STYRENE PARK OFFSITE

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Specification For Grounding and Lightning Protection

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1. APPLICABLE DOCUMENTS

Grounding and lightning protection shall be completed in accordance with the applicable sections of the latest edition, plus addenda of the codes and standards as detailed in Section 1.2 and Section 1.3.

It is intended that grounding and lightning protection be in compliance with Iranian Petroleum Standards, however, when doubtful or conflicting interpretations arise, precedence shall be determined as follows:

a) Engineering drawing and data sheet
b) Technical specification.
c) IPS standard
d) Other code and standard

1.1 Unit

This standard is based on International System of Units, (SI) except where otherwise specified.

1.2 Codes and Standards

The design, selection and installation of grounding systems shall comply with the following codes and standards:

International Electro technical Commission (IEC)

IEC 60364-1	Electrical installations of buildings – Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364-4-41	Electrical installations of buildings – part 4-41: Protection for safety – protection against electric shock
IEC 60364-4-44	Electrical installations of buildings – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances

IEC 60364-5-54	Electrical installations of buildings – part 5-54: selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors
IEC 60079-14	Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in hazardous areas (other than mines)
IEC 61024-1	Protection of structures against lightning – Part 1: General principles

British Standard Institution (BSI)

BS 6651	Protection of Structures Against Lightning

Iranian Petroleum Standards (IPS)

IPS-E-EL-100	Engineering Standard for Electrical System Design, Appendix I, Earthing, Bonding and Lightning Protection Construction Standard for Electrical Installation, Clause 6 and Clause 7

1.3 IPS Clarification

IPS-E-EL-100 often refers to outdated or withdrawn issues of various standards. Standards listed in Section *1.2*, are the latest issue of the equivalent standards referred to in the IPS standard.

IPS-E-EL-100 shall be respected in all other requirements for the engineering and installation of grounding systems.

2. ELECTRICAL POWER SYSTEM GROUNDING

2.1 High-voltage Systems

Each transformer with secondary voltage of 6 kV and 20 kV shall have its neutral grounded through a resister;

2.2 Low-voltage Systems

Low-voltage transformer and generator neutrals shall be solidly grounded. The system of grounding shall be TN-C-S, in accordance with IEC 60364-1.

All low-voltage cables shall be provided with Protective Equalization (PE) conductors, based upon the following type of the service:

- Three-phase balanced loads: Three conductor cables with ground conductor as PE conductor.
- Three-phase unbalanced loads: Four conductor cables with ground conductor as PE conductor.
- Single-phase loads: Two conductor cables with ground conductor as PE conductor.

2.3 UPS Systems

AC UPS system neutrals, either single- or three-phase, shall be ungrounded.

DC UPS systems for switchgear closing/tripping operations and instrument supplies, shall not be grounded (i.e., they shall be IT systems with ground-fault monitoring devices).

DC UPS systems for telecommunication equipment shall be solidly grounded at the positive pole, as per normal industry practice.

3. GROUNDING AND BONDING

Grounding and bonding shall be designed and installed in accordance with IEC 60364-1 and IEC 60079-14.

3.1 Electrical Equipment

All switchgear and control panels shall be supplied with ground busbar(s), to which all metal work shall be connected.

In substations, and electrical and control buildings with multiple electrical equipment, ground busbars shall be provided. Equipment ground busbars shall be connected to ground busbars installed at convenient locations within the rooms.

Connection of other electrical equipment (such as generators, transformers, distribution panels and so forth) to the main ground grid shall be shown on the relevant drawings.

3.2 Electronic Equipment

Electronic equipment in control buildings shall be grounded.

A system of ground busbars for safety grounding, grounding of intrinsically safe circuits (when applicable) and instrument clean ground shall be provided. These busbars shall be installed on insulators to prevent inadvertent connections to the ground. However, each busbar shall be connected through two separate insulated 6 mm^2 (minimum) ground conductors to a common grounding system.

3.3 Cables

HV cable armor and lead sheath shall be solidly bonded to the equipment at one end of the cable.

LV cable, instrumentation cable and control cable lead sheath and armor shall be bonded through the glands, which are in contact with metallic enclosure at one ends.

3.4 Piping

In process plants it is not necessary to ground piping or to bond across flanges, as an effective and reliable contact normally exists between the flange faces and bolts. Removable flexible copper-braid jumpers shall be provided for piping flanges where electric continuity is not normally maintained.

Piping that crosses the boundary between safe and hazardous areas, shall be bonded and connected to the main ground grid inside the hazardous area.

Cathodically protected piping shall be electrically insulated from non-protected piping and equipment (normally connected to the common ground grid).

3.5 Process Equipment

Process equipment shall be grounded as per the relevant drawings and standards.

3.6 Miscellaneous Metal Work

Miscellaneous metal work, such as handrails, walkways and cable trays, need not be bonded or grounded if it can be demonstrated through testing that electrical continuity exists with the rest of the structure.

If testing reveals discontinuity, bonding shall be required.

3.7 Fences

3.7.1 Electrical Facilities

Fences around electrical facilities (switch yards and transformer yards) shall be bonded in such a way to ensure that the entire fence, including discontinuities (gates), is continuous with the facility ground grid.

3.7.2 Production Facilities

Perimeter fences need not be bonded to a common ground grid. However for lightning protection, fences shall be bonded at intervals not exceeding 75 m in accordance with BS 6651, Clause 23.3.1.

3.8 Protection against Static Electricity

All process equipment shall be connected to the ground grid with a resistance to ground not exceeding 2 Ω (as per Electrical Design Criteria), which is considered adequate to prevent the build-up of static electricity. As a result, no additional measures are required.

3.9 Lightning Protection

3.9.1 Steel Buildings, Tanks and Other Structures

All steel buildings shall be effectively protected against lightning by the structure's design and connection of every second column to the ring ground electrode. Tanks and other structure shall be connected at several points to the plant's ground grid.

3.9.2 Masonry Buildings

Air-termination networks on masonry buildings shall be designed in accordance with IEC 61024 or BS 6651.

The same tape shall be used for down conductors to the test point on building walls.

3.9.3 Ground Termination Network

A ground electrode shall be connected to each down conductor, or in the case of metallic structures to each ground boss. The resistance of the lightning protection ground termination network for each building or major structure (e.g., tank, vessel), shall not exceed 5 Ω without taking into account bonding to any other services.

3.9.4 Electronic Systems

Power supply for electronic equipment, including telecommunication, shall be provided from Uninterruptible Power Systems (UPS).

All buildings with extensive electronic equipment shall be provided with equipotential busbars connected to the main ground ring. All incoming and outgoing cable armors shall be connected to these bars, as close as possible to their points of entry into the buildings.

Instrumentation cables and telecommunication cables shall be separated from current carrying cables.

All field devices connected to electronic or telecommunication circuits shall be protected against direct lightning injection by either the surrounding structures or as per BS 6651:1999, Appendix C, Figure 53.

Electronic systems shall be protected against induced voltages by using surge protection devices located at incoming and outgoing cable termination points. For specific details, Manufacturer's system specifications shall be reviewed. Electronic systems requiring surge protection devices shall include:

- Distributed Control Systems (DCS).
- Emergency Shutdown systems (ESD).
- Fire and Gas detection systems.
- Security systems.
- Telecommunication systems.
- PLC systems.

3.10 Sizing of Ground Conductors

The size of grounding conductor shall be determined using the table shown below as per IPS-D-EL-417:

Equipment	No. of Grounding Points	Grounding Conductor Size(mm^2)
HV/LV transformer to ground resistor	--	Acc. To grounding calculation
Ground resistor to ground	--	Acc. To grounding calculation
Frame of ground resistor	--	70
Neutral connection of transformers	--	Acc. To grounding calculation
PE for ground fault return of transformers	--	70
HV and MV switchgear	2	120
LV switchgear and MCC	2	70
LV distribution boards	1	70
UPS, relay panels, control panels	1	25
Miscellaneous small panels, (e.g., ITB and LCS)	1	25
Local Lighting Panel Board	1	35
Welding Outlet	1	35
Tanks	2 (2)	35

Equipment	No. of Grounding Points	Grounding Conductor Size(mm^2)
Extraneous conductive parts (non-electrical equipment)	1	25
Bonding conductors	1	6 or 25(1)
Note 1:6 mm^2 bonding conductors may be used when mechanical strength is not critical, or if the physical size of the equipment is a limiting factor.		
Note 2: The interval between grounding points along tank circumference shall not exceed 30 meters.		

Conductor of main and substation loop shall be sized accordance with Grounding System Calculation Note.

4. DESIGN OF GROUNDING SYSTEMS

4.1 General

The use of pipe racks, equipment module structures and concrete foundations shall serve as the primary means for grounding contacts. Anchor bolts securing structures to foundations provide continuity between metal structures and foundations and thus the surrounding soil. Rebar bonding is not required.

The localize application of buried ground conductors and electrodes shall be used in areas around substations or/and electrical rooms, where pipe racks do not exist and for interconnection to existing grounding systems. Do not use buried ground conductors along pipe racks.

A combination of pipe racks, foundations and trays provide an excellent grounding system.

4.2 Plant Grounding

The parallel cable tray with the highest voltage power cables, shall carry 70 mm² green insulated copper wires connected to the plant grounding system. Connections between the plant grounding system and the steel structure shall occur every 50 m along the pipe rack module; and be bonded to the other cable trays at these points using a 25 mm² green/yellow PVC, insulated copper wire. Only one of the parallel cable trays shall contain ground wires.

Use only green insulated copper conductors for underground applications.

Connect all electrical equipment as per Section 3.10.

Connect all switchgear ground buses to the building/room ground busbars in two locations. Connect building/room ground busbars to the plant grounding system in at least two locations.

Enclose ground rod tops within an inspection well, when there is a requirement to remove the conductor for testing or inspection.

When no requirement exists to inspect or test connection points, electrodes shall be direct buried.

Bond all process furnaces, process equipment and tanks (including steel-supporting structures) to plant grounding systems.

Provide static grounding cable for off-loading vehicles.

Plant grounding system resistance shall be 5 ohms or less, when one group of electrodes is disconnected.

The plant grounding system shall be extended throughout the plant, with branch interconnections to equipment, modules and structures.

Provide grounding bars at selected locations for grounding equipment not resident on pipe racks, and connect the grounding bars to the plant grounding system.

Use Compression-type (C-Type) connections and Thermo weld (CADWELD) type connections adequately covered with PVC insulated tape for all above ground and underground grounding cable connections respectively as per IPS-D-EL-402.

Install bonding jumpers at each cable tray expansion splice, and at locations where cable trays are not mechanically/electrically continuous to the ground.

Bond all equipment in the plant to the plant grounding system. Connect the internal ground wire in any power cable to the motor or equipment grounding terminal stud, and to the ground bus in the MCC/switchgear.

400 V motors shall be grounded with the feeder cable's internal grounding conductor.

6000 V and larger motors shall have an additional 25 mm^2 grounding wire installed from the motor base to the plant grounding system.

Vessels and tanks not installed on concrete piles shall be grounded to the plant grounding system.

4.3 Substation Grounding

For sizing grounding conductors, assume that all system neutral points are solidly grounded.

Design substation grounding as per Grounding System Block Diagram. Additional bare conductors within the outdoor switchyard shall be are added to ensure touch and step potential values meet safety requirements.

To minimize touch and step potential, buried ground conductors must be bare copper.

Measure grounding resistance upon completed installation, and compare with calculated values.

When resistance grounding is used, connect grounding resistors to the ground rod in the test pit. Connect rod to the plant grounding system.

When solid grounding is used, connect transformer neutral to its ground rod, and then to the ground rod in the test pit.

The design of the grounding grid shall be based upon the following that will be calculated in Grounding System Calculation Note:

- Measurement of soil resistivity.
- Determination of maximum ground fault current.
- Calculation of maximum grid potential rise.
- Calculation of tolerable and maximum step and touch voltage.
- The safe let-go touch voltage.

4.4 Instrumentation Grounding

Provide a separate single-point grounding system for computer systems and instrumentation (DCS and SCADA) equipment. This system shall be connected to the plant grounding system.

Using an equipment grounding conductor, connect the metallic housing for instrumentation equipment to the plant grounding system. Where interconnection between instrument clean earth and electrical earthing system may be subjected the effect of electrical storms, or high voltage induced, the interconnecting lines or cables shall be equipped with suitable surge diverters to prevent damage to instrument equipment.

Connect all isolated equipment grounds to a separate isolated grounding system. This system shall be connected to the plant grounding system.

Use isolated grounds for grounding instrumentation equipment, such as power supply isolation transformers and signal cable shields.

Connect shields to isolated grounds at one point only (connection shall be at the end closest to the control equipment).

Isolate signal cable shields from their armouring (if any), instrument enclosures and metal structures. Grounding interconnections inside the instruments and junction boxes is unacceptable.

4.5 Lightning Protection

Lightning protection system shall protect all buildings and structures that can be occupied by people, contain equipment necessary for the safe or normal operation of the plant, or contain flammable substances, unless they are within the zone of protection from adjacent protected structures.

Where the plant is located in proximity to the process area substation the lightning earthing system shall be connected to the power earthing system at two points.

Consider open steel structures constructed of 5 mm^2 steel or thicker, as self-protected when properly connected to plant grounding systems.

Consider steel tanks constructed of 5 mm^2 steel or thicker, as self-protected when properly connected to plant grounding systems. A tank containing a flammable substance, and having a vent or floating roof, may require additional protection in the area of the vent or floating roof seat.

Tanks shall be provided with at least two connections to the plant grounding system.

Protect non-protected tanks with air terminals, conducting masts or overhead ground wires.

5. DOCUMENTATION

The following drawings must be developed, based on the plant grounding philosophy:

- Area Grounding Layout.
- Substation Grounding Layout.