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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

GENERAL ELECTRICAL WORKS

QUALITY ASSURANCE PAGE

CHANGES LOG

REVISIONS LOG

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CONTENTS

REFERENCE DOCUMENTS

Job Spec. No. 700/4
[Electrical Engineering Documents]
Job Spec. No. 700/6
[Electrical Installation in Civil Building]
Job Spec. No. 700/7
[Area Classification]
Job Spec. No. 710/1
[General Earthing System]
Job Spec. No. 720/1
[Checking System for earth fault of low voltage users]
Job Spec. No. 721/3
[Electrical Switchboards]
Job Spec. No. 740/1
[Outdoor Lighting]
Job Spec. No. 783/2
[External Lightning Protection]
Job Spec. No. 783/3
[Internal Lightning Protection]
Job Spec. No. 799/5
[Field Installation and Testing of Electrical Equipment]
Job Spec. No. 900/4
[Noise Control]

EU DIRECTIVES

- 2004/108/EEC EMC
  [Electromagnetic Compatibility Directive]
- 2006/95/EEC LVD
  [Low Voltage Directive]
- 94/9/EC ATEX
  [Equipment Explosive Atmospheres Directive]

BS 5000
[Rotating Electrical Machines of Particular types or for particular applications]
BS 5345
[Code of Practice for the Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive]
ELOT EN 62305-1
[Protection against lightning - Part 1: General principles]
(IEC 62305-1, modified)

ELOT HD 308 S2
[Identification of cores in cables and flexible cords by colours]
ELOT HD 384
[Erection of power installations with nominal voltages up to 1000 V]

IEC 60027
[Letter Symbols to be used in Electrical Technology]
IEC 60034
[Rotating Electrical Machines]
IEC 60056
[High-Voltage Alternating-Current Circuit-Breakers]
IEC 60076
[Power Transformers]
IEC 60079-0-EN 50014
[Electrical Apparatus for Explosive Gas Atmospheres
Part 0: General Requirements]
IEC 60079-1-EN 50018
[Electrical Apparatus for Explosive Gas Atmospheres
Part 1 : Flameproof Enclosures "d"]
IEC 60079-2-EN 50016
[Electrical Apparatus for Explosive Gas Atmospheres
Part 2 : Pressurized Enclosures "p"]
IEC 60079-5-EN 50017
[Electrical Apparatus for Explosive Gas Atmospheres
Part 5 : Powder Filling "q"]
IEC 60079-6-EN 50015
[Electrical Apparatus for Explosive Gas Atmospheres
Part 6 : Oil-Immersion "o"]
IEC 60079-7-EN 50019
[Electrical Apparatus for Explosive Gas Atmospheres
Part 7 : Increased Safety "e"]
IEC 60079-10
[Electrical Apparatus for Explosive Gas Atmospheres
Part 10 : Classification of Hazardous Areas]
IEC 60079-11-EN 50020
[Electrical Apparatus for Explosive Gas Atmospheres
Part 11 : Intrinsic Safety "i"]
ELOT EN 60079-15-EN 50021
[Electrical Apparatus for Explosive Gas Atmospheres
Part 15 : Type of protection "n"]
IEC60129
[Alternating Current Disconnectors and Earthing Switches]
I EC 60152
[Identification by Hour Numbers of the phase Conductors of 3-Phase Electric Systems]
IEC60158
[Low-Voltage Controlgear]
IEC 60269
[Low-Voltage Fuses]

IEC 60282
[High-Voltage Fuses]
IEC 60298
[A.C. Metal-Enclosed Switchgear and Controlgear for 1 kV and up to and including 52 Rated Voltages above kV]

REFERENCE DOCUMENTS Cont'd

IEC 60364
[Electrical Installations of Buildings]
I EC 60364-5-523
[Electrical Installations of Buildings
Part 5 : Selection and Erection of Electrical Equipment - Section 523 : Current-Carrying Capacities in Wiring Systems]
IEC 60445
[Basic and Safety Principles for Man-Machine Interface, Marking and Identification
- Identification of Equipment Terminals and of Terminations of Certain Designated Conductors, Including General Rules for an Alphanumeric System]
IEC 60529
[Degrees of Protection Provided by Enclosures]
IEC60617
[Graphical Symbols for Diagrams]
IEC 60742
[Isolating Transformers and Safety Isolating Transformers - Requirements]
IEC 60947
[Low-Voltage Switchgear and Controlgear]

1.0 **SCOPE**

This specification covers the general requirements for the equipment, materials and design of the electrical installation for the operation for company area(s), plants and attendant facilities. Throughout this specification different degrees of authority and emphasis are denoted by the use of the words "must", "shall", "should" and "may". The following interpretations apply in the four cases :

a. "must" implies either a legal obligation which is totally-binding or, alternatively, a requirement which can be relaxed only with the express authorization by Owner;
b. "shall" implies a strong recommendation based upon good engineering experience or upon the position adopted by recognized authorities;
c. "should" implies a recommendation based upon experience, but recognizes that some discretion is appropriate;
d. "may" is used in the permissive sense.

It is intended that this specification shall be supplemented by one line diagram(s) and by individual particular standard and specifications.

2.0 **BASIS OF DESIGN**

All the electrical installations shall be designed to provide :

- safety to personnel,
- reliability, operability, availability,
- provision for possible future requirements,
- a graded system of protective devices,
- equipment and material with adequate interrupting capacity, continuous current carrying capacity and insulation levels, all as required by systems voltages, capacities and short circuit levels.

3.0 **CODES. STANDARDS AND REGULATIONS**

Unless where otherwise indicated either in this Specification or in any particular specification all the electric and electronic material, apparatus, machinery, equipment and installation must comply with the latest edition of the following codes, standards and regulations.

3.1 **LOCAL REGULATIONS**

Any general or particular regulation issued by local authorities, such as Fire Brigade, Safety Inspectorate, Municipality, Public Telephone Company, PPC Regulations etc, must be complied with as supplied by Owner.

3.2 **OWNER'S SAFETY REGULATIONS**

All the regulations issued by Owner covering safety and pollution matters shall be complied with, as far as supplied by Owner.

3.3 **TECHNICAL CODES AND STANDARDS**

Equipment and materials shall be selected in accordance with Recommendations and Standards issued by IEC (International Electrotechnical Commission) and/or

CENELEC (European Committee for Electrotechnical Standardization - EN) and/or with Codes and Standards of the country of origin (i.e. BS for U.K. origin, VDE for German origin, ELOT for Greece origin., CEI for Italian origin etc.) provided that their requirements are so high or higher than IEC requirements.

In special cases where no codes, standards or recommendations, as above specified, are available, the recommendation of good engineering practice, and/or specifications issued by Contractor may be applied, provided that Owner's approved is obtained.

3.4 HAZARDOUS AREA CLASSIFICATION AND SELECTION OF TYPE OF SAFETY ELECTRICAL INSTALLATION

3.4.1 HAZARDOUS AREA CLASSIFICATION

The following shall apply:

Terminology Symbols
and drawings preparation : **ELOT EN 60079-10**

Sources of hazard and
hazardous boundary : **ELOT EN 60079-10**

3.4.2 OFFICIAL MARKING AND CERTIFICATION

Equipment and materials to be installed in hazardous locations shall be certified by a national or international recognized testing organization. The equipment and materials shall bare certificates and shall be marked according to CENELEC and IEC.

A Dossier of certificates must be supplied by each Vendor and/or Contractor for all electrical equipment concerned.

3.4.3 SELECTION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

The selection and type of protection of electrical equipment to be installed in hazardous locations will be in accordance with:

BS 5345, ELOT EN 60079 series, **IEC 79 and BS 5000** PTS 15, 16.

3.5 INSTALLATION

In general multicore cables shall be used running either U/G or A/G where required. The installation shall generally be in accordance with IP and wiring regulations. Where the cables require mechanical protection they shall be armoured. Cables in ducts or on cable trays do not have to be armoured.

The installation of explosion proof equipment and the installation in hazardous areas shall comply with **BS 5345, CENELEC and IEC 79** Stds.

3.6 EUROPEAN DIRECTIVES GUIDELINES

3.6.1 GENERAL

This document contains guidelines on the application of **European Directives**, which shall be followed for this project.

3.6.2 SCOPE

The design and construction of the plant must meet all applicable European and National legislation. This document provides guidelines to the requirements on the New Approach Directives (sometimes referred to as the CE Marking Directives) which are expected to apply to this project. Issues relating to electrical equipment are also identified.

3.6.3 NEW APPROACH DIRECTIVES

Products intended to be used in Europe or the European Economic Area must comply with all applicable European "New Approach" directives. Contractor is required to provide installation that complies with all applicable Directives.

Before Directives become mandatory there is a transitional phase during which the product may comply with either existing National rules or the Directive. National legislation must be withdrawn from the date the Directive becomes mandatory.

All New Approach Directives follow a similar format. They define mandatory "essential requirements" often involving safety. The product design and manufacture is subject to "conformity assessment" to confirm that the product conforms to the requirements of the Directive. The Directive defines whether the party performing conformity assessment can be the manufacturer or a Notified Body. The Manufacturer must draw up a technical file (technical documentation) which must be retained by the Manufacturer for a period stated in the applicable Directive. The Manufacturer must also provide information on the design, manufacture and operation of the product.

Products that comply with the "New Approach" directives are provided with:

- a physical CE Marking and other information as required by the relevant Directive(s)

- a "Declaration of Conformity" which lists all the Directives with which the product complies

- Any other information specified by the Directive e.g. user instructions.

3.6.4 MANUFACTURER

It is important to understand the term "manufacturer" in the context of the New Approach Directives. It is better described as the responsible party. The Manufacturer is the party who places product on the (community) market. This does not mean that the party must offer the product to more that one party. There may be only one customer.

Placing on the market means making a product available for the first time on the Community market. It usually involves a transfer of ownership.

The Manufacturer does not need to design or make the product. The party may have had no involvement in the way it was designed or manufactured, so the manufacturer could be the importer if made outside Europe.

There can be only one Manufacturer and it is a Manufacturer who is potentially liable if the product causes damage to individuals or private property.

The Manufacturer must comply with the essential requirements in the Directive and subject the product to conformity assessment.

The Manufacturer applies CE Marking and issues the Declaration of Conformity.

3.6.5 APPLICABLE DIRECTIVES

The following are the relevant directives to this project:

2004/108/EEC EMC
[Electromagnetic Compatibility Directive]

2006/95/EEC LVD
[Low Voltage Directive]

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

3.6.6 PRODUCTS FOR WHICH THE SUPPLIER IS THE MANUFACTURER

Most products fall into this category.

Suppliers shall be requested in the Contractor's enquiry to provide:

- Confirmation that the product will comply with all applicable European Directives
- A list of applicable Directives
- Justification where the supplier decides that a Directive is not applicable
- Confirmation that the will compile and retain a Technical File in accordance with the applicable Directives
- Confirmation that the product will include a physical CE Marking and that the manufacturer will provide a Declaration of Conformity and other documentation identified in the Directive.

The Contractor must be careful not to accept products that do not comply with the legislation. This is a concern where products are manufactured outside of Europe, supplied by stockists or where the supplier holds old stock; i.e. does not manufacture the product to supply an order. Electrical equipment for hazardous areas are a particular concern in this regard.

3.6.7 EQUIPMENT AND PROTECTIVE SYSTEMS IN POTENTIALLY EXPLOSIVE ATMOSPHERES DIRECTIVE (ATEX)

This Directive since 30 June 2003 is mandatory.

The Directive requires that a risk assessment be performed to determine the requirements for the selection of electrical equipment suitable for use in potentially explosive atmospheres.

The Contractor will need to provide information e.g. hazardous area information, so that the User of the plant can meet his responsibilities.

The Contractor should confirm with suppliers that their products could be provided with correct certification prior to placing orders.

4.0 ENGINEERING DOCUMENTS

4.1 ENGINEERING DOCUMENTS BY CONTRACTOR AND/OR MANUFACTURER/ VENDOR

The Engineering documentation shall be provided as part of the electrical engineering work and is mentioned on the relevant part of the Technical Volume.

4.2 GENERAL REQUIREMENTS FOR ENGINEERING DOCUMENTS

Electrical symbols shown on drawings and diagrams shall be in accordance with **IEC 60617.**

The information required by the **Job Spec. No. 700/4** shall be furnished as a minimum.

Metric system and letter symbols in accordance with **IEC 60027,** shall be used.

Drawing and forms shall be metric size (210x297 mm) or multiple of them and shall be suitable for metric size filers.

Exception to metrical system shall be for con- duit size, which shall be expressed in inches.

Where necessary, the phase relation of conductors and the phase shiftment through transformers shall be indicated with hour numbers (clock-wise system) in accordance with **IEC 60152.**

Generally conductors and terminals on multiwire diagrams, schematics and wiring diagrams should be identified with alphanumeric notation as per **IEC 60445.**

5.0 ENVIRONMENT'S BASIC DESIGN DATA

Unless otherwise specified on particular design documents (specifications, Material Requisitions, drawings etc.), the design of electrical installations shall be based on the following data.

The following basic design data are given for reference. It shall be responsibility of Contractor to verify the actual site conditions influencing their project.

5.1 GENERAL

The plant shall be considered with dry temperate climate.

5.1.1 HEIGHT ABOVE SEA-LEVEL
Various locations

5.1.2 EARTHQUAKE

According to the seismic Greek Regulations.

5.2 OUTDOOR (OPEN AIR) CLIMATE

5.2.1 TEMPERATURE

See **BEDD.**

5.2.2 HUMIDITY

See **BEDD.**

5.2.3 WIND

See BEDD.

5.3 SOIL CONDITIONS

5.3.1 SOIL TEMPERATURE (FOR BURIED CABLES)

See **BEDD.**

5.3.2 SOIL THERMAL RESISTIVITY

For preliminary design purpose a thermal soil resistivity of 150°C cm/w shall be considered (final data shall be given after soil investigation).

5.3.3 SOIL ELECTRICAL RESISTIVITY

For preliminary design purposes an electrical soil resistivity of 100 ohm.m shall be considered. (Final data shall be completed by Contractor after a detailed soil investigation).

6.0 CLASSIFICATION OF ENVIRONMENTS

The environmental conditions shall be classified as follows:

6.1 OUTDOOR INSTALLATION

Installation outdoor with no protection against rain, storm, solar radiation and exposure to plant polluting atmosphere; presence of snow in winter.

6.2 PROTECTED OUTDOOR INSTALLATION

Installation in a open sided building, where wind driven rain and storm can not enter. Spray drops of water, sand, and dust may be present. Protection against solar radiation by means of screens is provided for electrical canalizations and equipment in general.

6.3 INDOOR INSTALLATION

Installation in a completely closed room, with negligible presence of sand and dust, negligible solar radiation.

6.3.1 WET AND/OR MOIST LOCATION

Presence of water in form of sprayed drops or free-falling drops of water (condensed water).

Temperatures: (various locations)

- minimum 0°C
- maximum 40°C

Humidity: maximum relative 80%

6.3.2 DRY LOCATION

Negligible presence of water (generally no trace of dampness or vapour). Temperature as per **para 6.3.1,** humidity: negligible.

6.3.3 PRESSURIZED ROOM (IF REQUIRED)

It is a room in which an internal over pressure is maintained in order to prevent the entry of external atmosphere with polluting agents. Filters shall be provided on air intakes. Temperature and humidity as per **para 6.3.1** or **6.3.2.**

6.3.4 NORMAL CLOSED ROOM (NOT PRESSURIZED)

It is a room which the entry of sand and dust is prevented only by means of gasketed doors and windows. Temperature and humidity as per **para 6.3.1 or 6.3.2.**

6.3.5 CONDITIONED ROOM

It is a room in which air temperature and humidity are artificially maintained at the following values:

- minimum temperature	15°C
- maximum temperature	25°C
- minimum relative humidity	40%
- maximum relative humidity	50%

In case of failure of air conditioning, conditions shall be as per para 6.3.1 or 6.3.2.

6.3.6 CONDITIONED ROOM WITH CONSTANT TEMPERATURE

It is a room as specified in **para 6.3.4** in which the ambient temperature is maintained at a constant value of **para 6.3.5.**

7.0 CLASSIFICATION OF HAZARDOUS LOCATIONS

7.1 BASIS FOR CLASSIFICATION OF HAZARDOUS LOCATIONS

In addition to the documents listed in **para 3.4** the following specifications shall be used for the classification of hazardous locations: **Job Spec. No. 700/7.**

7.2 RESPONSIBILITY FOR THE CLASSIFICATION OF HAZARDOUS LOCATIONS

It shall be responsibility of Contractor to prepare area classification drawings in accordance with above mentioned documents and to keep them up to dated during the design stages. The owner is responsible to approve final area classification.

8.0 ENCLOSURES AND TYPE OF MECHANICAL PROTECTION OF MATERIAL. EQUIPMENT AND MACHINERY

8.1 GENERAL

Material equipment and machinery shall be as hereinafter specified and shall comply with the requirements dictated by the classification of the environment and of the hazardous location in which they are to be installed. Materials shall conform to the standards called for in **para 3.0.**

Unless otherwise stated in the contract documents, material selection shall be as specified in **para 9.0** and shall be the Contractor's responsibility.

8.2 GENERAL PURPOSE ENCLOSURES

8.2.1 ENCLOSERS

Enclosures shall be classified as specified in the following, in relation to:

- protection of persons against contacts which live or moving parts inside the enclosure.
- protection of equipment against ingress of foreign bodies.
- protection of equipment against ingress of liquids.

Definitions of degree of mechanical protection shall be in accordance with IEC Recommendations:

- **IEC 60034.**
- **IEC 60298.**
- **IEC 60529.**
- **IEC 60947.**

8.2.2 ROTATING ELECTRICAL MACHINES

Enclosures shall be of one of the following types:

- dripproof, screen protected	IP 22,S
- weather protected	IP W 24
- totally enclosed, protected against splashing water	IP 44
- totally enclosed, protected against water jets	IP 45
- totally enclosed protected against harmful deposit of dust and against splashing water	IP 54
- totally enclosed, protected against harmful deposit of dust and against water jets	IP 55

Terminal boxes shall be with protection degree not less than IP 55 or with the protection required for the machine itself, what ever is the higher.

8.2.3 LOW VOLTAGE EQUIPMENT (< 1000 V)

This group of equipment shall include low voltage switchgear and control gear, push-button stations, lighting fixtures, terminal and junction boxes, communication equipment and alike.

For communication equipment other kind of protection equivalent to these here specified may be used. Reference shall be made to **IEC 60529.**

(a) External enclosures shall be one of the following types:

- protected against contact with live moving parts inside the enclosure with objects of thickness greater than 2,5 mm and against drops of water	IP 31
- protected against contact with live or moving parts inside the enclosure with objects of thickness greater than 1 mm and against drop of water	IP 41
- protected against contact with live or moving parts inside the enclosure with objects of thickness greater than 1 mm and against splashing water	IP 44
- protected against contact with live on moving parts inside the enclosure with objects of thickness greater than 1 mm and against jets of water	IP 45
- complete protection contact with live or moving parts inside the enclosure and protection against harmful deposits of dust & against splaghing water	IP 54
- complete protection against contact with live or moving parts inside the enclosure and protection against harmful deposits of dust and against jets of water	IP 55

(b) Prevention of access to internal parts of the enclosures shall be provided by means of fixed barriers or screens, having mechanical protection degree not less than IP 30.

Where it is necessary to make provision for removal of barriers, opening of enclosures or withdrawal parts of enclosures (doors, casings, lids, covers and the like), removal, opening or withdrawal shall necessitate the use of a tool.

The use of key locks shall be considered as a single handle or knob; only the use of padlocks shall be considered equivalent to the use of a tool from the point of view of prevention of accessibility.

(c) Accessibility to internal parts of the enclosures, where needed for occasional handling (such as replacing of fuses, lamps, setting or resetting of relays etc) shall be permitted only if one of the following protective measure is assured :

- automatic deenergization of all power and control circuits, except circuits at a voltage level lower than 24 V A.C or 36 V D.C., which have to be of the safety extra low voltage (SELV) type (see **para 11.2.2).**

- permanent protection of live parts. Removal, opening or withdrawal of barriers may be by means of handles, knobs and alike, without the use of a tool.

c1) Deenergization of all live parts behind the barrier or enclosure shall be by means of an interlocking device. Restoration of the supply shall be possible only after replacement of barriers of reclosure of the enclosure.

Removal, opening or withdrawal shall initiate automatic switching- off before live parts behind the barrier or enclosure can be touched accidentally;

c2) A second barrier with mechanical protection degree not less than IP 30 shall prevent contact with live parts, which might be accessible after opening of doors or removal or withdrawal of barriers.

8.2.4 HIGH-VOLTAGE (> 1000 V) METAL ENCLOSED SWITCHGEAR AND CONTROLGEAR AND CUBICLE SWITCHGEAR (HV EQUIPMENT).

Reference shall be made to **IEC 60298 and IEC 60529.**

Enclosure accessibility shall be as specified above for low voltage equipment (para 8.2.3.a) and b); in addition:

- external covers shall have degree of protection not less than IPH 3,
- internal partitions which may be accessible without use of a tool shall have a degree of protection not less than IPH 3,
- grates and wire screens for ventilation and gas venting shall have openings not greater than 6 mm and shall not be located in correspondence to live parts.

8.3 TYPE OF PROTECTION OF ENCLOSURES AND APPARATUS FOR USE IN HAZARDOUS LOCATIONS

8.3.1 TEMPERATURE CLASS OF MATERIAL EQUIPMENT AND ENCLOSURES

All material, equipment and enclosures of any electrical apparatus to be used within hazardous locations shall be classified with a temperature class, with regard to the maximum permitted surface temperature and to the minimum ignition temperature of the substances which may present. Temperature classes shall be in accordance with **IEC 60079** part 0, **EN 50014.**

8.3.2 INTRINSICALLY SAFE APPARATUS (Ex-i)

An intrinsically safe apparatus is an apparatus so constructed that when connected and used in the prescribed conditions, any sparking that may occur therein or in the circuit associated therewith is incapable of causing ignition of the specified flammable gas or vapour. Intrinsically safe apparatus are classified into two categories, defined as stated by **IEC 60079-11, EN 50020.**

- category "ia" - apparatus which are incapable of causing ignition in normal operation or which a single fault, or with any combination of two faults, applied with the specified safety factors,
- category "ib" - apparatus which are incapable of causing ignition in normal operation or which a single fault applied, with the specified safety factors.

8.3.3 EXPLOSION PROOF ENCLOSURE (FLAMEPROOF) - (EX-d)

Explosion proof enclosures (flameproof enclosures) for electrical apparatus shall comply with the requirements set forth by **IEC 60079-1, EN 50018.**

8.3.4 PRESSURIZED ENCLOSURE (EX-p)

Pressurized enclosures for electrical apparatus shall comply which the requirements set for by **IEC 60079-0 and 60079-2, EN 50014 and EN 50016.**

8.3.5 INCREASED SAFETY (EX-e)

Increased safety electrical apparatus shall comply with the requirements set for by **IEC 60079- 7, EN 50019.**

8.3.6 OIL IMMERSED APPARATUS (EX-o)

Oil immersed apparatus shall comply with the requirements set for by **IEC 60079-6, EN 50015.**

8.3.7 SAND FILLED APPARATUS (EX-q)

Sand filled apparatus shall comply with the requirements set for by **IEC 60079-5, EN 50017.**

8.3.8 HERMETICALLY-SEALED APPARATUS

Low voltage arching or sparking devices, such as pressure switches, temperature switches and alike, may be hermetically- sealed type provided that they comply with the Codes and regulations of the country of origin.

8.3.9 CAST-RESIN COMPOUNDED APPARATUS

Static apparatus, such as small transformers, capacitors, reactors, solid- state devices etc., may be cast-resin compounded, provided that they comply with the Codes and regulations of the country of origin.

8.3.10 NON-SPARKING MOTORS (TYPE n MOTORS)

This type of construction applies only to squirrel-cage induction motors without brushes, switching mechanism etc. Mechanically and electrically non sparking motors, are general purpose motors, which in normal operating conditions, including starting and reacceleration (if it is applicable) with the specified supply and service conditions, do not produce arcs or sparks or excessive temperatures on external surfaces capable of igniting the explosive mixture which may be present in the surrounding atmosphere.

Non-Sparking motors shall comply with the requirements of **IEC 60079-15, EN 50021.**

8.3.11 VAPOUR TIGHT LIGHTING FIXTURES

Vapour tight lighting fixtures are completely enclosed and gasketed fixtures in which the operating temperatures of any part of the fixture or lamp must not exceed 80% of the ignition temperature of the explosive mixture which may be present. The mechanical protection corresponds to IP 55.

8.3.12 APPROVED TYPE APPARATUS

Approved type apparatus are apparatus for which the suitability of safety provisions is recognized by a testing station as per **para 8.4.**

8.4 CERTIFICATION OF EQUIPMENT FOR USE IN HAZARDOUS LOCATIONS

Electrical material equipment and machinery to be installed in hazardous locations shall be suitable for the particular location in which they are located, as specified in **para 9.2.**

Material, equipment and machinery with any of the following type of protection:

- Ex-n	Non-Sparking
- Ex-i	intrinsically safe apparatus
- Ex-d	explosion proof enclosure
- Ex-e	increased safety

- Ex-p	pressurized enclosure
- Ex-o	oil-immersed apparatus
- Ex-q	sand-filled apparatus

- approved type apparatus shall be furnished with prototype test certificate. Certification of equipment must be in accordance with **para 3.4.2.**

Above listed materials shall be marked as specified by the applied standard and/or code.

Hermetically sealed apparatus and cast resin compounded apparatus shall be furnished complete with certificates stating the suitability of equipment to the specified installation conditions, by a appropriate testing station or authority. This type of protection may be used only in class 1 division 2 locations.

9.0 SELECTION OF MATERIAL, EQUIPMENT AND MACHINERY WITH REGARD TO ENVIRONMENT AND HAZARDOUS LOCATION CLASSIFICATION-SELECTION OF TYPE OF INSTALLATION

In general the type of protection required and recognized as suitable for a kind of environment and for a classified hazardous location may also be used where less heavy conditions exist.

9.1 SELECTION WITH REGARD TO ENVIRONMENT

9.1.1 <u>OUTDOOR INSTALLATION</u>

Rotating electrical machines shall be with enclosure not less than IP 55 Low voltage equipment shall be with enclosure not less than IP 55.

9.1.2 <u>PROTECTED OUTDOOR INSTALLATIONS OR INDOOR IN WET AND/OR DUSTY ROOMS</u>

Rotating electrical machines shall be with enclosure not less than IP 55 Low voltage equipment shall be with enclosure not less than IP 55.

9.1.3 <u>INDOOR INSTALLATIONS</u>

9.1.3.1 INDOOR INSTALLATIONS IN WET AND/OR MOIST LOCATION Rotating electrical machines shall be with enclosure not less than IP 55.

Low voltage equipment shall be with enclosure not less than IP 31; in addition high voltage equipment shall be with enclosure not less than IPH 3.

9.1.3.2 INDOOR INSTALLATION IN DRY LOCATION

Rotating electrical machines shall be with enclosure not less than IP 55.

Low voltage equipment shall be with enclosure not less than IP 31; in addition high voltage equipment shall be with enclosure not less than IPH 3.

Exception shall be considered for high voltage neutral grounding resistors, which shall have enclosure not less than IP 21 -IP H 2.

9.2 SELECTION IN RELATION TO THE CLASSIFICATION OF HAZARDOUS LOCATIONS

Unless otherwise specified the minimum degree of mechanical protection of enclosures shall be that specified in relation to the environment.

9.2.1 CLASS 1. DIVISION 0

Power and control equipment shall not be installed; only instrumentation circuits may be installed with protection type Ex- ia.

9.2.2 CLASS 1. DIVISION 1

In general, electrical equipment and wiring material shall be furnished, as required by **ELOT EN HD 384** and **ELOT EN HD 308 S2,** with the following specific interpretation and additions:

- Equipment shall have protection type Ex-d, or Ex-ib or Ex-p or Ex-q or be approved type apparatus.

- For protection type Ex-p, if the pressurizing medium is air, the air intake shall be located outside of locations classified Class 1 division 1 or 2, at a distance in all directions of at least 3 m. Apertures provided for the control of out-flow of pressurizing medium to the external atmosphere shall be located outside of locations classified Class 1, division 1.
The supply of the pressurizing medium to enclosures which shall remain in service also if the prescribed over-pressure falls under 5 mm water gauge shall be by means of a dual system and shall have pressure- measuring devices for the operation of an alarm in the control room and trip devices whenever the pressure within the casing falls below the permitted minimum.

If one of the two pressuring systems fails, an alarm shall sound in the control room; if the second system fails the equipment shall be automatically deenergized.

9.2.3 CLASS 1. DIVISION 2 LOCATIONS

In general electrical equipment and wiring materials shall conform to the requirements of **ELOT EN HD 384** and **ELOT EN HD 308 S2,** with the following specific interpretation and additions:

- Equipment which may produce arcs or sparks or excessive temperatures in normal operating conditions shall have protection type Ex-d, or Ex-ib, or Ex-p, or Ex-o, or hermetically sealed or shall be approved type apparatus.

- For protection type Ex-p, requirements given in **para 9.2.2** shall be applied, which the exception that (a) out- flow of air may be directly in division 2 locations, (b) automatic trip devices and dual pressurizing systems may be not required. Decision shall be Contractor's responsibility.

- Squirell-cage induction motors shall be Ex-n type non-sparking as defined in **para 8.3.10** or Ex-e, suitable for the specified temperature class.

- Synchronous motors shall be as above specified for induction motors, except motors with slip rings shall be provided with enclosed slip ring housing with positive pressure purging, using clean air or inert gas (Ex-p).

- Non-sparking equipment as oil immersed or dry type transformers, resistors, lighting fixtures, meters, junction boxes, communication equipment etc., shall be with protection type not less than Ex-e or as specified for Class 1, division 1, locations.

- Lighting fixtures may also be vapour right type as specified in **para 8.3.11** suitable for the specified temperature class and with enclosure not less than

IP 55.

9.2.4 SPECIAL NON-HAZARDOUS LOCATIONS

Electrical equipment shall be selected only as specified in **para 9.1.3.**

9.2.5 NATURAL NON-HAZARDOUS LOCATIONS

Electrical equipment shall be selected only in relation to the environment.

9.2.6 TYPE OF CANALIZATIONS

The type of canalizations to be adopted for the various hazardous locations shall be specified in **para 19.2.**

9.3 NOISE LEVEL

Machinery shall be selected in order to limitate the noise level in accordance with the **Job Spec. No. 900/4.**

10.0 CLASSIFICATION OF ELECTRICAL USERS IN RELATION TO THE OPERATIVE CONDITIONS REACCELERATION AND LOAD SHEDDING

10.1 CLASSES OF USERS

Electrical users shall be generally classified as follows:

10.1.1 NORMAL LOADS

The operation of these loads is required in normal plant operation at design conditions and at normal supply conditions; single ended operation of a double radial substation shall be considered as normal supply condition under this respect.

Provisions for maintaining in service or restarting loads shall be foreseen only for the case of automatic transfer, short time power failure and voltage dips.

10.1.2 PREFERENTIAL LOADS

Operation of these loads is required to keep the plant operating even at reduced capacity or generally to prevent damages to the installations and to prevent heavy losses of materials (reduced plant operation) in the event of disturbance or reduction in the power supply availability (reduced plant operation, such as in case of failure of a generator or of one external feeder).

10.1.3 ESSENTIAL LOADS

Operation of these loads is required to assure safety conditions to the plant or to prevent damages to personnel (emergency plant condition).

10.1.4 PRIORITY LOADS

Operation of these loads is required also in exceptionally heavy abnormal conditions, such as complete power failure (failure of external supply, internal generation), to prevent catastrophic situations (explosions, break down, heavy danger to personnel or to installations etc.).

Priority loads shall be identified by Owner and shall include as a minimum, but not limited to:

- safety pressurizing of process control houses and of other pressurized rooms,

- communication system,
- emergency lighting in control rooms,
- fire system alarm,
- emergency instrument.

10.2 REACCELERATION

Provisions to reaccelerate electrical motors shall be adopted in order to restart automatically users which shall be kept in service in the different particular plant operating conditions (normal, reduced, emergency etc.).

Reacceleration of these users shall permit the recovery of them after a short voltage dip or an automatic transfer.

More than one step of reacceleration shall be considered, to provide satisfactory voltage conditions.

Step priority shall be based on process requirements.

10.3 LOADSHEDDING

A load shedding strategy shall be developed in order to permit normal, preferential and essential loads, selected in relation to the actual power availability, to remain in stream up to the capability of the available power, when part of the power supply fails.

11.0 DISTRIBUTION SYSTEM DESIGN

The distribution system shall be single radial for plants, having preferential and/or essential users.

11.1 POWER SOURCES

11.1.1 SUPPLY FROM PPG

The supply from Utility (Public Power Corporation) shall be through 0.4 KV for M/R Stations, line valves Stations and C.P. Stations.

11.1.2 OTHER POWER SOURCES

Besides the power sources for auxiliary circuits such as D.C. batteries and relevant D.C. power supply, other kinds or power sources may be provided, such as motor-generators sets, inverters etc., depending on special needs of particular items of each plant unit.

11.2 POWER DISTRIBUTION AND UTILIZATION SYSTEMS

11.2.1 MAIN DISTRIBUTION SYSTEM

The main distribution system shall be single radial, 0,4 KV , 3 phase, 4 wire with grounded neutral. It shall consist of:

- Low voltage systems, unless otherwise specified, shall include power circuits 400/230 V 3 phase and neutral, with solidly earthed neutral, for ordinary power users and ordinary lighting circuits.

11.2.2 CIRCUITS AT EXTRA LOW VOLTAGE (ELV) (IF REQUIRED)

Extra low voltage circuits shall be at a voltage not exceeding 50 V A.C. and 75 V. D.C.

11.2.2.1 CIRCUITS AT SAFETY EXTRA LOW VOLTAGE (SELV)

These circuits shall be supplied from an isolation transformer, complying with specification for safety insulation.

Circuits at a voltage not exceeding 24 V A.C. and 36 V D.C. shall have one point connected to protective earth; circuits at higher voltages shall have the intermediate point connected to protective earth.

11.2.2.2 CIRCUITS AT FUNCTIONAL EXTRA LOW VOLTAGE (FELV)

Extra low voltage circuits which are not supplied from a safety isolation transformer shall be considered as functional ELV circuits.

11.3 USER'S VOLTAGE SUPPLY

Unless otherwise specified and/or agreed by Contractor and Owner, the user's supply voltage shall be as follows:

11.3.1 INDUCTION MOTORS

- motors from 0,37 KW 160 KW-400 V,3 phase
- fractional motors shall be 230 V, single phase.
  Exception fractional HP motors in critical process service shall be 400V -3 phase, 50 Hz.

11.3.2 LIGHTING

(a) Ordinary lighting system shall be fed at 400/230 V, 3 phase and neutral, with solidly earthed neutral.
Lighting branch circuits shall be 230 V, single-phase, 3 wires.

(b) Emergency lighting system generally shall be 400/230 V from diesel generator, or 110 V D.C. from battery.

11.3.3 ELECTRICAL SPACE HEATERS

Space-heaters for switchgears, motors and other equipment up to 1500 W shall be 230 V, single phase (phase to neutral); above 1501 W. shall be 400 V.

11.3.4 WELDING RECEPTACLES AND CONVENIENCE OUTLETS

The voltage used for receptacle circuits shall be:

- 400 V, 3 phase; 3 wire with earth protective conductor for power users, such as welding and similar;
- 230 V, single phase, 2 wires with earth protective conductor for lights and small users in civil areas;
- 24 V, single phase, 2 wires completely separated circuit safety extra low voltage supplied through a safety transformer
  The safety isolating transformer shall be in accordance with **IEC 60742.**
- 48 V, single phase, 2 wire, supply circuit as above for hand tools.

11.4 DIRECT CURRENT SYSTEMS

Unless otherwise specified, all D.C. systems shall be 110 V (exception D.C. power and control systems of variable speed D.C. motors for which standard D.C. system shall be used). Each 110V d.c. system shall consist of:

a) Stationary batteries sized for 10 hours discharge:

b) Three branches static rectifier:

- one charging branch for fast-rate battery charging
- one trickle-branch for trickle charging
- one load-branch to feed the loads in ordinary conditions.

The battery shall be permanently connected to the load through a blocking diode at n,th (e.g. 75% of total) element in order to get no break transfer in case of a.c. supply failure.

Direct current systems shall supply:

(a) control and alarm circuits of M.V. switchgears;

(b) control and alarm circuits of L.V. power centers limited to incomer's functional units, bus-tie unit and possibly to out- going feeder to secondary distribution switchgear units.

(c) emergency lighting (see **para 11.3.2.b)** (In substation buildings, station batteries may supply emergency lighting).

11.5 VOLTAGE SPREAD ON M.V. AND L.V. BUS BARS

11.5.1 NORMAL VOLTAGE SPREAD

The difference between the highest and the lowest voltages which appear at the utilization (M.V. and L.V.) under ordinary operating conditions, shall not exceed 10% of the bus rated voltage. Normal operating conditions exclude transients such as those due to system switching and temporary voltage variations due to abnormal system conditions (such as fault conditions, sudden disconnecting of large loads, starting of larger motors and alike).

11.5.2 EXCEPTIONAL VOLTAGE SPREAD

The difference between the highest and lowest voltage which appear at the main utilization busses (20 KV and 400 V), under exceptional abnormal conditions, shall not exceed 30% (+ 10% above and -20% below rated bus voltage). Exceptionally abnormal conditions include the case of external supply system voltage exceeding + 10% of rated value, transient conditions due to faults in the electrical system, starting of large motors and alike.

11.6 FREQUENCY SPREAD

11.6.1 NORMAL FREQUENCY SPREAD

Under normal supply conditions, the frequency spread shall not exceed 4% (+ 2%, - 2%) of rated frequency (50 Hz.).

11.6.2 EXCEPTIONAL FREQUENCY SPREAD

Under exceptionally abnormal supply conditions, the frequency spread shall not exceed 10% (+ 5%, - 5%) of rated frequency. Exceptionally abnormal service conditions shall include transients due to switching of external supply.

Note: The PPC input voltage has variation +10%, -10%. The PPC frequency has variation +1 %, -1 %.

11.7 VOLTAGE SPREAD AT USERS TERMINALS

11.7.1 NORMAL VOLTAGE SPREAD

Under normal supply conditions voltage spread at users terminals (M.V. or L.V.) including variations on main utilization busbars and rated load to no load variations, shall not exceed the limits allowed by the applicable IEC Recommendations and/or by particular equipment specifications. In case no reference exists, the following figures shall be considered;

+5% at no load with maximum normal bus bar voltage.

-5% at rated load with minimum bus bar voltage.

11.7.2 EXCEPTIONAL VOLTAGE SPREAD

Exceptional abnormal voltages at users terminals shall not exceed the limits compatible with equipment performance. Such abnormal operating conditions shall be considered to have short duration.

12.0 POWER TRANSFORMERS

In general power transformers shall comply with the requirements set for in the following document:

IEC 60076.

12.1 20 KV SUBSTATION TRANSFORMERS

These transformers shall be for indoor installation, oil immersed, self-cooled, STAR-DELTA connected and fitted with on-load tap changers, on 20 kV side and with all necessary accessories, as per applicable standards and specifications.

Provision for forced ventilation (future) shall be provided. Voltage regulation shall be automatic by automatic voltage regulation.

12.2 LOW VOLTAGE DISTRIBUTION TRANSFORMERS

Low voltage 6/0,4 kV distribution transformers shall be 3 phase, oil-immersed, self-cooled.
Generally the transformers to be installed in electrical substations of plant units, shall be outdoor installation; transformers, which shall be installed inside the buildings, shall be for indoor installation, and shall be air cooled type, not oil filled.

12.2.1 CONNECTION AND VECTOR DIAGRAM

Generally, transformers with 0,4 kV secondary voltage shall be delta-star connected with neutral brought out; vector group Dyn 11.

12.2.2 SIZING OF TRANSFORMERS

Generally the maximum rating of low voltage transformers shall be 1600 KVA. Transformers to be used in double radial systems, in single radial systems, shall be sized for continuous operation with the maximum one hour power demand and with an uprating of about 10% of this latter; no consideration shall be made for future expansions.
Consequently the no-load and short circuit losses for all distribution transformers shall be optimized for operation at 75% of the rating.

Transformers of same rating and primary and secondary voltages shall be mechanically interchangeable, by adopting standardized flanges and terminal boxes.

12.2.3 ACCESSORIES

Transformers shall be fitted with all necessary accessories, as specified by applicable standards and specifications.

12.3 PROTECTIONS

Besides external protections on primary and, in the secondary side by means of circuit breakers and suitable relaying system, distribution transformers shall have inner protective devices as required in AF specifications. For transformers connected to tapped feeders the relays acting on the common primary circuit breaker shall assure back-up short circuit protection of each individual connected transformer.

13.0 SWITCHGEAR

13.1 MEDIUM VOLTAGE SWITCHGEAR

Switchgears rated above 1000V and including 20KV shall be considered medium voltage switchgears shall be indoor metal clad type of manufacturer's standards design. Switchgears shall be dead-front structure with removable, electrically operated circuit breakers.

Circuit breakers shall be air break, vacuum break, SF6 type depending on short circuit levels and on operating conditions.

Medium voltage switchgears shall comply with the requirements set for in the following documents:

(a) **IEC 60298, 60282, 60129, and 60056;**

(b) **Job Spec. No. 721/3** for general requirements.

Switchgears shall include the minimum required accessories and arrangements in accordance with manufacturer's standard. The devices shall include:

- "anti-pumping", electrically trip-free control circuits,
- semi-flush draw-out type protective relays, unless otherwise specified.
- current and potential transformers for metering and relaying. Potential transformers shall be furnished with draw- out type primary protective fuses,

- necessary auxiliary devices, as specified in the specification for electrical switchboards. Short circuit level to be considered shall be as specified in para **16.0.**

13.2 110V D.C. CONTROL POWER

Power supply for control and protection circuits shall not be integral with the switchgears (see **para 13.4).**

13.3 LOW VOLTAGE SWITCHGEARS

In general, switchgears for service at 400 V and below shall be free standing, dead-front steel structure for indoor installation. Switchgears shall be sized to allow 20% more addition breakers to the main-bars for future installation.

Low voltage switchgears shall comply with the requirements set for in the following documents:

(a) **IEC 60947, 60158, 60269, 60129.**

(b) **Job Specifications No. 721/3** for general requirements.

13.3.1 TYPES LOW VOLTAGE SWITCHGEAR

Switchgears shall be one of the following types.

13.3.1.1 400 V POWER CONTROL CENTER

It may include the following units :

a) incomers from step-down distribution transformers or PPC;

b) motor starters for low voltage users rated up to 160 KW.

c) outgoing feeders to other users, such as power control panels for D.C. motors, electric heaters etc.

Auxiliary and priority services switchgears (TAPC-turn around power centers). These switchgears shall be generally fed from a single radial power center by means of automatic circuit breakers or contactors. Where an emergency power source exists (e.g. emergency generator set), one section shall be connected to the normal power source and the second section to the emergency power sources. In the latter case the loads shall be connected as follows:

a) normal section:

- external lighting (streets, yards, tank yards etc.) controlled by a clock-switch and photocell,
- plant lighting, supplied from local lighting panels,
- welding receptacles and convenience outlets,
- space heaters (of switchgears, motors etc.),
- small users,
- D.C. panels;

b) priority loads section :

- A.C. instrument circuit (unless a separate power source is provided),

- emergency lighting,
- safety electric services.

13.3.2 EQUIPMENT OF LOW VOLTAGE SWITCHGEARS

Circuit breakers of any type and on load switches associated with fuses shall have the required making and breaking capacity. Integral fuse isolators shall not be used. Unless otherwise specified, the following equipment shall be used:

(a) **13.3.1.1 a)**: air- break type circuit breakers;

(b) **13.3.1.1 b)**: combination of air-break type magnetic contractor and fuses or circuit breakers;

(c) **13.3.1.1 c)**: same as a) or on-load switches with fuses;

Feeders to external lighting circuits (roads, yards, etc.) shall be combination of fuses and magnetic contactor.

All fuses shall be current limiting type

Switchgears shall be suitable for future extension on at least one end. Unequipped spare units shall be furnished only as required to balance the switchgear assembly. No spare breaker elements shall be installed.

13.4 SWITCHGEAR'S CONTROL POWER

In general control system shall be as described herebelow.

13.4.1 110VD.C.

110V D.C., supplied from a D.C. distribution board, shall be used for:

(a) medium voltage circuit breakers closing and trip circuits;

(b) medium voltage contractor;

(c) low voltage incomers;

(d) any possible transfer system;

(e) alarm and signalling system.

In all electrical substation a stationary lead-acid battery shall be provided.

13.4.2 230 V.A.C.

230 V.A.C. supplied from a control power transformer for each busbar system of a low voltage switchgear, shall be used for:

(a) low voltage motor starters;

(b) low voltage outgoing feeders;

13.4.3 INDEPENDENT CONTROL POWER SOURCE

Where required by technological reasons, an independent control power source shall be provided.

13.5 MOTOR CONTROL EQUIPMENT

Unless otherwise specified, motor control shall be for direct-on-line full voltage starting.

Besides the power equipment set for above for motor starters in switchgears, motor control equipment shall include overload protective devices to provide a minimum of five seconds delay at locked rotor current. This delay shall be properly increased, as required for motors with abnormal duration of acceleration time.

Motor starters for single-phase motors and 3- phase-motors less than 0,37 KW, which are not automatically controlled, may be direct hand operated type, located near the motor (instead of push-button station and contractor).

13.6 OUTDOOR MOTOR CONTROL AND AUXILIARY SWITCHGEARS

Where convenient on the basis of technical and economical considerations, outdoor type switchgears may be provided.

13.6.1 NON-HAZARDOUS LOCATIONS

In non hazardous locations, control for low voltage motors shall be similar to the indoor equipment described in **para 13.3.2** but furnished with weather resistant enclosures, suitable for the environment.

An incoming fully rated, manually operated, circuit breaker shall be provided on each assembly.

Where the switchrack includes more than five individual units, the switchrack shall be arranged for back to back mounting and shall have a weatherproof busduct; bus-bars mounted on suitable insulators shall be furnished.

When the switchrack is exposed to sun and rain, a sloping shed shall be provided.

13.6.2 CLASS 1 DIVISION 2 LOCATIONS

In general, the installation of switchrack in hazardous location must be avoided. If it is required, for design purposes or other reasons installation in class 1, division 2 locations, switchracks shall be furnished similarly to those described for non hazardous locations, except that enclosures shall have suitable type of protection in accordance with **para 8.0.** The use of type of protection Ex-p (see **para 8.3.4)** shall be limited to a minimum.

13.7 CONTROL STATIONS

In general, control stations shall be of the heavy-duty, rotary type momentary contact type, sealed type contacts shall be used as far as possible.

Exception to the above shall be special control circuits, which require the use of maintained contact "on-off" control stations or "hand-off- automatic" selector switches.

In general, control stations shall be mounted adjacent to, and with-in sight of the controlled motor, back and at the right side of the motor, facing the driving end.

14.0 RELAYING AND PROTECTIVE DEVICES

14.1 GENERAL

A selective system of protective devices shall be furnished in so far as practical. In accordance with foregoing, relays and protective devices shall be selected and coordinated to provide a system permitting to the circuit interruption device closest to a fault to operate first.

Contractor shall provide relay settings and coordination curves for the protective devices furnished.

It shall be Contractor's responsibility to select and adopt all relevant relays for the good operation of the system in case of any kind of faults. The following relays shall be provided as a minimum:

(a) Low voltage induction motor feeders (up to 160 KW).

- Thermal relay (49).
- Instantaneous 3 phase overcurrent (50)
  (For motors controlled by automatic circuit breaker; not required in case of combination of magnetic contractor and fuse).
- Single phasing (46)
  (For motors more than 0,37 KW or critical process motors even though less than 0,37 KW).

(b) Power transformer feeder

Protection relays shall be as following:

- Overcurrent instantaneous and time delayed (50/51).
- Neutral back-up relay (51G)
- Differential (87) (for power transformers rated 5 MVA and above).
- Lock-out relay (86)
- Ground fault (50 GS)

(c) Medium and low voltage switchgear

Protection relays shall be as following:

- Overcurrent instantaneous and time delayed (50/51).
- Overcurrent protection relay inverse time with high-set (50N/51N)
- Auxiliary undervoltage relays (27M, 27R).

15.0 CONTROL. ALARM AND SIGNALLING

15.1 ALARM AND SIGNALLING

In Control Room a centralized alarm and signalling panel shall collect the alarms and signalling for abnormal conditions of the electrical system.

15.1.1 LOCAL ALARM AND SIGNALLING PANELS

In each substation a local centralized alarm and signalling panel shall be foreseen on which all the local abnormal conditions and protective actions shall be picked up.

Position indicating devices in Substation control panel.

15.1.2 CATEGORIES OF ALARMS

Generally alarms shall be provided for the following purposes:

(a) inform on protective device intervention for faults or severe abnormal conditions;

(b) inform on abnormal situations which could evolve in faults or severe abnormal situations;

(c) inform on loss or deficiency of auxiliary supply for control, alarms, protective circuits, of pressurization, of compressed air (if any); and alike;

(d) inform attendant personnel on intervention of automatic devices (transfer, load shed etc.);

15.1.3 GROUPING OF ALARMS

Alarms shall be selected and combined in such a manner that the analysis of the informations recorded on sending devices (flag relays and similar) may permit exact interpretation of the event and of their causes. These criteria shall be applied in particular to generator and to substations abnormal conditions.

The basic criteria of "first out" shall be applied as far as possible. Transient alarms not corresponding to actual abnormal conditions shall be properly time delayed.

Collective alarms may be provided in the relevant process control room, if required.

15.1.4 INSCRIPTIONS ON ALARM WINDOWS

Inscriptions shall be concise, clear and self explanatoring. Alphanumeric identification of equipment, devices and functions shall be consistent with drawings and diagrams.

15.2 POWER SUPPLY FOR 110 V D.C. CONTROL CIRCUITS

15.2.1 CONTROL POWER SUPPLIES

In the main substation and in each secondary distribution substation a separate D.C. system, including stationary battery, battery charger and D.C. distribution board, shall be provided (refer to **para 11.4).**

15.3 MARSHALLING BOX

Marshalling Box-Electrical Signals for the exchange of signals (alarms, remote control, indications etc.) between a local substation and a remote location a Marshalling Box equipped with terminal strips shall be provided.

Marshalling Box-Instrument Signals for the exchange of signals between motor starters in a substation and process control (autostart, autostop, shutdown, indications etc.) a separate Marshalling box equipped with terminal strips shall be provided.

16.0 SHORT CIRCUIT LEVELS

Unless otherwise specified, the following initial symmetrical short circuit level shall be considered:

a.	20 KV distribution	250	MVA
b.	0.4 kV power distributio	50	KVA

17.0 LIGHTING

17.1 LIGHTING DESIGN

Lighting fittings shall not be located directly over equipment with exposed moving parts.

The lighting design for outdoor facilities shall be based on the maximum use of flood lighting.

In general, circuits shall be switched from local lighting distribution panels. The use of local switches shall be kept to a minimum.

Since the requirements for aviation obstruction lights are dependent on the location and conditions of the specific site, Contractor shall obtain information from Owner on actual requirements and shall include suitable provision in the lighting design.

17.2 LIGHTING INTENSITY

The lighting system shall be designed for the levels of illumination tabulated below and calculated on the basis of initial average illumination intensity. The illumination intensity in-service will result modified by the "maintenance factor".

The maintenance factor value, ranging from 0,6 to 0,8, depends from ambient condition (internal, external, clean, dusty, dirty) and from maintenance procedure.

The illumination levels shall be taken as herebelow specified and shall be as follows (minimum required levels). For outdoor lighting refer to **Job Spec. No. 740/1;** for civil building lighting, refer to **Job Spec. No. 700/6.**

LOCATION	Plane or Place of Utilization	Initial Light Intensity in Lux
Process Plants		
Control Houses, General	*	500
Equipment Area of Process Control Panel	Panel Surface	500
Desks or Tables for Wiring	On Desk or Table	500
Compressor House	Top of Units	200-250
Pump Rows and Pump Houses	*	50-100
Ladders	Upper and Lower Landings	50-100
Stairs and Walkways	Tread Level	50-100
Vessel Platforms	Platform Level	200-250
Elevator Gauges and Locally Mounted Instruments	At gauges	100-150
Extensive Valve Manifolds	At valves	100-150
General Areas, within Plot Limits	Over working areas	20-40

* Horizontal plane 0.75 m (30 in.) above finished floor.

LOCATION	Plane or Place of Utilization	Initial Light Intensity in Lux
Power Plants		
Boiler Rooms	*	200-250
Auxiliary Equipment Area in Boiler Room	*	200-250
Outside Work Areas	Over Working areas A equipment	20-40 100-150
Switchgear and Motor Control Panels	Panel Surface	400-500
Open Switchyard	*	100-150
Yard and Buildings		
Loading Manifolds	At valves	50-100
Lunch Rooms	*	300-500
Kitchen	*	500
Offices, General	*	200-250
Desk Work	*	500

* Horizontal plane 0.75 m (30 in.) above finished floor.

LOCATION	Plane or Place of Utilization	Initial Light Intensity in Lux
Yard and Buildings (Cont'd)		
Offices, (cont'd)	*	
Drafting Work File Rooms Hall and Stairs	* *	1000 500 50-100
Substation (indoor)	*	200
Laboratory	*	1000
Machine Shop, General Rough Work Bin Storage	* *	500 500 1000
Main Roads	Road Surfaces	5-10
Main Roads Intersections	Road Surfaces	5-10
Warehouse, Bulk Storage Bin Storage	* *	50-100 300-500
Wash and Locker Rooms	*	200-300
Security Lighting		
Fences	*	5-10
Material Stockpiles	*	5-10

*Horizontal plane 0.75 m (30 in.) above finished floor

17.3 LIGHTING FITTINGS

17.3.1 INTERIOR LIGHTING FITTINGS

Interior lighting fittings shall consist of fluorescent high power factor type fixtures with energy save circuit (i.e. 36W) and high output rate (i.e. 3400 lummens). The use of incandescent type fixtures shall be avoided but may be used depending on particular requirements (i.e. storage, lockers).

For high-bay buildings (i.e. maintenance rooms) high pressure sodium type fittings shall be used.

Degree of mechanical protection and Ex- protection for the above lighting fixtures shall be indicated in the electrical standard construction details drawings.

17.3.2 EXTERIOR LIGHTING FITTINGS

Lighting for process areas, platforms, valves, local control stations, roads, general areas all important controls and flow signs, and all other outdoor areas described in **para 17.2** shall consist of high pressure sodium type lighting fixtures. The fixtures shall be equipped with integral high power factor ballast.

Area floodlighting and street lighting fixtures shall consist of high pressure sodium type fixtures. Maintenance facilities shall be provided for pole mounted lighting fixtures.

Degree of mechanical protection and Ex- protection for the above lighting fixtures shall be as indicated in the electrical standard construction details drawings.

17.3.3 USE OF RAPID START LAMPS

Incandescent lamps or other rapid restoring lamps shall be provided for the emergency lighting fixtures and for a 10% of the total illumination of lighting fixtures in areas which are illuminated by H.I.D. lamps only or other lamps with restoring delay after voltage dips.

Degree of mechanical protection and Ex- protection shall be as indicated in the electrical standard construction details.

17.4 LIGHTING DISTRIBUTION BOARDS

17.4.1 DESIGN CONSIDERATION

Lighting distribution shall be 3 phase and neutral, 400/230 V, with single phase branch circuits, protected by 4 pole automatic switches.

One spare circuit shall be provided for each five active circuits in the initial design.

The lighting fixtures for a particular area shall be equally distributed among the three phases R-S-T.

17.5 EMERGENCY LIGHTING

Local emergency lighting shall be provided at critical process points and in front of load instrument panel and shall be supplied by diesel generator or by batteries. All working indoor and outdoor areas shall be provided with emergency lighting fixtures of the type stated in **para 17.3.3.** The number of fixtures shall be sufficient to achieve at least 10% of the normal illumination level with a minimum of 10 Lux.

The emergency illumination level for instrument panels, operating panels, critical process points, control rooms and switchgear panels shall be at least 25 Lux.

Emergency lighting fixtures shall be provided at all substations and shall be supplied from D.C. distribution board (see **para 11.4**).

Emergency lighting shall be installed in control rooms and shall be supplied directly from the instrument power supply, if it includes a back- up battery, or from a local battery provided for the scope.

Emergency lighting in the process areas and in the control-rooms shall be switched on automatic upon normal lighting supply failure, while at substations the emergency lighting shall be switched manually at the door of the substation, with the same switch for normal lighting.

The emergency lighting fixtures shall be fed by separate wiring, cabling and switching arrangements independent from the normal lighting fixtures.

17.6 LEVEL GAUGES GLASS ILLUMINATORS

Level gauge glass illuminators, shall be local manually switched; they shall be fed from the same circuit feeding the Convenience outlets, supplied from the lighting distribution board.

18.0 WELDING AND CONVENIENCE OUTLETS

18.1 BASIS OF DESIGN

In general, welding outlets shall be provided only in process units. They shall be supplied on the basis of reaching any point within the unit where welding will be performed, assuming the use of 45 m extension loads. Welding outlets shall not be provided on structures.

Welding outlets shall be arranged in groups of no more than eight outlets for each welding circuit. The size of the welding power supply feeder shall be based on a 0,4 demand factor.

In process areas convenience outlets shall be provided on the basis of adequate plant coverage, assuming the use of 15 m extension leads. In operating off-site areas, convenience outlets shall be installed on the basis of adequate coverage using 30 m extension leads, except for substations, where adequate number of outlets shall be arranged in groups of no more than (5) five for each distribution board circuit. Unless otherwise specified, plugs shall not be provided.

18.2 OUTLETS TYPES

18.2.1 WELDING OUTLETS

Welding outlets shall be 63 A, 3 + 1 pin, 400 V, 2,5 KV, with the additional contact for electrical interlocking with protection earth.

Within hazardous locations welding outlets shall be of the mechanical interlocked type, with type of protection suitable for the location.

Within non classified locations the mechanical interlock shall not be requested, but only an upstream circuit breaker or switch fuses shall be requested.

Each circuit supplying sockets installed within class 1, division 1 locations shall be equipped with differential relays, to provide instantaneous trip in case of leakage current exceeding 0,5 A.

18.2.2 SAFETY EXTRA VOLTAGE OUTLETS

Special outlets shall be provided for safety extra low voltage circuits.

Outlets for 24 V portable lamps shall be 10 A, 2 wire, 2 pin, 2.5 KV, with transformer rated 100 VA.

18.2.3 230 V CONVENIENCE OUTLETS

Convenience outlets shall be 2+1 pin, V, 2,5 KV.

Within hazardous locations convenience outlets shall be of the mechanical interlocked type, with of protection suitable for the location.

Within non classified location mechanical interlock shall not be requested, but only an upstream circuit breaker, or switch fuses shall be requested.

Each circuit supplying outlets installed within class 1, division 1 locations shall be equipped with current differential re- lays, to provide instantaneous trip in ca- se of a leakage current exceeding 0,5 A.

18.2.4 OUTLET FOR CIVIL INSTALLATIONS

Refer to **Job Spec. No. 700/6.**

Power outlets: 400 V, 16 A, 3 wire, 3 + 1 pin, 2,5 KV

Convenience and safety extra low voltage outlets as per above **para 18.2.2 and 18.2.3.**

19.0 ELECTRICAL CANALIZATIONS

19.1 GENERAL

Unless otherwise specified, the type of electrical canalizations shall be one of the following, depending on plant requirements.

19.1.1 DIRECT BURIED CABLES
Armoured cables.

19.1.2 CABLES ON CABLE-TRAYS
Unarmoured cables.

19.1.3 CABLES ON RACKS
Unarmoured cables.

19.1.4 CABLES IN CONDUIT

a) above ground;

b) underground.

19.1.5 CABLES IN TUBING OR DUCTS

a) metallic;

b) plastic.

Exposed cables with mechanical protection.

In classified locations in which this type of canalization is permitted (class 1, division 2) cables shall be mechanically protected from grade or working deck to at least 2,5 m height. Suitable mechanical protection may be conduit and continuous cable tray.

19.2 **PROCESS HAZARDOUS LOCATIONS**

The type of canalization shall be in accordance with the rules set for in the standards , depending on the choice of the type of "Safety installation" consistently with classification of the concerned hazardous locations.This is applicable also to plant general auxiliary services canalization (see **para 19.4).**

19.3 NATURALLY NON HAZARDOUS LOCATIONS

Canalizations shall conform to the general rules set for in the Standards.

19.3.1 OFF-SITE AREAS AND OUTDOOR PROCESS AREAS

The type of canalizations shall be as per **para 19.1.1** for underground installations, 19.1.2 with mechanical protection, for above-ground installations.

19.3.2 PROCESS BUILDINGS

The type of canalizations shall be as **para 19.1.1 or 19.1.2 or 19.1.3, or 19.1.4, or 19.1.5 a, or 19.1.6.**

19.3.3 GENERAL SERVICES AREAS (WAREHOUSE. MAINTENANCE. LABORATORIES ETC.)

The type of canalizations shall be as per **19.3.2 and 19.1.5 a) and b).**

19.3.4 CIVIL BUILDINGS (ADMINISTRATION. CAFETERIA. LOCKERS ETC.)

The type of canalizations shall be as per **19.1.5 b).** Plastic tubing shall be embedded in walls, ceilings or floors. Refer also to **Job Spec. No. 700/6.**

19.4 ELECTRICAL CANALIZATIONS FOR COMMUNICATIONS

The factory communication services, such as telephone system, clock system, fire alarm system etc. shall have electrical canalizations as follows.

19.4.1 INTERCONNECTING CANALIZATION

Interconnecting canalization among units (if any), shall be by means of multicore cables in plastic tubing in concrete envelope for telephone system only; for the other communication system, multicore cables direct buried cables shall be used.

Separate tubes shall be provided for each different service. Suitable pull and junction boxes shall be provided.

19.4.2 PROCESS AREAS CANALIZATIONS

a. Non hazardous Process Area

In non hazardous process areas the type of canalization shall be as per **19.1.2 and 19.1.3,** except for telephone system, which shall have canalization as per **para 19.1.5.**

b. Hazardous Process Area

In Hazardous process areas the type of canalization shall be as per **19.1.1 or 19.1.4.**

19.4.3 GENERAL SERVICE AREAS

Canalization type shall be as per **para 19.1.5 a) or b).**

19.4.4 CIVIL BUILDINGS

Canalization type shall be as per **para 19.3.2, 19.3.4 or 19.1.5 a) or b).** Refer also to **Job Spec. No. 700/6.**

19.5 FIRE STOPS ON CABLE ROUTINGS

Fire stops on horizontal and vertical cable trays and/or racks and/or cable and/or conduits shall be provided when crossing walls or entering buildings in accordance with the fire safety requirements or regulation set out for the plant.

20.0 CONDUIT

20.1 CONDUIT TYPE

Where conduit is used, it shall conform to the following:

Rigid steel galvanized conduit (other than enamelled) shall be used for above ground installations, underground installations for sizes 1 1/2" or smaller and for all sizes, where the conduit leaves the ground.

Fiber duct or rigid PVC conduit may be used for underground installations, where conduit size is 2" and larger.

20.2 CONDUIT SYSTEM DESIGN

Where non metallic conduit is used, the transformation to metallic conduit shall be made underground, using a metallic elbow when leaving a duct bank to go above grade to switchgear or utilization equipment.

Minimum size conduit shall be 3/4" except than 1/2" size may be used for control board wiring, or where the conduit is an integral part of machine tool equipment.

No conduits shall be reduced in size below grade.

No conduits shall be located to avoid sub- surface obstruction, furnaces, hot pipe lines with outside surface continuously operating above 260°C or other places of high ambient temperature. Conduits shall not be installed closer than 300 mm parallel to the hot surfaces.

In general, pull-points shall be provided so that neither does the spacing exceed 70 m, nor does the maximum deflection between pull points exceed 225°. In determining the maximum deflection between pull points, a 90° bend at one end shall be considered as a 45o bend. Where straight run, exists between manholes, the maximum distance shall be 100 m.

In process areas pull points shall be located above ground. Manholes or above ground pull points shall be used outside of process areas, depending on economics and practicability.

Underground duct banks shall be enclosed in concrete encasement. The duct bank concrete encasement shall be free from voids and shall extend over the duct bank 75 mm on all sides.

Underground conduit duct banks for metallic conduits shall have a minimum depth of 450 mm.

Where the duct bank includes non metallic conduits, the minimum depth shall be 600 mm, except where necessary to avoid obstructions, where the depth may be reduced to 500 mm.

Concrete encasement shall be red coloured. The concrete encasement shall be extended at least 150 mm. above grade where conduit leaves the ground.

In general, exposed conduit shall run parallel or at right angles to beams and walls and shall be properly fastened to structures. Supports shall not be more than 3 m apart.

Horizontal conduits supporting pendant fixtures shall have conduit clamps installed as near to the fixture as possible.

All rigid steel conduit joints shall be weatherproofed, using suitable metal oxide paint for joint make-up. For conduits used for protective earth conductors, refer to **para 25.7.**

21.0 CONDUIT FITTINGS

21.1 GENERAL

In Class 1, division 1 locations, metallic conduit, fittings and junction boxes shall be explosion proof as required by **ELOT EN 60079 series.**

In Class 1 division 2 locations, conduit fittings shall be as required by **ELOT EN 60079 series.**

In indoor non hazardous locations, general purpose sheet steel boxes or general purpose heavy duty non metallic boxes may be used.

21.2 SEAL AND DRAIN FITTINGS IN HAZARDOUS LOCATIONS

The installations of seal fittings shall conform to the requirements of **ELOT EN 60079 series**. Sealing fittings, shall be installed on each conduit run leaving a hazardous location and entering a lower classified hazardous location.

Seal and drain fittings shall be provided in conduit lines which start at an elevation substantially above grade and terminate in explosion proof equipment, control houses, substation and similar structures at a point below starting elevation.

Drain fittings shall be installed at the low point, grade.

Sealing fittings shall be filled with an approved sealing compound.

22.0 CABLES

22.1 BASIS FOR CABLE SIZING

22.1.1 CURRENT CARRYING CAPACITY

The allowable current carrying capacity of cables shall be in accordance with **IEC 60364-5-523** Proper derating factor shall be applied considering the duct bank configuration, the cable demand factor and all salient derating factors.

22.1.2 CABLE SHALL BE SIZED AS FOLLOWS:

(a) feeders to transformer and from transformers to power centers shall be sized on the transformer rating, forced cooling rating have to be considered only for transformer having this provision;

(b) distribution and subdistribution switchboard feeders shall be sized on the 125% of the apparent power required for the normal design through the plant or 125% of nameplate whichever is greater.

(c) user feeders shall be sized on the 125% of the maximum connected load.

Due consideration shall be given to different time constant depending on cable installation.

22.1.3 ALLOWABLE VOLTAGE DROP

Cables sizes shall be checked in order to comply with the conditions specified in chapter 11. The followings voltage drop figures shall be considered as a general guide:

-feeders and sub-feeders	2% of rated voltage
-motor feeders	5% of motor rated voltage at rated output
-lighting	3% of the lamp rated voltage

22.1.4 MINIMUM CROSS SECTIONAL AREA

The smallest conductor cross sectional area shall be 2,5mm^2 for lighting, power and control circuits, provided that suitable mechanical protection is afforded for the canalization.

The smallest conductor cross sectional area shall be 25 mm2 for 20 KV cables, when not sized to withstand short circuit stresses.

22.1.5 SHORT CIRCUIT WITHSTAND CAPACITY OF CABLES

a. All cables shall be sized to withstand short circuit thermal stresses without injurious over heating or mechanical damage. The maximum short circuit level of the supply and the clearing time of the feeder protective device shall be used to determine this condition. Cables at 400 V and below with current limiting devices shall not be increased in size because of short circuit duty, unless otherwise specified for particular reasons.

b. Conductor limit temperature at the end of the short circuit time with regard to the insulation shall not exceed the temperature prescribed by the applicable standard or by the cable manufacturer, or the following temperatures, whichever the lower:

- 160°CforPVC,
- 220°C for butyl-rubber (M/R),
- 250°C for ethylen-propylene rubber (EPR).

22.2 CABLE CONSTRUCTION

All cables comply with the relevant applicable IEC Recommendations.

Except for possible special application conductors shall be copper solid or standed cores.

Insulation materials shall be generally as follows:

- polyvinil chloride (PVC),
- butyl-rubber (IIR),
- ethylene-propylene rubber (EPR),
- cross linked polyethylene (XLPE).

Sheathing materials shall be generally as follows:

- polyvinil chloride (PVC),
- polychloroprene (PCP),

It is Contractor's responsibility to select type and characteristics of sheathing materials in relation to the environmental conditions, particularily in relation to danger of corrosion, oil penetration etc.

Overall shielding shall be provided on multicore cable rated up to 20 XV;

Cable armouring, if required, shall be of the following types:

- flat metal tape armouring,
- round steel wire armouring, - round copper wire armouring covered by a helix of copper tape equivalent to armoring used in cable type NYFGBY per **ELOT HD 308 S2.**

Cables installed in hazardous locations with canalization type as per **para 19.1.6** (Class 1, division 2) shall be of the flame retardant.

22.3 INSULATION LEVELS FOR CABLES

Insulation levels for cables shall not be less than:

System Voltage (KV)		Cable rated voltage (KV) Uo/U	Test voltage at 50 Hz (KV)	Impulse test voltage (KV)
rated	highest			
1	Un+10%	0,6/1	3,5	
20	24	12/20	30	125

22.4 COLOUR CODING OF CABLES

External sheathing of cable shall have the following colour:

- black or grey: cables with degree 1 KV and below for power, lighting, control circuits and alike;
- red: cable with degree above 1 KV.
- light blue : for intrinsically safe cable only.
- cables non flame propagation type shall be suitably marked.

Conductors shall be identified with the following colours: (by means of colouring of the insulation or by means of identification markers): As per **ELOT HD 308 S2.**

In no case the colours green and yellow shall be used to identify phase or other conductors.

22.5 TERMINATIONS AND JOINTS

Terminations and joints shall be by means of mechanical clamps or compression type sockets, which shall correspond to the number and cross sectional area of the conductors.

In case of short circuit, terminations and joints shall not exceed the maximum temperatures given by cable manufacturer of the followings temperatures, whichever the lower:

a. Soldered, welded or brazed joints: 160°C for copper or aluminum conductors.

b. Mechanical clamps or compression type joints: for copper or aluminum conductors the maximum allowable temperatures depend on the characteristics of the insulation material.

23.0 CABLE INSTALLATION

23.1 UNDERGROUND CABLE INSTALLATION

Cable shall be direct buried and when practical they shall be routed in unpaved areas. Cables shall be laid 700 mm minimum below grade in hazardous locations and 500 mm minimum in naturally non hazardous locations.

400 V cables, controls and auxiliary cables shall be installed without spacing; H.V. cables shall be spaced one diameter minimum.

The bottom of the trench shall be backfilled with a 75 mm layer of sand or sifted fill and, after the cables are laid, the trench shall be back filled with sand or sifted fill to a level 75 mm above the top of the cables.

Suitable compacting of the bottom of the trench and of the layers of sand or sifted fill shall be provided in order to ensure continuous surface contact of cables with the ground.

Cables directly buried in unpaved areas shall have a continuous protective covering 50 mm thick, of red concrete over the upper layer of sand or sifted fill. The cover shall consist of concrete slabs with linear dimensions not exceeding 500 mm. The remainder of the trench shall be back filled with earth.

In unpaved areas suitable markers shall be provided to indicate the trench location and shall be located at 15 m intervals and where the trench changes direction.

Cables directly buried in paved areas. Over the upper layer of sand the trench shall be backfilled with earth or sand. Suitable compacting of backfill shall be provided before laying the paving, in order to prevent migration of sand or of backfill and prevent formation of cavities.

In paved areas the paving shall be scored and red coloured, to indicate the trench location; markers shall not be installed.

Unless otherwise specified, direct buried cables shall be armoured. Power and associated control cables shall be laid adjacent.

Cables serving as dual feeders of double radial substations shall be laid on opposite sides of the trench, and in all cases there shall be a minimum separation between them of 400 mm.

Cables shall be installed in one length where practical, but underground splices may be provided when necessary.

Where cables pass through a building foundation, ducts or an opening in the foundation shall be provided to permit entry.

A compression type fitting shall be used for terminating armoured cables.

Cables crossing roadway shall be run in duct bank, suitable to with stand road traffic.

Cables shall be fitted with suitable markers at their points of termination.

Where cables leave the ground, they shall be mechanically protected to a height of 150 mm above grade by means of heavy PVC or metal sleeve; metal conduit shall be longitudinally cut to prevent closed magnetic loop, when using single core cables.

In the interest of safety, cables will run U/G as far as possible and leave the ground as close to the equipment as possible.

23.2 OVERHEAD NON ARMOURED CABLE INSTALLATION

Non armoured cables shall be mechanically protected in location where they are subject to physical damage.

Cables shall be supported as required to prevent sagging: trays, ladders, supports & other fittings shall be made of hot dip galvanized steel.

The supports of fire resistant cables shall be such as to match with the fire resistance characteristics of fire cables.

23.3 PROTECTION AGAINST DIRECT SOLAR RADIATION

Protection against direct solar radiation shall be afforded by the following:

- laying of cables in shaded location; - protection by means of screens;
- suitable conduit painting.

24.0 PROTECTION AGAINST SHOCK FOR INDIRECT CONTACT

24.1 GENERAL REQUIREMENTS

Protection against shock due to indirect contact with conductive parts in case of faults within the electrical system shall be afforded by means of automatic disconnection of the supply, which is intended to prevent a touch or a step voltage from persisting for such a time that a damage to persons could occur.

The combination of the characteristics of the protection devices and of the system of earthing shall permit to comply with curve of limit touch or step voltage versus maximum operating time, as shown herebelow.

Prospective touch or step voltage (v)	Maximum operating time (s)
25	
50	5
75	1
90	0,5
110	0,2
150	0,1
220	0,05
280	0,03

24.2 TOUCH VOLTAGE

Touch voltage is to be considered as appearing between simultaneously accessible parts. Simultaneously accessible parts are:

- live parts;
- exposed conductive parts (masses);
- extraneous conductive parts;
- protective conductors;
- accessible earthing conductors;

If they can be touched simultaneously by a person, i.e.

If they are situated within the arm's reach, as defined by the **IEC 60364.** In particular locations where operators and workers are supposed to handle long conducting objects, such as spanners etc., the distances given in the above mentioned IEC Recommendation shall be increased accordingly.

24.3 STEP VOLTAGE

Step voltage calculation shall be made to comply with **IEEE Std. 80.**

25.0 EARTHING

25.1 GENERAL

Suitable earthing shall be installed for:

- safety to personnel;
- to limit the voltage on a circuit when exposed to a higher voltage, than that the circuit is designed;
- protection against static electricity; - protection against lightning;
- service earthing;
- electronic instrumentation and electronic data processing circuits (if any);
- communication systems.

A common earthing system shall be provided for all earthing requirements. All earth electrodes relevant to the electrical system shall be connected together.

Earthing for electronic data processing installation shall be separate system unless otherwise specified.

Earthing system shall be in accordance with the **Job Spec. No. 710/1.**

25.2 EARTHING FOR SAFETY PERSONNEL

Exposed conductive parts or masses (parts which can readily be touched and which are not live parts, but which may become live under fault conditions), such as frames of motors, transformers, switchgears, motor starters, lighting fixtures, junction boxes, conduits, control devices etc., if operating at a voltage level exceeding the safety extra low voltage (25 V A.C.), shall be earthed by a connection to the common earthing system.

If an individual electrical equipment, as listed above, is installed outside of the area covered by the common earthing system a local earth electrode shall be provided in addition to the protective conductor, which shall connect the common earthing system to the local earth electrode. Deviation may be necessary in particular cases.

Extraneous conductive parts (parts which are not forming part of the electrical installation) shall be connected to the common earthing system or shall be bonded to adjacent exposed conductive parts.

25.3 EARTHING FOR PROTECTION AGAINST STATIC ELECTRICITY

Tanks, piping and process vessels containing flammable liquids or gases shall be earthed by a connection to the earthing system, 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.

25.4 EARTHING FOR PROTECTION AGAINST LIGHTNING

Earthing system protection against lightning shall be in accordance with **Job Spec. No. 783/2 and 783/3.**

Where structures are protected by a lightning system (air terminals, down conductors, electrodes) it is recommended that due to the expected high ohmic resistance of the sub-soil, the lightning protection system to be separated from the electrical power grounding system.

25.5 SERVICE EARTHING

Service earthing shall be provided for operational reasons of the electrical system, such as earthing of neutral of transformers, metering, relaying, communications etc.

25.6 PLANT COMMON EARTHING SYSTEM

Refer to **Job Spec. No. 710/1.**

In general, earthing electrodes shall be installed around substations, process units, off-site facilities, structures, switchracks and generally around electrical installations.

The earth electrode shall mainly consist of a main cable loop, connected to individual connection and inspection points. Conductor, for main loop shall be 70 mm^2 minimum and for branch earth runs shall be 25 mm^2 minimum. Earth electrode conductors shall be stranded tinned bare copper.

As far as possible, earth electrode conductors shall be laid directly in the ground without breaks or joints.

When unavoidable, underground joints shall be brazed, suitably protected by a resin moulding and at convenient locations attached, without break, to copper bar straps with solderess connectors.

The purpose of the copper bar strap is to serve as a point of connection of earth electrodes and of attachment of branch circuits from loop to equipment. Where possible, the copper straps shall be attached to the steel of structures, thus serving a double purpose of earthing the structure too. The bar straps shall permit also the inspection and measurement of earth resistance of individual earth electrode loop branches and of earth rods.

Additional earth rods may be required connected to the main cable electrode, to reduce the total earth resistance, to meet the requirements relevant to touch and step voltages.

All interconnecting underground 20 XV cable banks shall have at the bottom, one or more 70 or 95 mm^2 earth conductors for draining possible cable leak current and to interconnect among them the individual earth electrodes of the different plant units. Same draining earth conductors shall run along 20 KV and LV cable trenches and racks or trays.

The buried earth conductor shall be slack.

25.7 PROTECTIVE CONDUCTORS

Protective conductors, used for protective measures against shock risk in case of fault and for connecting exposed and extraneous conductive parts shall have a minimum cross sectional area as follows and shall be made of bare copper.

a. In the case the protective conductors form part of the supply wiring:

- same cross sectional area as the phase conductor up to and including 16 mm^2 with a minimum of 2,5 mm^2 (see **para 22.1.4.);**

- half cross sectional area of the phase conductor with a minimum of 16 mm^2 if phase conductor has cross sectional area larger than 16 mm^2.

b. In case the protective conductors it's not part of the supply wiring:

- same cross sectional area as above with the minimum of 2,5 mm^2 for lighting fixtures, control devices and alike and 16 mm2 for motors, heaters and alike.

c. Within substations the minimum cross sectional area for protective conductors shall not be less than area determined with the following formula, unless other circumstances dictate a highear value:

$$\mathbf{A = (I/13)^*(t/\Delta\theta)^{1/2}}$$

in which:

A is the cross sectional area of the protective conductor (mm^2),

I is the r.m.s. value of the maximum earth fault (A)

t is the operating time of the disconnection device (s),

$\Delta\theta$ = s the permitted temperature rise of the conductor,

$\Delta\theta$ = 60°C if the conductor is insulated, or f the conductor is bare, with soldered, welded or brazed joints,

$\Delta\theta$ = 80°C if the conductor is bare, with mechanical compression joints.

Use of metallic structures as protective conductors shall be kept to minimum. However shall be permitted only if they satisfy the following requirements:

- their electrical continuity shall be assured, either by construction or at least by suitable connection, in such a way so to be protected against mechanical, chemical or electrochemical deterioration,

- their conductance shall be at least equal to that correspondent to the cross sectional areas.

- the integrity of the structure is requested for the physical support of the electrical equipment, so that the equipment may not be energized in absence of the structure.

The above requirements cannot generally be fulfilled, unless the metallic structure has been modified or adapted for such use.

The use of heavy gauge metallic conduits (explosion proof as per **para 21.1)** as protective conductors it's not permitted.

However metallic conduits shall be grounded (see earthing system **Job Spec. No. 710/1).**

25.8 BONDING

Bonding conductors may be required between exposed conductive parts, between extraneous conductive parts and between both, in order to meet the requirements of **chapter 24.0.** The minimum cross sectional area of bonding conductors shall not be less than 16 mm^2 copper.

25.9 PRESERVATION OF ELECTRICAL CONTINUITY OF THE MAIN EARTH ELECTRODE, OF PROTECTIVE CONDUCTORS AND OF BONDING CONDUCTORS

Conductors shall be suitably protected against mechanical and chemical deterioration and electrodynamic effects. Connections must be made by brazing, thermowelding or by means of screw or twist clamps, or by devices requiring the use of a tool or assuring equivalent security. The connections and splices shall be protected from corrosion. Clamping screws, if used, shall be provided with a device preventing their loosening. No mechanically connected apparatus (such as switch, or isolator) shall be inserted in the protective conductors. However, it is admitted that the protective conductor may be disconnected by an arrangement which disconnects the protective conductor only after safe disconnection of live conductors and viceversa.

26.0 COMMUNICATIONS SYSTEMS

The communication system shall include:

- private telephone system (connected to public network (*).
- VHP- radio-search (paging) system (*)
- VHP and UHF radiotelephone (*)
- telex-system
- intercommunication system
- centralized electric clock system
- watchman's supervisory system.
- Public address system (*)

In the process areas, off-site areas, utilities, control rooms and electrical substations, telephone sets connected to the private automatic branch exchange shall be provided.

In the process areas, the systems marked with (*) shall be provided.

27.0 ELECTRICAL FIELD TESTS

For more details see **Job Spec. No 799/5,"Field** Installation and Testing of Electrical Equipment".

27.1 **GENERAL**

Field testing shall be performed prior to energizing the electrical system and shall include tests as hereinafter specified.

A 500 V megohm-meter shall be used for the insulation and other resistance tests required for equipment rated 380 V and below. For 20 KV systems and above a suitable D.C. testing device shall be used for current leakage tests.

Accepted insulation values shall be according to the applicable IEC Recommendations, if they are not available manufacturer's recommendations shall be used for testing. Where Manufacturer's recommendations are not available, Contractor's electrical testing Standards shall apply.

27.2 **MOTORS**

Motors insulation resistance shall be checked prior to connecting leads and, if required, insulation shall be dried by an approved method.

Motors shall be mechanically checked for allignement, end play, lubrication etc., prior being energized.

27.3 **TRANSFORMERS**

All transformers shall have their windings tested for insulation as follows:

- primary to earth,
- secondary to earth,
- primary to secondary.

Transformers shipped assembled and filled with oil shall have an oil sample tested, when there are indications of damage, oil leakage, ingress of moisture, low insulation resistance or when the transformers have been stored, or have been in transit for long periods.

Samples of oil shall be tested before filling the transformers, when they are shipped without oil. Transformer insulation shall be tested by a megohm-meter prior to filling and, if required, the insulation shall be dried using an approved method.

The oil test shall be industry standard and the minimum acceptable break down value shall be 50 kV/2,5 mm. Where breakdown is less than 50 kV/2,5 mm the oil and the insulation shall be dried using an approved drying method.

27.4 **SWITCHGEAR**

Refer to **Job Spec. No. 721/3.**

All switchgear control and power circuits shall be tested for satisfactory insulation levels.

Before switchgear are energized, all circuit breakers shall be subject to mechanical and electrical operations, all circuits shall be tested to check proper operation and all adjustable relays shall be set, calibrated and tested.