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TECHNICAL JOB SPECIFICATION

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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

GENERAL EARTHING AND BONDING SYSTEMS

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CHANGES LOG

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CONTENTS

REFERENCE DOCUMENTS

1.0 SCOPE

2.0 GENERAL

3.0 BASIS

4.0 APPLICABLE STANDARDS

5.0 DEFINITIONS

6.0 DESIGN CRITERIA

7.0 PROTECTIVE EARTHING SYSTEM

8.0 PROTECTION AGAINST LIGHTNING

9.0 EARTHING FOR PROTECTION AGAINST STATIC ELECTRICITY

10.0 ATTACHED DOCUMENTS

LEGISLATION

94/9/EC ATEX
[Equipment Explosive Atmospheres Directive]

Υ.Α. Φ.7.5/1816/88 (ΦΕΚ 470Β/5.3.2004)
«Αντικατάσταση του ισχύοντος Κανονισμού Εσωτερικών Ηλεκτρικών Εγκαταστάσεων (Κ.Ε.Η.Ε) με το Πρότυπο ΕΛΟΤ HD 384 και άλλες σχετικές διατάξεις»

REFERENCED DOCUMENTS

Job Specification 700/5
[General Electrical Works]

Job Specification 783/2
[External Lightning Protection]

ELOT HD 308 S2
[Identification of cores in cables and flexible cords by colours]

ELOT HD 384
[Requirements for Electrical Installations]

ELOT EN 50164 series
[Lightning Protection Components (LPC)]

ELOT EN 60079 series
[Electrical apparatus for explosive gas atmospheres]

ELOT HD 60364 series
[Electrical Installation of Buildings]

ELOT HD 60364-5-54
[Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors]

ELOT EN 61340 series
[Electrostatics]

ELOT EN 62305 series
[Protection against lightning]

CLC/TR 50404
[Electrostatics - Code of practice for the avoidance of hazards due to static electricity]

BS 7430
[Code of Practice for Earthing]

1.0 SCOPE

This Specification specifies the basic criteria for engineering, design, material selection, erection of the earthing network within an installation fed from internal and external electrical substation.

Some details are given to standardize criteria, also details for connections and materials to be used for the earthing system.

2.0 GENERAL

This Specification shall be applied in conjunction with the **Job Specification 700/5, para 24.0 and 25.2 to 25.9.**

3.0 BASIS

Earthing shall be provided for:

- The safety of personnel and of equipment by limiting the voltage and current for intrinsic safety reasons according to relevant **ELOT EN 60079 series**.

- Limiting the voltage on a circuit when exposed to a higher voltage than that for which the circuit is designed.

- Static electricity protection.

- Lightning protection.

- Service earthing.

- Electric and electronic instrumentation.

- Communication system.

Formal calculations shall be performed and submitted to demonstrate compliance with the Codes and Standards, and the step, touch and voltage rise limits.

All buildings, structures, plant and electrical and instrumentation equipment shall be interconnected by the earthing system. The new system shall also be interconnected to the existing system for the existing areas.

4.0 APPLICABLE LEGISLATION AND STANDARDS

For the design requirement for earthing of the plants the following shall govern:

- **Y.A. Φ.7.5/1816/88 (ΦΕΚ 470Β/5.3.2004)**

- **ELOT HD 384** and **ELOT HD 308 S2**

- **ELOT EN 50164 series**

- **ELOT HD 60364 series** (including **ELOT HD 60364-5-54**)

- **ELOT EN 62035 series**

- ELOT EN 61340 series
- ~~BS 5958~~
- BS 7430

5.0 DEFINITIONS

Bonding: Two or more objects are considered to be bonded if connected together though a conducting path. Objects which are not inherently in contact with each other through a conducting path may be bonded by connecting them together with a bonding conductor.

Grounding: An object is considered earthed when connected by a conducting connection, either inherently or by earth electrodes, to the earth.

Grounds: are, grounding electrodes, buried grounding conductors, or underground metallic water piping.

Equipment: The term equipment as used in this specification applies to all electrical distribution and control equipment.

6.0 DESIGN CRITERIA

6.2 EARTH FAULT ON THE HV SYSTEM

The protection against dangerous step and touch voltage arising because of earth faults on the HV system shall be achieved by means of the earthing electrode installed in the HV switchyard, interconnected with the general earthing system of the complete installation.

The design of the general earthing system shall be as determined by the requirements of protection of individual areas; additional requirements for interconnection between the earth electrodes of such individual areas shall be provided if required.

Acceptance tests shall give indication about requirements for improvement of the earth electrode, isolation or similar corrective actions.

6.2 EARTH FAULT ON THE MV AND LV SYSTEMS

Earth fault currents within medium voltage and low voltage systems are practically running in closed metallic fault loops, i.e. the earth fault current does not travel entirely through the earth electrode and the ground.

These earth fault loops include: line conductor, earth fault (contact to exposed conductive parts), protective conductor, earth conductor and return path to supply transformer neutral.

Two adjacent electrical users, connected to different earthing bus bars, shall be bonded together with a supplementary bonding conductor, at least of the same cross sectional area as the protective conductor used for the smaller user, with a minimum of 25 mm^2.

Ground fault relay shall be used in case where the automatic disconnection of the supply is required.

Earth fault relay may be used in combination with the overload protection in order to comply with the maximum disconnecting time(s) for TN systems, as shown on **Job Specification 700/5 para 24.1** considering the following formula:

$$V = V_0 * (Zrp/Zg)$$

V = prospective touch or step voltage
V_0 = phase voltage
Zg = earth fault loop impedance
Zrp = earth fault return path impedance (from use to source neutral)

6.2.1 6 kV SYSTEM

The system shall be low ohmic resistance earthed (LORE).

The neutral of 6 kV system supply transformers shall be connected to earth via a current limiting resistance (about 400 A earth fault current) and tripping shall be foreseen for all 6 kV circuits in case of earth fault.

For this reason the double phase to earth fault shall not be taken into consideration.

The cross sectional area of protective and earth conductors pertaining to 6 kV shall be as dictated by mechanical stresses and corrosion as shown on **Table 1** (25 mm^2 minimum).

6.2.2 LOW VOLTAGE SOLIDLY EARTHED SYSTEMS

Minimum impedance earth fault loops shall be obtained for low voltage circuits, by installing return path as near as possible to line conductors. Resistance to earth shall not exceed 2Ω.

6.2.3 EARTHING PLANT DESIGN

The earthing plant shall be designed by contractors on the basis of the following:

- Extension of the area,
- Earth current, and
- Soil resistivity.

7.0 PROTECTIVE EARTHING SYSTEM

7.1 MAIN EARTHING PROTECTIVE CONDUCTORS

Where the protective conductor does not form part of the user feeding cable, one or more earthing protective conductors, having cross sectional area as shown on **Table 1,** shall be laid within cable routing (cable or cable tray).
These conductors shall be used as earthing cable drain and as main earthing return path for the earth fault current from user to transformer neutral. If the wiring method is underground conduit, grounding conductors shall be laid along a formed side of the duct banks. Where grounding cables cross under roads or paved areas they shall be run in rigid metal conduits.

7.2 EARTHING BUS BARS

Size and type of the earthing bus bars for connection of protective conductors to single electrical users (earthing main terminals) shall be as shown on **Table 1.**

Earthing bus bars shall be connected to main earthing conductor(s), with compression type connectors, so as earthing conductor to provide an uninterrupted, earthing connection.

7.3 CONNECTION OF PROTECTIVE CONDUCTORS TO USERS

Each electrical user shall be earthed through protective conductors to the nearest earthing bus bar. Type and cross sectional area of protective conductors shall be as per **Table 1.**
Two adjacent electrical users, connected to different earthing bus bars, shall be bonded together with a supplementary bonding conductor, at least of the same cross sectional area as the protective conductor used for the smaller user, with a minimum of 25 mm^2.

Lighting fixtures shall be grounded with a separate grounding conductor incorporated with feeding cable. Canalization of lighting fixtures system shall be grounded as well by using the following methods:

a. **Metal rigid conduit canalization system.** In order to ensure electrical continuity, at threaded connections between conduit and conduit fittings suitable conductive grease shall be used.
Conduit lines shall be earthed at feeding point (lighting distribution panel board) and at the last point of contact with an extraneous conductive part, bonded to earthing system.

b. **Cable tray canalization system.**
Cable trays shall be grounded in the same way as metal rigid conduits. Cable ways should be bridged when physical continuity (of cable tray) is interrupted.

A typical earthing system of a unit plant is shown on **Figures 1 & 2.**

7.4 EARTHING OF SECONDARY SUBDISTRIBUTION SUBSTATIONS

An earthing bus bar shall be provided around the substation building.
It shall be laid under the operating (switchboard) floor, fastened to the building internal wall or beam.
To this earthing bus bar the following parts shall be connected:

- Switchboard earthing bus bar.
- Main protective conductors laid within each cable or tray for incoming and outgoing cables.
- All exposed and extraneous conductive parts of the substation, including transformer yard fences, transformer rails, substation doors, reinforcing bars of the concrete structures etc.

Sizing and shapes of earthing materials shall be as per **Table 1.**

A typical earthing net work at distribution substation is shown on **Figure 3**

8.0 PROTECTION AGAINST LIGHTNING

The protection against lightning shall be provided in accordance with the **Job Specification 783/2.**

Additional details for tank areas, are shown on **Figure 6.**

The number of connections to tanks depends on their dimensions. Tank connection details are shown on **Figure 7.**

9.0 EARTHING FOR PROTECTION AGAINST STATIC ELECTRICITY

For protection against static electricity metallic parts containing flammable liquids, gases or dusts shall be earthed by a connection to the earth network, or by bonding to an earthed metal structure, except that metal enclosures in intimate contact with the ground may be considered to be adequately protected.

Metallic parts to be earthed are for example, processing, storage and conveying installations such as pumps, compressors, turbines, heat exchangers, filters, mechanical screeners, containers, piping.

Conveyors, elevators, boilers and furnaces, stacks, chimney etc. and the metallic devices for absorbing the electrostatic chargers shall be earthed and bonding of all components (floating roofs, strippers etc) shall be ensured.

Metallic pipes of installations delivering substances, which may originate building up of electrostatic chargers, shall be earthed at the ends, even if they are outside classified zones. If joints of the said piping do not ensure electrical continuity, junctions (e.g. flanges) shall be provided with suitable electrical continuity jumpers as per **Figures 8, 9 and 10.**

On shore installations for loading and unloading means of transport for dangerous fluids belonging to classes 1 and 3, shall be provided with devices for earth connection of vehicles.

The connection devices between vehicles and earthing system shall be such that the closing of the circuit discharging electrostatic electricity will occur within explosion proof enclosures.

Earthing shall precede loading or unloading operation.

The earthing for protection against electrostatic electricity does not require a low resistance: a resistance of 10^5 Ohm may be enough to avoid dangerous sparks.

In general, sizing of conductors for earthing against electrostatic electricity shall depend on mechanical and corrosion resistance. Shapes and sizing of materials are given on **Table 2.** Components for electrostatic discharging shall be tested according to **ELOT EN 61340 series**.

10.0 ATTACHED DOCUMENTS

1. **Figure 1**
   [Typical Earthing Network Layout]
2. **Figure 2**
   [Typical Earthing Network at Unit Distribution Substation]
3. **Figure 3**
   [Typical Earthing Connection to Transformer and Main Distribution Switchboard]
4. **Figure 4**
   [Typical Earthing Connection to Transformer and Main Distribution Switchboard]
5. **Figure 5**
   [Typical Earthing Network for Tankage Area]
6. **Figure 6**
   [Tank Connection Details]
7. **Figure 7**
   [Typical Jumper Details]
8. **Figure 8**
   [Typical Jumper Details]
9. **Figure 9**
   [Typical Jumper Details]
10. **Table 1**
    [Earthing Materials for Protective System]
11. **Table 2**
    [Earthing Materials for Protection System against Lighting and Static Electricity]

FIGURE 1

TYPICAL EARTHING NETWORK LAYOUT

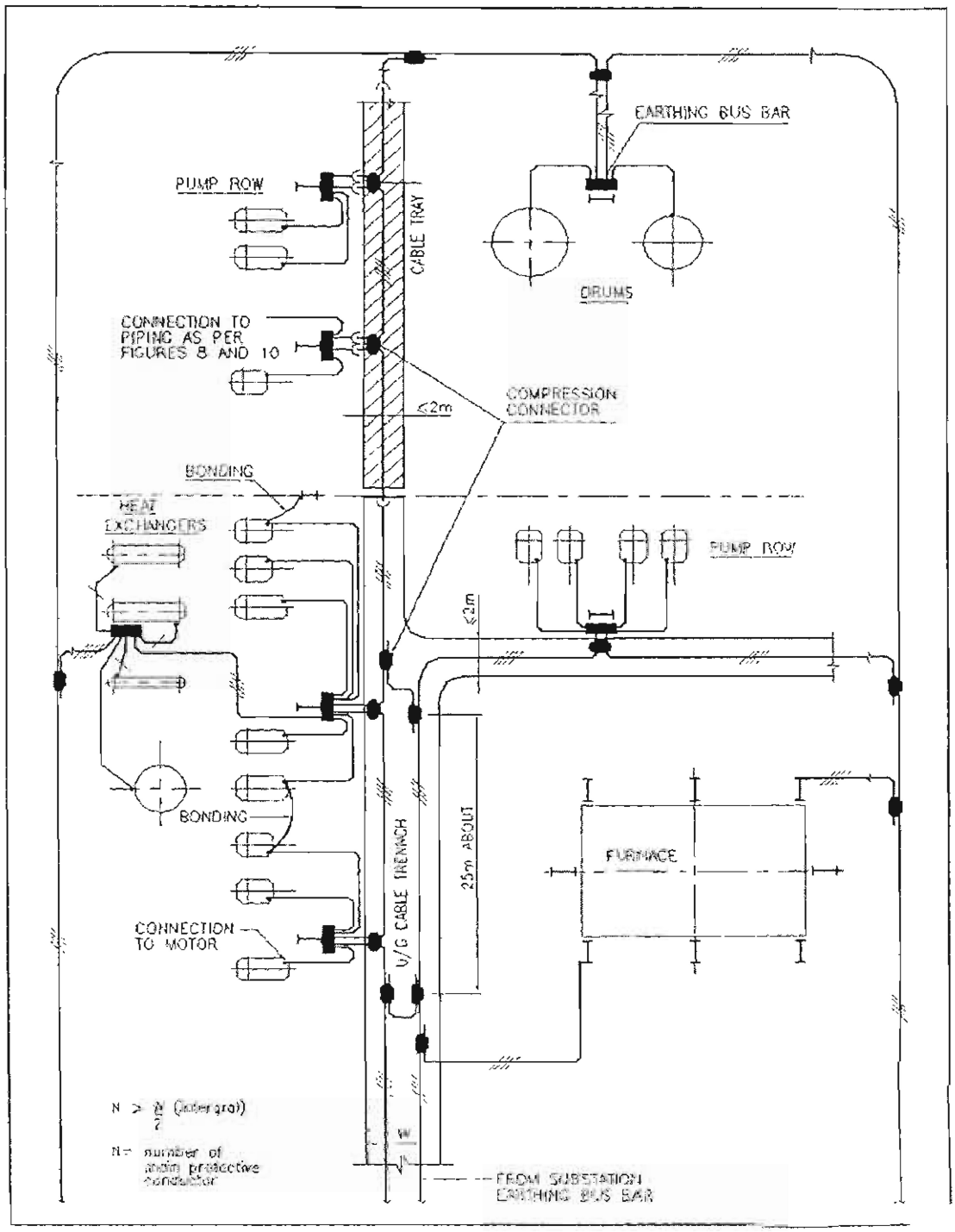


FIGURE 2

TYPICAL EARTHING NETWORK AT UNIT DISTRIBUTION SUBSTATION

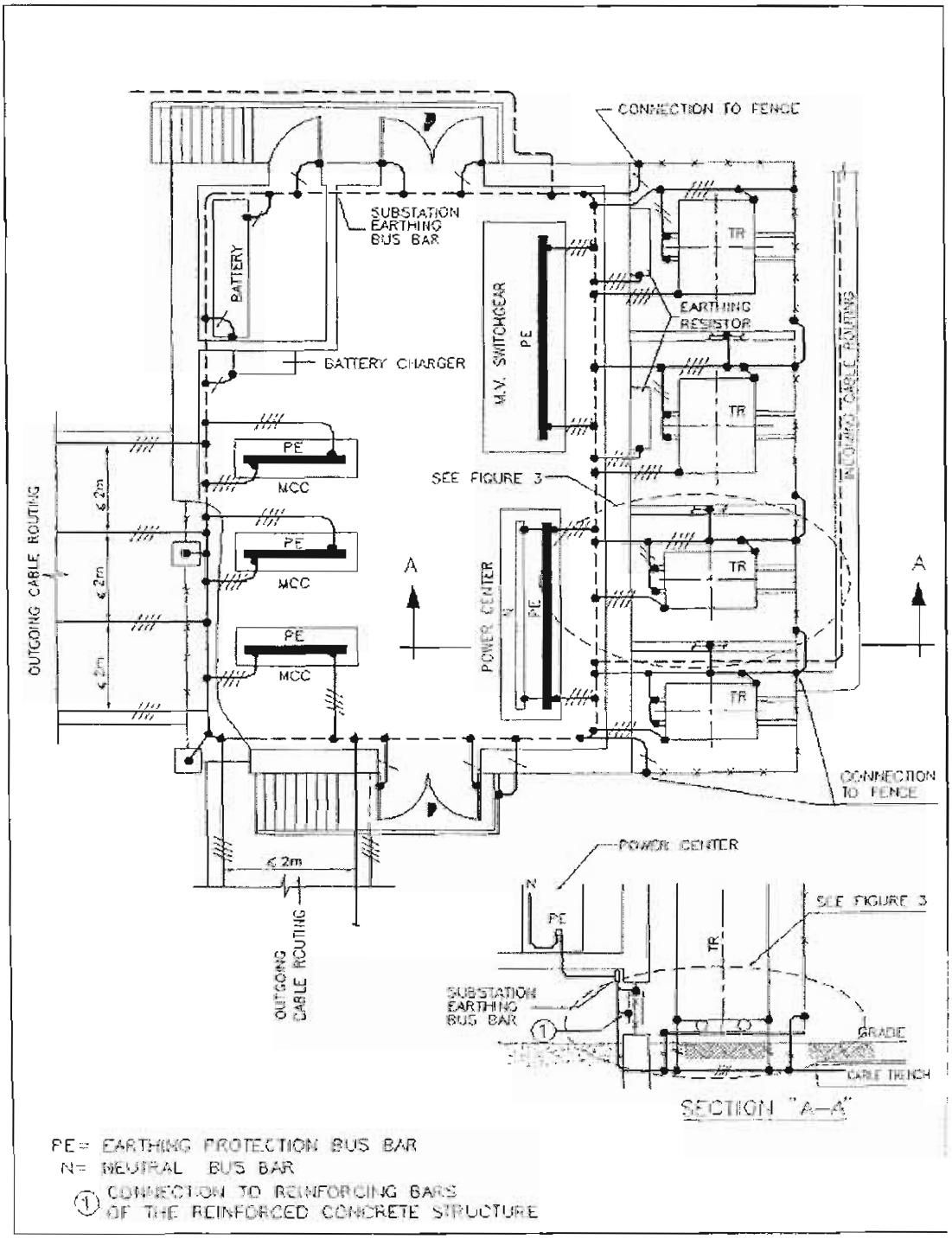


FIGURE 3

TYPICAL EARTHING CONNECTION TO TRANSFORMER
AND MAIN DISTRIBUTION SWITCHBOARD

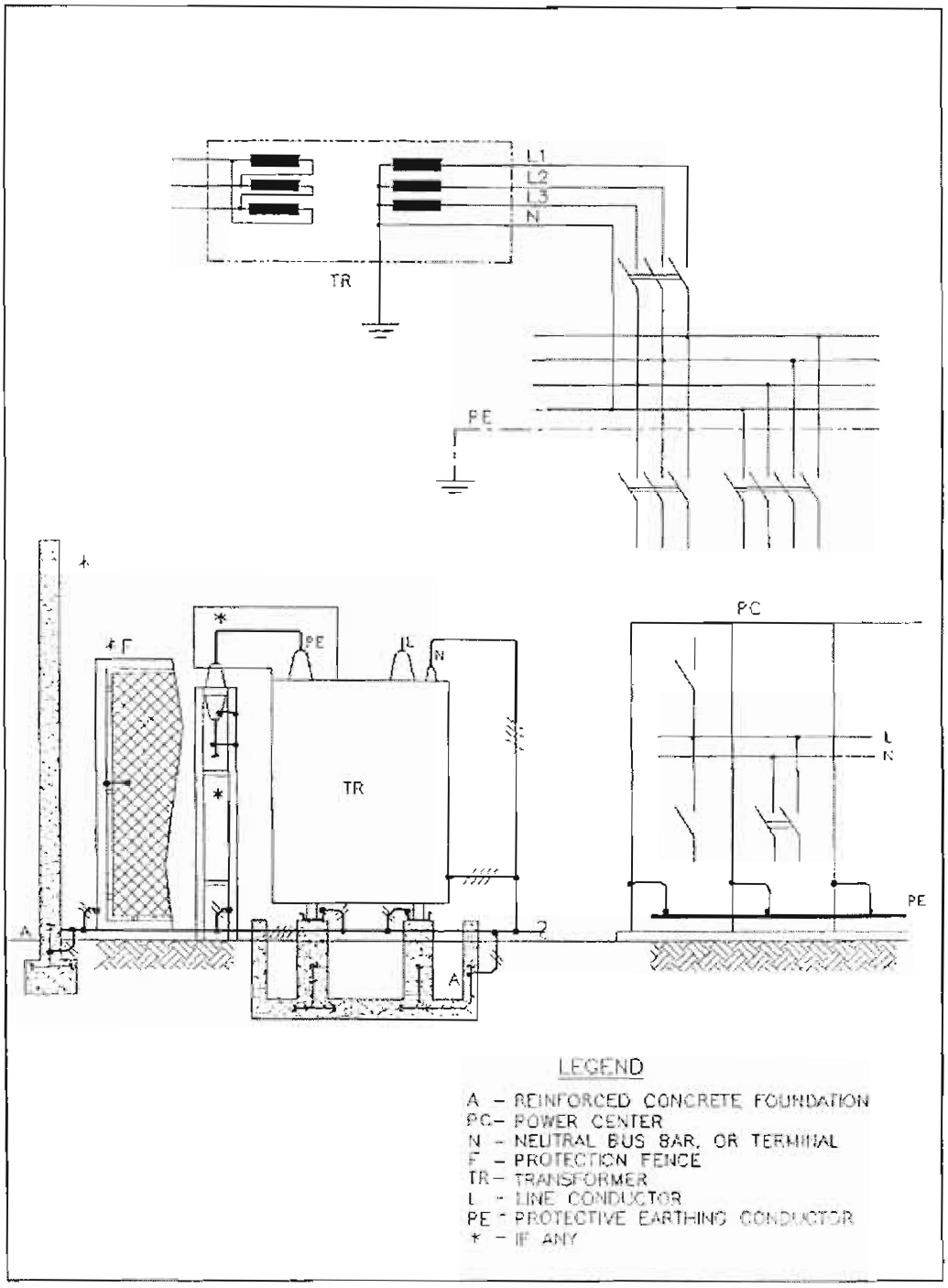


FIGURE 4

TYPICAL EARTHING CONNECTION TO TRANSFORMER
AND MAIN DISTRIBUTION SWITCHBOARD

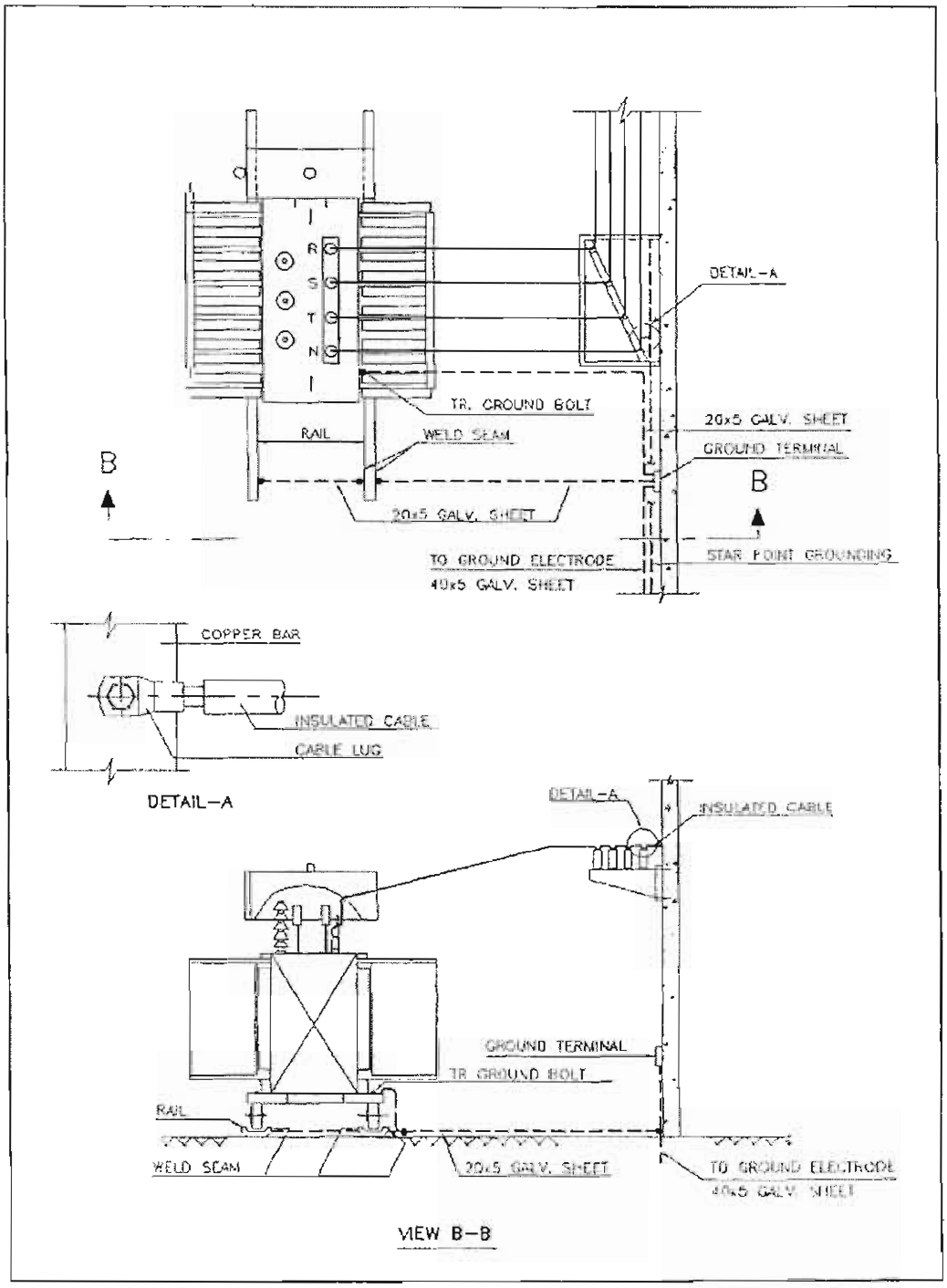


FIGURE 5

TYPICAL EARTHING NETWORK FOR TANKAGE AREA

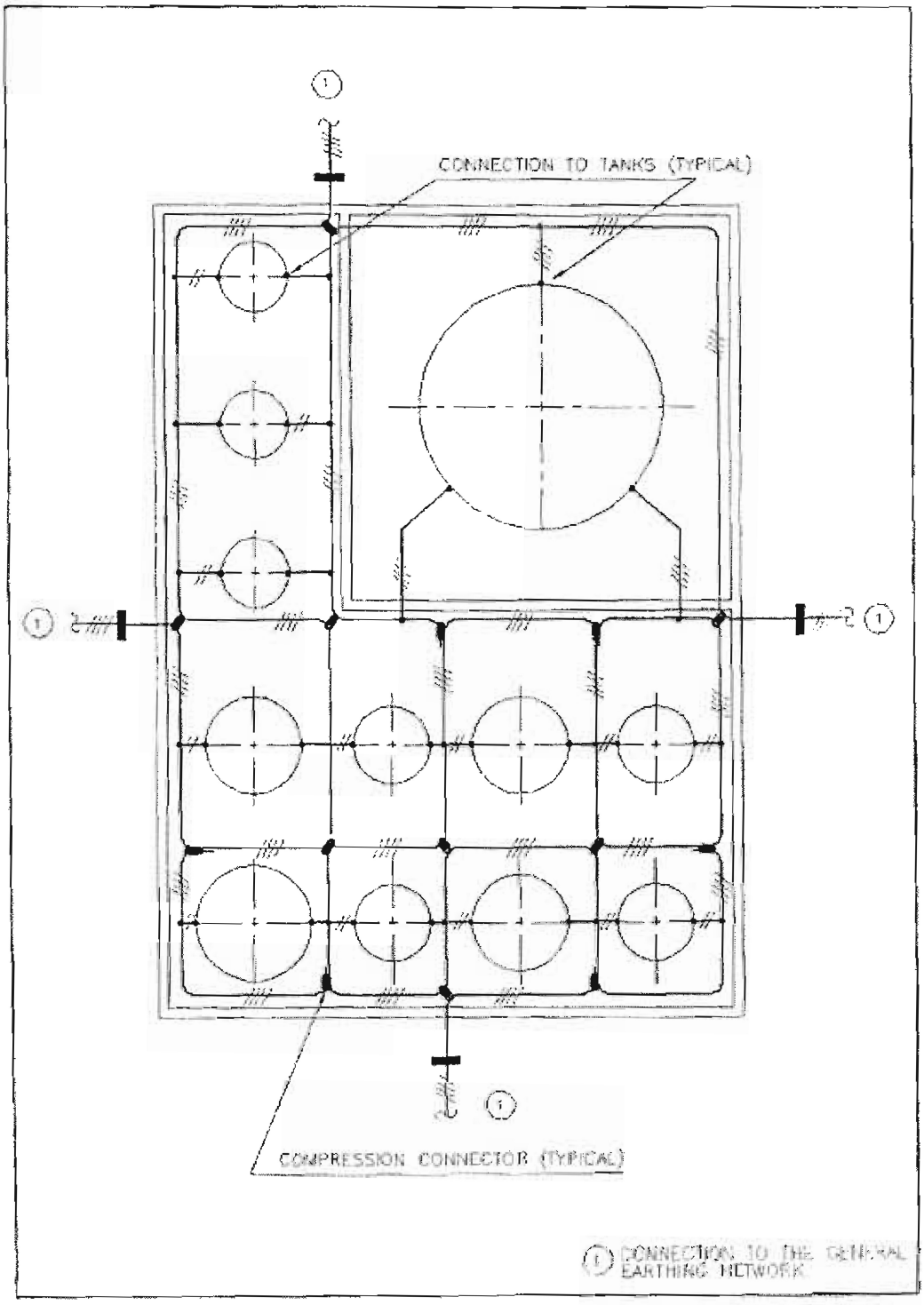


FIGURE 6

TANK CONNECTION DETAILS

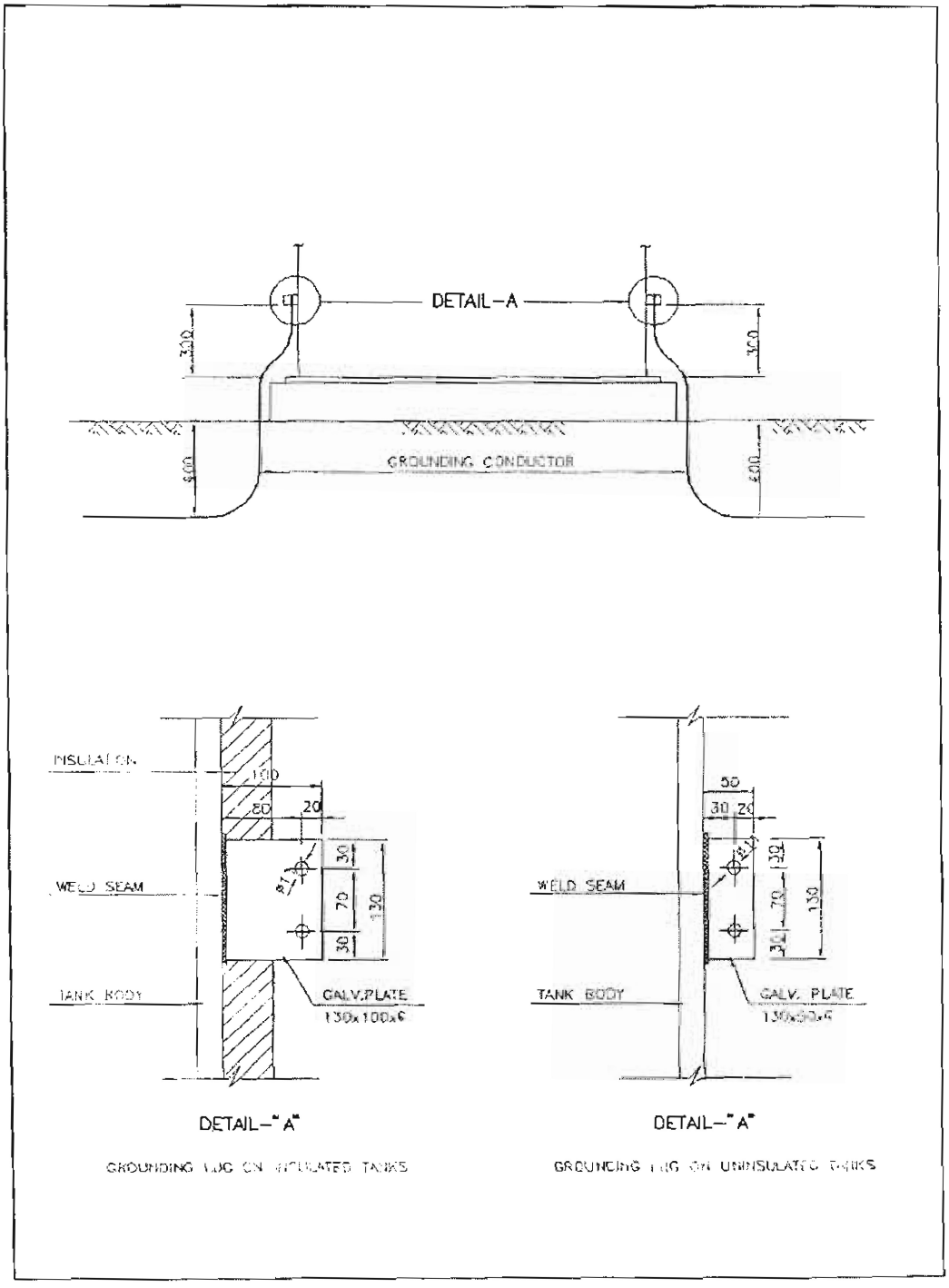
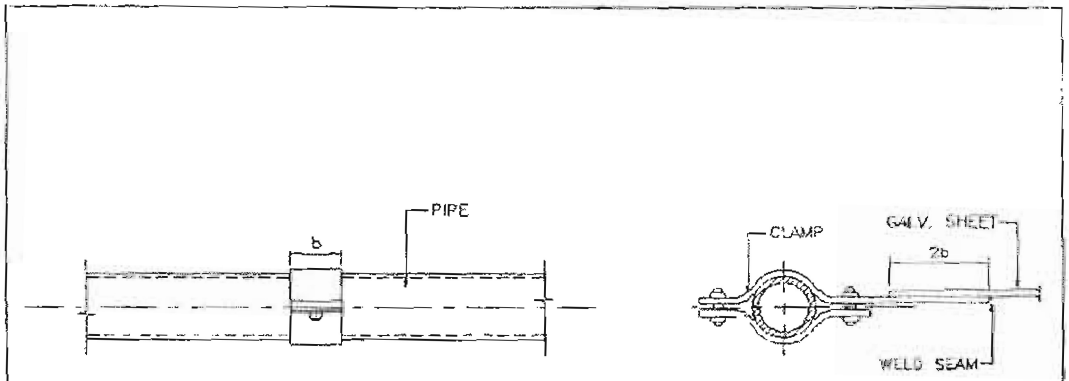
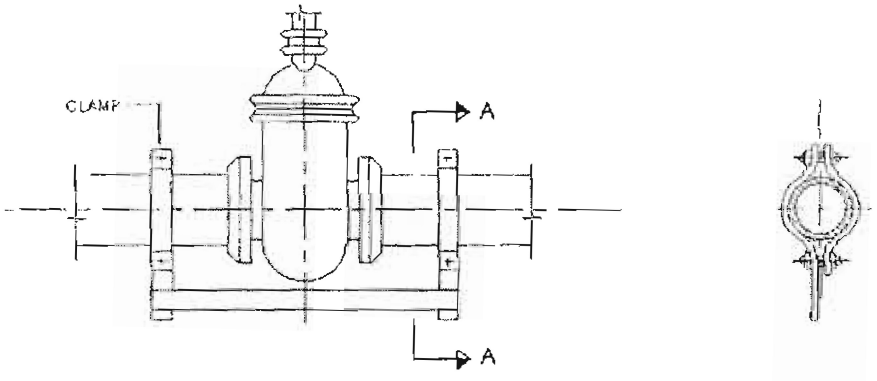


FIGURE 7

TYPICAL JUMPER DETAILS



GROUNDING WITH GALVANIZED SHEEL STEEL

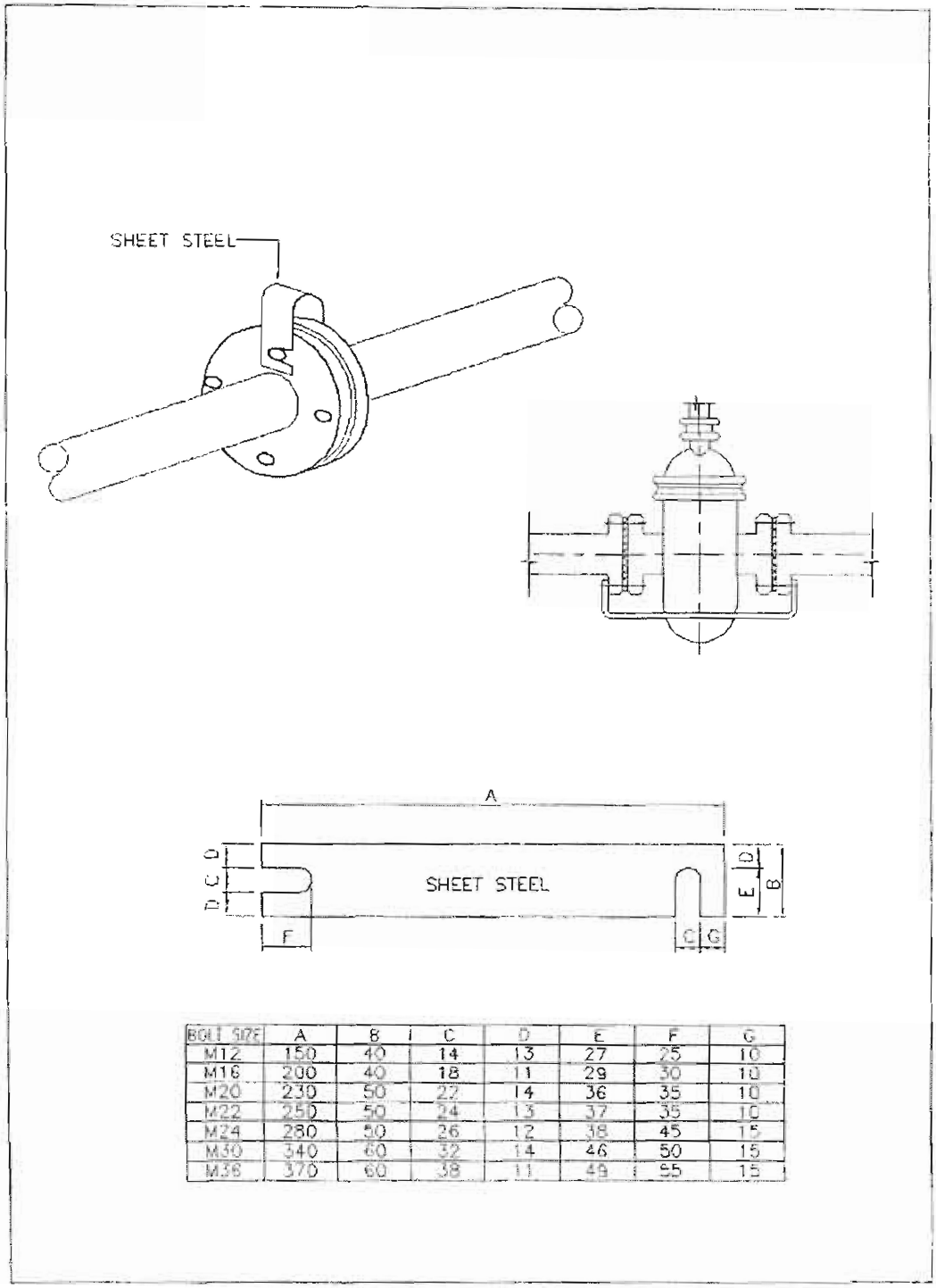


SECTION A–A

VALVE GROUNDING DETAIL

FIGURE 8

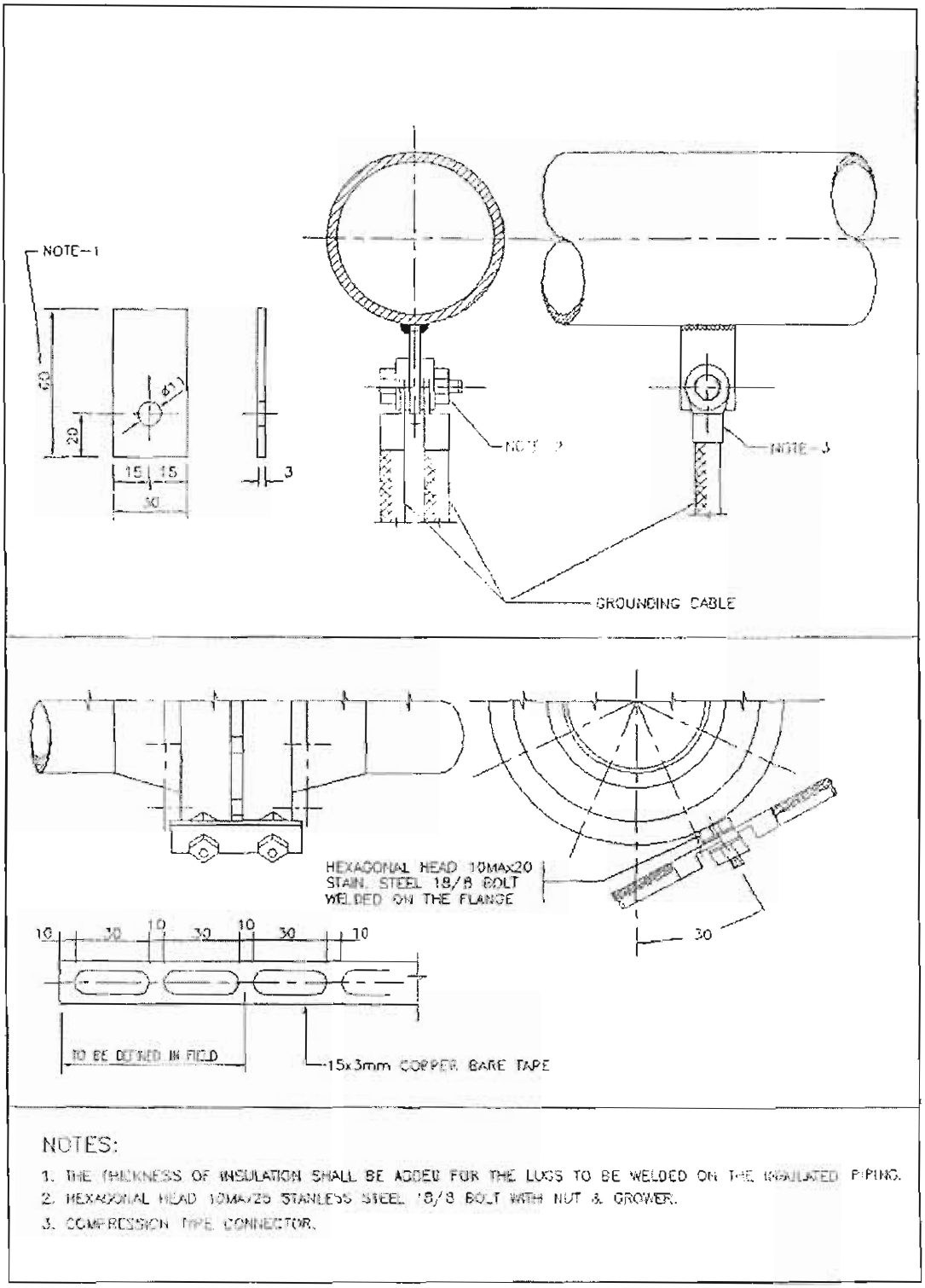
TYPICAL JUMPER DETAILS



BOLT SIZE	A	B	C	D	E	F	G
M12	150	40	14	13	27	25	10
M16	200	40	18	11	29	30	10
M20	230	50	22	14	36	35	10
M22	250	50	24	13	37	35	10
M24	280	50	26	12	38	45	15
M30	340	60	32	14	46	50	15
M36	370	60	38	11	49	55	15

FIGURE 9

TYPICAL JUMPER DETAILS

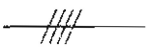
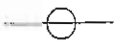
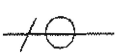
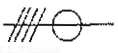
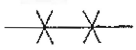


NOTES:

1. THE THICKNESS OF INSULATION SHALL BE ADDED FOR THE LUGS TO BE WELDED ON THE INSULATED PIPING.
2. HEXAGONAL HEAD 10MAX20 STAINLESS STEEL 18/8 BOLT WITH NUT & GROWER.
3. COMPRESSION TYPE CONNECTOR.

TABLE 1

EARTHING MATERIALS FOR PROTECTIVE SYSTEM

SERVICE DESCRIPTION	MATERIALS AND SIZES	SYMBOL USED IN THE LAYOUT DRAWINGS	SEE FIGURE
Main earthing protection network and earthing drain conductor for 6 kV and 400 V cable routing	Bare copper conductor 1x70 mm^2		
Earthing bus bar in substation	Bare copper flat 25x3mm		
Local earthing bus bar	Tinned bare copper flat 25x6xL drilled L depends on the number of connections		
Earthing conductors for user connections : Feeding conductor cross sectional area :	Insulated copper conductors		
≤ 35 mm^2	1 x 16 mm^2		
≥ 50 ≤ 70 mm^2	1 x 25 mm^2		
≥ 95 ≤ 120 mm^2	1 x 50 mm^2		
≥ 150 ≤ 185 mm^2	1 x 70 mm^2		
Main Earthing conductor for lighting system (separate conductor laid outside of cable or conduit) Feeding lighting conductor cross sectional area :	Insulated copper conductors	Generally not shown on the layout dwgs	
≤ 6 mm^2	1 x 6 mm^2		
≥ 10 ≤ 16 mm^2	same as per feeding		
≥ 25 mm^2	half of cross sectional area of feeding conduct		
Earthing drain conductor for 20 kv cable routing	Bare copper conductor 2x95 mm^2		

NOTE : Buried grounding conductors should normally be bare copper cable or tapes. However, if there is a likelihood of corrosion a green/yellow PVC coating shall be provided.

TABLE 2

EARTHING MATERIALS FOR PROTECTION SYSTEM AGAINST LIGHTNING AND STATIC ELECTRICITY

SERVICE DESCRIPTION	MATERIALS AND SIZES	SYMBOL USED IN THE LAYOUT DRAWINGS	SEE FIGURE
Main earthing protection	Bare copper conductor 1x35 mm^2	—//—	
Earthing connection conductor for big tanks	Bare copper conductor 1x35 mm^2	—//—	
Air termination and down conductors used for non metallic structure	Galvanized steel flat 25x4 mm^2	———	
Metallic frames of big dimensions	Bare copper conductor 1x35 mm^2	—//—	
Metallic frames of small dimensions	Bare copper conductor 1x16 mm^2	———	
Bonding of equipment for electrostatic protection purpose only	Bare copper conductor 1x16 mm^2	———	