required by IEC/IS, the following information shall be shown on motor rating plate:

- Temperature rise in ºC under rated condition and method of measurement.
- Degree of protection.
- Bearing identification no. and recommended lubricant.
- Location of insulated bearings.

3.23.0 Canopy

Canopy shall be provided for all the motors located outdoor. For details, please refer Civil section.

4.0.0 DC MOTORS

DC motors shall be provided where specified/required. DC Motors shall be sized for operation with fixed resistance starting for reliability. DC motors shall be shunt wound type. Motors shall be capable of delivering the rated output at 220 V DC with (+) 10% and (-) 15% variations without exceeding its guaranteed temperature limits. 220 V DC system shall be unearthed. Starting current of the DC motors shall be limited to 200% of the full load current of the motor, and is subject to IS tolerance. DC Motors shall be similar to AC Motors with respect to other features like enclosure type, cooling and class of insulation.

5.0.0 INSTALLATION

Installation shall be carried out as per IS: 900.

6.0.0 PAINTING

Painting shall be carried out by an approved process. Pretreatment shall conform to applicable standard. The equipment shall be subject to a coat of red oxide primer paint. All inside and

outside surface shall be painted with epoxy based paint. The final thickness of paint film on steel shall not be less than 100 microns. Finish shade shall be 631 of IS: 5 (smoke grey).

7.0.0 TESTING AND INSPECTION

7.1.0 Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished for the motors rated 30 kW and above.

7.2.0 The following type tests shall be conducted on LT motors.

- Measurement of resistance of windings of stator and wound rotor.
- No load test at rated voltage to determine input current power and speed
- Full load test to determine efficiency power factor and slip.
- Temperature rise test.
- Momentary excess torque test.
- High voltage test.
- Test for vibration severity of motor.
- Test for noise levels of motor
- Test for degree of protection
- Over speed test.

7.3.0 The following additional type tests shall be conducted on HT motors.

- No load saturation and loss curves up to approximately 115% of rated voltage
- Measurement of noise at no load.
- Momentary excess torque test
- Full load test
- Temperature rise test at rated conditions.
- Lightning Impulse withstand test on the sample coil shall be as per IEC-60034, part-15
- Surge-withstand test on interturn insulation shall be as per clause no. 5.1.2 of IEC 60034, part-15
- Degree of protection test for the enclosure followed by IR, HV and no load run test.
- Terminal box-fault level withstand test for each type of terminal box.

7.4.0 The following routine tests shall be carried out for the motors as per applicable standards.

- IR of Winding before and after HV tests
- HV test on main winding space heater, RTD, BTD
- Resistance measurement
- No load run test Major Electrical
- Phase sequence and direction of rotation
- Vibration check Major Electrical
- Reduced voltage running test
- Locked rotor test at reduced voltage
- Record of RTD & BTD resistance at the end of no load test
- Test on space heater & RTD
- Visual Control of terminal box and verification of construction with respect to short tested terminal box

7.5.0 The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- Measurement of vibration.
- Measurement of insulation resistance and polarization index.
- Measurement of full load current.
- Test running of the motors, checking the temperature rise and identifying the hot spot etc.

8.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Motor sizing calculation
- Technical particulars
- General arrangement drawings
- Performance curves (Efficiency, power factor, starting current)
- Characteristic curves (Speed torque, Hot/cold with stand time, Negative sequence current)
- Terminal box details
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

SECTION–3.25: CABLE TRAYS, SUPPORTS & ACCESSORIES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Cable trays & accessories.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

a) Ladder type Cable trays
b) Perforated type Cable trays
c) Cable troughs
d) Cable Tray bends, Tees, Cross, Coupler plates, etc.
e) Cable tray covers
f) Bolted (Unistrut type) cable tray support system
g) Erection hardware
h) Consumables
i) Tools & tackles
j) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, except where modified and /or supplemented by this specification.

a) IEC: 61537 Cable tray systems.
b) IS: 1079 Specification for hot rolled carbon steel sheet and strip.
c) IS: 1730 Dimensions for steel plates, sheet strips and flats for general engineering purposes.
d) IS: 1363 Hexagon head bolts, screws and nuts.
e) IS: 6005 Code of practice for phosphating iron & steel.
f) IS: 2629 Recommended practice for hot dip galvanising on iron and steel.
g) IS: 2633 Methods for testing uniformity of coating on zinc coated articles.
h) IS: 6745 Methods for determination of mass of zinc coating on zinc coated iron and steel articles.
i) IS: 816 Code of practice for use of metal arc welding for general construction of mild steel.
j) IS:4759 Specification for hot-dip zinc coatings on structural steel and allied products

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Cable Trays

4.1.1 Cable trays shall be ladder type for power and electrical control cables and perforated type for signal cables, prefabricated, made out of hot / cold rolled mild steel sheets complete with matching fittings, accessories and hardware as required. Cable trays shall be with standard width of 150 mm, 300 mm, 450 mm, 600 mm, 750 mm and 900 mm and standard lengths of 2.5 metre or more. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. For ladder trays, rung spacing shall be 250 mm maximum. The thickness of side coupler plates shall be minimum 2 mm and of tray covers shall be minimum 1.6 mm.

4.1.2 In corrosive areas, FRP cable trays shall be provided in general.

4.1.3 FRP cable trays also shall be provided for the following areas

- Water Treatment Plant
- Coal Handling Plant
- Sea Water intake system
- Interplant cable trays

4.1.4 Separate cable trays shall be provided for the following cables:

- HT Cables
- LT power cables
- Electrical Control cables
- Signal cables
- Fiber optic cables

Cable trays shall be designed to cater to a load of minimum 75 kg/m.

4.1.5 Cable trays shall be complete with matching fittings and accessories (like elbows, bends, reducers, tees, crosses, side coupler plates, etc.) and hardware (like bolts, nuts, washers, etc.) as required. At both the ends of cable trays, four holes shall be provided for fixing side coupler plates. All the slots and coupler holes shall be machine punched.

4.1.6 Cable trays, fittings and accessories and covers shall be hot dip galvanized. Thickness of galvanizing shall be not less than 610 grams/sq.m. Fasteners like bolts, nuts; screws washers etc. shall also be hot dip galvanized.

4.1.7 For branch cabling routes involving fewer cables, sheet steel galvanized cable trough of size 50/75/100 mm shall be provided.

4.1.8 Cable tray covers shall be provided for horizontally laid outdoor trays, on top most trays. It shall be prefabricated made out of hot/cold rolled mild steel sheets, complete with hardware as required. Special clamps shall be provided for fixing tray covers without drilling holes on trays.

4.2.0 Cable Tray Support System

4.2.1 Cable tray supports shall be of prefabricated preformed sections of sheet steel, bolted type and shall be hot dip galvanized.

4.2.2 Cable tray support system shall be similar or equivalent to "Unistrut make". Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of following two types:

- Single channel strut support for supporting cable trays on one side
- Double channel strut support for supporting cable trays on both sides

4.2.3 Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

4.2.4 The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardware fittings and accessories shall be prefabricated factory galvanised.

4.2.5 The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. of the components shall not be allowed.

4.2.6 All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drilling and other machining operation.

4.2.7 The typical arrangement of flexible support system shall comprise the following:

4.2.8 The main support channel and cantilever arms shall be fabricated out of minimum 2.5 thick rolled steel sheets conforming to IS.

- Cantilever arms of required length to match cable tray width. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.
- The size of structural steel members or thickness of sheet steel of main support channel and cantilever arms and other accessories as indicated above or in the enclosed drawings are indicative only.
- Main support channels may be supplied in any suitable lengths to minimize the wastage. Nevertheless, the support system shall be designed by the bidder to fully meet the requirements of type tests as specified.

4.2.9 Thickness of galvanizing on steel sections shall be not less than 610 gm/sq.m on all steel sections.

4.2.10 Horizontally running cable trays shall be clamped by bolting to cantilever arms at an interval of 1500 mm for outdoor and 2000 mm for indoor locations. Vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 1500 mm. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000 mm.

4.2.11 The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm.

5.0.0 TESTS

Equipment offered shall be type tested and proven type. Tests shall be carried out for galvanizing thickness of trays and supports. Load test shall be carried out for trays and supports.

Load Test for Cable trays shall be carried out as follows:

A 2.5 metre straight section of each type of cable tray shall be simply supported at the two ends. A uniformly distributed load of 100 kg per meter shall be applied along the length of tray. The maximum deflection at mid span shall not exceed 7 mm.

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- General arrangement drawings for trays and fittings
- General arrangement drawings for support system
- Technical data sheet
- Test reports
- Installation details
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

SECTION–3.26: CABLING ACCESSORIES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of cabling accessories.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

a) Cable joints & terminations
b) Cable glands
c) Cable lugs
d) Camps
e) Tags
f) Conduits & Pipes
g) Junction boxes
h) Consumables
i) Tools & tackles
j) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Standards except where modified and /or supplemented by this specification.

a) VDE 0278 Joints and Terminations
b) IS: 13573 Joints and Terminations for polymeric cables for working voltages from 6.6 kV up to and including 33 kV-Performance requirements and type tests.
c) BS:6121 Mechanical cable glands (Part 1 -Specification for metallic glands)
d) IS: 12943 Brass Glands for PVC Cables
e) IS: 8309 Specification for compression type tubular terminal ends for aluminium conductors of insulated cables.

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Joints & terminations

4.1.1 Termination and jointing kits shall be of proven design and make which have already been extensively used and fully type tested. Kits shall be complete with all accessories and consumables required for complete termination or jointing. Copper cable lugs & jointing ferrules for straight through joints shall form part of the kit.

4.1.2 Termination and jointing kits shall be suitable for the following types of cables as per IS.

- 19/33 kV earthed grade cable
- 11/11 kV unearthed grade cable
- 6.6/6.6 kV unearthed grade cable
- 1.1 kV grade power cables

4.1.3 Termination kits shall be ‘elastimold’ or ‘Push on type’ or ‘heat shrinkable type’.

4.1.4 Cable joints shall be avoided to the extent possible. If joints are unavoidable due to circuit length, in excess of permissible maximum drum length. Jointing kits shall be ‘heat shrinkable type’.

4.1.5 Straight through joint and termination shall be capable of withstanding the fault level of 50 kA for 11/11 kV cables and 31.5 kA for 6.6/6.6 kV Cables and 25 kA for 33 kV cables.

4.1.6 Straight through joints shall be protected against mechanical damage, rodent and termite attack. It shall be suitable for directly buried cables.

4.2.0 Cable glands

Cables shall be terminated using cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass machine finished and tinned. Cable glands shall be supplied with neoprene seal and earth lugs suitable for the fault capacity of the armour of the installed cables. Cable glands shall be double compression, weather proof type for armoured cables. For flame proof equipment cable glands shall be of flame proof type

4.3.0 Cable lugs

4.3.1 Cable lugs shall be of aluminium for aluminium cables and tinned copper for copper cables. Thickness of tinning shall be not less than 10 microns Type of end connection shall be solder less crimping type.

4.3.2 Cable lugs for conductors of power cables shall be "heavy duty" long barrel type. The type & size of cable lugs for power cables shall be selected according to the number and sizes of strands of the cable.

4.3.3 Solder less crimping of terminals shall be done by using corrosion inhibiting compound. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ ring type/U Type to suit the terminals provided in the panels.

4.3.4 Type of cable lugs shall be as follows:

- Power cables with aluminium conductor : Aluminium crimping type.
- Power cables with copper conductor : Copper crimping type.
- Control Cables : Copper pin type /Copper screw type
- Special cables : pin type / maxi-termi type

4.4.0 Trefoil Cable Clamps

- Clamps required for single core cables carrying alternating current shall be suitable for holding three cables together in delta formation. Clamps shall be of FRP material.
- Clamps shall be of suitable sizes to firmly hold the cables of various outer diameters including tolerance in OD.
- Clamps should have been type tested for Short Circuit Withstand Test.
- For Trefoil clamps run spacing shall be 2000 mm and axial spacing shall be double the diameter of larger adjacent trefoils cable or 150 mm whichever is less. Supports shall also be provided at each bend

4.5.0 Omega Cable clamps

- Omega clamps shall be of galvanized mild steel and shall be used to fasten the individual multi-core cables.
- Clamps shall be of simple construction, made of 2 mm thick, 25 mm wide strip of omega shape and suitable for clamping on the rungs / perforated sheet of tray with the help of two bolts.
- Clamps shall be of different sizes for different outer diameters of cables. Omega cable clamps shall be used for individual cables above 35 mm outer diameter.

- Steel clamps shall be hot dip galvanized. Weight of zinc not less than 610 grams. per sq. metre
- For cables of above 35 mm OD, cables shall be individually clamped at 5000 mm interval for Horizontal runs and shall be individually clamped at 1000 mm interval for Vertical runs. Supports shall also be provided at each bend.
- For cables of up to 35 mm OD, cables shall be collectively clamped at 5000 mm interval for Horizontal runs and shall be collectively clamped at 1000 mm interval for Vertical runs. Supports shall also be provided at each bend.
- For cables supported along structures/ceiling, clamp spacing shall be 750 mm. Supports shall also be provided at each bend.

4.6.0 Strip Cable Clamps

- Strip clamps shall be of galvanized mild steel and shall be used to fasten the group of multi-core cables up to 35 mm diameter only on a full or part of the tray width.
- Clamps shall be of simple construction, made of 3 mm thick Steel, 25 mm wide strip to cover the entire width up to 300 mm wide tray and part of the tray for more than 300 mm wide trays. Strip shall have two right angle bends at each end for fixing on to the rung/ perforated sheet of tray with the help of two bolts.
- Clamps shall be of different sizes for different sizes of tray width. However, the maximum size of clamp shall be 300 mm and for cable trays of greater width, two clamps shall be used.
- Clamps shall be hot dip galvanized. Weight of zinc not less than 610 grams. per sq. metre

4.7.0 Self-locking Clamps

- Clamps shall be of FRP material. Clamps shall have self-locking feature when the cord is looped. Clamps shall be provided with manual lock release.
- Clamp cord shall not move in the backward position once it has been locked, unless the lock release is applied.
- Type test certificates to ascertain the strength of clamps shall be submitted for Owner's approval.
- Not more than four (4) cables shall be clamped together, wherever collective clamping is permitted.
- Clamp length shall be selected such that not more than 80% of lockable length is utilised for clamping.
- Nylon self-locking tie strips for collective clamping (up to 35 mm OD max. group of 4 cables) shall be 4 mm having Tensile strength 30 kg.
- Nylon self-locking tie strips for individual multicore clamping (above 35 mm OD up to 55 mm OD) shall be 4 mm having Tensile strength 20 kg.
- Nylon self-locking tie strips for individual multicore clamping (above 55 mm OD) shall be 7 mm having Tensile strength 60 kg.

4.8.0 Tags

- Cables shall be provided with cable number tags for identification.
- Cable tags shall be of aluminium.
- Cable numbers shall be engraved type
- Tags shall be of durable quality of size 60 mm x 12 mm with a tie hole at each end.
- Samples of tags shall be approved by the Owner before delivery.
- Tags shall be provided with non-corrosive wire of sufficient strength for tagging.

4.9.0 Junction Boxes

4.9.1 Junction box with IP 55 degree of protection shall comprise of a case with hinged door constructed from FRP material. The junction box shall be provided with canopy. The boxes shall include brackets, bolts, nuts, screws, glands, lugs, M8 earthing stud etc.

4.9.2 Terminal blocks shall be of 650 Volt grade, rated for 10 A and in one piece moulding. It shall be complete with insulating barriers, clip-on-type terminal numbering on wiring diagrams. Terminal block shall be suitable for terminating 2Cx2.5mm^2 cable on both sides and arranged to facilitate easy termination. Cable entry shall be from bottom.

4.9.3 The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable / conduit entry knockouts and terminals.

5.0.0 TESTS

Equipment offered shall be type tested and proven type. Test reports shall be submitted for review. For junction boxes degree of protection test shall be carried out.

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- General arrangement drawings
- Technical data sheet
- Test reports
- Installation details for junction boxes
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

SECTION - 3.24: CABLES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of cables.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

a) 19/33 kV grade XLPE insulated armoured FRLS power cables
b) 11/11 kV grade XLPE insulated armoured FRLS power cables
c) 6.6/6.6 kV grade XLPE insulated armoured FRLS cables
d) 1.1 kV grade XLPE insulated armoured FRLS cables
e) 1.1 kV grade XLPE insulated armoured FRLS control cables
f) Trailing cables
g) Shielded cables
h) Telephone cables
i) Fiber optic cables

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and / or supplemented by this specification.

a)	IS: 3975	Mild steel wires formed wires and tapes for armouring of cables.
b)	IS: 4905	Methods for random sampling.
c)	IS: 5831	PVC insulation and sheath of electric cables.
d)	IS: 7098 Part-I	Cross-linked polyethylene insulated PVC sheathed cables (LV)
e)	IS: 7098 Part-II	Cross-linked polyethylene insulated PVC sheathed cables (HV)
f)	IS: 8130	Conductors for insulated electric cables and flexible cords.
g)	IS: 10418	Drums for electric cables.
h)	IS: 10810	Methods of tests for cables.
i)	IS: 3961	Recommended current ratings for cables

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Power cables shall be provided for the following systems:

- 33 kV earthed system having phase fault current and earth fault current of 25 kA.
- 11 kV unearthed system having phase fault current of 50 kA and earth fault current of 300 A.
- 6.6 kV unearthed system having phase fault current of 31.5 kA and earth fault current of 300 A.
- 415 V earthed system having phase fault current and earth fault current of 65/50 kA.
- 220 V DC unearthed system having fault current of not less than 25 kA.

4.2.0 Power cables shall be sized to withstand the system fault current for the fault clearing time indicated below:

- Breaker operated Motor feeders and transformer feeders: 0.16 second.
- Breaker operated outgoing feeders: 0.5 second.
- Tie between two switchgear: 0.5 second.
- Incomers: 1 second.

4.3.0 Power cables shall be sized to satisfy the following Criteria:

- To withstand specified system short circuit current for the specified fault clearing time.
- To carry full load current under applicable installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer's recommendation.
- To limit the voltage drop under steady state/transient state conditions to permissible values.

4.4.0 Cables shall be armoured type only.

4.5.0 Power cables shall be XLPE insulated. Control cables shall be PVC / XLPE insulated.

4.6.0 PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90 °C and short circuit conductor temperature of 250 °C.

4.7.0 Cables for 33 kV system shall be rated for 19/33 kV earthed grade, cables for 11 kV system shall be rated for 11/11 kV unearthed grade and Cables for 6.6 kV system shall be rated for 6.6/6.6 kV unearthed grade. Cables for 415/230 V AC and 220 V DC shall be rated for 1.1 kV grade.

4.8.0 To minimize the damage that can be caused by a fire, conductors installed in electrical cable tray systems shall have jackets which have non-propagating, and self-extinguishing flame retardant, low smoke (FRLS) characteristics. Outer sheath shall be of PVC black in colour. These cables shall meet the following test requirements.

- Oxygen index of minimum 29 when tested as per IS 10810 Part-58
- Temperature index of minimum 250°C when tested as per IS 10810 Part-64
- Acid gas emission of maximum 20% when tested as per IS 10810 Part-59 Average light transmission of 40% minimum when tested as per IS 10810 Part-63 (average smoke density is maximum 60%)
- Flame test requirements as per IS 10810 Parts-53 and 62
- Flame retardant test requirements as per IS 10810 Part-61

4.9.0 For power cables, copper conductor shall be used for current rating of up to 10 A. For higher current rating, conductor can be aluminium/copper. Minimum size of copper conductor shall be 2.5 sq.mm and aluminium conductor shall be 6 sq.mm.

4.10.0 Conductor of control cables shall have plain annealed copper. The minimum size of control cable shall be of 1.5 sq.mm. For CT circuit minimum size shall be 2.5 sq.mm copper. Control cables shall have 20% spare cores.

4.11.0 Current transformers leads shall be checked for the lead burden vis-a-vis the current transformer VA capacity and knee point voltage. Minimum 2.5 sq.mm copper cables shall be used for connection of CT to load. In case 2.5 sq.mm size impose unacceptably high burden on CTs, 4 sq.mm copper shall be used. Voltage transformer leads shall be checked for voltage drop which shall be limited to within 1% for all cases other than tariff metering. For tariff metering the voltage drop shall be limited to 0.2%. In case the voltage drop with 2.5 sq.mm copper conductor exceeds this value, higher conductor sizes shall be used.

4.12.0 Power cables shall carry the full load current of the circuit continuously under site conditions considering the various derating factors like thermal resistivity of soil, ambient air/ground temperature, grouping, method of laying, etc.

4.13.0 Design ambient air temperature and ground temperature shall be considered at 50℃ and 40℃ respectively for cable sizing.

4.14.0 For 11 kV & 6.6 kV cables, screen of each core shall be sized to withstand 300 A for 1 sec. For 33 kV cables, screen of each core shall be sized to withstand system earth fault current for 0.16 sec.

4.15.0 For HT motors the voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 2.5% of the rated voltage. However, the voltage drop from transformer secondary to motor terminals during full load running of motors shall be limited to 5% of rated voltage

4.16.0 For LT motors the voltage drop in the cable, during motor starting condition, shall be limited to 15% and during full load running condition, shall be limited to 3% of the rated voltage. However, the voltage drop from transformer secondary to motor terminals during full load running of motors shall be limited to 6% of rated voltage.

4.17.0 Cables for the following systems shall be fire survival type.

- DC emergency lube oil pumps
- DC seal oil pump
- DC emergency lighting cables for main building.
- Batteries to chargers and DC distribution boards
- Turbine lub oil pumps
- Jacking oil pumps
- Emergency turbine trip by push button in control room
- Inter trip cables between Boiler master fuel trip and turbine trip relays
- Inter trip cables between Generator trip relays and turbine trip relays/400 kV circuit breaker/generator field breaker/UT breakers

4.18.0 Method of curing for HT XLPE insulation shall be **gas/steam curing**.

4.19.0 Conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied with XLPE insulation in one operation through triple extrusion.

4.20.0 For armoured cables, armouring shall be of aluminium for single core cables. For multicore armoured cables, armouring shall be of galvanised steel.

4.21.0 All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added into the PVC compound of the outer sheath. The sheath shall be resistant to water, UV radiation, fungus, etc.

4.22.0 Multi-core cable color coding shall be as follows:

- Red, yellow, blue, black and gray for five core cables
- Outer sheath shall be of black in colour.
- For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.

4.23.0 Three core 19/33 kV earthed grade, 11/11 kV unearthed grade, 6.6/6.6 kV unearthed grade cables shall constitute the following:

- Circular stranded and compacted aluminium conductor
- Extruded semi conducting compound as conductor screen
- Extruded XLPE insulation
- Extruded semi conducting compound as insulation screen
- Copper tape as metallic screen for each core
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.24.0 Single core 19/33 kV earthed grade,11/11 kV unearthed grade, 6.6/6.6 kV unearthed grade cables shall constitute the following:

- Circular stranded and compacted aluminium conductor
- Extruded Semi conducting compound as conductor screen
- Extruded XLPE insulation
- Extruded Semi conducting compound as insulation screen
- Copper tape as metallic screen
- Hard drawn aluminium wire armour
- Extruded FRLS PVC outer sheath

4.25.0 Multicore 1.1 kV earthed grade cables shall constitute the following:

- Circular / shaped, stranded aluminium conductor (compacted for >10 sq.mm)
- Extruded XLPE insulation
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.26.0 Single core 1.1 kV earthed grade cables shall constitute the following:

- Circular stranded and compacted aluminium conductor
- Extruded XLPE insulation
- Hard drawn aluminium wire armour
- Extruded FRLS PVC outer sheath

4.27.0 **Trailing power and control cables for mobile equipment shall constitute the following:**

Unearthed grade HT power cables, earthed grade LV power cables and control cables shall be flexible trailing with annealed tinned copper conductor, EPR insulated, EPR inner sheathed, CSP outer sheathed. For HT cables, insulation screen shall be provided. Cables shall conform to applicable IS/IEC standard requirements.

4.28.0 **Fire survival cables**

Fire survival cable shall be of copper conductor and comply with IEC-60331 (withstanding 750 degree C temperature for 3 hours). Also the halogen acid contents in outer sheath shall not be more than 2% when tested as per IEC-60754 and the smoke density in percent light absorption shall not exceed 20% when tested as per ASTM-D-2843. 1.1 kV earthed grade fire survival cables shall constitute the following:

- Circular/shaped stranded and compacted annealed copper conductor
- Elastomeric materials (XLPE, EPR, SR, or LSOH) insulated
- Glass mica tapped
- Extruded FRLS compound or LSOH material as inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS compound or LSOH material as inner sheath

4.29.0 Multicore 1.1 kV earthed grade control cables shall constitute the following as per IS:1554-1 / 7098-1:

- Multi stranded annealed copper conductor
- Extruded PVC / XLPE insulation
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.30.0 Multi pair 1.1 kV earthed grade, overall screened signal cables shall constitute the following as per BS EN 50288-7:

- Multi stranded annealed copper conductor
- Extruded PVC insulation
- Twisted pair
- Overall polyester taped, Al-mylar screened with ATC drain wire
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.31.0 Multi pair 1.1 kV earthed grade, individual and overall screened signal cables shall constitute the following as per BS EN 50288-7:

- Multi stranded annealed copper conductor
- Extruded PVC insulation
- Twisted pair

- Individual polyester taped, Al-mylar screened with ATC drain wire
- Overall polyester taped, Al-mylar screened with ATC drain wire
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.32.0 **Cable drums**

Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. All ferrous parts shall be treated with suitable rust protective finish or coating to avoid rusting during transit and storage. All wooden parts shall be manufactured from durable quality wood duly seasoned and treated with copper nepthenates or zinc nepthenates for preserving the wood. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps, secured by `U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

4.33.0 **Cable identification system**

a) In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed/printed on the outer sheath at an interval of one metre throughout the length of cables.

- BIS mark
- Manufacturer's name and or trade mark.
- Year of manufacture
- Cable code
- Type of cable and voltage class.
- Nominal cross section area of conductor and no.of cores.
- Progressive sequential length making.

b) Cables shall be marked as having FRLS outer sheath at every 5 meters.

c) The embossing/printing shall be progressive, automatic, in line and marking shall be legible and indelible.

d) Multi-core cable color coding shall be as follows:

- Red, yellow and blue for three core cables
- Outer sheath shall be of black in colour.
- For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.
- For multi pair cables, each pair shall be coloured and numbered.

5.0.0 **TESTS**

Cables offered shall be type tested and proven type. Routine tests shall be carried out on 100% drums. Type tests, special tests and acceptance tests shall be carried out on 1 drum selected on random basis, out of every 10 or less number of drums of each type and size of cable of each lot. Size shall mean area of cross section in sq.mm read in conjunction with the number of cores. Type shall mean type of insulation, sheath, volt grade FRLS/FS etc.

5.1.0 **Type Test**

a) Tests on conductor

i) Annealing Test (for copper)
ii) Tensile test (for aluminium)
iii) Wrapping test (for aluminium)
iv) Resistance test

b) Tests for armour wires/strips
c) Tests for thickness of insulation and sheath
d) Physical tests for insulation

i) Tensile strength and elongation at break
ii) Ageing in air oven
iii) Shrinkage test
iv) Hot test
v) Water absorption (gravimetric)

e) Physical test for outer sheath

i) Tensile strength and elongation at break
ii) Ageing in air oven
iii) Shrinkage test
iv) Hot deformation
v) Heat shock test
vi) Loss of mass test in air oven
vii) Thermal heat stability test (as per IS : 5831)
viii) Bleeding and blooming test

f) Anti-termite and anti-rodent test (on outer sheath).
g) Partial discharge test
h) Bending test
i) Dielectric power factor test

i) As a function of voltage
ii) As a function of temperature

j) Insulation resistance (volume resistivity) test
k) Heating cycle test
l) Impulse withstand test
m) High voltage test
n) Flammability test
o) Cold impact test

5.2.0 **Acceptance Test**

a) Annealing test (for copper)
b) Tensile test (for aluminium)
c) Wrapping test (for aluminium)
d) Conductor resistance test
e) Test for thickness of insulation and sheath
f) Hot set test for insulation
g) Tensile strength and elongation at break test for insulation and outer sheath
h) Partial discharge test (for screened cables)
i) High voltage test
j) Insulation resistance (volume resistivity) test

5.3.0 **Routine Test**

a) Conductor resistance test
b) Partial discharge test

c) High voltage test

5.4.0 **Special Test**

a) Oxygen index test as per IS 10810 Part-58
b) Temperature index test as per IS 10810 Part-64
c) Acid gas generation test as per IS 10810 Part-59
d) Smoke generation test as per IS 10810 Part-63
e) Flammability tests as per IS 10810 Parts-53 and 62
f) Flame retardant test as per IS 10810 Part-61

5.5.0 **Site Test**

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.
a) Insulation resistance test
b) High voltage test

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Cable sizing calculation
- General arrangement drawings
- Technical data sheet
- Test reports
- Catalogues
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

SECTION–3.29: ELECTRICAL INSTALLATION

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Electrical installation and also supply and installation of the following items:

- Rubber mats for switchgear
- Caution boards
- Sand buckets
- First aid box
- Sheet steel cover for /cable shaft/trench etc.
- Sheet steel hood for the outdoor electrical equipment/motor
- Cable route markers & Cable joint markers
- Shock hazard chart
- Erection hardware

2.0.0 CODES AND STANDARDS

Installation of cabling work shall comply with the latest edition of following Indian standards, rules, regulations and acts.

- IS: 1255 : Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
- IS: 732 : Electrical wiring installation (system voltage not exceeding 650 V).
- IS 10028 : Code of Practice for selection, Installation & maintenance of transformers.
- IS 10118 : Code of practice for selection, installation & maintenance of Switchgear & Control gear.
- IS: 5216 : Guide for safety procedures and practices in electrical works.
- IS 2551 : Danger notice plates
- IS 8923 : Warning Symbol for dangerous voltages.
- Indian Electricity Act.
- Indian Electricity Rules.
- Fire insurance regulations.
- Regulations laid down by the Chief Electrical Inspector of the State.
- Regulations laid down by the Factory Inspector of the State.

3.0.0 GENERAL REQUIREMENTS

3.1.0 The work shall be carried out in the best workman like manner in conformity with the latest editions / amendments of relevant specifications / codes / standards / regulations.

3.2.0 Manufacturer's drawings, instructions and recommendations shall be correctly followed in handling, erecting, testing and commissioning of all items / equipment and care shall be exercised in handling to avoid distortion to stationary structures, marring to finish, or damaging of delicate instruments or other electrical parts.

3.3.0 All the equipment covered under this specification shall be installed in neat, professional manner such that the structures and equipment are level, plumb, squat, properly aligned and oriented. Clearance around electrical panels / equipment shall be as per relevant standards.

3.4.0 The Contractor shall effectively protect his work, equipment and materials under his custody from theft, damage or tampering. Finished work where required shall be suitably covered to

keep it clean and free from defacement or injury. Contractor shall be held responsible for any loss or damage to equipment and material issued to him until the same is taken over by the Owner according to Contract.

3.5.0 All safety rules and codes as applicable to work shall be followed without exception. All safety appliance and protective devices including belts, hand gloves, aprons, helmets, shields, goggles, safety shoes etc. shall be provided by the Contractor for his personnel.

3.6.0 The Contractor shall provide guards and prominently display caution notices if access to any equipment / area is considered unsafe and hazardous. In order to avoid hazards to personnel moving around the equipment such as switchgear etc. which is kept charged after installation, before commissioning, such equipment shall be suitably cordoned off to prevent anyone accidentally going near it.

3.7.0 The Contractor shall have a separate cleaning gang to clean all equipment under erection as well as the work area and the project site at regular intervals to the satisfaction of Owner. In case this is not done, the Owner shall have the right to carry out the cleaning operation and any expenditure incurred in this regard shall be to the Contractor account.

3.8.0 The Contractor shall ensure that instruments and gauges to be used for testing and inspection have valid calibration and the accuracy can be traced to National Standards.

3.9.0 It shall be the Contractor's responsibility to obtain approval from local statutory authorities including Electrical Inspector / CEA, wherever applicable, for carrying out any work or for installation carried out which comes under the purview of such authorities. All such documents and original certificates shall be handed over to Owner which then shall be property of the Owner.

3.10.0 The installation shall be carried out only by electrical Contractor, holding a valid license, issued by relevant authorities for carrying out installation work of the voltage classes involved, under the direct supervision of a person holding valid certificates of competency for the same voltage classes, issued or recognized by the state Government.

3.11.0 The installation shall have to be approved by statutory government authorities like Electrical Inspector, Factory Inspector, Insurance Officials etc. It shall be the responsibilities of Contractor to prepare and submit all necessary drawings, calculations and test certificates to electrical inspectorate and obtain approval/certification prior to installation and commissioning work and also arrange inspection by them after installation.

Necessary fees and other charges for the same shall be paid by Contractor.

3.12.0 Contractor shall take utmost care in holding instruments, relays and other delicate mechanisms wherever these are supplied separately. They shall be installed only after the associated panels have been erected and aligned. The packing materials employed for safe transit of these shall be removed after ensuring that panel have been completely installed and no further movement of the same are necessary. Any damage shall be immediately reported to Owner.

3.13.0 All the electrical equipment, panels, motors, busduct, cables etc. shall be stored under covered shed and oil filled power transformers can be stored outdoor. The OEM recommendation for electrical equipment shall be strictly adhered and proper periodical record shall be maintained, which shall be inspected by Owner.

4.0.0 CABLING CONCEPT

4.1.0 Cabling installations shall be carried out on trays. In all electrical rooms and control rooms, cable spreader room shall be provided. A clear working space of 800 mm shall be provided

horizontally between trays and on either side of the trays. A clear head room clearance of 1800 mm shall be provided in the cable spreader room.

4.2.0 In transformer yard and outdoor switchyard, cables shall be laid in cable trenches. Cable trenches shall have cable trays installed at a vertical spacing of 300 mm between the trays and supported at every 1500-2000 mm to trench wall. Cables shall be laid on trays only. Separate trays shall be provided for each of HT, LT, Control, signal cables. In the cable trench, a clear working space of atleast 600 mm shall be provided adjacent to trays. Cable trenches shall be properly sloped and connected to sump. For Cabling from equipment to trenches, GI pipe can also be used.

4.3.0 For short cable runs in auxiliary plant areas local to equipment shall be laid in floor slits up to near the equipment. Cable trenches are not permitted in other areas.

4.4.0 In the plant buildings and structures cables shall be laid overhead suitably supported on along wall/structures.

4.5.0 All interplant cable tray routing shall be on overhead cable trestles or combined with pipe trestles in a separate tier..

4.6.0 Cable routes shall be segregated unit wise, to the extent possible. Similarly, cables for the standby drives shall preferably be taken through the alternative route. Separate routes shall be considered for duplicate control supply cables, first and second channel protection cables, and cables to common station service of two or more units.

4.7.0 Cables shall be avoided below oil pipes and in the vicinity of steam pipes.

4.8.0 Cable trays shall be laid in vertical formation in boiler, mill and ESP areas to avoid accumulation of coal-dust / ash on cables and cable-trays.

4.9.0 Cables shall not be routed in coal conveyor gallery, a separate cable gallery shall be provided.

4.10.0 In cable trenches, pipe racks/ cable racks, overhead routes, cable shafts and cable spreader rooms, cables shall be laid in cable trays only. Fewer cables installed along buildings, structures, ceilings, walls, etc., which are required to be protected against mechanical damage, shall be taken in GI conduits.

4.11.0 GI Conduits shall be used for flameproof installations, wherever required, with sealing at both ends.

4.12.0 Entry of cables from trenches into buildings shall be atleast 300 mm above finished ground level.

4.13.0 Where direct heat radiation from equipment/pipes exists, heat isolating barriers for cabling system shall be adopted.

4.14.0 Wherever cables are to be laid below roads and railway tracks, the same shall be taken through ducts buried at a suitable depth.

4.15.0 At certain places where leakage of oil or other hazardous material may cause damage to the cables, cable trenches/slits may be sand-filled, after installation of cables.

4.16.0 In corrosive atmosphere, PVC conduits shall be used for routing cables. Metallic pipes / conduits shall not be used in corrosive areas.

4.17.0 Three phase AC single core cables, while laying in steel conduits, shall be laid in trefoil formation only.

4.18.0 Complete cable tray & accessory installation work shall be inspected for proper alignment, leveling (by use of plumb lines), use of proper accessories, provision of proper bending radius and high quality workmanship.

4.19.0 Cable trays shall be ladder type for power and electrical control cables, while perforated type cable trays shall be used for instrumentation and control cables. However, in vertical cable tray risers, all trays shall be ladder type.

4.20.0 Flexible conduits shall be used between fixed conduits and equipment terminal boxes, where vibration is anticipated.

4.21.0 Junction boxes shall be installed so that they are level, plumb & properly aligned and present a pleasing appearance. Boxes shall be adequately supported by means of proper supporting arrangement.

5.0.0 CABLE TRAY AND SUPPORT SYSTEM INSTALLATION

5.1.0 Cable trays shall be bolted to tray mounting supports with a minimum clearance of 300 mm between cable tray tiers / as shown in the drawings.

5.2.0 For horizontal runs in door and in trenches, cable trays shall be supported at an interval of 1500 mm and for outdoor installation it shall be 2000 mm. For vertical cable risers/shafts cables shall be supported at every 1000 mm interval.

5.3.0 Support system shall be so designed that it is able to withstand weight of the cable trays, weight of the cables (75 Kg/metre run for each cable tray), concentrated load of 75 Kg between every support span without any permanent deflection. Factors of safety of atleast 1.5 shall be considered.

5.4.0 Cable tray supports shall be of bolted (similiar to Unistrut) type, which shall be installed at site, by bolts. Fixing of tray supports by welding is not allowed. Cable tray support structure shall be bolted to the steel structure by clamping and to concrete structures by embedding or using anchor fasteners.

5.5.0 All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 60 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted / stenciled with identification numbers at every floor.

5.6.0 Tray covers shall be provided for outdoor overhead cable trays on top most tiers. Tray covers shall be provided for top tray of horizontal tray runs located under grating floor or insulated piping, and for all trays routed in areas where oil might enter or accumulate. The cable risers or vertical raceways shall also be covered by cable tray covers up to 1.5 metres from respective floor for mechanical protection. The tray cover shall be of galvanized sheet steel, removable type.

5.7.0 Atleast 250 mm spacing shall be maintained between top of the trays and beams/piping etc..

5.8.0 Typical cable tray installation details are shown in the drawings enclosed in Section-7 of Volume-II.

6.0.0 CONDUITS/PIPES/DUCTS INSTALLATION

6.1.0 Rigid steel conduits shall be used indoors in non-hazardous areas. Unplasticised PVC conduit shall be used for duct banks and for some below grade concrete encased conduit.

6.2.0 Exposed conduits shall be routed parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical conduit bends or fittings. Conduits shall be securely supported within 900 mm of connections to boxes and cabinet.

6.3.0 Embedded conduits shall have a minimum concrete cover of 50 mm. All conduits to be embedded in concrete shall be inspected to ensure continuity and accuracy of placement before concrete is poured. All embedded pipes/conduits, sleeves, long radii bends etc. shall have at least 50 mm long extension beyond the embedded part, for extension of the same or for providing end plugs. If any embedded conduit is not required, it shall be plugged/sealed. All accessories/fittings required for making the installation complete, shall include tees, elbows, check nuts brass or galvanized steel end caps, PVC/brass bell mouths for water proof sealing, pull boxes, saddles, spacers and required steel supporting work.

6.4.0 Flexible conduit shall be terminated using suitable end coupler and check nut at both ends.

6.5.0 All conduits installed outdoor shall be sloped towards pull boxes, hand holes/manholes for drainage. Low points of conduits not terminating in pull boxes, hand holes/manholes shall be provided with weep holes for drainage. Care shall be taken to see that no rough edge is left around the weep holes. Where no provision for drainage can be made, both ends of conduits shall be sealed after cable is laid through. Minimum slopes of 1 in 400 shall be provided.

6.6.0 Exposed conduit shall be adequately supported by racks, clamps, straps or by other approved means. Conduits supports shall be erected square and true to line and grade. For bending of conduits, bending machine shall be arranged at site by the Contractor to facilitate cold bending. The bends formed shall be smooth.

6.7.0 When two lengths of conduits are joined together through a coupling, running thread equal to twice the length of coupling shall be provided on any one length to facilitate easy dismantling. The Contractor shall have at site die for threading pipe or conduit. After threading of conduits anti corrosive paint shall be provided.

6.8.0 Occupancy of conduits shall not be greater than 40%.

6.9.0 Liquid tight flexible metallic conduit shall be used for connections to solenoid valves, limit switches; pressure switches etc., and for connection to motors or other vibrating equipment and across areas where expansion or movement of the conduit is required.

6.10.0 Minimum bending radius for conduits shall be 10 times the external diameter of the conduit.

6.11.0 All conduits shall be permanently identified at each end with the conduit number assigned to it as per the applicable drawings.

6.12.0 Pull boxes shall be installed between termination points wherever required to facilitate cable out at a maximum interval of 30 metres.

6.13.0 Conduits shall be firmly fastened within 900 mm of each junction box, cabinet or fitting. Conduits shall be supported at least every 2000 mm.

7.0.0 CABLE INSTALLATION

7.1.0 Power and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. Generally HT cables shall be laid on top most tier and cables of subsequent lower voltage grades on lower tiers of trays. Separate cable trays shall be used for the following:

- HT Power Cables
- LT Power Cables
- Control Cables

- Instrumentation/communication cables
- Fire Survival cables

7.2.0 Single core cable in trefoil formation shall be laid with spacing equal to the diameter of the Trefoils and clamped at every two metre. All multicore cables shall be laid in touching formation. Power and control cables shall be securely fixed to trays /supports with self-locking type nylon cable strap with de-interlocking facility at every 5 meter interval for horizontal run and cables laid in vertical run of trays shall be securely fixed to trays/supports by galvanized steel clamps at every one metre interval. All power cables should be clamped individually.

7.3.0 HT cables and LT power cables of >16 sq.mm shall be laid in one layer only. LT power cables of up to 16 sq.mm can be laid in two layers. Control cables can be laid in 3 layers.

7.4.0 Bending radii for cables shall be as per manufacturer's recommendations.

7.5.0 Where cables cross roads/rail tracks, the cables shall be laid in hume pipes embedded in ground with a minimum cover of 1 metre or with RCC covering for lower depth.

7.5.0 In each cable run some extra length shall be kept at suitable point to enable one straight through joints to be made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.

7.6.0 For Directly Buried cables, construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, concrete protective covering, back filling and compacting, provision of route markers and joint markers. Before the cables are placed, the excavated portion shall be filled with a layer of sand and leveled. The cables laid over it shall then be covered with 150 mm sand on top of the largest diameter cable and sand shall be lightly pressed. A protective covering of concrete shall then be provided on top. The remaining portion of the excavated trench shall then be back filled with soil, rammed and leveled.

7.7.0 RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint'. The marker shall project 75 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

7.8.0 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 30 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminium with number punched on it and securely attached to the cable GI wire.

7.9.0 Where a cable route crosses a permanent road/railway line cables shall be drawn through hume pipes or G.I. pipes. Pipes should be laid in a straight configuration. Filling criteria in any pipe shall not be more than 40%.

7.10.0 Conduits shall be used for routing of cables (power / control) from cable trays to equipment/ junction boxes. Pipe sleeves shall be used for routing of cables between floors, road crossing, entry/exit from outside of building etc. All conduits/pipe shall have their ends closed by caps till the cables are pulled. After the cables are pulled, the ends shall be sealed by suitable sealing compound having 2 hour fire withstand capability.

7.11.0 The location of cable joints, if any, shall be clearly indicated with cable marker with an additional inscriptions "Cable-Joint" and "Cable Number".

8.0.0 CABLE TERMINATION AND JOINTING

8.1.0 All cable entries in the equipment shall be sealed by cable glands.

8.2.0 Adequate length of cables shall be pulled inside the switchgear, control panels, terminal boxes etc. so as to permit neat termination of each core / conductor.

8.3.0 Power cable terminations shall be carried out in a manner such as to avoid strain on the terminals by providing suitable clamps near the terminals.

8.4.0 Control cable cores entering switchgear or control panels shall be neatly bunched and strapped with PVC perforated tapes / nylon ties and suitably supported to keep them in position at the terminal block. All spare cores shall be connected to spare terminals, wherever possible. If spare terminals are not available, spare cores shall be neatly dressed and suitably taped at both ends.

8.5.0 Screened control cables of small cross sectional area, shall be terminated by means of Maxi-Termi termination system.

8.6.0 Termination and jointing of HT cables shall be done with approved type termination/ jointing kits. Cable joints are permitted, only when the route length exceeds one full drum length.

8.6.0 Screened control cables of small cross sectional area, e.g. 0.5 mm^2, shall be terminated by means of maxi-termi termination system. Contractor shall ensure the availability of all tools, tackles and accessories such as maxi-termi guns, clips, wire etc. required for the termination of small cross section screened control cables by this method. Compressed air supply for maxi-termi guns shall also be the responsibility of Contractor.

8.7.0 Individual cores of control cables shall have ferrules for identification. Ferrule numbers shall be provided as per control schemes and other related documents. The spare cores shall be ferruled as spare.

8.8.0 Fiber optic termination and splicing equipment shall be used for cutting, finishing and joining fiber optic cables. An optical fiber tool shall be used to slice into the cable's outer coating and unpack the fibers without damaging them. Fiber optic cleaners, cleaning chemicals or solvents and cleaner dispensers shall be used for preparation of the cut and polished joint or splice. Fiber optic cables shall be terminated by using connectors to couple the cable to network devices. Fiber optic connectors shall be specifically designed to limit light loss and provide a secure connection to a device. The fiber optic termination connectors shall have a bayonet mount and a cylindrical ferrule to hold the fiber in place.

9.0.0 OVERHEAD LINE STRINGING WORK

9.1.0 Stringing work shall mean the activities of fixing of insulator and insulator hardware, jointing, tensioning, clamping with armour rod, providing dampers, repairing of conductors (if any), fixing the conductor at tension hardware etc.

9.2.0 The stringing work shall be carried out with the help of tensioner and puller machine. Manual stringing shall not be allowed. Stringing work shall be carried out as per approved sag tension chart.

9.3.0 Sufficient numbers of aluminum snatch blocks shall be used for paying out the conductors. Necessary precautions shall be taken to avoid conductor rubbing on the ground by providing

adequate ground roller, rollers on supports etc. Additional rollers shall also be provided to cross thorny hedges, footing and other obstructions to avoid scratching of conductor.

9.4.0 The conductor and earth wire shall be made to sag correctly as per stringing charts, before they are finally transferred to the hardware for conductors and to clamps for earth wire. No joint shall be made at less than 30 m from the tower end and no joint shall be permitted in road and other important crossings spans. There shall not be more than one joint in a span of each conductor.

9.5.0 Dynamometers shall be used in tensioning the conductors. All conductors shall be stressed to their maximum working load at the time of stringing, as per approved stringing charts. The minimum clearance between the lowest point of conductor and ground shall not be less than required.

9.6.0 The stringing sheaves, when suspended on the transmission structure for sagging, shall be so adjusted that the conductor shall be on the sheaves at the same height as the suspension clamp to which it is to be secured.

9.7.0 Proper guys shall be provided to counter balance the paving out tension of conductor / earth wire at the tension locations, to avoid damage to towers and / or accident.

10.0.0 SAFETY REQUIREMENTS

10.1.0 Provisions of Indian Electricity Rules in respect of various safety requirements (especially as provided at Rule 29, 35, 36, 42, 43, 44, 64, 74 to 80, 87 & 92) shall be complied with.

10.2.0 The minimum safety working clearances shall be maintained for the bare conductors or live parts of any apparatus in outdoor substations as per IE rule 64 a) ii).

10.3.0 All practical steps shall be taken to prevent operating the earth moving, lifting and housing machinery in dangerous proximity to a live overhead power line.

10.4.0 Barricades or barriers shall be installed to prevent accidental contact with energized lines or equipment. Where appropriate, signs indicating the hazard shall be pasted near the barricade or barrier.

10.5.0 Rubber gloves and insulated shoes shall invariably be worn in all cases while operating gang operating switches controlling high tension lines and equipment where accidental contact of operating personnel with live parts are likely. While working near live lines and equipment and working on live low-tension lines and equipment, gloves shall be worn.

10.6.0 Safety belts shall invariably be used in all cases while working on overhead systems like lines, bus bars, substation equipment etc.

10.7.0 Tested rubber mats shall be kept in front of operating panels / switches etc. They shall be checked for condition periodically and replaced as necessary.

10.8.0 First aid box shall be maintained. These shall be checked periodically and refilled or items replaced as necessary.

10.9.0 Chart for providing relief and treatment of person electrocuted shall be displayed prominently at suitable places in the substation. These shall be checked for condition periodically and replaced as and when necessary.

10.10.0 Firefighting equipment such as fire buckets filled with sand and fire extinguishers for both electrical and oil fires shall be maintained and kept at easily accessible place in substation

10.11.0 The Contractor shall supply and install all danger plates as per IS 2551. The danger plates shall be written in Hindi, local language and English and shall be provided as required for all electrical equipment.

10.12.0 All safety appliances and protective devices including belts, hand gloves, aprons, helmets, shields, goggles, safety shoes etc. shall be provided by the Contractor for his personnel.

10.13.0 The following minimum safety working clearances shall be maintained for the bare conductors or live parts of any apparatus in outdoor substations excluding overhead lines of installations of voltage exceeding 650 volts.

Highest System Voltage (kV)	Safety Working Clearance (Metres)
12	2.6
36	2.8
72.5	3.1
145	3.8
245	4.6
420	6.4

10.14.0 The above safety working clearances are based on an insulation height of 2.44 m, which is the height of lowest point on the insulator (where it meets the earthed metal) from the ground.

11.0.0 TESTING AND COMMISSIONING

11.1.0 The Contractor shall take full responsibility of testing at erection, pre-commissioning and commissioning stages of all the equipment / system being installed by him. The Contractor shall submit to the Owner a checklist for testing and commissioning and the activities shall be carried out in accordance with the checklist. The Contractor shall carry out the commissioning tests and checks after erection at site as per applicable standards and also as recommended by manufacturers.

11.2.0 On completion of erection work, the Contractor shall request the Owner for inspection and test. The Owner shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Contractor. The installation shall be then tested and commissioned in the presence of the Owner and put on trial run for stipulated contract period.

11.3.0 The Contractor shall arrange for inspection of his installation work by Electrical Inspector and shall obtain necessary approval certificate for his installation work and charging. Any modification work required by Electrical Inspector must be undertaken by the Contractor at his own cost. All rectification, repair or adjustment work found necessary during inspection, testing, commissioning and trial run shall be carried out by the Contractor without any extra cost.

11.4.0 Following successful inspection and testing, all the equipment shall be commissioned and put on trial run in a manner mutually agreed upon based on the commissioning schedule.

11.5.0 The Contractor shall have to bring all testing equipment and instruments in sufficient numbers to carry out the job simultaneously in more than one area. Tests shall be conducted by qualified and experienced personnel. Valid calibration certificates for the testing equipment shall be produced.

11.6.0 All documents / records regarding test data and all other measured values shall be submitted to Owner for approval and subsequent record and reference. The results of all tests shall conform

to the specification requirements as well as any specific performance data guaranteed during finalization of Contract.

11.7.0 All checks and tests as per manufacturer's drawings / manuals, relevant codes of installation and commissioning checklists for various electrical equipment such as transformers, breakers, motors, switchgear, relays, meters etc. shall be carried out.

11.8.0 The Contractor shall perform operating tests on all switchgear and panels to verify operation of switchgear / panels and correctness of the interconnections between various items of the equipment. This shall be done by applying normal AC or DC voltage to the circuits and operating the equipment for functional checking of all control circuits, e.g. closing, tripping, control interlock, supervision circuits, alarm circuits etc. All connections in the switchgear shall be tested from point to point for possible earth or phase faults.

11.9.0 Contractor shall submit specified copies of site testing procedures, test formats along with details of site test instruments proposed to be deployed at site along with respective valid calibration certificates, six weeks prior to commencement of site testing, for approval by Owner. Only procedures and test formats approved by Owner shall be used for site testing. After completion of commissioning of all equipment and prior to handing over, six sets of such signed test data in the agreed / approved formats shall be furnished prior to issue of provisional acceptance of the equipment / installation.

11.10.0 The testing of all electrical equipment as well as the system as a whole shall be carried out at site to ensure that the equipment and its components are in satisfactory condition and shall successfully perform its functional operation. The inspection of the equipment shall be carried out to ensure that all materials, workmanship and installation conform to the accepted design, engineering and construction standards as well as accepted codes of practice.

11.11.0 All tests shall be carried out by the Contractor using his own instruments, testing equipment as well as qualified testing personnel.

11.12.0 The results of all tests shall conform to the specification requirements as well as any specific performance data guaranteed during finalization of the Contract.

11.13.0 At site, all equipment shall be energized only after certification by the personnel performing the test that the equipment is ready for energizing and with concurrence of the Owner.

11.14.0 The various commissioning checks / tests to be carried out shall be in accordance with applicable standards and equipment supplier's recommendation.

11.15.0 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a. Cables

- Check for physical damage.
- Check for insulation resistance before and after termination/ jointing.
- HT cables shall be pressure tested before commissioning.
- Check of continuity of all cores of the cables.
- Check for correctness of all connections as per relevant wiring diagrams.
- Check for correct polarity and phasing of cable connections.
- Check for proper earth connections for cable glands, cable boxes, cable armour, screens etc.
- Check for provision of correct cable tags, core ferrules, and tightness of connections.

b. Cable trays/ supports and accessories

- Check for proper galvanizing/ painting and identification number of the cable trays/ supports and accessories.
- Check for continuity of cable trays over the entire route.
- Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
- Check for earth continuity and earth connection of cable trays.

12.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Block diagram for cabling
- Typical details of cabling installation
- Details of cable trays and accessories
- Layout of IPB Busduct , Segregated phase Busduct layout and 415 V NSPB Busduct
- DG Room layout
- Transformer Yard Layout
- Electrical room equipment layout for Power house building
- Electrical equipment layout for ESP building
- Electrical room equipment layout for various auxiliary buildings
- Electrical room equipment layout for non-plant buildings
- Cable Trench layout for Transformer Yard
- Cable routing layout for power house building
- Cable routing layout for Boiler floors
- Cable routing layout for ESP
- Interplant Cable routing layout
- Cable routing layout for Main control building
- Cable routing layout for switchyard and switchyard control building
- Cable routing layout for DG building
- Cable routing layout for all electrical rooms & control rooms
- Cable Routing layout for all plant buildings
- Cable Routing layout for all non-plant buildings
- Cable Schedule for power cables, control cables and signal cables for all Switchgear, equipment and control panels
- Interconnection Schedule for all Switchgear, equipment and control panels
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

SECTION–3.28: EARTHING & LIGHTNING PROTECTION SYSTEM

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Earthing & Lightning protection system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

a) Buried earth mat for the main plant, auxiliary plants, non plant buildings and switchyard
b) Embedded earth mat in the concrete floor of buildings, electrical rooms including GIS building.
c) Equipment enclosure earthing for all electrical equipment
d) Earthing of all metallic structures including cable racks
e) Electronic earthing for all DCS/Respective control system/SAS/EMS and other electronic equipment
f) Earthing for communication system
g) Lightning protection for GIS building, Switchyard and transformer yard
h) Lightning protection for main plant building, Boiler, ESP
i) Lightning protection for Chimney
j) Lightning protection for Cooling tower
k) Lightning protection for Ash silo structure
l) Lightning protection for CHP buildings and structures
m) Lightning protection for Ash buildings and structures
n) Lightning protection for all auxiliary plant buildings/structures and outdoor equipment/structures
o) Lightning protection for all non-plant buildings and structures

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Standards except where modified and /or supplemented by this specification.

a) IS: 3043 Code of Practice for Earthing
b) IS: 2309 Protection of building and allied structures against lightning - Code of practice
c) IS: 1079 Specification for hot rolled carbon steel sheet and strips
d) IS: 2629 Recommended practice for hot dip galvanizing on iron & steel
e) IS: 4759 Specification for hot-dip zinc coatings on structural steel and , allied products
f) IS: 6745 Methods for determination of weight of zinc-coating on zinc coated articles.
g) IEEE 80 IEEE Guide for safety in AC substation grounding
h) IEEE 142 Grounding of industrial & commercial power system.
i) CBIP manual on AC earthing system
j) Indian Electricity Rules

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Earthing System

4.1.1 Earthing system shall be provided for complete power station including switchyard.

4.1.2 Earthing system shall comprise the following:

- Neutral earthing to establish the ground reference of the electrical system
- Safety ground connections for protecting personnel from injury and property from damage
- Equipment earthing to ensure a low impedance return path for ground current should an electrical fault occur between the live conductors and the equipment enclosure

4.1.3 Various system earthing envisaged in the power project are as follows:

S. No.	System Voltage	Neutral	Maximum earth fault current
1.	400 kV system	Solidly earthed	63 kA
2.	33 kV system	Solidly earthed	25 kA
3.	Generator	High impedance earthed	10 A
4.	11 kV system	Medium resistance earthed	300 A
5.	6.6 kV system	Medium resistance earthed	300 A
6.	415 V system	Solidly earthed	65/50 kA

The safety and equipment earthing systems should meet the following requirements:

a) All metallic enclosures on equipment and exposed noncurrent-carrying conductive materials capable of becoming energized due to either insulation failure, inadvertent contact with an energized conductor, or building up of a static or induced voltage should be earthed.

b) The earthing arrangement should ensure a deliberate earth fault current return path, so that the (overcurrent or earth fault) protection shall sense the fault and either trip the faulty circuit or provide an alarm to the station operator.

c) The earthing should limit the step and touch voltage to acceptable limits during an earth fault.

d) The earthing conductors and connections should withstand the earth fault current for the duration of the fault, without being damaged by thermal, thermo-mechanical or electromechanical stresses.

e) The earthing conductors should be continuous; no switching device should be inserted in the earthing conductors (except where the operation of the switching device shall also automatically disconnect all power sources to the equipment earthed by that conductor).Equipment enclosures should not be used as part of the earthing conductor.

f) The earthing conductors should be mechanically reliable or protected in order to withstand any possible mechanical stress imposed on them. The exposed connections of earthing conductors should be accessible for inspection.

g) The earthing system should be designed to minimize corrosion to adjacent structures, equipment and enclosures.

4.1.4 The earth mat design for GIS building , switchyard and transformer yard shall be designed as per IEEE 80. The earthing system of Switchyard shall meet the following requirements:

- Ensure adequate earth fault current for operation of earth fault protection
- Limit step and touch voltages to acceptable limits during earth fault
- Earthing conductors and connections shall withstand earth fault current for the duration of the fault

4.1.5 The earth mat shall be designed with grid spacing such that safe voltage gradients are maintained. Earth conductors shall be installed below ground shall be spaced in a grid pattern to provide the earthing mesh grid throughout the site. Switchyard earth mat shall be interconnected with main plant earth mat by a minimum of two parallel conductors.

4.1.6 The mild steel earth grid shall be designed to withstand 40 years of corrosion and still retain safe touch and step potentials in accordance with IEEE 80. Corrosion rate shall be arrived at as per soil resistivity report.

4.1.7 The earth mat of the station shall be designed such that the total ground resistance does not exceed 0.5 ohm.

4.1.8 Earth mat and all earthing conductors for GIS building earthing shall be of copper. The earthing conductor material for other locations shall be corrosion resistant steel.

4.1.9 400 kV system earth fault current of 63 kA shall be considered for earthing design. The earthing design shall consider the following:

- Earth fault current duration for conductor sizing : 1 sec
- Shock duration for mesh sizing : 0.5 sec
- Depth of buried earthing conductor : minimum 600 mm
- Human body weight for step / touch voltage calculation : 70 kg
- Resistivity of concrete : 500 ohm m

4.1.10 Contractor shall carry out earth resistivity test of power project site and shall establish homogeneous soil resistivity for earthing design. Number of earth resistivity test locations shall be not less than 10. The test locations shall be subject to Owner's approval.

4.1.11 For Gas insulated switchyard the following aspects shall be considered:

- All metallic enclosures should normally operate at ground voltage level.
- When grounded at the designated points, the bus enclosure design should ensure that no significant voltage differences exist between individual enclosure sections and that neither the supporting structures nor any part of the grounding systems is adversely influenced by the flow of induced currents.
- To avoid the circulation of enclosure currents beyond regular return path within the GIS assembly, power cable sheath grounds should be tied to the grounding system via connections that are separated from the GIS enclosures. Very fast transients generated by switching or by faults in the GIS may cause these insulation elements to flashover. In such cases, the consequences of such flashovers on current distribution within the grounding system should be considered.
- Enclosure return currents also cannot be permitted to flow through any mounted current transformers.
- In GIS building, earth mat of copper flat shall be embedded in the concrete floor in grid / mesh form. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

4.1.12 The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences. The following shall be ensured.

- The grounding system shall ensure safe touch & step voltages in all the enclosures
- All GIS equipment, bus ducts, enclosures, control cabinets, supporting structure etc. shall be connected to the ground bus of GIS.
- The enclosure of the GIS shall be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections

should be provided for each of circuit breaker, transformer terminals, cable terminals, surge arrestors, earth switches and at each end of the bus bars.

- The grounding continuity between each enclosure shall be effectively interconnected with copper bonds of suitable size to bridge the flanges.
- Suitable measure shall be provided to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, phase/ earth fault and discharges between contacts during switching operation. Suitable barrier of non-linear resistor at SF6/ Air termination, cable bushing etc. to mitigate transient enclosure voltage shall be provided.

4.1.13 Earthing terminal of each lightning arrester and capacitor voltage transformer shall be directly connected to earth electrode which in turn, shall be connected to station earthing grid.

4.1.14 Isolation of main plant earth mat and GIS Switchyard earth mat shall be provided by test link.

4.1.15 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it.

4.1.16 Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

4.1.17 Earthing conductor shall be buried 2000 mm outside the Switchyard fence. All the gates and every alternate post of the fence shall be connected to earthing grid.

4.1.18 For the power house building involving turbine hall, boiler and ESP, earthing conductor shall be buried in ground in mesh form to enable earthing of all major steel structures, electrical equipment etc.

4.1.19 For auxiliary plants, earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building. Earth risers shall be extended to the building interior for equipment earthing.

4.1.20 In all the electrical rooms, earth mat (galvanized steel flat) shall be embedded in the concrete floor in grid / mesh form. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

4.1.21 Earth pit shall be constructed as per approved drawing. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 6000 mm. Earth pits shall be treated with salt and charcoal.

4.1.22 Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment / structure foundations. Earthing conductors crossing the road / rail tracks shall be laid at 600 mm depth.

4.1.23 All earth electrodes shall preferably be driven to a sufficient depth to reach permanently moist soil. Electrodes shall preferably be situated in a soil which has a fine texture and which is packed by watering and ramming as tightly as possible. The electrodes shall have a clean surface, not covered by paint, enamel, grease or other materials of poor conductivity.

4.1.24 Earth pits shall be located avoiding interference with road, building foundation, column, equipment foundation etc. The disconnect facility shall be provided for individual earth pits to check their earth resistance periodically. Proper symmetry and distance between earth pits shall be maintained as per applicable standards and procedures. Treated earth pits shall conform to relevant standard.

4.1.25 Construction of trench for earthing conductor shall include excavation, laying of conductor, back filling and compacting. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm. Minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench / foundation / underground pipes at crossings.

4.1.26 HV Neutral point of the following transformers shall be directly connected to earth through two numbers treated earth pit.

- Generator transformers
- Standby transformer
- 33 kV winding of Auxiliary transformer

4.1.27 LV Neutral point of the following transformers shall be directly connected to earth through two numbers treated earth pit.

- LT Service transformers

4.1.28 LV Neutral Points of the following transformers shall be connected to Neutral Grounding Resistors (NGRs). NGR shall be connected to earth through two numbers treated earth pit.

- Unit transformer
- Station Transformer
- Unit auxiliary transformer
- Station auxiliary transformer
- Other auxiliary transformers

4.1.29 Earth pits/earth electrodes shall be interconnected to near by station earthing grid.

4.1.30 For equipment earthing, earthing conductor shall be sized to withstand earth fault current of the system for the duration permissible by the protection device. Thickness of galvanising shall be atleast 610 gm/sq.m for all steel conductors.

4.1.31 Size of the earthing conductor shall be not less than the following:

Sl. No.	Equipment	Size/ type of Earthing material
1)	Main earthing conductor / Earth mat	40 mm dia corrosion resistant steel rod
2)	Earth risers from earth mat	40 mm dia corrosion resistant steel rod or 65X8 mm size GS flat
3)	Rod earth electrode	40 mm dia corrosion resistant steel rod
4)	Earth conductor embedded in concrete in GIS building	Copper flat
5)	Earth conductor embedded in concrete	50X6 mm GS flat
6)	Treated earth pit for power circuit	Minimum 65 mm dia galvanized steel pipe electrode as per IS:3043
7)	Electronic earthing	Chemical earth pit with copper electrode
8)	EHV Equipment	
	a) Equipment earth pad to structure, Structure to earth mat	2 nos. 75X8 mm galvanized steel (GS) flat
	b) Control cubicle, Mechanism box	2 Nos. 50X6 mm GS flat

Sl. No.	Equipment	Size/ type of Earthing material
	c) Lightning arrester Insulating base to surge counter	50 mm^2 copper cable
	d) Lightning arrester Surge counter to earth (without touching structure)	75X8 mm GS flat
	e) CVT neutral to earth electrode	75X8 mm GS flat
	f) Earth switch rod to isolator frame	2 nos. copper flexible
9)	Switchyard Towers	
	a) Tower peak to test link	7/3.66 mm galvanized steel shield wire
	b) Test link to main earth mat	50X6 mm GS flat
	c) Structure to earth mat	75X8 mm GS flat
10)	HT transformers (enclosure and neutral)	65X8 mm GS flat
11)	LT transformers (enclosure and neutral)	75X8 mm GS flat
12)	DG set (enclosure and neutral)	50X6 mm GS flat
13)	Generator, LAPT, NGT, NGT neutral	50X6 mm GS flat
14)	HT Switchgear, HT motors, HT busducts	50X6 mm GS flat
15)	LT Switchgear (PCC & MCC), LT busduct	75X8 mm GS flat
16)	All distribution boards	50X6 mm GS flat
17)	LT motors of 75 kW and above	50X6 mm GS flat
18)	LT motors of 30 kW to <75 kW	32X5mm GS flat
19)	LT motors of 9.3 kW to <30 kW	25X3mm GS flat
20)	LT motors of 5.5, 7.5 kW	4 SWG GS wire
21)	LT motors of <5 kW	6 SWG GS wire
22)	Charger / UPS	50X6 mm GS flat
23)	Lighting panels	25X6 mm GS flat
24)	Relay panels / SAS panel	25X6 mm copper flat
25)	Cable trays	50X6 mm GS flat
26)	CT junction box / PT junction box	50X6 mm GS flat
27)	Lighting / Control junction boxes	14 SWG GS wire
28)	Lighting poles/masts	20 mm dia, mild steel earth electrode
29)	Local push button stations	8 SWG GS wire

4.1.32 Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity. Steel columns, metallic stairs, hand rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing.

4.1.33 Metallic conduits shall not be used as earth continuity conductor.

4.1.34 Flexible earthing connectors shall be provided for moving parts.

4.1.35 50 mm x 6 mm galvanized steel flat shall run all along the cable tray routes and the same shall be welded / connected to each of the tray /rack. Further, this flat shall be earthed at both ends and at an interval of 30 m.

4.1.36 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making earth connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint / compound.

4.1.37 Connection between earthing conductors shall be welded type. For rust protection, the welds shall be treated with red lead and coated with two layers bitumen compound.

4.1.38 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.

4.1.39 Metallic sheaths and armour of all multi-core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

4.1.40 Earthing conductors along their run on cable trench, ladder, walls etc. shall be supported by suitable welding / cleating at intervals of 1000 mm. Wherever it passes through walls, floors etc., pipe sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

4.1.41 Railway tracks within the plant area shall be bonded across fish plates and connected to earthing grid at several locations.

4.1.42 Electronic panels and equipment shall be grounded utilising an insulated copper ground wire terminated at separate earth electrode.

4.1.43 For electronic equipment such as DCS, Respective control system, SAS, EMS etc., chemical earthing pit shall be provided. The earth pit shall be tested and proven type and shall be guaranteed for service life of 40 years. The chemical earth pit shall comprise pipe electrode, crystalline conductive mixture, bentonite etc. constructed in a pit of not less than 4000 mm depth. The pit shall be effective in all weather conditions and offer medium resistance. For electronic earthing system, earthing conductor shall be of copper.

4.1.44 **Earthing of chimney**: Earthing shall be carried out by routing 50x6 mm galvanised steel strip earthing conductor from chimney top up to ground. Each earthing conductor shall be earthed by using 40 mm dia 4 metre mild steel rod and shall also be interconnected with the power station earthing grid.

4.1.45 Earthing of cabling system

- Armour of the HT cables and LT single core cables shall be earthed only at one end of cable.
- Armour of other cables shall be earthed at both ends of cable.
- Screen of HT power cables shall be earthed at one end only.
- Screen of C&I screened control cables shall be earthed at one end.
- Screen of electronic earthing system cables shall be earthed as per the requirements.

4.1.46 After completion of grounding system installation, the measurement of ground resistance shall be performed by the Contractor. continuity of earth conductors and efficiency of all bonds and joints shall be checked. Before measurement, the overhead ground wires shall be disconnected from the GIS Switchyard. The method of measurement shall be as per relevant standards / codes. The ground resistance of GIS Switchyard grounding system shall be not more than 0.5

ohm. Earth resistance at earth terminations shall be measured in presence of Owner's representatives

5.0.0 LIGHTNING PROTECTION SYSTEM

5.1.0 Direct stroke lightning protection (DSLP) shall be provided in the GIS Switchyard by lightning masts and shield wires including connections, earth pits etc. to make the lightning protection complete for the outdoor GIS Switchyard including reactors. The arrangement shall be based on DSLP calculations. Contractor shall furnish necessary design calculation for approval by Owner.

5.2.0 The lightning protection system in the transformer yard shall cover the following equipment in the protection zone.

- Generator transformers
- Station transformers
- Standby transformers
- Auxiliary transformers

5.2.0 All areas of the power station shall be provided with lightning protection. The lightning protection system for buildings shall consist of air termination network, down conductors, test link and earth electrodes.

5.3.0 Air termination network consisting of vertical or horizontal conductors or combination of both shall be provided for the building. Down conductors shall follow the most direct path possible between the air terminal network and the earth termination network. Each down conductor shall be provided with a test link for testing. An earth electrode shall be connected to each down conductor.

5.4.0 For Lightning protection, material & sizes shall be as follows:

- Vertical air termination : 20 mm dia galvanised steel rod
- Horizontal air termination : 25X6 mm Galvanised steel Strip
- Down conductor : 25X6 mm Galvanised steel Strip
- Test link : 150x50x6 mm Galvanised steel Strip with Box
- Earth Electrodes : Treated earth pit with rod electrode as per IS:3043

5.5.0 Thickness of galvanising shall be atleast 610 gm/sq.m for all galvanised steel conductors.

5.6.0 The lightning protection system shall not come in direct contact with other equipment/systems such as cables, conduits, electrical equipment, underground metallic ducts etc. All metallic structures within vicinity shall be bonded to the lightning protection system.

5.7.0 All welded/brazed joints shall be coated with anti- corrosive paint for rust protection.

5.8.0 Lightning conductor when used above ground level and shall be connected through test link with earth electrode/earthing system. Down conductors shall be as short and straight as practicable and shall follow a direct path to earth. Down conductor shall not be connected to other earthing conductors above ground level.

5.9.0 Each down conductor shall be provided with a test link at 1500 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point. All joints in the down conductors shall be of welded type.

5.10.0 Down conductors shall be cleated on outer side of building wall/ welded to outside building columns at 750 mm interval.

5.11.0 Lightning conductor on roof shall be cleated on surface of roof using insulated clamps/saddles for conductor fixing at an interval of 1000 mm for horizontal run and 750 mm for vertical run..

5.12.0 Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

5.13.0 Installation of lightning conductors on the roofs of buildings shall include construction of support, laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying, fastening / cleating / welding of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level.

5.14.0 Lightning protection system for chimney

5.14.1 The lightning protection system for chimney shall be installed in accordance with IS 2309. Pointed vertical air terminal rods shall be provided at the top and these shall be equally spaced at 120 degree around the circumference of the top flue cane. Air terminals shall project not less than 1000 mm above the highest part of the flue cane. Air terminals shall be mechanically and electrically connected to a continuous circumferential conductor.

5.15.0 For Lightning protection, material & sizes shall be as follows:

- Vertical air termination : 20 mm dia lead coated steel rod
- Horizontal air termination (top 12 metre): 25X3 mm lead coated copper strip
- Horizontal air termination (remaining portion): 50X6 mm Galvanised steel Strip
- Down conductor (top 12 metre) : 25X3 mm lead coated copper strip
- Down conductor (remaining portion) : 50X6 mm Galvanised steel Strip
- Coronal band (top) : 70 sq.mm lead coated copper conductor
- Coronal band (mid-height) : 70 sq.mm copper conductor
- Test link : 150x50x6 mm Galvanised steel flat in steel enclosure
- Earth Electrodes : Treated earth pit with rod electrode as per IS:3043

5.14.2 Two cable collars, , shall encircle the chimney; one at the top, interconnecting the lower ends of the air terminals and the down conductors, and one approximately mid-height of the chimney, connecting the down conductors. Not less than four down conductors along shell shall be located along the exterior wall of the shell, shall extend to the chimney base to earth electrode pit, and shall be connected to the plant grounding grid.

5.14.3 Air terminals, connections, conductors, clamps, fixtures, anchors, etc., exposed within 12000 mm of the top of the chimney shall have a continuous lead covering of a sheath of commercially pure lead not less than 2 mm in thickness.

5.14.4 During construction, temporary lightning protection should be maintained by connecting the concrete reinforcement to two permanent electrical grounding conductors. After the top lift of the chimney shell has been completed, temporary air terminals which may consist of reinforcing bars, should be installed at the top to serve as a temporary protection until the lining and cap are completed and permanent air terminals are installed.

5.16.0 Lightning Protection System for cooling tower and Ash Silo

5.15.1 Pointed vertical air terminal rods shall be provided at the top and these shall be spaced around the circumference of the top. Air terminals shall consist of galvanized steel conductors, each not less than 20 mm diameter galvanized steel rod, projecting not less than 1000 mm above the highest part structure. Air terminals shall be mechanically and electrically connected to a continuous circumferential conductor. Number of down conductors as per IS: 2309, shall be located along the exterior wall, shall extend to the base to earth electrode pit, and shall be connected to the power station earth grid.

5.17.0 For Lightning protection, material & sizes shall be as follows:

- Vertical air termination : 20 mm dia lead coated steel rod
- Horizontal air termination : 50X6 mm Galvanised steel Strip
- Down conductor : 50X6 mm Galvanised steel Strip
- Coronal band (at top)) : 70 sq.mm copper conductor
- Test link : 150x50x6 mm Galvanised steel flat in steel enclosure
- Earth Electrodes : Treated earth pit with rod electrode as per IS:3043

5.15.2 During construction, temporary lightning protection should be maintained by connecting the concrete reinforcement to two permanent electrical grounding conductors.

5.16.0 On completion of lightning installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured in presence of Owner. Resistance of individual earth electrode shall be measured after disconnecting it from the grid. Tests shall be carried out as per IS : 3043 for earthing installation including the following:

a) Earth continuity checks
b) Earth resistance of the complete system, sub-system and earth pits

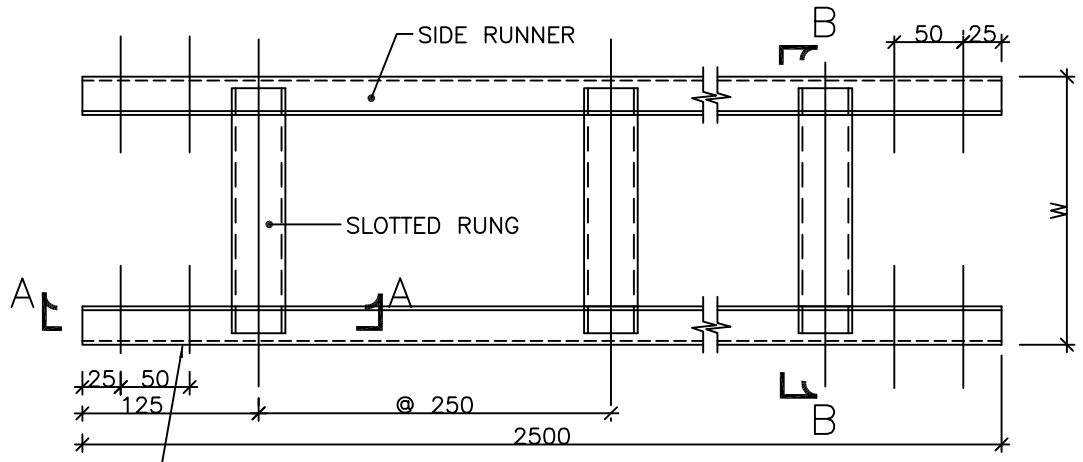
6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

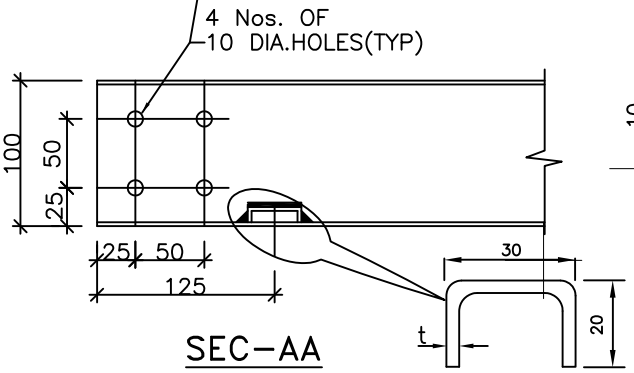
- Soil resistivity report
- Design basis report for earthing and lightning protection system
- Earthing design calculation
- Typical installation drawings for earthing and lightning protection
- Electronic earthing layout and details
- Earthing layout for Transformer Yard
- Earthing layout for Power house building, Boiler and ESP
- Earthing layout for Chimney
- Earthing layout for Cooling tower
- Earthing layout for all auxiliary plant buildings
- Earthing layout for all non-plant buildings
- Earthing layout for GIS building and Switchyard
- Lightning protection design calculation
- Lightning protection layout for Power house building, Boiler and ESP
- Lightning protection layout for transformer yard
- Lightning protection layout for all auxiliary plant buildings
- Lightning protection layout for all non-plant buildings
- Lightning protection layout for GIS building and Switchyard
- Lightning protection layout for Chimney
- Lightning protection layout for Cooling tower
- Field quality plan

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS AND FRP TYPE)

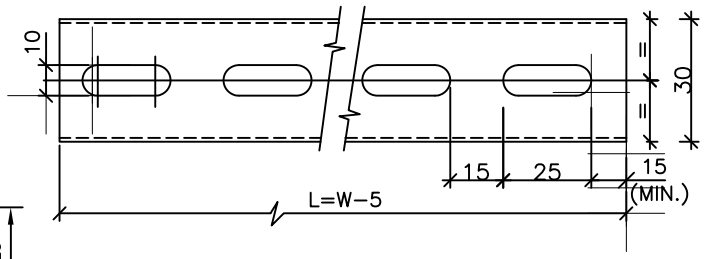
CUSTOMER	TAMIL NADU GENERATION & DISTRIBUTION CORPORATION LIMITED				
PROJECT	2 X 660 MW UDANGUDI STPP STAGE–I				
JOB NO. 435	BHARAT HEAVY ELECTRICALS LIMITED POWER SECTOR PROJECT ENGINEERING MANAGEMENT NOIDA(U.P) INDIA	DPT CODE–E		NAME	SIGN	DATE
			DRN	SKS		
			DSN	SKS		
			CHD	VY		
			APP	SL		
		DWG. NO. PE–DG–435–507–E005				
		SHT. 01 OF 26 REV. 0				



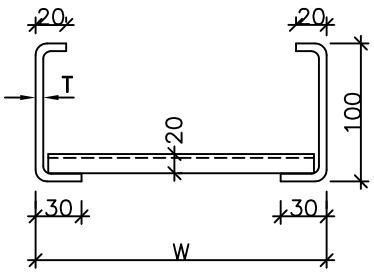
LADDER TYPE CABLE TRAY



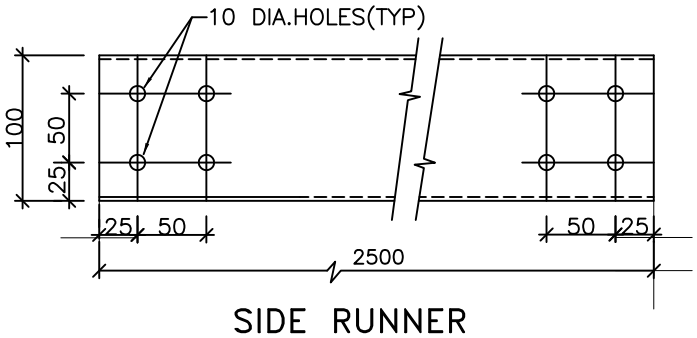
SEC–AA



SLOTTED RUNG



SEC–BB

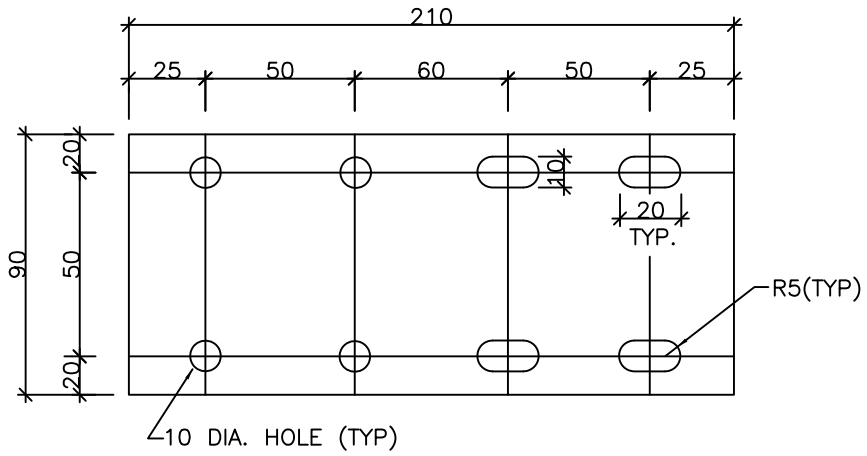


SIDE RUNNER

W	150	300	450	600
L	145	295	445	595
T	2	2	2	2
t	2	2	2	2

FOR GENERAL NOTES REFER SHEET 13 OF 26

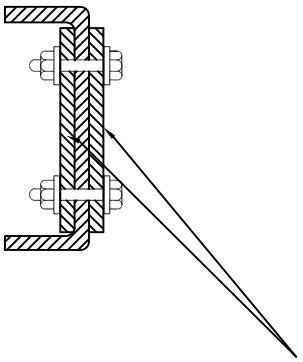
भेल BHEL — TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 02 OF 26 REV. 0



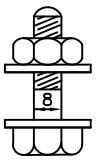
SIDE COUPLER PLATE FOR LADDER/PERFORATED TYPE TRAYS

(600/450/300/150W TRAYS)

QTY. REQUIRED/TRAY SECTION : 4 NOS.

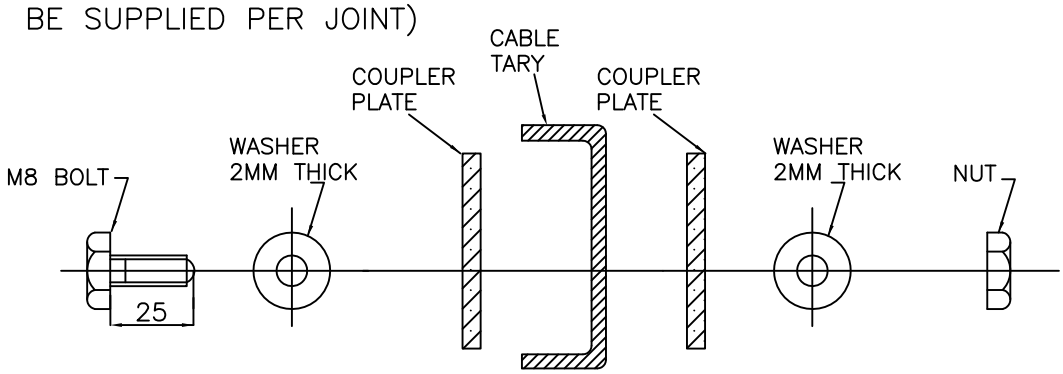


(2 NOS. COUPLER PLATES OF 2 MM THICKNESS TO BE SUPPLIED PER JOINT)



QTY. REQD/TRAY SECTION

A) 16 NOS. M8 BOLTS
B) 16 NOS. NUTS
C) 32 NOS. WASHERS

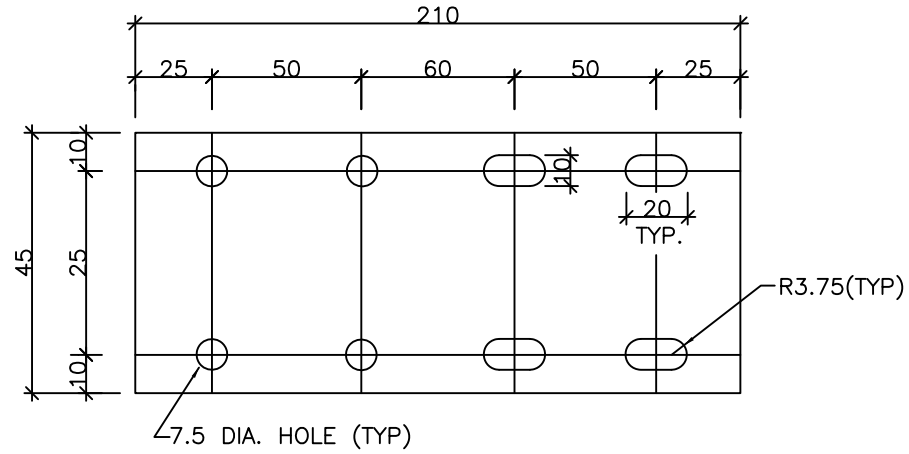


SEQUENCE OF M8 BOLT, WASHER, NUT, COUPLER PLATE & CABLE TRAY

FOR TYPICAL CABLE TRAY JOINT

FOR GENERAL NOTES REFER SHEET 13 OF 26

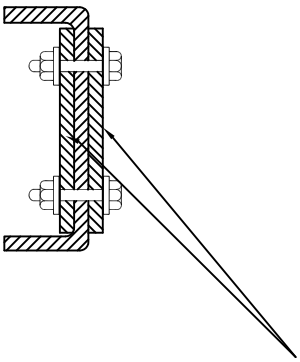
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE-DG-435-507-E005
	SHT. 03 OF 26 REV. 0



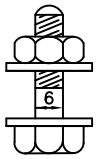
SIDE COUPLER PLATE FOR PERFORATED TYPE TRAYS

(100/50W TRAYS)

QTY. REQUIRED/TRAY SECTION : 4 NOS.



(2 NOS. COUPLER PLATES OF 2 MM THICKNESS TO BE SUPPLIED PER JOINT)



QTY. REQD/TRAY SECTION

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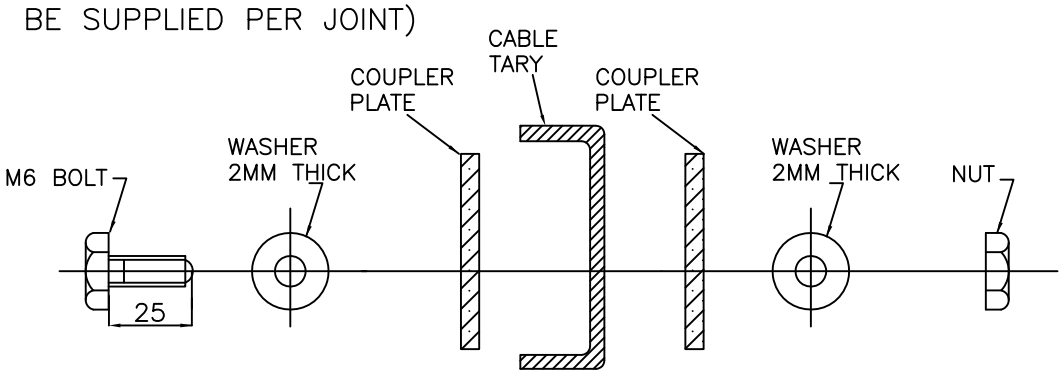
B) 16 NOS. NUTS
C) 32 NOS. WASHERS

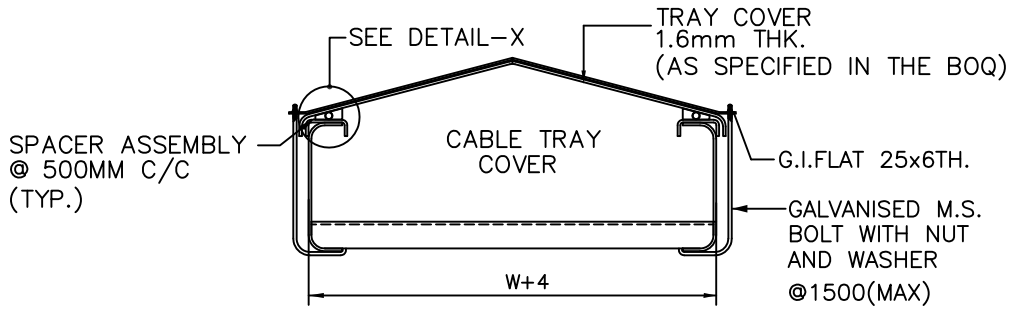


SEQUENCE OF M6 BOLT, WASHER, NUT, COUPLER PLATE & CABLE TRAY

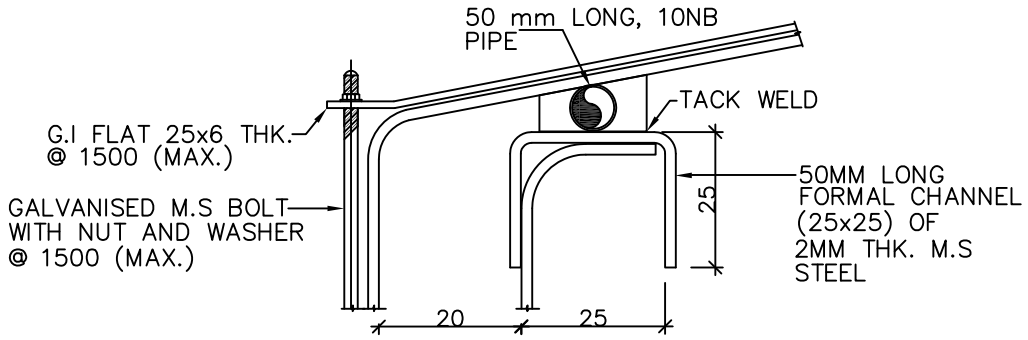
FOR TYPICAL CABLE TRAY JOINT

FOR GENERAL NOTES REFER SHEET 13 OF 26

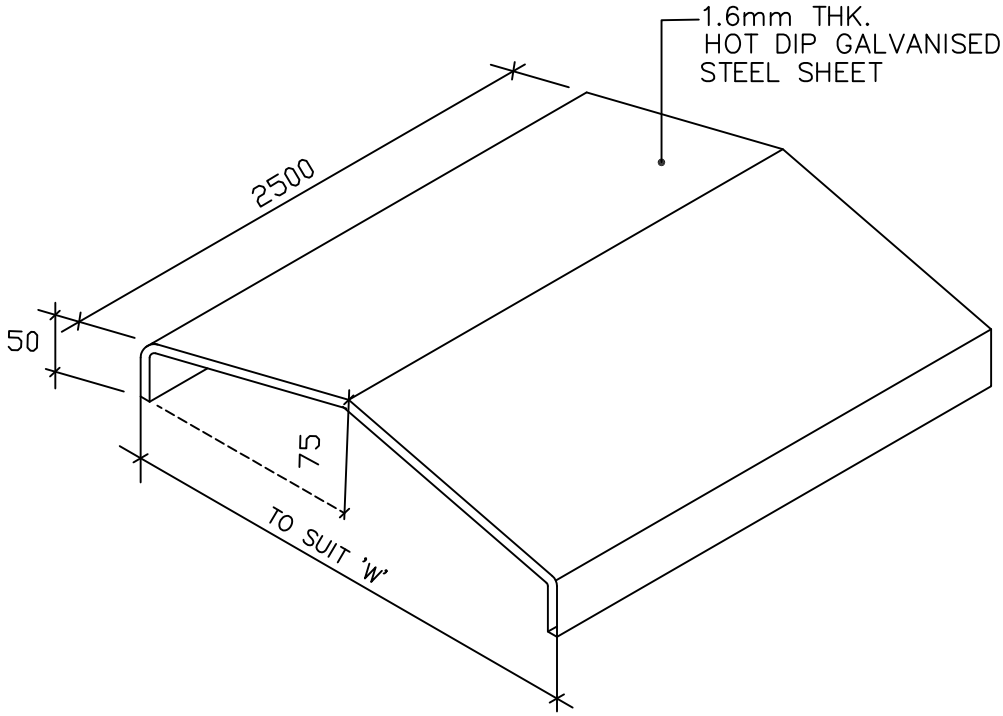
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE-DG-435-507-E005
	SHT. 04 OF 26 REV. 0



COVER FIXING (TYP.)



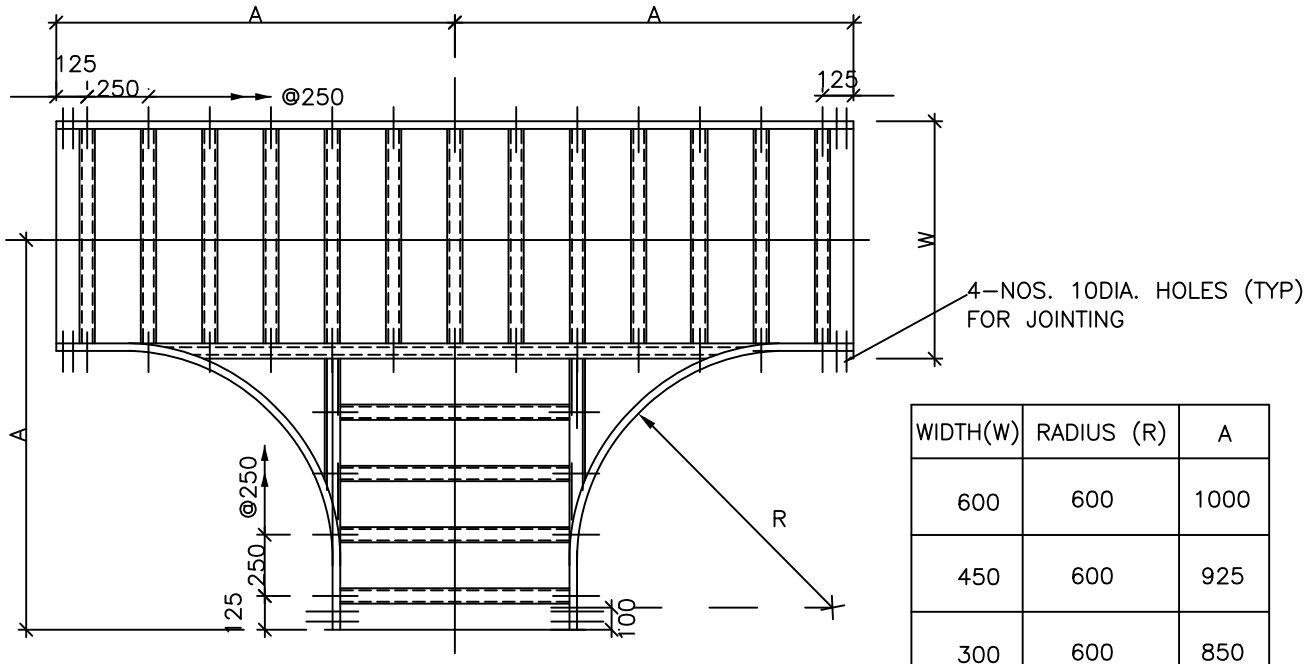
DETAIL–X



CABLE TRAY COVER

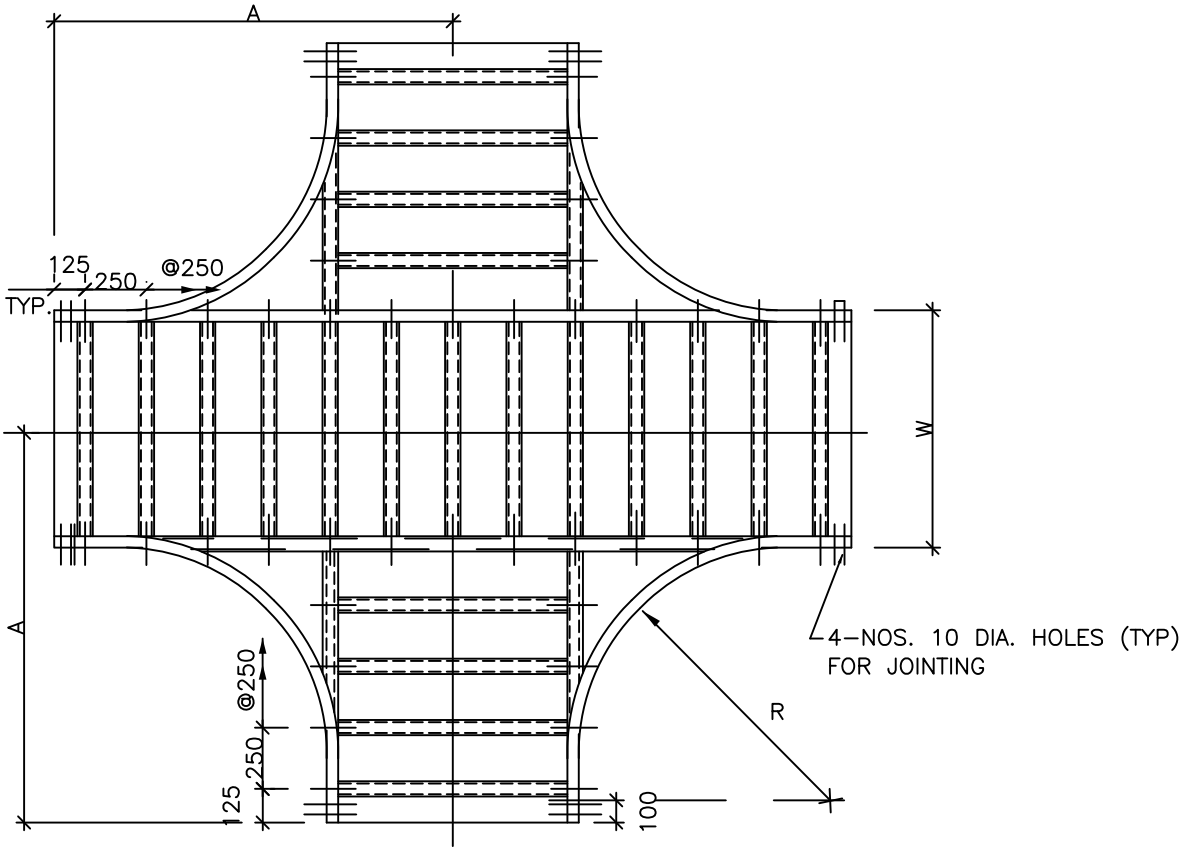
FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 05 OF 26 REV. 0



WIDTH(W)	RADIUS (R)	A
600	600	1000
450	600	925
300	600	850

HORIZONTAL TEE–PLAN

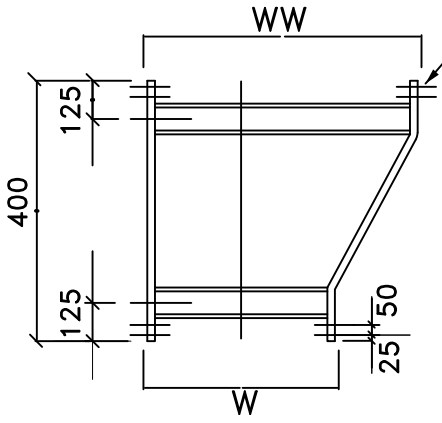


HORIZONTAL CROSS–PLAN

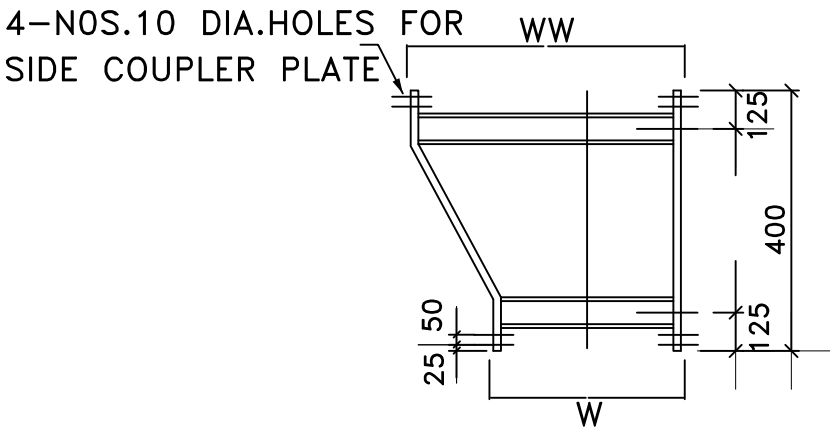
LADDER TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 06 OF 26 REV. 0



LEFT HAND REDUCER–PLAN



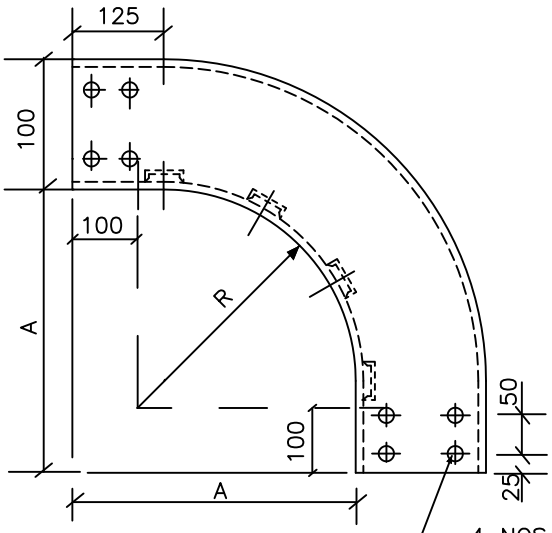
RIGHT HAND REDUCER–PLAN

WIDTH	WW	600	600	450
	W	450	300	300

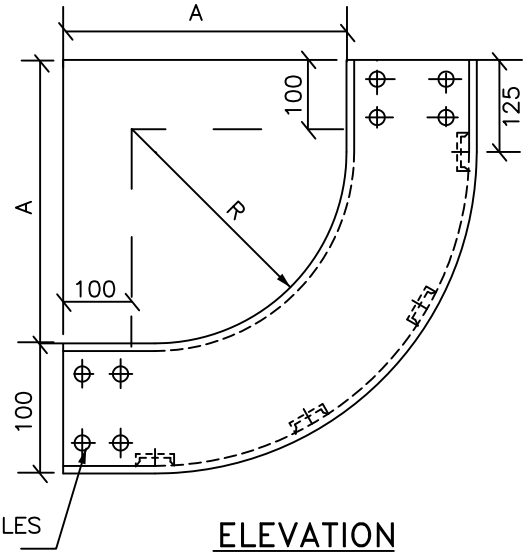
LADDER TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 07 OF 26 REV. 0



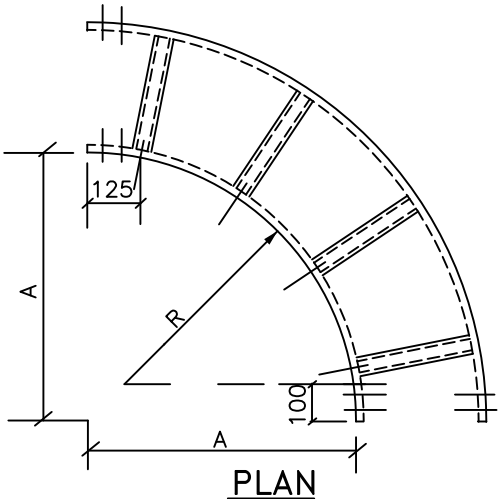
ELEVATION
90° VERTICAL BEND
(OUTSIDE)



ELEVATION
90° VERTICAL BEND
(INSIDE)

LADDER TYPE TRAYS

WIDTH(W)	RADIUS (R)	A
600	600	700
450	600	700
300	600	700

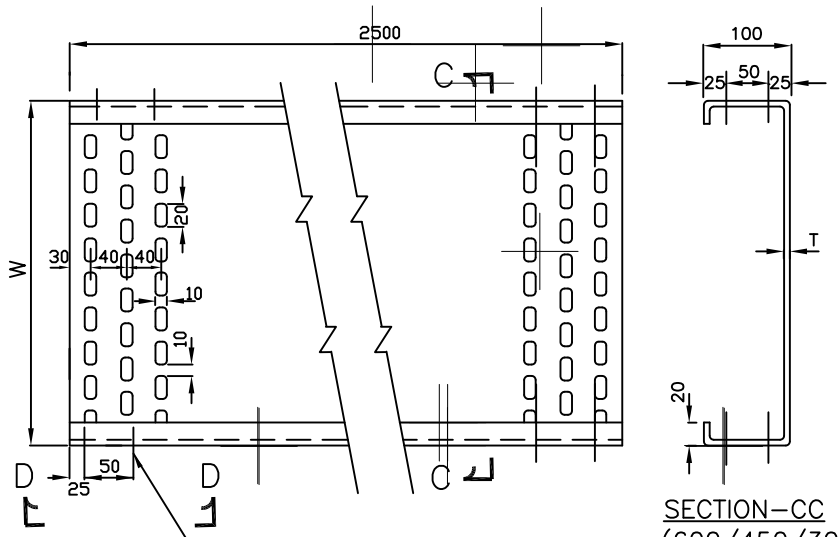


PLAN
90°HORIZONTAL BEND

LADDER TYPE ACCESSORIES

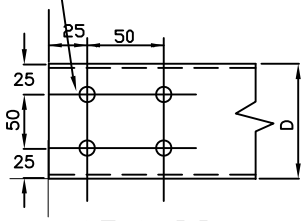
FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE-DG-435-507-E005
	SHT. 08 OF 26 REV. 0



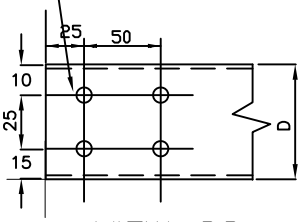
SECTION–CC
(600/450/300/150 TRAYS)

4 HOLES 10mm DIA.

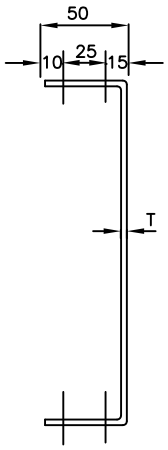


VIEW–DD
(600/450/300/
150W TRAYS)

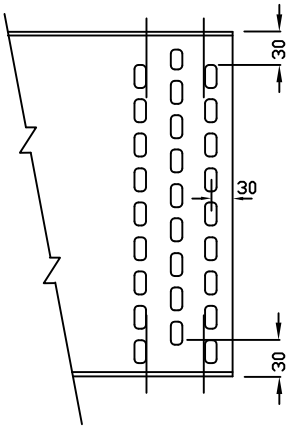
4 HOLES 7.5mm DIA.



VIEW–DD
(100/50W TRAYS)



SECTION–CC
(100/50 TRAYS)



ARRANGEMENT OF
PERFORATIONS

TRAY WIDTH W (mm)	600	450	300	150	100	50
TRAY DEPTH D (mm)	100	100	100	100	50	50
T (mm)	2	2	2	2	2	2

PERFORATED TYPE TRAY

FOR GENERAL NOTES REFER SHEET 13 OF 26

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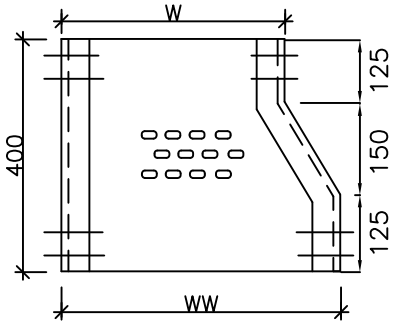
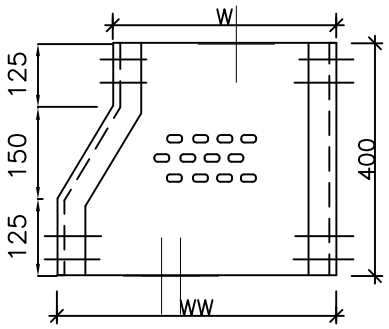
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)

DWG. NO.
PE–DG–435–507–E005

SHT. 09 OF 26 REV. 0



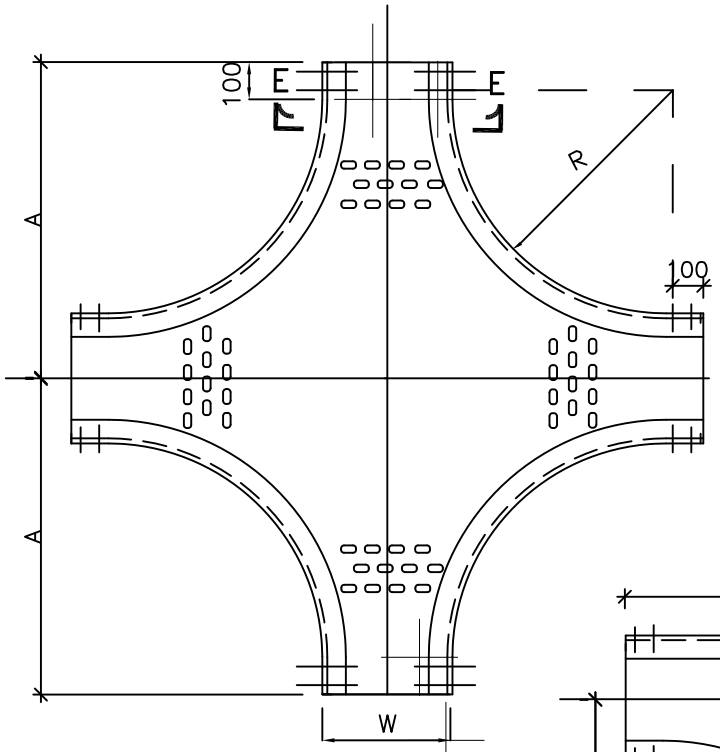
LEFT HAND REDUCER



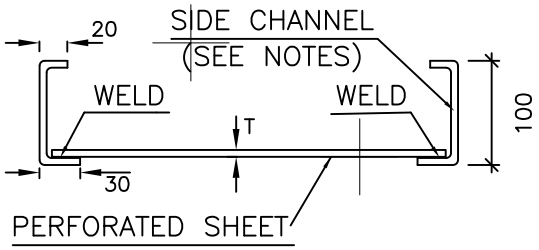
RIGHT HAND REDUCER

WW	W	DEPTH	THICKNESS
600	450	100	2
600	300	100	2
450	300	100	2

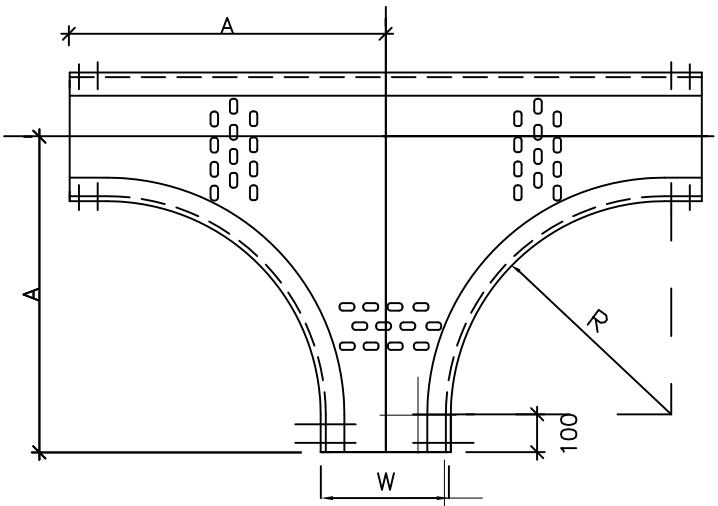
PERFORATED TYPE



CROSS



SECTION–EE



TEE

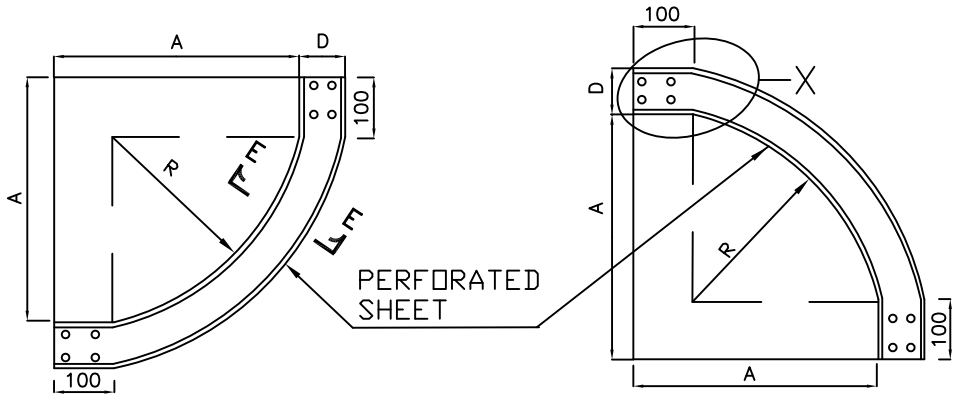
PERFORATED TYPE

WIDTH(W)	RADIUS (R)	A	T
600	600	1000	2
450	600	925	2
300	600	850	2

PERFORATED TYPE ACCESSORIES

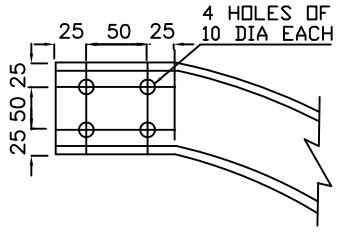
FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 10 OF 26 REV. 0

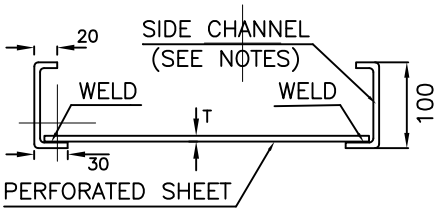


INSIDE TYPE

OUTSIDE TYPE

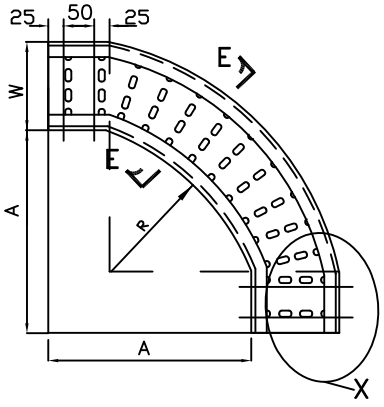


ENLARGED VIEW OF "X"



SECTION–EE

90° VERTICAL BEND – PERFORATED TYPE



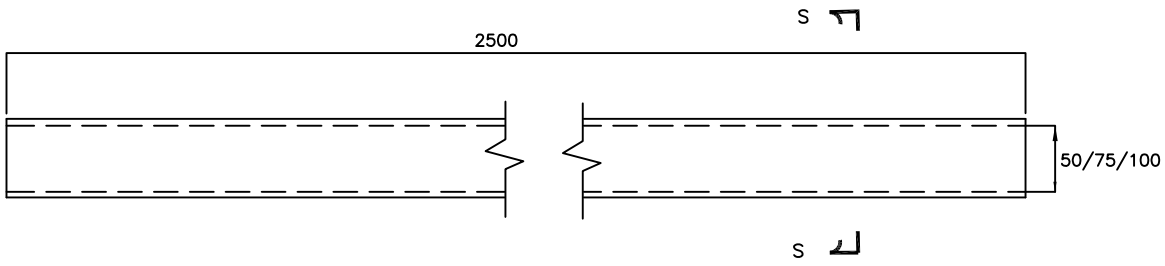
WIDTH(W)	RADIUS (R)	A	T
600	600	700	2
450	600	700	2
300	600	700	2

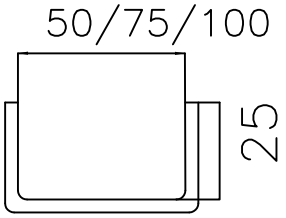
90° HORIZONTAL BEND – PERFORATED TYPE

PERFORATED TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 11 OF 26 REV. 0





SECTION–SS

CABLE TROUGH

FOR GENERAL NOTES REFER SHEET 13 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (GS TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 12 OF 26 REV. 0

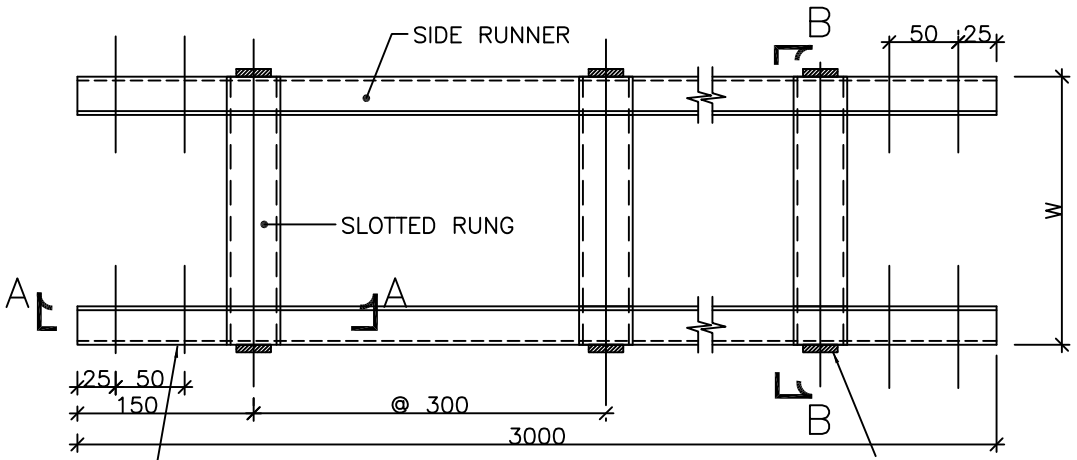
NOTES:–

1. THE LADDER AND PERFORATED TYPE CABLE TRAYS AND ACCESSORIES (INCLUDING SIDE RUNNERS OF LADDER TYPE TRAYS & ACCESSORIES) SHALL BE MADE OF 2MM HOT ROLLED M.S. SHEET. ALL THE COUPLER PLATE SHALL BE 2 MM THICK.
2. THE CABLE TRAYS & ACCESSORIES SHALL BE HOT DIP GALVANISED AS PER IS 2629. THE MASS OF ZINC COATING SHALL BE 610 gm/m² AND THICKNESS SHALL BE 86 MICRONS (MINIMUM).
3. FOR LADDER TYPE CABLE TRAYS AND ACCESSORIES, ALL RUNGS SHALL BE SLOTTED. PERFORATED TRAYS SHALL BE FABRICATED OUT OF A SINGLE M.S. SHEET.
4. STANDARD TRAY ACCESSORIES SHALL BE WITH THE RADIUS INDICATED IN THIS DRAWING.
5. SIDE CHANNELS OF PERFORATED TYPE CABLE TRAY ACCESSORIES SHALL BE WELDED WITH THE PERFORATED SHEET AT INTERVALS OF 100mm.
6. LENGTH OF WELDING SHALL NOT BE LESS THAN 25mm FOR CABLE TRAYS. THE THICKNESS OF WELDING SHALL BE AS PER IS 9595.
7. ALL TRAY CORNERS SHALL BE SMOOTH AND FREE OF SHARP EDGES.
8. THE CABLE TRAY COVER SHALL BE OF 1.6MM THICK MS SHEET AND SHALL BE HOT DIP GALVANISED.
9. THE DEPTH, WIDTH AND LENGTH OF TRAYS & TRAY COVERS SHALL BE WITHIN A TOLERANCE OF (+/–) 2 mm.
10. THE THICKNESS OF THE FINISHED PRODUCT CABLE TRAYS & ACCESSORIES SHALL NOT BE LESS THAN 2MM.
11. TO FACILITATE ASSEMBLY, ALL ACCESSORIES AT ENDS SHALL HAVE 100mm STRAIGHT PORTION.
12. ALL NUTS, BOLTS, WASHERS ETC., SHALL BE HOT DIP GALVANISED AS PER IS:1367 PART XIII FOR SIZES 12 MM & ABOVE, AND ELECTROPLATED/ZINC PASSIVATED FOR SIZES UPTO 12 MM.
13. ALL CUTTING & FORMING OPERATIONS SHALL BE COMPLETED PRIOR TO GALVENIZING.
14. FINISHED TRAYS SHALL BE FREE FROM BURRS AND SHARP EDGES.
15. ALL DIMENSIONS ARE IN mm UNLESS NOTED OTHERWISE.
16. WIDTH OF CABLE TRAYS PROPOSED TO BE USED FOR THE PROJECT ARE AS UNDER:
    A)LADDER TYPE: 600W, 450W, 300W, 150W.
    B)PERFORATED TYPE: 600W, 450W, 300W, 150W, 100W, 50W.
17. THE DEPTH OF 600W, 450W, 300W, 150W TRAYS & ACCESSORIES SHALL BE 100MM. DEPTH OF 100/50W TRAYS SHALL BE 50MM.
18. 600MM WIDE TYPE CABLE TRAYS SHALL BE SUITABLE FOR A CABLE WEIGHT OF 100 Kg PER METRE (INCLUDING LIVE LOAD) OF RUNNING LENGTH OF TRAY.
19. CABLE TROUGHS OR 50/100MM WIDE PERFORATED TYPE TRAY SHALL BE USED FOR LOCAL CABLING/BRANCHING OUT FEW CABLES FROM MAIN ROUTE.

BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES	DWG. NO. PE–DG–435–507–E005
		SHT. 13 OF 26 REV. 0

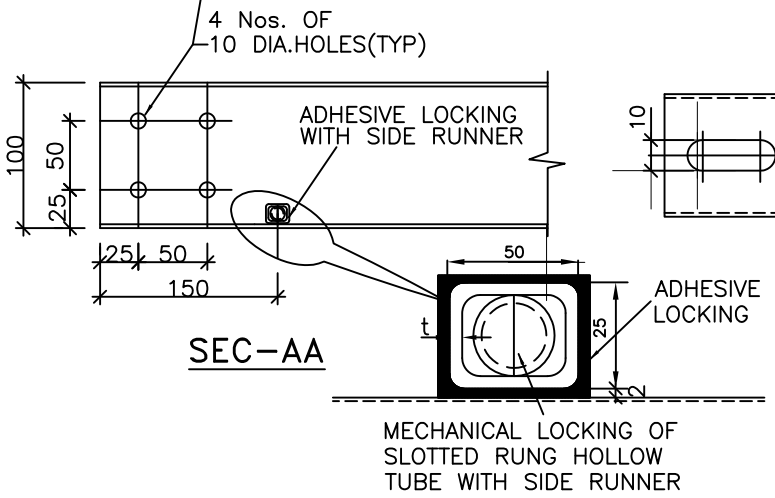
TYPICAL DETAILS OF
FRP TYPE CABLE TRAYS AND ACCESSORIES

CUSTOMER	TAMIL NADU GENERATION & DISTRIBUTION CORPORATION LIMITED					
PROJECT	2 X 660 MW UDANGUDI STPP STAGE–I					
JOB NO. 435	BHARAT HEAVY ELECTRICALS LIMITED POWER SECTOR PROJECT ENGINEERING MANAGEMENT NOIDA(U.P) INDIA	DPT CODE–E		NAME	SIGN	DATE
			DRN	SKS		
			DSN	SKS		
			CHD	VY		
			APP	SL		
		DWG. NO. PE–DG–435–507–E005				
		SHT. 14 OF 26 REV. 0				

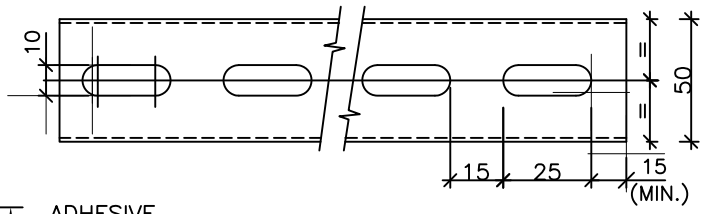


FRP LADDER TYPE CABLE TRAY

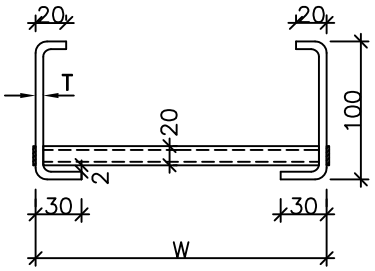
MECHANICAL LOCKING SUITABLE TO WITHSTAND LOADING SPECIFIED IN DATA SHEET–A



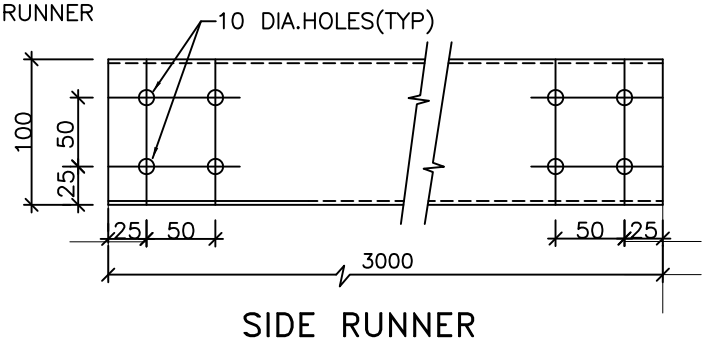
SEC–AA



SLOTTED RUNG



SEC–BB

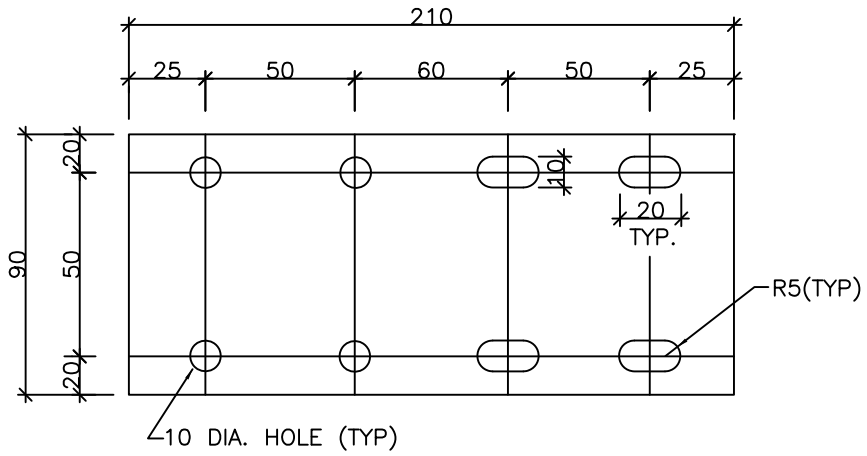


SIDE RUNNER

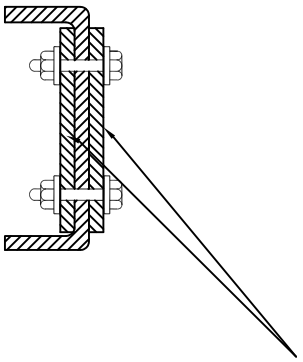
W	150	300	450	600
T	4	4	4	4
t	4	4	4	4

FOR GENERAL NOTES REFER SHEET 26 OF 26

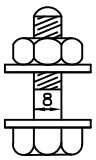
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 15 OF 26 REV. 0



FRP SIDE COUPLER PLATE FOR
FRP LADDER/PERFORATED TYPE TRAYS
(600/450/300/150W TRAYS)
QTY. REQUIRED/TRAY SECTION : 4 NOS.

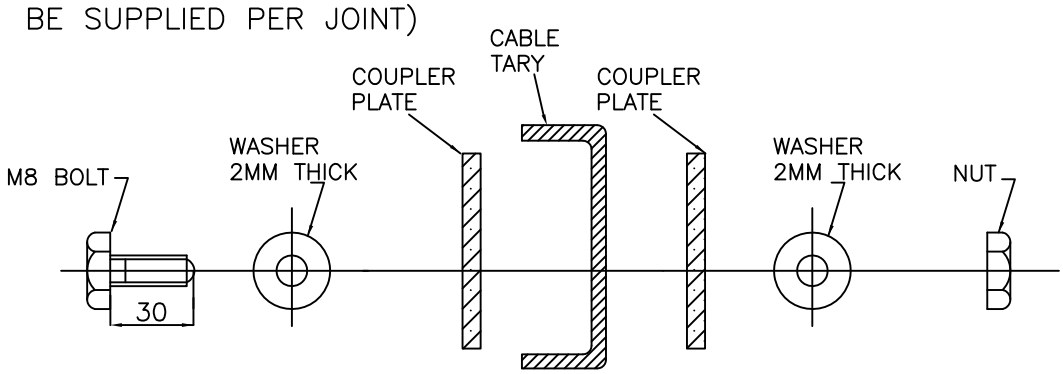


(2 NOS. COUPLER PLATES
OF 2 MM THICKNESS TO
BE SUPPLIED PER JOINT)



QTY. REQD/TRAY SECTION

A) 16 NOS. M8 BOLTS
B) 16 NOS. NUTS
C) 32 NOS. WASHERS

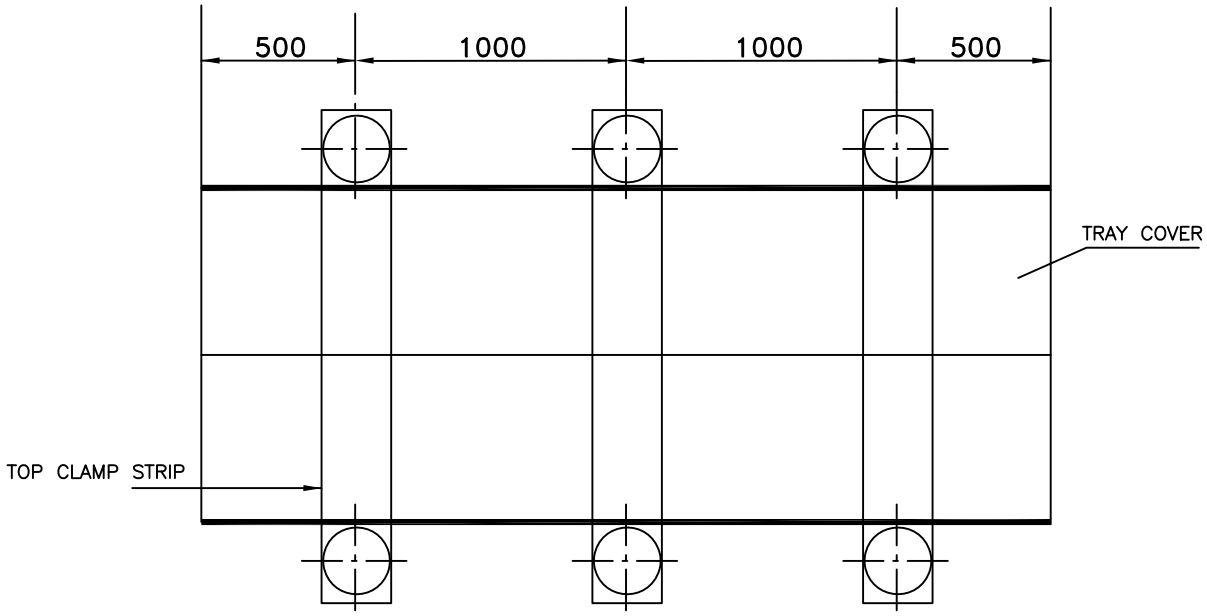


SEQUENCE OF M8 BOLT, WASHER, NUT, COUPLER PLATE & CABLE TRAY

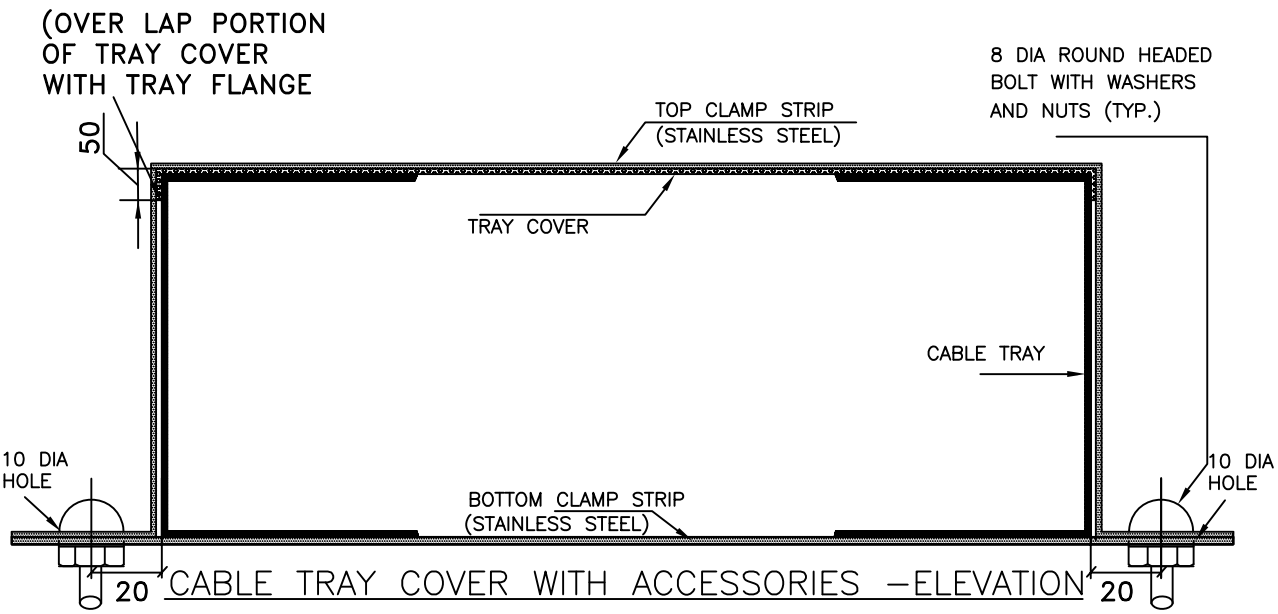
FOR TYPICAL CABLE TRAY JOINT

FOR GENERAL NOTES REFER SHEET 26 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE-DG-435-507-E005
	SHT. 16 OF 26 REV. 0



CABLE TRAY COVER WITH ACCESSORIES –PLAN



CABLE TRAY COVER WITH ACCESSORIES –ELEVATION

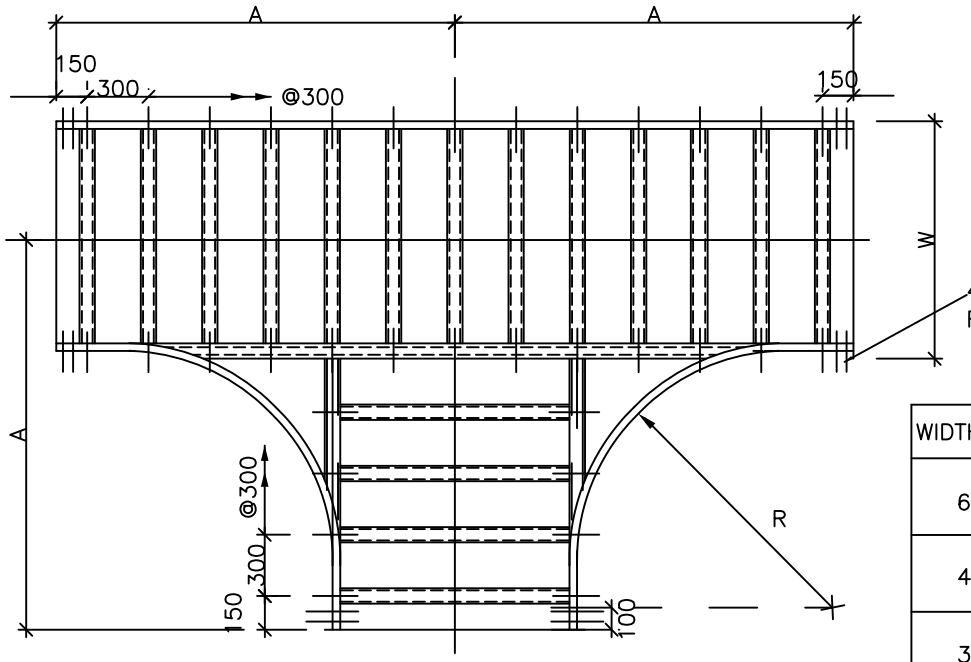
TRAY WIDTH(W)	TOP CLAMP SIZE (LxWxT)	BOTTOM CLAMP SIZE (LxWxT)
600	900X20X2	680X20X2
450	750X20X2	530X20X2
300	600X20X2	380X20X2
150	450X20X2	230X20X2

CABLE TRAY COVER SHALL INCLUDE 1 NO. OF TRAY COVER OF 3000MM LENGTH ALONG WITH 3 NOS. OF TOP CLAMP STRIP, 3 NOS. BOTTOM CLAMP STRIP AND 6 NOS. OF BOLTS ALONG WITH NUTS & WASHERS.

CABLE TRAY COVER

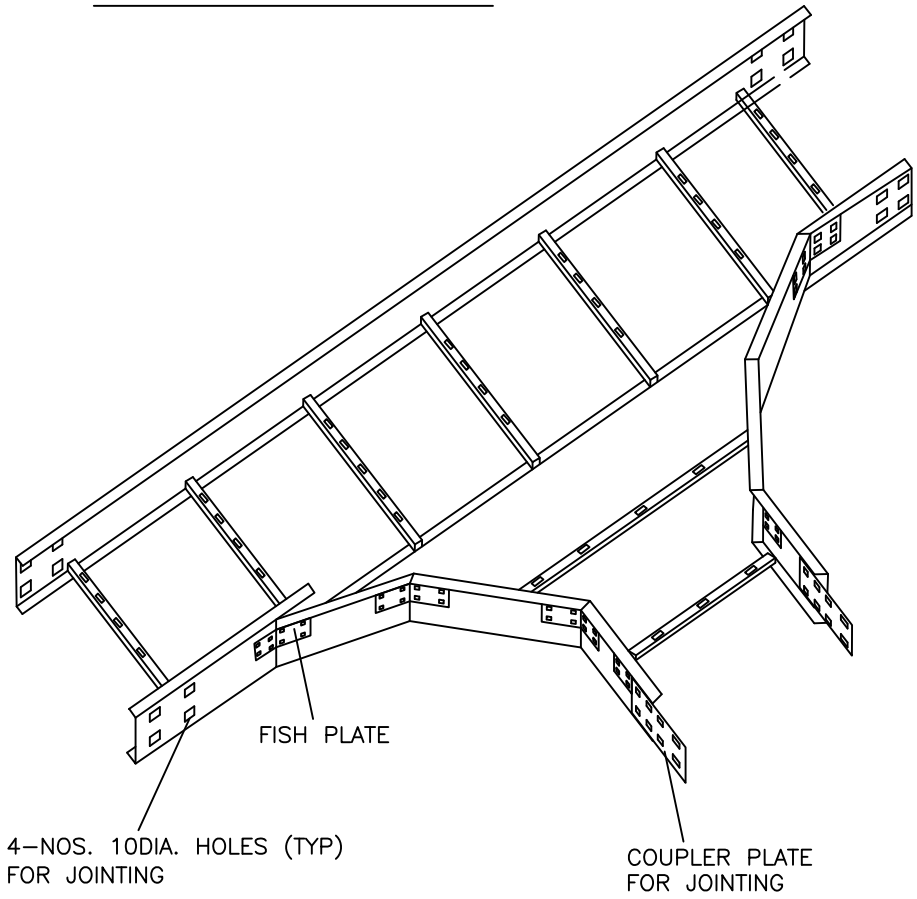
FOR GENERAL NOTES REFER SHEET 26 OF 26

बीएचईएल BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE–DG–435–507–E005
		SHT. 17 OF 26 REV. 0



WIDTH(W)	RADIUS (R)	A
600	600	1000
450	600	925
300	600	850

HORIZONTAL TEE–PLAN

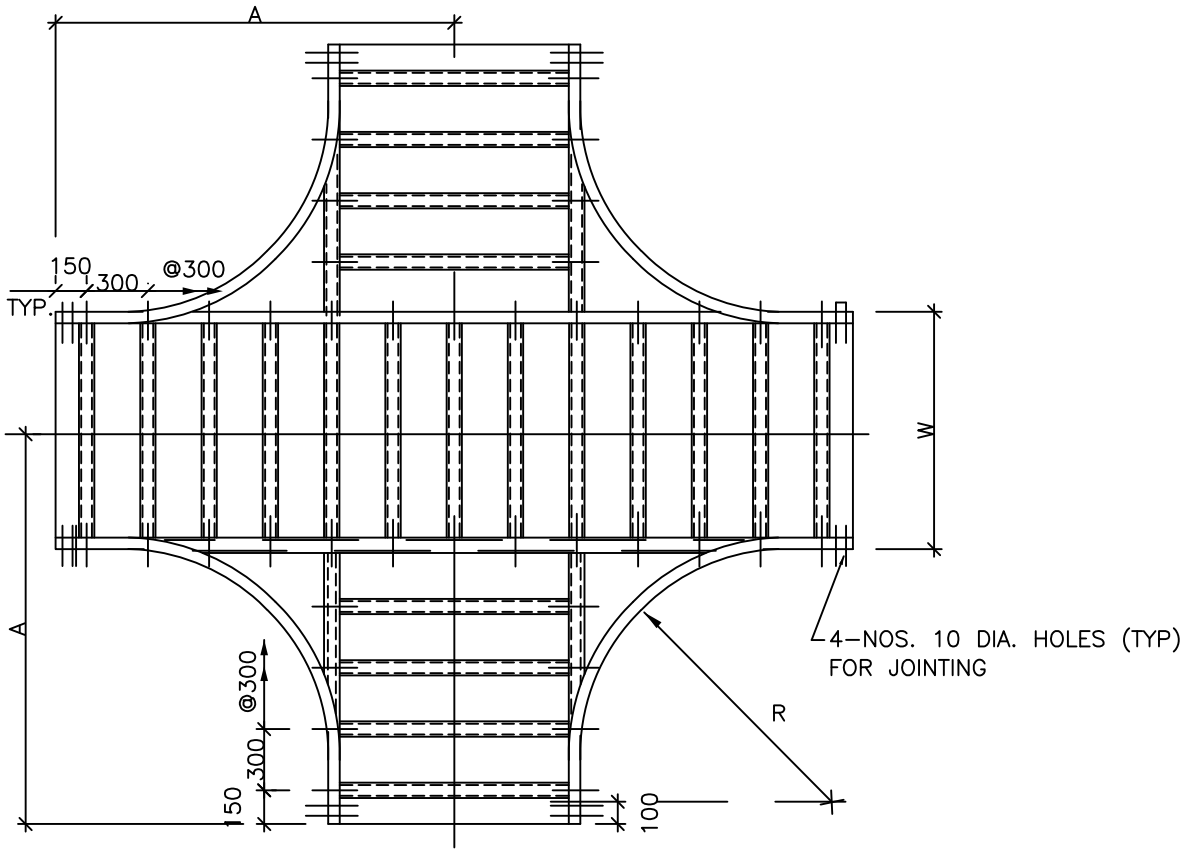


HORIZONTAL TEE

LADDER TYPE ACCESSORIES

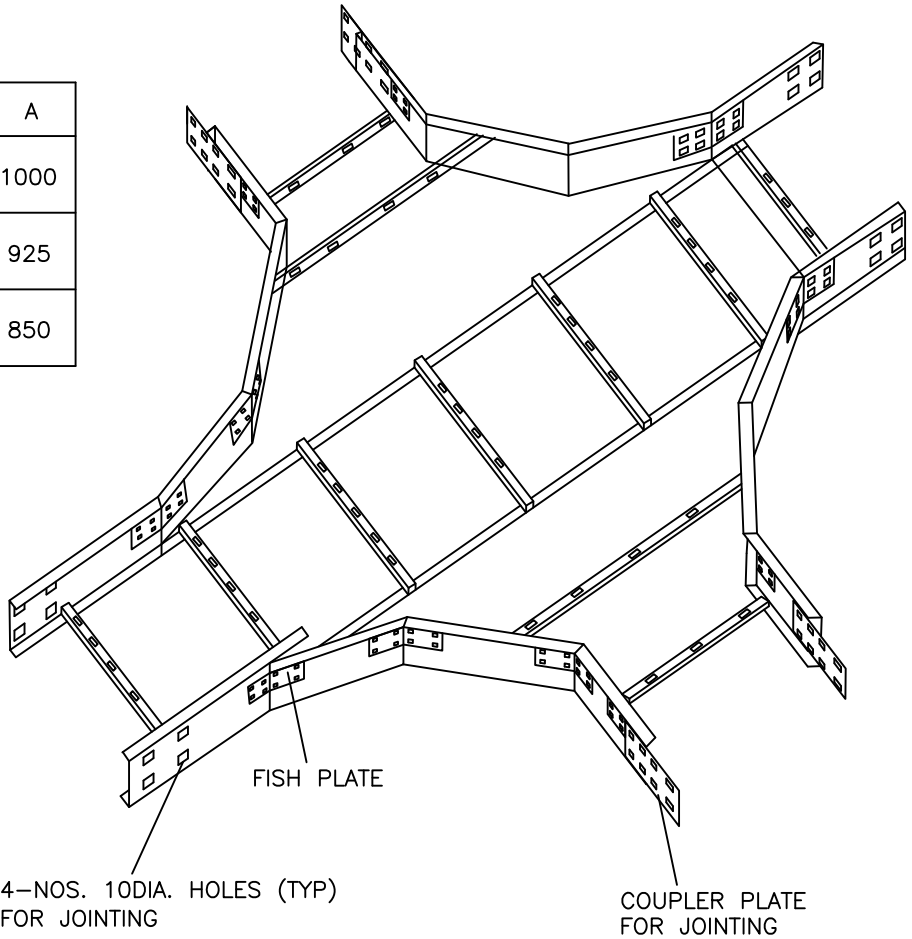
FOR GENERAL NOTES REFER SHEET 26 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE–DG–435–507–E005
	SHT. 18 OF 26 REV. 0



HORIZONTAL CROSS–PLAN

WIDTH(W)	RADIUS (R)	A
600	600	1000
450	600	925
300	600	850

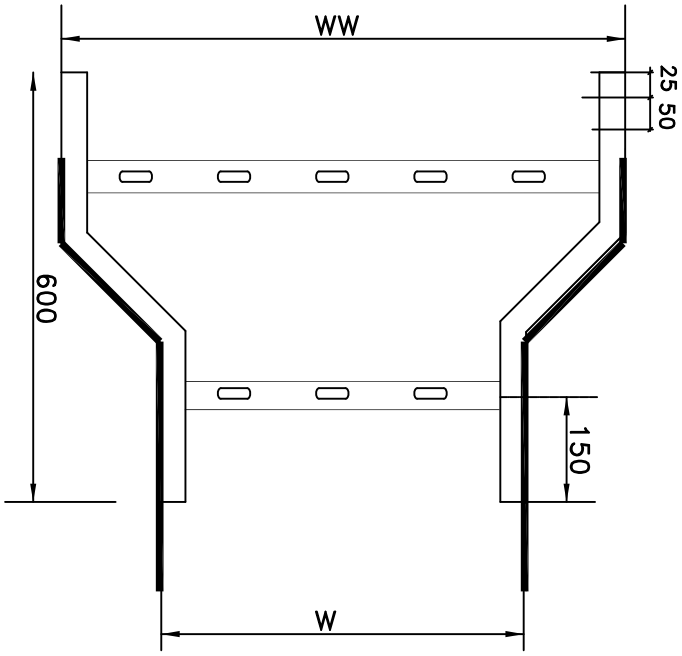


FOR GENERAL NOTES REFER SHEET 26 OF 26

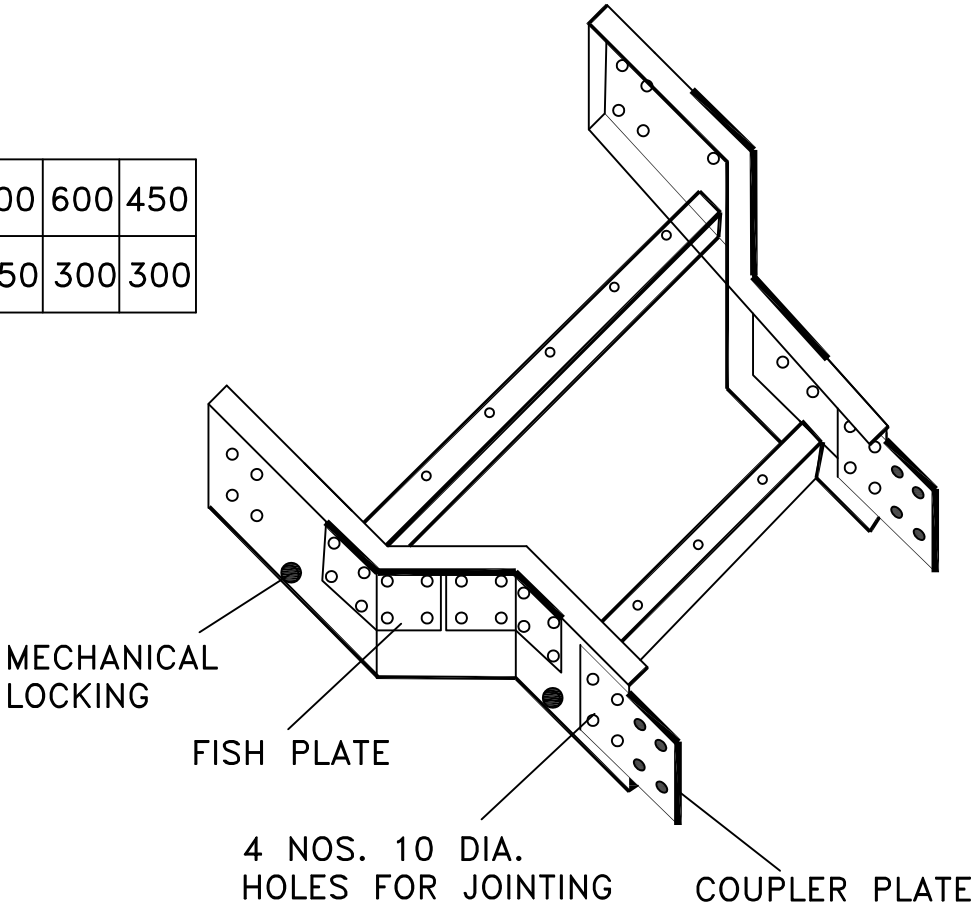
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)

DWG. NO.
PE–DG–435–507–E005

SHT. 19 OF 26 REV. 0



WIDTH	WW	600	600	450
	W	450	300	300

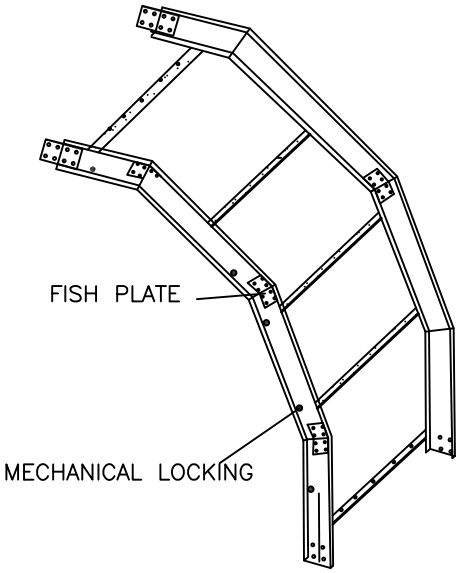


REDUCER–LADDER TYPE

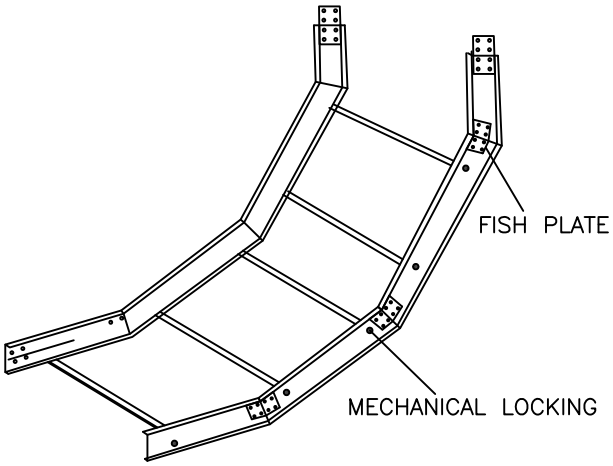
LADDER TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 26 OF 26

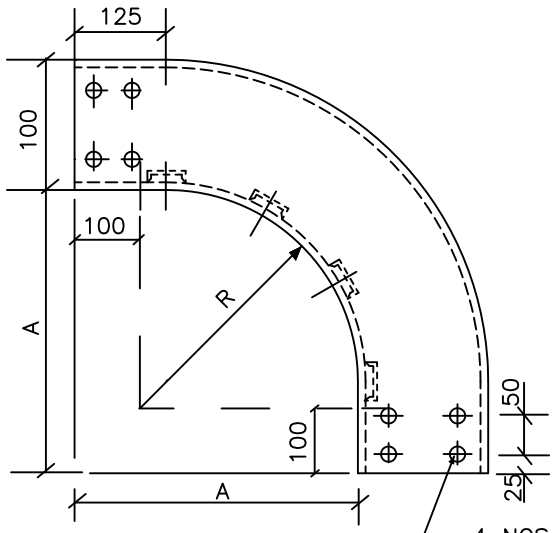
बी एच ई एल BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE–DG–435–507–E005
		SHT. 20 OF 26 REV. 0



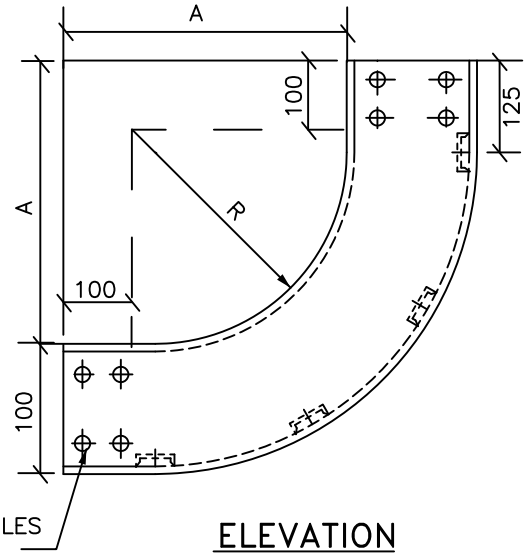
90° VERTICAL BEND
(OUTSIDE)



90° VERTICAL BEND
(INSIDE)



ELEVATION
90° VERTICAL BEND
(OUTSIDE)



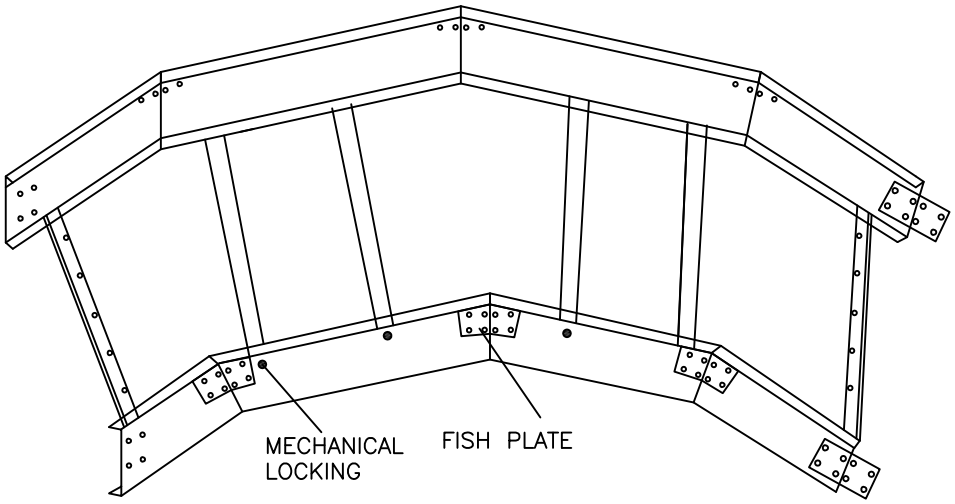
ELEVATION
90° VERTICAL BEND
(INSIDE)

WIDTH(W)	RADIUS (R)	A
600	600	700
450	600	700
300	600	700

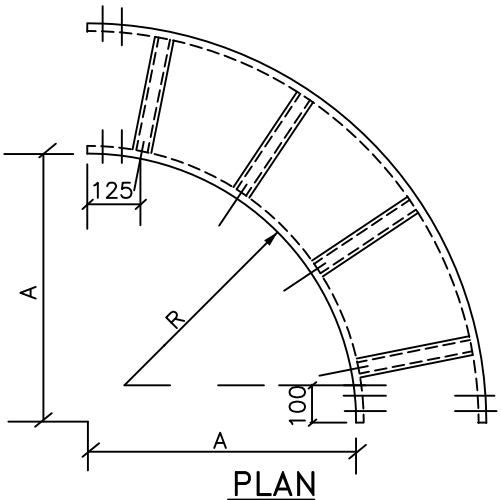
LADDER TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 26 OF 26

बीएचईएल BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE-DG-435-507-E005
		SHT. 21 OF 26 REV. 0



90° HORIZONTAL BEND



PLAN

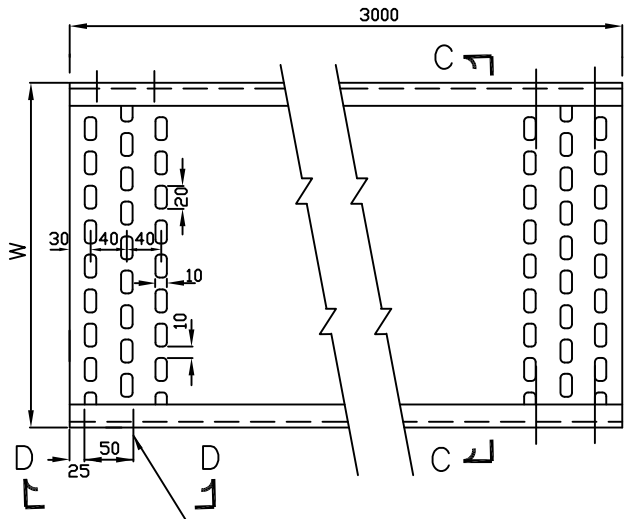
90°HORIZONTAL BEND

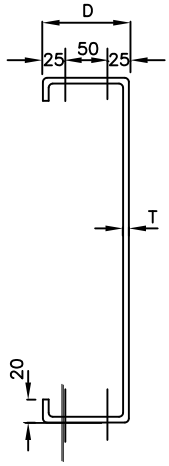
WIDTH(W)	RADIUS (R)	A
600	600	700
450	600	700
300	600	700

LADDER TYPE ACCESSORIES

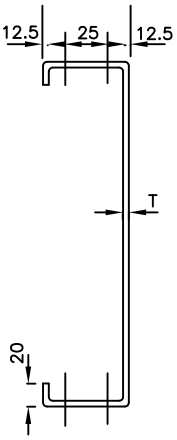
FOR GENERAL NOTES REFER SHEET 26 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE-DG-435-507-E005
	SHT. 22 OF 26 REV. 0

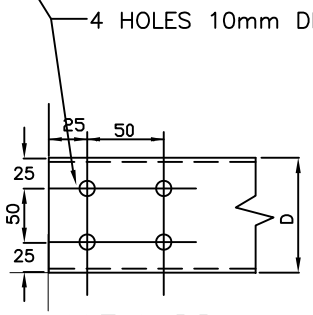




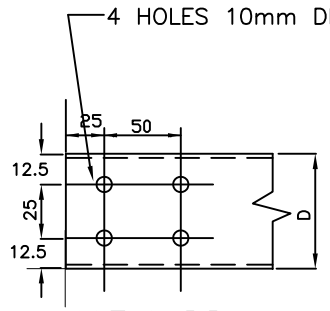
SECTION–CC
(600/450/300/
150 TRAYS)



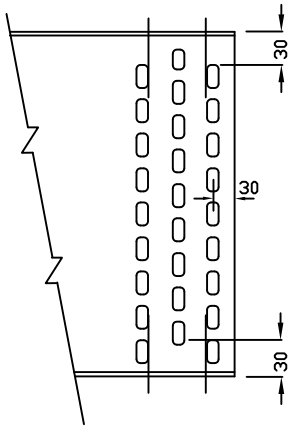
SECTION–CC
(100/50 TRAYS)



VIEW–DD
(600/450/300/
150W TRAYS)



VIEW–DD
(100W/50W
TRAYS)



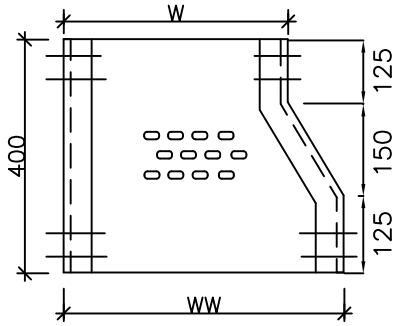
ARRANGEMENT OF
PERFORATIONS

TRAY WIDTH W (mm)	600	450	300	150	100	50
TRAY DEPTH D (mm)	100	100	100	100	50	50
T (mm)	4	4	4	4	4	4

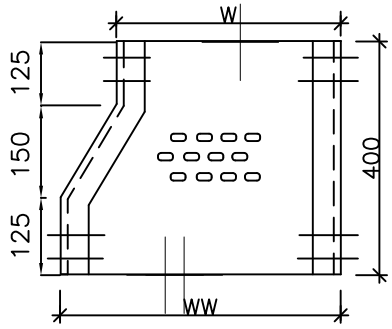
PERFORATED TYPE TRAY

FOR GENERAL NOTES REFER SHEET 26 OF 26

बी एच ई एल BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE–DG–435–507–E005
		SHT. 23 OF 26 REV. 0



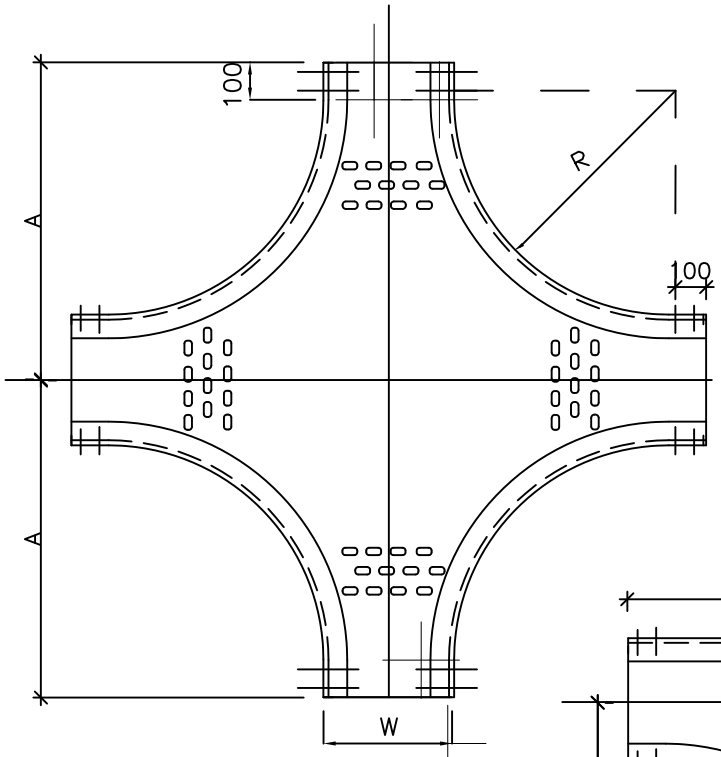
LEFT HAND REDUCER



RIGHT HAND REDUCER

WW	W	DEPTH	THICKNESS
600	450	100	4
600	300	100	4
450	300	100	4

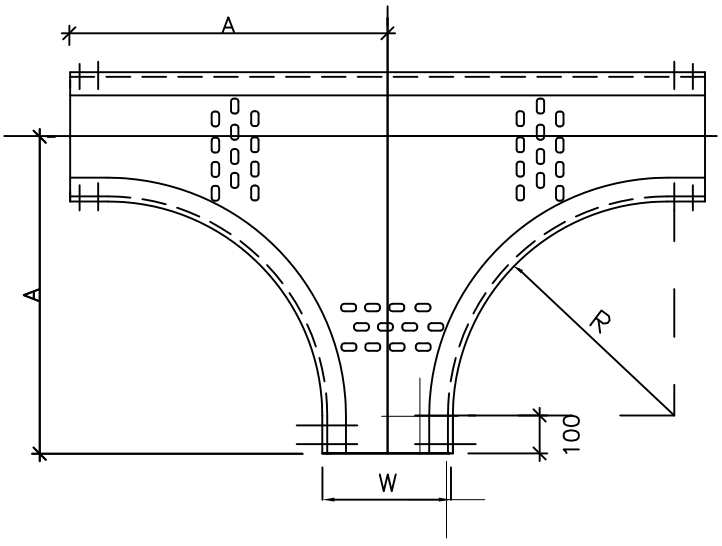
PERFORATED TYPE



CROSS

PERFORATED TYPE

WIDTH(W)	RADIUS (R)	A	THICKNESS
600	600	1000	4
450	600	925	4
300	600	850	4



TEE

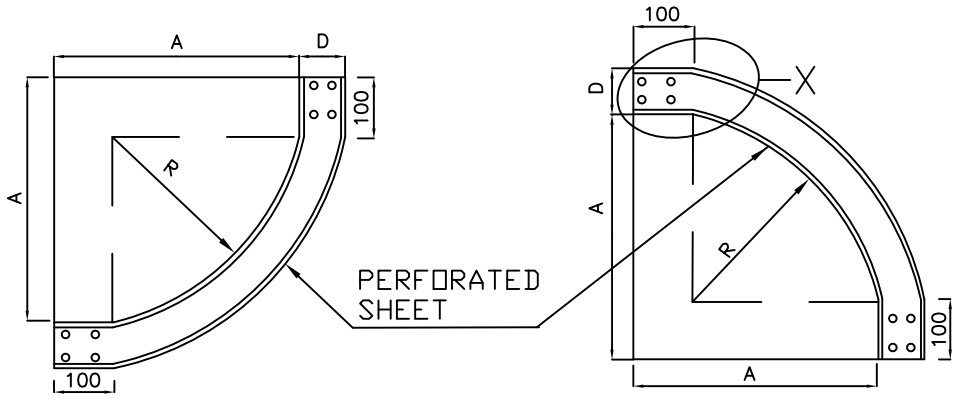
PERFORATED TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 26 OF 26

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)

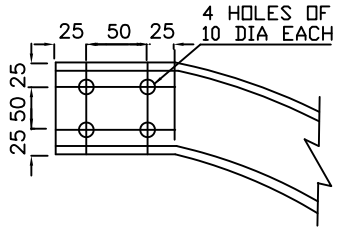
DWG. NO.
PE-DG-435-507-E005

SHT. 24 OF 26 REV. 0



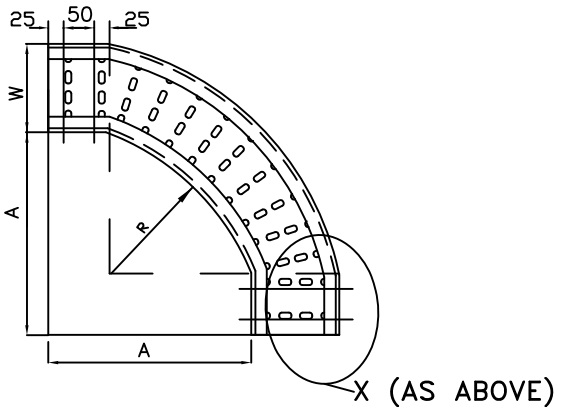
INSIDE TYPE

OUTSIDE TYPE



ENLARGED VIEW OF "X"

90° VERTICAL BEND - PERFORATED TYPE



WIDTH(W)	RADIUS (R)	A	T
600	600	700	4
450	600	700	4
300	600	700	4

90° HORIZONTAL BEND - PERFORATED TYPE

PERFORATED TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 26 OF 26

बीएचईएल BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE-DG-435-507-E005
		SHT. 25 OF 26 REV. 0

NOTES:–

1. THE FRP TYPE LADDER AND PERFORATED TYPE CABLE TRAYS AND ACCESSORIES (INCLUDING SIDE RUNNERS OF LADDER TYPE TRAYS & ACCESSORIES) SHALL BE MADE OF 4MM THICKNESS. COUPLER PLATE SHALL BE 4 MM THICK.
2. FOR LADDER TYPE CABLE TRAYS AND ACCESSORIES, ALL RUNGS SHALL BE SLOTTED.
3. STANDARD TRAY ACCESSORIES SHALL BE WITH THE RADIUS INDICATED IN THIS DRAWING.
4. ALL TRAY CORNERS SHALL BE SMOOTH AND FREE OF SHARP EDGES.
5. THE CABLE TRAY COVER (FRP) SHALL BE OF 3MM THICKNESS SHALL BE PROVIDED ON OUTDOOR TRAYS. IT SHALL BE PROVIDED ON TOP MOST CABLE TRAY.
6. THE WIDTH, LENGTH & HEIGHT OF TRAYS & TRAY COVERS SHALL BE WITHIN A TOLERANCE OF (+) 2 mm. THE THICKNESS TOLERANCE SHALL BE (+) 0.5 mm. NO NEGATIVE TOLERANCE IN THICKNESS, WIDTH, HEIGHT OR LENGTH IS PERMITTED.
7. TO FACILITATE ASSEMBLY, ALL ACCESSORIES AT ENDS SHALL HAVE 100mm STRAIGHT PORTION.
8. ALL NUTS, BOLTS, WASHERS ETC., SHALL BE OF STAINLESS STEEL (SS 304).
9. FINISHED TRAYS & COVERS SHALL BE FREE FROM BURRS AND SHARP EDGES.
10. ALL DIMENSIONS ARE IN mm UNLESS NOTED OTHERWISE.
11. WIDTH OF CABLE TRAYS PROPOSED TO BE USED FOR THE PROJECT ARE AS UNDER:

    A)LADDER TYPE: 600W, 450W, 300W, 150W.

    B)PERFORATED TYPE: 600W, 450W, 300W, 150W, 100W, 50W
12. THE DEPTH OF 600W, 450W, 300W, 150W TRAYS & ACCESSORIES SHALL BE 100MM WHILE DEPTH OF 100W & 50W CABLE TRAY SHALL BE 50MM.
13. FOLLOWING SHALL BE LOADING ON CABLE TRAYS AT 1500MM SUPPORT SPAN:–

    FOR LADDER TYPE CABLE TRAYS:–
    600W CABLE TRAY – 90KG/M
    450W CABLE TRAY – 75KG/M
    300W CABLE TRAY – 60KG/M
    150W CABLE TRAY – 30KG/M

    FOR PERFORATED TYPE CABLE TRAYS:–
    600W CABLE TRAY – 90KG/M
    450W CABLE TRAY – 75KG/M
    300W CABLE TRAY – 60KG/M
    150W CABLE TRAY – 30KG/M
    100W CABLE TRAY – 15KG/M
    50W CABLE TRAY – 7.5KG/M

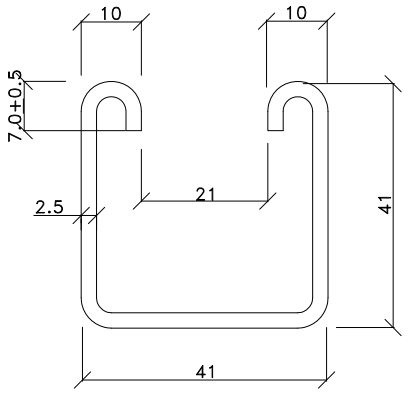
    IN ADDITION TO THIS 80KG POINT LOAD AT MID SPAN SHALL ALSO BE CONSIDERED.

बीएचईएल BHEL	TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES (FRP TYPE)	DWG. NO. PE–DG–435–507–E005
		SHT. 26 OF 26 REV. 0

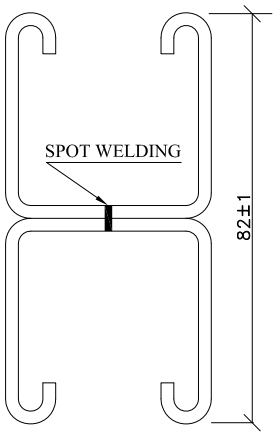
INSTALLATION DETAILS FOR CABLE TRAY SUPPORT SYSTEM

(BOLTABLE TYPE)

CUSTOMER	TAMIL NADU GENERATION & DISTRIBUTION CORPORATION LIMITED					
PROJECT	2 X 660 MW UDANGUDI STPP STAGE-I					
JOB NO. 435	BHARAT HEAVY ELECTRICALS LIMITED POWER SECTOR PROJECT ENGINEERING MANAGEMENT NOIDA(U.P) INDIA	DPT CODE-E		NAME	SIGN	DATE
			DRN	SKS		
			DSN	SKS		
			CHD	VY		
			APP	SL		
		DWG. NO. PE-DG-435-507-E006				
		SHT. 01 OF 20 REV. 0				



SINGLE CHANNEL SC1



DOUBLE CHANNEL DC1

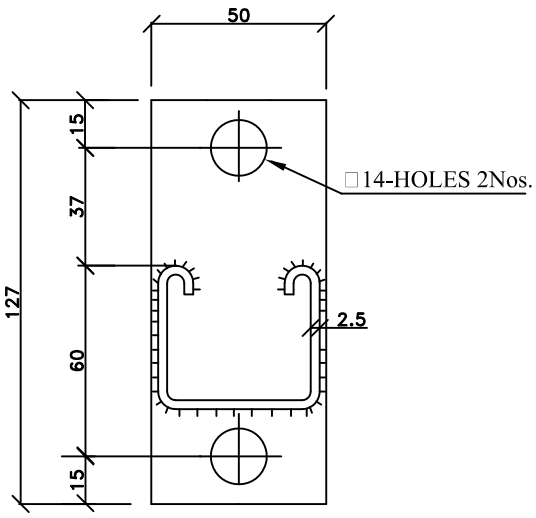
TWO LENGTHS OF SINGLE CHANNEL
SPOT WELDED BACK TO BACK
AT 75MM C/C

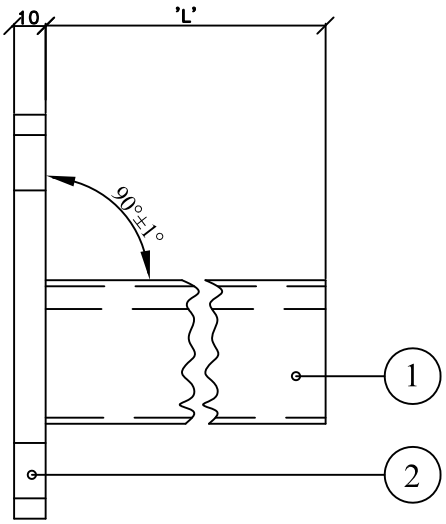
NOTE:

1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : HOT ROLLED M.S. AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

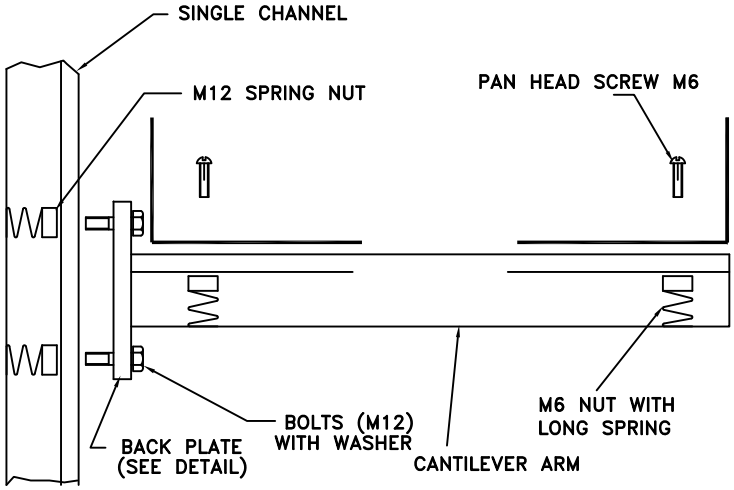
BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	DRG. NO. PE-DG-435-507-E006
		SH 2 OF 20





CANTILEVER ARMS

TRAY WIDTH IN MM	CANTILEVER ARM LENGTH (L) IN MM
150	200
300	350
450	500
600	650



TYPICAL ASSEMBLY OF CHANNEL SUPPORTS AND CABLE TRAY

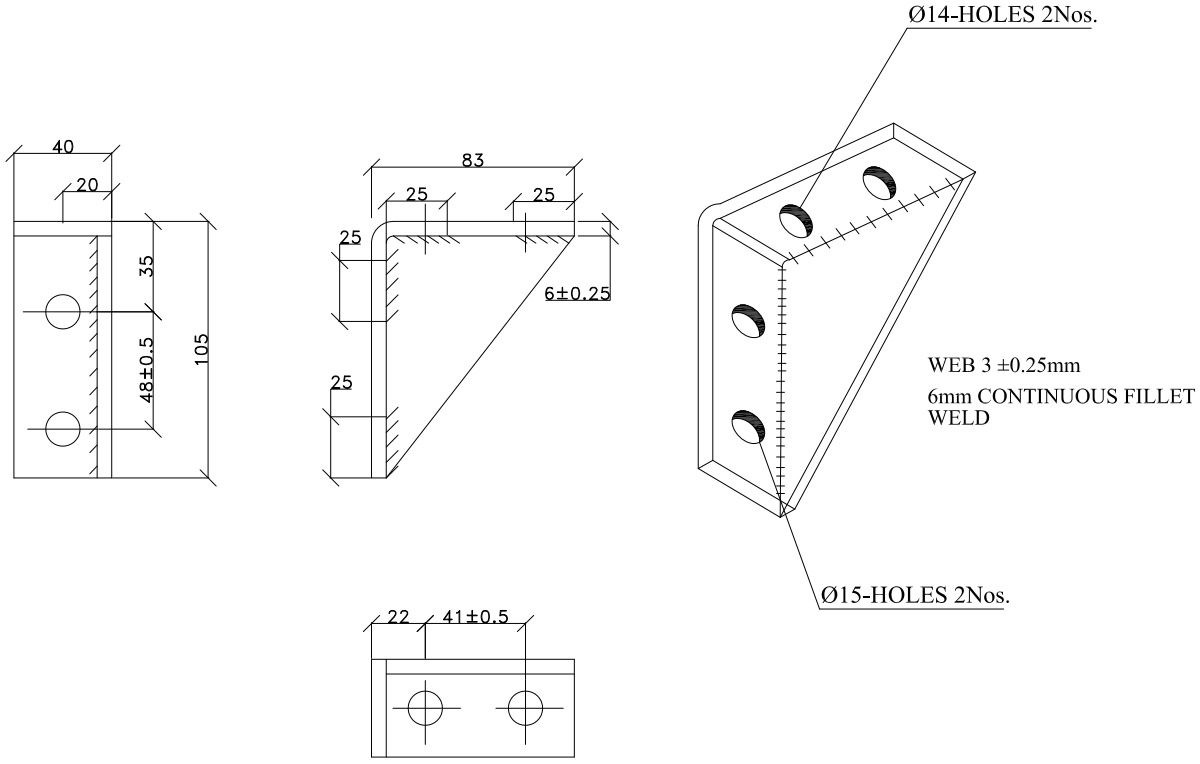
M12 HEX BOLT & WASHER–2NOs.
M12 SPRING NUTS–2NOs.
M6 PAN HEAD SCREWS & WASHER–2NOs.
M6 SPRING NUTS–2NOs.

NOTE:

1. ALL DIMENSIONS ARE IN mm.
2. ITEM NO.1 MATERIAL : HOT ROLLED M.S. AS PER IS-2062.
3. ITEM NO.2 MATERIAL : MILD STEEL AS PER IS-2062.
4. FINISH : HOT DIP GALVANISED AS PER IS 2629
5. TOLERANCE ON THICKNESS IS AS PER IS 1852
6. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
7. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	DRG. NO. PE–DG–435–507–E006
		SH 3 OF 20



90^0 ANGLE FITTING HL1

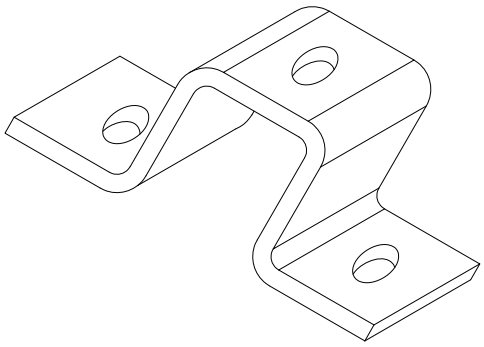
ANCHOR FASTENER–2NOs.
SPRING NUT & WASHER–2NOs.

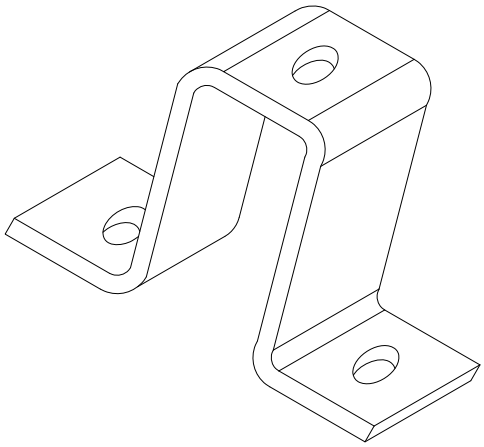
NOTE:

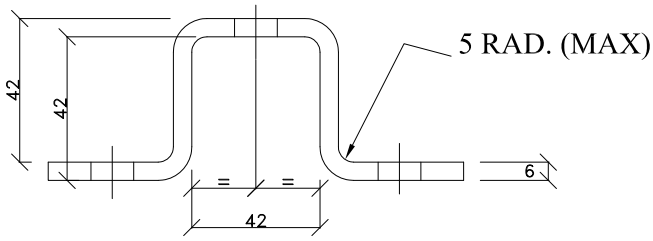
1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

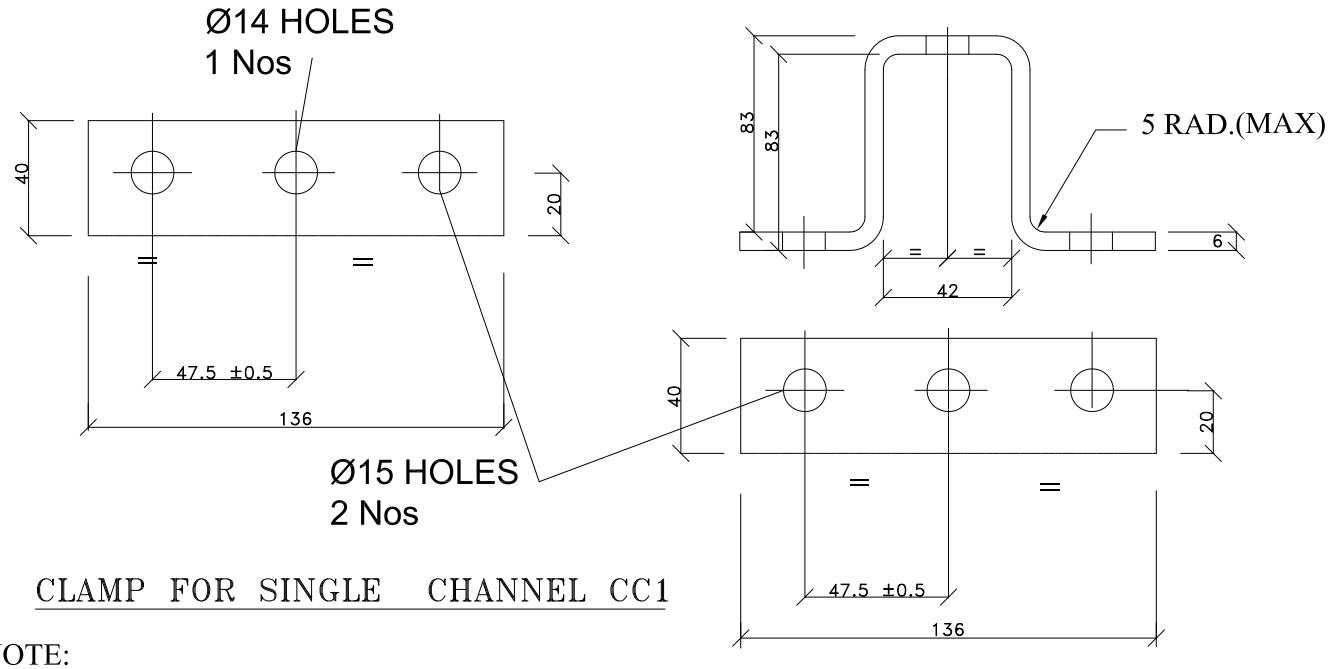
TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	DRG. NO. PE–DG–435–507–E006
		SH 4 OF 20









CLAMP FOR SINGLE CHANNEL CC1

CLAMP FOR DOUBLE CHANNEL CC2

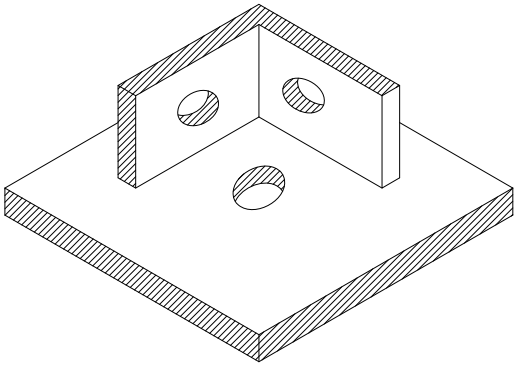
NOTE:

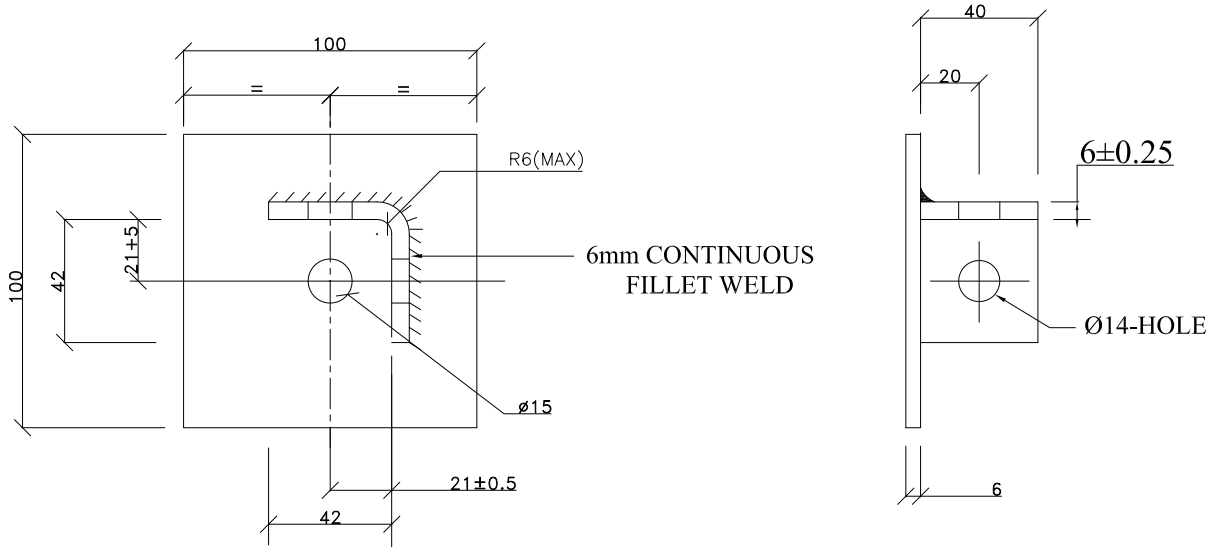
1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

ANCHOR FASTENER–2NOs.
SPRING NUT & WASHER–1NO.

TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	DRG. NO. PE–DG–435–507–E006
		SH 5 OF 20





BASE PLATE FOR SINGLE CHANNEL BP1

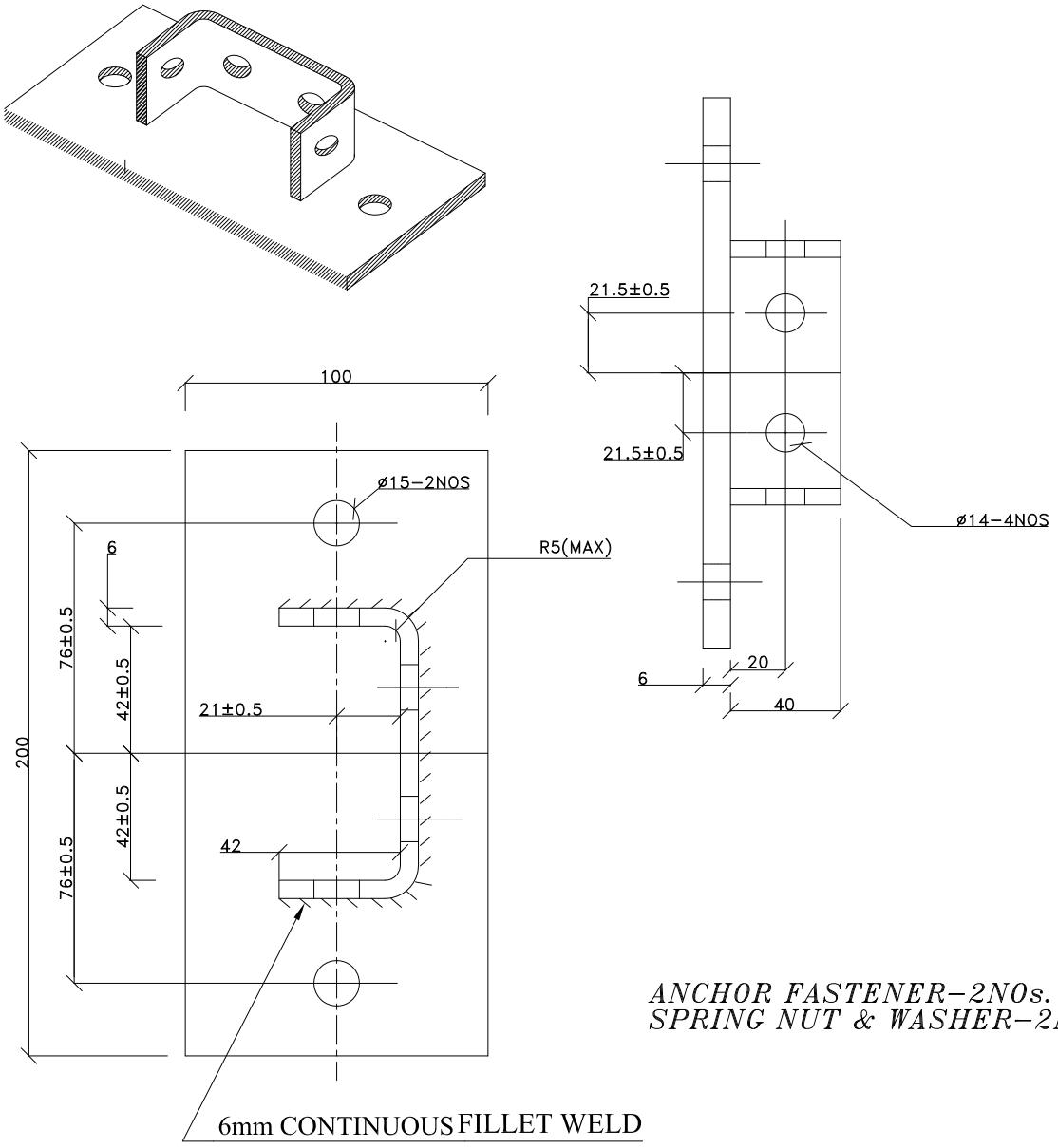
NOTE:

ANCHOR FASTENER–1NO.
SPRING NUT & WASHER–1NO.

1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	DRG. NO. PE–DG–435–507–E006
		SH 6 OF 20



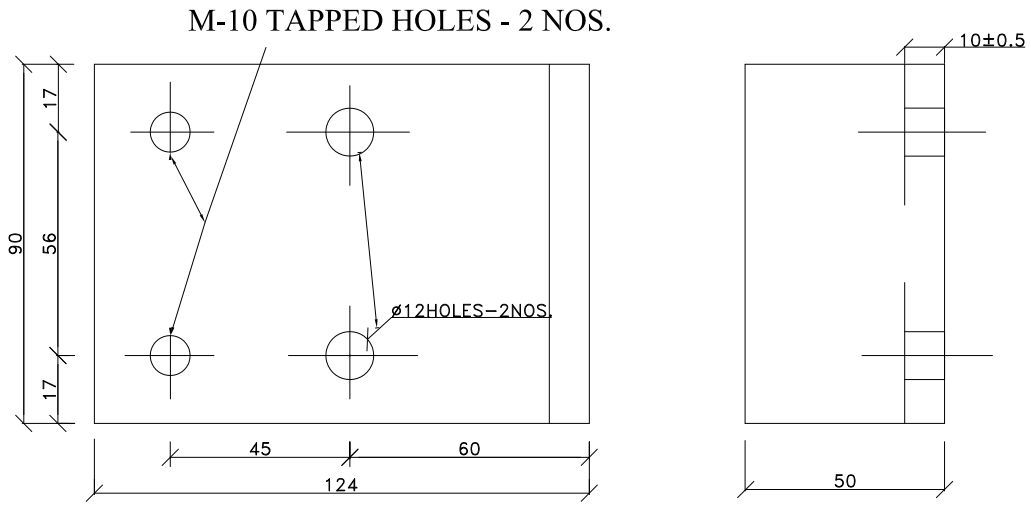
BASE PLATE FOR DOUBLE CHANNEL BP2

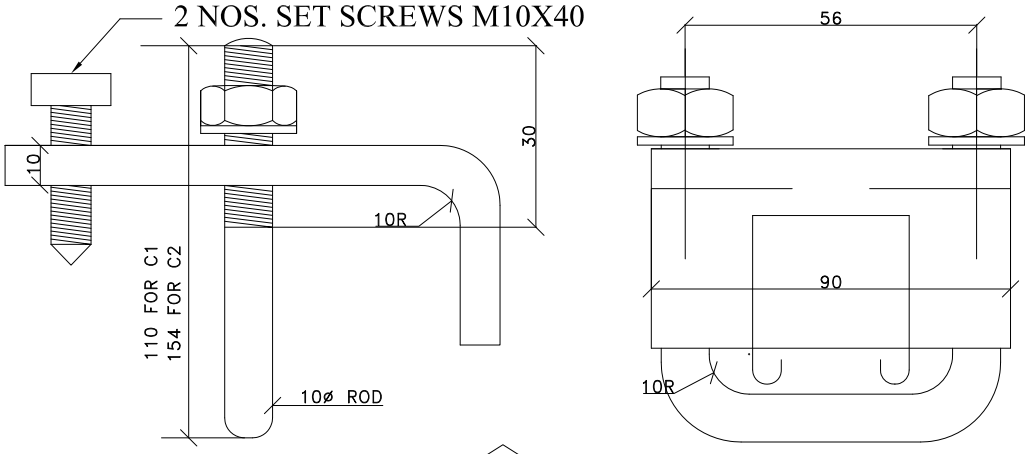
NOTE:

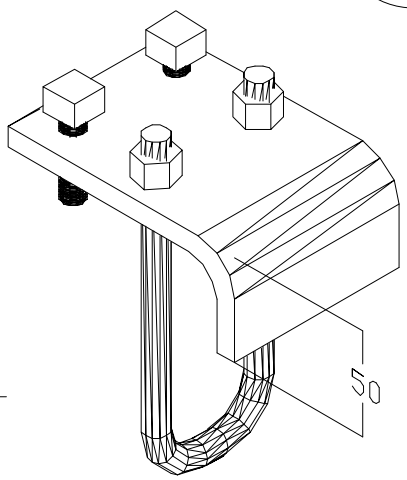
1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	DRG. NO. PE–DG–435–507–E006
		SH 7 OF 20







BEAM CLAMP - BC1

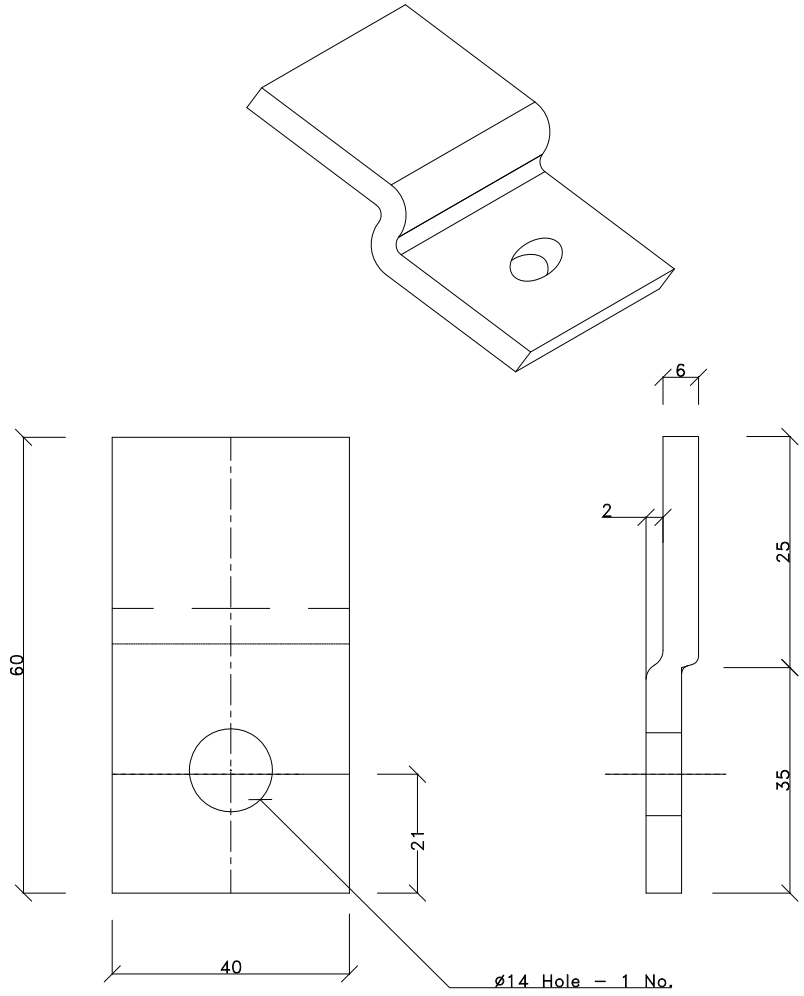
M-10 U-BOLT WITH
2Nos PLAIN WASHERS & NUTS
110 mm FOR SC 1
154 mm FOR DC1
2 NOs. SET SCREWS M10X40

NOTE:

1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE-DG-435-507-E006
		SH 8 OF 20



TRAY FIXING CLAMP - TC1

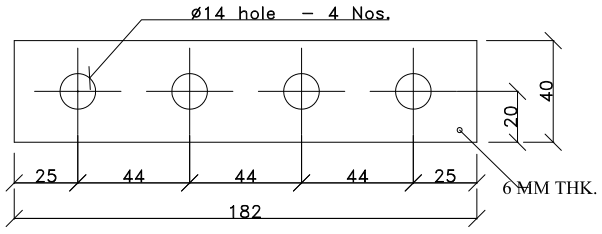
NOTE:

SPRING NUT & WASHER–1NO.

1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

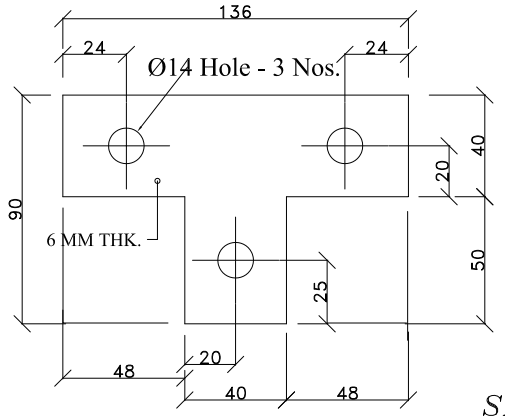
TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE–DG–435–507–E006
		SH 9 OF 20



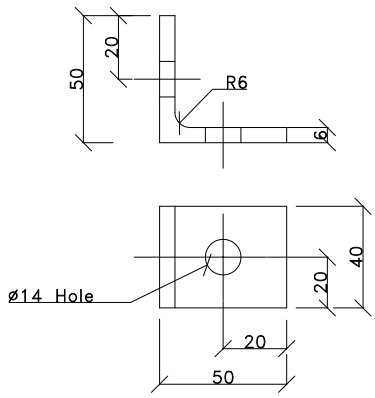
SPRING NUT & WASHER–4NOs.

FLAT PLATE STRAIGHT FITTING PF2



SPRING NUT & WASHER–3NOs.

FLAT PLATE TEE FITTING PF1



SPRING NUT & WASHER–2NOs.

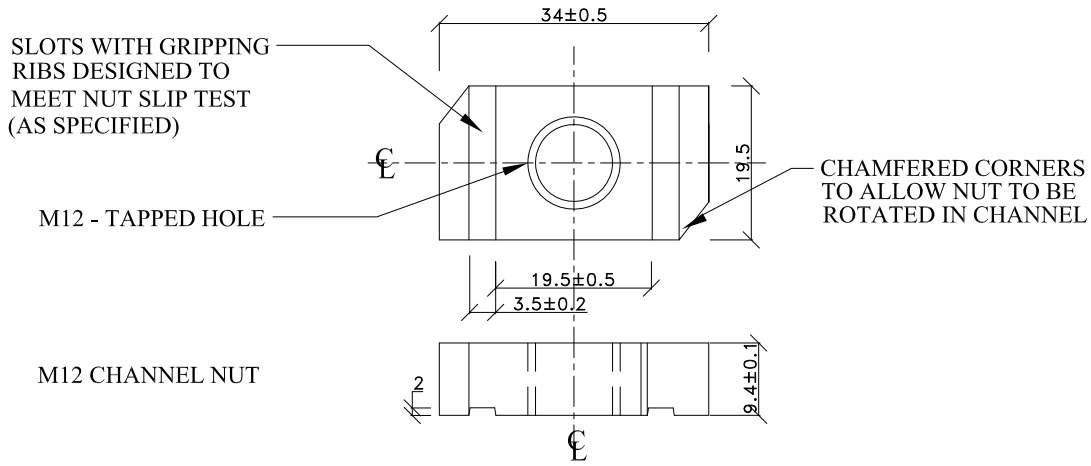
NOTE:

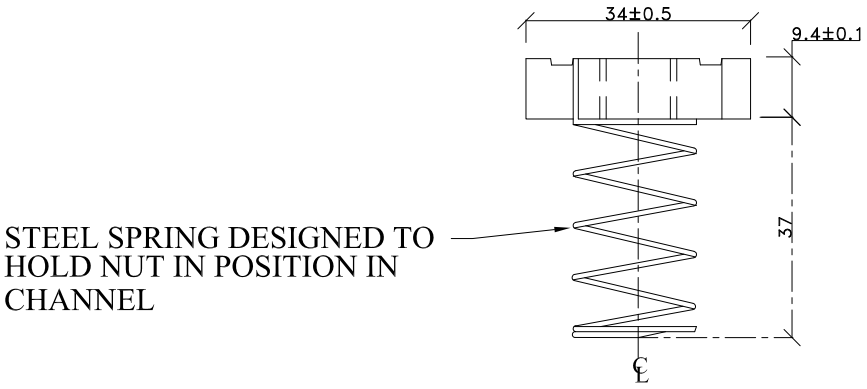
90^0 ANGLE FITTING LA1

1. ALL DIMENSIONS ARE IN mm.
2. MATERIAL : MILD STEEL AS PER IS-2062.
3. FINISH : HOT DIP GALVANISED AS PER IS 2629
4. TOLERANCE ON THICKNESS IS AS PER IS 1852
5. ALL FABRICATION TOLERANCE AS PER RELEVANT IS.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

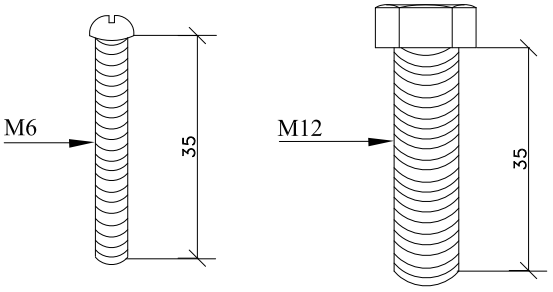
TYPICAL DETAILS OF BOLTABLE TYPE CABLE TRAY SUPPORT MATERIAL & ACCESSORIES

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE–DG–435–507–E006
		SH 10 OF 20



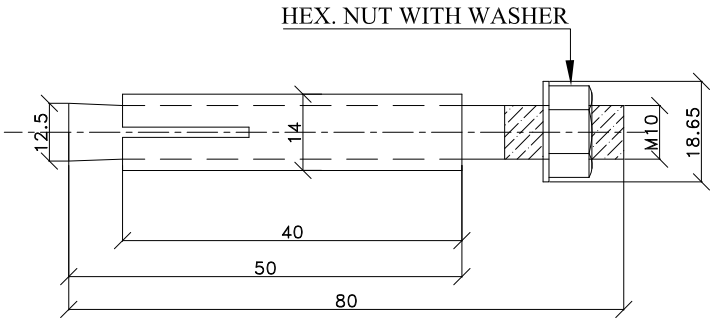


SPRING NUT ASSEMBLY



PAN HEAD SCREW

HEX BOLT

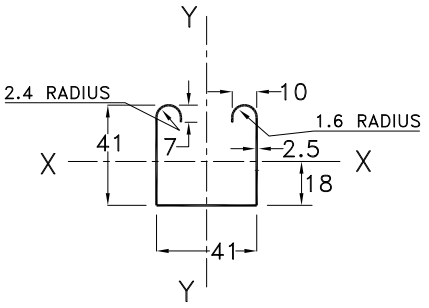


ANCHOR BOLT M10

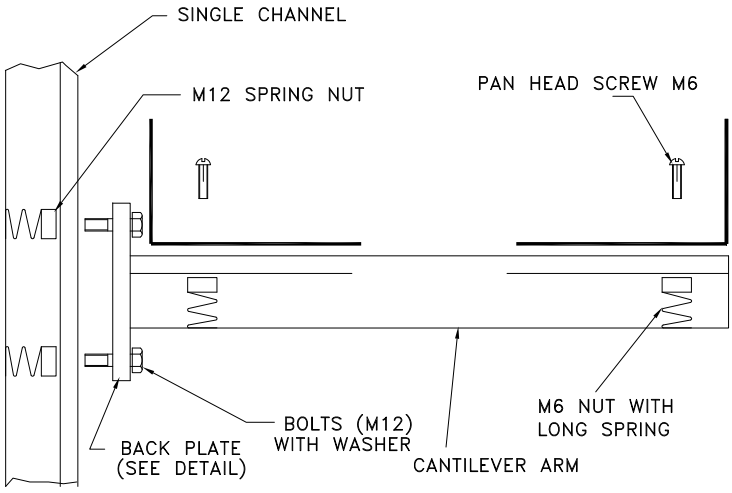
NOTES:

1. MATERIAL - MS AS PER IS - 2062.
2. M6 CHANNEL NUT DIMENSIONAL SIMILAR TO M12.
   EXCEPT HOLE DRILLED AND TAPPED TO M6 PAN HEAD SCREWS.
3. TAPPED HOLE THREADING TO MATCH WITH THREADING OF BOLTS.
4. SURFACE PROTECTION ELECTROGALVANISED / CADMIUM PLATED.
5. ALL DIMENSIONS ARE IN MM.
6. ZINC COATING SHALL BE MIN. 75 MICRON/ 610 G/SQ.M.

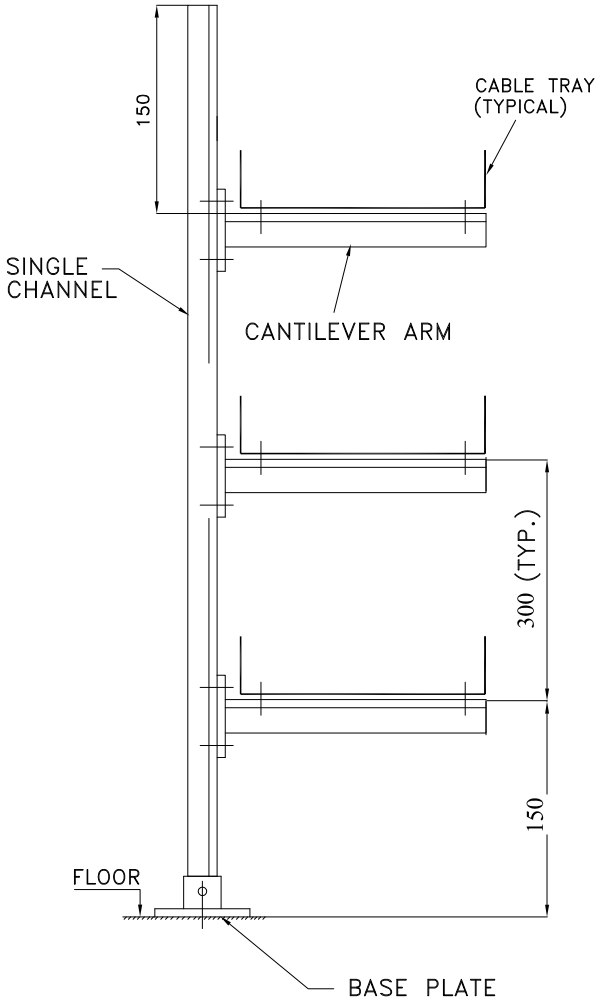
BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE-DG-435-507-E006
		SH 11 OF 20

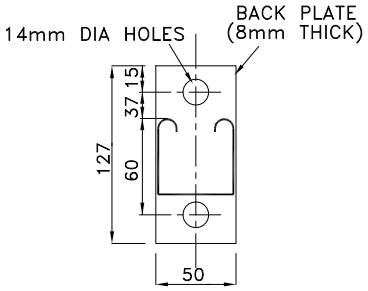


DETAIL OF ITEM–1
(SINGLE CHANNEL)

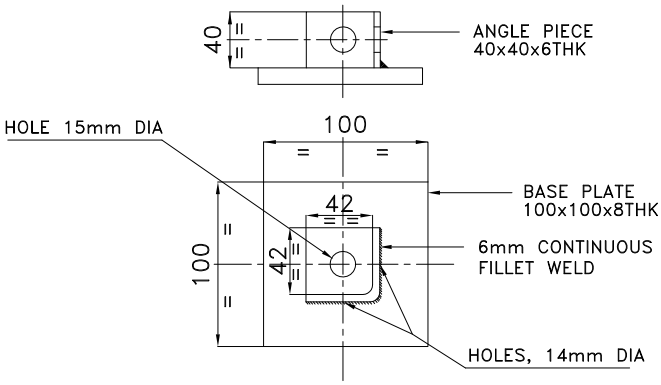


TYPICAL ASSEMBLY OF CHANNEL
SUPPORTS AND CABLE TRAY





END VIEW OF
(CANTILEVER ARM)



DETAILS OF BASE PLATE
FOR SINGLE CHANNEL

FLOOR SUPPORTED (SINGLE SIDE TYPE)

SEE GENERAL NOTES IN SHEET 17.

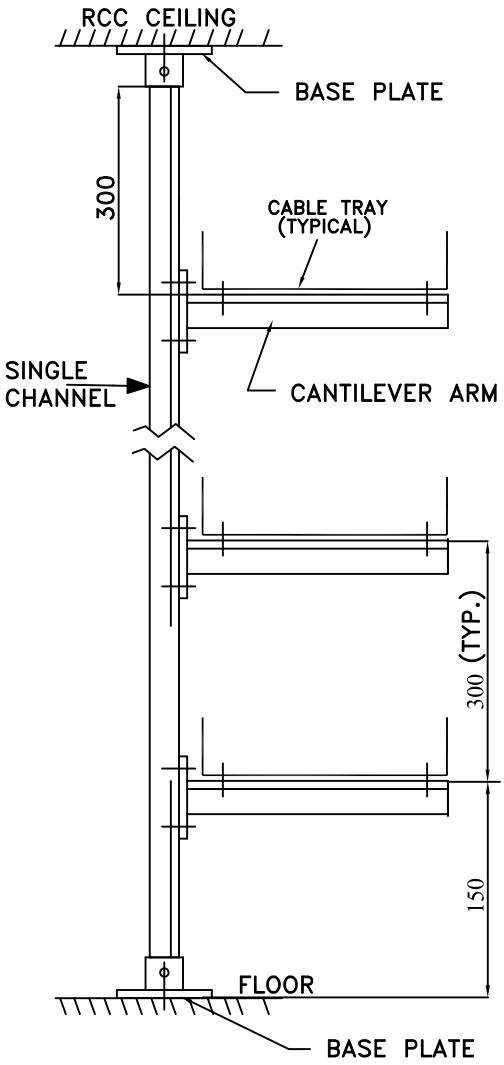
TITLE:

INSTALLATION DETAILS FOR
CABLE TRAYS SUPPORT SYSTEM

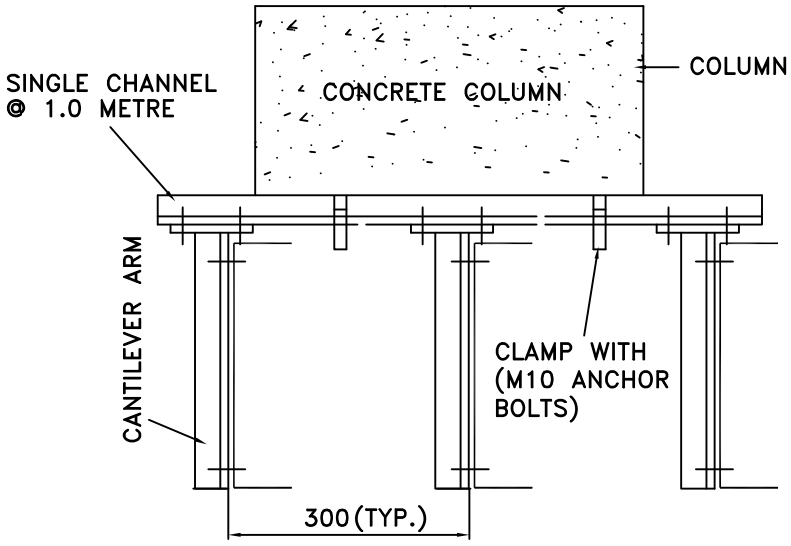
BHEL DRAWING NO.

PE–DG–435–507–E006

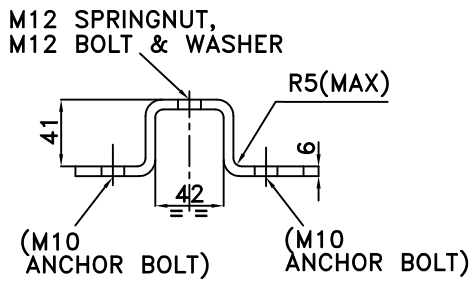
SH 12 OF 20



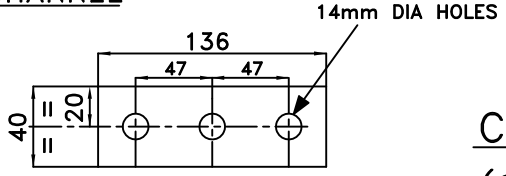
SUPPORTING ARRANGEMENT
BETWEEN FLOOR AND CEILING
(SINGLE SIDE TYPE)

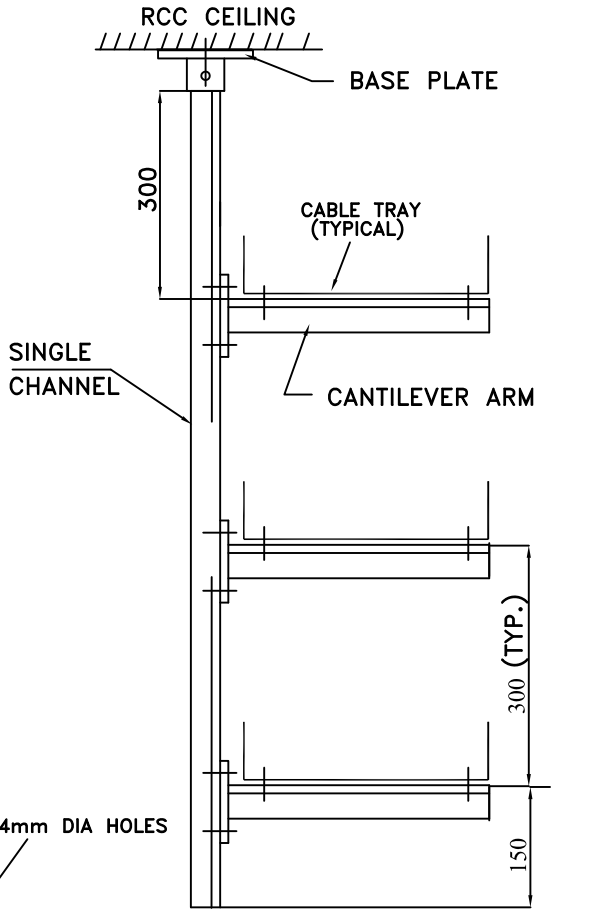


SUPPORT ARRANGEMENT
FROM BUILDING COLUMN



CLAMP FOR SINGLE CHANNEL

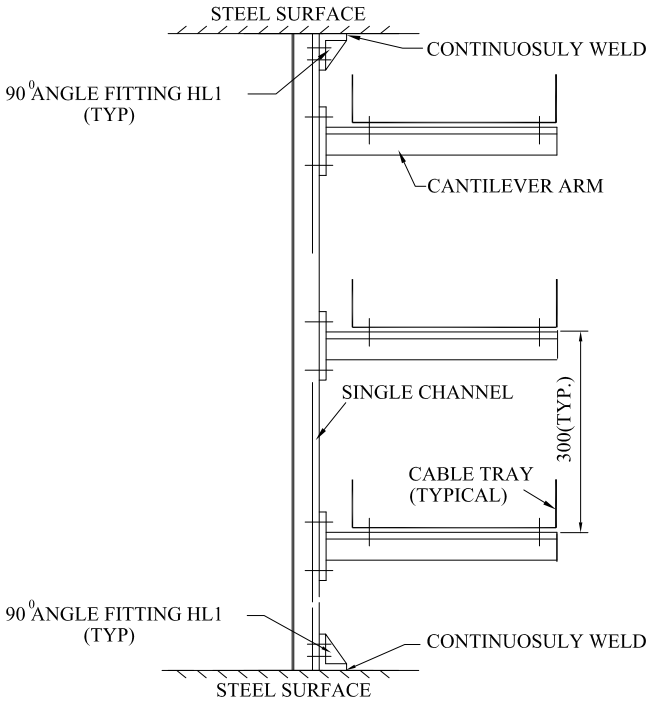


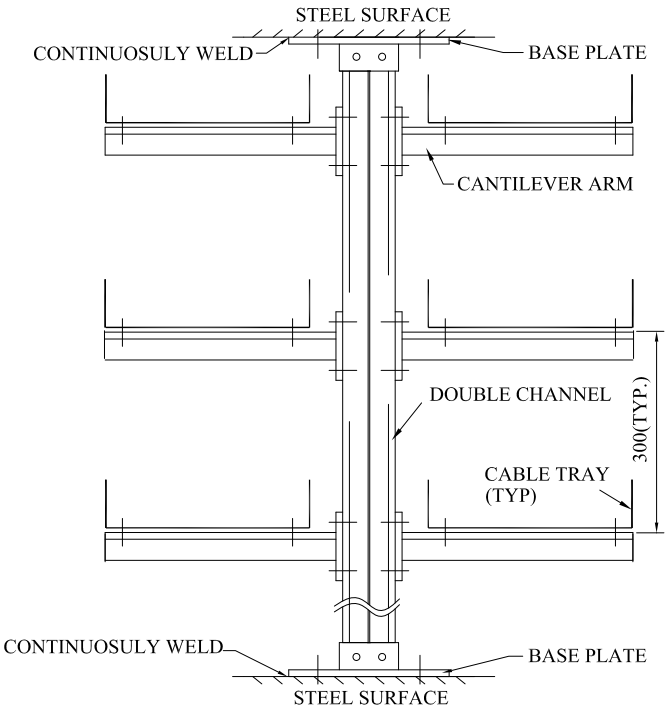


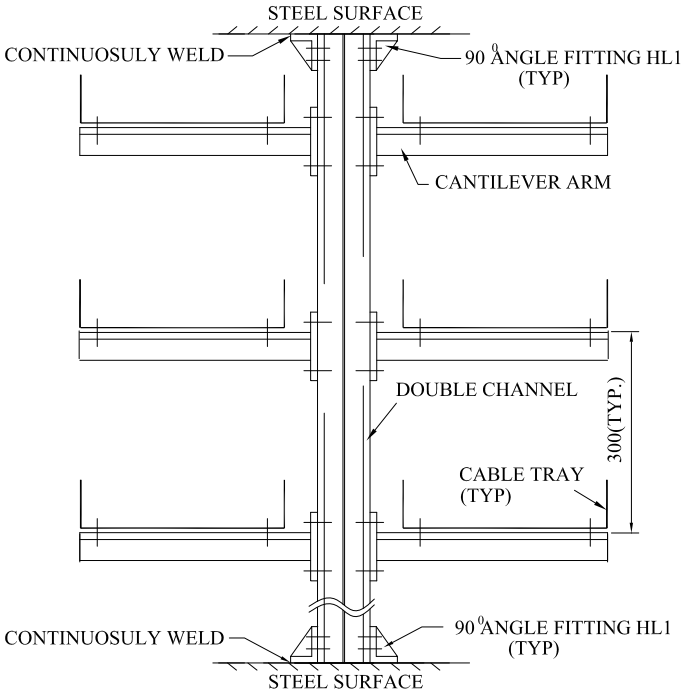
CEILING SUPPORTED
(SINGLE SIDE TYPE)

SEE GENERAL NOTES IN SHEET 17.

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE-DG-435-507-E006
		SH 13 OF 20



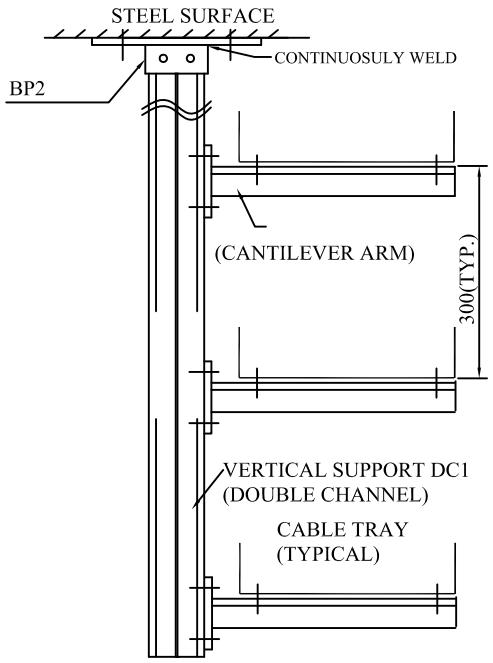




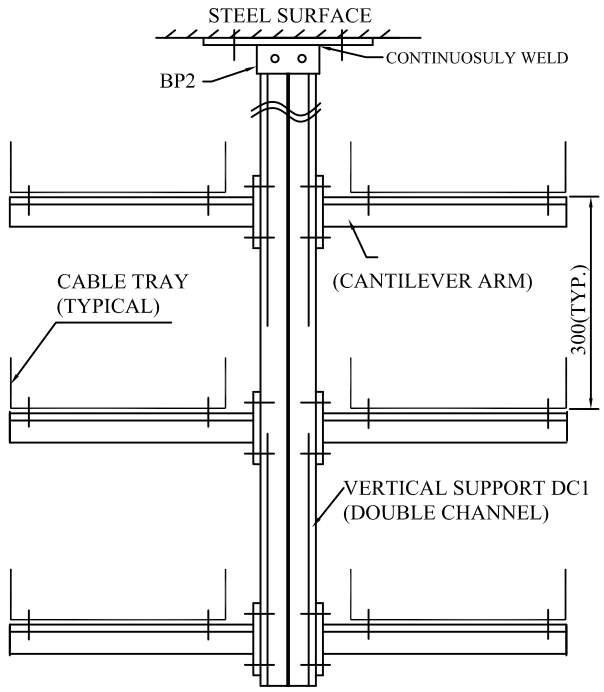
SUPPORTING ARRANGEMENT OF (SINGLE SIDE/DOUBLE SIDE) BETWEEN TWO STEEL SURFACE

SEE GENERAL NOTES IN SHEET 17.

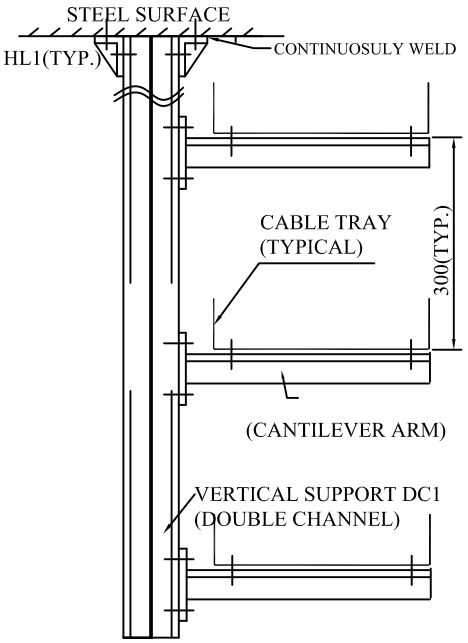
	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE-DG-435-507-E006
		SH 14 OF 20



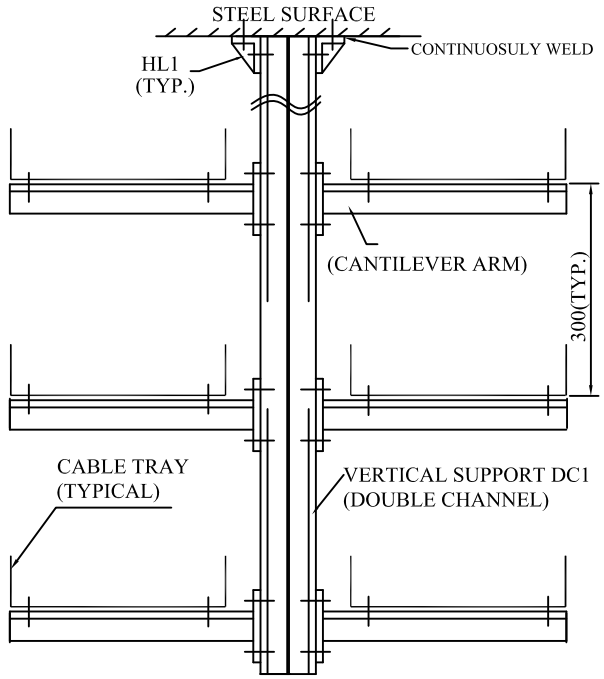
INSTALLATION DETAIL TYPE DS1:
DOUBLE CHANNEL SUPPORT INSTALLATION
ONLY TOP END FIXED
BASEPLATE AT TOP
APPLICABLE FOR THREE TRAYS ON SINGLE SIDE



INSTALLATION DETAIL TYPE DS2:
DOUBLE CHANNEL SUPPORT INSTALLATION
ONLY TOP END FIXED
BASEPLATE AT TOP
APPLICABLE FOR UPTO THREE TRAYS ON BOTH SIDES



INSTALLATION DETAIL TYPE DS3:
DOUBLE CHANNEL SUPPORT INSTALLATION
ONLY TOP END FIXED
WITH ANGLE FITTING HL1 AT TOP
APPLICABLE FOR MORE THAN TWO TRAYS
ON SINGLE SIDE



INSTALLATION DETAIL TYPE DS4:
DOUBLE CHANNEL SUPPORT INSTALLATION
ONLY TOP END FIXED
WITH ANGLE FITTING HL1 AT TOP
APPLICABLE FOR UPTO THREE TRAYS ON BOTH SIDES

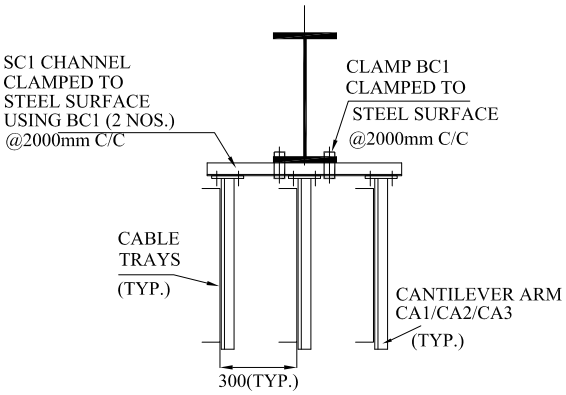
SEE GENERAL NOTES IN SHEET 17.

TITLE:

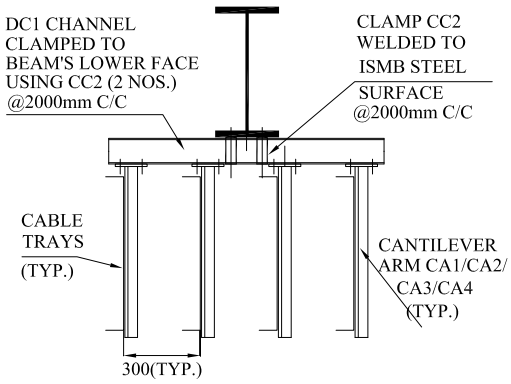
INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM

BHEL DRAWING NO.

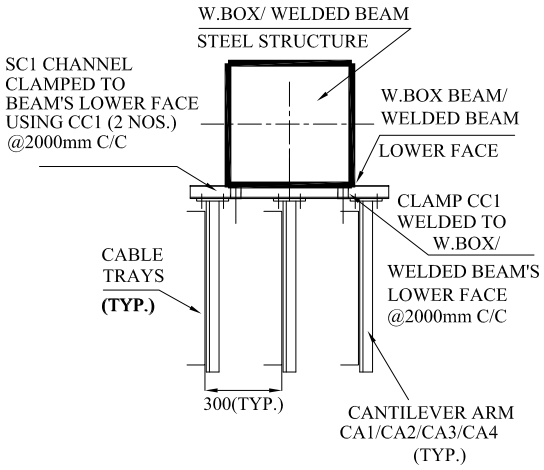
PE-DG-435-507-E006



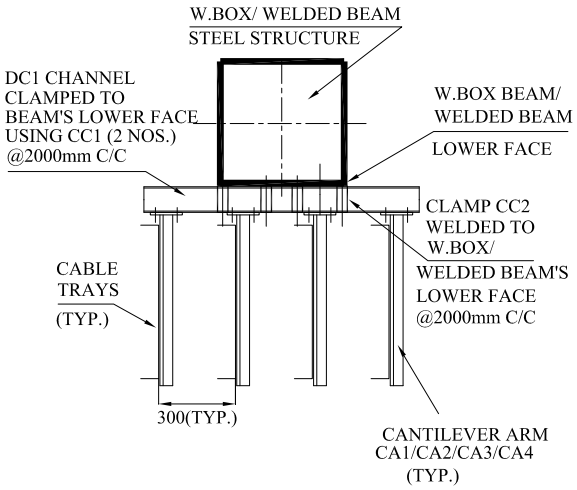
INSTALLATION DETAIL TYPE BB1:
CABLE TRAYS BELOW I-BEAMS
(UPTO & INCLUDING THREE TRAYS)



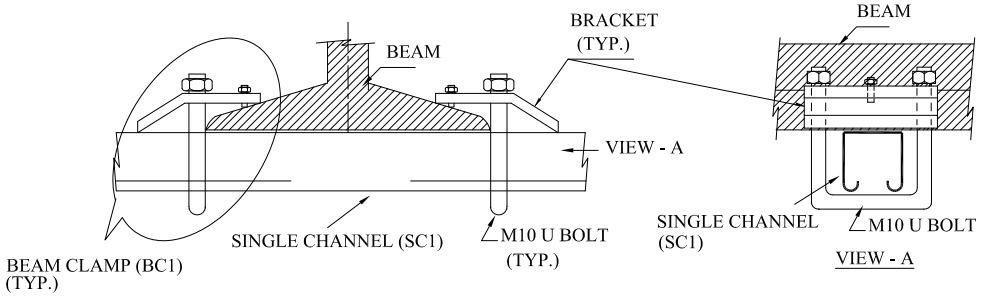
INSTALLATION DETAIL TYPE BB2:
CABLE TRAYS BELOW I-BEAMS
(MORE THAN THREE TRAYS)



INSTALLATION DETAIL TYPE BB3:
CABLE TRAYS BELOW W. BOX/
WELDED BEAM'S (APPLICABLE FOR
UPTO & INCLUDING THREE TRAYS)



INSTALLATION DETAIL TYPE BB4:
CABLE TRAYS BELOW W. BOX/
WELDED BEAM'S (APPLICABLE FOR
MORE THAN THREE TRAYS)



SINGLE CHANNEL FIXING ARRANGEMENT WITH BEAM

CABLE TRAYS SUPPORTING ARRANGEMENT AROUND BOILER PLATFORMS

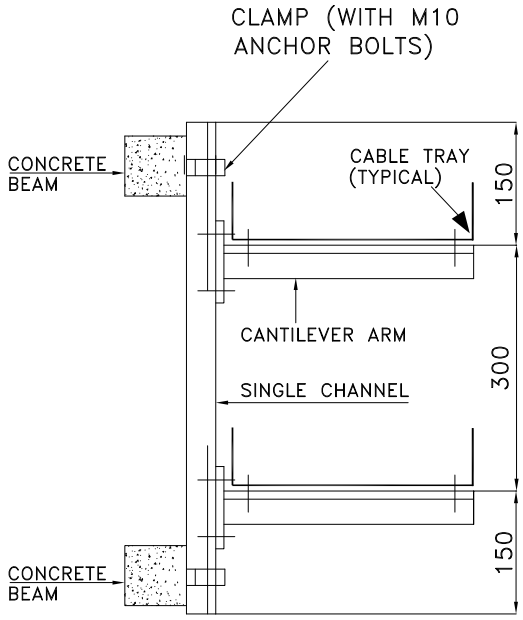
SEE GENERAL NOTES IN SHEET 17.

TITLE:

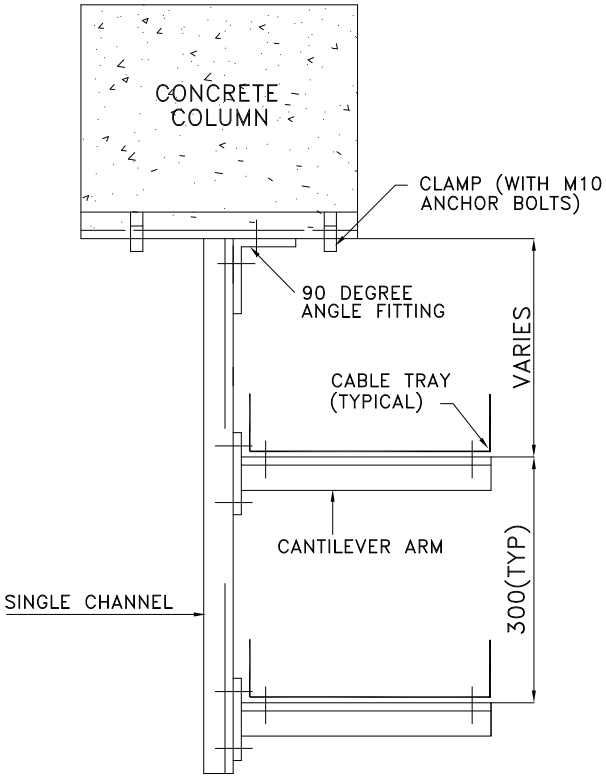
INSTALLATION DETAILS FOR
CABLE TRAYS SUPPORT SYSTEM

BHEL DRAWING NO.

PE-DG-435-507-E006



SUPPORT ARRANGEMENT
FROM CONCRETE BEAMS

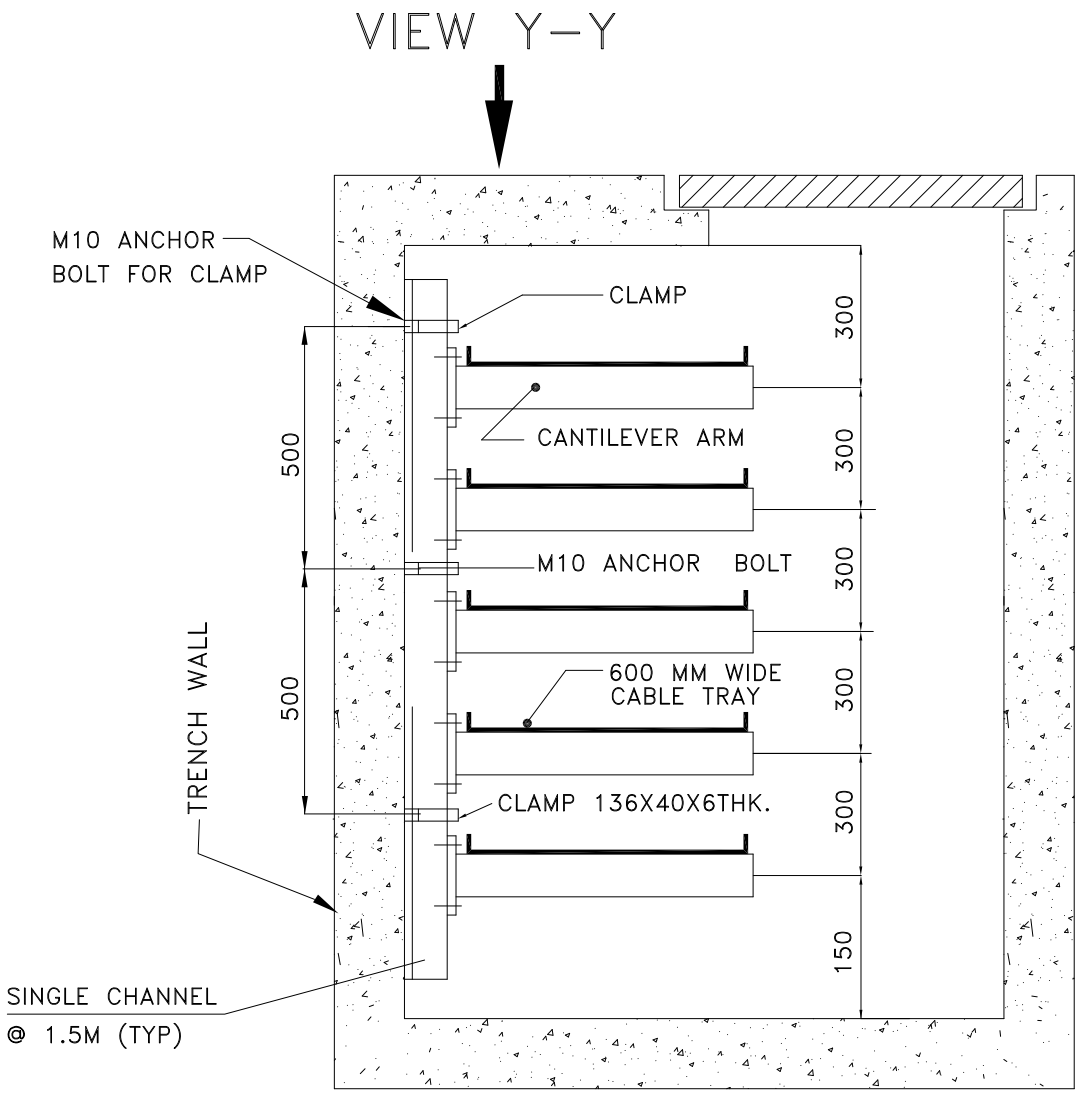


SUPPORT ARRANGEMENT
FROM CONCRETE COLUMNS
WITH ANGLE FITTING

GENERAL NOTES

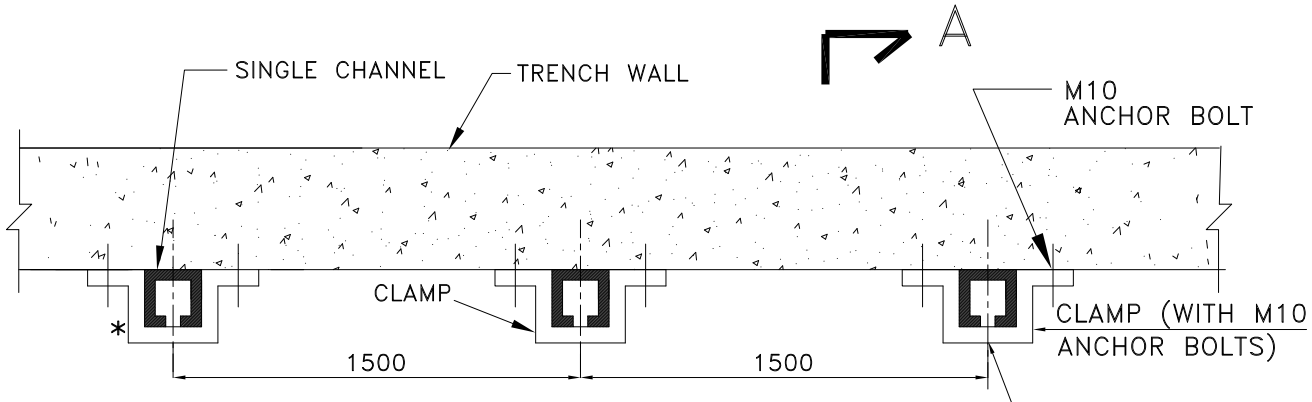
1. ALL DIMENSIONS ARE IN MM UNLESS INDICATED OTHERWISE.
2. ALL SUPPORTS ARE OF 2.5 MM THICK MS CHANNEL SECTIONS AND GALVANISED.
3. ALL FASTENERS SHALL BE ZINC PASSIVATED/ CADMIUM PLATED.
4. ALL SUPPORT SHALL BE FIXED ON WALL / COLUMN / TRENCH BY MEANS OF 136 X 40 X 6 MM THICK CLAMP.
5. ARRANGEMENT SHOWN ARE TYPICAL ONLY.
6. ALL WELDS FOR CABLE TRAY SUPPORTS SHALL HAVE A MINIMUM THROAT THICKNESS OF 6 MM.

BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE-DG-435-507-E006
		SH 17 OF 20



SECTION–AA

TYP. CABLE TRAYS FIXING ARRANGEMENT IN TRENCH

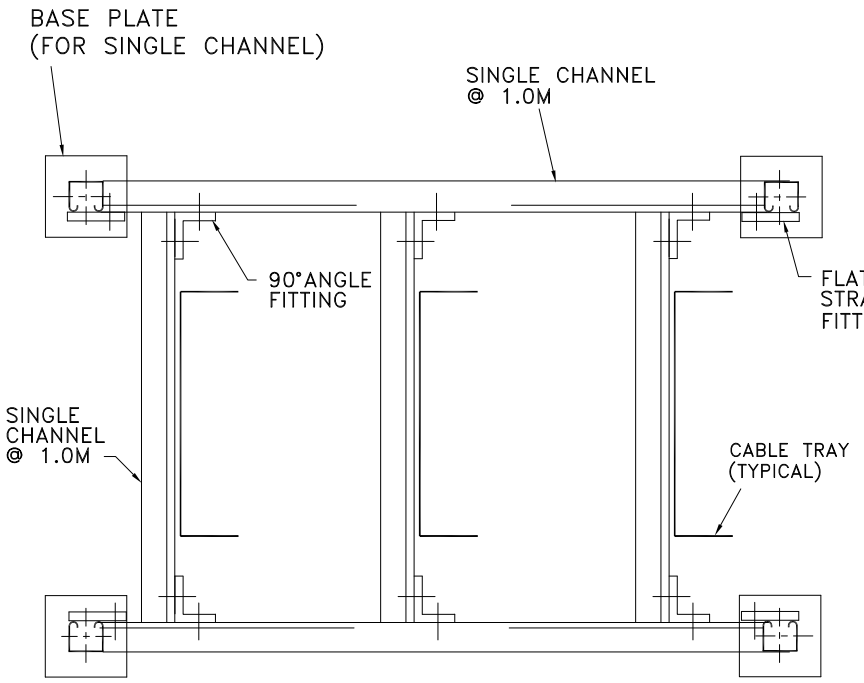


*CANTILEVER ARM IS NOT SHOWN IN PLAN

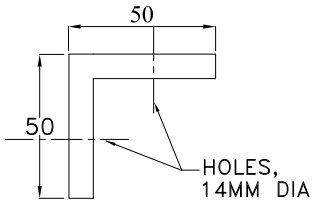
VIEW Y–Y

SEE GENERAL NOTES IN SHEET 17.

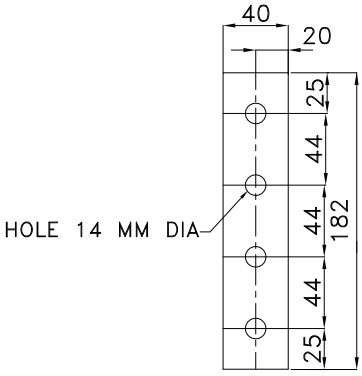
BHEL	TITLE: INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM	BHEL DRAWING NO. PE–DG–435–507–E006
		SH 18 OF 20



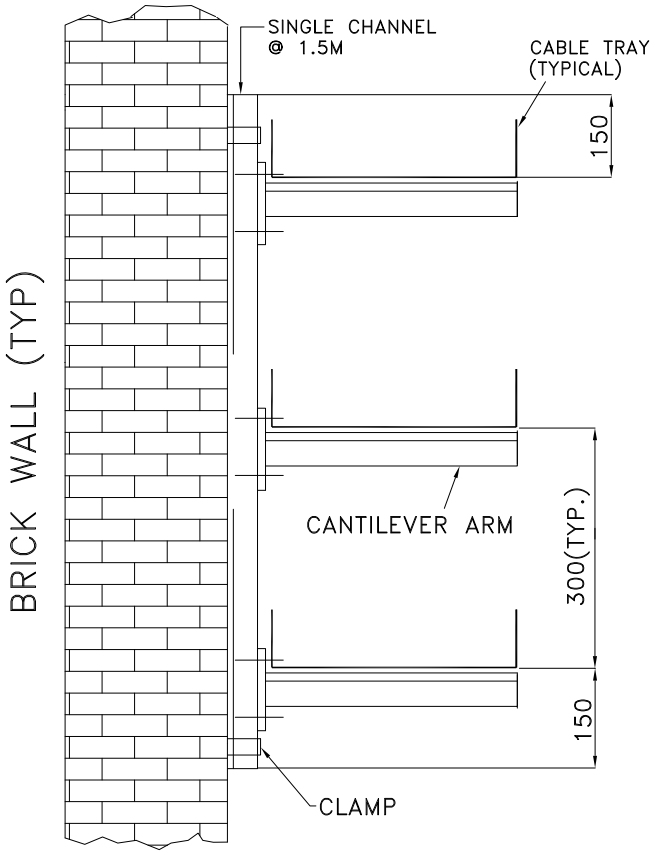
TYPICAL FLOOR SUPPORTED CHANNEL FRAME WORK (FOR BOLTABLE TYPE CABLE TRAY RISER)



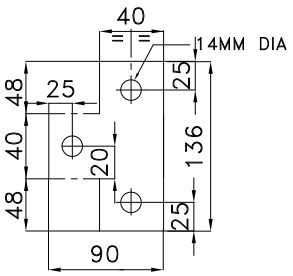
90 DEG. ANGLE FITTING
(6 MM THICK, 40 MM WIDE)



FLAT PLATE
STRAIGHT FITTING
(6 MM THICK)



TYPICAL CHANNEL SUPPORT
(ON WALL)



FLAT PLATE TEE FITTING
(6 MM THICK)

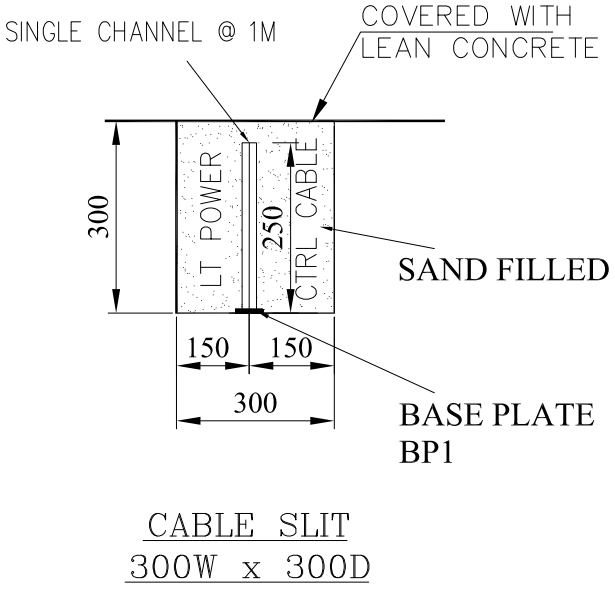
SEE GENERAL NOTES IN SHEET 17.

TITLE:

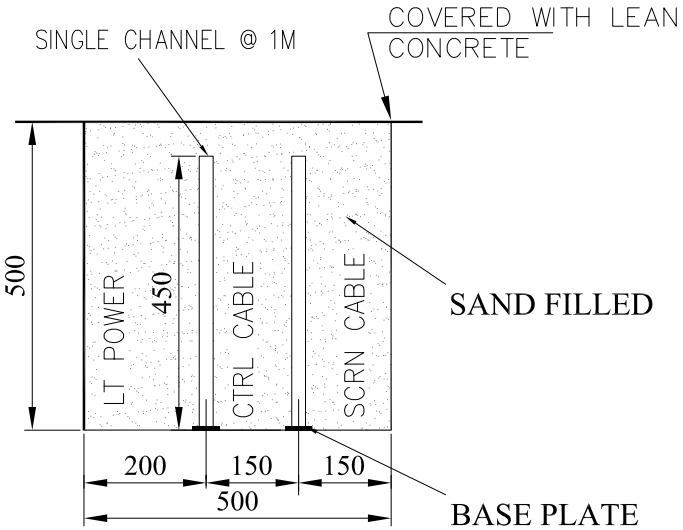
INSTALLATION DETAILS FOR CABLE TRAYS SUPPORT SYSTEM

BHEL DRAWING NO.

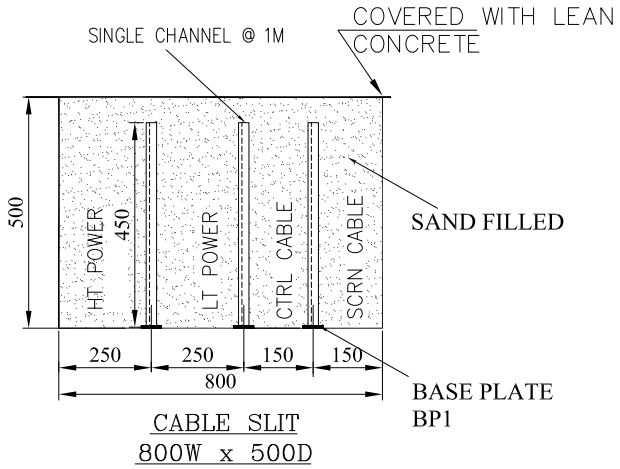
PE-DG-435-507-E006



CABLE SLIT
300W x 300D



CABLE SLIT
500W x 500D



CABLE SLIT
800W x 500D

TYPICAL CABLE SLIT ARRANGEMENT

SEE GENERAL NOTES IN SHEET 17.

TITLE:

INSTALLATION DETAILS FOR
CABLE TRAYS SUPPORT SYSTEM

BHEL DRAWING NO.

PE-DG-435-507-E006

SH 20 OF 20

TYPICAL ABOVE GRADE

GROUNDING DETAILS

PROJECT	2 X 660 MW UDANGUDI STPP STAGE–I	
	OWNER	TAMIL NADU GENERATION & DISTRIBUTION CORPOARATION LIMITED
	OWNER'S CONSULTANT	
	EPC CONTRACTOR	BHARAT HEAVY ELECTRICALS LIMITED POWER SECTOR PROJECT ENGINEERING MANAGEMENT NOIDA(U.P) INDIA

REV	DATE	ALTD	CHD	APPD

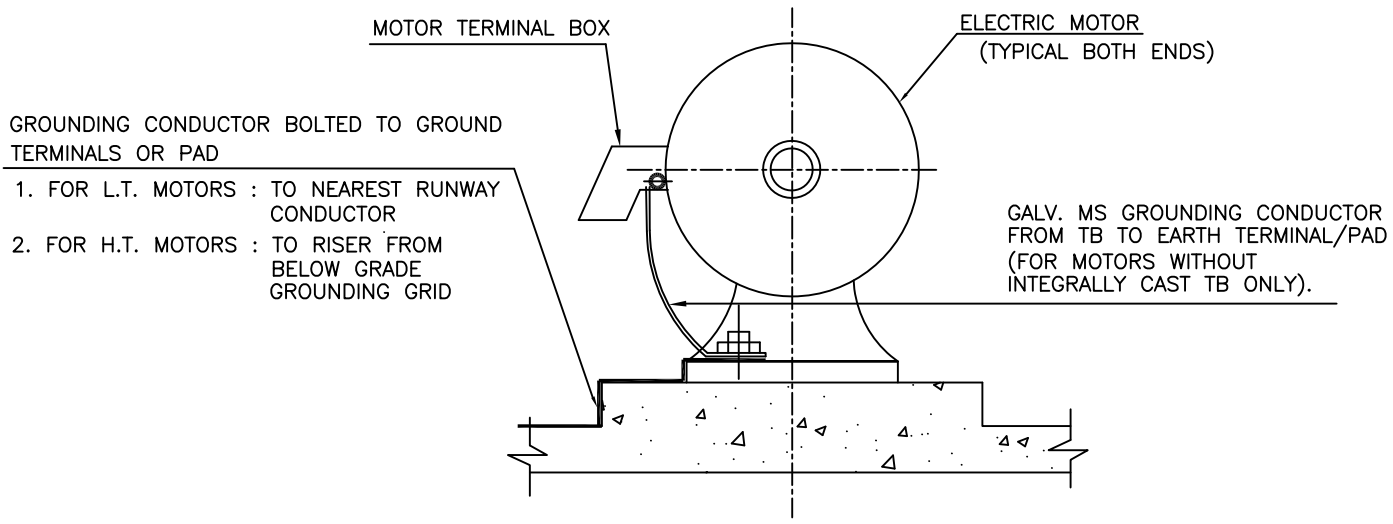
BHARAT HEAVY ELECTRICALS LTD.
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

DEPT CODE		NAME	SIGN	DATE
E	DRN	AAT	–S.D.–	
	DSGN	AAT	–S.D.–	19.03.18
	CHD	VY	–S.D.–	19.03.18
	APPD	SL	–S.D.–	19.03.18

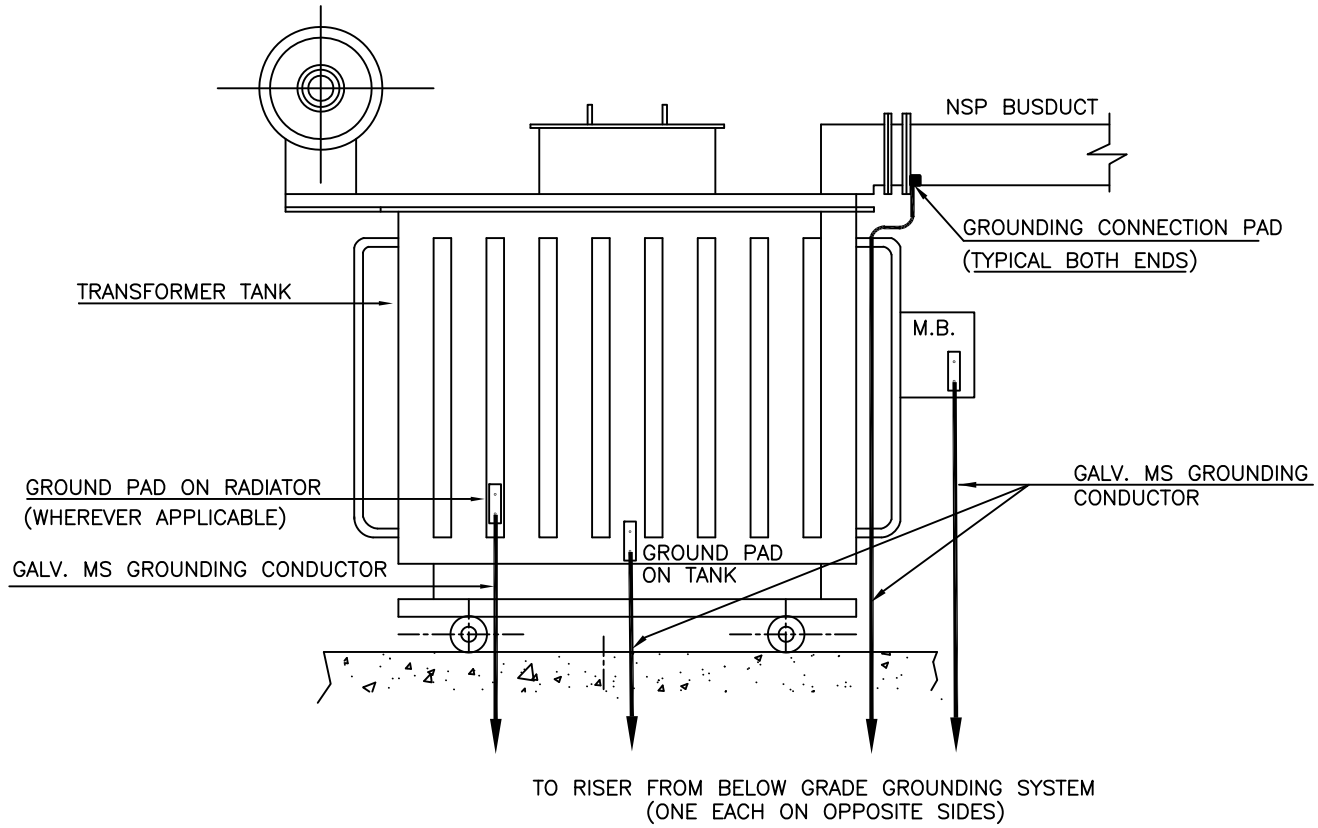
TITLE: TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS

DRAWING NO. PE–DG–435–509–E004

SHEET 1 OF 15 REV. 00



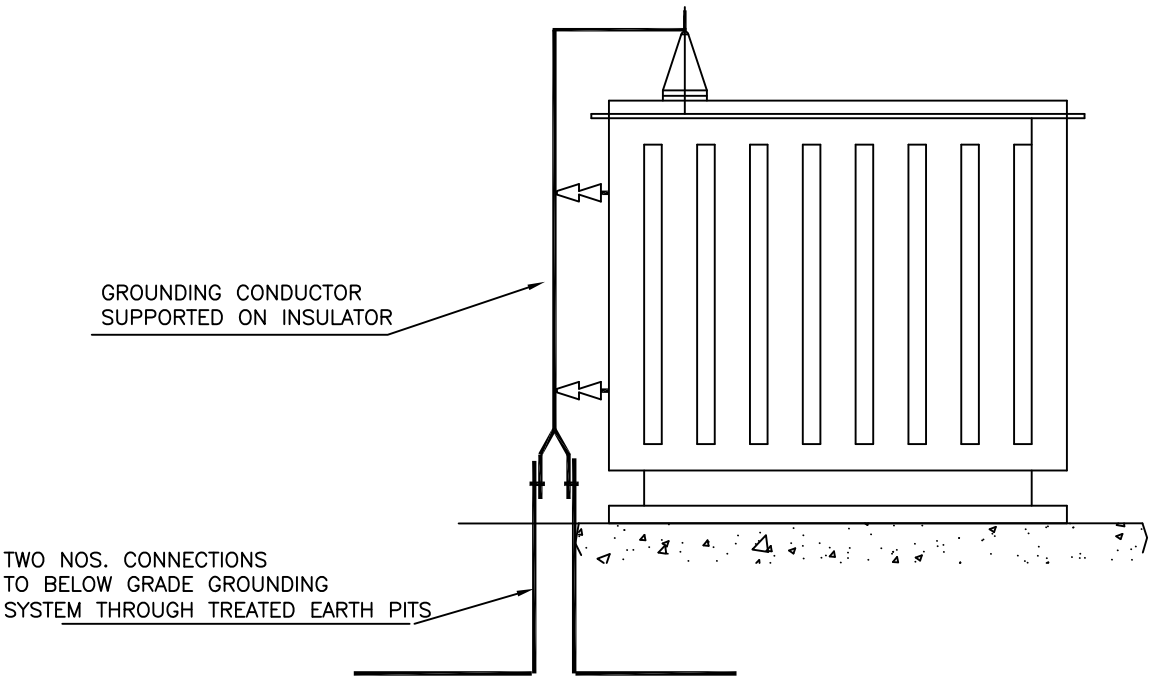
E1 : TYPICAL MOTOR GROUNDING DETAILS



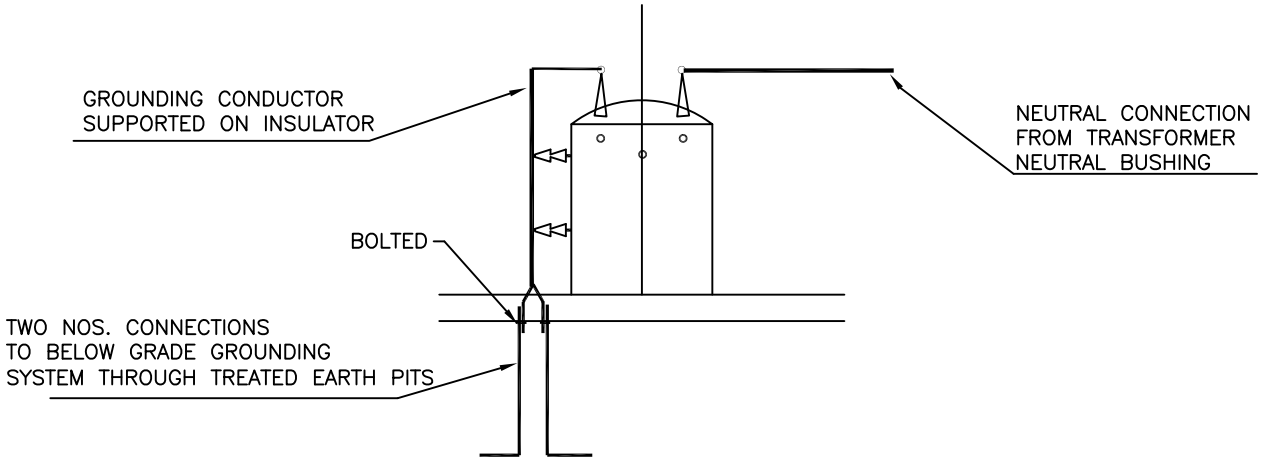
E2 : TRANSFORMER GROUNDING

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
	REV. No. 00
	SHEET 2 OF 15



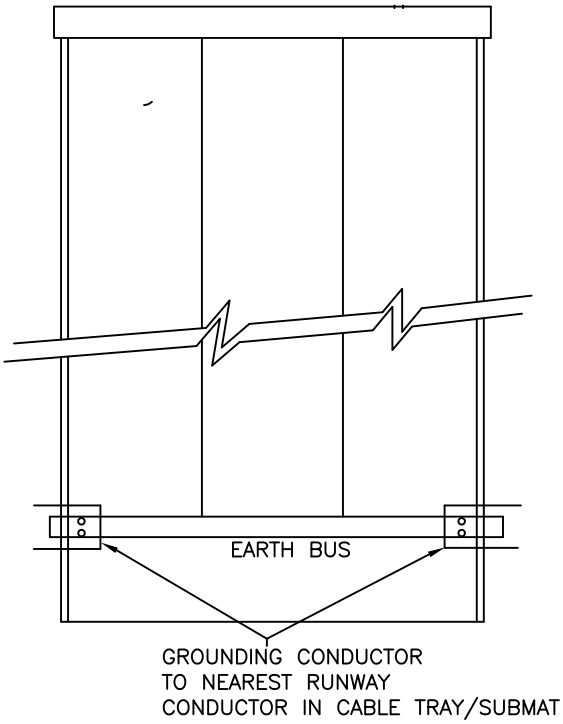
E3A : TRANSFORMER NEUTRAL EARTHING (DIRECTLY GROUNDED)



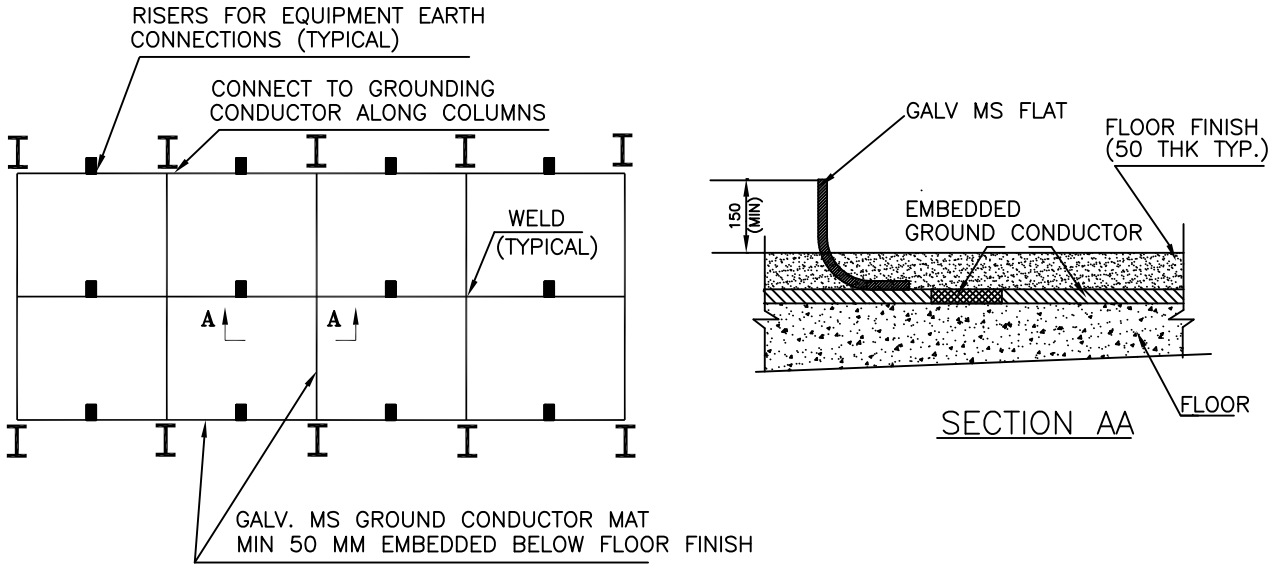
E3B : NEUTRAL EARTHING (THROUGH RESISTOR)

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
	REV. No. 00
	SHEET 3 OF 15



E4 : FLOOR MOUNTED PANEL GROUNDING

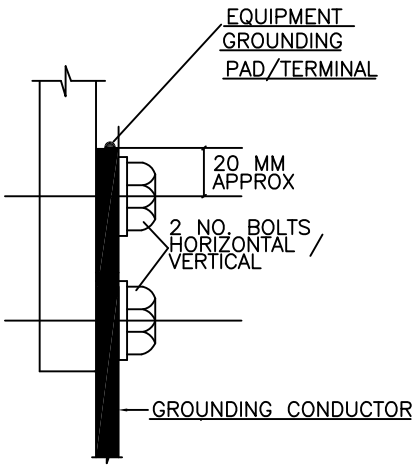


E5 : FLOOR SUBMAT TYPICAL DETAILS

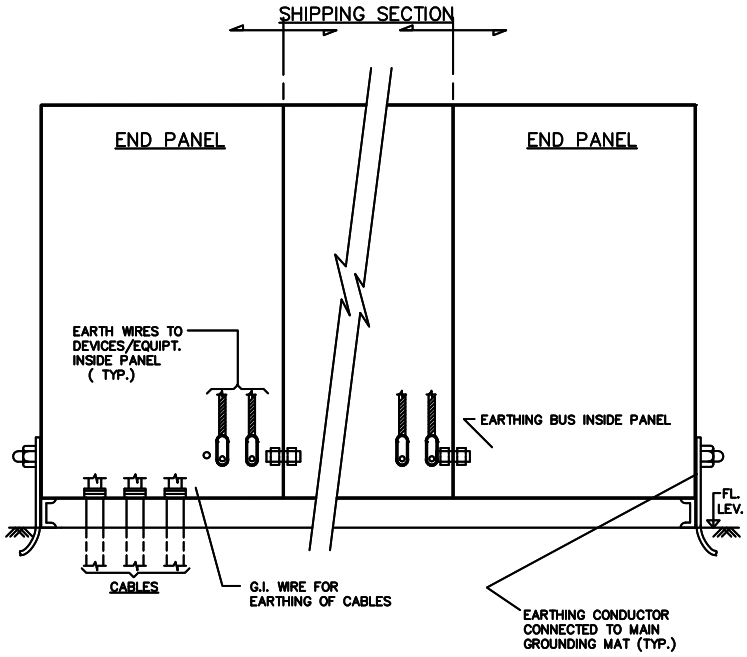
(TO BE PROVIDED ONLY IN ELECTRICAL SWGR ROOM)

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
	REV. No. 00
	SHEET 4 OF 15



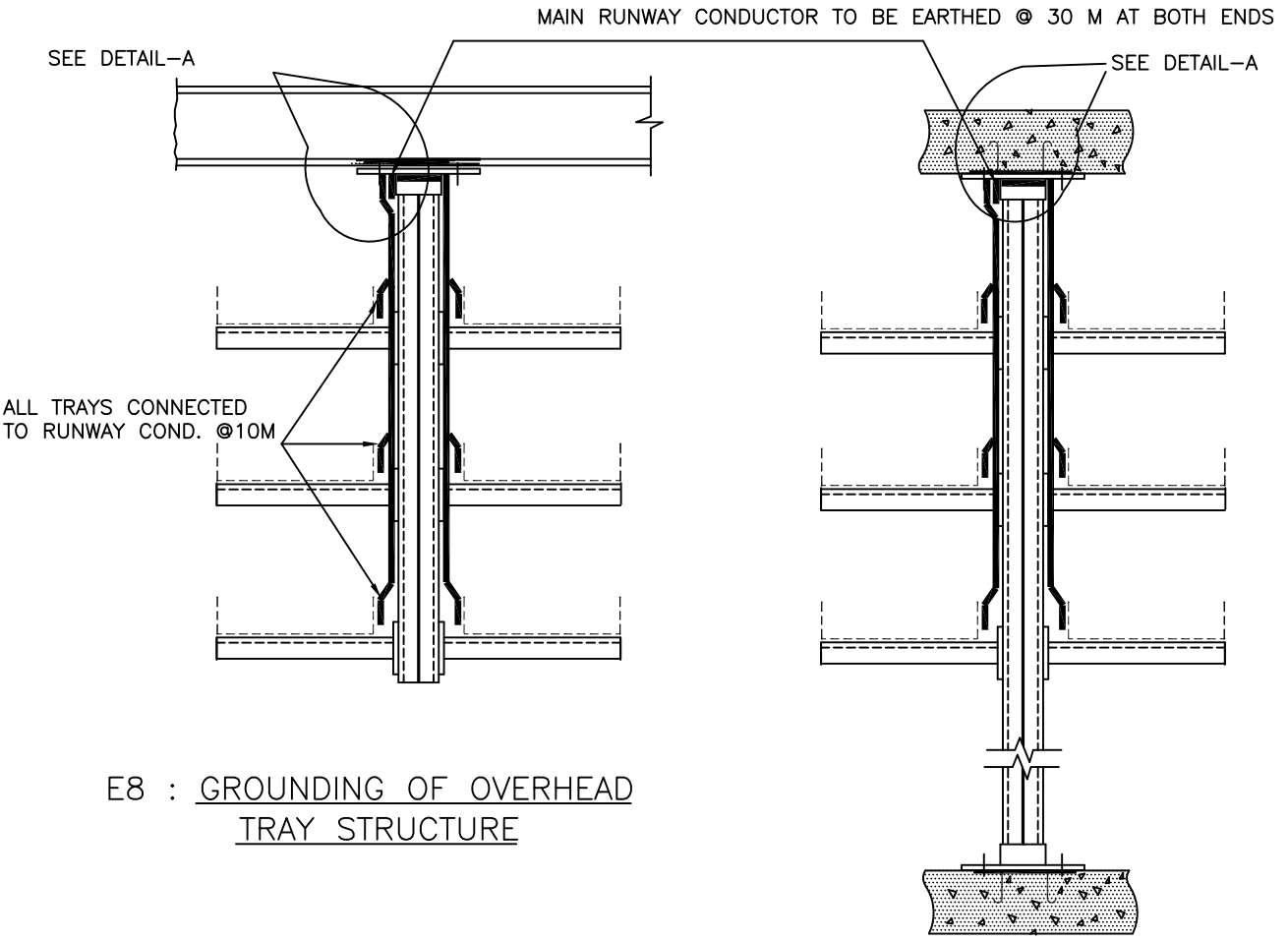
E6 : TYPICAL ARRANGEMENT BOLTED JOINT FOR EQUIPMENT GROUNDING



E7 : GROUNDING FOR ARMOURED CABLES

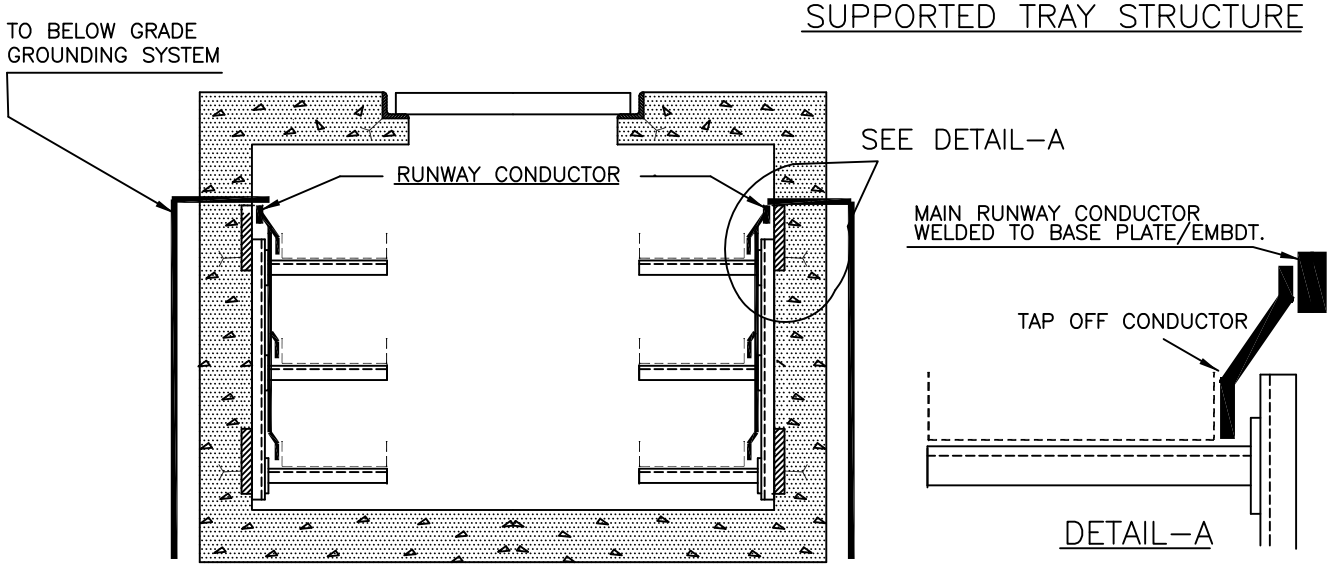
* ARMOUR OF SINGLE CORE HT & LT CABLE, GROUNDING WILL BE DONE AT ONE END ONLY

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
	REV. No. 00
	SHEET 5 OF 15



E8 : GROUNDING OF OVERHEAD TRAY STRUCTURE

E9 : GROUNDING OF FLOOR SUPPORTED TRAY STRUCTURE



E10 : GROUNDING OF TRAYS IN CABLE TRENCH

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE–DG–435–509–E004
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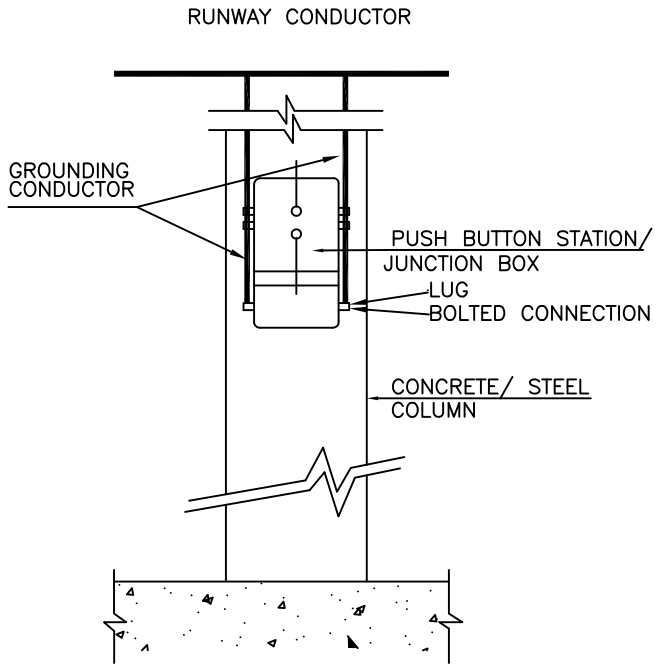
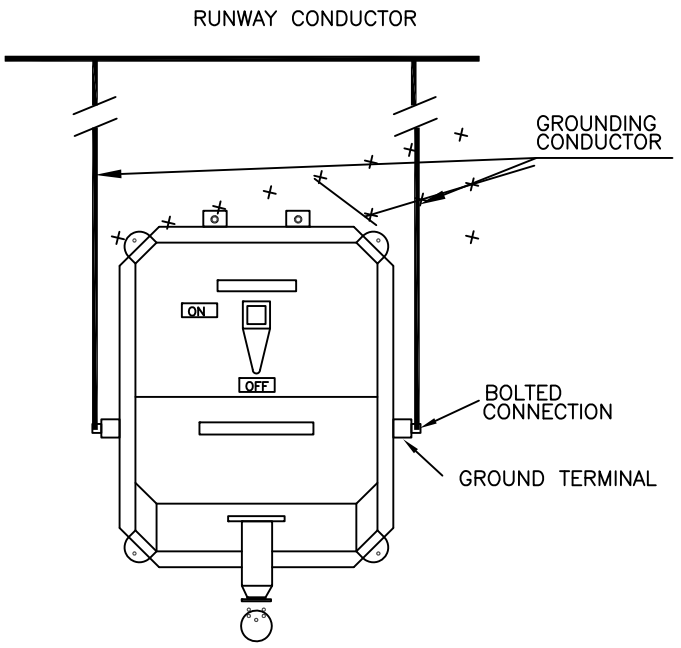
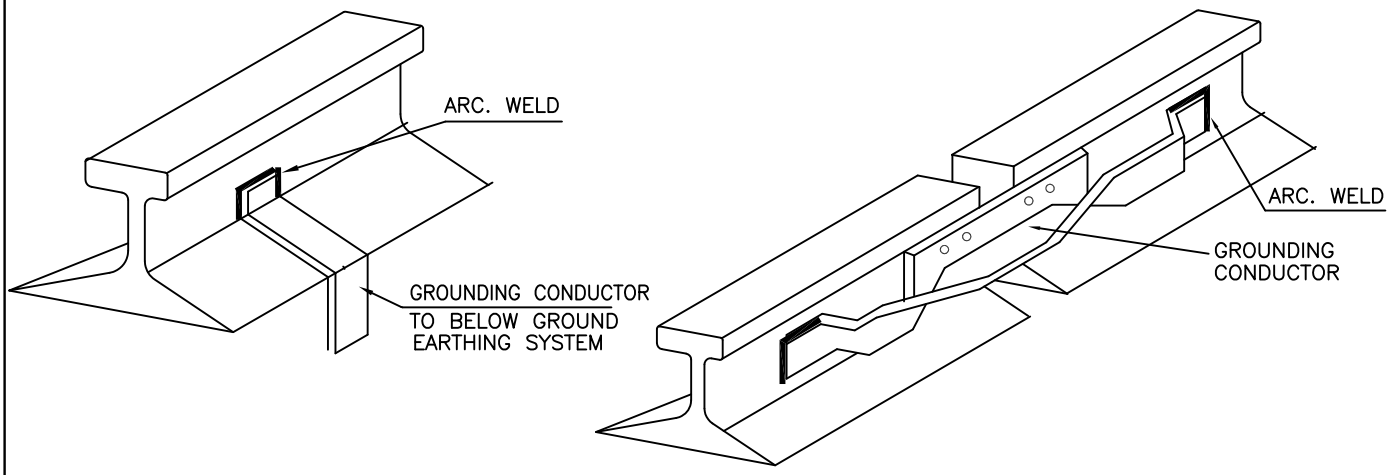


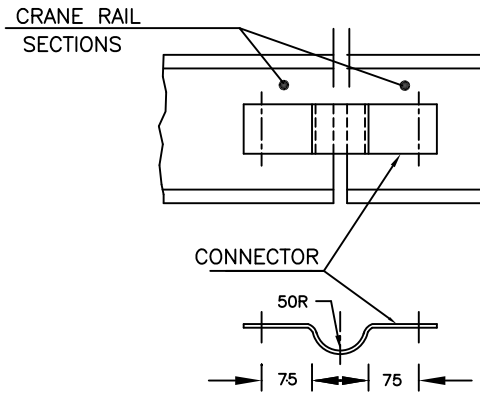
E11 : PUSH BUTTON STATION/ JUNCTION BOX GROUNDING



E12 : 3-PHASE WELDING RECEPTACLE GROUNDING



E13 : RAIL BONDING/ GROUNDING



E14 : BONDING OF CRANE RAIL

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
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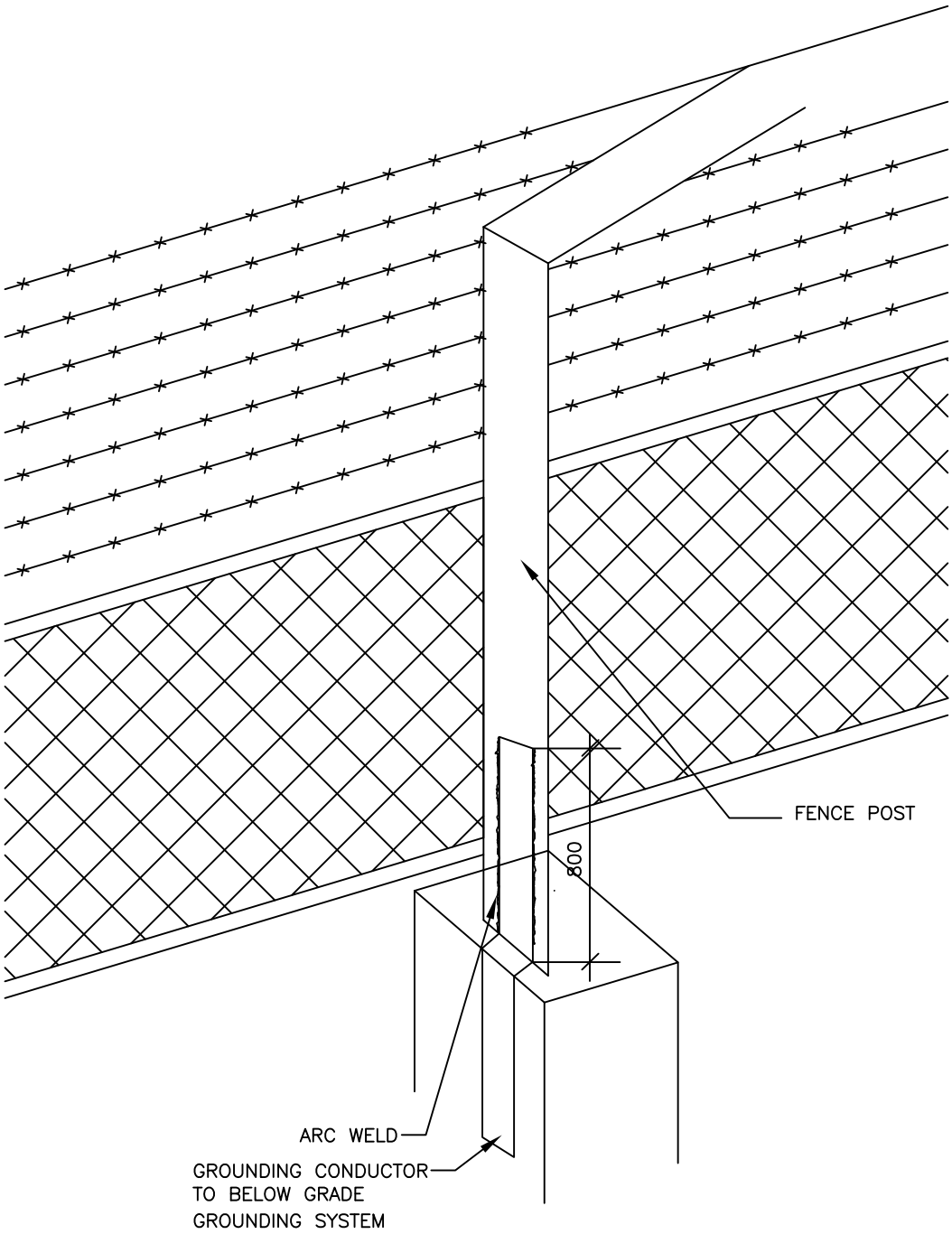
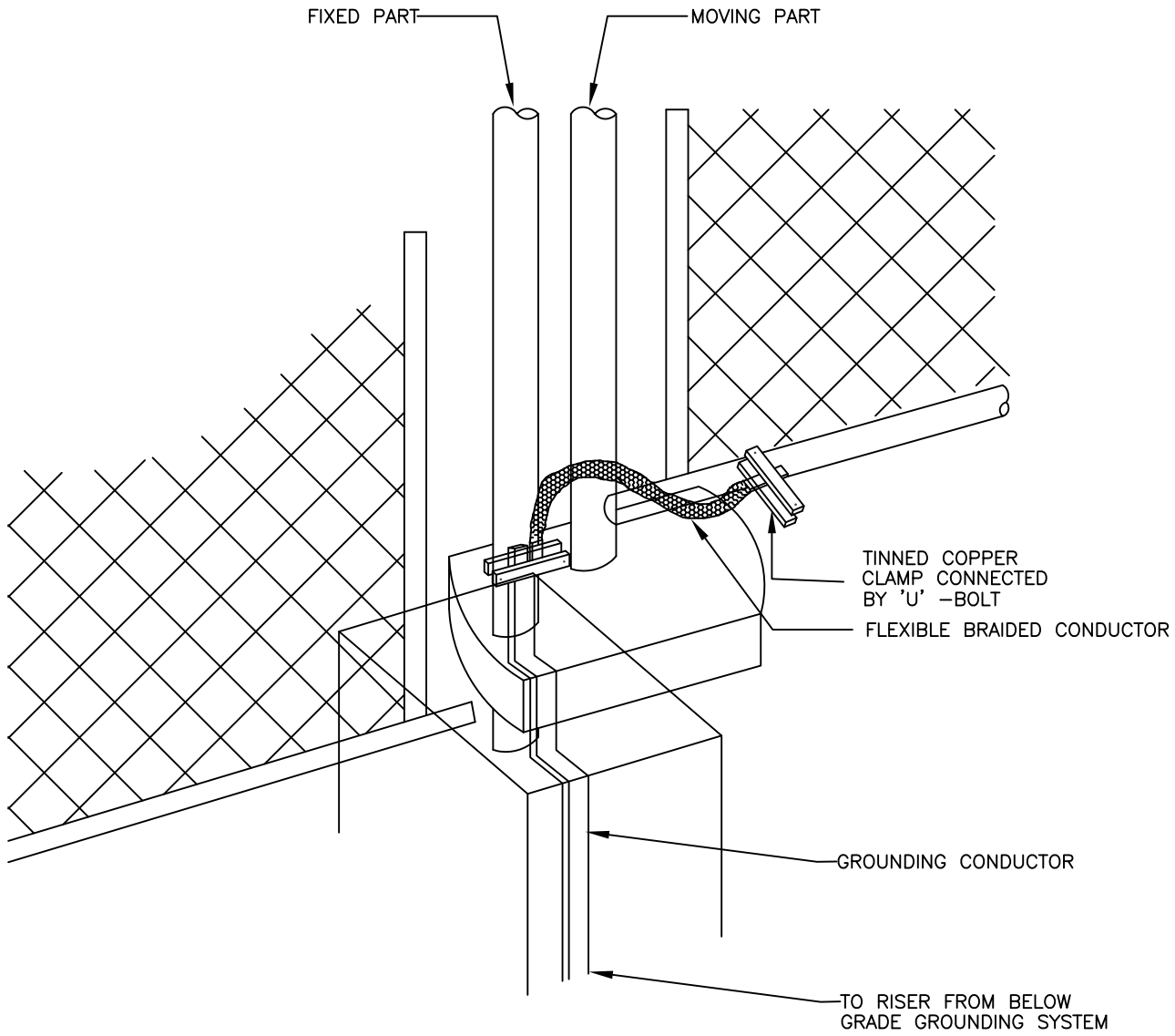


E15: FENCE GROUNDING

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
	REV. No. 00
	SHEET 8 OF 15



E16: FENCE GATE GROUNDING

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE–DG–435–509–E004
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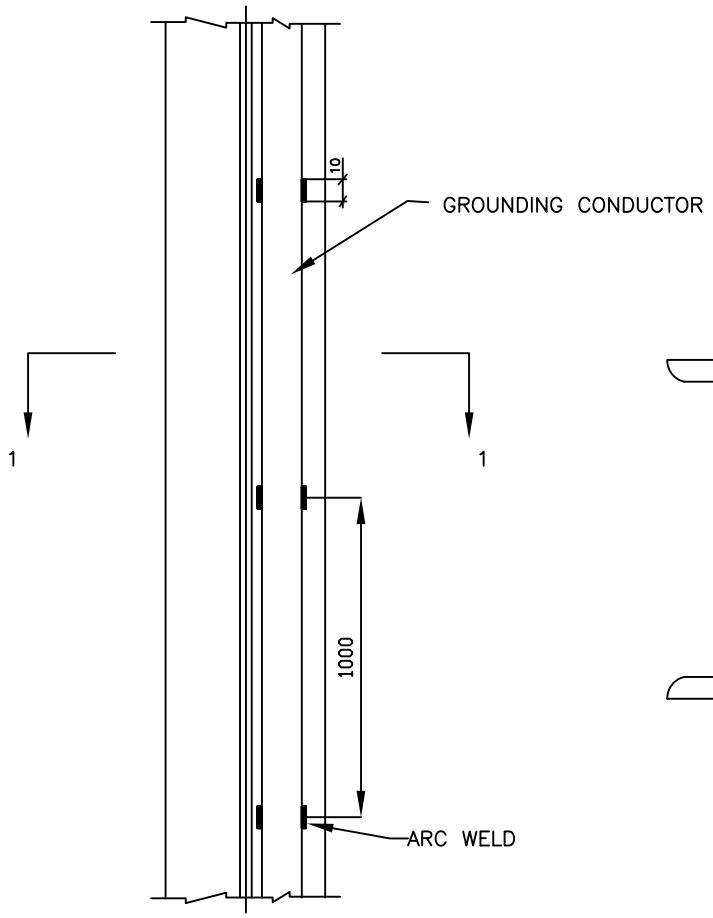

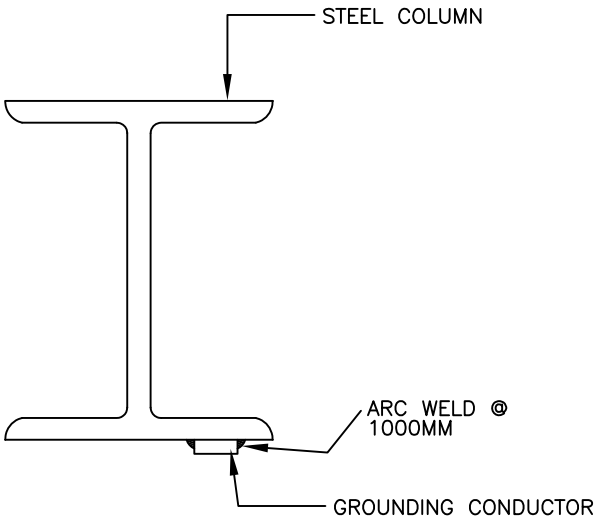

SECTION 1–1

E17: GROUNDING CONDUCTOR ALONG STEEL COLUMN

FOR GENERAL NOTES REFER SHT 13

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE–DG–435–509–E004
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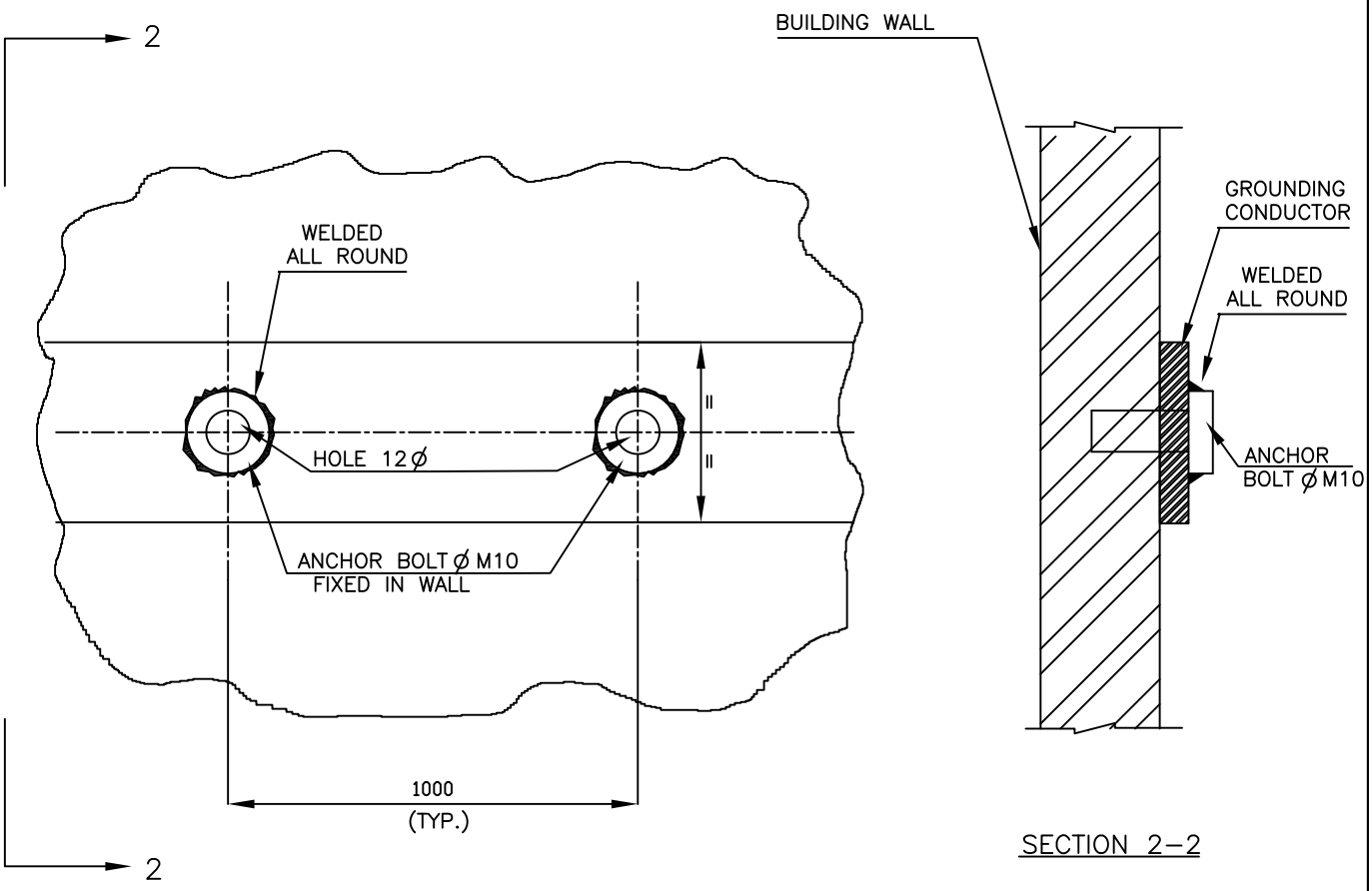

E18: GROUNDING CONDUCTOR ALONG BUILDING WALL

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE–DG–435–509–E004
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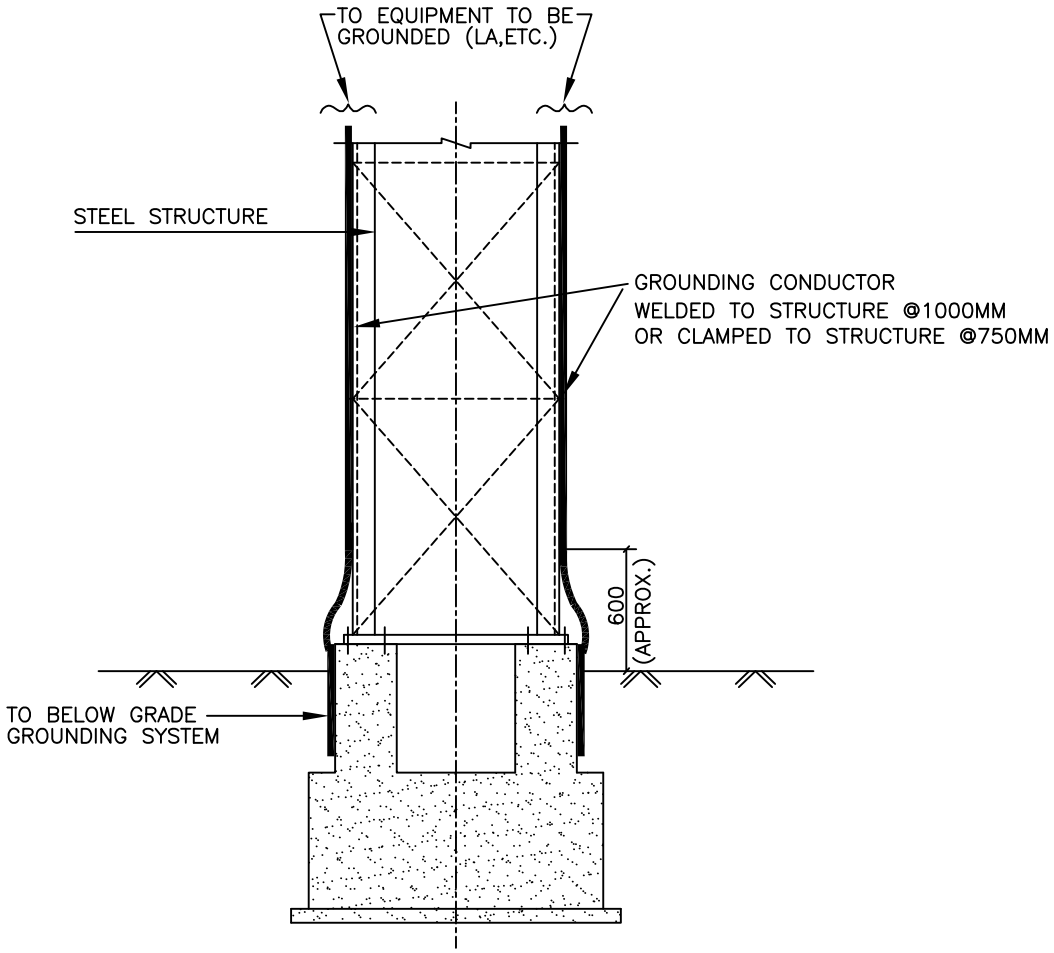
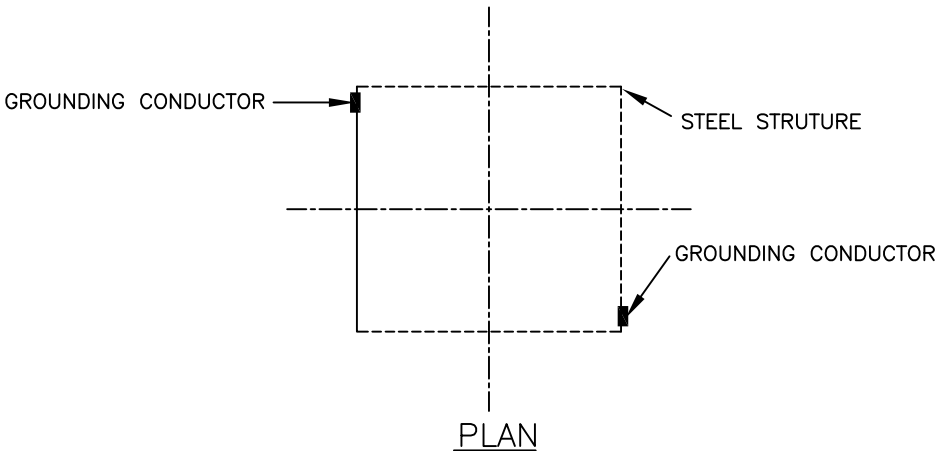


SECTION



PLAN

STRUCTURE AND EQUIPMENT GROUNDING

TITLE	BHEL DRAWING No.
TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS	PE-DG-435-509-E004
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GENERAL NOTES:

1. THE DETAILS SHOWN IN THIS DRAWING ARE APPLICABLE TO THE ABOVE GRADE LEVEL GROUNDING FOR MAIN PLANT AREA, AND AUXILIARY PLANTS IN BHEL SCOPE. FOR DETAILS OF EQUIPMENT GROUNDING IN SWITCHYARD AND FACILITIES WHICH ARE NOT IN BHEL–PEM SCOPE, SEPARATE DOCUMENTS SHALL BE REFERRED.

2. GALVANISED M.S. CONDUCTORS ARE USED FOR EQUIPMENT GROUNDING. SIZE OF GROUND CONDUCTOR SHALL BE AS PER TABLE–1 ON SHEET 15.

3. ALL GROUNDING CONDUCTOR CONNECTIONS AT EQUIPMENT ENDS ARE BOLTED.

4. ALL FASTENERS (NUTS/BOLTS/WASHERS) SHALL BE GALVANISED / ZINC PASSIVATED.

5. FROM BELOW GRADE GROUNDING SYSTEM, 65 X 8 MM GALVANISED MILD STEEL FLATS SHALL BE BROUGHT OUT FROM RISERS (40MM DIA ROD) AND CONNECTED TO MAIN GROUND CONDUCTORS (65x8 MM MS FLAT) RUN ALONG BUILDING COLUMNS/ WALLS & SECURELY FIXED TO THE SAME BY WELDING/ CLEATING AT INTERVALS OF 1000 MM. CONNECTIONS FROM EQUIPMENT GROUND TERMINALS, CABLE RACEWAYS RUNWAY CONDUCTORS, FLOOR SUBMAT, ETC. SHALL BE CONNECTED TO THESE MAIN CONDUCTORS.

6. A CONTINUOUS 50X6 MM. GALVANISED M.S. FLAT GROUND CONDUCTOR (RUNWAY CONDUCTOR) SHALL BE INSTALLED ALONG ALL CABLE RACEWAYS / RACKS, WHICH SHALL SERVE AS THE MAIN GROUNDING CONDUCTOR FOR RECEIVING INDIVIDUAL GROUND CONNECTIONS. ALL TRAY TIERS OF EACH SECTION SHALL BE CONNECTED TO THE RUNWAY CONDUCTOR AT AN INTERVAL OF ABOUT 10 M.FURTHER THIS FLAT SHALL BE EARTHED AT BOTH ENDS @ 30 M. THE RUNWAY CONDUCTORS AT DIFFERENT BUILDING ELEVATIONS SHALL BE INTERCONNECTED BETWEEN THE MAIN RISERS ALONG COLUMNS/WALLS & SHALL ALSO BE CONNECTED TO THE NEAREST RISER/ STRUCTURAL COLUMNS.

7. ALL ELECTRICAL EQUIPMENT AND ASSOCIATED NON CURRENT CARRYING METAL WORKS, SUPPORTING STRUCTURES, ETC. SHALL BE CONNECTED TO MAIN RUNWAY CONDUCTOR OR BELOW GRADE GROUNDING SYSTEM, WHERE AVAILABLE.

8. TWO SEPARATE AND DISTINCT GROUND CONNECTIONS SHALL BE PROVIDED FOR GROUNDING OF EACH ELECTRICAL EQUIPMENT FRAMEWORK.

9. ALL BUILDING STEEL COLUMNS, STRUCTURAL STEEL COLUMNS, METALLIC RAILING DEVICES SUCH AS JUNCTION BOXES, PULL BOXES, PUSH BUTTON STATIONS, LOCKOUT SWITCHES, CABLE END BOXES ETC. SHALL BE GROUNDED WHETHER SPECIFICALLY SHOWN IN THE DRAWING OR NOT.

10. GROUND CONDUCTOR CONNECTIONS ABOVE GRADE LEVEL SHALL BE GENERALLY MADE BY ELECTRIC ARC WELDING EXCEPT AT EQUIPMENT TERMINALS. RESISTANCE OF JOINTS SHALL NOT BE MORE THAN THE RESISTANCE OF EQUIVALENT LENGTH OF CONDUCTOR. M.S. GROUND CONDUCTOR ABOVE GRADE LEVEL & WELDS SHALL BE TREATED WITH ZINC CHROMATE PRIMER COATED WITH ZINC RICH PAINT TO PREVENT CORROSION. DAMAGED PORTIONS OF GALVANISED MS SHALL BE COATED WITH TWO COATS OF COLD GALVANISING AND ANTI–CORROSIVE PAINT AFTER WELDING.

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11. AT EQUIPMENT ENDS, ONLY BOLTED CONNECTION SHALL BE MADE FOR GROUNDING OF EQUIPMENT/DEVICES AND REMOVABLE STRUCTURES. THE CONTACT SURFACE SHALL BE THOROUGHLY CLEANED BEFORE CONNECTION TO ENSURE GOOD ELECTRICAL CONTACT. EQUIPMENT BOLTED CONNECTION AFTER BEING CHECKED AND TESTED SHALL BE PAINTED WITH ANTI-CORROSIVE PAINT COMPOUND.

12. EARTHING METHOD INSIDE THE SWGR ROOM SHALL BE IN THE FORM OF SUB-MAT (EARTHING GRID EMBEDDED IN THE FLOOR SLAB WITH APPROXIMATELY 50 MM OF CONCRETE COVER) OF GALVANIZED CONDUCTOR OF 50X6 MM . FURTHER IN CASE OF BUILDINGS HAVING MORE THAN ONE FLOOR, SWGR ROOM OF EACH FLOOR SHALL BE PROVIDED WITH SEPARATE EARTH GRID. THESE FLOOR EARTH GRIDS SHALL BE INTERCONNECTED. THIS SUB-MAT IS CONNECTED TO THE BELOW GRADE GROUNDING SYSTEM AT MINIMUM TWO POINTS THROUGH GALVANIZED FLATS. BEFORE FLOOR FINISHING IS DONE AND CONNECTED TO THE BELOW GROUND EARTHING SYSTEM THROUGH TWO RISERS LOCATED PREFERABLY DIAMETRICALLY OPPOSITE TO EACH OTHER, SUITABLE RISER STUBS SHALL BE PROVIDED ABOVE THE FINISHED FLOOR IF THE EQUIPMENT IS NOT AVAILABLE AT THE TIME OF LAYING THE MAIN GROUNDING CONDUCTOR.

13. GROUNDING INSTALLATION SHALL CONFORM TO THE FOLLOWING:
    (A) IS:3043
    (B) INDIAN ELECTRICITY RULES
    (C) BHEL DOCUMENT NO. PE-DC-435-509-E002 (GROUNDING SYSTEM DESIGN MEMORANDUM)

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TABLE-1

MATERIAL AND SIZES OF ABOVE GROUND EARTHING SYSTEM

SL.NO.	TYPE OF EQUIPMENT	SIZE (MM)	MATERIAL	NO. OF LEADS
1	INTERCONNECTION BETWEEN RISER AND STEEL COLUMN & ALONG COLUMNS	65X 8	GALVANISED MS FLAT	N.A.
2	SUB-MAT BURIED IN FLOOR FINISH	50X 6	GALVANISED MS FLAT	N.A.
3	RUNWAY CONDUCTOR	50X 6	GALVANISED MS FLAT	N.A.
4	11 kV / 3.3 kV SWITCHGEAR / BUSDUCT	65X 8	GALVANISED MS FLAT	TWO
5	LT TRANSFORMER (ENCLOSURE & NEUTRAL)	75X 8	GALVANISED MS FLAT	TWO
6	415 V DISTRIBUTION BOARDS , LT BUSDUCT	75X 8	GALVANISED MS FLAT	ONE FOR EACH SECTION
7	DG SET & FUSE DISTRIBUTION BOARDS	50X 6	GALVANISED MS FLAT	TWO
8	11 kV & 3.3 kV MOTORS	50X6	GALVANISED MS FLAT	TWO
9	415 V MOTORS: ABOVE 75 KW	50X 6	GALVANISED MS FLAT	TWO
10	415 V MOTORS: ABOVE 30 KW & UPT0 75KW	32X5	GALVAN ISED MS FLAT	TWO
11	415 V MOTORS: 9.3 KW UPTO 30 KW	25X3	GALVANISED MS FLAT	TWO
12	415 V MOTORS: BELOW 5.5, 5.5,7.5 kW	6/4/4 SWG	GI WIRE	TWO
13	CONTROL PANEL &CONTROL DESK	25X3	GALVANISED MS FLAT	TWO
14	PUSH BUTTON STATION & JUNCTION BOX	14 SWG	GI WIRE	TWO
15	RELAY PANEL	25X6	GALV MS FLAT	
16	CHARGER/UPS/ CT/PT JUNCTION BOX	50X 6	GALVANISED MS FLAT	TWO
17	LIGHTING/ CONTROL JUNCTION BOX	8 SWG	GI WIRE	TWO
18	RAILS & METAL PARTS, FENCE	25X6	GALVANISED MS FLAT	ONE
19	HT TRANSFORMER (ENCLOSURE & NEUTRAL)	65X8	GALVANISED MS FLAT	TWO
20	GENERATOR , LAPT,NGT, NGT NEUTRAL	50X6	GALVANISED MS FLAT	TWO
21	WELDING OUTLETS 3-PHASE RECEPTACLES	25X6	GALVANISED MS FLAT	TWO
22	LIGHTING DISTRIBUTION BOARD, LIGHTING PANELS	50X 6	GALVANISED MS FLAT	TWO
23	LIGHTING POLES/ LIGHTING MASTS	25X6 *	GALVANISED MS FLAT	ONE
24	FIXTURES &SOCKETS	8 SWG	GI WIRE	ONE

* 20 DIA ROD FOR BELOW GROUND EARTHING

TITLE

TYPICAL ABOVE GRADE LEVEL GROUNDING DETAILS

BHEL DRAWING No.
PE–DG–435–509–E004

REV. No.
00

TYPICAL LIGHTNING PROTECTION DETAILS

PROJECT	2X660MW UDANGUDI STPP,STAGE-I	
	CUSTOMER	TAMIL NADU GENERATION & DISTRIBUTION CORPOARATION LIMITED
	EPC CONTRACTOR	BHARAT HEAVY ELECTRICALS LIMITED POWER SECTOR PROJECT ENGINEERING MANAGEMENT NOIDA(U.P) INDIA

REV	DATE	DRN	CHD	APPD	REV	DATE	DRN	CHD	APPD

DOCUMENT TITLE:
TYPICAL LIGHTNING PROTECTION DETAILS

DPT CODE-E

	NAME	SIGN	DATE
DSN	AAT	-SD-	09.04.18
CHD	VY	-SD-	09.04.18
APP	SL	-SD-	09.04.18

DOCUMENT NO: PE-DG-435-509-E006

REV. 00

CONTENT SHEET

SL. NO.	DESCRIPTION	SHEET NO.
1.	TYPICAL FIXING/CONNECTION DETAILS OF VERTICAL AIR TERMINAL ROD ON THE ROOF OF BUILDING	3
2.	TYPICAL DETAILS OF CLAMPING HORIZONTAL AIR TERMINATION CLAMPING OVER ROOF	4
3.	TYPICAL DETAILS OF DOWNCONDUCTOR FIXING AND TEST LINK	5
4.	TYPICAL DETAILS OF CONNECTION AMONG HORIZONTAL AIR TERMINAL, DOWN CONDUCTOR AND RISER	6
5.	TYPICAL DETAILS OF CONNECTION AMONG HORIZONTAL AIR TERMINAL, DOWN CONDUCTOR FOR 'A' ROW CLADDING	7
6.	NOTES	8 & 9

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS

BHEL DOCUMENT No.
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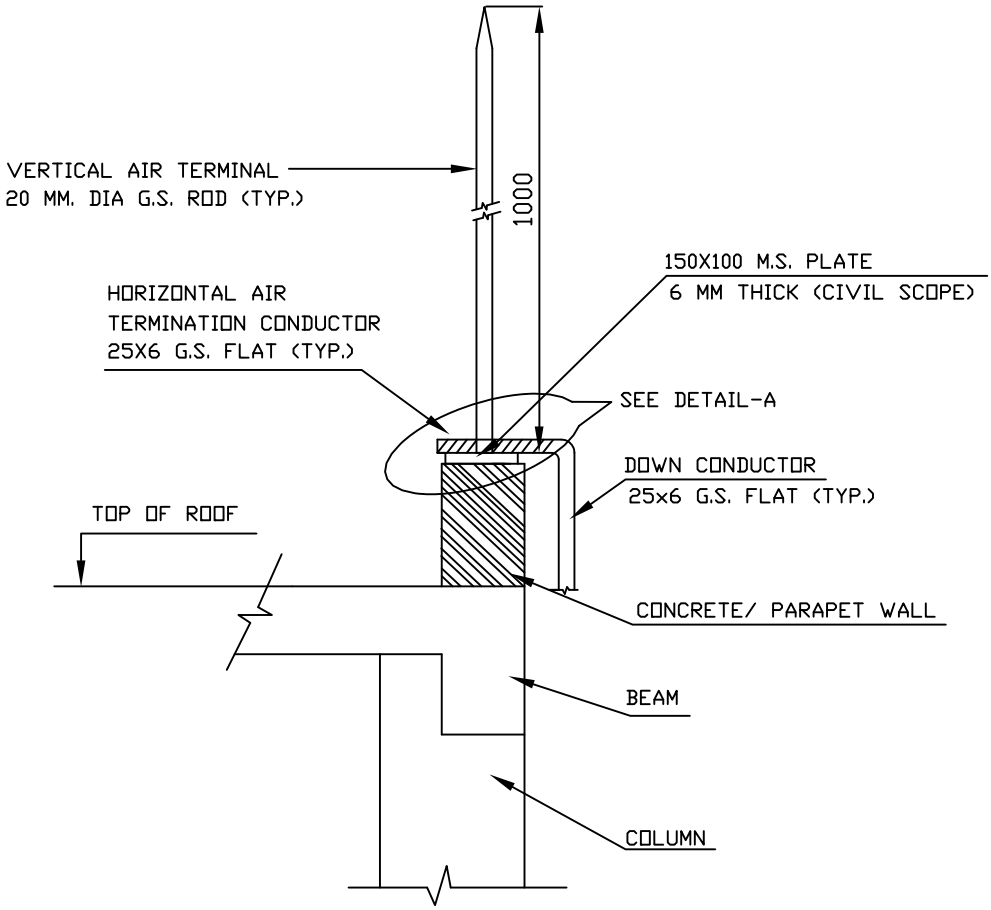

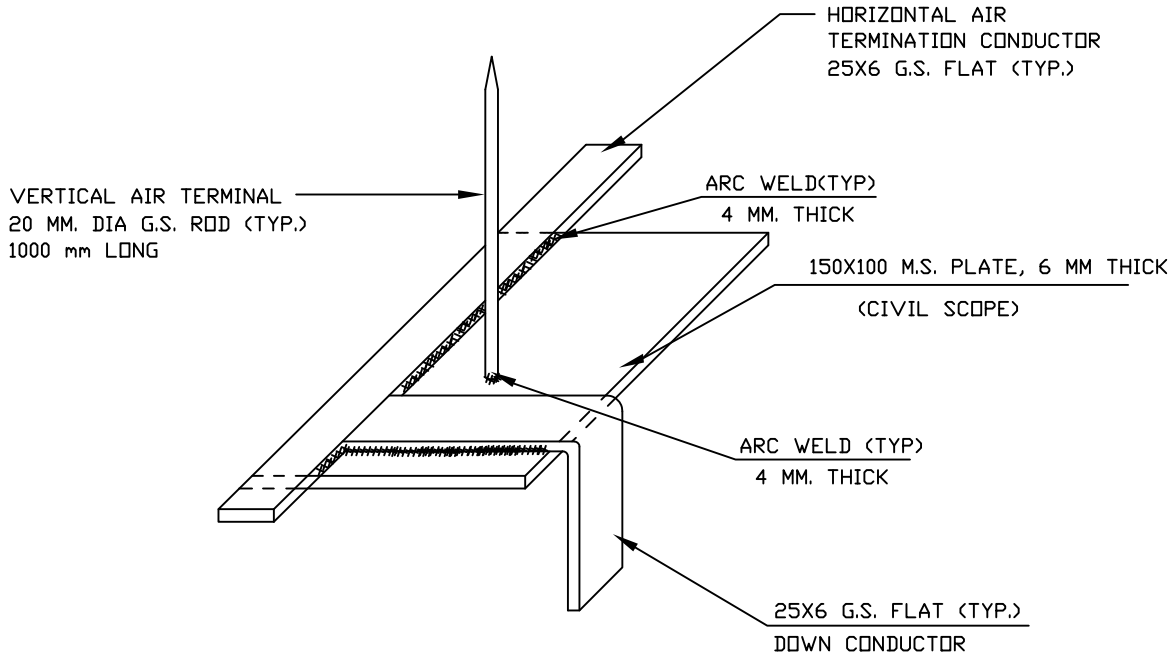

DETAIL-A

TYPICAL FIXING/CONNECTION DETAILS OF VERTICAL AIR TERMINAL ROD ON THE ROOF OF BUILDING

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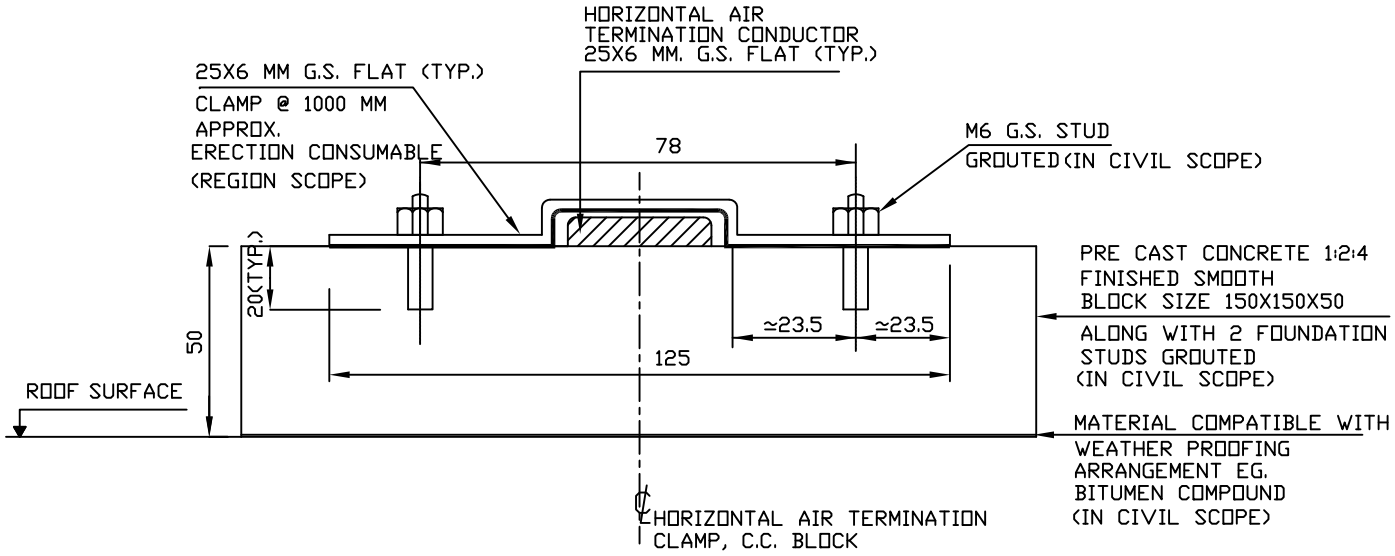
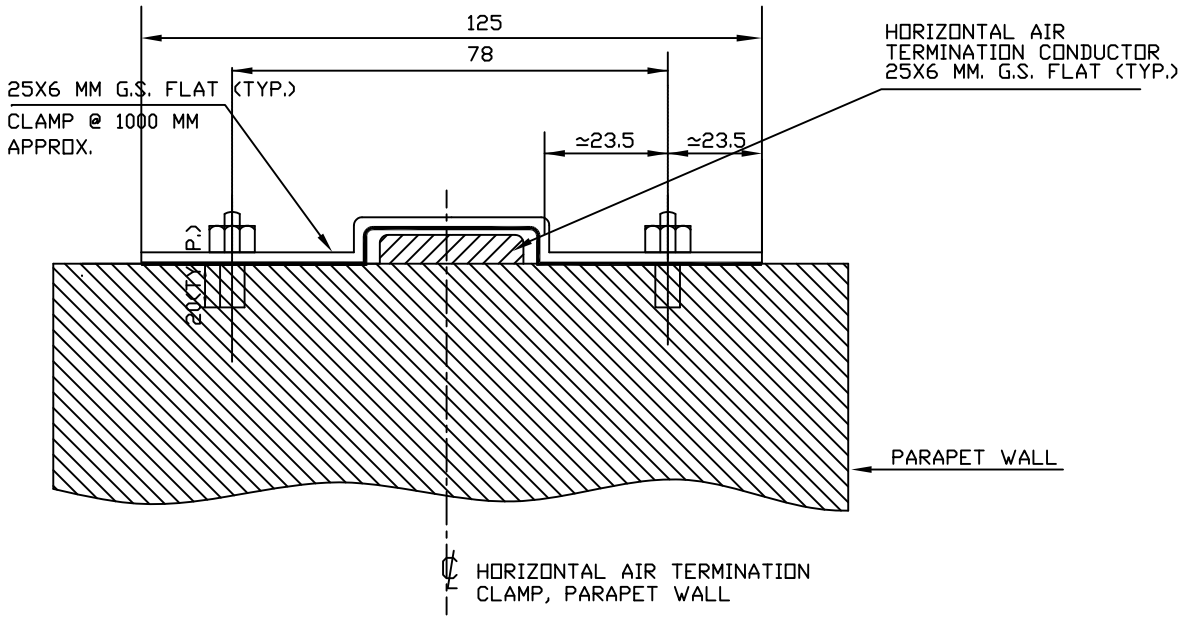


(A) OVER ROOF SURFACE



(B) OVER PARAPET WALL

TYPICAL DETAILS OF CLAMPING HORIZONTAL AIR TERMINATION

CLAMPING OVER ROOF

TITLE **TYPICAL LIGHTNING PROTECTION DETAILS**	BHEL DOCUMENT No. PE-DG-435-509-E006
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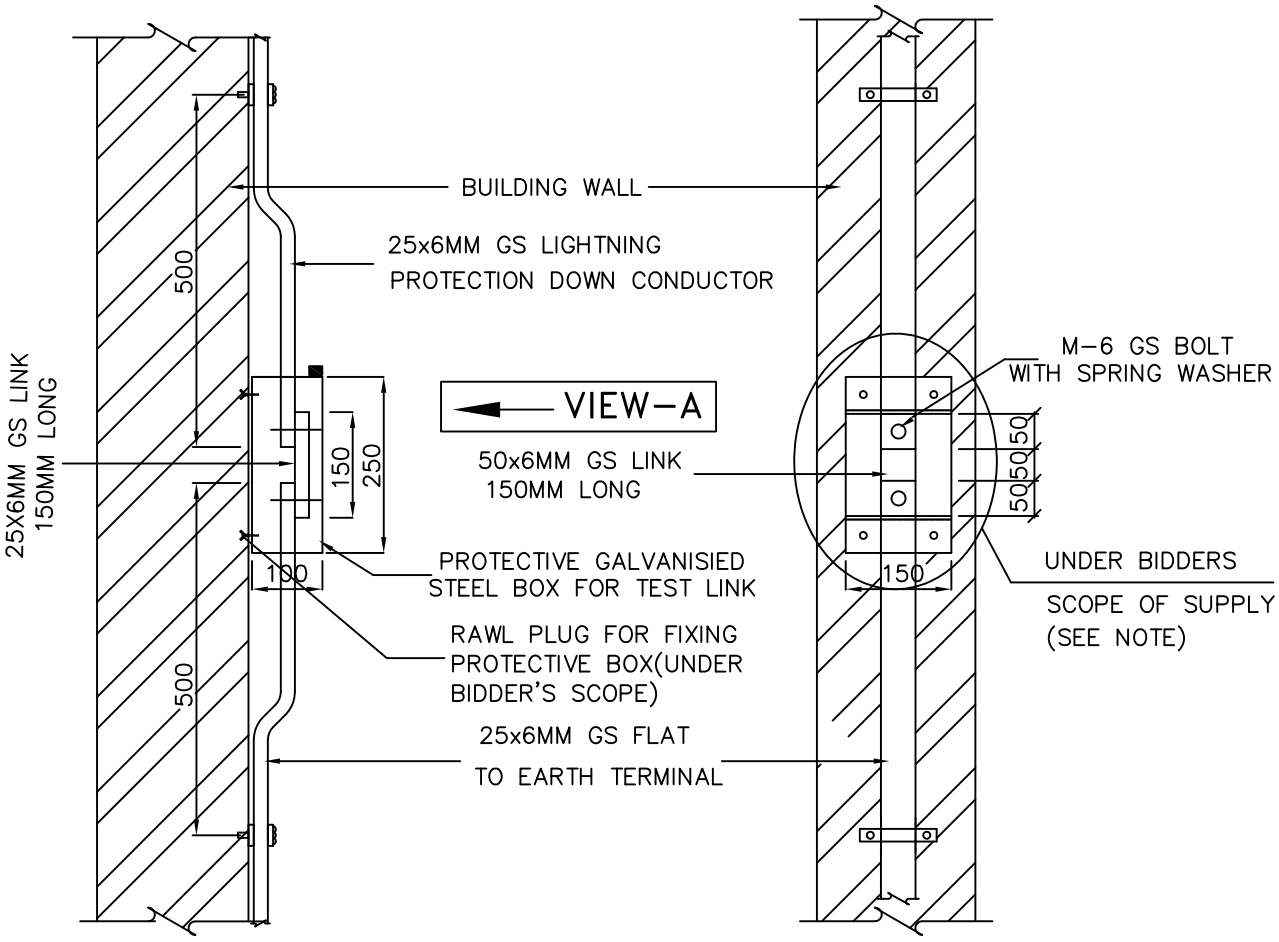

NOTE: BIDDER'S SCOPE INCLUDES THE 150 MM LONG 50X6MM GS LINK ALONG WITH HARDWARES (2 NOS. OF M–6 GS NUTS & BOLTS & 4 NOS. SPRING WASHERS) & 250X150X100 MM GALVANISED MS COVERING BOX (1.6 MM THICK) WITH 4 NOS. M12 SCREWS & RAWL PLUGS FOR FIXING OF THE SAME.

TYPICAL DETAILS OF DOWNCONDUCTOR FIXING AND TEST LINK

TITLE	BHEL DOCUMENT No.
TYPICAL LIGHTNING PROTECTION DETAILS	PE–DG–435–509–E006
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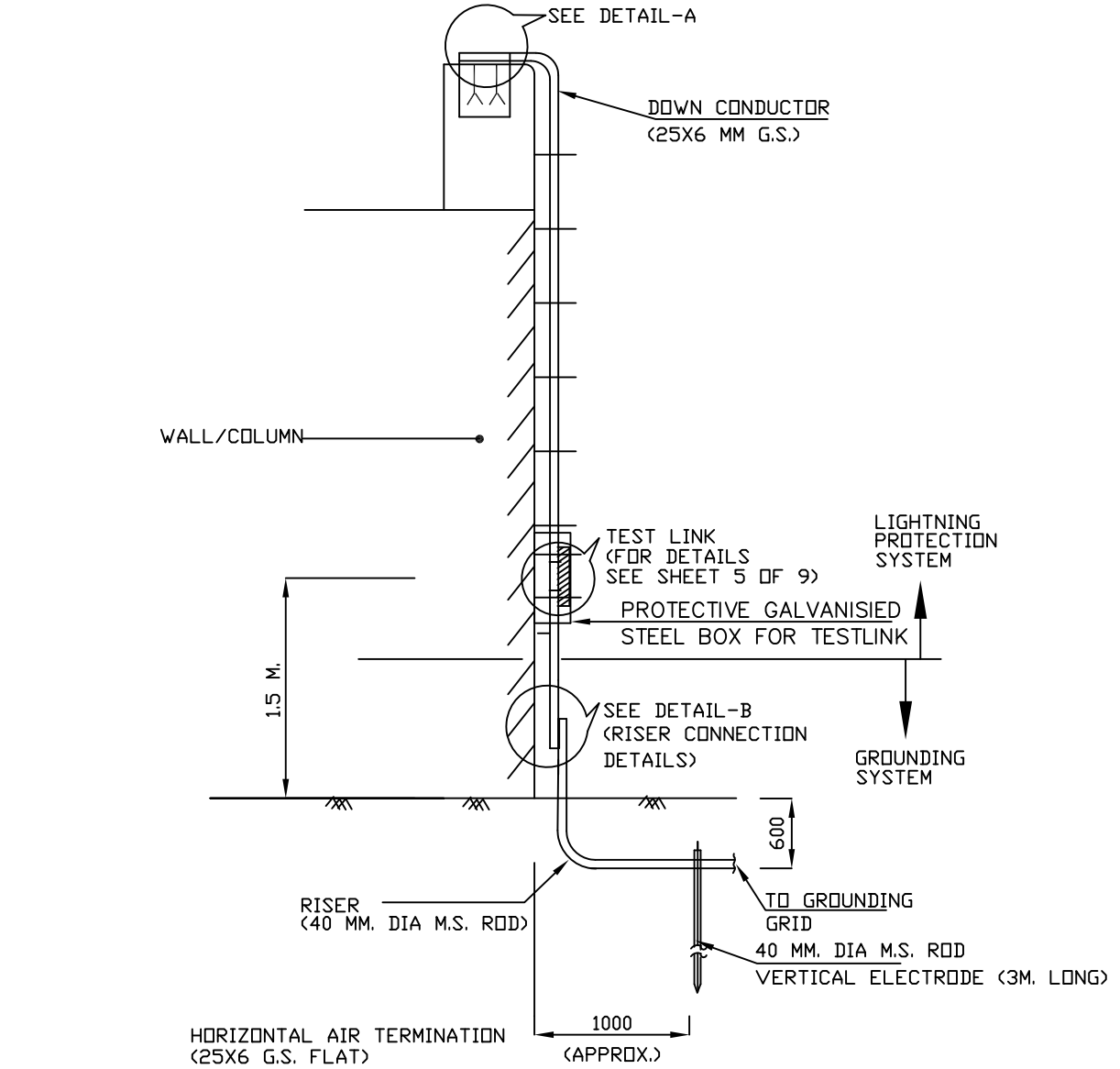
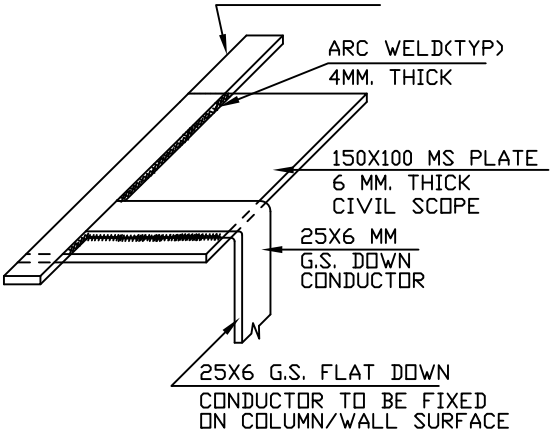
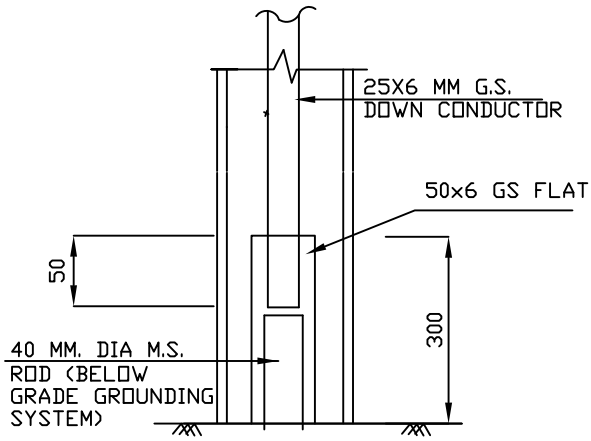




DETAIL-A



DETAIL-B

(RISER CONNECTION DETAILS)

TYPICAL DETAILS OF CONNECTION AMONG HORIZONTAL AIR TERMINAL, DOWN CONDUCTOR AND RISER

TITLE **TYPICAL LIGHTNING PROTECTION DETAILS**	BHEL DOCUMENT No. PE-DG-435-509-E006
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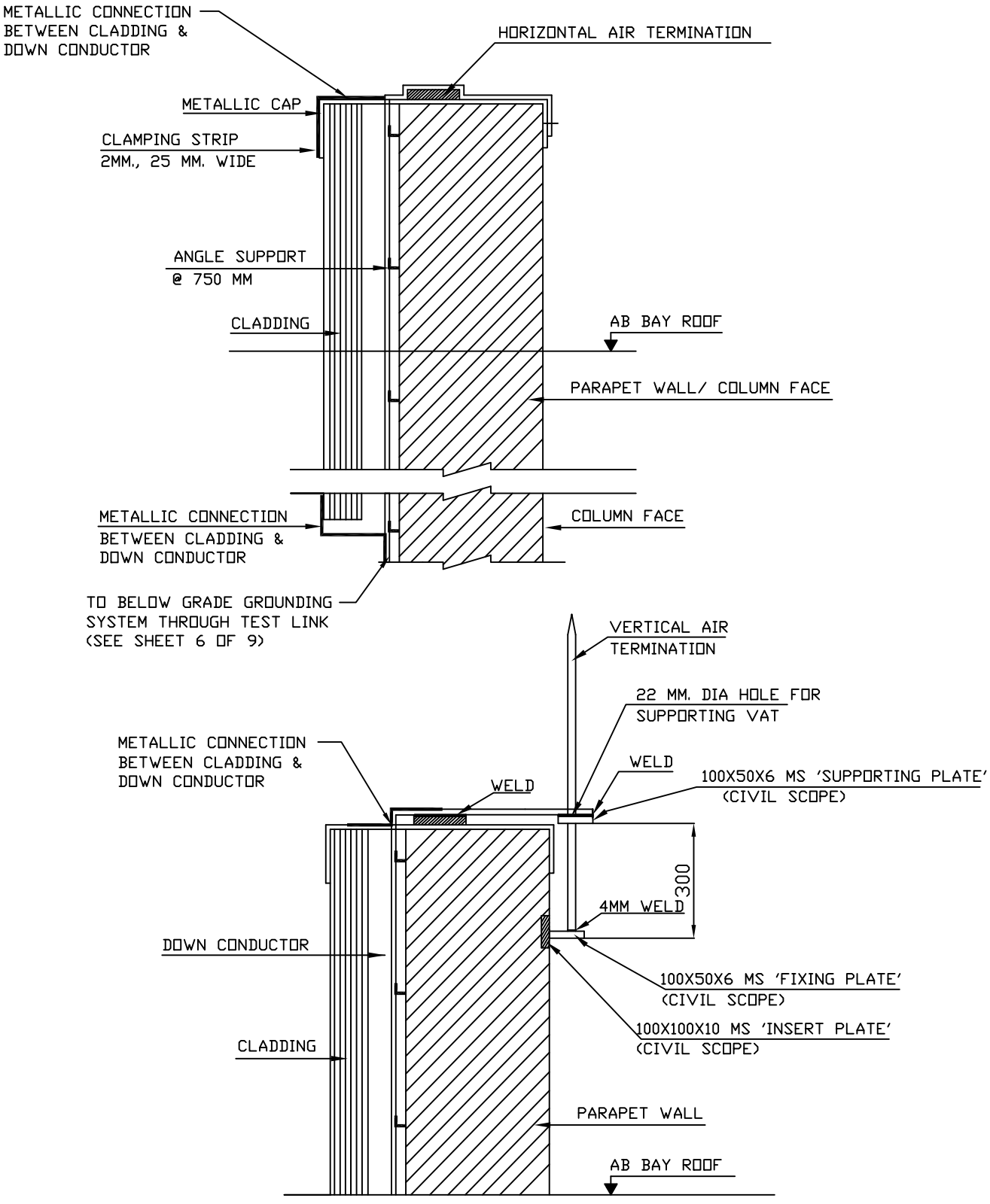

TYPICAL DETAILS OF CONNECTION AMONG

HORIZONTAL AIR TERMINAL, DOWN CONDUCTOR FOR 'A' ROW CLADDING

TITLE TYPICAL LIGHTNING PROTECTION DETAILS	BHEL DOCUMENT No. PE-DG-435-509-E006
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NOTES:–

1.0 AIR TERMINATIONS

1.1 HORIZONTAL/ VERTICAL AIR TERMINATION NETWORK WILL BE INSTALLED ON THE TOP OF ALL STRUCTURE/ BUILDINGS TO BE PROTECTED FROM LIGHTNING STROKES. THE INSTALLATION WORK SHALL BE DULY COORDINATED BY SITE WITH THE OTHER ACTIVITIES SUCH AS WEATHER PROOFING APPLICATION ON ROOF, ETC.

1.2 HORIZONTAL AIR TERMINATIONS SHALL BE OF 25MM x 6MM GALVANISED STEEL FLATS CLAMPED TO THE SURFACE AT EVERY 1000 MM. VERTICAL AIR TERMINATION'S SHALL BE 20 MM DIA GALVANISED MILD STEEL ROD 1000 MM LONG.

1.3 HORIZONTAL AIR TERMINATIONS NETWORK SHALL BE LAID AS PER IEC : 62305

1.4 THE VERTICAL AIR TERMINATION ROD WILL BE PROPERLY FIXED AS PER DETAILS GIVEN IN THE DRAWING ON THE TOP OF THE BUILDING/ STRUCTURE TO WITHSTAND VERY HIGH WIND PRESSURE. THE HORIZONTAL & VERTICAL AIR TERMINATIONS SHALL BE PROPERLY FIXED ON THE TOP OF ROOF OF THE BUILDINGS SUCH AS NOT TO MAKE THE PENETRATION IN THE WATER PROOFING LAYER

2.0 DOWN CONDUCTORS

2.1 THE DOWN CONDUCTORS SHALL BE 25MM X 6MM GALVANISED STEEL FLATS. ONE END OF DOWN CONDUCTORS SHALL BE CONNECTED TO THE VERTICAL/HORIZONTAL AIR TERMINATION NETWORK ON THE TOP OF ROOF/STRUCTURE AND THE OTHER END TO THE NEAREST EARTH TERMINAL. DOWN CONDUCTORS SHALL BE AS PER IEC : 62305

2.2 EACH DOWN CONDUCTOR WILL HAVE AN INDEPENDENT GROUND TERMINATION. IN NO CASE CONDUCTORS OF THE LIGHTNING PROTECTION SYSTEM WILL BE CONNECTED WITH THE CONDUCTORS OF THE GROUNDING SYSTEM ABOVE GROUND LEVEL.THE INDEPENDENT GROUND TERMINATION WILL COMPRISE OF A RISER CONNECTION FROM A 3000 MM LONG GROUND ELECTRODE (IN BHEL'S SCOPE) , WHICH IN TURN WILL BE CONNECTED TO THE BELOW GRADE GROUNDING SYSTEM. DETAILS OF THE ELECTRODE CONNECTION WITH EARTH MAT SHALL BE AS PER DRG No. PE–DG–435–509–E005 (TYPICAL BELOW GROUND EARTHING DETAILS).

2.3 THE CONNECTION BETWEEN EACH DOWN CONDUCTOR AND EARTH TERMINAL WILL BE MADE VIA A TEST LINK LOCATED AT APPROXIMATELY 1500MM ABOVE GROUND LEVEL.

2.4 THE DOWN CONDUCTORS WILL BE LAID STRAIGHT AND SHARP BENDS WILL BE AVOIDED AS FAR AS PRACTICABLE. THESE WILL BE FIXED ON THE OUTSIDE OF THE BUILDING WALL AND OR COLUMNS/STRUCTURES AT INTERVALS OF ABOUT 750 MM, AS INDICATED IN DRAWING.

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2.5 ALL EXPOSED METALLIC PARTS OF A BUILDING WILL BE BONDED TO THE DOWN CONDUCTORS. SUCH PARTS WILL INCLUDE LADDERS, BALCONIES, CONDUITS, METALLIC SHEET CLADDING, ETC.

2.6 NO NATURAL DOWN CONDUCTOR SHALL BE CONSIDERED, DEDICATED DOWN CONDUCTORS SHALL BE CONSIDERED FOR LIGHTNING PROTECTION ARRANGEMENT.

3.0 JOINTING

3.1 MINIMUM NUMBER OF JOINTS IN THE LIGHTNING CONDUCTORS WILL BE PROVIDED.

3.2 ALL THE JOINTS WILL BE DONE BY ARC WELDING PROCESS. OVERLAPPING OF CONDUCTORS AT STRAIGHT JOINTS WILL NOT BE LESS THAN 150MM. THE CONTACT SURFACES WILL BE PROPERLY CLEANED BEFORE JOINTING.

3.3 THOSE PORTIONS OF GALVANISED STEEL FLATS, WHICH HAVE BEEN WELDED AT SITE, SHALL BE COATED WITH TWO (2) COATS OF RED OXIDE PAINT FOLLOWED BY TWO COATS OF ZINC PAINT.

3.4 THE VERTICAL AIR WILL BE COATED WITH WEATHER RESISTANT ANTI-CORROSIVE PAINT. (ZINC CHROMATE FOLLOWED BY TWO COATS OF ALUMINIUM PAINT)

4.0 LIGHTNING PROTECTION SYSTEM INSTALLATION SHALL CONFORM TO IEC : 62305 (INTERNATIONAL STANDARD FOR PROTECTION AGAINST LIGHTINING)

5.0 AS PER IEEE : 142, STEEL TANKS (CONTAINING FLAMMABLE LIQUIDS OR GASES) WITH STEEL ROOFS OR FLOATING METAL ROOF HAVING STEEL THICKNESS OF 4.76 MM OR MORE ARE TO BE CONSIDERED SELF-PROTECTING TYPE AGAINST LIGHTNING, & SHALL BE PROVIDED WITH MINIMUM TWO EQUALLY SPACED CONNECTIONS TO THE NEAREST BELOW GRADE GROUNDING SYSTEM.

6.0 CONDUCTORS OF THE LIGHTNING PROTECTION SYSTEM SHALL NOT BE CONNECTED WITH CONDUCTORS OF SAFETY EARTHING OF ABOVE GROUND LEVEL.

7.0 REFERENCE DRAWINGS:

6.1 TYPICAL ABOVE GRADE GROUNDING DETAILS, PE-DG-435-509-E004

6.2 TYPICAL BELOW GROUND EARTHING DETAILS, PE-DG-435-509-E005

6.3 DESIGN MEMORANDUM FOR LIGHTNING PROTECTION SYSTEM, PE-DC-435-509-E003

TITLE	BHEL DOCUMENT No.
TYPICAL LIGHTNING PROTECTION DETAILS	PE-DG-435-509-E006
	REV. No. 00
	SHEET 9 OF 9

SECTION–3.23: ILLUMINATION SYSTEM

1.0.0 INTENT OF SPECIFICATION

This specification covers requirements of Illumination system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following for all plant buildings, non plant buildings, watch towers, boundary wall, roads, parking areas, outdoor areas, etc.

a) Light pipe solar lighting system (100 nos.)
b) Lighting fixtures
c) Aviation obstruction lights for chimney & cooling tower
d) Lighting distribution boards
e) Lighting panels
f) Receptacle panels
g) Receptacles
h) Minimum 25 nos. Lighting mast (Winch operated)
i) Lighting poles
j) Switchboxes
k) Junction boxes
l) Hand lamp units
m) Conduits
n) 100 nos. wall mounted fans
o) Ceiling fans
p) 25 nos. pedestal fans
q) Wires
r) Commissioning spares and consumables
s) Mandatory spares
t) Tools & tackles
u) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Indian Standards, IEC publications and other standards as listed, except where modified and / or supplemented by this specification. The design and testing shall follow the following standards.

a)	IS: 1777	Industrial luminaire with metal reflectors.
b)	IS: 1913	General and safety requirements for Luminaires.
c)	IS: 10322-5-5	Luminaires- Flood lights
d)	IS/IEC 60079 -1	Equipment Protection by Flameproof Enclosures "d"
e)	IS: 2149	Luminaires for street lighting.
f)	IS: 2206	Flame proof electric lighting fittings
g)	IS: 4013	Dust-light electric lighting fittings.
h)	IS: 8224	Electric Lighting fittings for Div. 2 areas.
i)	IS: 9583	Emergency lighting units.
j)	IS: 9974	High Pressure sodium vapour lamps.

k)	IS: 10322	Specification for Luminaires
l)	IS: 732	Electrical wiring installation (system voltage not exceeding 650 V).
m)	IS:5216	Guide for safety procedures and practices in electrical works.
n)	IS: 12640	Residual Circuit operated Circuit breakers.
o)	IS/IEC: 60947-1	low-voltage switchgear and control gear.
p)	IS/IEC:60898-1	Miniature circuit breakers
q)	IS/IEC 60715	Dimensions of low-voltage switchgear and control gear.
r)	IEC: 60309-1	Plugs, socket-outlets and couplers for industrial purposes
s)	IS/IEC 60529	Degrees of protection provided by enclosures (IP code)
t)	IS: 694	PVC insulated cables for working voltages up to and including 1.1 kV.
u)	IS: 9537	Conduits for electrical installation.
v)	IS: 3480	Flexible steel conduits for electrical wiring.
w)	IS: 1239	Mild steel tubes, tubular and other wrought steel fittings. (for size above 63 mm dia of rigid conduits)
x)	IS: 14768	Fittings for rigid steel conduits for electrical wiring.
y)	IS: 3837	Accessories for rigid steel conduits for electrical wiring.
z)	IS: 14772	Boxes for enclosures of electrical accessories.
aa)	CIE-173	Tubular day light guidance system

4.0.0 LIGHTING DESIGN

4.1.0 The plant lighting system shall comprise following categories :

- Tubular day light guidance system
- Normal 230 V AC Lighting System
- Normal-cum-Emergency 230 V AC Lighting System
- Emergency DC Lighting System

4.1.1 Tubular daylight guidance systems are linear devices that channel daylight into the core of a building. They consist of a light transport section with, at the outer end, some device for collecting natural light and, at the inner end, a means of distribution of light within the interior. Collectors may be either mechanical devices that actively focus and direct daylight (usually sunlight), or be passive devices that accept sunlight and skylight from part or whole sky hemisphere. The transport element is usually a tube lined with highly reflective or prismatic material or may contain lenses or other devices to redirect the light. Light is distributed in an interior by output components, commonly diffusers made of opal or prismatic material.

4.1.2 Normal AC lighting shall be provided by lighting distribution boards and lighting panel distributed throughout the plant. Supply to these lights shall be ON as long as the station AC supply is available. AC lighting fixtures shall be fed from respective area lighting panels. If fault level at lighting panel is more than 10 kA, lighting distribution boards shall be fed through 415/433 V ratio lighting transformers.

4.1.3 Emergency AC lighting shall be provided by DG set through unit emergency switchgear and lighting distribution boards. In main plant area, about 20% lighting shall be fed from AC emergency source.

4.1.4 In main plant area and other auxiliary plants, emergency DC lighting shall be provided in control rooms, in critical operating area, and for safe exit in case of black out. These lights shall be fed from DC distribution board backed by DC batteries. These lights shall be of LED type. DC lights shall remain continuously ON along with AC lighting system.

4.1.5 For Off-site buildings, where DC supply is not available, Emergency lighting units with integral batteries shall be used. Offsite area building emergency DC lighting shall be provided by self-contained emergency lighting fixtures. Each emergency fixture shall provide emergency light for

3-4 hours when the normal power source is lost. Each emergency light fixture shall be provided with Ni-cd gel battery, battery charger and two CFL lamps.

4.2.0 Tubular day light guidance system

4.2.1 The sunlight is captured from a transparent dome on the rooftop of a building and then the light travels through a daylight pipe (by way of multiple reflections from the daylight pipe's specular inside surface) to inside the building where sunlight is delivered to the indoor spaces through diffusers.

4.2.2 The transparent dome collects sunlight from above the roof level and then the daylight pipe guides the same to the interior spaces of a building. So, at the interface with open sky, the light pipe is provided with a transparent dome having the following attributes: adequate impact strength, sufficient daylight capture surface, high transmittance for the visible spectrum i.e. 400–750 nm, surface designed to scatter light uniformly; fire resistance, U-V stabilized, U-V blocking (up to 380 nm) and capable of preventing the ingress of moisture, dust, anti-bird measures, etc.

4.2.3 The light pipe system should have the following features: high impact strength; high transmittance for visible portion of sunlight spectrum i.e. 400–750 nm; purest color rendition (no color shift); U-V stabilized; U-V blocking (up to 380 nm); fire resistance; low attenuation of solar radiation while traversing the length of light pipe and any bends therein; minimal transmission of heat along with daylight; (preferably) low aspect ratio (length : diameter); and arrangement for control of available sunlight. For negotiating non-straight paths, light pipe bends should also be available. The daylight pipe and associated items are required to be maintenance free.

4.2.4 The diffuser should be designed so as to achieve the following goals: transmittance of required amount of daylight and to spread it efficiently throughout the space to be illuminated; there should be no glare; visual comfort; 99% U-V blocking (up to 380 nm); resistance to impact; fire resistance; prevent ingress of moisture and dust; U-V stabilized; control of light output, including switching off the light during daytime.

4.2.5 While installing the daylight pipe, correct type of roof flashing should be used so that no ingress of water, dust, etc. takes place at the junction between masonry work and daylight pipe. The dome, light pipe and diffuser should be electrostatically neutral during installation.

4.3.0 Lighting shall be provided in all the areas of power plant. Lux level proposed are given below:

S. No.	Area	Lux level
1.	Turbine Hall (operating floor)	200
2.	Turbine Hall other floors	100
3.	Boiler Platforms & ESP platforms	100
4.	Switch gear /MCC rooms, Battery room, DG Room, Elevator machine room	200
5.	Transformer yard	50
6.	Gas insulated switchgear building	200
7.	Control room	400/500
8.	Control equipment room	300
9.	Office area	300
10.	Air compressor house	150

S. No.	Area	Lux level
11.	Crusher house, Transfer tower and other indoor areas of coal handling plant	150
12.	Pump houses, WTP area, Chlorination building, AHU room	150
13.	Sea water intake pump house	150
14.	Main Road	20
15.	Secondary Roads	10
16.	Cable galleries	100
17.	Stair cases, Passages, Toilets	100
18.	Stockyard	30
19.	Conveyors	50
20.	Tank area and outdoor equipment location	20
21.	Chimney platforms	100

4.4.0 For indoor Areas, average lumen method shall be adopted to calculate luminance. Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries' surface dirt and room surface dirt, etc.

- Air-conditioned clean interiors such as office rooms, Control and Electrical room : 0.8
- Clean interiors such as office rooms, laboratories : 0.75
- Industrial areas with normal interiors such as workshops. : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors : 0.5

4.5.0 Lighting level design shall also include the coefficient of utilization factor as calculated from table of reflectance provided by manufacturer for respective type of fixture.

4.6.0 For Outdoor flood lighting design, 'point by Point' method shall be adopted based on computer aided design package of the Contractor software. Uniformity in horizontal illuminance Emin/Eavg should be greater than 0.25.

4.7.0 Lighting for chimney

4.7.1 Chimney shall be provided with aviation obstruction lights. Aviation obstruction lights shall meet the requirements of Annexure-14 of 'International Civil Aviation Organization' (ICAO). Lights shall be of high intensity type or combination of medium intensity and low intensity. In case of later option, day time marking shall be provided on chimney as per the requirements of ICAO.

4.7.2 Number of levels of installation for obstruction lights shall be provided as per ICAO. Four lights shall be spaced at quarter points around the chimney at each elevation level. Photoelectric lighting controls shall adjust the lighting to one of three illumination levels depending on ambient light conditions (daylight, twilight, or night). All obstruction lighting fixtures shall be suitable for lamp replacement from internal platforms. Necessary swing door arrangement shall be provided for aviation obstruction lights.

4.7.3 Temporary aviation lights shall be installed above the top most point of the obstruction as construction progresses. This arrangement shall continue to exist till permanent arrangement to provide such lights are completed.

4.7.4 Aviation obstruction lighting shall be powered from AC emergency power supply.

4.7.5 Lighting shall be provided for various platforms and ground floor. Lighting fixture with LED lamps shall be provided to have maintenance free installation.

4.8.0 Aviation obstruction lights for natural draught cooling tower (NDCT)

4.8.1 NDCT shall be provided with aviation obstruction lights. Aviation obstruction lights shall meet the requirements of Annexure-14 of 'International Civil Aviation Organization' (ICAO). Lights shall be of medium intensity type.

4.8.2 Number of lights at each level shall be provided as per ICAO. Photoelectric lighting controls shall adjust the lighting to one of three illumination levels depending on ambient light conditions (daylight, twilight, or night).

4.8.3 Temporary aviation lights shall be installed above the top most point of the obstruction as construction progresses. This arrangement shall continue to exist till permanent arrangement to provide such lights are completed.

4.8.4 Aviation obstruction lighting shall be powered from AC emergency power supply.

4.9.0 LIGHTING CONTROL

4.9.1 Switch control shall be provided for controlling lighting fixtures located indoor.

4.9.2 Electric power to light fixtures located outdoors shall be switched with photoelectric controllers and timers. Provision shall be made to bypass the photoelectric controller and timer. For Road lighting, alternative lighting fixtures shall be fed from different phases.

4.9.3 Load on each lighting circuit and single phase receptacle circuit shall be limited to about 1500 W and the number of luminaries connected to lighting circuit shall be limited to about fifteen (15).

4.9.4 Electronic ballasts shall be provided for fluorescent fittings. For main plant control room, low loss copper ballast shall be provided. All the fixtures shall be provided with rapid start lamps and long life ballasts.

4.9.5 At least one 6/16 ampere, 230 volt AC universal socket outlet with switch shall be provided in offices, cabins, etc. In service building, atleast 4 nos. 5 Amp plug points shall be provided in each cubicle. Receptacles with decorative cover plates shall be used in office / Control rooms.

4.9.6 20 Amp, 230 V, Single phase convenience receptacle with switch shall be provided in plant area. The convenience outlets shall be spaced to provide access to any point in the interior industrial areas with a 25 meter extension cord.

4.9.7 63 Amp, 415 V, 3 phase welding receptacle with switch shall be provided in plant area. The receptacles shall be provided in all the floors of power house building at 50 m interval along A-row and B-row. Further in Boiler at alternate floors, welding receptacles shall be provided. In ESP top platform welding receptacle at 100 m interval shall be provided. In chimney at alternate floors, welding receptacles shall be provided. In outdoor locations, in the vicinity of major equipment, welding receptacles shall be provided. In pump houses, water treatment plant, compressor house, coal crushers, mill bay, coal transfer towers, ash handling plant, fuel oil pump house, H2 plant, GIS building, Switchyard, etc., minimum one welding receptacle shall be provided at each elevation at each enclosed area. In Transformer yard, 4 nos. 63 Amp welding receptacle and 4 nos. 250 Amp receptacle with MCCB unit shall be provided to extend power for oil filtration units during maintenance.

4.9.8 Each receptacle panel shall be provided with one earth leakage circuit breaker rated 30 mA in outgoing circuits.

4.9.9 In areas with hazardous atmospheres such as Hydrogen generation plant, fuel oil pump house, oil decanting pump house, lighting and convenience outlets shall be flame proof type. Receptacles located in Conveyor galleries shall be flame proof type.

4.9.10 Wall mounted fans shall be provided for all cubicles of admin building, service building, laboratories and other non-plant buildings.

4.9.11 Search lights of halogen lamps having adequate coverage shall be provided in watch towers.

5.0.0 EQUIPMENT DESCRIPTION

5.1.0 LIGHTING FIXTURES

5.1.1 For all service building, admin building, laboratory, conference rooms, SWAS room etc., LED lamp light fittings shall be used.

5.1.2 For other buildings/installations having room height of up to 5 metre, Fluorescent light fittings of following types shall be used:

- Industrial trough type/Industrial General purpose Rail type for all industrial areas
- Corrosion proof type for battery room and chemical areas, etc.,
- Anti-glare mirror optic type for Control rooms housing VDUs.
- Mirror optic type for other Control rooms.

5.1.3 In false ceiling areas, type of light fixtures shall suit the type of false ceiling provided.

5.1.4 For low bay and medium bay areas, LED light fittings of well glass / medium bay type shall be used for the installations having room height of above 5 metre.

5.1.5 For high bay areas, light emitting plasma (LEP) light fittings shall be provided.

5.1.6 For outdoor areas involving road lighting and flood lighting, light emitting plasma (LEP) light fittings shall be provided.

5.1.7 Road lighting / Flood lighting poles shall be of galvanised steel pole. Each Street lighting pole/Flood lighting pole shall be provided with MCB protection.

5.1.8 Winch operated high mast lighting shall be provided in select outdoor areas such as transformer yard, switchyard, coal yard, stock yard, fuel tank farm etc.

5.1.9 For DC lighting LED lights shall be used.

5.1.10 Flame proof equipment shall be provided in H2 plant, coal tunnels, underground conveyor gallery, and Fuel Oil unloading & forwarding areas.

5.1.11 AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of ± 10%, frequency variation of ± 5% and combined voltage and frequency variation of absolute sum of 10%. DC lighting fixtures and accessories shall be suitable for operation on 220 V, DC with variation between 190 V & 240 V.

5.1.12 Power factor of fluorescent lamp fixtures shall be not less than 0.90. Suitable power factor improving capacitors shall be provided for this purpose. Capacitors shall be hermetically sealed in aluminium enclosures to prevent seepage of impregnate & ingress of moisture.

5.1.13 Luminaires shall meet atleast Electrical safety class-I as per relevant IEC.

5.1.14 The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.

5.1.15 Twin fluorescent lamp fixtures shall be wired in lead lag circuit to minimise stroboscopic effect.

5.1.16 High bay fixtures shall be suitable for pendant mounting and provided with safety chains.

5.1.17 Fluorescent Tubular Lamp shall be 36 Watt rated, cool day light type with Triband Phosphor having lumen output of 3250 lumens.

5.1.18 High Frequency Electronic ballast shall be suitable for 1X36 Watt FTL / 2X36 Watt FTL. Operation at high frequency shall increase lumen output. It shall conform to IS 13021 (Part I). It shall have following features:

- System loss less than 4 Watt.
- Circuit power factor 0.95 or better
- No humming noise.
- Protected against mains disturbances.
- Automatic cut off protection for a de-activated tube.

5.1.19 Copper Ballast shall be low loss design, copper wound, silicon lamination, manufactured using Vacuum pressure impregnation technology. Winding temperature shall not exceed 70 degC over an ambient of 50 deg C.

5.1.20 Recommended luminaries at various places are listed below :

Sl. No.	Area	Type of Luminaries
1	Turbine Hall operating floor	LED high bay
2	Turbine building other floors	LED Medium bay/ well glass
3	Switch gear /MCC rooms	Fluorescent industrial fixture
4	UPS, Battery charger room,	Fluorescent industrial fixture
5	Lead acid battery Room	Corrosion proof fluorescent fixture
6	Boiler area/ESP area	LED well glass
7	Cable galleries	LED well glass fixture
8	Stair cases, Passages, Toilets	Fluorescent rail type fixture/Mini lights
9	Office	Mirror optics, decorative Fluorescent fixture
10	Chemical house/ Chlorination plant	Fluorescent Corrosion proof surface-bracketed mounted
11	Control rooms with PCs/VDUs	Mirror optics non-glare type Fluorescent fixture
12	Air compressor house	LED Medium bay
13	GIS building	LED Medium bay
14	Water treatment plant/ DM plant	Fluorescent industrial fixture / LED / well glass
15	Fuel oil Pump House	Flameproof luminaries
16	DG Room	LED well glass fixture

Sl. No.	Area	Type of Luminaries
17	Emergency 220 V DC Lighting	DC LED Lamps
18	Transformer yard / Outdoor Area	LEP plasma type flood lighting fixtures on steel poles / Masts
19	Pump houses	LED Medium/LEP plasma High bay
20	Roads	LEP plasma type street light fixtures on galvanized Steel poles

5.2.0 Lighting distribution board

Lighting distribution board shall comprise, TPN MCCB as incomer and required no.of TPN MCCB feeders as outgoing feeders to feed lighting panels and receptacle panels. Construction of lighting DB shall be similar to ACDB and is detailed in LV switchgear section.

5.3.0 Lighting Panels & Receptacle Panel

5.3.1 The panels shall be rated for 415 V, 3 phase, 4 wire, AC with neutral bus and suitable for either wall/column mounting. Indoor panels shall have degree of protection of IP 54 and outdoor type shall have degree of protection of IP 55 and shall have a sloping canopy. Panels shall be constructed from CRCA sheet. Sheet thickness shall be 2.0 mm.

5.3.2 Miniature circuit breakers (MCB) shall have thermal elements for overload protection and an instantaneous magnetic trip to protect against severe faults. All MCBs provided shall be suitable for breaking capacity of 10 kA (minimum) at 240 V AC.

5.3.3 Contactors shall be of the air break type fitted with arc shields. Time switch shall be suitable for automatic switching ON and OFF of street lighting / flood lighting circuits. Time switch has 00 - 24 hours clock base. Time switch shall indicate actual time and shall permit accurate time setting. Time switch shall be provided with Ni-Cd gel battery.

5.3.4 Lighting panel shall be provided with 415 V AC, 63 Amp, TPN MCB with ELCB as incomer, required nos. of 20 A, 240 V AC, single pole MCBs for outgoing circuits, Separate neutral at terminal block for each outgoing circuit.

5.3.5 DC lighting panel shall be provided with 220 V DC , 63 Amp, DP MCB isolator as incomer, required nos.of 20 A, 220 V DC, double pole MCBs for outgoing circuits.

5.3.6 Street lighting panel shall be provided with 415 V AC, 63 Amp, TPN MCB isolator as incomer, 63 Amp Three pole AC Contactor, 00 - 24 hours timer and a photo-electric switch for automatic switching of contactor, a by-pass switch for timer/photo switch, 6 Nos. 20 A, 415 V AC, TPN MCBs for outgoing circuits, Separate neutral at terminal block for each outgoing circuit. One number light sensor in weather proof enclosure having IP: 55 degree of protection shall be installed separately with necessary interconnecting cable for each street lighting panel. Additionally 100% sensors shall be supplied for future use

5.3.7 Receptacle panel shall be provided with 415 V AC, 63 Amp, TPN MCB with ELCB as incomer, 6 Nos. 20 Amp, 240 V AC, single pole MCBs for outgoing circuits, Separate neutral at terminal block for each outgoing circuit.

5.4.0 Three Phase Industrial Receptacles

The receptacle shall be of 63 A, industrial heavy duty insulated type with 5 pin (with earth connection) suitable for 415 V, 3 phase, 50 Hz supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic enclosure of IP-55 protection

class. Socket shall be provided with safety cover. Terminal blocks of adequate rating shall be provided for incoming/loop-in-loop out connection.

5.5.0 Three Phase Flame proof Industrial Receptacles

The receptacle shall be of 63 A, industrial heavy duty insulated type with 5 pin (with earth connection) suitable for 415 V, 3 phase, 50 Hz supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic flame proof enclosure of IP-65 protection class. Socket shall be provided with safety cover.

5.6.0 Single Phase Industrial Receptacles

The receptacles shall be heavy duty type rated for 20 A, 240 V AC supply he receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic enclosure of IP-55 protection class. Socket shall be provided with safety cover. Terminal blocks of adequate rating shall be provided for incoming/loop-in-loop out connection.

5.7.0 Single Phase Flame proof Industrial Receptacles

The receptacles shall be heavy duty type rated for 20 A, 240 V AC supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic flame proof enclosure of IP-65 protection class. Socket shall be provided with safety cover.

5.8.0 Flush type indoor receptacles

Flush type 3 pin, 6/16 A, 240 V AC sockets shall be provided for office rooms and control rooms. The receptacle shall be complete with 16 A modular type switch & safety shutter. It shall be housed in suitable thermoplastic enclosure.

5.9.0 Lighting mast

5.9.1 Each Lighting Mast shall be 20 to 30 M high, complete with the following accessories.

- High mast shaft in two/three section, hot dip galvanised
- Head frame, steel wire rope & double drum winch.
- Galvanised Lantern carriage arrangement
- Integral power tool installed inside base compartment for its operation.
- Foundation bolts
- Luminaires
- Aviation obstruction light with 2 nos. LED lamps.
- Control panel
- Power & control cables and cabling accessories required for the installation.
- Special tools & tackles

5.9.2 The High mast shall be of continuously tapered, polygonal cross section, at least 20 sided, presenting a good and pleasing appearance and shall be based on proven design to give an assured performance, and reliable service. The entire fabricated mast shall be hot dip galvanized, internally and externally, having a uniform average thickness of atleast 85 microns.

5.9.3 An adequate door opening shall be provided at the base of the mast and the opening shall permit clear access to equipment like winches, cables, plug and socket, etc. and also facilitate easy removal of the winch.

5.9.4 A fabricated Lantern Carriage shall be provided for fixing and holding the flood light fittings and control gearboxes. The lantern carriage shall be of steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grommets.

5.9.5 The winch shall be completely self-sustaining type, without the need for brake shoe, springs or clutches. Each driving spindle of the winch shall be positively locked when not in use, gravity activated PAWLS. Individual drum also shall be operated for fine adjustment of lantern carriage. The minimum-working load shall be not less than 750 kg. The winch shall be self-lubricating type by means of an oil bath and the oil shall be readily available grades of reputed producers.

5.9.6 The suspension system shall essentially be without any intermediate joint and to consist of only non-corrodible stainless steel of AISI 316 grade. The breaking load of each rope shall not be less than 2350 kg, giving a factor of safety of over 5 for the system at full load. The thimbles shall be secured on ropes by compression splices.

5.9.7 A suitable, high-powered, electrically driven, internally mounted power tool with motor, with manual over ride shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The power tool shall be of single speed, provided with a motor of the required rating. The power tool shall be supplied complete with suitable control.

5.10.0 Lighting poles

Lighting pole shall be octagonal type, galvanized steel, supplied with base plate, foundation bolts, and necessary fixing-bracket for fixing the luminaire. Street lighting pole shall have integral junction box. All poles shall be provided with heavy square nuts on the anchor bolts under the pole base plate and hex nuts on the top. GI conduits shall be embedded in muff for incoming and outgoing cables. Height of poles shall be about 10 m. Junction box shall be integral to the pole, supplied along with MCB and neutral link.

5.11.0 Wires

XLPE/PVC insulated wires shall have multi stranded copper conductor. Wires shall be of 1.5 sq.mm/2.5 sq.mm/4 sq.mm sizes. The insulation material shall be resistant to flame, oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling. Wires shall have following colors.

- Red for R phase
- Yellow for Y phase
- Blue for B phase
- Black for Neutral
- Yellow-Green for Earth wire
- Grey & white for positive and negative connections respectively.

5.12.0 Rigid Conduits and Fittings

Rigid conduits shall conform to the requirements of IS: 9537 (Part I & Part II). However conduits above 63 mm diameter shall conform to the requirements of IS: 1239. All conduits and pipes shall be of medium duty. The rigid conduits shall be hot dip galvanized inside and outside. Weight of zinc shall be as per IS: 4759. Conduits shall be thoroughly cleaned and pretreated, conforming to IS: 6005.

Conduit fittings shall be made out of tube or cast to the shape as to match with corresponding conduit sizes. All fittings shall be screwed type and hot dip galvanized inside and outside.

In corrosive areas, epoxy coated conduits shall be provided.

5.13.0 Flexible Metallic Conduits and Fittings

Flexible metallic conduits shall conform to the requirements of IS: 3480. Flexible conduits shall be made of strip steel which shall be of cold rolled mild steel. The strip shall be of uniform width and thickness throughout. The strip shall be electro galvanized to a minimum thickness of 25 microns. The surface of the strip shall be thoroughly cleaned before application of protective coating. Pretreatment, before galvanization, shall conform to IS: 6005. Flexible conduits shall be supplied with suitable end coupler nipple and check nut.

5.14.0 GI pipes shall be of medium duty as per IS: 1239

5.15.0 Hume pipes shall be of reinforced concrete conforming to class NP3 for road crossings as per IS: 458.

5.16.0 Switch Boxes

The switch boxes shall be of surface/flush mounting type with steel construction. Switch boxes shall have conduit knock out on the sides. The switches shall be of quick make and quick break type and shall be of modular type. Where required, 3 pin 240 V type receptacles shall be provided with safety shutter and modular switch in the switch box. The switch box shall be flush mounted in places such as control rooms and office rooms.

Switches furnished shall be 6 or 16 Amps, 240 Volt totally enclosed modular type with side connected screw type terminals, phenolic compound housing and operating levers, and single mounting yoke design.

Switches used for switching direct current shall be 10 amperes, 240 Volt T-rated AC/DC switches.

5.17.0 Lighting Junction Box

The junction boxes shall be of FRP weather proof type. 650 Volt grade multiday terminal blocks complete with screws, nuts, washers and marking strips shall be furnished for connection of incoming/outgoing wires in the junction boxes. The Junction box shall be suitable for mounting on wall/column/poles/masts.

5.18.0 Hand lamp units (24 V Supply Module)

Hand lamp unit shall comprise 240/24 V transformer with 3 pin 24 Volt hand lamp socket. Required MCB protection shall be provided at the incomer. The unit shall be enclosed in sheet steel enclosure. 24 V hand lamp with guard and flexible cord of atleast 15 Metre length shall be supplied as specified. Module shall be portable box type suitable for providing local lighting requirements during maintenance and inspection.

5.19.0 Fans

Ceiling fans shall be of reputed make, BIS approved, 1200 mm sweep complete with copper wound, class E insulated motor, and three nos. balanced blades, suspension rod, canopy and other accessories conforming to applicable IS. Ceiling fans shall be supplied with a wall mounted controller to turn the fan on and off and to vary the fan speed from 0 to 100%. Controller shall be Electronic type free from humming noise.

Pedestal fans shall be of reputed make, BIS approved, 500 mm sweep, complete with aluminium blades, cast iron base, copper wound, class E insulated motor, support column, control switch and other accessories conforming to applicable IS.

6.0.0 INSTALLATION

6.1.0 The bottom of wiring devices shall be mounted the following distances above the finished floor.

Wiring Devices	Location	Distance above Floor (minimum)
Receptacles	Offices and finished areas	500 mm
Receptacles	All other locations	900 mm
Switches	All locations	1500 mm
Ceiling fan control	All locations	1500 mm
Ceiling fans	All locations	2500 to 3000 mm

6.2.0 The location of the light fittings, receptacles, switches, etc. shall be such as to avoid interference with piping / ventilation ducts / busduct or other equipment and to avoid objectionable shadows and glare.

6.3.0 In false ceiling areas the switchgear and the conduits shall be recess mounted.

6.4.0 In all Office rooms & Control rooms conduit shall be concealed type. In, admin building, canteen, dispensary, , concealed conduit wiring shall be adopted.

6.5.0 Wooden plugs in walls and ceilings for fixing of lighting fixtures and accessories are not acceptable. Nylon rawl plug shall be offered.

6.6.0 In the rooms where false ceilings are provided, the lighting fixtures shall be supported separately by false ceiling grid over false ceiling if it is of steel structural or from ceiling or from cable trough / channel and not by the false ceiling board. The arrangement shall be to the approval of Owner.

6.7.0 A four (4) way terminal junction box shall be provided near each lighting fixture, for loop-in, loop-out and off connection of lighting wires or as required.

6.8.0 Conduit shall be routed at least 150 mm from the insulated surfaces of hot water, steam pipes and other hot surfaces. Where conduit must be routed parallel to hot surfaces, special high temperature cable shall be used.

6.9.0 Conduits supports shall be provided at an interval of 750 mm for horizontal runs and 1000 mm vertical runs.

6.10.0 Conduit shall be clamped on to approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs.

6.11.0 Wiring for indoor Lighting installation shall be carried with insulated wire following sizes laid in Galvanised steel conduit of

- Lighting Panel to lighting Fixtures : 2.5 sq.mm copper
- Lighting Panel to Switch box : 2.5 sq.mm copper
- Switch box to lighting Fixtures : 1.5 sq.mm copper
- Lighting Panel to Sockets : 4 sq.mm copper

6.12.0 Voltage drop in the cable shall be limited as follows,

- Lighting panel to lighting fixtures :3%
- Switchbox to lighting fixtures :1.5%

- Lighting panel to socket :3%
- Lighting panel to switch box :1.5%

6.13.0 For outdoor lighting & road lighting, XLPE insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed cables shall be provided.

6.14.0 Wiring for lighting circuits of Normal AC system, Emergency AC System and DC system shall run in separate conduits.

6.15.0 Wiring for lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits.

6.16.0 Two different phase circuits shall not be laid in the same conduit.

6.17.0 Ceiling fans with variable speed electronic regulators shall be installed in the non-air-conditioned areas as specified.

6.18.0 Ceiling Fans & pedestal fans for of required size and quantity to be provided in individual rooms / areas like Workshop, Stores, Office building / areas, Service building, etc.

6.19.0 Receptacles and lighting circuits shall be fed from different circuits. The switch controlling these circuits shall be on the live side (phase wire) of the circuits.

6.20.0 Wiring shall be spliced only at junction boxes. Maximum two wires shall be connected at each terminal.

6.21.0 Lighting branch circuits, telephone circuits, and intercommunication circuits shall be routed in conduit. Lighting circuits shall be routed in electrical metallic tubing (EMT) for indoor areas, rigid conduit for hazardous and outdoor areas.

6.22.0 All conduit system shall be sized considering fill criteria specified in IS: 732.

6.23.0 Each lighting poles and lighting / lightning mast junction box shall be earthed by 25 x 3 mm GS flat bonded to one (1) 20 mm dia MS earth electrode of 3 meter length driven vertically in the ground.

6.24.0 The lights shall not be fixed at gantry. In buildings it shall be fixed with suitable fixtures and not directly on the walls.

6.25.0 One (1) no. of mini truck mounted with adjustable hydraulic lift for the maintenance of street lights.

6.26.0 For the maintenance of lighting fixtures within the high bay areas, four (4) nos. free standing adjustable aluminium ladder, adjustable from 5 m to 10 m shall be provided.

6.27.0 Three nos. Portable Aluminium Ladders of various sizes suitable for main control room, switchyard control room etc., shall be provided.

7.0.0 TESTS

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

8.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Illumination design calculation
- Tubular day light guidance system
- GA drawing and single line diagram of lighting distribution board
- GA drawing and single line diagram of lighting panel & receptacle panels
- GA drawing of poles and masts
- GA drawing of receptacles
- General arrangement drawings of lighting fixtures
- Lighting design software
- Technical data sheet
- Test reports
- Catalogues
- Illumination layout for Transformer Yard
- Illumination layout for GIS building
- Illumination layout for switchyard control building
- Illumination layout for Switchyard
- Illumination layout for Power house building
- Illumination layout for Boiler and mill bay
- Illumination layout for ESP
- Illumination layout for plant roads
- Illumination layout for Main control building
- Illumination layout for Control room
- Illumination layout for outdoor yards
- Illumination layout for coal handling plant
- Illumination layout for Ash handling plant
- Illumination layout for Water treatment plant
- Illumination layout for Chimney
- Illumination layout for Cooling tower
- Illumination layout for Sea water intake system
- Illumination layout for Fuel handling system
- Illumination layout for CWPH
- Illumination layout for Electro chlorination plant
- Illumination layout for other auxiliary plant buildings
- Illumination layout for Admin building
- Illumination layout for Service building
- Illumination layout for Watch tower
- Illumination layout for Boundary wall
- Illumination layout for other non-plant buildings
- Illumination and Small power distribution arrangement
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan