## BOQ\_ANNEXURE\_2

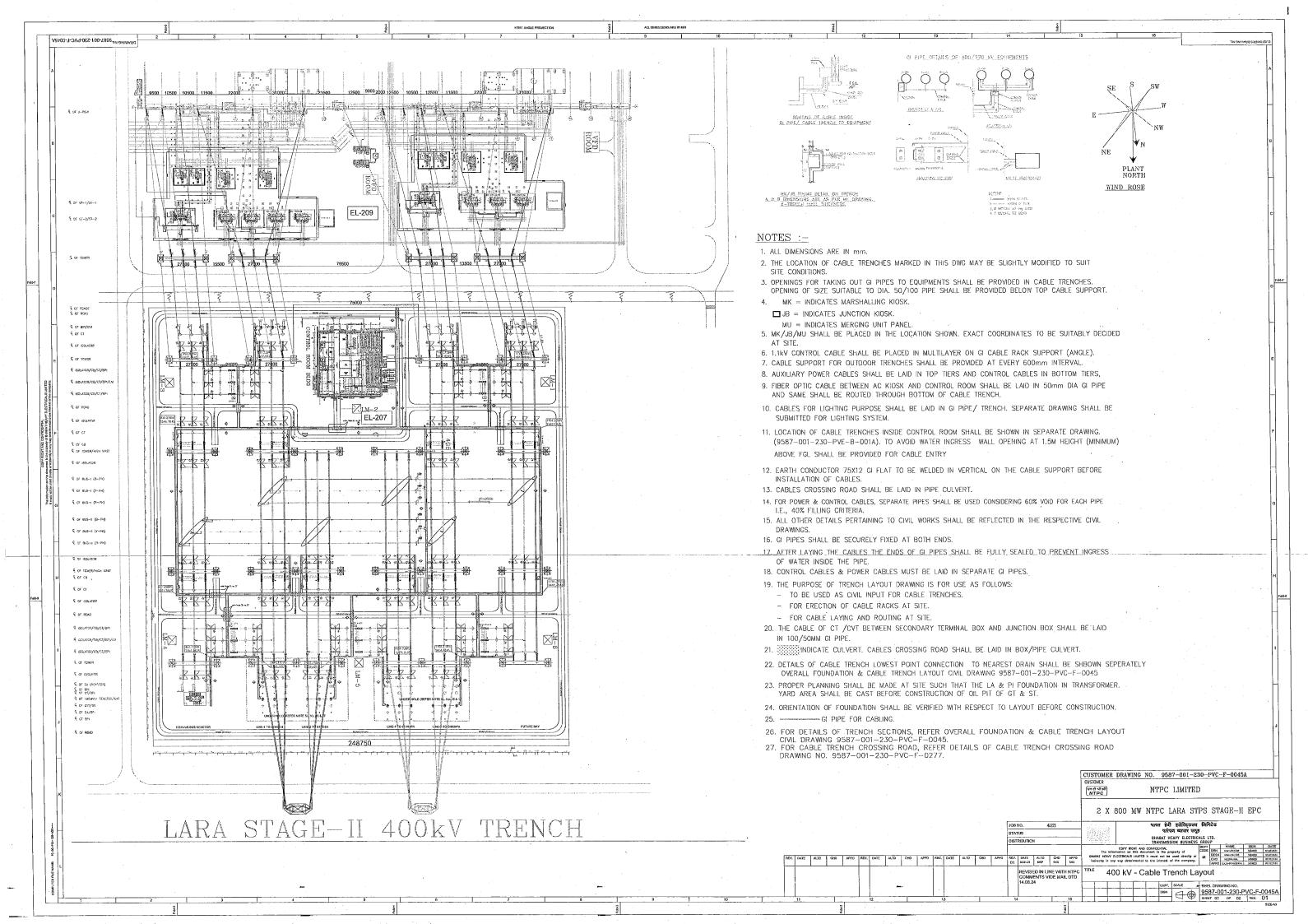
## **PROJECT SPECIFIC DRAWING & DOCUMENT LIST**

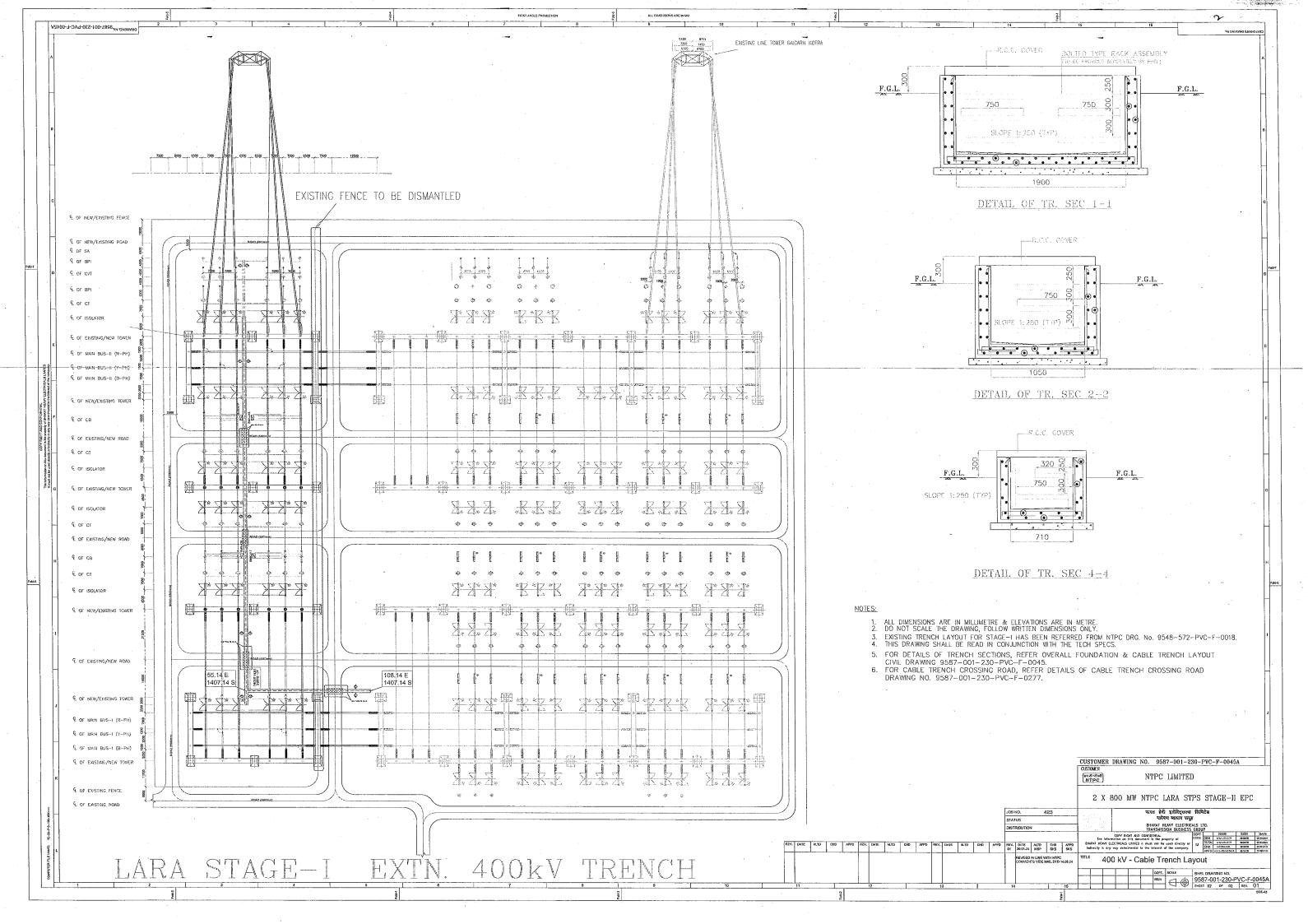
SI. No.	DRAWING / DOCUMENT NUMBER	DRAWING / DOCUMENT TITLE
1	9587-001-230-PVE-P-0002, REV-02	400 kV Switchyard Single Line Diagram
2	9587-001-230-PVE-F-0013, rev-04	400kV Layout Plan & Section
3	9587-001-230-PVC-F-0045A rev-01	400 kV - Cable Trench Layout
4	9587-001-230-PVE-F-0038, REV-02	400 kV - Equipment Earthing Philosophy & Details
5	Annexure-Aluminium_Welding	PROCEDURE FOR WELDING OF ALUMINIUM BUSES
6	TB-XXX-618-002a	TECHNICAL SPECIFICATION FOR EQUIPMENT FIXING HARDRWARE
7	Annexure-TRF	N2 FILLING/ VACCUMING/ PURGING AND HEATING (IF REQUIRED) AS PER BHEL BHOPAL PROCEDURE FOR
	Annexure-TRF	TRANSFORMERS/ REACTORS
8	TB-XXX-316-041-REV 02	TECHNICAL SPECIFICATION-PVC PIPES & BENDS
9	TB-XXX-316-040-REV 02	TECHNICAL SPECIFICATION-GI PIPES & BENDS
10	ANNEXURE-ILLUMINATION	BILL OF QUANTITY OF ILLUMINATION ITEMS
11	ANNEXURE-MANDATORY SPARES	BILL OF QUANTITY OF MANDATORY SPARES

## Note:

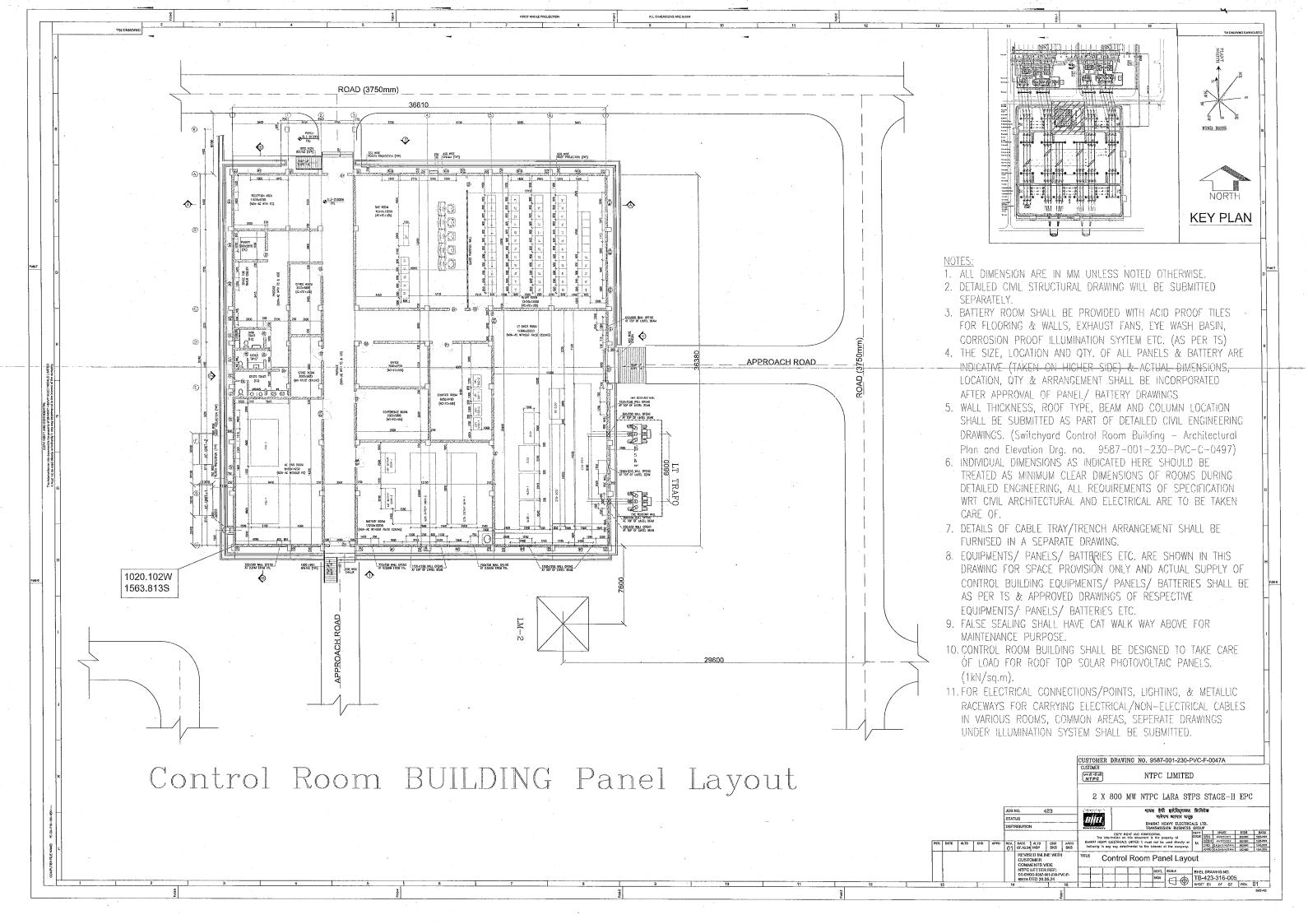
- Above drawings are given for reference purpose. Latest revision of above drawings will be shared with successful bidder, which is to be followed, during contract 1 execution stage.
- Any other drawing/document related to BOQ line item will be shared with successful bidder during detailed engineering stage. 2

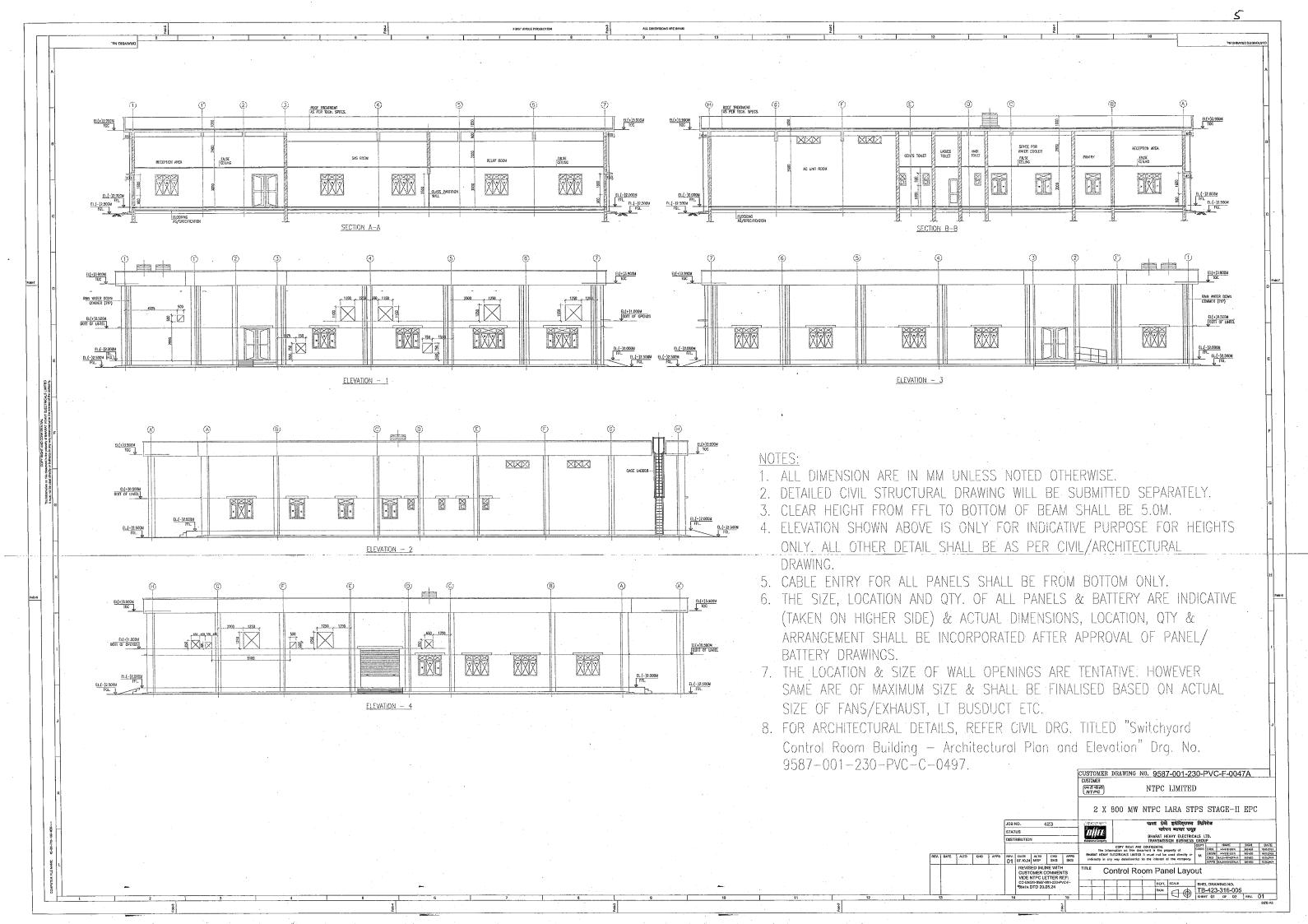
BOQ\_ANNEXURE\_2 PAGE 1 OF 1

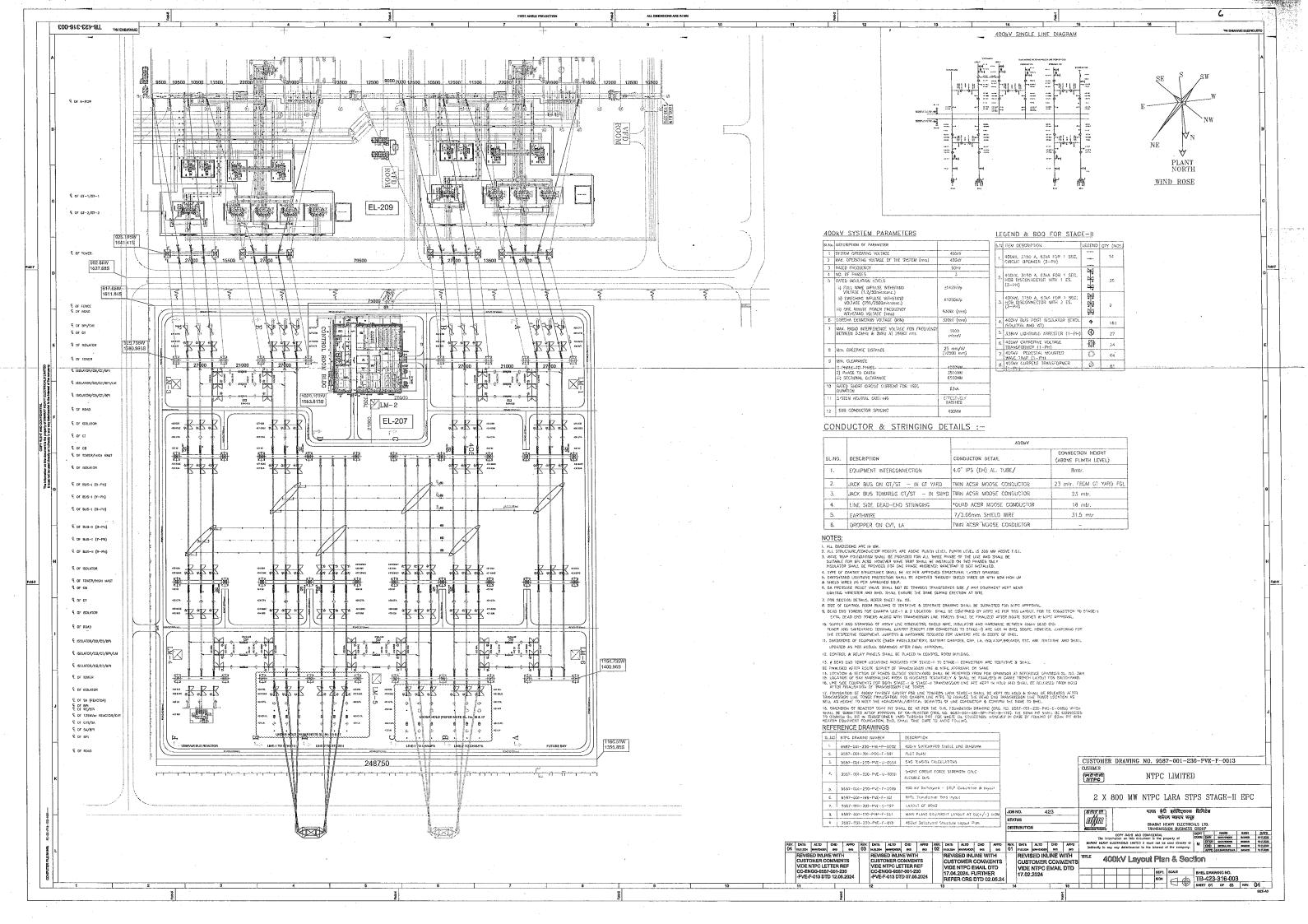


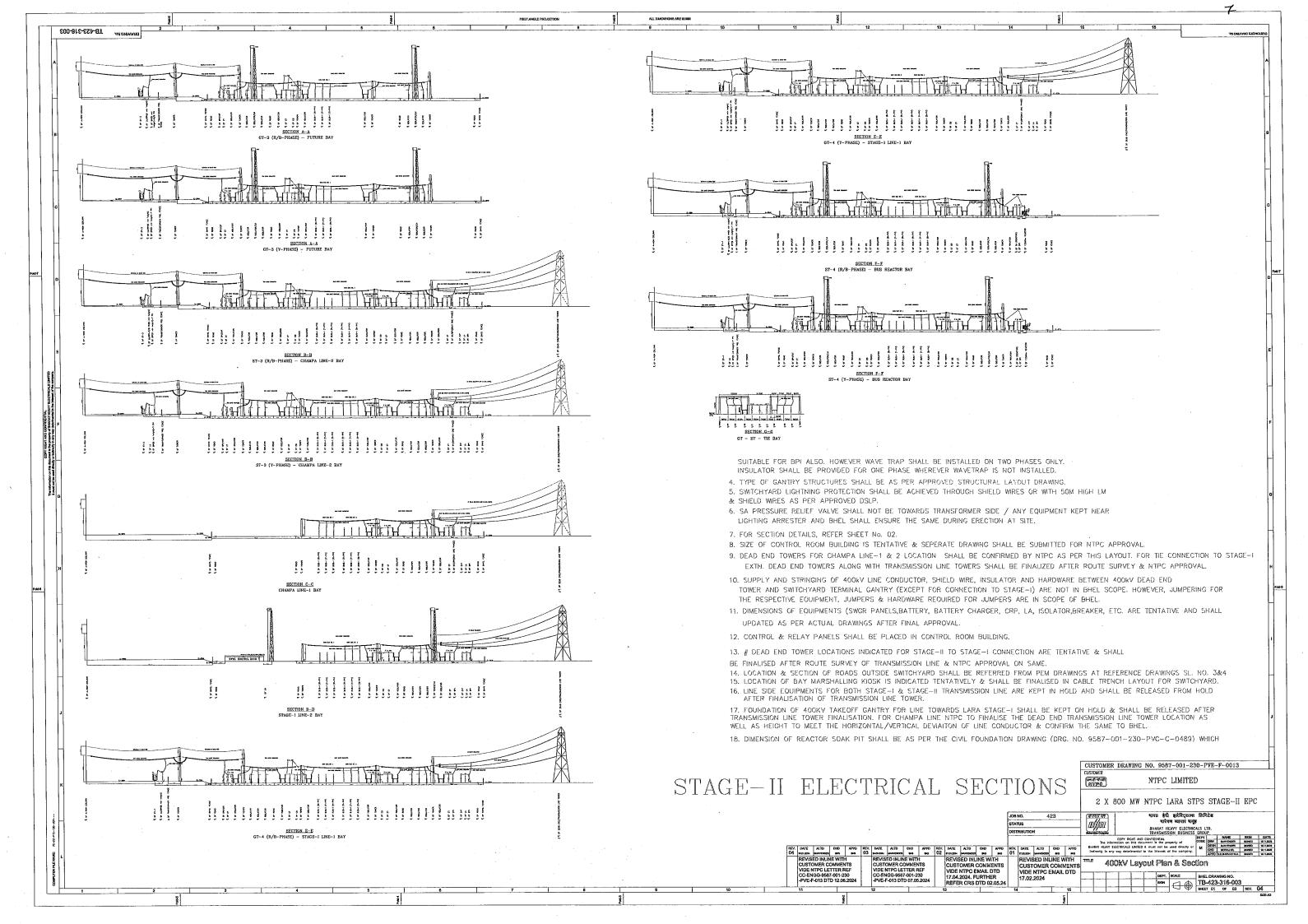


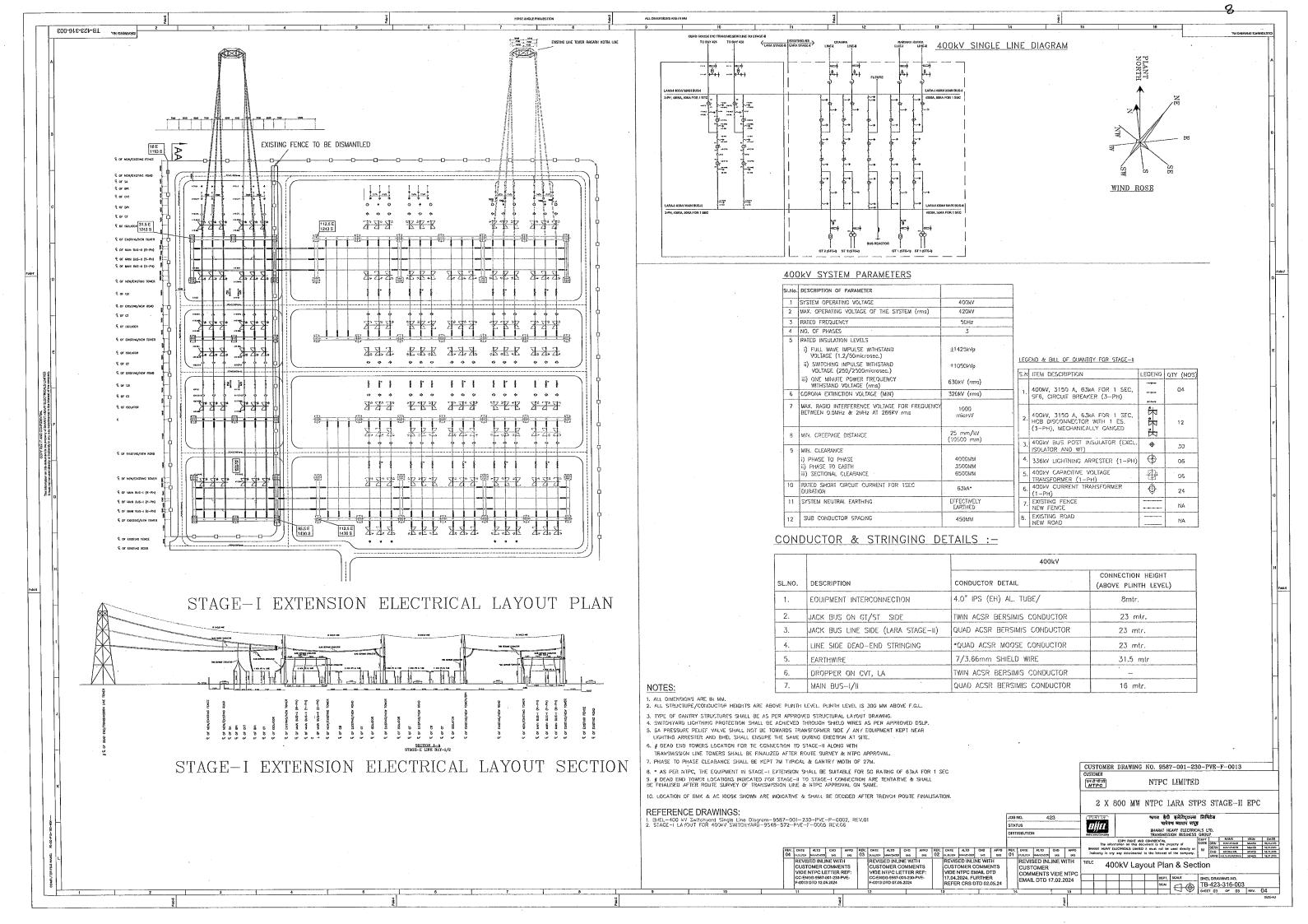
DRG / DOC TITLE NTPC DRG / DOC NO.						
	9587-001-230-PVC-F-00	047A				
BHEL DRG/ DOC NO.	TB-423-316-005					
Revision	0					
Reviewed By	NTPC					
NTPC COMMENTS REF:	CC-ENGG-9587-001-230-PVC-F-0047A, DTD. 20.05.2024					
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	400kV AIS SWITCHYARD					
Page No. / Clause No. / Sheet No.	NTPC Observations / Comments dtd. 20.05.2024	BHEL Reply dtd 07.10.2024				
Sheet 1 of 2	a) Show approach road to Porch for access.	a) Confirmed & incorporated in the revised document.				
	b) Also check for Lighting provision and concealed lighting in this area	B) The same shall be taken care during Illumination system drawings for Control room buildin which shall be submitted seperately.				
Sheet 1 of 2	Provide access to reception area	Confirmed & incorporated in the revised document				
Sheet 1 of 2	Provide rolling shutter in LT SWGR room with approach road	Confirmed & incorporated in the revised document				
Sheet 1 of 2	Provide fire door in LT SWGR room	Confirmed & incorporated in the revised document				
Sheet 1 of 2	Requirement of fence with gate to be checked for LT Transformer area	Confirmed & incorporated in the revised document				
Sheet 1 of 2	Indicate space between DB's & clearance from walls	Confirmed & incorporated in the revised document				
Sheet 1 of 2	Wall toward LT Transformer shall be 350mm thick fore resistant wall	Confirmed & incorporated in the revised document				
Sheet 1 of 2	Mark reference drawings for Note SL. No. 4,5 & 7	For Note SI. No. 4 drawing no shall be marked after purchase order placement for Battery,				
		charger, panels, etc. For Note SL. No. 5, reference Civil drawing marked. For Note SL. No. 7, the Drawing no is not available in NTPC MDL as of now. Same shall be				
Sheet 1 of 2	Also check for metallic raceways on floor for carrying IT/LAN & non electrical cables particularly in office room, conference room, seating area, reception etc. 'Check for provision of electrical points in seating area, office area, conference room, pantry etc. or add note or mark reference drawings	The same shall be taken care during Illumination system drawings for Control room building which shall be submitted seperately.				
) Sheet 2 of 2	a) False sealing of mineral fibre board, GRG board, calcium silicate or metal shall be as per internal finishing schedule at Table A of technical specification and approved architectural drawings.	a) For details, please refer Civil Switchyard Control Room Building - Architectural Plan and Elevation Drg. no. 9587-001-230-PVC-C-0497.				
	b) Underdeck insulation shall be provided on the ceiling (underside of roof slab) and underside of floor slab of air conditioned area depending on functional requirements. The under deck insulation shall consist of 50mm thick mineral wool insulation with 0.5mm thick aluminium foil & 0.6 mm X 25mm mesh wire netting & shall be fixed to	drawing. However for technical details, please refer Civil Switchyard Control Room Building				
	ceriling with 2mm wire ties.  c) Suitable cut-outs shall be provided in false ceiling to facilitate fixing of lighting fixtures, AC grills, smoke detectors, etc.	c) Confirmed & same shall be taken care inline with actual lighting fire fighting layouts.  d) Confirmed. However please refer Civil Switchyard Control Room Building - Architectural Fand Elevation Drg. no. 9587-001-230-PVC-C-0497.				
	d) As per technical specification, Control room false ceiling shall have catwalk way above for maintenance. Please ensure the same.	e) PLease refer our reply on above point SL. No. 9.				
	e) Mark reference drawing to Architectural drawing, internal cable trench layout drawing.					



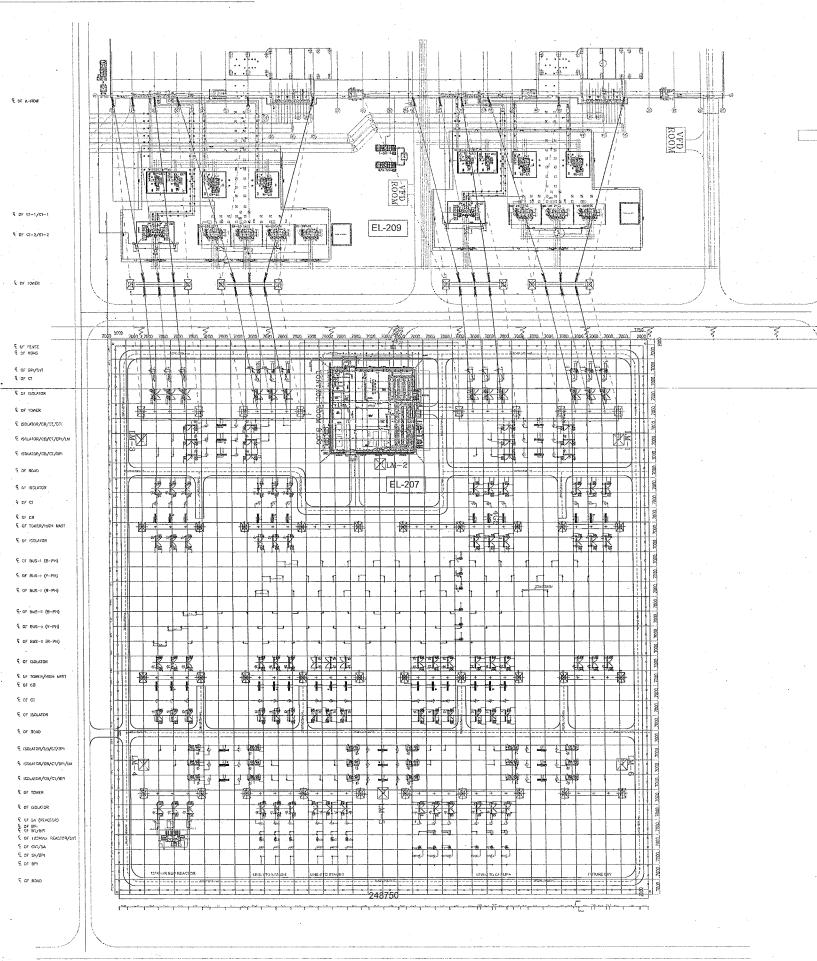








-3.24.1		COMMENT RESOLUTION SHEET For Rev 01					
	DRG / DOC TITLE	400 kV - Earthing Laye	out				
	NTPC DRG / DOC NO.	9587-001-230-PVE-F-0	0034				
	BHEL DRG/ DOC NO.	TB-423-509-001, Rev.00					
	Revision	0					
	Reviewed Bÿ	NTPC					
	NTPC COMMENTS REF:	CC-ENGG-9587-001-230-PVE-F-0034	4, DTD. 28.09.2024				
		400kV AIS SWITCHYARD					
SR. No.	Page No. / Clause No. / Sheet No.	NTPC Observations / Comments dtd 28.09.2024	BHEL Reply dtd 18.10.2024				
1	Sheet-1 of 2	Please check coordinate w.r.t layout drawing	The coordinate are being removed here. Same shall be referred from Layout drawing & Civil foundation drawing for Control room building.				
2	Sheet 1 of 2	Indicate no of Rod electrodes in table.	Same is already there in the table of rod electrodes. Remark column added for applicability of test pit.				
3	Sheet 1 of 2	Indicate no of Pipe electrodes in table.	The same is already available in the table below qty of rod electrodes				



1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
2. TYPICAL EARTHMAT GRID SPACING IN SWITCHYARD AREA IS CONSIDERED AS 7M, AS PER THE EARTHMAT DESIGN IS MEETING THE STEP & TOUCH POTENTIAL REQUIRMENT.
3. ALL EQUIPMENTS AND STRUCTURES SHALL GENERAL BE GROUNDED AT TWO POINTS AT OPPOSITE CORNERS WHETHER SHOWN IN DRAWING OR NOT AND THESE SHALL BE CONNECTED TO DIFFERENT PARTS OF THE MATS WHEREVER POSSEBLE.IN ADDITION ALL EARTHMING AS PER TYPICAL EARTHMING DETAIL IN DROWN, 9587-901-230-PVE-F-0038 TO BE FOLLOWED.
4. GROUNDING CONDUCTOR IN CUITODOR AREAS STALL BE BURDED 600MM BELOW FINISHED CROUND LEVEL.
5. WHENEVER A GROUNDING CONDUCTOR ROOSSES ROADS, CABLE TRENCHES, UNDERGROUND SERVICE DUCTS, PIPE TUNNELS, RAILWAY TRACKS, OIL RECOVERY TANK, TRANSFORMER SOAK PITE TC. SHALL BE LADD AT LEAST JODOMS BELOW THEM, BUT NOT LESS THAN 600MM BELOW FIG. AND SHALL BE REPOUTED ROUND THE BUILDING SHALL BE DIRIED IN GROUND AT A MINIMUM DISTANCE OF 1500MM FROM THE OUTER BOUNDARY OF THE BUILDINGS.
6. GROUNDING CONDUCTORS ARROUND THE BUILDING SHALL BE DIRIED IN GROUND AT A MINIMUM DISTANCE OF 1500MM FROM THE OUTER BOUNDARY OF THE BUILDINGS.
6. GROUNDING CONDUCTORS SHALL BE PERFORMED SHALL BE DIRIED IN GROUND AT A MINIMUM DISTANCE OF 1500MM FROM THE OUTER IS REQUIRED TO BE EMBEDDED IN CONCRETE SHALL HAVE APPROXIMATELY 50MM CONGRETE BELOW COVER, IF GROUNDING CONDUCTOR IS REQUIRED TO BE EMBEDDED IN CONCRETE SHALL HAVE APPROXIMATELY 50MM CONGRETE BELOW COVER, IF GROUNDING CONDUCTOR IS REQUIRED TO BE EMBEDDED IN CONCRETE SHALL HAVE APPROXIMATELY 50MM CONGRETE BELOW COVER, IF GROUNDING CONDUCTORS SHALL BE WELDED TYPE, CORNECTION BETWEEN EQUIPMENT GROUNDING CENDUCTOR SHALL BE WELDED TYPE, CORNECTION BETWEEN EQUIPMENT GROUNDING CENDUCTOR SHALL BE PRESED TO THE WELD SHALL BE CLEANED WITH WIRE BRUSH, TREATED WITH RED PRIMER AND ATTEMPRATIVELY COATED WITH BITUMEN.

9. ALL GROUND CONNECTION SHALL BE MEDE BY ELECTRIC ARC WELDING, ALL WELDED JOINTS SHALL BE ALLOWED TO GOOD DOWN GRADUALLY TO A SHAPE SHALL BE CONNECTED TO MAN EARTHMY ON THE SHAPE

HE PASSAGE OF THE CONDUCTOR, BOTH END OF THE SLEEVES SHALL BE SEALED TO PREVENT THE PASSAGE OF WARR THROUGH THE SLEEVES.

16. ALL STEEL COLUMNS METALLIC STAIRS ETC. SHALL BE CONNECTED TO THE NEAREST GROUND CONDUCTOR BY GROUNDING LEADS. ELECTRICAL CONTINUITY SHALL BE INSURED BY BONDING THE DIFFERENT SECTIONS OF HAND RAILS AND METALLIC STARS.

17. METALLIC PIPES, CONDUCTS AND CABLE TRAY SECTION FOR CABLE INSTALLATION SHALL BE BONDED TO ENSURE ELECTRICAL CONNECTION TO GROUNDING CONDUCTOR AT NOT MORE THAN TOM INTERNAL APART FROM INTERMEDIATE CONNECTION, BOTH ENDS SHALL ALSO BE CONNECTED TO THE GROUNDED SYSTEM.

IN THE GROUNDED STSTEM.

IN WHEREVER GROUNDING COMDUCTOR CROSSES OR RUNS ALONG METALLIC STRUCTURES SUCH AS GAS/WATER/STEAM/COMDUIT/ PIPES ETC.

AND STEEL REINFORCEMENT OF CONCRETE. IT SHALL BE BONDED TO THE SAME.

J. LIGHTING POLES, JUNCTIONES BOXES ON THE POLES, CABLE BOXES/GLANDS, SWITCHES ETC, SHALL BE CONNECTED TO CONDUCTOR RUNNING

ALONG WITH THE SUPPY CABLE WHICH IN TURNS SHALL BE CONNECTED GRID CONDUCTOR AT LEAST TWO POINT WHETHER SPECIFICALLY ALONG WITH THE SUPPY CABLE WHICH IN TURNS SHALL BE CONNECTED GRID CONDUCTOR AT LEAST TWO POINT WHETHER SPECIFICALLY SHOWN OR NOT.

20. 75X12MM OF FLAT SHALL BE USED FOR EARTHING CABLE TRENCHES ALL TRENCHES SHALL BE EARTHED AT AND INTERNAL OF 20M ALONG THE LENGTH OF THE TRENCHES & AT ALL BENDS.

21. FOR EQUIPMENT, FENCE, GATE ETC, EARTHING DETAILS REFER DRG. 9587—DD1—239—PVE—F—0038.

22. EVERY POST OF FENCE, GATE ETC, EARTHING DETAILS REFER DRG. 9587—DD1—239—PVE—F—0038.

23. THE RISER CONNECTION TO EARTHING WILL BE CONNECTED TO EARTH MESH BY ONE LEAD.

24. THE RISER CONNECTION TO EARTHING WILL BE 40MM DIA ROD. THE RISER TO EQUIPMENT/STRUCTURE CONNECTION WILL BE BY 75X12MM G.I. FLAT.

FIAT.

24. IN CASE HIGH TEMPERATURE AT SOME LOCATION THE EARTHING CONDUCTOR SHALL BE LAID MINIMUM 1500MM AWAY FROM SUCH LOCATIONS.

25. RAILWAY TRACKS WITHIN SWITCHYARD AREA SHALL BE BONDED ACROSS FISH PLATES AND CONDUCTOR TO EARTHING GRID AT SEVERAL.

25. RAILWAY TRACKS WITHIN SWITCHYARD AREA SHALL BE BUNDLU ALKOUSE FIRE FLATED AND VARIABLES AND VARIABLES AND AREA SHALL BE BUNDLU ALKOUSE FIRE FLATED AND VARIABLES PLEASE REPER EQUIPMENT EARTHING FINEOSOPHY DRAWING.
27. TRISER'S FOR MK, JB, CB,MBS ARE NOT SHOWN FOR SARE OF CLARITY. FOR TYPICAL DETAILS PLEASE REPER EQUIPMENT EARTHING FINEOSOPHY DRAWING.
28. FOR EQUIPMENT IN TRANSFORMER YARD, INTERMEDIATE TOWERS IN FRONT OF A-POW, EARTHING WILL BE DONE BY CONNECTION TO THE NEAREST EARTHMAT AVAILABLE.
29. AUXILARY EARTHMAT OF SIZE 1500X1500 MM2 (WITH GRID SPACING OF 300MM IN EACH DIRECTION) AT DEPTH OF 300MM FOR EACH MOTOR OPERATED MECHANISM BOX (MAIN SWITCH & EARTH SWITCH).
30. EARTHMAT LAYOUT SHOWN IN DRAWING IS DIAGRAMATIC ONLY. THE CONDUCTOR SPACING CAN BE CHANGED SUGHTLY TO SUIT SITE CONDITION.

31. THIS DRAWING IS TO BE READ FOR EARTHING/GROUNDED FOR OUTDOOR SWITCHYARD ONLY.

REFERENCE DRAWING:

1. EARTHING DESIGN CALCULATION -400KV OUTDOOR SWITCHYARD, DOC NO. 9587-001-230-PVE-U-001.

2. STAGE-IL LAYOUT FOR 400KV SWITCHYARD-9987-001-230-PVE-F-0013

## LEGENDS:

MAIN EARTHMAT CONDUCTOR 40mm DIA MS ROD

RISER FOR EQUIPMENT/STAUCTURE EARTHING

EXISTING MAIN EARTHMAT CONDUCTOR 40mm DIA MS ROD

PIPE ELECTRODE WITH TREATED PIT

(R) ROD ELECTRODE WITH TEST PIT

()ROD ELECTRODE WITHOUT TEST PIT

AUXILIARY EARTHMAT (40mm dia M.S. Rod)

ESTIMATION OF MS ROD REQUIRED FOR MAIN EARTHMAT/ RISERS/AUX EARTHMAT FOR EQUIPMENTS ITEM DESCRIPTION QTY, 40mm dis M.S. Rod required in Metera 1 40MM DIA MS ROD FOR MAIN EARTHMAT EXTENSIO 21935 Mtr (Approx 216,50 MT) 2 40MM DIA MS ROD FOR RISERS 3 46MM DIA MS ROD FOR AUX EARTHMAT SIZE (1500 X 1500 MM2- Specing 300mm) 78 NOS. 1404 Mir (Approx 13,85 MT) TOTAL 2800 Melers (Approx-263.85 MT)

ESTIMATION OF MS ROD ELECTRODE 13 M LONG VERTICAL ROD) FOR EQUIPMENTS QTY. M.S. Rod Electrode with Test link (Un-treated type) as per IS-2043 420 kV CVT (BHEL Scope) 3 SURGE ARRESTER 336 KV (BHEL So WITH TEST PIT 4 CONTROL Room 400KV (GHEL Scope) WITH TEST PIT 5 PERIPHERY 04 NOS. 04 NOS. WITHOUT TEST PI 92 NOS. Q2 NOS. WITH TEST PIT TOTAL 93 NOS. (276 MTR-APPROX 2,76 MT)

40NB DIA PIPE ELECTPODE- 6 NOS.

CUSTOMER DRAWING NO. 9587-001-230-PVE-F-0034 एन ही पी ਸੀ NTPC NTPC LIMITED

2 X 800 MW NTPC LARA STPS STAGE-II EPC

423 REV. DATE ALTO CHO APPO 01 18.10.2024 MSP 8K5 SKS

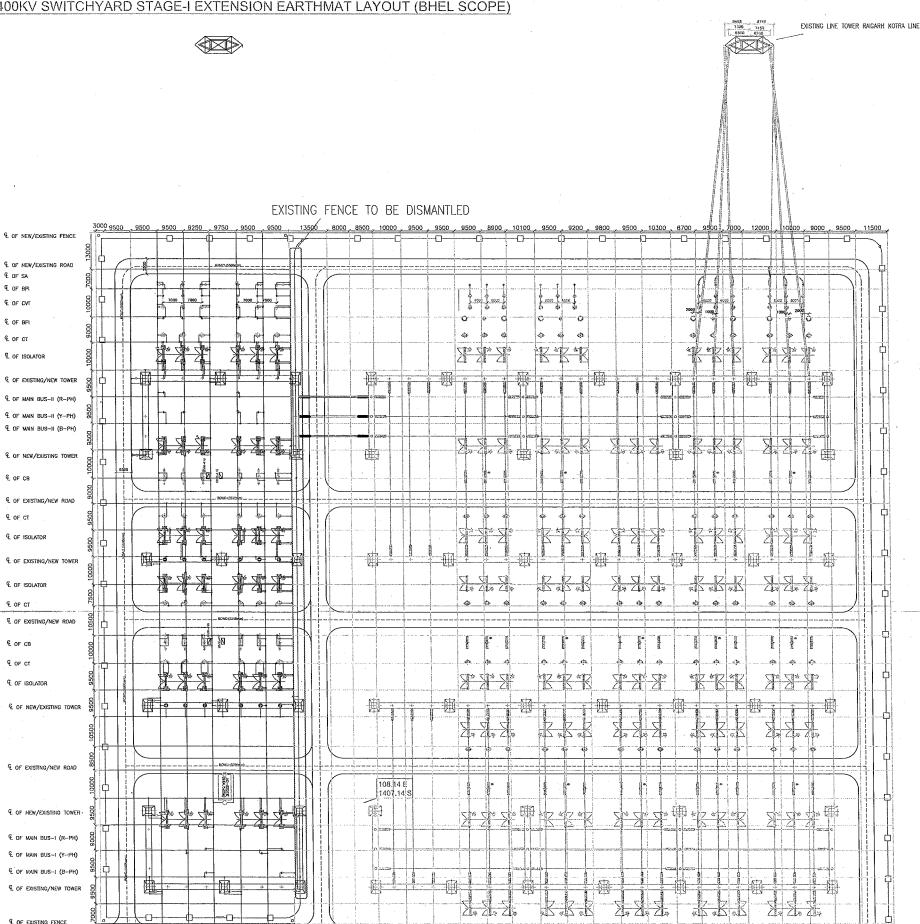
400 KV - EARTHING LAYOUT

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SCALE BHEL DRAWING NO.

TB-423-509-001

SHREY 01 OF 02



STAGE-I EXTENSION EARTHMAT LAYOUT

## NOTES:

- ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.

  EXISTING STAGE-I MAIN EARTHMAT OF 40MM DIA M.S. ROD AT SPACING OF 9.5MTRS SHALL BE EXTENDED IN BHEL SCOPE.

  ALL EQUIPMENTS AND STRUCTURES SHALL GENERALJE GROUNDED AT TWO POINTS AT OPPOSITE CORNERS WHETHER SHOWN IN DRAWING OR

  NOT AND THESE SHALL BE CONNECTED TO DIFFERENT PARTS OF THE MATS WHEREVER POSSIBLE.IN ADDITION ALL EARTHING AS PER TYPICAL

  EARTHING DETAIL IN DRAWON, 0.587-001-230-PVE-F-0038 TO BE FOLLOWED.

  GROUNDING CONDUCTOR IN OUTDOOR AREAS SHALL BE BURIED GOOMM BELOW FINISHED GROUND SERVICE DUCTS, PIPE TUNNELS, RAILWAY TRACKS,

  OIL RECOVERY TANK, TRANSFORMER SOAK PIT ETC. SHALL BE LAID AT LEAST 300MM BELOW THEM, BUT NOT LESS THAN 800MM BELOW FOLLOWED.
- OIL RECOVERY TANK, TRANSFORMER SOAK PIT ETC. SHALL BE LAID AT LÉAST 300MM BELOW THEM, BUT NOT LESS THAN 600MM BELOW FCL
  AND SHALL BE REROUTED ROUND THE EQUIPMENT/STRUCTURE FOUNDATIONS.
  6. GROUNDING CONDUCTORS AROUND THE BUILDING SHALL BE BURED IN GROUND AT A MINIMUM DISTANCE OF 1500MM FROM THE OUTER
  BOUNDARY OF THE BUILDINGS.
  6. GROUNDING CONDUCTORS EMBEDDED IN CONCRETE SHALL HAVE APPROXIMATELY 50MM CONCRETE BELOW COVER, IF GROUNDING CONDUCTOR
  IS REQUIRED TO BE EMBEDDED IN MAJOR FOUNDATION, THEN IT SHALL BE LAID IN A SLEEVES.
  6. CONNECTION WITH EQUIPMENT EARTHING PAD SHALL BE BOLIED TYPE; CONNECTION BETWEEN EQUIPMENT GROUNDING LEADS AND MAIN
  GROUND CONDUCTORS SHALL BE WELDED TYPE. FOR RUST PROTECTION THE WELD SHALL BE CLEANED WITH WIRE BRUSH, TREATED WITH RED
  PRIMER AND AFTERWARDS THICKLY COATED WITH BITUMEN.
  9. ALL GROUND CONNECTION 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 THEM. ARTIFICIAL COOLING SHALL NOT BE ALLOWED.
  10. BENDING OF LARGE DIAMETER ROOV/THICK CONDUCTOR SHALL BE DONE BY GAS HEATING.
  11. ALL ARC WELDING OF LARGE DIAMETER CONDUCTORS SHALL BE DONE BY GAS HEATING.
  12. (OCATION OF PIPSE LECTRICOSES WITH-WITHOUT TEST PIT ARE SHOWN TENTATIVELY.

- 11. ALL ARC WELDING OF LARGE DIAMETER CONDUCTORS SHALL BE DONE BY GAS HEATING.

  12. LOCATION OF PIPE ELECTRODES PE & ROO ELECTRODES WITH/MITHOUT TEST PIT ARE SHOWN TENTATIVELY.

  13. ALL ELECTRODES SHALL BE 409 × 3000ML NON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MON 61.S. ROO EXCEPT FOR TRANSFORMER NEUTRAL/REACTOR WHERE IT IS 409 X 3000ML MPIPE ELECTRODES SHALL BE PROVIDED.

  14. EARTHING TERMINAL OF EACH SURGE TRENCHES, SHALL BE DIRECTLY CONNECTED TO ROD ELECTRODES WHICH IN TURNS SHALL BE CONNECTED TO MAIN EARTHING GRID.

  15. GROUNDING CONDUCTOR ALONG THEIR RUN ON CABLE TRENCHES, LADDER COLUMNS BEAMS WALLS, ETC, SHALL BE SUPPORTED BY SUITABLE WELDING/CLEATING AT AN INTERVALS OF 750ML GROUNDLOOR ALONG CABLE TRENCHES SHALL BE ON THE WALL NEAR TO THE COUNTER AND INTERVAL SO F 750ML REVERS SHALL BE PROVIDED FOR THE PASSAGE OF THE CONDUCTOR, BOTH END OF THE SLEEVES SHALL BE SEALED. TO PREVAIT THE PASSAGE OF WATER THROUGH THE SLEEVES.

  16. ALL STEL COLUMNS METALLIC STAIRS ETC. SHALL BE CONNECTED TO THE NEAREST GROUNDING CONDUCTOR BY GROUNDING LEADS.

  17. METALLIC PIPES, CONDUCTS AND CABLE TRAY SECTION SO OF HAND RAILS AND METALLIC STAIRS.

  18. METALLIC PIPES, CONDUCTS AND CABLE TRAY SECTION FOR CABLE TIMES ALL ALSO BE CONNECTED TO THE GROUNDED SYSTEM.

  19. THE GROUNDED SYSTEM.

  19. THE GROUNDING CONDUCTOR CROSSES OR RUNS ALONG METALLIC STRUCTURES SUCH AS GAS/WATER/STEAM/CONDUIT/ PIPES ETC.

- TO THE GROUNDED SYSTEM.

  B. WHEREVER GROUNDING CONDUCTOR CROSSES OR RUNS ALONG METALLIC STRUCTURES SUCH AS GAS/WATER/STEAM/CONDUIT/ PIPES ETC.

  AND STEEL REINFORCEMENT OF CONCRETE. IT SHALL BE BONDED TO THE SAME.

  19. LIGHTING POLES, JUNCTIONS BOXES ON THE POLES, CABLE BOXES/GLANDS, SWITCHES ETC. SHALL BE CONNECTED TO CONDUCTOR RUNNING ALONG WITH THE SUPPLY CABLE WHICH IN TURNS SHALL BE CONNECTED GRID CONDUCTOR AT LEAST TWO POINT WHETHER SPECIFICALLY SHOWN OR NOT.

  20. 75X12MM GI FLAT SHALL BE USED FOR EARTHING CABLE TRENCHES ALL TRENCHES SHALL BE EARTHED AT AND INTERVAL OF 20M ALONG THE LENGTH OF THE TRENCHES & AT ALL BENDS OF THE TRENCHES, RISES SHALL BE PROVIDED FOR TRENCHES EARTHING AT EVERY 20M & AT ALL BRIDS

- AT ALL BENDS.

  AT ALL
- DRAWING.
  28. FOR EQUIPMENT IN TRANSFORMER YARD, INTERMEDIATE TOWERS IN FRONT OF A-ROW, EARTHING WILL BE DONE BY CONNECTION TO THE
- NEAREST EARTHMAT AVAILABLE.
  29. AUXILARY EARTHMAT OF SIZE 1500X1500 MM2 (WITH GRID SPACING OF 300MM IN EACH DIRECTION) AT DEPTH OF 300MM FOR EACH MOTOR
- OPERATED MECHANISM BOX (MAIN SWITCH & EARTH SWITCH).
  30. EARTHMAT LAYOUT SHOWN IN DRAWING IS DIAGRAMATIC ONLY. THE CONDUCTOR SPACING CAN BE CHANGED SLIGHTLY TO SUIT SITE
- 31. THIS DRAWING IS TO BE READ FOR EARTHING/GROUNDED FOR OUTDOOR SWITCHYARD ONLY.

- REFERENCE DRAWING:

  1. EARTHING DESIGN CALCULATION -400KV OUTDOOR SWITCHYARD, DOC NO. 9587-001-230-PVE-U-001.

  2. STAGE-IL LAYOUT FOR 400KV SWITCHYARD-9587-001-220-PVE-F-0013

  3. STAGE-IL LAYOUT FOR 400KV SWITCHYARD-9588-572-PVE-F-0005 REV.06.

  4. LARA SUPER THERMAL POWER PROJECT STAGE-1- EARTHING DESIGN CALCULATIONS; DOC NO. 9548-572-PVE-U-0027, REV-04.

## LEGENDS:

- MAIN EARTHMAT CONDUCTOR 40mm DIA MS ROD
- RISER FOR EQUIPMENT/STAUCTURE EARTHING
- EXISTING MAIN EARTHMAT CONDUCTOR 40mm DIA MS ROD
- (PE) PIPE ELECTRODE WITH TREATED PIT
- (R)ROD ELECTRODE WITH TEST PIT
- $\bigcirc$ ROD ELECTRODE WITHOUT TEST PIT



AUXILIARY EARTHMAT (40mm dia M.S. Rod)

CODE	DESCRIPTION	QTY,	40mm die M.S. Rod required in Metars
1	40MM DIA MS ROD FOR MAIN EARTHMAT EXTENSION	T	4800 Mtr (Approx 47.50 MT)
2	40MM DIA MS ROD FOR PISERS	-	3500 Mtr (Approx 34,50 MT)
3	40MM DIA MS ROD FOR AUX EARTHMAT SIZE (1500 X 1500 MM2- Spacing 300mm)	24 NOS.	432 Mtr (Approx 4.30 MT)
		TOTAL	2300 Malera (Approx 86.30 MT)

CODE	DESCRIPTION	QTY.	M.S. Rod Efectrode with Test link (Un-treated type) as per IS-3043	REMARKS
1	420kV. Tower with Peak (BHEL scope)	12 NOS.	12 NGS.	WITH TEST FIT
2	426 KV CVT (BHEL Scope)	06 NOS.	09 N/JS.	WITH TEST FIT
3	SURGE ARRESTER 336 KV (BHSL Scope)	66 405.	OE NGS.	WITH TEST PIT
4	SPR Room 496KV (BHEL Scope)	01 NOS.	02 NOS.	WITH TEST PIT
5	PERIPHERY	04 NOS.	04 NO3.	WITHOUT TEST PI
G	INTERCOMMECTION	62 NOS.	92 NGS.	WITH TEST PIT
		TOTAL	32 NOS, (96 MTR-	

40NB DIA PIPE ELECTRODE- NIL			CUSTOMER DRAWING NO. 9587-001-230-PVE-F-0034 CUSTOMER ভারতার NTPC LIMITED
			2 X 800 MW NTPC LARA STPS STAGE-II EPC
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		REVISED INLINE WITH NTPC COMMENTS VIDE THEIR LETTER REF:	1ΠLE 400 KV - EARTHING LAYOUT
	-	CC-ENGG-9587-001-230-PVE-F-0034 DTD 28.09.2024	BHEL DRAWING NO, SIGN T TB-423-509-001
,	,		SHEET 02 OF 02 REV. 01

———⊗ RE

-⊗ PE

CONNECTION TO GROUND MAT THROUGH RISER

CONNECTION TO ROD ELECTRODE WITH NON- TREATED PIT.

CONNECTION TO PIPE ELECTRODE WITH TREATED EARTH PIT

75x12mm GS FLAT 50x6mm GS FLAT 40mm DIA MS ROD

## **GENERAL NOTES:**

- 1 EARTH STRIP CLEATED TO LATTICE /PIPE TYPE STRUCTURE AT AN INTERVAL OF 0.75M SUITABLE PROVISION SHALL BE MADE WITH SUPPORT STRUCTURE.
- 2 ALL EARTH STRIPS SHALL BE TAKEN ALONG EDGE OF STRUCTURE. ALL DRAWING SHOWS TYPICAL ARRANGEMENT ONLY.
- 3 ALL STRUCTURES/EQUIPMENTS SHALL BE EARTHED AS SHOWN IN THE FOLLOWING SHEETS.
- 4 BOLT SIZE FOR CONNECTING EARTHING FLAT TO THE EQPT/STRUCTURE SHALL BE TO SUIT RESPECTIVE HOLE SIZE.
- 5. ALL EARTHING SHALL BE DONE IN ACCORDANCE WITH IS:3043 UNLESS OTHERWISE STATED IN TECHNICAL SPECIFICATION
- 6 EACH RISER OF A PARTICULAR EQUIPMENT SHALL BE CONNECTED TO A DIFFERENT EARTHROD (EITHER HORIZONTAL OR VERTICAL CONDUCTORS OF MAIN EARTHMAT).
- 7 FOR WELDING DETAILS REFER SHEET #15 & 16.
- 8 E/WIRE DOWN CONDUCTOR SHALL BE CLEATED AT AN INTERVAL OF 2.0 M ALONG WITH STRUCTURE .

SHEET NO.	<u>DESCRIPTION</u>
01.	TITLE
1A.	NOTES
2A.	400kV LINE CVT (WITH LMU)
2B.	400kV CVT (WITHOUT LMU)
03.	400kV POST INSULATOR (SOLID CORE TYPE)
04.	336kV LIGHTNING ARRESTER
05.	TOWER WITH PEAK
06.	CABLE TRENCH
07	PIPE EARTH ELECTRODE WITH TREATED PIT
08.	ROD ELECTRODE WITH TEST PIT
09.	RAIL BONDING
10A.	BUS REACTOR
10B.	SWITCHYARD SERVICE TRANSFORMER
11.	CONTROL AND RELAY PANELS/BATTERY CHARGER/ AC DC BOARDS/MLDB
10	400KV WAVE TRAP
12.	GATE/FENCE POST
13.	TYPICAL ARRANGEMENT OF BOLTED JOINTS
14.	WELDING DETAILS
15.	
16.	WELDING DETAILS

	NTPC DRO	F. No. 9587-001-230-PVE-F	-0038			
	PROJECT	2 X 800 MW NTPC LARA	STPS STA	GE-II EP	С	
JOB NO. 423 STATUS CONTRACT DISTRIBUTION	OWNER	OWNER NTPC LTD.				
No. CIF	QBTGM	BHARAT HEAVY ELECTRICALS LTD TRANSMISSION BUSINESS GROUP NOIDA	DEPT CODE DESN CHD APPD	NAME MSP SKS	SIGN DATE 09.04.24 09.04.24 09.04.24	
REVISED INLINE WITH NTPC COMMENTS VIDE THEIR LETTER REF- CC-ENGG-9587-001-230-PVE-F-0038 JTD 19.04-2024 (REFER CRS SHEET ENCLUSED)		kV – AIS EQUIPMENT EARTHING	DRAWING			

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E NAME : 100\_M03BR0

- 1. RISER FROM THE EARTH GRID SHALL BE 40MM DIAMETER MILD STEEL ROD. RISER SHALL RISE FROM THE GROUND ALONG THE NEAREST EQUIPMENT FOUNDATION/BUILDING COLUMN/WALL TO AVOID ANY OBSTRUCTION TO MOVEMENT OF PERSONNEL.
- CONNECTION TO ALL EQUIPMENT AND TOWERS SHALL BE BY BOLTED JOINTS. CONTACT SURFACES SHALL BE THOROUGHLY CLEANED BEFORE CONNECTIONS. EQUIPMENT BOLTED CONNECTIONS AFTER BEING TESTED AND CHECKED SHALL BE PAINTED WITH ANTI CORROSIVE PAINT/COMPOUND.
- 3. CONNECTIONS BETWEEN EQUIPMENT EARTHING LEADS AND BETWEEN MAIN EARTHING CONDUCTORS SHALL BE OF WELDED TYPE. FOR RUST PROTECTION THE WELDS SHOULD BE TREATED WITH RED LEAD COMPOUND AND AFTERWARDS THICKLY COATED WITH BITUMEN COMPOUND. THE SURFACES TO BE WELDED SHALL BE CLEANED OF DIRT, OIL, GREASE AND OXIDES BEFORE WELDING. ANY OXIDE FILMS THAT MAY HAVE FORMED DURING WELDING MUST BE REMOVED FROM THE WELDED JOINT.
- 4. EARTHING CONDUCTOR FOR EQUIPMENT SHALL BE OF GALVANISED M.S. OF SIZE 75x12/50x6 mm. THE CONDUCTOR BELOW THE GROUND LEVEL SHALL BE 40 mm DIA BLACK MS ROD.
- 5. IN THE ATTACHED DRAWINGS GL REPRESENTS GROUND LEVEL.
- 6. ALL EQUIPMENT STRUCTURES, CABLE TRENCHES & TOWERS SHALL BE EARTHED AT TWO POINTS WITH 75x12 mm. G.S. FLAT EVEN THOUGH THEY ARE SHOWN OR NOT IN THE DRAWING DUE TO CLARITY.
- 7. ALL JUNCTION BOXES, MECHANISM BOXES, GROUND MOUNTED CONTROL CABINETS, CUBICLES, PANELS, MBs ETC. SHALL BE EARTHEDAT TWO POINTS WITH 50x6mm G.S. FLAT BY TWO SEPARATE AND DISTINCT EARTH CONNECTERS.
- 8. EARTHING CONDUCTORS FROM EQUIPMENT STRUCTURES SHALL BE CONNECTED TO THE NEAREST POSSIBLE EARTH MAT RISER. EQUIPMENT EARTHING SHALL BE AS PER IS 3043.
- 9. ALL JOINTS BETWEEN 40 DIA M.S. ROD AND 75x12 mm. G.S. FLAT SHALL BE BELOW GROUND LEVEL.
- 10. FOR WELDED JOINTS LOW HYDROGEN CONTENT ELECTRODES SHALL BE USED.
- 11. METTALIC SHEATHS/SCREENS, AND ARMOUR OF MULTI CORE CABLES SHALL BE EARTHED AT BOTH ENDS.

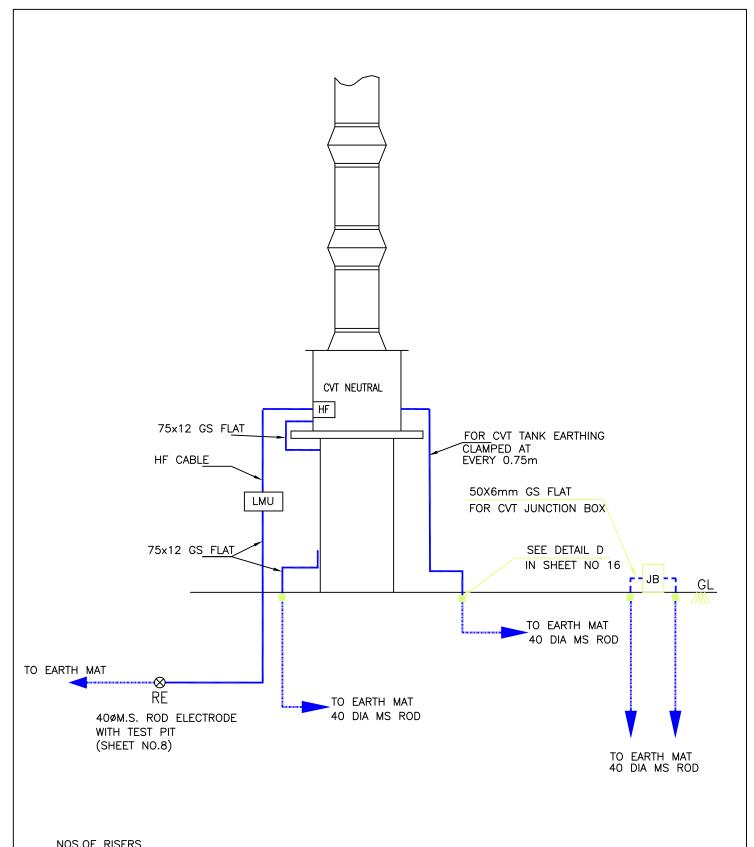
  METTALIC SHEATHS AND ARMOUR OF SINGLE CORE CABLES SHALL BE EARTHED AT SWITCHGEAR END ONLY
  UNLESS OTHERWISE INSTRUCTED BY THE EMPLOYER.
- 12. EQUIPMENT BOLTED CONNECTIONS AFTER BEING TESTED AND CHECKED SHALL BE PAINTED WITH ANTI CORROSIVE PAINT/COMPOUND.
- 13. LOCATION OF EARTHING CONDUCTORS/RISERS SHOWN IN THE EARTHING DRAWING MAY CHANGE TO SUIT THE SITE CONDITION.
- 14. FOR SURGE ARRESTER, EARTHING LEAD FROM SURGE COUNTER TO MAIN EARTHMAT SHALL BE SHORTEST IN LENGTH AS PRACTICALLY AS POSSIBLE.
- 15. ALL NON CURRENT CARRYING METALIC PARTS SHALL BE EARTHED AT TWO DIFFERENT PLACES.
- 16. ALL EQUIPMENT DRAWINGS SHOWN ARE INDICATIVE ONLY.
- 17. WELDING OF EARTHING CONDUCTOR SHALL BE CONNECTED IN VERTICAL PLANE WHEREVER POSSIBLE.
- 18. ALL GROUND CONNECTIONS SHALL BE MADE BY ELECTRIC ARC WELDING.
- 19. BENDING OF LARGE DIAMETER CONDUCTORS SHALL BE DONE PREFERABLY BY GAS HEATING.
- 20. WHEREVER EARTHING CONDUCTOR PASSES THROUGH WALLS, FLOORS ETC. GALVANIZED IRON SLEEVES SHALL PROVIDED FOR THE PASSAGE OF THE CONDUCTOR. BOTH ENDS OF THE SLEEVES SHALL BE SEALED TO PREVENT THE PASSAGE OF WATER THROUGH THE SLEEVES.
- 21. EARTHING CONDUCTORS EMBEDDED IN THE CONCRETE FIBRE SHALL HAVE APPROXIMATELY 50MM CONCRETE COVER



# EQUIPMENT EARTHING DETAILS NOTES

DRG. No.

9587-001-230-PVE-F-0038



## NOS.OF RISERS

= 2 NOS. PER PHASE

+ 2 NOS. FOR CVT JUNCTION BOX

ROD ELECTRODE = 1 NO. PER CVT (NEUTRAL IS CONNECTED TO GROUND VIA LMU)



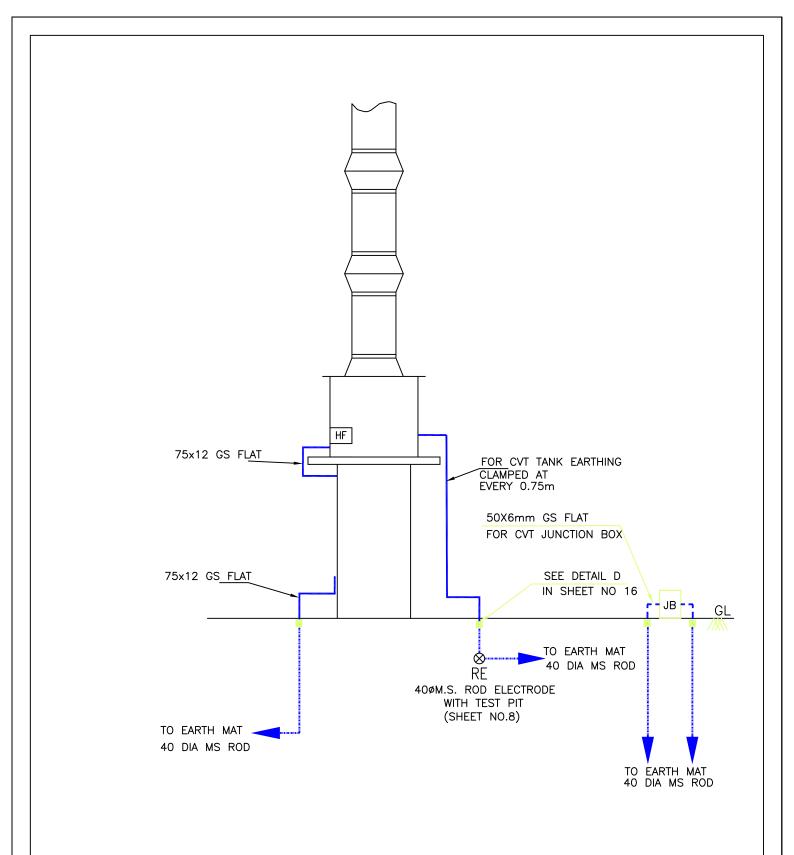
EQUIPMENT EARTHING DETAILS 400kV LINE CVT (WITH LMU)

COMPUTERREF.NO.

DRG. No.

9587-001-230-PVE-F-0038

SHEET No. 2A



## NOS.OF RISERS

= 2 NOS. PER PHASE

+ 2 NOS. FOR CVT JUNCTION BOX ROD ELECTRODE = 1 NO. PER CVT



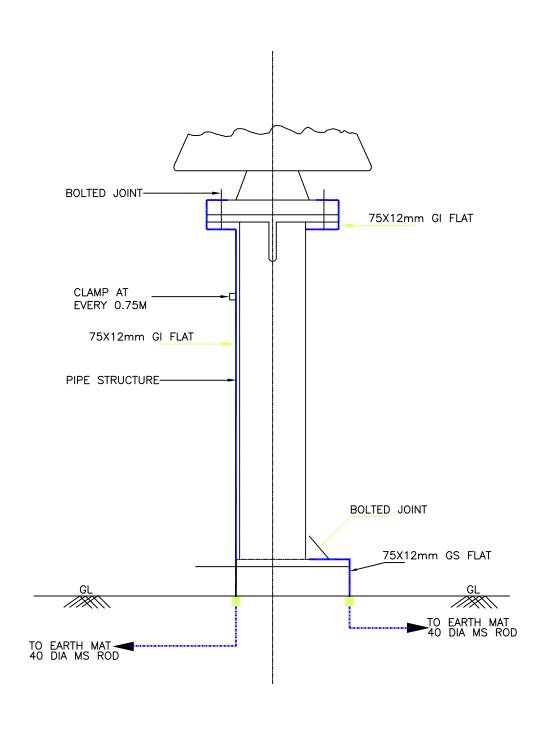
EQUIPMENT EARTHING DETAILS 400kV CVT (WITHOUT LMU)

COMPUTERREF.NO.

DRG. No.

9587-001-230-PVE-F-0038

SHEET No. 2B



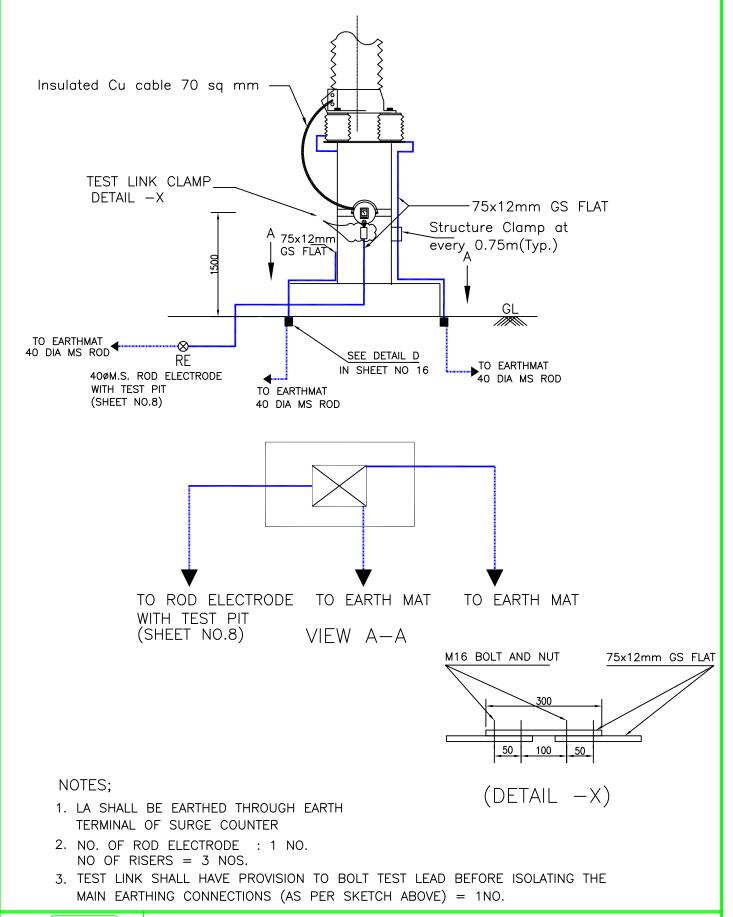
NOS.OF RISERS = 2 NOS.



EQUIPMENT EARTHING DETAILS 400kV POST INSULATOR (SOLID CORE TYPE)

DRG. No.

9587-001-230-PVE-F-0038



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EQUIPMENT EARTHING DETAILS

336kV LIGHTNING ARRESTER

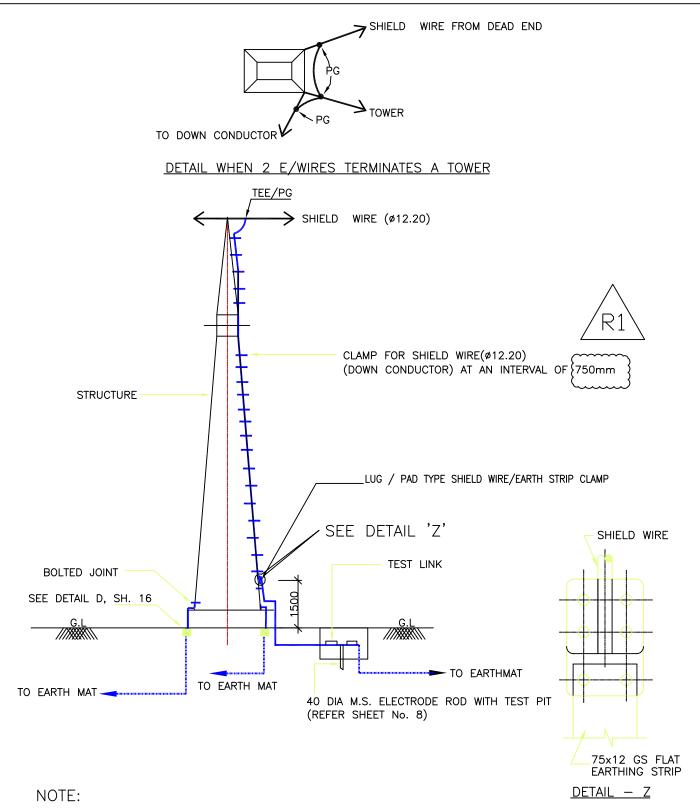
COMPU. DRG. REF.

DRG.NO.

9587-001-230-PVE-F-0038

SHEET No.

04





2. NO. OF ROD ELECTRODE: 1 NO. PER TOWER WITH DOWN CONDUCTOR. 3. NO. OF RISERS = 2 NOS.

Each down conductor shall be provided with a test link at 1000 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.

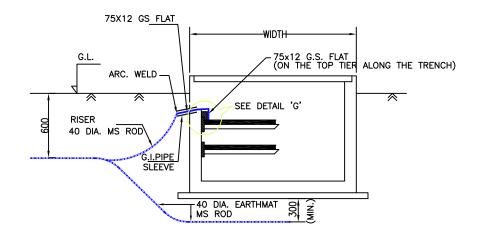


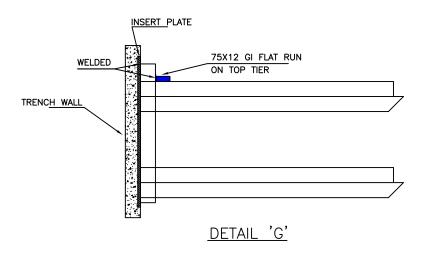
EQUIPMENT EARTHING DETAILS TOWER WITH PEAK

COMPUTERREF.NO.

DRG. No.

9587-001-230-PVE-F-0038





DETAIL FOR CONNECTING GI FLAT RUNNING ON TOP TIER TRENCH TO EMBEDDED PLATE.

## NOTE:

- 1. RISERS SHALL BE PROVIDED AT AN INTERVAL OF 20M ALONG THE LENGTH OF TRENCH.
- THE EARTH STRIP (75x12 G.S. FLAT) SHALL BE WELDED/CLEATED TO TOP RACK ALONG THE TRENCH RUN AT EVERY 0.75M.
- 3. WHERE THE CABLE RACKS ARE PROVIDED ON BOTH SIDES OF THE TRENCH, BOTH SIDES SHALL BE EARTHED AS PER ABOVE.
- 4. CABLE & CABLE TRAY EARTHING SHALL BE DONE AS PER SPECIFICATION.

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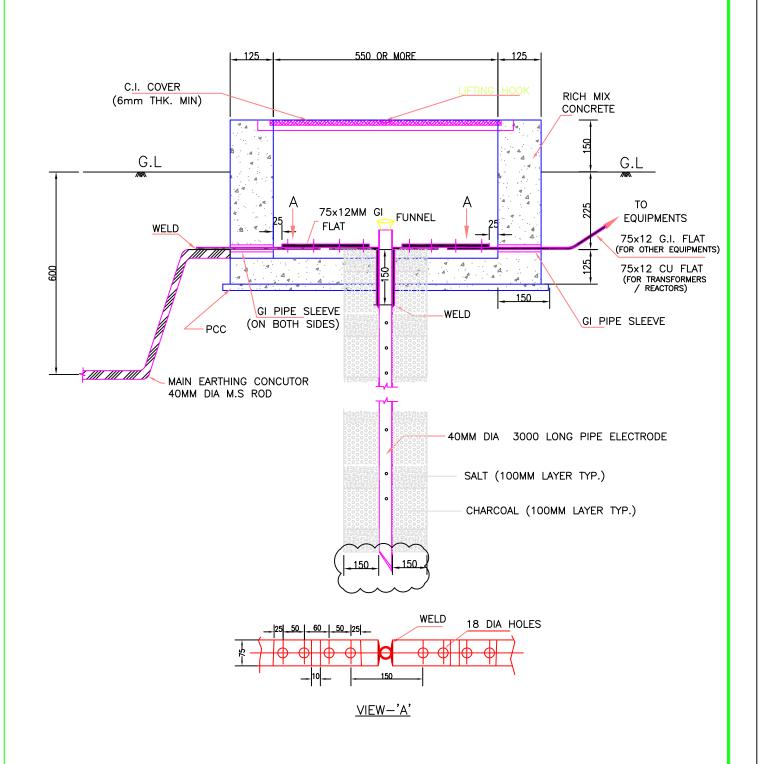
EQUIPMENT EARTHING DETAILS CABLE TRENCH

COMPU. DRG. REF.

DRG. NO.

9587-001-230-PVE-F-0038

SHEET 06



## NOTE:

- SUPPLY OF FIXING BOLTS NUTS & WASHERS FOR GI FLAT EARTHING CONDUCTOR IS ALSO FORMS PART OF THE SCOPE.
- 2. TO BE USED FOR CONNECTING TRANSFORMER / REACTOR NEUTRAL
- 3. GI PIPE SHALL CONFORM TO IS 1239.
- 4. PIPE EARTHING SHALL CONFORM TO IS 3043.



EQUIPMENT EARTHING DETAILS
PIPE EARTH ELECTRODE WITH TREATED PIT

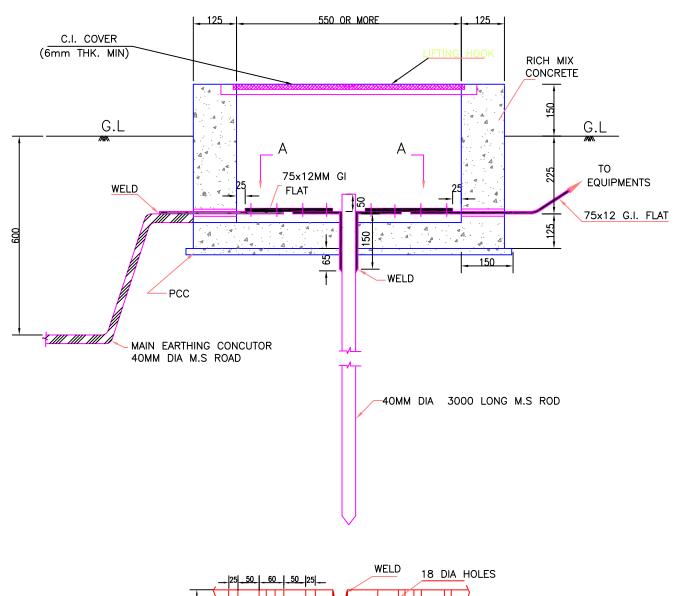
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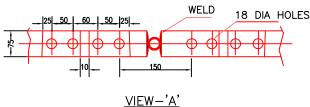
DRG. No.

TB-419-316-006

SHEET No.

07





## NOTES:-

- 1. SUPPLY OF FIXING BOLTS NUTS & WASHERS FOR GI FLAT EARTHING CONDUCTOR IS ALSO FORMS PART OF THE SCOPE.
- 2. TO BE USED FOR CONNECTING DOWN CONDUCTOR OF LIGHTINING MASTS & TOWERS WITH PEAK.
- 2. ALSO APPLICABLE FOR CVT AND LA.



# EQUIPMENT EARTHING DETAILS

ROD EARTH ELECTRODE WITH TEST PIT

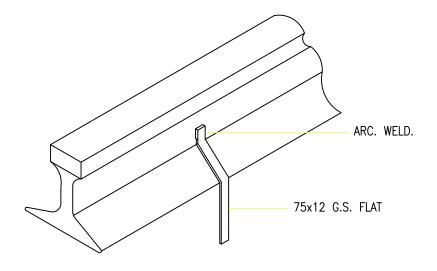
COMPU. DRG. REF.

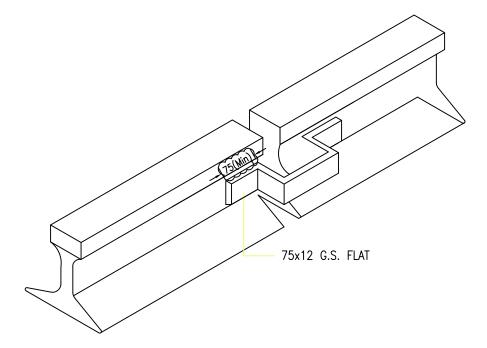
DRG. No.

9587-001-230-PVE-F-0038

SHEET No.

8





## NOTE:-

1. RAILWAY TRACKS WITHIN SWITCHYARD AREA SHALL BE EARTHED AT A SPACING OF 30 m AND ALSO AT BOTH ENDS.

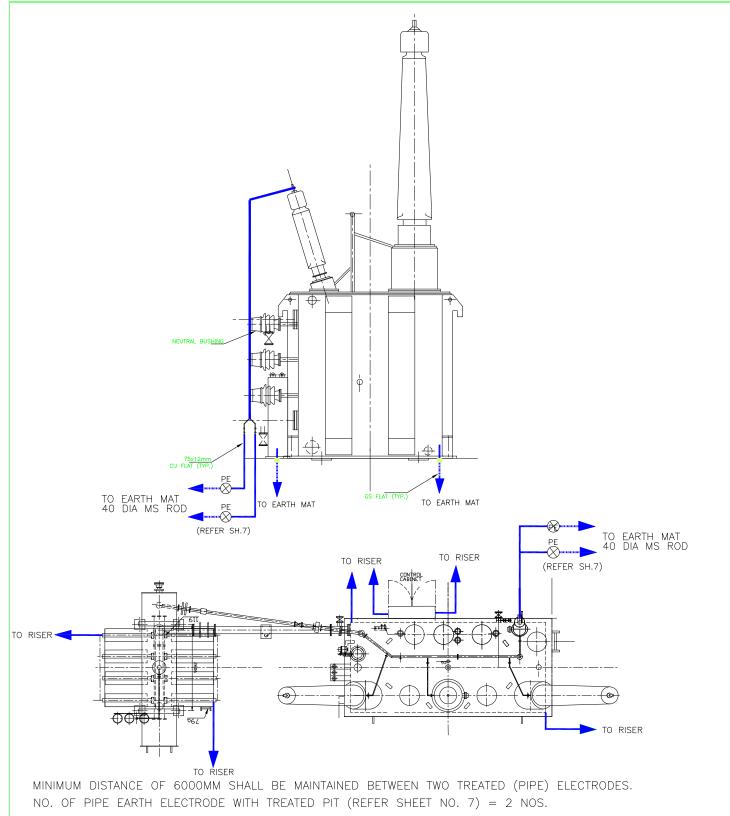


EQUIPMENT EARTHING DETAILS RAIL BONDING

COMPU. DRG. REF.

DRG. NO.

9587-001-230-PVE-F-0038



NO.OF RISERS = 8 NOS. FOR EARTHING OF FOLLOWING PARTS OF 400KV BUS REACTOR (TWO EARTHING STRIPS CAN BE CONNECTED TO ONE RISER)

MAIN TANK - 2 Nos. (75x12 GS FLAT)

RADIATOR SUPPORT - 2 Nos. (75x12 GS FLAT)

CONTROL CABINET/MB - 2 Nos. (50x6 GS FLAT)

NEUTRAL EARTHING - 2 Nos. (75x12 CU FLAT THROUGH PIPE ELECTRODE)



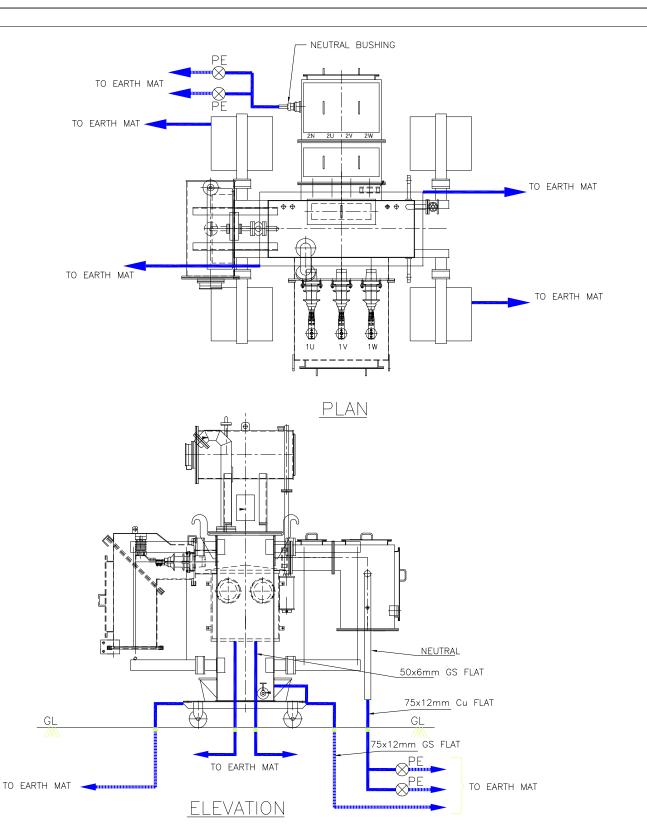
# EQUIPMENT EARTHING DETAILS BUS REACTOR

COMPU. DRG. REF.

DRG. NO.

9587-001-230-PVE-F-0038

SHEET 10A



MINIMUM DISTANCE OF 6000MM SHALL BE MAINTAINED BETWEEN TWO TREATED (PIPE) ELECTRODES. NO.OF PIPE EARTH ELECTRODE WITH TREATED PIT (REFER SHEET NO. 11) = 2 NOS. NO.OF RISERS = 6 NOS. FOR EARTHING OF FOLLOWING PARTS OF TRANSFORMER (TWO EARTHING STRIPS CAN BE CONNECTED TO ONE RISER):

MAIN TANK 2 Nos. (75x12 GS FLAT) RADIATOR BANK 2 Nos. (75x12 GS FLAT) MARSHALLING BOX 2 Nos. (50x6 GS FLAT)

NEUTRAL EARTHING 2 Nos. (75x12 Cu FLAT THROUGH PIPE ELECTRODE)

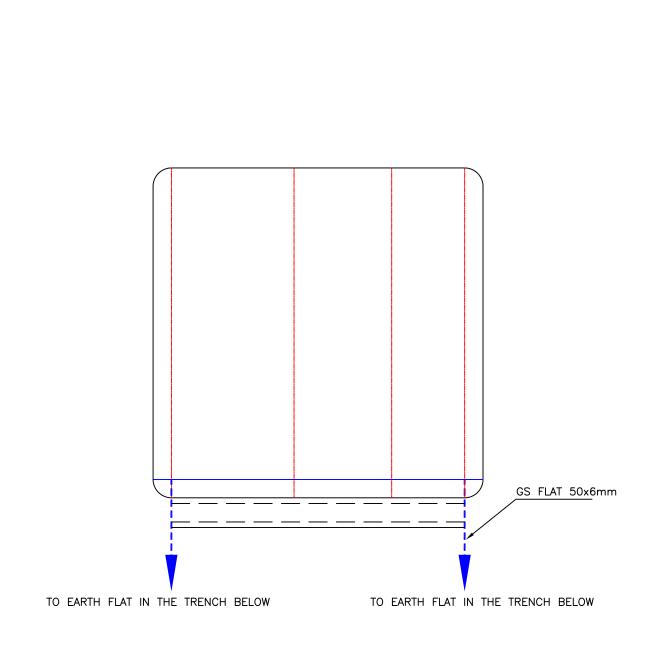


EQUIPMENT EARTHING DETAILS SWITCHYARD SERVICE TRANSFORMER

DRG. No.

9587-001-230-PVE-F-0038

SHEET No. 10B



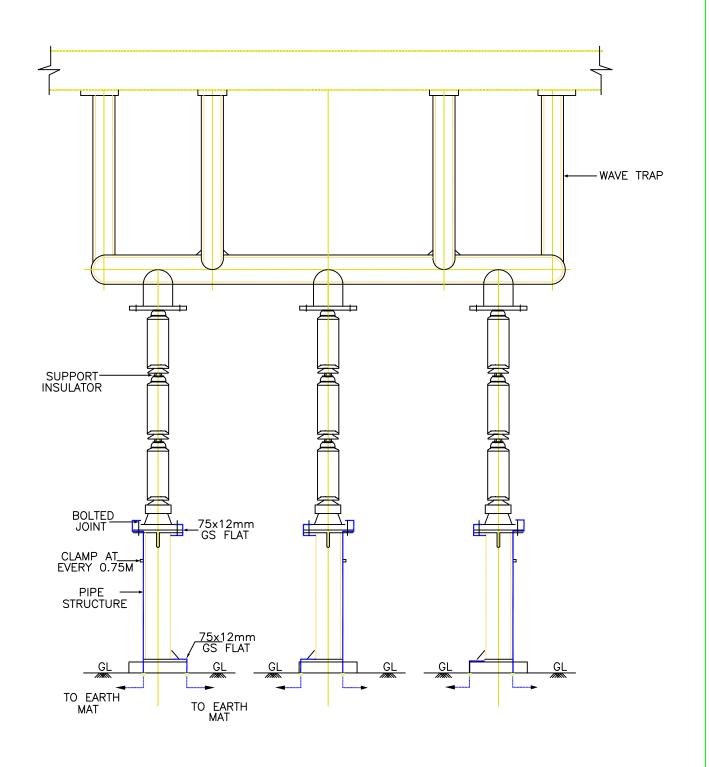


# EQUIPMENT EARTHING DETAILS

ALL PANELS/KIOSKS/MBs/BATTERY CHARGER/AC DC BOARDS/MLDB

DRG. No.

9587-001-230-PVE-F-0038



NOS.OF RISERS= 2 NOS./STRUCTURE

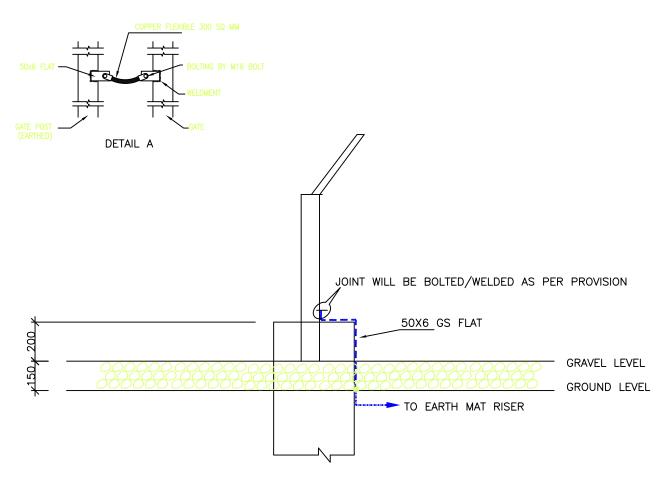


EQUIPMENT EARTHING DETAILS 400kV WAVE TRAP

DRG. No.

9587-001-230-PVE-F-0038

# CLAMP AT EVERY 0.75M TO EARTH MAT TO EARTH MAT MS ROD FENCE GROUNDING TO EARTH MAT TO EARTHMAT AT EVERY POST



EVERY POST OF FENCE & GATES SHALL BE CONNECTED TO EARTHING LOOP BY 50X6 MM GS FLAT. EARTHING CONDUCTOR SHALL BE BURRIED 2000mm OUTSIDE THE SWITCHYARD FENCE.

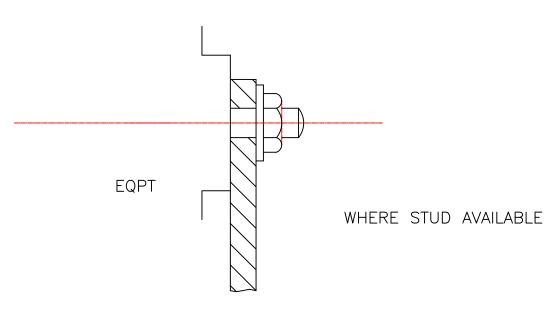
# FENCE EARTHING



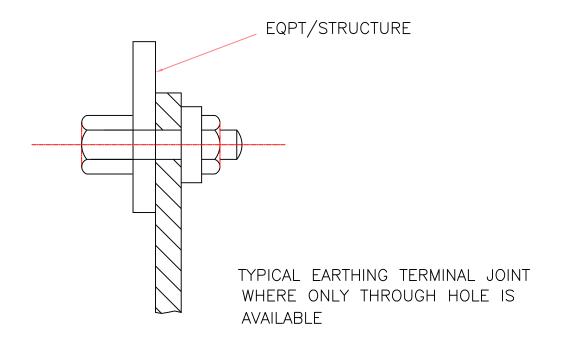
EQUIPMENT EARTHING DETAILS GATE/FENCE POST

DRG. No.

9587-001-230-PVE-F-0038



TYPICAL EARTHING TERMINAL JOINT



## <u>NOTE</u>

- 1. THIS IS GENERAL TYPICAL BOLTING ARRANGEMENT APPLICABLE TO ALL PANELS, EQUIPMENT ETC. WHERE BOLTING ARRANGEMENT IS PROVIDED.
- 2. IN CASE EARTHING TERMINAL COMPRISES ONLY A TAPPED HOLE SUITABLE BOLT/ SCREW WITH WASHER MAY BE USED FOR EARTHING CONDUCTOR TERMINATION

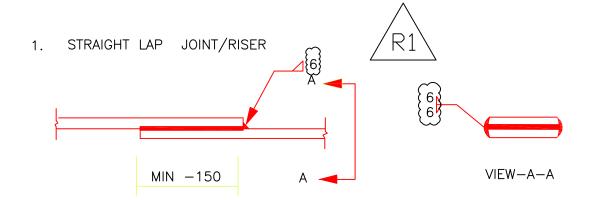


EQUIPMENT EARTHING DETAILS TYPICAL ARRANGEMENT OF BOLTED JOINTS

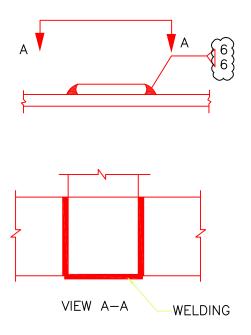
DRG. No.

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# STRIP TO STRIP (75x12/50X6 MS FLAT)



## 2. CROSS LAP JOINT

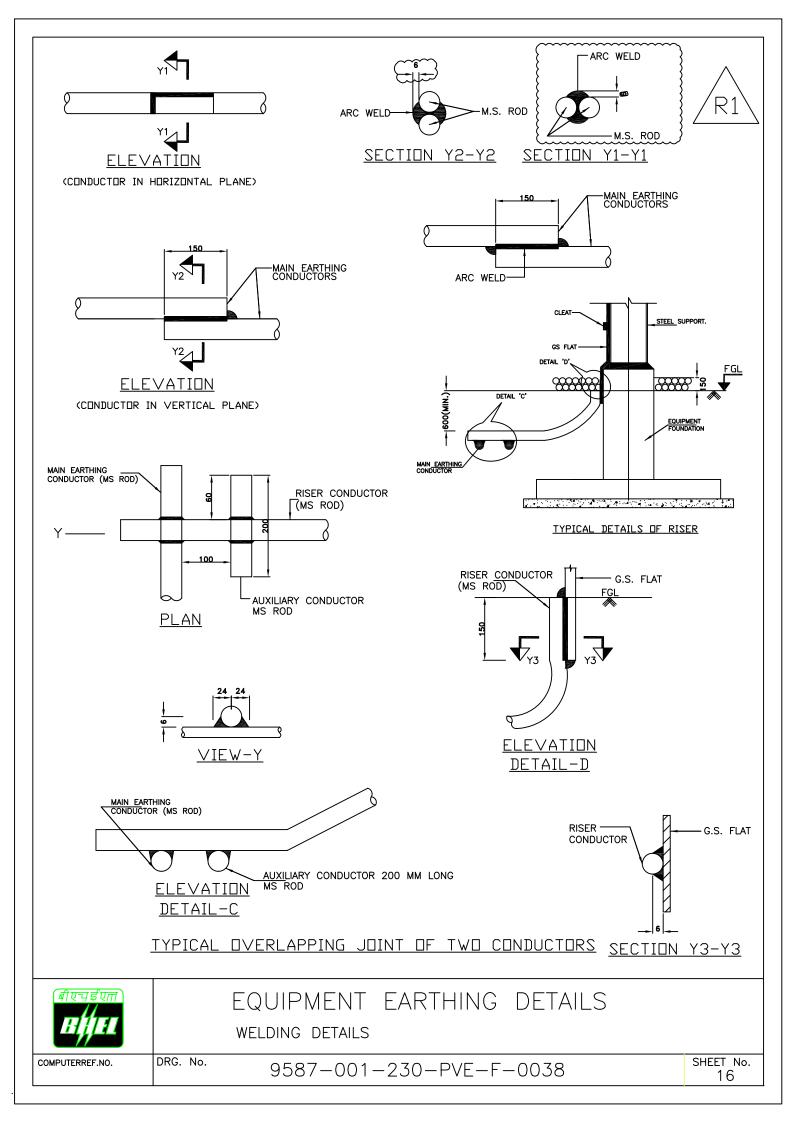




EQUIPMENT EARTHING DETAILS WELDING DETAILS

DRG. No.

9587-001-230-PVE-F-0038



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# **BHARAT HEAVY ELECTRICALS LIMITED**

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yway detrime	TROJECT	400KV 31	witchyard	d for LAR		THERM TENTS	1AL POW	/ER PROJI	ECT (2X800	MW)
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PROJECT: 400kV Switchyard for LARA SUPER THERMAL POWER PROJECT (2x800MW)

CUSTOMER: NTPC LTD.

400 KV Switchyard - DSLP Calculation & Layout TB-423-509-003

REV.00

## 1.0 INTRODUCTION

This document covers the design calculations made to verify the adequacy of Shield wire and lightning mast arrangement provided against lightning protection of 400kV AIS Switchyard at LARA STAGE-II

The calculations have been made by Razevig method. The calculations and results are given in the following annexure:

## 2.0 DESIGN INPUTS AND RESULTS

The 400kV AIS switchyard for LARA STAGE-I EXTENSION (BHEL SCOPE) & LARA STAGE-II and buildings in switchyard are being protected by 7/3.66mm Shield Wire and 50m high lightning mast. The jack bus, main bus & equipment level heights from plinth levels for 400kV substations are as follows.

## 400kV SWITCHYARD STAGE-I EXTENSION (BHEL SCOPE):

Main Bus Height: 16.3m (Stringing Height)

Jack bus height: 23.3m (Stringing Height) for Outgoing Lines to Stage-II.

23.3m (Stringing Height) towards GT Yard.

Equipment height: 8.3m (Equipment level)

## **400kV SWITCHYARD STAGE-II:**

Main Bus Height: 16.3m (Stringing Height)

lack bus height: 25.5m (Stringing Height at Power House A-Row Wall Column)

16.3m (Outgoing Lines)

23.3 Switchyard to GT Yard Intermediate Gantry

Equipment height: 8.3m (Equipment/ Reactor level) & 10.3m max (transformer level)

Calculations revealed that all the equipment, buildings and stringing inside the boundary are protected by the proposed arrangement, & same can be seen from the enclosed "DSLP Layout" i.e. Annexure-2A & 2B. Calculation has been shown in Annexure-1.

## **ENCLOSURES TO THE DESIGN CALCULATIONS**

Annexure – IA: DSLP calculations by Shield Wires for LARA STAGE-I Extn. (BHEL Scope)

Annexure – IB: DSLP calculations by Lightning Masts for LARA STAGE-II

Annexure – 2A: DSLP layout using shield wires for LARA STAGE-I Extn. (BHEL Scope)

Annexure – 2B: DSLP layout using Shield wires/Lightning Masts for LARA STAGE-II

PROJECT: 400kV Switchyard for LARA SUPER THERMAL P CUSTOMER: NTPC LTD.	OWER PROJECT (2x800MW)
CUSTOMER. NIFCLID.	
400 KV Switchyard - DSLP Calculation & Layout	TB-423-509-003
	REV 00

## 3.0 DESIGN CALCULATIONS

- Overhead shielding design by Shield Wires and 50m high lightning masts is based on Reference-1.
- Detailed Design Calculations are as per Annexure 1.
- Hatched area shown in the Annexure 2A & 2B indicates the area which is protected, against lightning strokes.
- It is observed that with the proposed shield wire & LM arrangement, installations in BHEL scope of supplies are protected against lightning strokes. Also, it is concluded that proposed shield wire & LM arrangement meets specification requirements and safety aspect of personnel at site.

## 4.0 **REFERENCES**

- Book on "High Voltage Engineering" by Dr. Razevig.
- 9587-001-230-PVE-F-0013: 400kV Switch Yard Layout Plan & Section

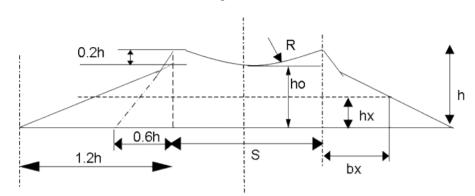


## Annexure-1A: DSLP CALCULATION BY RAZEVIG METHOD USING SHIELD WIRES FOR LARA STAGE-I EXTENSION (BHEL SCOPE)

As recommended in NTPC specification 7/3.66mm Shield wire is being used for lightning protection

## A. Mode of Protection: Two shield wire





h height of tower peak

h<sub>x</sub> height of the object to be protectedS Spacing between two shield wires

b<sub>x</sub> Distance from peak centreline upto which'hx' high objects are protected from side strokes

 ${\rm h_o}$  h-S/4,height protected within two shield wires from FGL

Formula for'bx'

if hx> 2/3 h, bx=0.6h(1-(hx/h)), (FORMULA 1) if hx< 2/3 h, bx=1.2 h(1-(hx/0.8h)), (FORMULA 2)

s.no.	Case Description	<b>h</b> (m)	<b>h</b> <sub>x</sub> (m)	<b>S</b> (m)	<b>b</b> <sub>x</sub> (m)	<b>h</b> <sub>o</sub> (m)	Check h <sub>o</sub> ≥h <sub>x</sub>	Zone identification	Remarks	Formulas used
1	SW-1 & SW-2, SW-2 & SW-3	31.8	23.3	27	5.100	25.05	Yes	ZONE 1	Highest conductor height=23.3m (Jack Bus) Main Bus bar height=16.3m	FORMULA 1
2	SW-3 & SW-4 (Existing Shield wire of Stage-I)	31.8	16.3	27	13.710	25.05	Yes	ZONE 2	Main Bus bar height=16.3m	FORMULA 2
3	SW-5, SW-6, SW-6, SW-7	31.8	23.3	27	5.100	25.05	Yes	ZONE 3	for O/G Line to LARA STAGE-II)	FORMULA 1
		31.8	8.3	27	25.710	25.05	Yes		Equipment height 8.3m	FORMULA 2

NOTES: All figures are in meters

All heights are given from ground level.

Doc. No.: 9587-001-230-PVE-F-0049 ANNEXURE-1B

Rev-00

CUSTOMER: NTPC Limited CONSULTANT: --

A) Mode of Protection: LIGHTNING MASTS

FORMULA FOR CHECKING ADEQUACY OF DSLP BY LIGHTNING MASTS BY RAZEVIG METHOD

FOR PROTECTION AGAINST LIGHTNING, ANY OBJECT WITHIN THE CONTAINED AREA IS PROTECTED IF DIAMETER OF THE CIRCLE PASSING THROUGH PEAKS OF MASTS (D) IS NOT MORE THAN EIGHT TIMES THE ACTIVE HEIGHT OF THE MAST THAT IS (MAST HEIGHT - HEIGHT OF OBJECT TO BE PROTECTED) MULTIPLIED BY A FACTOR 'p', OR D < 8\*(h-hx)\*p ---- (FORMULA 1)

p = 5.5/ SQRT h, If h>30m =1 , IF h<30m

I) LOCATION	OF LIGHTNING M	ASTS (3 MAST	<b>IS METHOD</b>	)								
ZONE	DISTANCE BETWEEN			$(a_2^2+a_3^2-a_1^2)$	2a <sub>2</sub> a <sub>3</sub>	Teta1=	DIAMETER	MAST	FACTOR	ACTIVE HEIGHT	MAX. HEIGHT	WHETHER D<8(h-hx)p
BOUNDED				'- ' '		cos <sup>-1</sup>	OF CIRCLE,	LE, HEIGHT	'p'	OF MAST, ha	TO BE	SATISFIED ?
BY						((a <sub>2</sub> <sup>2</sup> +a <sub>3</sub> <sup>2</sup> -a <sub>1</sub> <sup>2</sup>	D=a <sub>1</sub> /	'h'		(m),	PROTECTED, hx	
					) / 2a <sub>2</sub> a <sub>3</sub> )	sin(Teta1)	(m)		where ha	(m)		
					// 20203/	(m)			=D/8p			
	a <sub>1</sub>	a <sub>2</sub>	a <sub>3</sub>									
LM-1,2,6	113.000	183.000	153.000	44129	55998	0.66316786	183.56	50.3	0.77549	29.59	16.30	TRUE
LM-1,2,5	113.000	158.000	201.000	52596	63516	0.59513144	201.56	50.3	0.77549	32.49	16.30	TRUE
LM-2,5,6	158.000	113.350	183.000	21373.2225	41486.1	1.02956705	184.35	50.3	0.77549	29.71	16.30	TRUE
LM-1,5,6	201.000	113.350	153.000	-4143.7775	34685.1	1.69055088	202.45	50.3	0.77549	32.63	16.30	TRUE
LM-2,3,4	113.000	183.000	153.000	44129	55998	0.66316786	183.56	50.3	0.77549	29.59	16.30	TRUE
LM-2,3,5	113.000	158.000	201.000	52596	63516	0.59513144	201.56	50.3	0.77549	32.49	16.30	TRUE
LM-2,4,5	158.000	113.350	183.000	21373.2225	41486.1	1.02956705	184.35	50.3	0.77549	29.71	16.30	TRUE
LM-3.4.5	201.000	113.350	153.000	-4143.7775	34685.1	1.69055088	202.45	50.3	0.77549	32.63	16.30	TRUE

Where D= $a_1/\sin(\text{Teta1})$  and Teta1= $\cos^{-1}((a_2^2+a_3^2-a_1^2)/2a_2a_3)$ 

II) Radius of zone protected by a single lightning mast/tower peak around itself (Rx) :  $Rx=1.5^*h^*p^*(1-(hx/0.8h)), if hx<2/3 \ h \eqno(FORMU)$ (FORMULA 2) Rx = 0.75\*h\*p\*(1 - (hx/h)), if hx > 2/3h(FORMULA 3) SINCE hx< 33.53 m, HENCE, FORMULA 2 IS USED FOR CALCULATING Rx BELOW.

Mast/Peak Height (m) Height to be protected (m)		Factor 'p'	'p' Radius (m) FORMULA USED		REMARKS	
h	hx		Rx			
50.3	16.3	0.775494	34.81	FORMULA 2	Height of Jack Bus to be protected 16.3m ma	(1) (Shown in Plot)
50.3	6	0.775494	49.79		Height of Control Room Building to be protected 6 m max.	(2) (Shown in Plot)
50.3	11	0.775494	42.52	FORMULA 2	Height of Reactor Bushing to be protected 11 m max.	(2) (Shown in Plot)

III) Zone protected by two lightning masts/ tower peak between them, against side strokes (OUTSIDE THE TRIANGULAR/QUADRANGULAR AREA CONTAINED BY LINES JOINING MASTS)

Rox= 1.5\*hox\*px\*(1-(hx/0.8\*hox)) if hx < 2/3 hox (FORMULA 4) Rox= 0.75\*hox\*px\*(1-(hx/hox)) if hx > 2/3 hox (FORMULA 5)

hox= h-(a/(7\*p)) (FORMULA 6)

px=5.5/SQRT(hox) if hox>30m (FORMULA 7) =1 if hox <30m (FORMULA 8)

where

h= Mast height

hox=Maximum height protected at a point which lies mid-way between the two lightning masts

a= Distance between towers/peaks

Rox= Distance from line joining masts upto which protection against side strokes is available for object of height 'hx'.

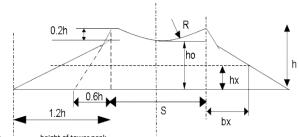
Protection between Masts/Towe r Peak	Distance between Masts/Tower Peak (m)	Mast/Peak Height (m)	Max. height to be protected (m)	Factor 'p'	Max. height protected (m)	Factor 'p <sub>x</sub> '	Rox (m)	2/3*hox (m)	FORMULA USED	
	a	h	hx		hox					
										(-) (-)
1&2	113.000	50.3	16.3	0.775494		1	13.663		FORMULA 4	(3) (Shown in Plot)
2&6	183.000	50.3	16.3	0.775494	16.589	1	0.217	11.059	FORMULA 5	(4)
6&1	153.000	50.3	16.3	0.775494	22.115	1	4.361	14.743	FORMULA 5	(5) (Shown in Plot)
2&5	158.000	50.3	16.3	0.775494	21.194	1	3.671	14.129	FORMULA 5	(6) (Shown in Plot)
5&6	113.350	50.3	16.3	0.775494	29.419	1	13.566	19.613	FORMULA 4	(7) (Shown in Plot)
6&1	183.000	50.3	16.3	0.775494	16.589	1	0.217	11.059	FORMULA 5	(8)
2&3	113.000	50.3	16.3	0.775494	29,484	1	13.663	19.656	FORMULA 4	(9) (Shown in Plot)
3&4	183.000	50.3	16.3	0.775494		1	0.217		FORMULA 5	(10)
4&2	153.000	50.3	16.3	0.775494	22.115	1	4.361	14.743	FORMULA 5	(11) (Shown in Plot)
										, ,,,, ,,,,,,,,,,,,,,,,,,,
2&4	158.000	50.3	16.3	0.775494	21.194	1	3.671	14.129	FORMULA 5	(12) (Shown in Plot)
4&5	113.350	50.3	16.3	0.775494		1	13.566		FORMULA 4	(13) (Shown in Plot)
5&2	183.000	50.3	16.3	0.775494	16.589	1	0.217	11.059	FORMULA 5	(14)

#### DSLP CALCULATION BY RAZEVIG METHOD USING SHIELD WIRES FOR LARA STAGE-II

As recommended in NTPC specification  $\,$  7/3.66mm Shield wire is being used for lightning protection

#### A. Mode of Protection: Two shield wire

Figure 1



height of tower peak height of the object to be protected Spacing between two shield wires h h<sub>x</sub> S b<sub>x</sub>

Distance from peak centreline upto which'hx' high objects are protected from side strokes

h-S/4,height protected within two shield wires from FGL

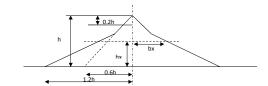
h<sub>o</sub> h-S Formula for'bx'

if hx> 2/3 h, bx=0.6h(1-(hx/h)) , (FORMULA 1) if hx< 2/3 h, bx=1.2 h(1-(hx/0.8h)), (FORMULA 2)

S.NO.	Case Description	<b>h</b> (m)	h <sub>x</sub> (m)	<b>S</b> (m)	<b>b</b> <sub>x</sub> (m)	<b>h</b> <sub>o</sub> (m)	Check h <sub>o</sub> ≥h <sub>x</sub>	Zone identification	Remarks	Formulas used
1	SW-1 & SW-2, SW-3 & SW-4, SW-5, SW-6, SW-7, SW-8	31.8	23.3	27	5.100	25.05	Yes	ZONE 1	Highest conductor height=23.3m (Jack Bus to GT/ST Intermediate gantry) Equipment height 8.3m	FORMULA 1
2	SW-9 & SW-10	33.5	25.5	30.5	4.800	25.875	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to A-row)	FORMULA 1
3	SW-10 & SW-11	33.5	11	11.5	23.700	30.625	Yes	ZONE 2	Highest equipment height=11m (GT/ST bushing height)	FORMULA 2
4	SW-11 & SW-12	33.5	25.5	22	4.800	28	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to A-row)	FORMULA 1
5	SW-12 & SW-13	33.5	25.5	31	4.800	25.75	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to Arow)	FORMULA 1
6	SW-14 & SW-15	33.5	25.5	30	4.800	26	Yes	ZONE 2	Highest equipment height=30m (DG stack)	FORMULA 1
		33.5	12	30	22.200	26	Yes	ZONE 2	Highest equipment height=12m (DG)	FORMULA 2
7	SW-15 & SW-16	33.5	25.5	23	4.800	27.75	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to A-row)	FORMULA 1
8	SW-16 & SW-17	33.5	25.5	24	4.800	27.5	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to A-row)	FORMULA 1
9	SW-17 & SW-18	33.5	25.5	22	4.800	28	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to A-row)	FORMULA 1
10	SW-18 & SW-19	33.5	25.5	31	4.800	25.75	Yes	ZONE 2	Highest conductor height=25.5m (GT/ST Intermediate gantry to A-row)	FORMULA 1
11	SW-20, SW-21, SW-21, SW-22, SW-23, SW-24, (Champa Line shield wire not in BHEL scope)	31.8	23.3	27	5.100	25.05	Yes	ZONE 3	Highest conductor height=23.3m (Jack Bus)	FORMULA 1
	SW-24, SW-25 (Champa Line shield wire not in BHEL scope)	31.8	8.3	27	25.710	25.05	Yes		Equipment height 8.3m	FORMULA 2

#### B. Mode of Protection: one shield wire

Figure 2



h height of tower peak

h<sub>x</sub> height of the object to be protected

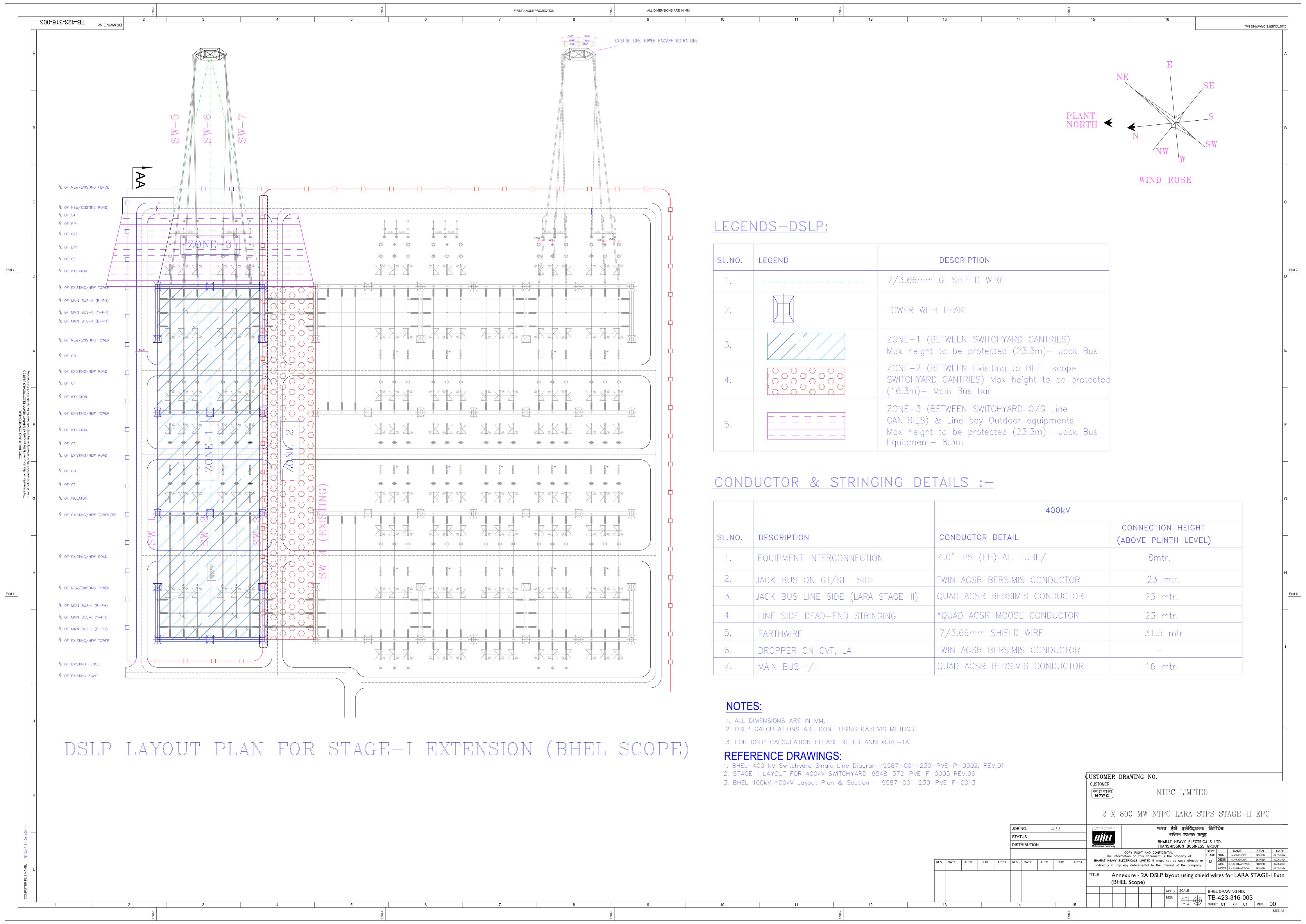
 $b_{x}$ Distance from peak centreline upto which'hx' high objects are protected from side strokes

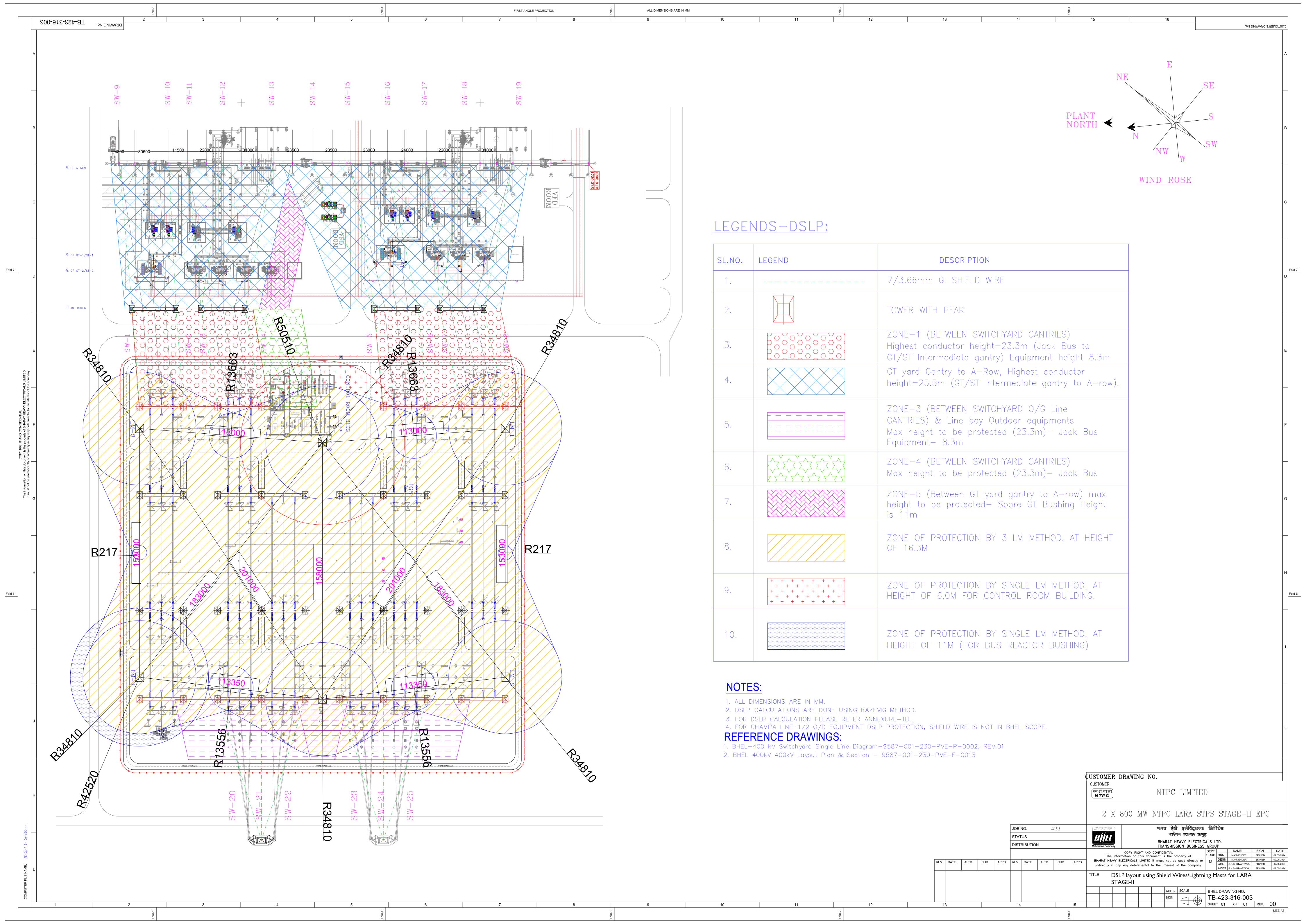
Formula for 'bx' if hx> 2/3 h, bx=0.6h(1-{hx/h})) , (FORMULA 1) if hx< 2/3 h, bx=1.2 h(1-{hx/0.8h}), (FORMULA 2)

S.NO.	Case Description	<b>h</b> (m)	h <sub>x</sub> (m)	<b>b</b> <sub>x</sub> (m)	Zone identification	Remarks
1	SW-4	31.8	6	29.16	I Zone 4	Single shield wire for Control room Bldg ( $h_x$ is CRB building height)
2	SW-13	31.8	11	21.66	7one 5	GT yard gantry to A-row, Spare GT Bushing Height is 11m (h <sub>x</sub> is Spare GT Bushing height)

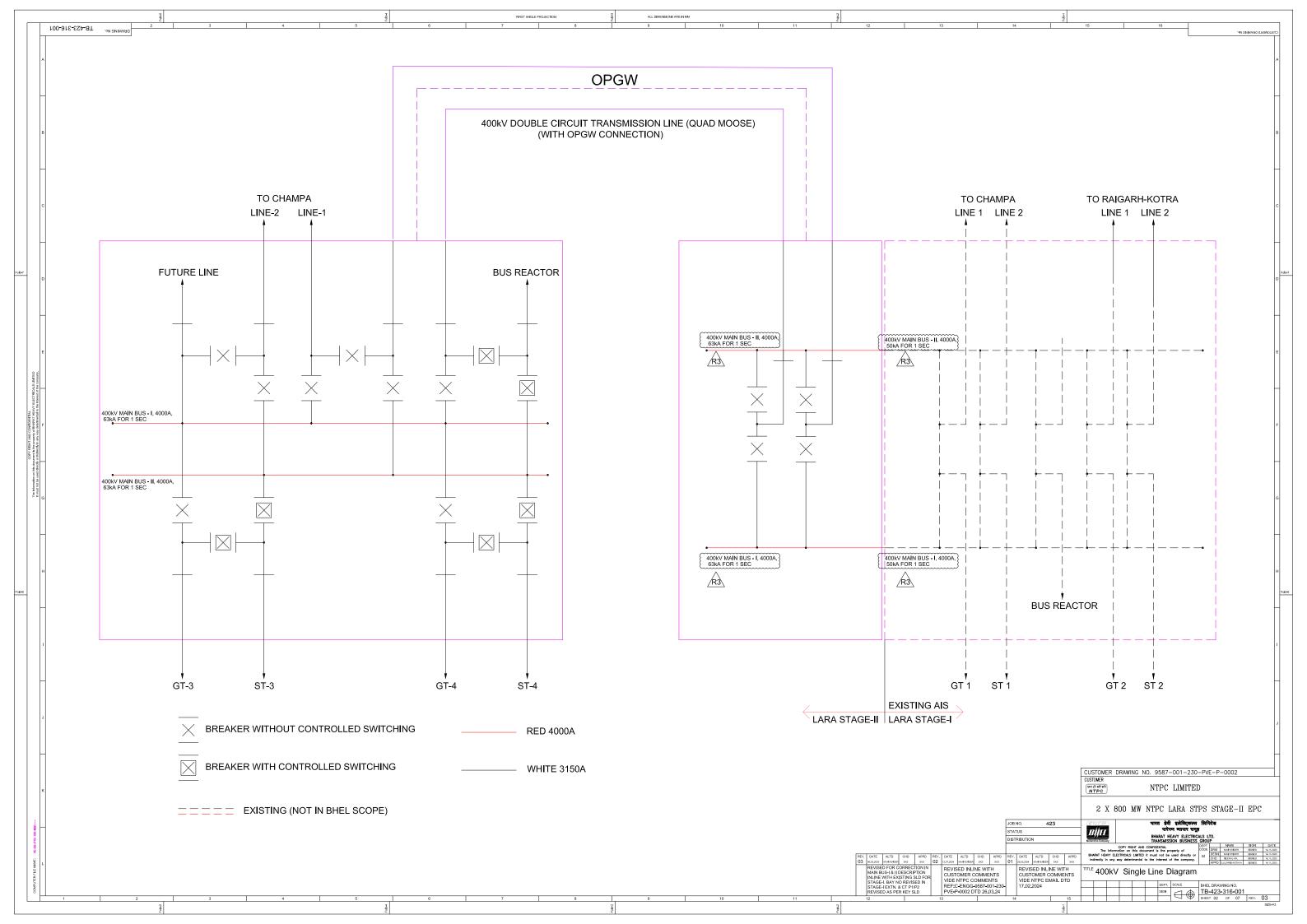
CONCLUSION:
From the above tables, it is clear that all equipments, buildings & Jack buses of the various Bays are well protected with the proposed shield wire & lightning mast arrangement.

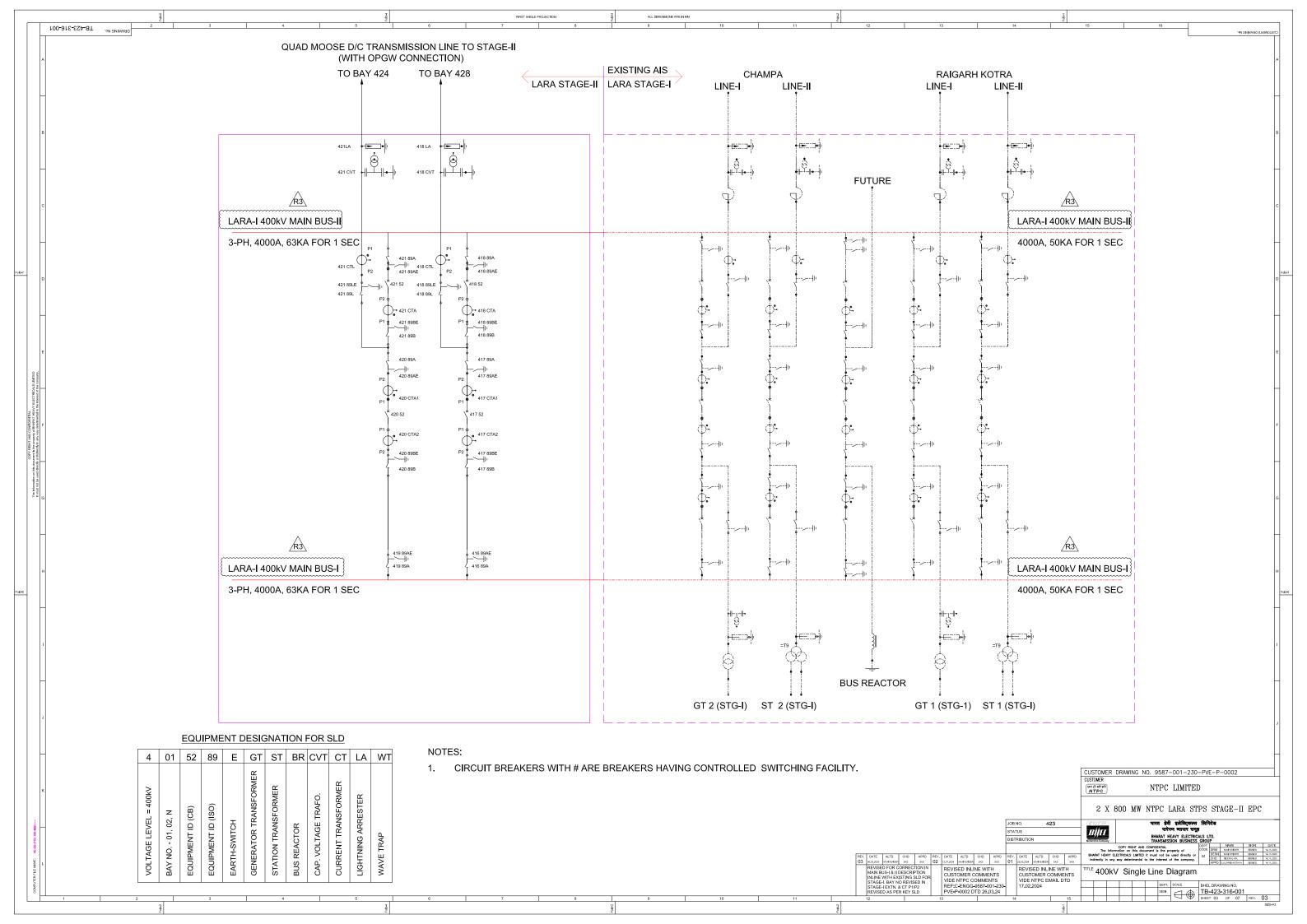
- 1) All vertical heights taken are from FGL. Plinth level is 0.3 m above ground level. 2) All figures are in meters.

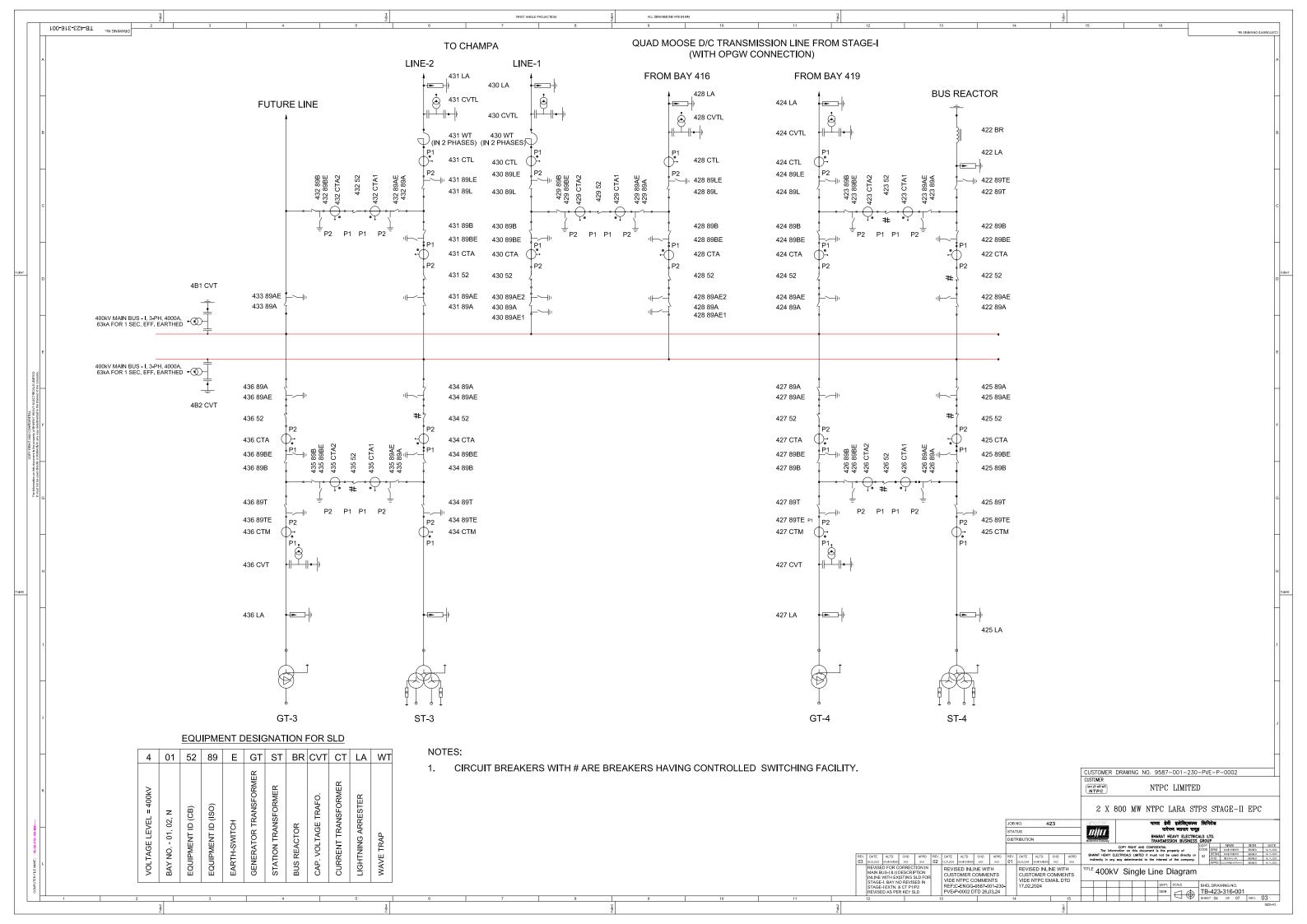












7. SWITCHING IMPULSE WITHSTAND VOLTAGE

8. CREEPAGE

9. SYSTEM EARTHING

± 1050 kVpeak

25mm/kV (10500 MM)

**EFFECTIVELY EARTHED** 

## 400kV CT DETAILS:

_								
_	CT CORE NO.	CURRENT RATIO	OUTPUT BURDEN (VA)	ACCURACY CLASS AS PER IEC	MIN. KNEE POINT VOLTAGE (Vk)	MAX. CT SEC WINDING RES.(OHM)	MAX. EXCITING CURRENT IN mA AT Vk	APPLICATION
-	1.	3000/2000/1000/1		PS	3000/2000/1000	15/10/5	20/30/60	BUS DIFF. CHECK
	2.	3000/2000/1000/1		PS	3000/2000/1000	15/10/5	20/30/60	BUS DIFF. MAIN
	3.	3000/2000/1000/500/1	20/20/20/20	0.2S				METERING/SYNCH.
	4.	3000/2000/1000/500/1	20/20/20/20	0.2S				ABT METERING
	5.	3000/2000/1000/500/1		PS	3000/2000/1000/500	15/10/5	20/30/60	TRF. BACKUP/ LINE PROTECTION
-	6.	3000/2000/1000/500/1		PS	3000/2000/1000/500	15/10/5	20/30/60	TRF. DIFF./ LINE PROTECTION

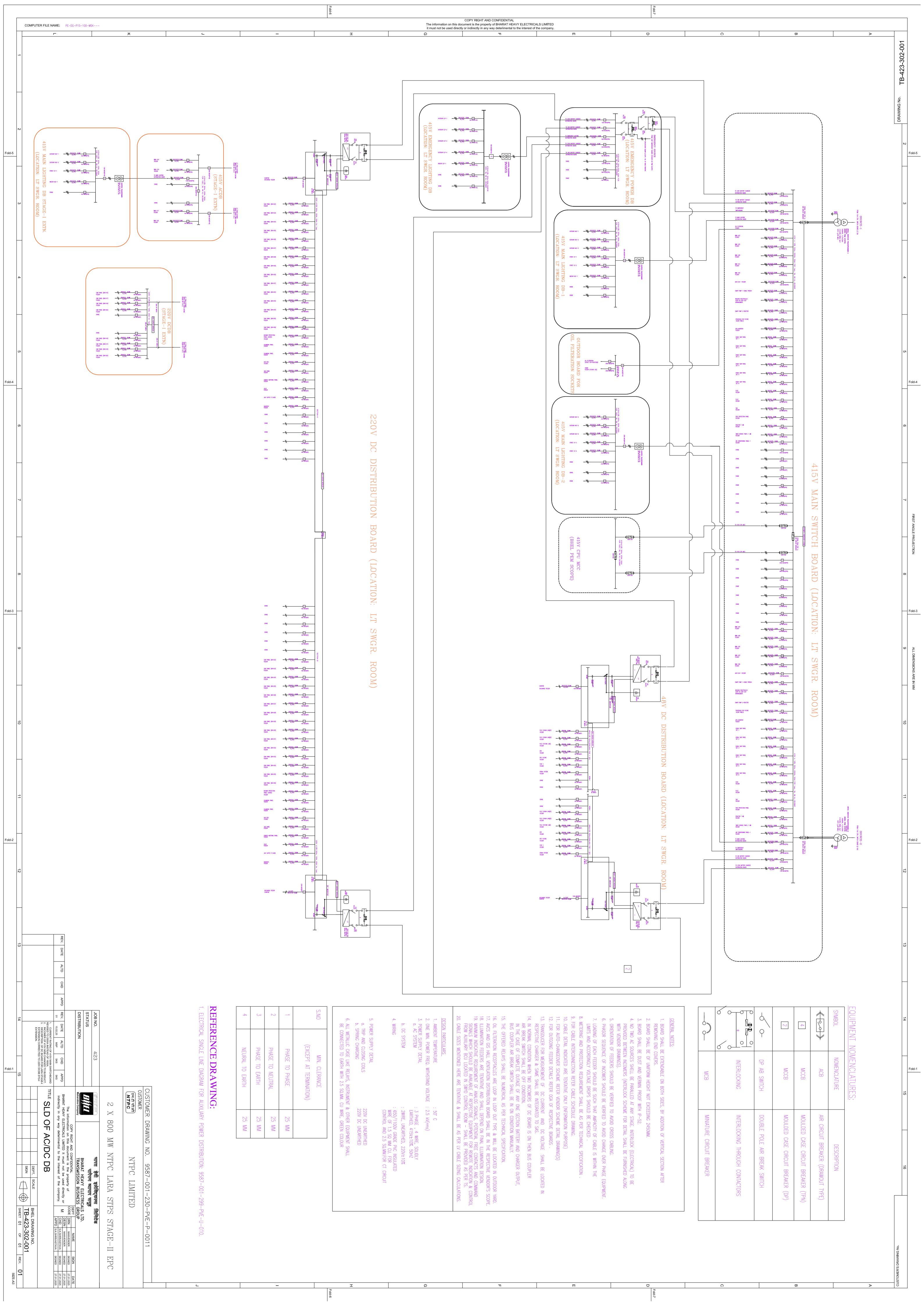
# 400kV GT/LINE CVT (4400pF, +10%, -5%) - DETAILS:

WDG. NO.	VOLTAGE RATIO	RATED BURDEN (MAX)	ACCURACY CLASS	PURPOSE
1.	$\frac{400}{\sqrt{3}} / \frac{0.110}{\sqrt{3}} \text{ kV}$	50VA	3P	PROTECTION
2.	$\frac{400}{\sqrt{3}} / \frac{0.110}{\sqrt{3}} \text{ kV}$	50VA	3P	PROTECTION
3.	$\frac{400}{\sqrt{3}} / \frac{0.110}{\sqrt{3}} \text{ kV}$	50VA	0.2	METERING
4.	$\frac{400}{\sqrt{3}} / \frac{0.110}{\sqrt{3}} \text{ kV}$	50VA	0.2	METERING

# 400kV BUS CVT (4400pF, +10%, -5%) - DETAILS:

WDG. NO.	VOLTAGE RATIO	RATED BURDEN (MAX)	ACCURACY CLASS	PURPOSE
1.	$\frac{400}{\sqrt{3}}$ / $\frac{0.110}{\sqrt{3}}$ kV	50VA	3P	PROTECTION
2.	$\frac{400}{\sqrt{3}}$ / $\frac{0.110}{\sqrt{3}}$ kV	50VA	3P	PROTECTION
3.	$\frac{400}{\sqrt{3}}$ / $\frac{0.110}{\sqrt{3}}$ kV	50VA	0.2	METERING

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#### MANDATORY SPARES FOR ELECTRICAL



Sr. No.	Description	Quantity
1.	Switchyard 400kV AIS	
1.01.00	Circuit Breaker	
	a. Relays, power contactors, switch-fuse units, limit	1 Set
	switches, Auxiliary switch assembly, push	
	buttons, timers & MCB for electrical control	
	circuit (consisting of one no. each of all types and	
	ratings)	1.0
	b. Set of gaskets, rings & seals	1 Set
	c. Molecular filter for Circuit breaker	1 Set
	d. Tripping coils with resistors and closing coil with resistor (each type)	6 Nos
		1 Set
	e. Density / pressure monitoring system for circuit breaker	1 361
	f. Set of spares for pneumatic/ Spring/ hydraulic	1 Set
	operated mechanism(as applicable ) as per the	1 500
	main supply of circuit breaker applicable.	
	g. Spare of pneumatic/spring/hydraulic operated	1 Set for each type
	mechanism:	Circuit Breaker
	Spare of pneumatic operated mechanism	
	Complete compressor assembly along with	
	motor, accessories and coupling along with	
	regenerating unit (wherever applicable) – 1	
	set.	
	<ul> <li>Micro Filters – 1No.</li> </ul>	
	Coupling for compressed air – 1set	
	<ul> <li>Pressure switch and valve – 1 no. of each type</li> </ul>	
	Pressure gauges – 1 Set	
	Gaskets – O-rings & seals – 1Set	
	Dowty Seal – 1set	
	Operating drive – 1 set	
	2) Spare of spring-operated mechanism(complete)	
	Spring charging Motor – 1 no     Limit gwitch etc. 1 no of each type	
	• Limit switch etc. – 1 no. of each type	
	• Closing dash pot – 1 Set	
	• Opening dash pot – 1 Set	
	• Opening catch gear – 1 Set	
	• Complete spring operating mechanism – 1 Set	
	3) Spare of hydraulic operated mechanism	
	Hydraulic operating mechanism with drive	
	Motor − 1 no.	
	<ul> <li>Ferrules and joints – 1 Set</li> </ul>	
	<ul> <li>Hydraulic Filter – 3 Sets</li> </ul>	
	<ul> <li>High Pressure Hose – 1 Set</li> </ul>	
	• N2 accumulator – 2 No.	
	Pressure Transducers – 1No.	
	• Valves – 1 Set	
	<ul> <li>Orings, gaskets and seals – 1 Set</li> </ul>	
	<ul> <li>Pressure switches and pressure gauges – 1 Set</li> </ul>	
	• Hydraulic oil – 15% of total used quantity in	
	substation	
		1

#### **CLAUSE NO.** MANDATORY SPARES FOR ELECTRICAL • Limit switch – 1 no. of each type h. Fixed and moving arcing contact assemblies 2 Set including insulating Nozzles etc. for 1 interrupter (each type & rating of Breaker) 3 Nos. of each type Terminal connector i. Actuator rings if required j. 6nos 3nos Magnetic ventile if required Operation counter 1no 1. m. SF6 gas 15% of total used quantity in switchyard Pressure Gauge and coupling 1set Pressure switches 1set o. Terminal Pads and connectors 2set p. Corona rings 1no

	r.	Grading capacitor if applicable	3nos
	S.	One complete pole (phase) of circuit breaker including CSD/Closing resistor, grading	1 No. of each type and Rating
		capacitor(as applicable), pole column,	
		interrupter, Unit operating mechanism, marshalling box excluding supporting structure,	
		terminal connectors and common operating	
		Mechanism	
1.02.00	Disc	connector	
	a.	One complete pole of each type of HCB isolator with 1 E/S along with operating mechanisms, insulators etc. without support structure	(1 no. of each type & rating)
	b.	Isolator Arms with finger contacts and current carrying assembly	(1set)
	c.	Relay, power contactors, switch fuses, timers, key interlock pushbutton switch for electrical control circuit	(1 Set)
	d.	Limit switch & aux. switch	6 Nos. of each type
	e.	Terminal Pads and connectors	3 Nos. of each type
	f.	Rotary Bearing for Isolator	(3 Nos. of each type)
	g.	Motor with hear assembly and bevel gear assembly	(lno)
	h.	Coronal shield rings	(3nos)
	i.	Hinge pins	3nos
	i.	Hinge pins	3nos

# **CLAUSE NO.** MANDATORY SPARES FOR ELECTRICAL Copper contacts fingers for male & female contacts 2sets

	k. Support insulators	1set
1.03.00	Current Transformer complete in all respects including terminal connectors etc. (120% Rating)	3 no of each type & rating
1.03.01	Primary Terminal Bushings	2 Sets
1.04.00	Surge Arrester complete in all respects with surge counter, terminal connector etc.	3no
1.04.01	Surge counter/Monitor	5 Nos
1.05.00	Capacitor Voltage Transformer complete in all respects including terminal connectors etc.	2 no of each type & rating
1.05.01	Bus Post Insulator Assembly (Complete)	3 Nos of each type
1.06.00	Clamps and connectors (Minimum 3 Nos. of each type)	10% of total population
1.07.00	Spacers and corona bells.	(Minimum 3 nos. of each type)
1.08.00	String Insulators and associated hardware's	3nos of each type
1.09.00	Disc Insulators	5% of the total number of discs of each voltage class installed at the switchyard
1.10.00	Long Rod insulator	5% of the total number of insulators of each voltage class installed at the switchyard subject to a min 3nos of insulators of each voltage class.
1.11.00	SAS Including GRPs	
	A. Bay Control unit (complete with all components)	2 No.
	B. Numerical Relays comprising various bay protection units, busbar( Both CU and PU), islanding scheme and GRP	1 No. of each type
	C. Switchgear control unit	2 No. of each type
	D. Merging unit	2 No. of each type
	E. Operator work station (OWS)/ Engineering Work Station (EWS) along with software, monitor, mouse, keyboard, printer etc.	1 No.
	F. Complete Network Controller / Server along with software	1 No.
	G. LAN switches for LAN	1 No. of each type
	H. Firewall	1 No. of each type
	I. Fuses	10 No. of each type and rating
		5 nos. of each type,

LARA SUPER THERMAL POWER PROJECT STAGE-II (2X800 MW) EPC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 3 OF 11
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CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीर्स NTPC
	K. Rela	ys other than numerical relay	ys total por 1 no.)	each type of oulation (min
	L. GPS	equipment	1 set con hardware each type	Modules of
	M. Medi sche	ia converters (applicable me) for SAS application	as per 1 set	
		face cables containing th of each type of cable nector for each type of periph		
	O. MCB		1 No. o make	f each type and mode he system
	P. LIU	of OFC including necessary o	1 no. of	each type
		Energy Meter – 0.2s		each type
	stan	ls/Modules of generator DR, d-alone)	1 100. 01	each type
		plete programming station aware, monitor etc.	along with 1 No.	
	T. Gate	eways		each type
		em/Firewall (if applicable)		each type
	V. Tran	isducers liary CT/PT		each type each type
	ERMAL POWER PROJECT E-II (2X800 MW)	TECHNICAL SPECIFICATION	SUB-SECTION-VI CHAPTER-11	PAGE

#### CLAUSE NO.

#### MANDATORY SPARES FOR ELECTRICAL



### 2. LIST OF MANDATORY SPARES for oil filled transformers/reactor

S. No	ITEMS DESCRIPTION	GT NOT	ST	UT	Aux. Trans. (for each rating)	REACTOR
1.	HV Bushing with metal parts and gaskets (See Note 1)	APPLI	CABLE		3 No.	3 No.
2.	HV Neutral bushing with metal parts and gaskets				1 No. (if applicable)	1 No.
3.	MV Bushing with metal parts and gaskets (See Note 1)				-	-
4.	LV bushing with metal parts and gaskets (See Note 1)	_			3 No.	-
5.	LV Neutral bushing with metal parts and gaskets				1 No. (if applicable)	-
6.	WTI with contacts	=			1 No.	1 No.
7.	OTI with contacts				1 No.	1 No.
8.	Pressure relief device				1 No. (if applicable)	1 No.
9.	MOG	_			1 No.	1 No.
10.	Buchholz relay complete				1 No.	1 No.
11.	Oil surge relay				-	-
12.	Set of gaskets (See Note 2)	_			1 Set	1 Set
13.	Set of valves				2 No. of each type/size	2 No. of each type/size
14.	Cooler fan with motor				-	-
15.	Oil Pump with motor				-	-
16.	Oil flow indicator				-	-
17.	Set of OLTC/OCTC contacts				-	-
18.	Air cell for conservator				1 No. (if applicable)	1 No.
19.	Neutral Grounding Resistor w/o supporting structure					

LARA SUPER THERMAL POWER PROJECT
STAGE-II (2X800 MW)
EPC PACKAGE

CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीमी NTPC
2.01.00	Note 2: 1 set consists of (a) protection and (b) cooler circuit (c) largest inspected (d) HV/LV turret, (e) OLTC inspected (e)	ction cover, if applicable		
	NOT APPLICABLE	<del>чаанньо гечанов пог г остирг</del> е	<del>tte transionnemeastor.</del>	
2.02.00	Dry Type Transform	ners(EXCEPT STACKER/RECL/	AIMER)	
	NOT APPLICABLE			
3	Note: 1 set consists of c	quantities required for 1 comple	te transformer.	
3	S.No. Item descri	ption OR BUS DUCT	Quantity	
STAGE-II (2X800 MW)   CHAPTER-11			PAGE 6 OF 11	

**EPC PACKAGE** 

CLAUSE NO.	MANDATORY SPARES FOR ELECTRICAL			
	NOT APPLICABLE			
	II MV Busduc NOT APPLICABLE	it		
4.		3kV / 11kV / 6.6kV / 3.3kV)	& PCM	
	S.No. NOT APPLICABLE	Item Description		Quantity
STAG	HERMAL POWER PROJECT GE-II (2X800 MW) PC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-V CHAPTER-11 ELECTRICAL	I PAGE 7 OF 11

CL	AUSE	NO.	
	$\neg \circ \circ \vdash$	110.	

#### MANDATORY SPARES FOR ELECTRICAL



NOT APPLICABLE

## 5. LT Switchgears & LT Busducts

S. No.	Item Description	Quantity
1	Complete breaker of each rating	10 Nos.
2	Numerical Relays of each type	5 Nos.
3	Auxiliary Relays of each type	10 Nos
4	Horizontal busbar support Insulators	12 Nos
5	Vertical busbar dropper support insulators	12 Nos
6	Current transformer of each type & ratio	3 Nos.
7	Voltage transformer of each type & ratio	3 Nos.
8	Control supply transformer of each type & rating	3 Nos.
9	Power Contactor of each type and rating	10 Nos.
10	Coil for above contactor for each type and rating	10 Nos.
11	MCCBs (equally divided for all ratings)	40 Nos.
12	MPCBs (equally divided for all ratings)	40 Nos.
13	Closing coil of each type of each rating	10 Nos.
14	Trip coil of each type of each rating	10 Nos.
15	Aux contact set of each type and Rating	6 Sets.
16	Fixed contact set of each type & rating	3 Sets.
17	Moving contact set of each type & rating	3 Sets.
13	Maintenance tools and accessories for maintenance of LT MCC	2 Nos.

LARA SUPER THERMAL POWER PROJECT	TEC
STAGE-II (2X800 MW)	150
EPC PACKAGE	

## CLAUSE NO. MANDATORY SPARES FOR ELECTRICAL



#### 6. DC BATTERY

S. No.	Item Description	Quantity
1	Complete dry cell	5% or 10 Nos. whichever is more for each set of battery bank
2	Inter-cell connectors with Hardware	5% or 5 Nos. whichever is more for each set of battery bank
3	BHMS Spares	5% of installed capacity

Provide breakup of Set or total numbers in case of each type or % mentioned

#### 7. BATTERY CHARGER

S. No.	Item Description	Quantity
1	Set of Electronic Cards / Modules	1 set of each type & rating
2	Set of Auxiliary relays	1 set of each type & rating
3	Set of Fuse Links and Glass Fuses	3 set of each type and rating
4	3 phase Rectifier Bridge complete assembly	1 set of each type and rating
5	Rectifier Transformer	1 No. of each type & rating
6	Control Transformers	1 No. of each type & rating

	ATOR SET

NOT APPLICABLE

LARA SUPER THERMAL POWER PROJECT
STAGE-II (2X800 MW)
EPC PACKAGE

CLAUSE NO.	MANDATORY SPARES FOR ELECTRICAL			
	NOT		,	
STAG	IERMAL POWER PROJECT EE-II (2X800 MW) CC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 10 OF 11

CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीमी NTPC
	NOT			
9.	APPLICABLE	NG – Aviation Obstruction	Lighting	
STAG	IERMAL POWER PROJECT IE-II (2X800 MW) IC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 11 OF 11

#### ANNEXURE- ILLUMNINATION

C No	ANNEXURE- ILLUMNINATION	11004	OTV
<b>S. No.</b>	Item Description Supply of 415V, 250A, 3-ph, 4W MLDB-1 with Lighting Transformer 100kVA	Nos.	QTY 1
2	Supply of 415V, 250A, 3-ph, 4W MLDB-1 with Lighting Transformer 100kVA  Supply of 415V, 250A, 3-ph, 4W MLDB-2 with Lighting Transformer 100kVA	Nos.	1
3	Supply of 415V, 100A, 3-ph, 4W MLDB-2 with Lighting Transformer 50kVA	Nos.	1
4	Supply of 415V, 160A, 3-ph, 4W ELDB with Lighting Transformer 100kVA	Nos.	1
5	Supply of Indoor Lighting Panel -Type LP-1	Nos.	2
6	Supply of Indoor Lighting Panel -Type LP-2	Nos.	1
7	Supply of Indoor DC Lighting Panel DCLP	Nos.	1
8	Supply of Outdoor Lighting Panel -Type LP-1	Nos.	2
9	Supply of Outdoor Lighting Panel -Type LP-2	Nos.	2
10	Supply of Switchboard -Type SWB-1	Nos.	28
11	Supply of Switchboard -Type SWB-2	Nos.	7
12	Supply of Switchboard -Type SWB-3	Nos.	2
13	Supply of Switchboard -Type SWB-4	Nos.	1
14	Supply of Switchboard -Type SWB-5	Nos.	1
15	Supply of Receptacle -5/15A (Decorative) RA type	Nos.	17
16	Supply of Receptacle -20A (Industrial) RB type	Nos.	7
17	Supply of Receptacle -415 V, 63A, 3-PH (Industrial) Indoor Receptacle -RC type	Nos.	1
18	Supply of Receptacle -63A, 415V 3-Phase, 4-Pin Interlocked industrial grade rotatry switch socket, Outdoor Receptacle - RC type (Necessary arrangement for looping incoming supply cables shall be provided )	Nos.	6
19	Supply of Receptacle -415V, 250A. 3-Phase, 4-Pin TPN MCCB Industrial type Outdoor Receptacle with earthing contacts RP type for Oil filtration machine (Necessary arrangement for looping incoming supply cables shall be provided)	Nos.	1
20	Supply of Indoor Junction boxes	Nos.	6
21	Supply of Outdoor Junction boxes	Nos.	5
22	Supply of Indoor lighting fixtures -LED Industrial Batten Aluminium 36-40W(Make CG,Philips,Havells, Bajaj)	Nos.	60
23	Supply of Indoor lighting fixtures -LED Industrial Batten Aluminium 18-20W(Make CG,Philips,Havells, Bajaj)	Nos.	11
24	Supply of Indoor lighting fixtures -Recessed mounted CRCA Panel 2X2 30 to 40W(Make CG,Philips,Havells, Bajaj)	Nos.	90
25	Supply of Indoor lighting fixtures -Surface Mounted CRCA Panel 2X2 30 to 40W(Make CG,Philips,Havells, Bajaj)	Nos.	2
26	Supply of Indoor lighting fixtures -Corrosion proof Led Batten 30 to40W(Make CG,Philips,Havells, Bajaj)	Nos.	15
27	Supply of Indoor lighting fixtures -Recessed Mounted LED Downlighter 9-10W DC 220V	Nos.	20
28	Supply of Indoor lighting fixtures -Surface Mounted LED Bulkhead 9-10W DC 220V	Nos.	10
29	Supply of Street lighting fixtures -Street Light (80-90W)(Make CG,Philips,Havells, Bajaj)	Nos.	8
30	Supply of Street lighting fixtures -Street Light (120-150W)(Make CG, Philips, Havells, Bajaj)	Nos.	90
31	Supply of Flood lighting fixtures -Flood Light 150W(Make CG, Phillips, Havells, Bajaj)	Nos.	14 120
32	Supply of Flood lighting fixtures -Flood Light 300-350W(Make CG,Philips,Havells, Bajaj)  Supply of Post Top Lighting Fixture-Post Top 35-40W LED (Make CG,Philips,Havells, Bajaj)	Nos. No.	4
34	Supply of Occupancy based Infra Red Sensors	Nos.	10
35	Supply of Exit Sign Boards	Nos.	10
36	Supply of Exhaust fans -600 CMH @ 7mm WC Exhaust fans	Nos.	2
37	Supply of Exhaust fans -1000 CMH @ 7mm WC Exhaust fans	Nos.	1
38	Supply of Ceiling fans 1200mm sweep with electronic regulator, fan hook, suspension rod etc.	Nos.	4
39	Supply of Wall mounted fans 400mm sweep	Nos.	2
40	Supply of Free-standing Aluminium Ladder, height adjustable (from 3m to 6m height)	Nos.	2
41	Supply of Wheel mounted Adjustable aluminium ladder for maintenance of Street Lights extendable up to 10mtr	Nos.	1
42	Supply of Portable emergency lighting unit -Type LED	Nos.	1
43	Supply of 30m high Lighting High Mast with Lantern Carriage (Winch type) for Switchyard Lighting along with feeder pillar & junction box (JB-M)	Nos.	6
44	Supply of 7m Hot Dip GI Octagonal Lighting Pole with J Type Foundation bolt for Street Lighting with junction for loop in loop out	Nos.	90
45	Supply of 4m high Lighting Pole for Post-top Lantern -Type E1 including JB-S	Nos.	4
46	Supply of PVC conduit of 20mm size with accessories	Mtr.	2100
47	Supply of PVC conduit of 25mm size with accessories	Mtr.	500
48	Supply of PVC conduit of 40mm size with accessories	Mtr.	10
49	Supply of 20mm Flexible conduits made with bright, cold rolled annealed and electro galvanized mild steel strips and	Mtr.	200
50	Supply of 1C, 1.5 sqmm PVC insulated stranded Cu. Wire	Mtr.	3000
51	Supply of 1C, 2.5 sqmm PVC insulated stranded Cu. Wire	Mtr.	5000
52	Supply of 1C, 4 sqmm PVC insulated stranded Cu. Wire	Mtr.	1060
53	Supply of 2C, 2.5 sqmm PVC insulated stranded Cu. Wire	Mtr.	700
54	Supply of 1C, 10 sqmm PVC insulated stranded Al. Wire	Mtr.	500
55	Supply of Earthing Material -25x6mm GI Flat	Mtr.	100
56	Supply of Earthing Material -3m , 20mm dia ms rod electrode	Nos.	5
57	Supply of Earthing Material -3m , 40mm dia ms rod electrode	Nos.	5
58	Supply of Earthing Material -GI wire for Earthing of size 8 SWG	Mtr.	2200
59	Supply of Earthing Material -GI wire for Earthing of size 16 SWG	Mtr.	800
60	Supply of Telephone points-single outlet telephone socket including cable/wire and accessories  Supply of Telephone JB suitable for 20 pair Indoor type	Nos.	6 1
61 62	Supply of Supply of 2 wire telephone cable (ISI marked).	Nos. Mtr.	200
63	Supply of LAN points incudiung accessories	Nos.	5
64	Supply of LAN Cable	Mtr.	200
	Josephi, or min. contr.	14101.	200

## Procedure for transformer / Reactor Installation , Testing and Commissioning



## BHARAT HEAVY ELECTRICALS LIMITED TRANSMISSION BUSINESS GROUP- NORTHERN SECTOR

Rev.0	roccaure for transformer / Reactor	Installation , Testing and Commissioning
SI no.	Description	Remarks
A.	On Arrival of Transformer Tank	
A.1	Checking of Pressure, Dew point , IR of CC- CL - Tank	Record the values If tank pressure is zero then reports to Bhopal
A.2	Removal of Impact Recorder after placement on Plinth	Sent to Bhopal for review
A3	Before signing LR on receipt of material - Transformer shall be physically checked for any damage /physical abrasion during transportation	Remarks to be mentioned on the LR .
В.	Installation work	
B.1	Drum oil test - BDV, PPM, Tan Delta, Resistivity and IFT	Number of sample to be tested as per customer standard procedure.
B.2	Ensure the availability of drawing (OGA, Assembly drawing like cooler bank, aux system and other piping work, Part List etc.)	
B.3	Material Verification	Shortages to be reported to BHEL prior installation of work.
B.4	Turret CT and Bushing to be tested, Dry Air Generator Dew point level to be examined before raise the call for internal inspection	Bushing to be tested on variable frequency upto 391Hz. Reports to be submitted for clearance. PS class CT's ratio error@ 100%rating to be <0.25%
B.5	Internal inspection and Bushing erection a. Ensure crane availability b. Ensure Dry air generator to achieve dew point -60 c. Dew point measurement kit (Vaisala Make kit) d. Ensure CT ratio measurement kit for internal CT test	23T capacity crane or last boom capacity 2T and minimum 60 feet boom length)
B6	Transformer GT/ICT /ST /UAT / Reactor to be examined for any loose earthing / core locking arrangement /Wall shunts / clearance between the Tanks and Bushing leads . Transformer should be flushed with Hot oil and thoroughly cleaned before Boxing up of Transformer.	Any abnormality may please be reported to the Manufacturing BHEL Unit
B.6	<b>TESTING AFTER ERECTION - BEFORE DRYOUT</b> Testing of WRM and Turn Ratio (HV/IV, HV/LV, IV/LV at all taps - applicable for transformer)and SFRA	Reactor- WRM and SFRA ICT - WRM & Turn ratio and SFRA for Transformer Acceptance Limit - error should be less than 0.5% for turn ratio and WRM <2.5%
С	PREPARATION BEFORE START OF ERECTION	
1	<b>PIPEWORKS</b> -All pipe works shall be checked as per checklist before start of the work . Pipe work be thoroughly cleaned before Erection and if required flushed with oil	Cleaning and Flushing of the pipe work to be ensured before Erection
2	CONSERVATOR - Air cell of the conservator to be tested for leak test at 1 PSI / 0.07kg/cm2 for 1 hrs . Conservator without Air cell may be checked for 2 PSI for a period of 1 hr .After successful testing of Air cell and Conservator and MOG and changing the inspection cover "O Ring " - Erection of Conservator to be carried out .	In case of the any leakage noticed , concerned OEM Unit to be informed .
3	RADIATORS/ COOLER BANKS - All Radiator to be mounted are to be leakage tested as per BHEL standard protocol through Air pressure of 2 psi for 15 min (time span for soap solution test). This is followed by Flushing of each radiator for 15min with the Transformer oil as provided by BHEL Engineer in charge at site	Details to be filled as per standard protocol
C.	Dry out of Transformer- (once WRM & turn ratio in Limit)	
C.1	Cooling bank & Conservator must be isolated from main tank	
C.2	Leakage test at pressure upto 5 PSI for Main Tank after complete Box up of Transformer .	If test is cleared go for the next cycle of vacuum test .

## Procedure for transformer / Reactor Installation , Testing and Commissioning

SI no.	Description	Remarks
C.3	Vacuum Test to be performed after successful leakage Test at vacuum (500-700mmHG)	Check for any leakage after 1 hrs and subsequent 0.5 hrs in 2 intervals .
C.4	Leakage test at vacuum (L1 & L2 method) between 1 to 2 torr in McLeod gauge	for PGCIL project . Calculate leakage rate (L2-L1)volume/Time) L1 is reading at start and L2 is reading at time duration. Leakage should be less than <100
C.5	1st Vacuum cycle for 72 hour after reaching 0.5 torr vacuum in McLeod Gauge	Continuous running of vacuum pump for 72 Hour
C.6	After 72 hour vacuum - fill the N2/dry air cylinder (prefably Nitrogen from cylinders) of Dew point better than -60 at 0.25 to 0.35 kg / sq cm (3.5 to 5 PSI)	
C.7	Check the Dew point after 24 hour of N2 filling	Record the values, If dew point is -20 or below. Process of Heating +vacuum of main tank to be done.
C.8	2nd cycle of Vacuum for 48 hour after reaching 0.5 torr vacuum in McLeod Gauge	
C.9	After 48 hour vacuum - fill the <b>N2/dry air cylinder</b> (prefably Nitrogen from cylinders) of <b>Dew point better than -60</b> at 0.25 to 0.35 kg / sq cm (3.5 to 5 PSI)	
C.10	Check the Dew point after 24 hour of N2 filling	Acceptable value of dew point is -36 <b>(0.5 RH)</b> or better. If desired dew point not obtained then go for 3rd cycle of 48 hrs ( depend on the 2nd cycle test results ). Dry out cycle to be repeated till achieving Main Tank - active part dew point -36 <b>(0.5 RH)</b> or better.
D.	Oil Filling and Filtration	
D.1	Provision for Storage capcity of complete required oil to be filled in Transformer Tank in one go to be maintained. Oil of each storage Tank to be tested at Power grid Lab. Complete oil to be made ready before oil filling.	BDV, PPM, Tan Delta @90, Interfacial tension & Resistivity. BDV value -75 (Min) and PPM<5
D.2	Oil filling in the ICT / Reactor Tank to be done under vacuum to be maintained for 24-48 hrs prior to oil filling . Oil to be inside the Tank shall be at temp 40-50 degree . Complete oil fillingto be done in one go after achieving the required parameters	Before filling, oil to be tested for each storage tank in PGCIL approved Lab. BDV - 75 (min) and PPM <5
D.3	OLTC to be filled through Main tank and after filling equalizing link atatched during entire process may be removed.	After OLTC filling upto tank level. Equalising pipe to be remove and connect all pipe of OLTC
D.4	Remove the Dummy plate between cooling bank and main tank	
D.5	under B/F in closed condition Oil filling in cooling to be filled through bottom pipe line through main tank or cooling to be filled separately .	Oil to be filled under open condition of air plug in header pipe and all B/F of cooling bank.
D.6	Fill the Oil in conservator to be done as per standard comissioning process after completion of HOC process .	Follow OEM instruction for Conservator commissioning .
Е	Filtration and HOT Oil Circulation	
E.1	Closed the B/F valve of Top/Bottom pipe of cooling bank if opened	
E.2	HOC to be done for min period of 72 Hour or more till achieving the PI value . Time of HOC shall be considered after reaching outlet oil temperature from ICT Tank /OTI/WTI Temp (60 degree ) or as per recommendation of OEM.  HOC period will be extended if PI value does not reach.	Ensure filter M/C outlet pipe (heated oil pipe) must be connected at bottom valve of main tank.  PI to be taken in last 24 Hour. Inlet and outlet temperature to be recorded. Following PI to be measured at Regular interval of 4 hour.  a. HV+IV+N /E+LV : PI >1.75 b. HV+IV+N/LV : PI>1.75 c. LV/E+ HV+IV+N: PI> 1.75

## Procedure for transformer / Reactor Installation , Testing and Commissioning

SI no.	Description	Remarks
E.3	After clearance of HOC . Each Cooling bank to be filtered separately with minor opening of B/F of top pipe line to ensure breathing of oil through conservator. Minimum 8 Hour	Local BDV (>75) & PPM (<5) to be checked. Minimum 4 rotation of oil (calculation based on with 50% capacity of Filter M/C)
E.4	After completion of filtration of cooling bank, oil to be mixed with main tank. Filtration to be done for minimum 24 hours	All B/F of Top and Bottom to be opened.
E.5	Particle count test to be done when the Transformer oil is completely mixed and under motion .Fine filtration carried out with Filter Machine of 0.3-0.5 micron filters . While carrying out particle count Filter machine to be kept under throughout during the process of Particle count .	Under running condition of cooling bank pump. Particle count must be <b>maximum 4 micron, 10,000 particle count per liter</b> (i.e. ISO 10) Minimum three sample to be tested. For measurement (Oil qty 100mL in each measurement) to be taken under each sample with test duration of 4.5- 5min.
E.6	Complete Electrical test to be done.  A. WRM & Turn Ratio as per factory test b. Bushing at variable freq & Winding Tan Delta Test c. Magnetic Balance /Vector group d. Magnetizing current e. SFRA test f. IR test of winding g. Short circuit impedance calculation . h. Floating point voltage calculation . i. Meaurement of Vibration in case of Reactor after charging g. Other Balance test as per PGCIL.	Testing kit with Calibration certificate is required. Test to be performed under electrical operation of OLTC tab.
E.7	Following oil Test to be done: sample to be taken from Tank Bottom & Tank Top  1. BDV , PPM, Tan Delta@90, DGA, IFT & resistivity  2. Any other test as per Power Grid contract	

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Updated by JAI K, DGM TBG BHEL, 12/03/2024



## CONTENTS

SECTION	2	INSTALLATION	
	2.1	RECEPTION AND ASSEMBLING OF TRANSFORMERS / REACTORS	21
	2.2	STORING OF TRANSFORMER / REACTOR DESPATCHED FILLED	28
	2.3	ASSEMBLING OF RADIATOR / COOLER BANK WITH PIPES	30
	2.4	INSULATING OIL, QUALITY AND TREATMENT	33
	2.5	OIL FILLING UNDER VACUUM	36
	2.6	OIL FILLING INSTRUCTIONS FOR CONSERVATORS WITH AIR	41
	2.7	UNTANKING OF ACTIVE PART	45
	2.8	MOUNTING OF GASKETS	47
	2.9	WELDED COVER (IF APPLICABLE)	49
	2.10	EARTHING OF ACTIVE PART AND CORE INSULATION TEST	49
	2.11	TOUCH-UP PAINTING	50
SECTION	3	COMMISSIONING	
	3.1	TESTING AFTER ASSEMBLY OF THE TRANSFORMER / REACTOR	63
	3.2	COMMISSIONING CHECKS - TRANSFORMER	64
	3.3	COMMISSIONING CHECKS - REACTOR	74



# SECTION 2 INSTALLATION

#### 2. INSTALLATION

## 2.1 RECEPTION AND ASSEMBLING OF TRANSFORMER / REACTOR DESPATCHED PARTLY DISMANTLED AND FILLED WITH NITROGEN.

To ensure that a Transformer will function satisfactorily it is important that handling, lifting, storing and assembling are carried out with great care and cleanliness by experienced personnel who know the various working operations very well.

This section gives instructions how handling, lifting, storing and assembling should be carried out. For large Transformers it is recommended that the work is done by BHEL or is under supervision by experts from BHEL.

#### 2.1.1 INSPECTION

In connection with receiving and unloading at site, and at the final storing place before assembling, the transformers shall be inspected carefully. External visible damages as dents, paint damages etc. may imply that the transformer has been subjected to careless handling during transport and/or re-loadings, and a careful investigation is therefore justified.

After the arrival of the material at receiving points, the customer should, in case of possible damage/loss of any component, make the necessary claims with the contractors representatives under intimation to BHEL so that such claims can be registered with the transport agents. Before unloading, the condition of packing and of the visible parts should be checked and possible traces of leaks verified (condenser bushings). If necessary, appropriate statements and claims should be made.

Drums containing oil which have been dispatched separately should be examined carefully for leaks or any sign of tampering. All drums are dispatched filled up to their capacity and any shortage should be reported.

In order to protect the active part against moisture, the transformer tank is filled with nitrogen during transport at an over pressure of 0.17 kg/ sq.cm (2.5 psi) approximately at room temperature.

Check immediately the gas pressure at the arrival. A positive pressure indicates that the tank and the transformer components respectively are tight, and that the active part including the insulation materials is dry.

If there is no positive gas-pressure, transformer should be immediately filled with dry Nitrogen gas at a pressure of 0.17 kg/cm<sup>2</sup> (2.5 psi) without loss of time as per instructions given para 1.2.3

Otherwise, it should be checked if the core isolation is satisfactory and that accessories packed separately have not been damaged during the transport. Instructions for checking of the core isolation are given in clause 2.10



#### 2.1.2 UNLOADING

Typical unloading arrangement of the transformer is shown in fig 2.1.

Whenever rollers/trolleys are supplied with transformer, movement of transformer at site is carried out by mounting these rollers/trolleys. For mounting of rollers refer roller mounting drawing included in Vol.I.

Alternatively for movement of transformer from loading bay to actual site of the equipment, skidding on greased rails etc. can also be resorted to.

#### **2.1.3 STORING**

Dismantled equipment and components are packed to be protected against normal handling and transport stresses. The instructions for lifting given on the packages, must be complied with to avoid damages. Goods stored outdoors must not be placed directly on the ground, and should be covered carefully with tarpaulin or similar material. Oil drums should be stored in horizontal (lying) position with both the bungs also in horizontal position.

#### **2.1.4 LIFTING**

Lifting devices on the transformer tank are dimensioned for lifting of the complete transformer filled with oil. The positioning of the lifting devices, permissible lifting angles, minimum height to crane hook and transformer weight, appear from the OGA drawings. Check at lifting of complete transformer that the lifting wires/ropes are not in contact with bushing or other components on the cover. For lifting with hydraulic jacks, the transformer is provided with jacking pads dimensioned for lifting of complete transformer filled with oil. The positions of the pads appear on the OGA drawings. If active part is to be lifted refer instructions given in clause 2.7.

#### 2.1.5 LOCATION AND SITE PREPARATION

- a) Reactor shall always be placed on concrete plinth without rollers as per foundation plan drawing whereas transformer may be even placed with rollers. Therefore it is very important to refer foundation drawing before placing the transformer/reactor on final location.
- b) Transformer/reactor should be placed on the foundation so that easy access is available all around and diagram plates, thermometers, valves, oil gauges, etc. can be easily reached or read. Adequate electrical clearances are also to be provided from various live points of the transformer to earthed parts.
- c) ONAN type transformers/reactors depend entirely upon the surrounding air for carrying away the heat generated due to losses. For indoor installation, therefore, the room must be well ventilated so that the heated air can escape readily and be replaced by cool air. Air inlets and outlets should be of sufficient size and number to pass adequate air to cool the transformer. The inlets should be as near the floor as possible and outlets as high as the building will allow. Where necessary, exhaust fans can be installed for the purpose.



- d) The transformers should always be separated from one another and from all walls and partitions to permit free circulation of air. In this connection reference is also drawn to IS: 10028 (Part II).
- e) Where rollers are not fitted, level concrete plinth with bearing plates of sufficient size and strength can be adopted for outdoor transformers. To prevent the formation of rust, it is essential to avoid presence of air and water in the space between the plinth and the base of the transformer by use of cretex or similar bituminous compound.
- f) Where rollers are fitted, suitable rails or tracks should be used and the wheels locked to prevent accidental movement of the transformer. Where walls are provided, it should be ensured that the transformer gets a good ventilation as mentioned above for indoor transformers. Provision should be made for the emergency drainage of the oil from the transformers (e.g. in case of fire in neighboring apparatus or bushing or the transformer tank), by surrounding the transformer plinth with sump filled with small pebbles.

## 2.1.6 INTERNAL INSPECTION AND CHECK POINTS FOR ASSEMBLING THE TRANSFORMER/REACTOR

### (a) Check-points before starting assembly:

- 1. Conditions of leads.
- 2. Bracing, clamping of leads.
- Connections.
- 4. Tap changer checks.
- 5. General conditions of insulation.
- 6. Core check that it has not moved in transit.
- 7. Core-ground; this is checked with the megger after removing earth connection.
- 8. CTs, including the secondary leads and their passage through metal parts.
- 9. Check that shipping frame for bushings have been removed.
- 10. Check that coil position has not moved in transit.
- 11. Check for dirt, metal swarf, moisture.
- 12. Check that the bushing leads set without being too close to ground or other points of different potential.



#### (b) Check-points during Assembly

By means of the Part list and the transformer/reactor OGA, the assembling of a fully completed transformer is carried out according to the following instructions. The following precautions are to be taken:

- 1. Fire-fighting equipment shall be available at the oil-treatment equipment as well as at work on and adjacent to the transformer.
- 2. Welding work on or adjacent to the transformer shall be avoided, but if this is not possible, the work shall be supervised by fire-protection personnel.
- 3. Smoking on or near the transformer shall not be allowed.
- 4. Transformer tank, control cabinet etc. as well as assembling and oil treatment equipment shall be connected with the permanent earthing system of the station.
- 5. Check that there is no overpressure in the transformer when blanking plates or connection lids are to be opened.
- 6. All loose objects, tools, screws, nuts etc., shall be removed from the transformer cover before opening the connection and blanking lids.
- 7. All loose objects (tools, pencils, spectacles etc.,) shall be removed from the boiler-suit pockets etc. before starting the work through man holes.
- 8. Tools to be used inside the transformer/reactor -e.g. for tightening of screwjoints- shall be fastened to the wrist or another fixed point by means of cotton tape or string.
- 9. Tools with loose sleeves and tools with catches must not be used at work inside the transformer.
- 10. Greatest possible cleanliness shall be observed at work inside the transformer/reactor, and at handling of parts to be mounted inside the transformer.
- 11. Fibrous cleaning material should not be used as it can deteriorate oil when mixed with it.
- 12. All components dispatched separately should be cleaned inside and outside before being fitted.
- 13. A transformer/reactor is best protected from damp hazard by circulating warm, dry, de-aerated oil through it until it temperature is 5 °C to 100 °C above ambient. This should be done before allowing external excess to the interior of the tank. The warm oil should be circulated all the time transformer is open to atmosphere,
- 14. Oil pump & all joints in the oil pipe work should be airtight to avoid entrance of air through leakage joints.



- 15. The active part (core and winding) should be exposed to the surrounding air as short time as possible. Open therefore only one blanking plate or connection lid at a time for remounting of bushings, valves etc.
- 16. Objects which-despite all precaution are dropped inside transformer/reactor, must absolutely be brought up from the equipment.
- 17. Check that the oxygen content inside the transformer tank is minimum 20% if a person is to enter the tank.

#### 2.1.7 ASSEMBLY OF WHEELS

Mounting of wheels under reactor/transformer is to be done as per roller arrangement drawing. The reactor however in service, is to be placed on plinth with anti-earthquake fastening without rollers. Transformer placement can be with or without rollers as per applicable OGA/foundation drawing.

#### 2.1.8 ASSEMBLY OF BUSHINGS

In case the bushings are mounted on turrets on the transformer/reactor cover, they are either delivered mounted on their turret or -in case of large bushings dismantled from the turrets. The turrets are often individually adapted; check therefore that they are re-mounted in correct places, which appear from the OGA drawing and part list.

Assembling of bushings is carried out according to bushings installation manual available. In case of draw rod / lead connection of bushing with transformer lead, half connector joint to be insulated with 3 layers of crepe paper after making proper connection.

#### 2.1.9 ASSEMBLY OF VALVES

Valves which may affect the loading gauge, or will be subjected to damages, should be dismounted before delivery. Re-mount the valves as per the positioning appear from the OGA drawing and part list. The gasketting surfaces shall be cleaned well and new gaskets fitted. Check that all valves are closed.

#### 2.1.10 ASSEMBLY OF COOLING DEVICES

Valves which are not dismantled like shut-off valves for radiators, coolers and possible headers shall be provided with blanking plates during the transport. Remove the blanking plates when the assembling of the coolers is to be started. Check first that the valves are closed. Check that each radiator and possible header is assembled in the correct positions according to OGA drawing. In case of OFAF or OFWF cooler mounting shall be done as per the relevant leaflet given in Vol.I

The shut-off valves against the transformer tank shall be closed until the oil-filling is started.

#### 2.1.11 ASSEMBLY OF OIL CONSERVATOR

The conservator, which may be with or without aircell is assembled either on the transformer, or on a separate frame. Before the conservator is assembled it shall be checked that belonging equipment -e.g. Oil-level indicator -functions satisfactorily.



The breather is connected to the oil conservator, and it is very important that joints and couplings in the pipe between breather and conservator are air tight. Refer Clause 2.6 for detailed instruction for oil filling.

#### 2.1.12 ASSEMBLY OF PIPE WORK

Pipes with flanges for connection of conservator, radiators, as well as pipes for equalizing of turrets etc. are mostly delivered completely ready for assembling according to OGA & part list. In certain cases -e.g. at a separately assembled oil conservator -certain fitting and welding of pipes and flanges on site is however required. Instruction for such assembly of external pipes is given in Clause 2.3. Before assembly, all associated pipework for cooler system/radiators to be physically inspected for the presence of any dirt/dust etc. and all visible dirt/dust to be thoroughly cleaned with clean cloth. Individual radiator/cooler and pipework to be flushed with compressed air followed by carrying out Pressure test on individual radiator/cooler Bank to check any leakages/damages before start of Erection at site

#### 2.1.13 FLANGES, BLANKING PLATES

When re-mounting blanking plates, connection flanges etc., the gasketting surface shall be cleaned well and new gaskets fitted.

#### 2.1.14 ACCESSORIES

Accessories like cooling fans, pumps, OLTC and components for supervision and control, oil-level indicator, flow indicators, gauges, Buchholz relay, PRV, thermometers etc. are assembled according to leaflet/description valid for the components (refer Vol. I).

#### 2.1.15 CONTROL CABLING

Re-assemble the control cables according to the drawing of wiring system and connect the cable ends to terminal blocks in instruments, terminal boxes, junction boxes and control cabinets according to valid connection diagram.

#### **2.1.16 GASKETS**

The sealing system normally used against oil and gas in BHEL's transformers and belonging components has rubber gaskets in grooves and nitrile rubber bonded cork gaskets at other places. Refer clause 2.8 for general information and assembly instructions for gasket mounting.

#### 2.1.17 OIL FILLING

The completely mounted Transformer is oil-filled according to directions in Clause 2.5 & 2.6. The oil shall be treated according to Clause 2.4. The lower and upper shut-off valves for radiators/coolers and possible headers shall be open during evacuation and oil-filling. If coolers are placed on suspension beams, which are mounted at right angle to the tank, the suspension beams shall be supported against the ground during the evacuation. Also radiators mounted on the tank wall shall be supported in a similar way. The hose for filling of oil is connected to the bottom valve of the transformer which must not be opened until the hose has been de-aerated and completely filled with oil.

#### 2.1.18 CLEANING & PAINTING

The transformer and its equipment are cleaned carefully from dirt, oil, lubricating grease, and damaged surfaces are touch-up painted with the primer paints and finish paints delivered as per clause 2.11.

#### 2.1.19 EXCHANGE OF BUSHING

When it is required at site to replace the Bushing (HV/ IV/ LV/ Neutral) due to reasons associated with the deviation in test results from the standard acceptable values or any other reason, following process to be adopted —

Close the Gate valve and Butterfly valve provided in the pipeline (80 NB ) between Transformer / Reactor Main Tank and Conservator .

Drain out the oil from Transformer Main tank into the storage Tank up to the level of stress shield.

Fill the Transformer Tank with Dry Nitrogen, UHP grade of Dew point less than -50 or better, if the replacement is not planned to be carried out immediately after draining out of oil from Main Tank up to the required level.

While carrying out the replacement, release the filled in Dry Nitrogen inside the Main Tank (as mentioned in step 3 of replacement procedure). During replacement of Bushing keep the Transformer tank pressurized from continuous flow of Dry air of UHP grade of Dew point less than -50 or better in order to avoid the ingress of moisture.

Before replacement of the Bushing, carry out IR, Tan Delta and capacitance measurement test on the new Bushing's to be replaced. Replacement of the bushing shall be carried out after clearance of pre-erection test results from concerned Division.

Carry out the replacement of bushing as per BHEL standard procedure, in case of replacement of 400 KV HV bushing having half connector joint between bushing and winding lead at Turret level care shall be taken that hardware used should be of appropriate length and after connection the bolt used in connection shall not be protruded from profile of half connector.

During replacement the half connector joint between Bushing and winding lead shall be wrapped by three layer of Crepe paper with half overlap.

Carry out the profile inspection of winding lead entering inside the bottom of stress shield of Bushing replaced. Also take the photographs of winding lead profile after replacement for record purpose. In case of any doubt during bushing replacement contact concerned Service division.

All Nitrile rubber cord of the inspection cover opened during the bushing replacement needs to be replaced by new Nitrile rubber cord.

After replacement of bushing, apply vacuum in the Main Tank and start filling the filtered oil (as per BHEL standard) in the main Tank under vacuum.



Equalize the Main Tank and Conservator after opening the valves in the pipeline between Main tank and Conservator of Transformer (as mentioned in step 1 of the process).

Carry out the de aeration from Turrets, Bushing and Main Tank, cooler bank and if required carry out conservator commissioning as per site requirement.

After replacement carry out the Tan Delta and Capacitance measurement of the bushing replaced and provide the test results to BHEL.

## 2.2 STORING OF TRANSFORMER/REACTOR DESPATCHED FILLED WITH NITROGEN

#### 2.2.1 STORING BEFORE COMPLETE ASSEMBLING

The storing place should be easily accessible for inspection and maintenance of the transformer. The bedding for the equipment should be larger than its bottom surface and dimensioned for the load. The transformer is placed on boardings or beams so that good ventilation is obtained underneath the transformer bottom.

Before storing, the transformer is inspected according to directions in Clause 2.1 "Reception and assembling of transformer/reactors dispatched partly dismantled and filled with nitrogen".

A transformer without remarks may be stored up to 6 months after arrival at the site without oil-filling. During the storing time, the inert gas (nitrogen) filling shall be maintained and pressure regulated, so that exposure of active part to atmosphere is avoided. If the storage time is judged to exceed 6 months, the transformer should be provided with oil conservator including oil-level indicator and breather, and oil-filled according to Clause 2.5. "Oil filling under vacuum". Certain valves must be remounted to enable the oil-filling being carried out. Furthermore, at the time at oil-filling of a completely assembled transformer, certain rules in Clause 2.5 & 2.6 must be complied with absolutely.

The oil quality should also be periodically monitored. If for some reason, oil filling cannot be carried out after a storage period longer than 6 months, the nitrogen pressure shall be maintained and supervised carefully. If the storage time without oil exceeds 18 months BHEL should be consulted about measures to be taken.

Wherever it is desired to keep the transformer energized at a low voltage so that its temperature is higher than the ambient temperature, the low voltage may be applied to LV winding with other winding in open circuit or short circuit conditions depending upon the current to be fed. However, before energizing the transformer, protection system of transformer (including electrical protection) must be checked. It may also be ascertained whether partial cooling is required in this case.

## 2.2.2 STORING OF COMPONENTS AND ACCESSORIES BEFORE

#### **COMPLETE ASSEMBLING**

Independent of the duration of the storing time, the directions below apply for dismounted components and accessories, as well as for material to be used in connection with the assembling work.

### (a) Storing indoors

In such a room, the following articles should be stored:

- 1. Insulation material as paper, pressboard, Bakelite, wood, cotton tape etc.
- 2. Insulated details as paper-insulated conductors, pressboard insulated shielding bodies etc.
- 3. Chemicals as solvents, glues, varnishes, hardeners etc.
- 4. Breathers, drying agents.
- 5. Terminal boxes, connection boxes, control cabinets.
- 6. Gas relays, oil-level indicators, thermometers, pressure valves etc.
- 7. M Box, OLTC motor drive, Fans, Pumps, Instruments & fittings. (Heating elements provided shall be connected to supply)
- 8. Online DGA, Online moisture removal system, sudden pressure relay, Conservator isolation valve

### (b) Storing outdoors

The below components may be stored outdoors. They should be placed above ground and covered with tarpaulin etc.

- 1. Oil-conservator with blanking plates for all openings.
- 2. Radiators and coolers with blanking plates for all openings.
- 3. Structures, A frames, Pipe supports, Supports for oil-conservators, radiators, control cabinets etc.

### 2.2.3 SUPERVISION

During the storing time, the storing place, transformer/reactor components and accessories are inspected regularly. Tap changer if provided should be operated at 6 monthly intervals. Two or three runs from one end of the range to the other and back are sufficient. Observations, readings, measures and dates should be noted and BHEL should be contacted for directions about possible measures. Check at even intervals -and further more at weather changes as rain, storm, frost or thawing the foundation material (boardings, beams etc.) and the condition of the ground.

Inspect the transformer/reactor periodically with regard to possible external faults and/or rust-damage.

Check also that screws and nuts in sealing joints (covers, lids etc.) are tightened. Check every second week that the connected-in heating elements in control cabinets function.

If the Transformer is inert gas filled, one shall check every second week the overpressure or inert gas consumption.

### 2.3.7 RADIATORS/COOLERS

The positioning of the radiators/coolers is indicated on OGA drawing. These are positioned so that the highest point of the oil-pipe system is always positioned below the bottom level of the conservator.

The pipe system is provided with filter valves at the start and finish to enable pumping the oil through the system.

All places where air may be collected are provided with air release plugs/ valves.

### 2.3.8 RADIATORS/COOLERS PIPES

The pipe having dimensions as per OGA drawing and may be provided with weld-flanges, expansion joints. No pipe part is allowed to be so long that internal inspection and cleaning will be difficult.

The pipes shall be placed so that air release plugs will be positioned at the highest point of the pipe part. The pipes shall be painted internally with a yellow, oil-resistant paint and externally according to the paint as per specification.

### 2.3.9 SHORTING LINKS / EARTHING STRIPS

All shorting links on tanks, turrets and fittings to be provided as per OGA



**Note – 2:** The documents, relevant to Oil, are prepared based on the IEC standard applicable as on October-2016. If user wants to refer the latest standard applicable, the confirmation shall be obtained from manufacturer.

**Note - 3:** For Mixing of oil, please refer IEC: 60296. Please ask the OEM, before mixing the oil.

### 2.4.3 HANDLING

Transformer oil should be carefully handled at site to ensure satisfactory service. Drums used for transport and storage should be kept under cover. In practice owing to contamination in the containers, difficulty may be experienced in maintaining the purity of the oil when it is transferred from one vessel to another, and once a vessel or drum has been filled with moist oil it is extremely difficult to clean. Drums should be clearly marked to indicate whether they are for clean or for dirty oil and should be reserved for the type indicated.

Oil drums should be stored at site preferably on pallets or Bricks layer, in horizontal position, with both the bung closures horizontally opposite (in 3 & 9 o'clock position) so that ingress of moisture is prevented. It is always recognized that storage of oil in drums is not always satisfactory, particularly when oil is stored in drums which have been bent or otherwise damaged in transit or storage, and the transfer of oil from such containers to electrical equipment should normally be through a suitable treatment plant.

In substations with fixed oil handling equipment like oil storage tank, the pipe work from the clean oil tank to the electrical apparatus should be kept clean and free from moisture. Where portable oil handling equipment is used, flexible pipe work and hand pump should be carefully inspected to ensure that they are free from dirt and water and should be flushed with clean oil before use. If the clean oil is being used from drums, it should have been recently tested and filling orifices of the drums should be clean. Hoses used for clean oil and dirty oil should be clearly marked and provided with plugs for sealing the ends when not in use.

Special care must be taken for oil filtration machine, which is used during treatment of oil. It is to be ensured that there is on residual quantity of oil left in oil filtration machine. The paper filters or centrifuges used with filtration machine shall be cleaned or replaced periodically as per supplier's recommendation. The pipe/hoses used with filtration machine should be properly blanked after use.

Before using oil tankers and filtration plant for handling of oil, the internals/chambers need to be thoroughly cleaned using good transformer oil so that the residual of earlier used chemical/oil is removed totally.

### 2.4.4 RECONDITIONING

Transformer oil is usually contaminated during handling, transport and storage due to ingress of moisture and solid impurities. Hence, oil shall be vacuum filtered separately at 50°C to 60°C using a suitable filtration machine and a spare clean tank before filling in the transformer. Details of filtration are given in Clause 11 of IEC: 60422-2013. Oil treatment shall be terminated when the following parameters are attained.

Table 2.1

Recommended Permissi

SI. no.	KV Class of	the	Recommended Permissible limit		
	transformer		Electrical strength	Moisture content ppm	
			(BDV) in kV (min)	(Max)	
1	Upto 170 kV		65	15	
2	245		70	10	
3	420 to 765 kV		70	05	

Storage Tank oil shall be tested for Electrical strength (BDV)/ Moisture content and Tan delta from NABL accredited lab / CPRI / ERDA/NETRA . Test Results carried out on Units mounted on filtration Machine will not be acceptable. Storage tank shall be as per typical arrangement shown in Fig 2.2 Electric strength and moisture content shall be determined following the test procedure of IEC: 60296-2012. Final oil test also needs to be carried out through NABL accredited lab / CPRI / ERDA

### 2.4.5 Evaluation of mineral insulating oil in new equipment

After reconditioning, Insulating Oil is filled into Transformer/ Reactor. As the oil comes into contact with insulating and other materials, it can no longer be considered as "unused oil" as defined in IEC 60296-2012. Therefore its properties are regarded as those applicable to oil in service, even though the electrical equipment itself may not have been energized. Oil properties should be appropriate to the category and functions of the equipment (see Annexure- 4.3).

The extent of the changes in properties may vary with the type of equipment due to the different types of material and ratios of liquid-to-solid insulation, and should be within the limits of Annexure- 4.3. Properties not included in Annexure- 4.3 (with the exception of oxidation stability for which no in-service limits have been established) should be within the limits of IEC 60296-2012.

### 2.5 OIL FILLING UNDER VACUUM

### 2.5.1 APPLICATION

Transformers and Reactors with vacuum-proof tanks shall be filled with oil according to this method.

### 2.5.2 STORING TIME

Generally it applies that Transformers and reactors which during transport are filled with dry nitrogen on arrival at the site shall be evacuated and oil filled. Before storing, the equipment shall be inspected according to the directions given in Clause 2.1 "Reception and assembling of transformer/reactor dispatched partly dissembled and filled with nitrogen". During the storing time, overpressure shall be maintained, and nitrogen consumption checked according Clause 2.2.

### 2.5.3 FLOW CHART FOR HANDLING

In Annexure 2.1 is given a flow chart of handling procedures. The pressure should be measured at different times. The pressure is OK if it is maintained according to instructions given in Clause 2.2. Reference is also drawn to para 9.0 of IS: 1866 regarding handling and filling of oil.

### **2.5.4 UNITS**

Annexure 2.1 gives the relation between different units.

### 2.5.5 PROCEDURE OF DRY OUT BY N2 / ASSOCIATED HEATING METHOD

For effective and faster removal of moisture from Transformer / Reactor, method of dry out by vacuuming followed by N2 filling and if required heating is to be adopted. The detail procedure are as under

### 2.5.5.1 FIRST CYCLE

- (i) Blank all the openings on the Transformer / Reactor Main Tank. Transformer / Reactor Main Tank is than subjected to vacuum up to 1.00 torr (1 mm of Hg) to be pulled and maintained for 72 hrs duration. During this first dry out cycle leakages if any observed in the system to be attended and rectified in this cycle.
- (ii) After vacuum cycle Dry Nitrogen of dew point more than -60°C or of UHP grade (purity 99.9999%) to be pushed in Main Tank under vacuum till Min. pressure of 2.0 psi is achieved in Transformer Main tank. The Transformer Tank is to be kept pressurized for a duration of 24 hrs.
- (iii) At the end of Nitrogen pressure cycle of 24 hrs, measure dew point values and recorded as dry out values of first dry out cycle. Moistened N2 inside transformer tank will be removed during second dry out vacuuming cycle.

### 2.5.5.2 SECOND CYCLE

- (i) Again start vacuuming of Transformer Main Tank up to 1.00 torr (1 mm of Hg) and vacuum is to be maintained for 48 hrs in second dry out cycle.
- (ii) Dry Nitrogen of dew point more than -60°C dew point or nitrogen of UHP grade (purity 99.9999%) is again pushed inside Main Tank under vacuum till pressure of Min. 2.0 psi is achieved in Transformer Main Tank. The Transformer Tank is to be kept pressurized for a duration of 24 hrs.



- (iii) Measure dew point after 24 hrs in second N2 cycle and record these dew point values as dew point values of second dry out cycle and refer these values with BHEL standard norms or contact concerned Services Deptt..
- (iv) If the dew point values of second cycle is in line with the BHEL Standard norms, Transformer is cleared for further vacuuming followed by filling of filtered oil under vacuum and carrying out Hot Oil Circulation process.
- (v) In case desired value of dew point is not achieved than Transformer tank is to be again subjected for vacuum pulling for 24 hrs, followed by N2 filling for duration of 24 hrs. After each dry out cycle measure the Dew point values and compare with BHEL standard norms.

As per BHEL standard norm's minimum 2 Dry out cycle of Transformer has to be carried out before filling of filtered oil under vacuum in Transformer Main Tank.

<u>Note</u>: If the dew point values were not achieved as per BHEL standard norms in 2 dry out cycle and higher content of moisture was noticed as per Dry out process carried out in 2 cycle, than further Dry out process shall be carried out in consultation with BHEL Transformer Services Deptt.

However for improving Dry out values it is suggested that Nitrogen Dry out cycle associated with heating cycle shall be carried out. In this process after vacuuming cycle pressurized Dry Nitrogen in Main Transformer Tank shall be heated externally to raise the temperature of Transformer upto 55-65°C during 24 hours duration followed by measurement of Dew point after completion of heated Nitrogen Dry out process. These Dew point values shall be compared with BHEL standard norms and the process of vacuum followed by insertion of Dry Nitrogen and heating is to be repeated till the dew point values were not achieved as per BHEL standards.

The equipment required for vacuum treatment and oil-filling under vacuum should generally be as per Annexure 2.2. The transformer tank and electrical terminals shall be earthed for safety reasons.

No electrical test on the Transformer is permitted during the evacuation.

Fig. 2.3 shows a typical example of pipe work and valve positioning.

### 2.5.6 OIL FILLING

### **2.5.6.1 OIL QUALITY**

The transformer/reactor shall be filled under vacuum with oil which has been purified and degassed according to Clause 2.4

### 2.5.6.2 OIL FILLING IN MAIN TANK

For main tank, the oil shall be heated to a temperature of 50°- 60°C measured at the filter outlet valve. The pressure during the filling shall be max. 1 torr. During the oil-filling, a transparent plastic tube (5) can be used as an oil-level gauge. The tube which



should be a wall thickness of 5-8 mm, may be connected to a top and a bottom valve on the transformer.

Oil-filling of the tank is done through valve (12) at a low level on the transformer and at a maximum rate of 4-5 kL/hour. The pressure in the oil pipes shall be kept positive and shall be checked by a manometer 13 (if provided). Oil filling to be done as per cl. 2.6.9.

For oil filling in diverter switch assembly of an OLTC refer leaflet (Vol.1).

Separate vacuum-proof cooler system/radiators can be evacuated for about 1-2 hours and filled separately with purified and degassed oil. The oil is then circulated through the vacuum filter at least twice via drain valves as near as possible to the transformer. Oil circulation is considered completed until the oil parameters as per table 2.3 is achieved. Care should be taken to keep all air release plugs and valves open to allow escape of trapped air during oil filling operation. These valves/plugs should be closed after completion of oil filling.

# 2.5.7 HOT OIL CIRCULATION/ DRYING OUT, OIL RINSING, PARTICLE REDUCTION AND PARTCLE COUNTING

To facilitate oil-penetration and absorption of possible gas bubbles, the temperature of transformer shall-after completed oil-filling-be increased by circulating the oil through the vacuum filter and with circulation direction according to Fig. 2.4.

The oil will be circulated through a high vacuum filter machine at 57 °C to 60 °C of transformer oil temperature for minimum 3 days. The start time for hot oil circulation is considered after achieving the stabilized temperature of oil i.e. Inlet and out let oil temp difference should not be more than 3 degree and the Oil temperature to be achieved in the process is between 57-60 degree centigrade and record the IR value at an interval of 4 hrs after achieving the stabilized oil temperature values. Also record the IR value along with temperature, vacuum of M/c & IR value till oil parameter achieved as per table 2.3. Polarisation Index should be preferably more than 1.75. Other than this limit please refer the case to BHEL Bhopal.

kV Class of Recommended Permissible Limits Transformer Tan delta\* at Electric Moisture Resistivity \* at Strength (BDV) Content ppm 90°C (Ohm-90°C in kV (min) (Max) cm)  $1x10^{12}$ **Upto 170** 60 15 0.005  $1x10^{12}$ 0.005 245 70 10 70 5  $1x10^{12}$ 0.005 420 & above

**TABLE 2.3** 

Method of test for Electric Strength and moisture content shall be as per IS: 335. / IEC-60296

<sup>\*</sup> Subject to availability of testing facility at site.



### **CAUTION:**

The temperature during oil circulation should not increase beyond 70°C otherwise this may cause oxidation of oil.

For transformer & reactor of 400 kV class or above, after completion of the hot oil circulation in main tank and cooler/radiator system separately, the valves between main tank and cooler/radiator system to be opened to allow the mixing of oil. The oil rinsing shall be carried out by connecting transformer/reactor to the oil rinsing plant connected with particle counter. Initially the oil inlet is connected to the lower portion of the tank and the outlet to the upper portion and start rinsing plant for circulation and creating turbulence of oil for approx. 1 hour. Thereafter the connection to be reversed (Oil inlet to the top of tank and oil outlet to the bottom of tank) and start rinsing plant. This process to be continued till the 3 consecutive readings at the interval of 1 hour of particle content of the insulation oil is achieved as per below:

If measured with particle counter which works on ISO 4402 and ISO 4406:1987	≥ 2 microns cumulative particle count should be <10000 particle/litre
If measured with particle counter which works on ISO 11171 and ISO 4406:1999	

Relevant ISO count for 4 Micron particle is in the range of 10.

### **2.5.7.1 SAMPLING**

Oil sampling at various stages shall be done in accordance with IS: 6855 / IEC-60475. When samples are taken from transformer tank, oil will be drawn from Top & bottom of the tank. When it is desired to know gas content and composition of dissolved gases in transformer oil before commissioning for reference purposes (required for interpretation of Dissolved Gas Analysis results during service), sampling shall be done as per IS 9434 / IEC: 60567.

### 2.5.8 STANDING TIME

Standing time is the time between 'finished oil circulation' and 'energization'. The time appears from table 2.2.

# 2.5.9 FINAL OIL FILLING OF TRANSFORMERS/REACTORS DESPATCHED OIL FILLED.

Smaller transformers/reactors are often factory-filled with degassed oil up to about 10% below the cover and transported in this condition. The final filling up to the correct level in the conservator is made at site.

### 2.5.9.1 TRANSFORMERS / REACTORS WITH SYSTEM VOLTAGE < 36 KV

Previously degassed oil (e.g., at the factory) stored in tight drums may be used for the filling. Check the dielectric strength of the oil which should be as per Clause 2.4.4. If accepted, the oil is pumped into the conservator and in this way fed into the transformer / reactor. To prevent any free water in the drums from entering the



transformer / reactor the opening of the suction tube must lie 0.1 m above the lowest point in the drum. A suitable valve on the cover and/or valves or upper tightening nuts at the bushings have to be opened for complete removal of air below the cover and in the bushings. When the oil is seeping out at these points, shut the valves and tighten the nuts at the bushings.

### 2.5.9.2 TRANSFORMERS/REACTORS WITH SYSTEM VOLTAGE > 36 KV

The filling is performed as described above, but at least a paper filter must be used for drying the oil.

### 2.6 OIL FILLING INSTRUCTIONS FOR CONSERVATORS WITH AIR CELL

### 2.6.1 INTRODUCTION

In all transformers specially in high voltage class, maintenance of insulating oil notably its dielectric property forms one of the determining factors of reliability of equipment in service. Oxidation and contamination of transformers/reactor oil can be avoided in a simple and effective way by use of above oil preservation system. The complete system is known as "Conservator with Air Cell". In this oil preservation system a flexible air cell made of oil resistant

Nitrile rubber is placed inside the conservator and floats on the oil surface. The air cell inflates or deflates as the oil level in the conservator falls or rises depending on the ambient temperature and load on the reactor. The inside of the rubber bag (Air Cell) is put into communication with atmosphere by means of a silica gel breather which ensures dry atmosphere inside the air cell. In addition to the above this system provides following advantages.

- i. It avoids saturation of absorbed gases.
- ii. As no gas is used in this system, which operates at constant pressure, this formation of gas bubbles at low ambient temperature and load is eliminated. The system thus preserves the oil quality particularly its dielectric properties.

The conservator with air cell is provided with a magnetic oil gauge having one electrical contact. The indication shown on the dial physically corresponds to the oil level in the conservator which is due to balance of static pressure between the oil of the conservator and the atmospheric air inside the air cell. This system is also provided sometimes with a set of pressure and vacuum valves. These valves operate to pass either oil or air in the event of over filling or under filling the conservator during installation.

When oil is to be filled by taking vacuum through conservator refer section 2.6.9 whereas when conservator is to be isolated during oil filling in transformer refers section 2.6.2. For deciding the applicability of either process consult OGA drawing / BHEL representative

### 2.6.2 DESCRIPTION OF OPERATION

Figure 2.5 indicates the general arrangement of oil preservation system. The oil connection between conservator and transformer tank is made through Buchholz relay and valves are provided in between.



The flexible air cell is connected to the top of the conservator through gasket joint. Under normal condition air cell is completely surrounded by oil and floats in the conservator. The air cell inflates/deflates as the oil volume changes. The float of the MOG which is always in contact with under side of the air cell moves up and down and indicates the oil level. The cell will sink in the remote event if it is damaged and MOG alarm will operate. The conservator then functions as a conventional conservator without affecting the performance of the transformers/reactor.

### 2.6.3 INSTALLATION

This system is shipped separately from main tank. The air cell is shipped fitted in the conservator. A low positive pressure of less than .07 kg/sq.cm (1 psi) is maintained to avoid excessive movement of air cell in the conservator during transit. MOG is also shipped fitted on the conservator. Install the conservator and associate parts except breather as per transformers/reactor outline drawings and assemble oil pipe work.

### 2.6.4 OIL FILLING

The following procedure is recommended.

- Close and blank the valve (14) to isolate the conservator from main tank. Fill
  the oil in transformer under vacuum upto Buchholz level as per instructions
  given elsewhere.
- ii. After filling the oil in transformer and breaking the vacuum, oil can be filled in the conservator either through reactor or by drain valve (4).
- iii. Remove the inspection cover (11) provided on the side of the conservator and check the air cell assuring that it is inflated. The air cell must remain in fully inflated condition during oil filling operation. If the air cell is found deflated fit the inspection cover and inflate the air cell with dry air/nitrogen gas to 0.035 kg/sq.cm max. through connection (8). A gauge may be put by removing plug (10). After filling close these connections.
- iv. Remove air release plugs (5) (6) and (7) provided on top of the conservator.
- v. Slowly pump the oil through the main reactor/drain valve (4). Temporarily stop filling operation when oil starts coming from opening (5) and (6) after ensuring that no air bubbles come out through these air release holes. Fit the two air release plugs.
- vi. Continue oil filling till oil start coming from air release plug (7) stop oil after ensuring that no air bubbles come out. Fit the plug (7).
- vii. Now release the air pressure held inside the air cell from point (8) and continue oil filling until magnetic oil gauge (3) indicates 35°C level.
- viii. Remove oil pump and connect air cell to breather (9) from point (8). Also remove pressure gauge and put plug (10).
- ix. The system is now properly filled. Air release plugs (5), (6) and (7) are fitted in normal operation.

### 2.6.5 PRECAUTIONS

- i. Oil filling in the conservator and also draining whenever required must be done very slowly. During oil filling, pressure in the air cell should not exceed 0.1kg/sq.cm (1.5 psi).
- ii. If a pressure or vacuum is ever applied to the main reactor tank the conservator must be disconnected and a blanking plate fitted on shut off valve.
- iii. Do not weld on conservator to avoid damage to the air cell.
- iv. Once all the air has been driven out during oil filling in the conservator do not remove air release plugs (5), (6) and (7). Otherwise air will be sucked inside the conservator.

### 2.6.6 MAINTENANCE

Little maintenance work will normally be required except routine visual inspection. However, it is desirable to check the breather opening to ensure it is not blocked. Further silica gel should be regenerated/replaced when its colour changes from blue to pink.

### **2.6.7 AIR CELL**

Air cell is made from Nylon fabric coated with Nitrile rubber, In the event it becomes necessary to replace or test the air cell for leaks the following method is recommended.

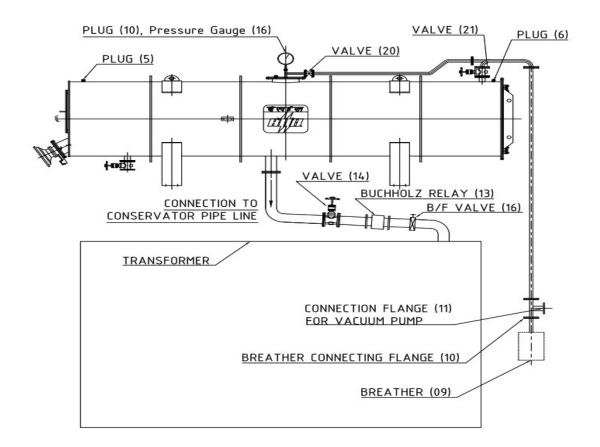
- i. De-energise the transformers/reactor.
- ii. Isolate the conservator by closing the valves (14).
- iii. Drain the oil from the conservator through the valve (4) by removing air release plugs (5) and (6).
- iv. Remove inspection cover (11) if necessary, Install the pressure gauge on point (10).
- v. Pressurize the air cell (2) by dry air/nitrogen to a max. pressure of 1.5 psi and seal. Check the pressure for 6 hours.
- vi. If leaks are found, air cell to be repaired by patching or replaced by a new air cell.
- vii. For taking out the air cell from conservator, remove the air cell flange and loops from hooks provided on inside of the conservator top. Collapse the air cell slowly and fold, remove it from conservator very carefully.
- viii. In the event air cell is not available immediately, conservator may be used as a conventional conservator.

### 2.6.8 OIL PRESSURE TEST

Oil pressure test on fully erected Transformer / Reactor to be conducted as per annexure 2.3 before hot oil circulation.



# 2.6.9 INSTRUCTION FOR EVACUATING OF THE TRANSFORMER / REACTOR VIA THE CONSERVATOR FOR FILLING OIL.



- 1. Release the overpressure in the Air cell by unscrewing the Plug (10). Open the plug (5) and (6) on the top of the conservator and blow dry compressed air for a short while, to relieve the air cell from the walls of the conservator. Wait for at least an hour to allow the Air cell to collapse completely. Tighten the plug (10) and close plug (5) and (6).
- 2. Remove the breather (09) and blank the flange (10).
- 3. Open the shut off valve (14) and (16) between conservator and transformer. Open the bypass pipe valve (20) between conservator and Air cell and valve (21). Connect the Vacuum pump to pipe flange (11) hanging down from conservator.
- 4. Filling of the oil through the tank can start when vacuum has reached below 1 torr. When the oil level reaches the Buchholz relay in the pipe between tank and conservator, the Shut off valve (14) located in same pipe to be closed.
- 5. End the vacuum and close the bypass pipe valve (20) between conservator and Air cell and open the plug 5 and 6 on top of conservator.



- 6. Open the Plug (10) provided on top of conservator.
- 7. Mount the pressure gauge (16) in position of plug (10) and close the valve (21).
- 8. Fill the Air in Air cell by opening valve (20) up to 1.5 PSI and close the Valve (20) when pressure reached.
- 9. Open the Shut off valve (14) between conservator and transformer and press up oil slowly.
- 10. Continue the Oil flow until oil flows from the plug (5) and (6).
- 11. Close the Shut off valve (14) and the plug (5) and (6), open the valve (20) and breather flange (9) to release air from Air cell.
- 12. When the pressure in the Air cell has decreased to atmospheric pressure, the pressure gauges (16) shows no detection open the Shut off valve (14) again and continue oil filling until the oil level specified has been reached and MOG shows 35 °C reading.
- 13. Connect the Breather (09) to flange (10) and blank flange (11).

Note: The above Oil Filling under Vacuum to be followed for 765 kV & above transformers /reactors in case of specific requirement.

### 2.7 UNTANKING OF ACTIVE PART

### **2.7.1 GENERAL**

If for some reason it becomes necessary to un-tank the active part (core and windings) of a large reactor/transformer, it ought to be done under supervision by BHEL erectors. Universal instruction for the un tanking procedure cannot be given, as the design practices of large equipment vary. The following general directions are, however, applicable in most cases.

The un tanking must be done indoors. If there is no suitable hall available, lifting can be done in the temporarily arranged room. e.g. a tent. The oil & the internal parts of the transformer must not in any case be exposed to rain or humidity.

In case of bell shaped transformer, only bell cover is lifted for access to active part.

### 2.7.2 OIL DRAINAGE

Drain off the oil from the transformers/reactor either partly or completely.

### 2.7.3 DISCONNECTING

Open all inspection covers for observation. Disconnect leads to bushings, current transformers, winding temperature devices, Oil temperature devices and earthing leads (common CC-CL-G) between active part and cover or tank side from earthing terminal board and any other connections like fiber optic probes from feed through plate welded on tank wall. Disconnections mentioned above can usually be made through hand holes in cover or tank side.

### 2.7.4 REMOVAL

Remove all large bushings, tank cover or top tank mounted conservator, lightning arrestors (if provided), thermo siphon (if provided), PRV pipe work, heavy gate valves (150 NB, 200 NB, 250 NB), neutral grounding arrangement: post insulator, copper strips & connectors (if provided). Break all connections between tank cover or top tank and tank-piping to oil conservator and cooler thermometers etc.

Remove the cover bolts. If the cover is welded to the tank flange, free the cover according to directions given in Clause 2.9.

### 2.7.4.1 COVER OR TOP TANK

Before lifting tank cover or top tank, refer the instructions given in outline general arrangement and on lifting bollard on tank wall. When lifting the cover or top tank use the cover-lifting eyes or lifting bollard which are designed for a minimum angle of 60 degrees between sling branches and the horizontal plane. The length of the sling should therefore be sufficient for at least this angle. Wall shunts with press board barriers (if provided) and tap changer should be properly mounted on tank wall and on tap changer mounting bracket welded on end frame or stool locked on bottom tank respectively. HV, IV, tapping & neutral leads should be properly clamped with supporting cleats provided with Terminal gear, to avoid damage.

Place the cover on suitable wooden supports and in such a way that thermometer pockets, small bushing etc. underneath the cover are not damaged.

No grinding or cleaning up of the tank flange is to be carried out before the active part is lifted out of the tank.

### **2.7.4.2 UNTANKING**

Loosen locking devices, if any, between top core clamps and tank side.

Refer instructions given in outline general arrangement before lifting. Lift the active part by means of lifting eyes or lifting lugs provided on the top core clamps. To avoid damages on the active part it is important that it is centered carefully in the tank during lifting procedure.

After un-tanking, place the active part on a horizontal foundation.

### 2.7.5 RE-TANKING

Grinding or/and cleaning up of the tank flange has to be done before the active part is lowered into the tank. Check that the tank inside is free from contaminations.

Re-tanking is then done in the reverse order that is outlined above. Note that guiding pins or blocks are welded to the tank bottom to prevent the active part from moving in the tank. When lowering the active part, check that it fits exactly the guiding pins or blocks.

### 2.7.6 REASSEMBLING

Wipe the underside of the cover free from any dirt or foreign matter before lifting it into correct position above the reactor tank. Lower the cover the last few inches exactly into position without sliding on the gaskets.

Reassemble bolts nuts of supporting devices. Weld the cover when the welded construction is used. Reassemble Bushings, conservator etc., and reconnect pipings, leads to bushings, current transformers, etc. Reassemble inspection covers.

After the transformer is completely assembled, it may be necessary to dry it before oil fining- see clause 2.5.

### 2.8 MOUNTING OF GASKETS

### 2.8.1

The gaskets have a circular/flat cross-section and are made of oil and heat- resistant synthetic nitrile rubber/nitrile rubber bonded cork. For small gaskets, O-rings are used with diameter 3,5.0 or 8.0 mm, while round rubber cords with diameters 8,12 or 19 mm are used for large gaskets.

The groove is normally milled or turned, but for large flanges the groove is created by means of steel bars welded on top of the flange. The width of the groove is slightly smaller than the cross-section diameter of the gasket in order to keep the gasket in position during the assembling work.

Opened sealing joints may be sealed again using the new gasket. When handling and lifting flange, cover etc. with gasket grooves, care should be taken when using tools and lifting devices to avoid that the grooves getting damaged or deformed.

Before assembling of groove gaskets, it is checked that the grooves and contactsurface in the joint are free from foreign particles and that the paint is free from thick coatings, trickles and drops.

When assembling the rubber cord in the groove, the cord length shall be continuous. The gasket is given a small surplus length to compensate for shrinkage.

The gasket is pressed down into the groove without stretching or slackening.

To prevent the gasket from falling from the groove on vertical surfaces, the gasket may necessarily be spot-glued to the bottom of the groove.

The screws in the sealing joint shall be tightened so that an even pressure is obtained on the gasket. This is obtained preferably by means of a moment spanner. Rubber gaskets in grooves need not normally be re-tightened.

Above description is followed generally for turrets, inspection cover etc. For main tank rim joint, LV turrets of Generator Transformers where metallic stops are provided, nitrile rubber bonded cork is used, for which following instructions shall apply.



### 2.8.2

- i. Gaskets when supplied loose, have no bolt holes in them. They are usually cut to the size and shape required, although they may be supplied as straight, angled pieces from which complete gaskets can be built up.
- ii. Scarfed joints should be used. A 40 mm scarf in 5 mm thick material is recommended. Joints should be located away from corners and bolt holes, and should be well bonded, smooth and free from local thickening. Neoprene solution is used as an adhesive for joints.
- iii. Gaskets are best stored in hermetically sealed containers in a cool place. They must be protected from damp, oil and grease-
- iv. To make a gasket joint, first clean the metal surfaces by thinner to ensure that they are free from oil, rust, scale etc. Using one of the flanges as a template, punch the necessary bolt holes. Insert the bolts and tighten the bolts sequentially, a little every time so that uniform pressure is exerted on the gasket until the gasket is compressed to about 2/3 of its original thickness. Joints should not be subjected to pressure until tightening is complete. If care is taken in making joints, and in handling the gasket, it is possible to break and remake a joint several times, using the same gasket.
- v. For making leak proof and good gasket joints, it is necessary that uniform pressure is achieved all over the gasket after matching rims/ flanges have been clamped with bolts/studs.

Following instructions be followed for proper tightening of bolts/studs.

a) Tighten lightly the bolts/studs diagonally in the sequence as shown in the fig. 2.6.

b) Tighten again bolts/studs in the same sequence with the torque given below:

Dalt Stud Siza	Max Toque in Kg.m				
Bolt Stud Size	IS 1367 CI. 4.6	IS 1367 CI. 8.8	IS 1367 CI. 12.9		
M 10	3	5	8		
M 12	5	9	14		
M 16	12	23	35		
M 20	12	47	69		
M 24	17	81	119		
M 27	23	117	172		
M 30	28	160	234		

In case of metallic stoppers tighten until metal to metal contact is achieved.

c) Do not overtighten, otherwise gasket will get crushed.

### 2.9 WELDED COVER (IF APPLICABLE)

In order to obtain a good sealing between the transformer tank and the cover a welded joint is recommended. The welding is performed in a certain way to permit opening and new welding repeated a number of times. The chiselling up and rewelding will take about the same time as dismantling and reassembling of bolted cover.

If the welded cover for any reason has to be removed proceed as follows:

### 2.9.1 OPENING THE COVER

When opening the cover the welding joint should be removed by a suitable grinding wheel. The cover should be clamped to the frame by means of G-clamps to prevent iron chips from penetrating into the tank. Any parts of the weld which may possibly remain on the tank flange should be removed by a chisel to enable a good result of the re-welding.

### 2.9.2 RE-ASSEMBLY

When fitting the cover again cork-rubber gaskets, 25 x 5 or as specified are fitted on the tank flange, see fig. 2.7.

The gaskets are kept in the correct position with glue base on rubber base. The cover should be clamped to the tank flange by means of G-clamps evenly distributed along the flange with about 600 mm spacing. Tack welding is carried out with about 100 mm spacing. An extra G-clamp is used during the tack welding and is moved along the flange during the progress of the work. The continuous weld is then applied. Finally the weld should be cleaned and painted.

### WARNING

When welding, a fire-extinguishing equipment should be available, and the work supervised by fire-protection personnel.

### 2.10 EARTHING OF ACTIVE PART AND CORE INSULATION TEST

### **2.10.1 REACTORS**

The ground-connection terminals for the reactor active part are located in a box at the tank end, close to the bottom. Please see fig. 2.8.

The terminals are protected by a cover. The cover can be removed with the tank oil-filled.

The terminal box contains a terminal block with three terminals.

- The terminal marked CL is connected to the core laminations.
- The terminal marked CC is connected to the core clamps.
- The terminal marked G is connected to ground (the tank).

For the core-insulation test, remove the cover. Disconnect the closing link that connects the two terminals CL-G. Use preferably 1000V mega direct voltage between CL and CC + G. The tank shall be grounded during the test. The insulation value after



1 min. test- time shall be minimum 1000 k-ohms. There is no general requirement on the insulation level CC-G .

### 2.10.2 TRANSFORMERS

For checking core insulation in case of transformers refer Fig. 2.9 for connection details.

### 2.11 TOUCH-UP PAINTING

### **2.11.1 PURPOSE**

A basic principle at touch-up painting should be to restore a damaged paint coat on a surface to the same quality and finish as of the surrounding surface. The touch-up painting should be limited to a surface as small as possible.

### **2.11.2 CLEANING**

Both damaged and surrounding surface should be cleaned so that all grease, dust and other impurities will be removed.

### 2.11.3 GRINDING OF DAMAGES

Large damages and defects are ground by means of a coarse abrasive paper, e.g. No.100. The surface is then ground with a finer paper in connection with the damage, e.g. 150 or 180. Damages that are limited to the paint coat only should be ground off completely at which glazing can be avoided.

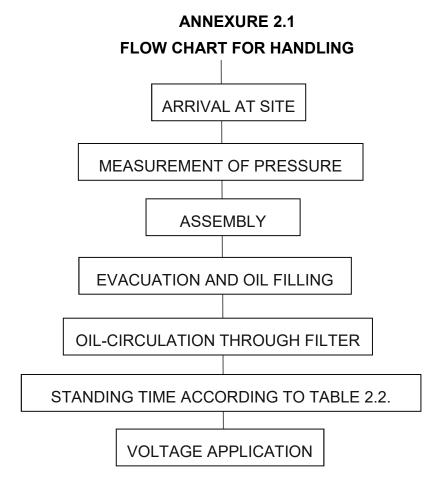
### 2.11.4 FINISHING PAINT

Two coats of finishing paint should be applied as per specification which is generally light grey shade No.631 of IS: 5. Please refer Table 2.4 for suppliers reference.

**TABLE 2.4** 

Paint Make	Internal Surface	External Surface			
Asian	APCODUR CF699 WHITE	APCODUR RAPID RECOAT ZP PRIMER GRAY	APCODUR RAPID RECOAT HB MIO	APCOTHANE CF678	
Akzo Nobel	INTERLINE 1012 WHITE	INTERGUAR D 251	INTERGUAR D 966	INTERTHANE 990	
Jotun	PENGUARD HB WHITE	PENGUARD HSP ZP	PENGUARD MID COAT MIO	HARD TOP XP	
Ching	CHING EP EMC 182 WHITE	CHING EP PRIMER EMD 183	CHING EP MIO EMD 30	CHING EP TOP COAT ADD47	





### Relationship between different units

1 bar =  $10^5$  Pa = 750 Torr = 14.5 psi = 1.02 kg/sq.cm

1 Torr = 1.33 mbar = 0.133 kPa

 $1 \text{ kPa} = 10^3 \text{ Pa} = 10 \text{ mbar} = 7.501 \text{ Torr}$ 

 $1 \text{ MPa} = 10^6 \text{ Pa}$ 

**Force** Volume

1 kp = 9.807 N1Liter = 0.26 US gallons

1 US gallon = 3.781Liters

1Liter = 0.22 Imp gallons

1 Imp gallon = 4.551Litres

## **Temperature**

 $C = 5 \times (F-32)/9$ 

 $F = 9 \times (C+32)/5$ 

# ANNEXURE 2.2 EQUIPMENT FOR OIL-FILLING UNDER VACUUM

- i. High-vacuum 2 stage oil filtration plant provided with thermostat controlled
- ii. oil heaters and vacuum-proof hoses with independent vacuum pumping system for tank evacuation. Capacity: 6000 LPH
- iii. Oil-storage tanks provided with silica-gel breathers and inlet/outlet valves for oil circulation. Recommended capacity 20 kL -30 kL (Clause2.4)
- iv. Vacuum gauges provided in filtration plant.
- v. Equipment for measurement of electric strength (BDV) of oil- 100 kV set.
- vi. Equipment for moisture content of oil.
- vii. Equipment for measurement of Resistivity and Tan delta at 90°C.
- viii. Oil-sampling cans or bottles.
- ix. Transparent vacuum-proof tubes for checking of oil-level during oil filling.
- x. Valves, fittings, gaskets etc.
- xi. Dry nitrogen cylinders.

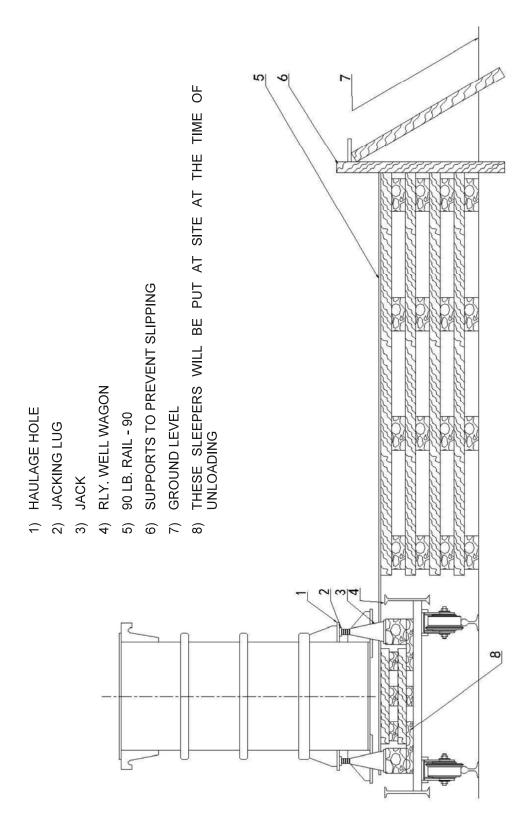


Fig. 2.1 Typical Unloading Arrangement of the Transformer

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CL	.AU	SE	NO.	.

### MANDATORY SPARES FOR ELECTRICAL



Sr. No.	Description	Quantity
1.	Switchyard 400kV AIS	
1.01.00	Circuit Breaker	
	a. Relays, power contactors, switch-fuse units, limit	1 Set
	switches, Auxiliary switch assembly, push	
	buttons, timers & MCB for electrical control	
	circuit (consisting of one no. each of all types and	
	ratings)	1.0
	b. Set of gaskets, rings & seals	1 Set
	c. Molecular filter for Circuit breaker	1 Set
	d. Tripping coils with resistors and closing coil with resistor (each type)	6 Nos
		1 Set
	e. Density / pressure monitoring system for circuit breaker	1 361
	f. Set of spares for pneumatic/ Spring/ hydraulic	1 Set
	operated mechanism(as applicable ) as per the	1 500
	main supply of circuit breaker applicable.	
	g. Spare of pneumatic/spring/hydraulic operated	1 Set for each type
	mechanism:	Circuit Breaker
	Spare of pneumatic operated mechanism	
	Complete compressor assembly along with	
	motor, accessories and coupling along with	
	regenerating unit (wherever applicable) – 1	
	set.	
	<ul> <li>Micro Filters – 1No.</li> </ul>	
	Coupling for compressed air – 1set	
	<ul> <li>Pressure switch and valve – 1 no. of each type</li> </ul>	
	Pressure gauges – 1 Set	
	Gaskets – O-rings & seals – 1Set	
	Dowty Seal – 1set	
	Operating drive – 1 set	
	2) Spare of spring-operated mechanism(complete)	
	Spring charging Motor – 1 no     Limit gwitch etc. 1 no of each type.	
	• Limit switch etc. – 1 no. of each type	
	• Closing dash pot – 1 Set	
	• Opening dash pot – 1 Set	
	• Opening catch gear – 1 Set	
	• Complete spring operating mechanism – 1 Set	
	3) Spare of hydraulic operated mechanism	
	Hydraulic operating mechanism with drive	
	Motor − 1 no.	
	<ul> <li>Ferrules and joints – 1 Set</li> </ul>	
	<ul> <li>Hydraulic Filter – 3 Sets</li> </ul>	
	<ul> <li>High Pressure Hose – 1 Set</li> </ul>	
	• N2 accumulator – 2 No.	
	Pressure Transducers – 1No.	
	• Valves – 1 Set	
	<ul> <li>Orings, gaskets and seals – 1 Set</li> </ul>	
	<ul> <li>Pressure switches and pressure gauges – 1 Set</li> </ul>	
	• Hydraulic oil – 15% of total used quantity in	
	substation	
		1

### **CLAUSE NO.** MANDATORY SPARES FOR ELECTRICAL • Limit switch – 1 no. of each type h. Fixed and moving arcing contact assemblies 2 Set including insulating Nozzles etc. for 1 interrupter (each type & rating of Breaker) 3 Nos. of each type Terminal connector i. Actuator rings if required j. 6nos 3nos Magnetic ventile if required Operation counter 1no 1. m. SF6 gas 15% of total used quantity in switchyard Pressure Gauge and coupling 1set Pressure switches 1set o. Terminal Pads and connectors 2set p. Corona rings 1no

	r.	Grading capacitor if applicable	3nos	
	S.	One complete pole (phase) of circuit breaker including CSD/Closing resistor, grading	1 No. of each type and Rating	
		capacitor(as applicable), pole column,		
		interrupter, Unit operating mechanism, marshalling box excluding supporting structure,		
		terminal connectors and common operating		
		Mechanism		
1.02.00	Disc	connector		
	a.	One complete pole of each type of HCB isolator with 1 E/S along with operating mechanisms, insulators etc. without support structure	(1 no. of each type & rating)	
	b.	Isolator Arms with finger contacts and current carrying assembly	(1set)	
	c.	Relay, power contactors, switch fuses, timers, key interlock pushbutton switch for electrical control circuit	(1 Set)	
	d.	Limit switch & aux. switch	6 Nos. of each type	
	e.	Terminal Pads and connectors	3 Nos. of each type	
	f.	Rotary Bearing for Isolator	(3 Nos. of each type)	
	g.	Motor with hear assembly and bevel gear assembly	(lno)	
	h.	Coronal shield rings	(3nos)	
	i.	Hinge pins	3nos	
	i.	Hinge pins	3nos	

# **CLAUSE NO.** MANDATORY SPARES FOR ELECTRICAL Copper contacts fingers for male & female contacts 2sets

	k. Support insulators	1set
1.03.00	Current Transformer complete in all respects including terminal connectors etc. (120% Rating)	3 no of each type & rating
1.03.01	Primary Terminal Bushings	2 Sets
1.04.00	Surge Arrester complete in all respects with surge counter, terminal connector etc.	3no
1.04.01	Surge counter/Monitor	5 Nos
1.05.00	Capacitor Voltage Transformer complete in all respects including terminal connectors etc.	2 no of each type & rating
1.05.01	Bus Post Insulator Assembly (Complete)	3 Nos of each type
1.06.00	Clamps and connectors (Minimum 3 Nos. of each type)	10% of total population
1.07.00	Spacers and corona bells.	(Minimum 3 nos. of each type)
1.08.00	String Insulators and associated hardware's	3nos of each type
1.09.00	Disc Insulators	5% of the total number of discs of each voltage class installed at the switchyard
1.10.00	Long Rod insulator	5% of the total number of insulators of each voltage class installed at the switchyard subject to a min 3nos of insulators of each voltage class.
1.11.00	SAS Including GRPs	
	A. Bay Control unit (complete with all components)	2 No.
	B. Numerical Relays comprising various bay protection units, busbar( Both CU and PU), islanding scheme and GRP	1 No. of each type
	C. Switchgear control unit	2 No. of each type
	D. Merging unit	2 No. of each type
	E. Operator work station (OWS)/ Engineering Work Station (EWS) along with software, monitor, mouse, keyboard, printer etc.	1 No.
	F. Complete Network Controller / Server along with software	1 No.
	G. LAN switches for LAN	1 No. of each type
	H. Firewall	1 No. of each type
	I. Fuses	10 No. of each type and rating
		5 nos. of each type,

LARA SUPER THERMAL POWER PROJECT STAGE-II (2X800 MW) EPC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 3 OF 11
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CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीर्स NTPC
	K. Rela	ys other than numerical relay	ys total por 1 no.)	each type of oulation (min
	L. GPS	equipment	1 set con hardware each type	Modules of
	M. Medi sche	ia converters (applicable me) for SAS application	as per 1 set	
		face cables containing th of each type of cable nector for each type of periph		
	O. MCB		1 No. o make	f each type and mode he system
	P. LIU	of OFC including necessary o	1 no. of	each type
		Energy Meter – 0.2s		each type
	stan	ls/Modules of generator DR, d-alone)	1 100. 01	each type
		plete programming station aware, monitor etc.	along with 1 No.	
	T. Gate	eways		each type
		em/Firewall (if applicable)		each type
	V. Tran	isducers liary CT/PT		each type each type
	ERMAL POWER PROJECT E-II (2X800 MW)	TECHNICAL SPECIFICATION	SUB-SECTION-VI CHAPTER-11	PAGE

### CLAUSE NO.

### MANDATORY SPARES FOR ELECTRICAL



### 2. LIST OF MANDATORY SPARES for oil filled transformers/reactor

S. No	ITEMS DESCRIPTION	GT NOT	ST	UT	Aux. Trans. (for each rating)	REACTOR
1.	HV Bushing with metal parts and gaskets (See Note 1)	APPLI	CABLE		3 No.	3 No.
2.	HV Neutral bushing with metal parts and gaskets				1 No. (if applicable)	1 No.
3.	MV Bushing with metal parts and gaskets (See Note 1)				-	-
4.	LV bushing with metal parts and gaskets (See Note 1)	_			3 No.	-
5.	LV Neutral bushing with metal parts and gaskets				1 No. (if applicable)	-
6.	WTI with contacts	=			1 No.	1 No.
7.	OTI with contacts				1 No.	1 No.
8.	Pressure relief device				1 No. (if applicable)	1 No.
9.	MOG	_			1 No.	1 No.
10.	Buchholz relay complete				1 No.	1 No.
11.	Oil surge relay				-	-
12.	Set of gaskets (See Note 2)	_			1 Set	1 Set
13.	Set of valves				2 No. of each type/size	2 No. of each type/size
14.	Cooler fan with motor				-	-
15.	Oil Pump with motor				-	-
16.	Oil flow indicator				-	-
17.	Set of OLTC/OCTC contacts				-	-
18.	Air cell for conservator				1 No. (if applicable)	1 No.
19.	Neutral Grounding Resistor w/o supporting structure					

LARA SUPER THERMAL POWER PROJECT
STAGE-II (2X800 MW)
EPC PACKAGE

CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीमी NTPC
2.01.00	Note 2: 1 set consists of (a) protection and (b) cooler circuit (c) largest inspected (d) HV/LV turret, (e) OLTC inspected (e)	ction cover, if applicable		
	NOT APPLICABLE	<del>чаанньо гечанов пог г остирг</del> е	<del>tte transionnemeastor.</del>	
2.02.00	Dry Type Transform	ners(EXCEPT STACKER/RECL/	AIMER)	
	NOT APPLICABLE			
3	Note: 1 set consists of c	quantities required for 1 comple	te transformer.	
3	S.No. Item descri	ption OR BUS DUCT	Quantity	
STAC	HERMAL POWER PROJECT GE-II (2X800 MW)	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 6 OF 11

**EPC PACKAGE** 

CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीमी NTPC
	NOT APPLICABLE			
	II MV Busduc NOT APPLICABLE	it		
4.		3kV / 11kV / 6.6kV / 3.3kV)	& PCM	
	S.No. NOT APPLICABLE	Item Description		Quantity
STAG	HERMAL POWER PROJECT GE-II (2X800 MW) PC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-V CHAPTER-11 ELECTRICAL	I PAGE 7 OF 11

CL	AUSE	NO.	
	$\neg \circ \circ \vdash$	110.	

### MANDATORY SPARES FOR ELECTRICAL



NOT APPLICABLE

### 5. LT Switchgears & LT Busducts

S. No.	Item Description	Quantity
1	Complete breaker of each rating	10 Nos.
2	Numerical Relays of each type	
3	Auxiliary Relays of each type	10 Nos
4	Horizontal busbar support Insulators	12 Nos
5	Vertical busbar dropper support insulators	12 Nos
6	Current transformer of each type & ratio	3 Nos.
7	Voltage transformer of each type & ratio	3 Nos.
8	Control supply transformer of each type & rating	3 Nos.
9	Power Contactor of each type and rating	10 Nos.
10	Coil for above contactor for each type and rating	10 Nos.
11 MCCBs (equally divided for all ratings)		40 Nos.
12	MPCBs (equally divided for all ratings)	40 Nos.
13	Closing coil of each type of each rating	10 Nos.
14	Trip coil of each type of each rating	10 Nos.
15	15 Aux contact set of each type and Rating	
16	16 Fixed contact set of each type & rating	
17	Moving contact set of each type & rating	3 Sets.
13	Maintenance tools and accessories for maintenance of LT MCC	2 Nos.

LARA SUPER THERMAL POWER PROJECT	TEC
STAGE-II (2X800 MW)	150
EPC PACKAGE	

# CLAUSE NO. MANDATORY SPARES FOR ELECTRICAL



### 6. DC BATTERY

S. No.	Item Description	Quantity
1	Complete dry cell	5% or 10 Nos. whichever is more for each set of battery bank
2	Inter-cell connectors with Hardware	5% or 5 Nos. whichever is more for each set of battery bank
3	BHMS Spares	5% of installed capacity

Provide breakup of Set or total numbers in case of each type or % mentioned

### 7. BATTERY CHARGER

S. No.	Item Description	Quantity
1	Set of Electronic Cards / Modules	1 set of each type & rating
2	2 Set of Auxiliary relays 1 set of each type & rating	
3	Set of Fuse Links and Glass Fuses	3 set of each type and rating
4	3 phase Rectifier Bridge complete assembly	1 set of each type and rating
5	5 Rectifier Transformer 1 No. of each type & ration	
6	Control Transformers	1 No. of each type & rating

8. DIESEL GENERATOR SET

TON		
APPL	<b>ICABL</b>	Ē

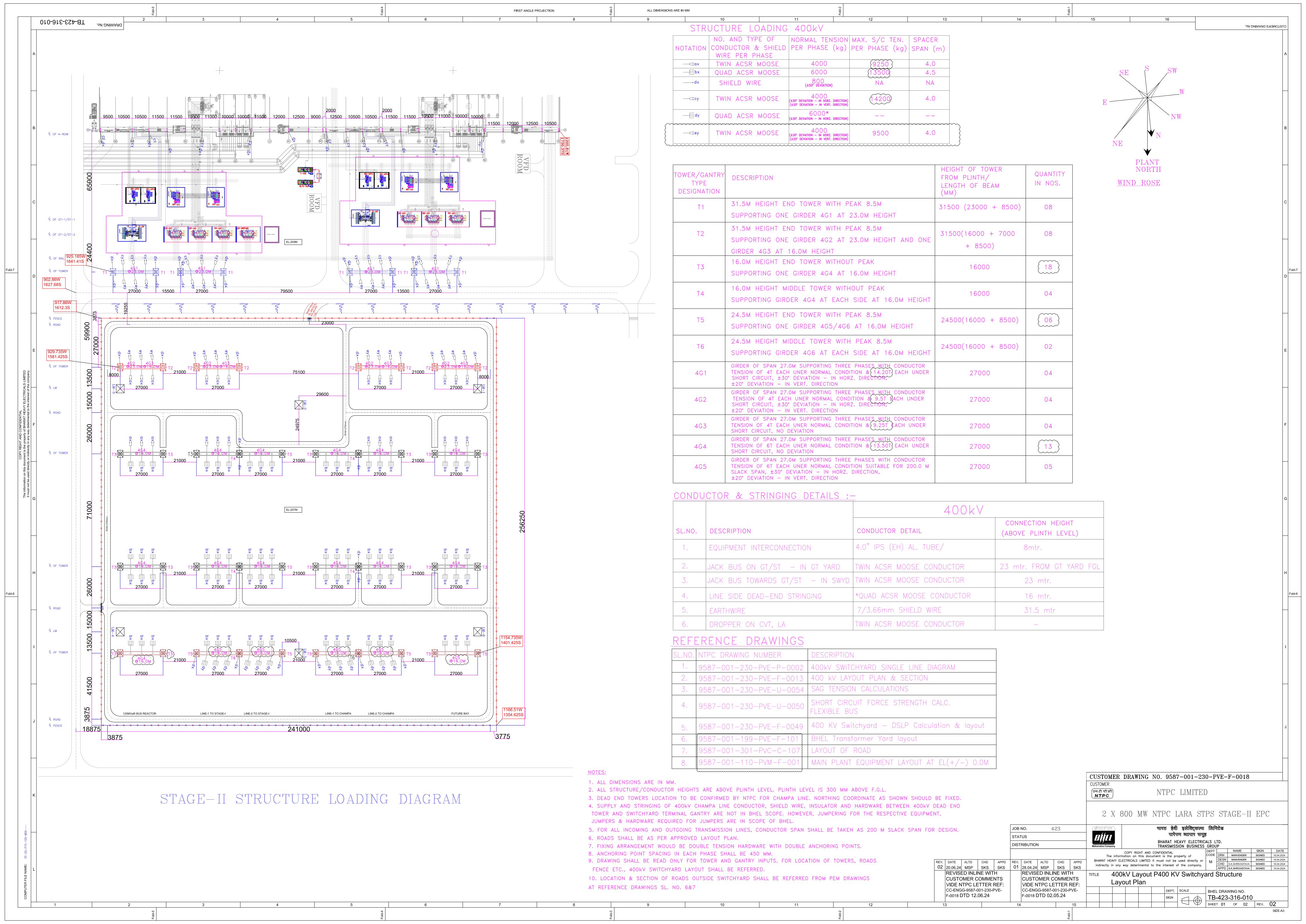
LARA SUPER THERMAL POWER PROJECT
STAGE-II (2X800 MW)
EPC PACKAGE

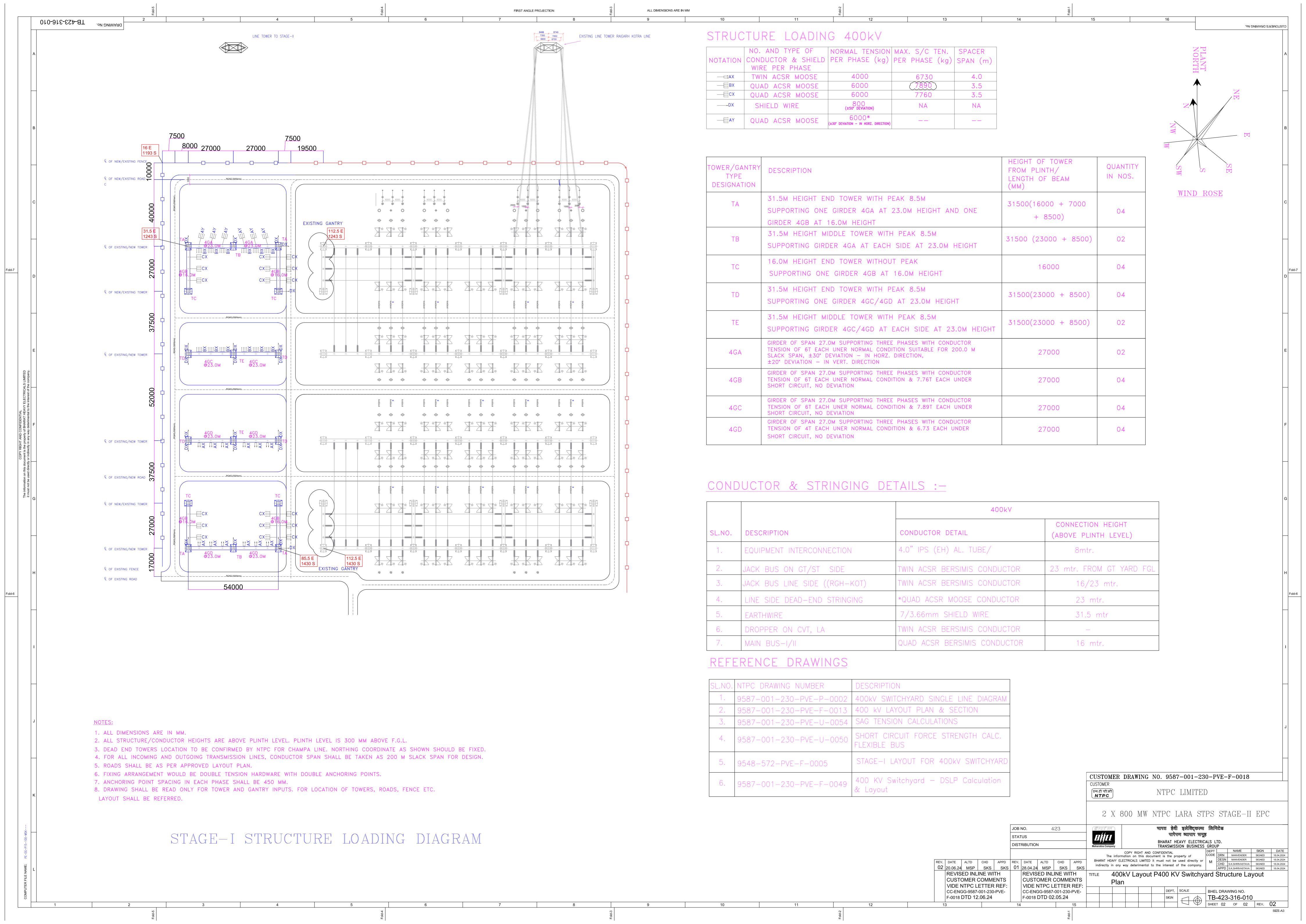
CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	CTRICAL	एनहीपीमी NTPC
	NOT		,	
STAG	IERMAL POWER PROJECT EE-II (2X800 MW) CC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 10 OF 11

CLAUSE NO.	MANDA	TORY SPARES FOR ELEC	TRICAL	एनरीपीमी NTPC
	NOT			
9.	APPLICABLE	NG – Aviation Obstruction	Lighting	
STAG	IERMAL POWER PROJECT IE-II (2X800 MW) IC PACKAGE	TECHNICAL SPECIFICATION SECTION-VI, PART-A	SUB-SECTION-VI CHAPTER-11 ELECTRICAL	PAGE 11 OF 11

	COMMENT RESOLUTION SHEET For Rev 02				
	DRG / DOC TITLE 400 KV Switchyard Structure Layout Plan & Section				
	NTPC DRG / DOC NO.	9587-001-230-PVF-F-0018			
	BHEL DRG/ DOC NO.	78-423-316-010 TB-423-316-010			
	Revision	15-42-3-15-010 1 1 1			
	Reviewed By		NTPC		
	NTPC COMMENTS REF:		CC-ENGG-9587-001-230-PVE-F-0018, DTE	12.06.2024	
	IVII C COMMENTS REF.		400kV AIS SWITCHYARD	12.00.2024	
SR.	Page No. / Clause No. /	NTPC Observations / Comments dtd 02.05.2024	BHEL Reply dtd 27.03.2024	NTPC Observations / Comments dtd 12.06.2024	BHEL Reply dtd 20.06.2024
No.	Sheet No.		. ,	·	. ,
1	Sheet 1 of 2	Mark distance between A-Row columns	Confirmed & incorporated in the revised document		Point closed
2	Sheet 1 of 2	Mark paving level in Transformer yard	Transformer yard as well has been marked. However the final level		Point closed
			shall be as per PEM Transformer yard layout (which is included in reference drawings)		
3	Sheet 1 of 2	Mark coordiunates of towers in transformer yard & Switchyard	Confirmed & incorporated in the revised document		Point closed
4	Sheet 1 of 2	Mark distance between towers	Confirmed & incorporated in the revised document		Point closed
5	Sheet 1 of 2	Mark FGL of Switcyard	Confirmed & incorporated in the revised document		Point closed
6	Sheet 1 of 2	Mark location of LM from any tower	Confirmed & incorporated in the revised document		Point closed
7	Sheet 1 of 2	Indicate througout slope	Confirmed & incorporated in the revised document		Point closed
8	Sheet 1 of 2	Ensure Approval of Sag tension & SCF calculation before finalising this drawing. Revise as per comments marked in Electrical layout & Section	Confirmed & incorporated in the revised document		Point closed
9	Sheet 1 of 2	Mark road section/width for road outside Switchyard	Refer Note SI. No. 10, road details outside Switchyard shall be referred from respective PEM reference drawings (included in list of reference drawings)		Point closed
10	Sheet 1 of 2	Check height of Tower T5 & T6 , which shall be 24500mm instead of 23500mm.	Corrected in the revised document		Point closed
11	Sheet 1 of 2	Shield wire shown for Tower T3 & T4. Kinldy check	The same was typographical error. Towers T3 & T4 are tower without peak & no sheild wire shall be there on these towers		Point closed
12	Sheet 1 of 2	Mark reference to Approved GLP/plot plan & road layout	Confirmed & incorporated in the revised document		Point closed
13	Sheet 1 of 2	Indicate reference drawing of DSLP design	Confirmed & incorporated in the revised document		Point closed
14	Sheet 2 of 2	Indicate Tower coordinates w.r.t Stage-I existing tower	22		Point closed
15	Sheet 2 of 2	Check road & drain interconnection. Refer to Stage-I & Stage-II road sections	The reference drawing of Stage-I is not available. Kinldy provide the same. The same shall be taken care in Civil drawing which shall be submitted by BHEL for its scope in Stage-I		Point closed
16	Sheet 2 of 2	Mark road width	Confirmed & incorporated in the revised document		Point closed
17	Sheet 2 of 2	Mark distance between existing & new tower	Confirmed & incorporated in the revised document		Point closed
18	Sheet 2 of 2	Include in refernce Existing Stage-I Electrical layout & Structural layout drawing	Confirmed & incorporated in the revised document. However exisitng Stage-I Structural layout is not available with BHEL. Kindly provide the same.		Point closed

	COMMENT RESOLUTION SHEET For Rev 02					
	DRG / DOC TITLE	400 KV Switchyard Structure Layout Plan & Section				
NTPC DRG / DOC NO.		9587-001-230-PVE-F-0018				
BHEL DRG/ DOC NO.		TB-423-316-010				
Revision		1				
Reviewed By		NTPC				
	NTPC COMMENTS REF:		CC-ENGG-9587-001-230-PVE-F-0018, DTD. 12.06.2024			
400kV AIS SWITCHYARD						
SR.	Page No. / Clause No. /	NTPC Observations / Comments dtd 02.05.2024	BHEL Reply dtd 27.03.2024	NTPC Observations / Comments dtd 12.06.2024	BHEL Reply dtd 20.06.2024	
No.	Sheet No.					
19	Sheet 1 of 2			Revise as per comments marked on 400kV Layout	Confirmed and incorporated except gate on the	
				Plan & Section Drawing as per NTPC comments ref:		
				CC-ENGG-9587-001-230-PVE-F-0013 dtd	requested to suggest the location of the gate for	
				12.06.2024	incorporation in drawing.	
20	Sheet 1 of 2			Unit-1 & Unit-2 to be renamed as Unit-3 & Unit-4	Confirmed & incorporated in the revised document	
				respectively & so their associated equipments like	·	
				GT, ST & UT/UAT		
21	Sheet 1 of 2			Some text in drawing are not legible. Please correct	Confirmed & incorporated in the revised document	
22	Sheet 1 of 2			Mark the slope as per NTPC comments	Confirmed & incorporated in the revised document	
23	Sheet 1 of 2			Mark NTPC drawing no for all reference drawings	Confirmed & incorporated in the revised document	
23	Sheet 1 of 2			Mark 1417 C drawing no for all reference drawings	Committee & incorporated in the revised document	
24	Sheet 1 of 2			Sag tension calculation document is not submitted.	The same is submitted & NTPC approved in CAT-I	
					vide transmittal ref: CC-ENGG-9587-001-230-PVE-U-	
					0054 dtd 18.06.2024	
25	Sheet 1 of 2				In addition to above the short circuit forces are	
					updated as per approved document ref: 9587-001-	
					230-PVE-U-0050. Also the types of beams & towers	
					are revised. The changes are marked in revision	
					cloud.	
					lioud.	
26	Sheet 2 of 2			mark all the distances between	Confirmed & incorporated in the revised document	
				towers/roads/fence		
	•			· · · · · · · · · · · · · · · · · · ·		





## PROCEDURE FOR WELDING OF ALUMINIUM BUSES

# A. Recommended welding procedures to insure a sound weld are as follows:

Pure aluminum melts at 660 Deg. C while aluminum alloy melts in the range of 519 Deg. C depending on the alloy content of the particular metal involved. When aluminum alloy are heated there is no change in color. This makes it difficult, if not impossible; to tell metal is near the welding temperature.

The ever present surface oxide films on aluminum have a melting point of 1982 Deg. C. The parent aluminum or aluminum alloy can therefore be melted without fusing the surface oxides. Unless this film is removed, cleanliness of the molten filler metal and the parent metal cannot be completed and both strength and conductivity may be sacrificed. Therefore, it is of prime importance that aluminum oxides be removed from the aluminum alloys before welding is started. In the shielded arc welding method the shielding gas has a tendency to clean the material as welding progresses.

## **B. CLEANING OF BUSES & FITTINGS:**

It is very important to remove all greases and oxides from the surfaces to be welded. This can be accomplished by using a mild alkaline solution or standard degreasing solution. The preferred method is to use a stainless steel wire brush and vigorously scrub the surfaces to be welded. The stainless steel brushes are specified because the stainless steel has fewer tendencies to pick up particles of aluminum.

## C. WELDING METHODS

The following types of welding methods for welding aluminum fittings and buses are recommended.

## 1. TUNGESTEN-ARC WELDING (TIG)

The inert-gas shielded tungsten are process is widely used for welding aluminum bus fittings. In this process the arc is established between a non-consumable tungsten electrode and the section to be welded. Inert gas envelopes the arc to prevent oxidation during welding.

Hence no flux is required. A bare filler rod supplies filler metal to the weld area. To initiate the arc the tungsten electrode is placed in contact with the component and then withdrawn to establish an arc length of approximately 3/16". The arc is given a circular motion until the base metal liquefies and the weld puddle is established. Filler metal is added by hand as required. In this process, if more than one pass is required for a sufficient weld, the weld should be wire brushed between passes, to remove any surface dirt or oxides which have accumulated from the previous pass. Since no flux is used the finished weld does not require cleaning. In this process the heat of the tungsten arc is concentrated in a smaller area and is much faster than the conventional type of welding and distortion of the weld is negligible since the heat is concentrated in a small area. In this process, if thickness is greater than 0.5" arc to be welded, pre-heating of parts will increase the arc speed.

## 2. METALLIC ARC INERT GAS SHIELDED WELDING

MIG welding process combines the advantages of tungsten arc welding with the increased welding speed. Welding can be done from any position and the process can be either manual or automatic, Manual welding techniques are somewhat different from other methods. However, a welder can be trained to use the MIG process with only a few days concentrated training. In the MIG process the bare filler rod is supplied as a coil of bare wire. In the commercially available equipment this wire is added to the weld at predetermined rate by a motor driven feed that can be adjusted to the magnitude of the welding current. In this process as well as the tungsten arc process, gas forms a shield around the arc to prevent oxidation during welding.

Either helium, argon or a mixture of helium and argon are suitable shielding gases. Pure argon is most widely used on the gas arc usually mixed to combine the hotter arc argon. If exceptionally hot arc characteristics are required pure helium can be substituted for the gas mixture. Precaution should be exercised if this substitution is made in that it is very easy to burn through the items that are to be welded with a pure helium atmosphere.

As it is readily apparent, the basic difference between the two types of welding apparatus is the automatic feeding mechanism for the filler wire. In both types of apparatuses the electrode holder and the welding gun can or cannot be cooled by water. If welding currents of more than 125 Amps are required, both methods will have to have water cooling apparatuses to the electrode holder and the welding gun.

#### **D.WELDERS QUALIFICATIONS**

No welding should be done until the operator has had experience with welding aluminum alloys by the methods described above, Men with previous experience with in metal welding should be selected for training in welding aluminum for a period of training of not less than one week after which time the man can be considered to be proficient in the use of the equipment and in the welding of aluminum joints. After this period there should be no difficulty experienced in welding aluminum alloys. It is suggested, if practical, that welders should practice on actual fittings or buses before proceeding with the welding of the required job.

The following is the recommended specification for the current fittings wire feeds, gas flows etc. These specifications are of a general nature to the extent that many factors have to be considered such as:

- 1. Type of equipment used, whether water cooled or not.
- 2. The size and mass of the piece to be welded.
- 3. The position of the weld.
- 4. And most important of all, the operator's skill
- 5. All persons in the welding area would wear the proper shields. The arc is approximately twice as strong as the standard AC welding arc. Extreme caution should be exercised for the protection of eyes.

# ACCEPTANCE STANDARDS FOR NON-DESTRUCTIVE TESTING LIQUID PENETRANT EXAMINATION OF WELDED JOINTS

- a) Evaluation of indications:
  - Relevant indications are those which result from mechanical discontinuities.
  - Linear indications are those indications in which the length is more than three times with width.
  - Rounded indications or indication, which are circular or elliptical with the length less than
    three times, the width.
  - Any questionable or doubtful indications shall be re-tested to verify whether or not actual
    defects are present.
  - Localised surface imperfections, such as may occur from machining marks, surface conditions, may produce similar indications, which are not relevant to detection of unacceptable discontinuities.

#### b) Acceptance standards:

- Linear indications
- Four or more rounded defects with any dimensions more than 1.6 mm in a line separated by 1/16 inch (1.6 mm) or less (edge to edge)

#### c) Defect removal and repair:

Unacceptable imperfections shall be removed and reexamination made to assure the complete removal. Whenever a defect is removed and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners. Where welding is required after removal of a defect, the area shall be cleaned and welding performed in accordance with a qualified welding procedure, Completed repairs shall be re-examined by the method originally used for detection of the defection.

#### d) Treatment of imperfections believed non-relevant.

Any indication of an imperfection, which is believed to be non-relevant, shall be regarded as defect unless, on re-evaluation, it is shown by re-examination by the same method or by the use of other non-destructive methods and/ or by surface conditioning that no unacceptable defect is present.

#### e) Examination of areas form which defects have been removed:

After a defect is thought to have been removed and prior to making weld repairs, the area shall be examined by suitable methods to ensure the defect has been eliminated.

#### f) Re-examination of repaired areas:

After repairs are made, the repaired areas shall be blended.

# ACCEOTANBCE STANDARDS FOR NON-DESTRUCTIVE TESTING RADIOGRAPHIC EXAMINATION OF WELDED JOINTS

Radiographic examination shall cover minimum 10% of weld seam and acceptance standard for visual examination and Radiography shall be as follows:

Any of the following imperfections shall not be acceptable.

- 1. Cracks
- 2. Zone of incomplete fusion or penetration, which exceed 10% of the weld length of the joint in longitudinal or transverse butt weld, where full penetration is intended by the weld procedure, some lack of penetration acceptable. The total length of weld with lack of penetration shall not exceed 10% of the overall weld length. At no place, shall weld penetration be less than 90% of the thickness of the material. Continuous occurrence of lack of penetration is permitted, but shall not exceed 50 mm in any 500 mm length of weld.
- 3. Inadequate weld dimensions, root cavity (shrinkage) and incompletely filled groove greater than 10% effective throat thickness.

- 4. Excess penetration shall be permitted provided it does not exceed 25% of the wall thickness or 4 mm whichever is smaller.
- 5. Weld reinforcement: Build up in excess of 25% of the effective throat thickness shall be dressed. Any reinforcement shall be substantially symmetrical about the center line of the weld and shall be of smooth contour blending smoothly at the toes with the parent material.
- 6. Undercutting and overlapping, greater than 10% effective throat thickness.
- 7. Elongated cavities and/or worm holes exceeding 3 mm dia or equivalent area in length provided the limitations on porosity are met with.
- 8. Copper, tungsten or oxide inclusions greater than t/1 or 3 mm whichever is smaller.
- 9. Crater pipes exceeding 25970 effective throat thickness or 3 mm whichever is smaller.
- 10. Porosity: Scattered porosity not exceeding 0.5% by volume is acceptable. In general, the size of the pores shall not exceed 0.8 mm dia, but occasional 1.6 mm dia pores may be acceptable, provided the following limits are not exceeded.
  - a) Where pore size is 0.4 mm or less, up to 150 t pores may be permitted in 1000 mm sq. area of radiograph.
  - b) Where pore size is 0.8 mm or less, up to 19 t pores may be permitted in 1000 mm. sq. area of radiograph.
  - where pore sizes are generally 0.8 mm dia or less, but occasional 1.6 mm dia/pores are present, up to 9t pores of 0.8 mm dia may be permitted in 1000 sq. mm area of radiograph, provided the number of pores up to 1.6 mm in dia does not exceed it.
  - d) However, visible surface porosity> 1mm dia is not acceptable.

#### Note:

- i. In all cases, t+ thickness of the thinnest section of the weld under examination.
- ii. Unacceptable weld defects shall be repaired in accordance with the original welding procedure. All repairs shall be 100% inspected in accordance with original testing procedure.



# ग्रेस्यादेशन **प्रदेश**

# BHARAT HEAVY ELECTRICALS LIMITED

## TRANSMISSION BUSINESS ENGINEERING MANAGEMENT

	NEW DELHI							
DOCUMENT No.	TB-XXX-316-040 Rev. 1	lo. 02		Prepared	Checked	App.		
TYPE OF DOC.	STANDARD TECHNICAL SPEC	IFICATION	NAME	NK	DS	SN		
TITLE			SIGN	Sd/-	Sd/-	Sd/-		
GI PIPE & BENDS					,			
			GROUP	TBEM	W.O. No			
CUSTOMER				-				
CONCLUENTANT								

CONSULTANT
PROJECT RATE CONTRACT (ONE YEAR)

#### SCOPE AND SPECIFIC TECHNICAL REQUIREMENT

## 1.0 SCOPE

This technical specification covers design, manufacture, testing at works, packing and dispatch of 'GI pipe, its fittings and bends'. The material supplied shall fully comply with relevant Indian Standard given below and the product shall be BIS certified. The sizes and types of Pipes shall be as specified below. No Technical Deviations shall be acceptable in this regard.

## 1.1 SPECIFIC TECHNICAL REQUIREMENT

## 1.1.1 Galvanized Iron (GI) Pipe

The GI pipes shall be of nominal diameter 50 mm and/ or 100 mm, as per the indent. The pipe shall be of medium Grade as per IS 1239 and shall be of standard length of 6 meters. The pipe shall fully comply with specified standard and carry the BIS certification marking. The pipe shall have a socket at one end and threaded at both ends.

#### 1.1.2 Sockets

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The sockets shall fully comply with the requirements of IS 1239 (Part-2).

#### 1.1.3 For Bends

The bends shall be of 90°, 112.5° and/ or Tee, as specified, for above mentioned pipes. The bends shall, in general, comply with the requirement of IS 1239 (part-2). The specific requirements and BIS certification marking of these bends shall be as per IS 1239 (Part-2). 90°, 112.5° and Tee bends shall have a socket at one end and threaded at all ends.

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02	25.04.13	(A)	Marchan	Qale	90° bends ha	as been included.
01	30.11.10	Sd/-	Sd/-	Sd/-	Document re	<del></del>
Rev No.	Date	Altered	Checked	Approved	RE	VISION DETAILS
Distribution	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			To	TBMM	OFFICE COPY
				Copies		

#### BHARAT HEAVY ELECTRICALS LIMITED TRANSMISSION BUSINESS ENGINEERING MANAGEMENT **NEW DELHI** DOCUMENT No. Prepared Checked App. TB-XXX-316-041 Rev. No. NAME TYPE OF DOC. STANDARD TECHNICAL SPECIFICATION NK MK KK SIGN TITLE Sd/-Sd/-Sd/-DATE PVC PIPE & BENDS GROUP TBEM W.O. No **CUSTOMER** CONSULTANT **PROJECT** RATE CONTRACT SCOPE AND SPECIFIC TECHNICAL REQUIREMENT SCOPE 1.0 COPYRIGHT AND CONFIDENTIALITY The information on this document is the property of BHARAT HEAVY ELECTRICALS LTD It must not be used directly or indirectly in anyway detrimental to the interest of the company This technical specification covers design, manufacture, testing at works, packing and dispatch of 'PVC pipe, its fittings and bends'. The material supplied shall fully comply with relevant Indian Standard given below and the product shall be BIS certified. The sizes and types of Pipes shall be as specified below. No Technical Deviations shall be acceptable in this regard. 1.1 SPECIFIC TECHNICAL REQUIREMENT **UPVC Pipe** The UPVC pipes shall be of nominal diameter 50 mm and/ or 110 mm, as per the indent. The pipe shall be of Class-IV & Class-IV Grade as per IS 4985: 2000 and shall be of standard length of 6 meters. The pipe shall fully comply with specified standard and carry the BIS certification marking. 1.1.2 Sockets The sockets shall fully comply with the requirements of IS 7834 (Part-6)-1977. 1.1.3 For Bends The bends shall be of 45°, 60°, 90° and Tee as specified, for above mentioned pipes. The bends shall, in general, comply with the requirement of IS 10124. The specific requirements and BIS certification marking of these bends shall be as per IS 10124 (Part-9) and IS 10124 (Part-10) respectively. **BILL OF MATERIAL** 1.2 As per enclosed Annexure-1. 90° Bends added. 02 06.09.13 30.11.10 01 -30-Document revised.

Rev No.

Distribution

Date

Altered

Checked

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## IS: 10124 ( Part 10 ) - 1988

- 2.2.2 Dimensions The dimensions of 45° bends shall comply with Table 1 read with Fig. 1.
- 2.2.3 The bends may either be plain at both ends or socketed either at one end or at both ends as agreed to between the manufacturer and the purchaser. In the case of socketed bends, the socket measurements shall comply with IS: 10124 (Part 1)-1988\*.

Note 1 — For 0.25 MPa pressure class, fabricated bends should not be made from 0.25 MPa pressure class pipes. For this, bends made from 0.4 MPa pressure class pipe should be used.

Note 2 — The drawing is only intended to define the terms used in Table 1 and is not intended to illustrate specific design features.

## 3. MARKING

- 3.1 Each 45° bend fitting shall be marked with the following information:
  - a) Manufacturer's name or identification mark,

\*Specification for fabricated PVC fittings for potable water supplies: Part 1 General requirements.

- b) The size of the bend and the appropriate class (working pressure) of IS: 4985-1988\* to which the pressure rating of the fitting corresponds,
- c) The degree of bend, and

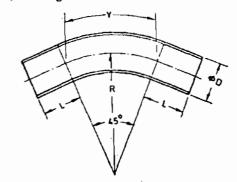


Fig. 1 45° Bend

\*Specification for unplasticized PVC pipes for potable water supplies ( second revision ).

## TABLE 1 DIMENSIONS OF 45° BENDS

(Clauses 2,2,2 and 2,2,3, and Fig. 1)

All dimensions in millimetres.

S <sub>1</sub> z <sub>8</sub> Y <sup>4</sup> Min	Min Min		R† Min	Minimum Wall Thickness (1) for Working Pressure		
		(Only for plain ends)		0:4 MPa ( Class 2 )	0:6 MPa ( Class 3 )	1.0 MPa ( Class 4 )
(1)	(2)	(3)	(4)	(5)	(6)	(7)
63	149	63	189	1.4	2:0	3.2
75	177	75	225	1.7	2.4	3.8
90	212	90	270	1.9	2.8	4.5
110	259	110	330	2·3	3.4	5.5
125	295	125	375	2-7	3.9	6.3
140	330	140	420	2.9	4.4	7.0
160	377	160	480	3.4	4.9	8.0
180	424	180	540	3.8	<b>5</b> ·5	9.0
200	471	200	600	4-2	6.3	10.0
225	530	225	675	4.7	6.9	11.2
250	589	250	750	5.2	7:7	12.5
280	660	280	840	5.8	8.6	13.9
315	742	315	945	6.2	9·7	15· <b>6</b>
355	837	355	1 065	7.3	10.8	17.7
400	842	400	1 200	8.2	12.2	19.8
450	1 060	450	1 350	9.3	13.7	22.4
500	1 178	500	1 500	10.3	15.3	24.8
560	1 319	560	1 680	11.6	17· <b>2</b>	27.8
630	1 484	630	1 890	13.0	19-2	31.3

Norz — Minimum wall thickness if calculated on the basis of 90 percent of the minimum wall thickness of the corresponding size and pressure class of pipe rounded off to the next higher 0.1 mm.

†R, radius of the bend, is equal to 3 times the nominal outside diameter (D).

<sup>•</sup>Y is calculated from  $\frac{45^{\circ}}{360^{\circ}}$  ×  $2_{\pi}$  R.

#### IS: 10124 ( Part 8 ) - 1988

2.2.2 Dimensions — The dimensions of 90° bends shall comply with Table 1 read with Fig. 1.

2.2.3 The bends may either be plain at both ends or socketed either at one end or at both ends as agreed between the manufacturer and the purchaser. In the case of socketed bend, the socket measurements shall comply with IS: 10124 (Part 1)-1988\*.

Note — For 0.25 MPa pressure class, fabricated bends should not be made from 0.25 MPa pressure class pipes. For this, bends made from 0.4 MPa pressure class pipe should be used.

Note — The drawing is only intended to define the terms used in Table 1 and is not intended to illustrate specific design features.

#### 3. MARKING

3.1 Each 90° bend fitting shall be marked with the following information:

- a) Manufacturer's name identification mark,
- b) The size of the bend and the appropriate class (working pressure) of IS: 4985-1988\* to which the pressure rating of the fitting corresponds,
- c) The degree of bend, and
- d) The bend shall be marked in colour as indicated below for different classes of fittings;

Class of Fitting	Colour
Class 2 (0.4 MPa)	Blue
Class 3 ( 0.6 MPa )	Green
Class 4 (1.0 MPa)	Yellow

<sup>\*</sup>Specification for unplasticized PVC pipes for potable water supplies (second revision).

## TABLE 1 DIMENSIONS OF 90° BENDS

( Clauses 2.2.2, 2.2.3 and Fig. 1)

All dimensions in millimetres.

Size Y* Min	L Min ( Only for	R† Min	MINIMUM WALL THICKNESS (1) FOR WORKING PRESSURE			
		plain ends)	•	0.4 MPa (Class 2)	0.6 MPa ( Class 3 )	1.0 MPa (Class 4)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
63	297	63	189	1.4	2.0	3.2
75	354	75	225	1.7	2.4	3.8
90	424	90	270	1.9	2.8	4.5
110	519	110	330	2.3	3.4	5.5
125	58 <b>9</b>	125	<b>3</b> 7 <b>5</b>	2.7	3.9	6.3
140	660	140	420	2.9	4·4	7 <b>•0</b>
160	754	160	480	3.4	4.9	8.0
180	848	180	540	3.8	5.2	9.0
200	942	200	600	4.2	6.3	10:0
225	1 060	225	675	4.7	6.9	11.2
250	1 178	250	750	5.2	<b>7·</b> 7	12.5
280	1 319	280	840	5.8	8.6	13.9
315	1 484	315	945	6.2	9·7	1 <b>5</b> 6
355	1 673	355	1065	7:3	10.8	17.7
400	1 884	400	1200	8· <b>2</b>	12.2	19.8
450	2 120	450	1350	9.3	13.7	22.4
500	2 355	500	1500	10.3	15.3	24.8
560	2 638	560	1680	11.6	17.2	27.8
630	2 968	630	1890	13.0	19·2	31.8

Note — Minimum wall thickness is calculated on the basis of 90 percent of the minimum wall thickness of the corresponding size and pressure class of pipe rounded off to the next higher 0.1 mm.

<sup>\*</sup>Specification for fabricated PVC fittings for potable water supplies: Part 1 General requirements (first revision).

<sup>\*</sup>Y is calculated from  $\frac{90^{\circ}}{360^{\circ}} \times 2\pi R$ .

 $<sup>\</sup>dagger R$ , radius of the bend, is equal to 3 times the nominal outside diameter ( D ).

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Bharat Heavy Electricals Ltd. Doc. No. TB-xxx-618-002a R4 Technical Specification GI HARDWARES

## **SECTION - 1**

## SCOPE, SPECIFIC TECHNICAL REQUIREMENTS & QUANTITIES

## 1.1 SCOPE

The scope of this specification is to specify all details required by a supplier for supply of galvanized hardwares for projects being executed by BHEL on turnkey basis for NTPC, PGCIL, SEBs and other Customers.

## 1.2 SPECIFIC TECHNICAL REQUIREMENTS

The specific technical requirements shall be as per Standard Technical Specification (Refer Section 2).

## 1.3 QUANTITIES

The quantities shall be as per attached BOQ.

SECTION-1, Page 1 of 1



Bharat Heavy Electricals Ltd. Doc. No. TB-XXX-618-002a R4 Technical Specification GI HARDWARES

#### **SECTION - 2**

#### 2.0 GENERAL

This section covers the standard technical specification for GI Hardwares.

#### 2.1 BOLTS:

M16 bolts shall be used in all types of structures except equipment mounting/ earthing bolts which shall be as per equipment requirement.

All bolts for member connections in towers, beams & equipment support structures shall conform to IS: 12427 - 2001 and for step bolts shall conform to IS: 10238 - 1982.

The mechanical properties shall conform to property class 5.6 of IS:1367 (part 3) - 1991.

All bolt heads shall have hexagonal shape, the heads being forged out of the solid material truly concentric and square with the shank, which must be perfectly straight.

Fully threaded bolts should not be used.

All bolts shall be threaded with metric standard thread to take the full depth of the nut and permit firm grip of the member.

All bolts shall be hot dip galvanized as per IS: 1367 (Part 13) - 1983.

#### 2.2 NUTS:

All nuts shall conform to IS: 1363 (Part 3) -1992.

The mechanical properties shall conform to property class 5 of IS:1367 (part 6) - 1980.

The nuts shall be capable of being worked with fingers along the entire threaded portion of the bolt with a neat fit capable of developing the full strength of the bolt.

All nuts shall be hot dip galvanized as per IS: 1367 (Part 13) - 1983.

## 2.3 PLAIN WASHERS:

All plain washers shall be punched washers, A type conforming to IS: 2016-1967.

These shall be hot dip galvanized as per IS: 4759 - 1984.

SECTION-2, Page 1 of 3



Bharat Heavy Electricals Ltd.
Doc. No. TB-XXX-618-002a R4
Technical Specification
GI HARDWARES

## 2.4 SPRING WASHER:

All spring washers shall be of spring steel, positive lock type and conforming to type B of IS: 3063-1972. The thickness of spring washer shall be as specified under:

**Bolt Diameter** 

Thickness of Spring washers

16 mm

3.5 mm

12 mm

2.5 mm

These shall be electro-galvanized as per IS: 1573 - 1986.

## 2.5 UNIT WEIGHT OF BOLTS I/C NUT, PLAIN AND SPRING WASHERS:

For purpose of payment, following unit weights as indicated below shall be considered.

## A.) STANDARD BOLTS I/C ONE NUT UNIT WEIGHTS

S. NO.	TYPE	SIZE OF BOLTS	TOTAL WT (KG)
1	M16	16 φ X 35 LG	0.117
2	M16	16 ¢ X 40 LG	0.125
3	M16	16 ¢ X 45 LG	0.133
4	M16	16 ¢ X 50 LG	0.141
5	M16	16 φ X 55 LG	0.149
6	M16	16 φ X 60 LG	0.157
7	M16	16 φ X 65 LG	0.164
8	M16	16 ¢ X 70 LG	0.172
9	M16	16 φ X 75 LG	0.180
10	M16	16 φ X 80 LG	0.188
11	M16	16 φ X 85 LG	0.196
12	M16	16 φ X 90 LG	0.204
13	<b>M</b> 16	16 ¢ X 95 LG	0.212
14	M16	16 φ X 100 LG	0.220
15	M12	12 ø X 35 LG	0.0620
16	M12	12 ¢ X 40 LG	0.0664
17	M12	12 ¢ X 45 LG	0.0708
18	M12	12 ¢ X 50 LG	0.0753
19	M12	12 φ X 55 LG	0.0797
20	M12	12 φ X 60 LG	0.0842

SECTION-2, Page 2 of 3





Bharat Heavy Electricals Ltd. Doc. No. TB-XXX-618-002a R4 Technical Specification GI HARDWARES

## **B.) SPRING WASHER**

S, NO.	TYPE	TOTAL WT (KG)
1	3.5mm thk (M16 bolt)	0.00891
2	2.5mm thk (M12 bolt)	0.00382

C.) For supplies of bolts i/c nuts, plain washers and spring washer other than those listed above, payment shall be made based on unit weights worked out considering theoretical dimensions & density of steel as 7850kg/cum.

SECTION-2, Page 3 of 3