

Pakistan Electric and Telecommunication Safety Code (PETSAC-2014)



Pakistan Engineering Council



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پاکستان الیکٹریک اور ٹلیکومیونیکیشن سیفٹنی کوڈ کو نیشنل ایئریکل سیفٹنی کوڈ C2-2012 کی بنیاد اور IEEE کی طرف سے لائنسس کے تحت بنایا گیا ہے۔ جملہ حقوق محفوظ ہیں۔

Pakistan Electric and Telecommunication Safety Code (PETSAC)

Pakistan Engineering Council
In collaboration with
USAID-Power Distribution Program

2014

The Gazette of Pakistan



**EXTRAORDINARY
PUBLISHED BY AUTHORITY**

ISLAMABAD, THURSDAY, JULY 30, 2015

PART II

Statutory Notifications (S.R.O.)

GOVERNMENT OF PAKISTAN

MINISTRY OF SCIENCE AND TECHNOLOGY

NOTIFICATION

Islamabad, the 30th July 2015

S.R.O. 716 (I)/2015.-In exercise of the powers conferred by Section 25 of the Pakistan Engineering Council Act, 1975 (V of 1976), the Governing Body of the Pakistan Engineering Council, with the previous sanction of the Federal Government, is pleased to direct that the following further amendment shall be made in the Pakistan Engineering Council (Construction and Operation of Engineering Works) Byelaws, 1987, namely:-

“10. Application of Pakistan Electric and Telecommunication Safety Code-2014 (PETSAC-2014).-(1) The Provisions of Pakistan Electric and Telecommunication Safety Code-2014 provide rules for safe practices in design, installation, operation and maintenance of electric supply and telecommunication systems that shall be adopted by electrical power and telecommunication utilities, both public and private. The PETSAC-2014 shall neither be considered as a design document, nor an instruction manual, and shall not preclude relevant design specifications and standards. This Code shall be effective after six months of this notification.

- (2) All relevant regulators shall ensure compliance and implementations of this Code.
- (3) All utility companies and other stakeholders defined in 5(a),shall comply with this Code by adopting or amending their relevant byelaws or rules for implementation.

(4) The scope of Provisions of Pakistan Electric and Telecommunication Safety Code-2014 shall:-

- a) Be applicable to:
 - i. The electric supply and telecommunication facilities, associated works and practices employed by an electrical or telecommunication utility, both public and private.
 - ii. Facilities and functions of Utilities on the line-side of the service point, located on public or private property, in accordance with legally established easements or right of way, or as authorized by regulating or controlling body.
 - iii. Utility facilities installed, maintained and controlled by utility companies on the surface of underground mine sites, including overhead and underground distributions system providing service upto buildings or outdoor equipment location on the line side of the service point.
 - iv. The transmission and distribution of electricity and telecommunications signals (voice, video and data) through public and private utility systems that are installed and maintained under the exclusive control of utilities or their authorized representatives.
 - v. Street and area lights where these facilities are supplied by underground or overhead conductors installed and/or maintained under the exclusive control of utilities or their representatives.
 - vi. Working environment for people who are employed on the aforementioned jobs.
 - b) Not applicable to:
 - i. Customer premises equipment and wiring, located beyond utility-service points (meters) to buildings or outdoor installations.
 - ii. Industrial complex or utility interactive systems that are not controlled by the utilities.
 - iii. Street and area lights not installed or maintained by utility.
 - iv. Underground mine wiring or installation in ships, railway rolling equipment, aircraft, or automotive equipment.
- 5) General;
- a. The utilities, consultants, authorized contractors, or other entities - as applicable - performing design, construction, operation, or maintenance tasks for electric supply or telecommunication lines, or equipment covered by this Code, shall be responsible for meeting applicable requirements.

- b. For all particulars not specified in this Code, installation, operation and maintenance should be done in accordance with accepted good practice for given local conditions, known at the time for construction or maintenance of telecommunication, supply lines and equipment.
- 6) The provisions of this Code shall also be applicable to new and modified installations;
 - a. Except that these may be waived or modified by the administrative authority. When so waived or modified, safety shall be provided in other ways; and
 - b. Where an existing installation meets, or is altered to meet this Code, such installation is considered to be in compliance.
- 7) Waivers and Limitations
 - a. In case of emergency installations, the clearance required and burial depth may be adjusted as per the provisions of this Code.
 - b. In case of any conflict, relevant provisions of safety, health, labor or environmental codes shall prevail.
 - c. This Code only specifies benchmarks that need to be accomplished for safety, and does not specify how to accomplish these.
- 8) Supplementary Information
 - a) This Code shall be reviewed and updated after two (2) years of implementation and thereafter every five (5) years or earlier on the basis of data and feedback received from the concerned regulators, by the Committee as constituted by Pakistan Engineering Council.
 - b) The utility companies shall provide to concerned regulators all necessary information to ensure compliance of this Code.

[F.No.PEC/SRO/PETSAC/15.]

ENGR. SYED ABDUL QADIR SHAH
Chairman
Pakistan Engineering Council
Islamabad

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- (2) All relevant regulators shall ensure compliance and implementations of this Code.
- (3) All utility companies and other stakeholders defined in clause (a) of sub-Bye-Laws 5 shall comply with this Code by adopting or amending their relevant byelaws or rules for implementation.

(4) The scope of Provisions of Pakistan Electric and Telecommunication Safety Code-2014 shall:-

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- 6) The provisions of this Code shall also be applicable to new and modified installations except that;
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PREFACE

The safety of employees and general public from electrocution and allied hazards should be a top priority of all utility companies (power and telecom) in Pakistan. Establishment of national level safety code is vital to prevent such accidents during installation, maintenance and operation of electric supply and telecommunication system facilities.

The power sector of Pakistan encompasses distribution companies providing electricity to the consumers, the transmission companies for transferring power to different areas and generation companies for power generation. Similarly, the telecom sector is divided into public and private entities. All these organizations are required to adopt safety standards for installation, operation and maintenance. The workforce of these entities particularly the live-line crew and linemen are at more risk. As an example, the statistics of fatal and non-fatal electrical accidents in distribution companies (DISCOs) present a grim picture showing no sign of reduction; rather there has been an increase in the number of accidents in the last few years. More than 200 employees and public lost their lives in 2011-12, having miserable effects on their families and the society at large. An equal number was seriously injured or disabled. Analysis of these accidents indicates that majority of these occurred due to non-adherence to safety procedures and the unavailability of a national safety code.

Pakistan Electric and Telecom Safety Code (PETSAC) provide a unified system of safety standards for safeguarding human lives and reducing material loss. The objective is to reduce fatal and nonfatal accidents of employees and general public and ensure the safety of assets of the related entities.

PETSAC shall be adopted by all concerned organizations in power and telecom sector, both public and private. The statutory notification through Ministry of Law and Justice (ML&J) shall provide general legal cover for adoption and enforcement of this Code. Such notification shall also allow required improvements and changes in this Code after five years, or earlier, after feedback from relevant stakeholders. The implementation and enforcement of this Code shall vest with all relevant regulators, e.g. National Electric Power Regulatory Authority (NEPRA), Pakistan Electronic Media Regulatory Authority (PEMRA), Pakistan Telecommunication Authority (PTA), Pakistan Engineering Council (PEC), within their respective domains. After notification by Government of Pakistan, the concerned power and telecom utility companies shall prepare a road map to implement the Code at grass-root levels.

The PETSAC shall be kept updated by a Task Force under the aegis of PEC, comprising of representatives from regulators, DISCO's, NTDC, telecommunication companies, industry, engineering professionals and other stakeholders, through open consultation before any change is suggested. PEC will create an enabling environment for implementation of this Code through capacity building and training.

While utmost care has been taken in developing this Code, the concerned individuals and their organizations accept no liability resulting from the compliance or non-compliance of the Code by practitioners. The power to ensure compliance vests only with the Government of Pakistan.

ACKNOWLEDGEMENT

A document as important and detailed as a Code has input from many individuals and stakeholders. While appreciating the efforts made by many individuals, it is important to acknowledge the following members of PEC Task Force who contributed for development of Pakistan Electric and Telecommunication Safety Code (PETSAC);

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The support and financial assistance extended by USAID-Power Distribution Program in the development of this Code is highly appreciated. The contribution from the concerned regulators is also recognized and appreciated. Furthermore, the support extended by IEEE Standards Association is also acknowledged.

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ABBREVIATIONS, SYMBOLS AND ACRONYMS

This Code uses the following abbreviations:

A	ampere
BIL	basic impulse insulation level
BSC	Base Station Controller
C	degree Celsius
CCTV	Closed circuit television
CFC	Chlorofluorocarbon
EHS	Environmental, Health and Safety
EIRP	Effective Isotropically Radiated Power
EMC	Electromagnetic Compatibility
EMF	Electromagnetic Field
EMFs	Electromagnetic fields
F	degree Fahrenheit
FLL	Fixed Local Loop
ft	foot
ft²	square foot
ft³	cubic foot
g	gram
GHz	Giga Hertz
h	hour
HVAC	Heating, ventilating, and air conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
in	inch
in²	square inch
k	kilo (10 ³)

kg	kilogram
kPa	kilopascal
km²	square kilometer
kV	kilovolt (1000 volts)
kVA	kilovoltampere
kW	kilowatt
lb	pound
LP Gas	Liquefied petroleum gas
m	meter
m²	square meter
m³	cubic meter
m	milli (10^{-3})
mA	milliampere
MDF	Main Distribution Frame
mi	mile (international)
mm	millimeter
min	minute (time)
MHz	Mega Hz
MSC	Mobile Switching Center
N	newton
NPFA	National Fire Protection Association
NEPRA	National Electric Power Regulatory Authority
NOC	No Objection Certificate
NTP	Network Termination Point
ODS	Ozone Depleting Substance
Pa	pascal
PAL	Phase Alternation by Line system of television transmission
PAEC	Pakistan Atomic Energy Commission

PCB	Polychlorinated Biphenyl
PEC	Pakistan Engineering Council
PEMRA	Pakistan Electronic Media Regulatory Authority
PTA	Pakistan Telecommunication Authority
PVC	Polyvinyl Chloride
RG	Radio Guide-Specification for coaxial cable
s	second (time)
SA	Specific Absorption
SAR	Specific Absorption Rate
SHF	Super High Frequency 3-30 GHz frequency range
TFC	Twisted Fiber Coax
TLV	Threshold Limit Value
TMA	Town Municipal Authorities
TV	Television
UHF	Ultra High Frequency 300-3000 MHz frequency range
V	volt
VHF	Very High Frequency 30-300 MHz frequency range
W	watt
WLL	Wireless Local Loop

Certified Minimum Qualification. means Basic diploma/3-year diploma (electrical/electronic/telecom) from recognized Government of Pakistan(federal/provincial)institutes and all such other certifications approved by the concerned authority from time to time;

Certified Telecommunication and Terminal Equipment Installer (Certificate)"means a person who has been issued a certificate for installation of telecommunication and terminal equipment by the concerned authority;

"License" means an authorization granted by the concerned authority for the establishment, operation and maintenance of any telecommunication system or provision of any telecommunications service;

"Person" shall include a natural person, class of persons, company or cooperation etc;

"Premises" means a Class 5 Central Office or equivalent, commercial building(s) with more than three storey's above ground along with terminating access network;

“Network Termination Point (NTP)” means the point of termination on a telecommunication system at which the terminal equipment may be connected.

SECTION 1

INTRODUCTION TO THE PAKISTAN ELECTRIC AND TELECOM SAFETY CODE

1.1 Title

This Code shall be known as the Pakistan Electric and Telecom Safety Code (2014), herein after referred to as PETSAC-2014.

1.2 Purpose

The purpose of PETSAC-2014 is safeguarding employees, general public and utility facilities from electrocution and allied hazards during installation, operation and maintenance of electric supply and telecommunication facilities.

The PETSAC-2014 provides standards for safe practices that shall be adopted by electrical power and telecommunication utilities, both public and private, in design, installation, operation and maintenance of electric supply and telecommunication systems. This will develop safety related awareness amongst employers, employees and the general public.

The PETSAC-2014 shall neither be considered as a design document, nor an instruction manual, and shall not preclude relevant design specifications and standards.

1.3 Scope

1.3.1 These provisions shall be applicable to;

- a. The supply and telecommunication facilities, associated works and practices employed by an electrical or telecommunication utility either public or private.
- b. Utility facilities and functions on the line-side of the service point, located on public or private property, in accordance with legally established easements or right of way, or as authorized by regulating or controlling body.
- c. Utility facilities installed, maintained and controlled by utilities on the surface of underground mine sites, including overhead and underground distributions system providing service up to buildings or outdoor equipment location on the line side of the service point.
- d. The transmission and distribution of electricity, telecommunications signals and data through public and private utility systems that are installed and maintained under the exclusive control of utilities or their authorized representatives.
- e. Street and area lights where these facilities are supplied by underground or overhead conductors installed and/or maintained under the exclusive control of utilities or their representatives.
- f. Safe working environment for people who are employed on the aforementioned jobs
- g. The scope is further elaborated in Figure 1-1 below.

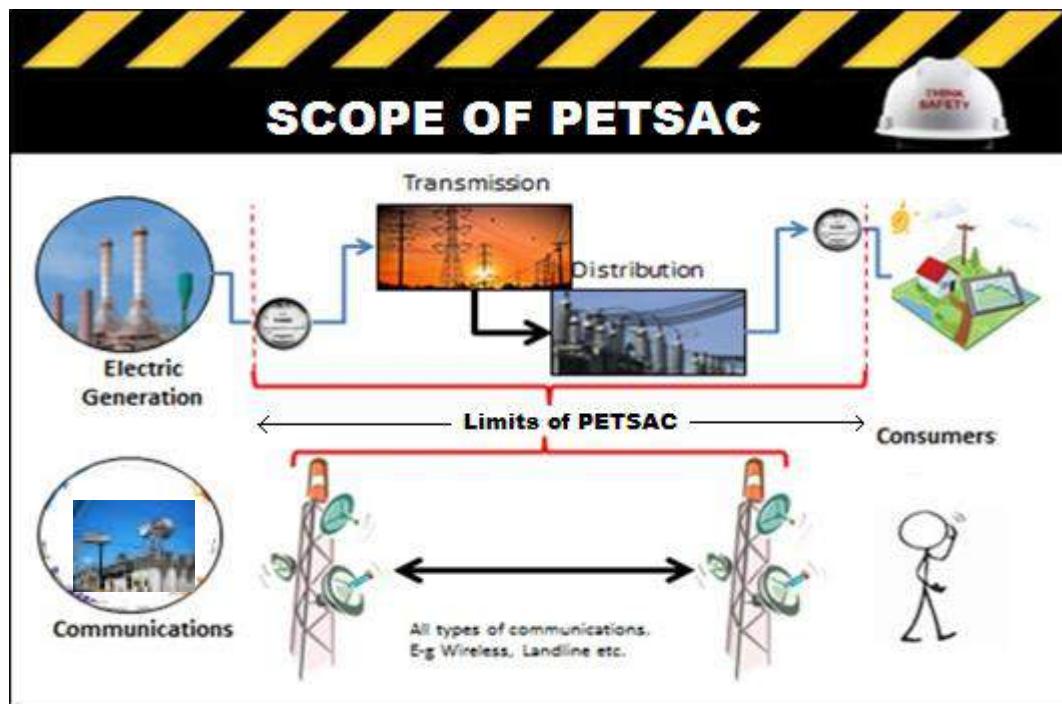


Figure 1-1: Scope of PETSAC-2014

1.3.2 These provisions shall not be applicable to;

- Utilization equipment and premises wiring located beyond utility service points (meters) to buildings or outdoor installations.
- Industrial complex or utility interactive systems that are not controlled by the utilities.
- This Code does not provide design provisions, and shall not be used as a design document or an instruction manual.
- The street and area lights not installed or maintained by utility.
- Terminal equipment and subscriber premises where telecom service is received.
- Underground mine wiring or installation in ships, railway rolling equipment, aircraft, or automotive equipment.

1.4 General

- All electric supply and telecommunication facilities and equipment shall be designed, constructed, operated, and maintained to meet the requirements of this Code.
- The utilities, consultants, authorized contractors, or other entities - as applicable - performing design, construction, operation, or maintenance tasks for electric supply or telecommunication lines, or equipment covered by this Code, shall be responsible for meeting applicable requirements.
- For all particulars not specified in this Code, installation, operation and maintenance should be done in accordance with accepted good practice for given local conditions, known at the time for construction or maintenance of telecommunication, supply lines and equipment.

1.5 Application

1.5.1 New Installations and Extensions

1. This Code shall apply to all new installations and extensions, except that they may be waived or modified by the administrative authority. When so waived or modified, safety shall be provided in other ways.

EXAMPLE: Alternative working methods, such as the use of barricades, guards, or other electrical protective equipment, may be implemented along with appropriate alternative working clearances as a means of providing safety when working near energized conductors.

2. Types of construction and methods of installation other than those specified in this Code may be used experimentally to obtain information, if:
 - a. Qualified supervision is provided,
 - b. Equivalent safety is provided, and
 - c. On joint use facilities, all affected joint users are notified in a timely manner.

1.5.2 Existing installations

1. Where an existing installation meets, or is altered to meet this Code, such installation is considered to be in compliance.
2. Existing installations, including maintenance and replacements, that currently comply with prior relevant safety rules, need not be modified to comply with this Code.

EXCEPTION 1: For safety reasons, the administrative authority may require compliance with this Code
EXCEPTION 2: When a structure is replaced, the current requirement of Rule 6.4.9.3.
3. Where conductors or equipment are added, altered, or replaced on an existing structure, the structure or the facilities on the structure need not be modified or replaced if the resulting installation will be in compliance with either (a) the rules that were in effect at the time of the original installation, or (b) the rules of this edition in accordance with Rule 1.5.2-1.

1.5.3 Inspection and work rules

Inspection rules and work rules in PETSAC-2014 shall apply to inspection of or work on all new and existing installations.

1.6 Waivers and Limitations

1. In case of emergency installation, the clearance required may be decreased as per Rule 6.4.1.1-B and burial depth may be adjusted as per Rule 7.2.2-C.
2. In case of any conflict, relevant provisions of safety, health, labor or environmental codes shall prevail.
3. These provisions shall neither be considered as a design document nor an instruction manual and shall not preclude the relevant design specification and standards.
4. This Code only specifies benchmarks that need to be accomplished for safety, and does not specify how to accomplish these.

1.7 Intent

1. The word “SHALL” indicates provisions that are mandatory.

2. The word “SHOULD” indicates provisions that are normally and generally practical for the specific condition.
3. The word “RECOMMENDATION” indicates provisions considered desirable but are not intended to be mandatory.
4. The word “EXCEPTION” indicates a specified option that may be substituted for one or more requirements stated in the rule or table.
5. The word “NOTE” or the word “EXAMPLE” used in a rule indicates material provided for illustrative purpose only.
6. The word ‘SEE’ used in this Code is for cross reference purpose only.
7. The footnotes to a table are designated by a circle surrounding the footnote number. Footnotes to the table have the same force and effect as required or allowed by the Rule as specifies the use of the table.

1.8 Units of measure

- A. Numerical values in the requirements of this Code are stated in the metric system (SI) as standard and where necessary in foot-pound system (FPS) inside parentheses.
- B. The SI values and the customary inch-foot-pound values are not, nor are they intended to be, identical measures. The values shown in each system of measurement have been rounded to convenient numbers in order to simplify measurement and to minimize errors. The values shown in each system are functional equivalents for safety purposes.

The values required in this Code have been carefully developed and evaluated to ensure that the intended levels of safety are provided in both systems; neither is distinguishable from the other for safety purposes. The values specified in either system of measurement may be used, or the values of the two systems may be intermixed, as desired.

- C. Unless dimensions are specifically stated in this Code, the dimensions of physical items referenced in this Code, such as wires, are “nominal values” assigned for the purpose of convenient designation. Due to manufacturing limitations or other restraints, other standards may set tolerances, variations, or ranges for the dimensions of such items.
- D. Appendix C provides cross-reference of AWG and SWG.

1.9 Source documents

In PETSAC-2014, National Electrical Safety Code® (NESC®)(C2-2012) has been referred as base document and necessary changes have been made by incorporating local conditions, national codes and standards, and good practices. Section 8 on Safety Rules for Telecommunication Facilities of PETSAC-2014 has been based on ITU, OSHA, ICNIRP recommendations and local environment. Further IEEE, NFPA, IEC, NEC, ANSI, ASME, ASCE, ACI, ASTM, and OSHA standards have also been referred for guidance.

SECTION 2

DEFINITIONS

The following definitions are for use with the PETSAC-2014.

accountable manager. A person usually the CEO or the owner of a company who can set objectives for the organization and has the authority to give resources

administrative authority. The governmental authority exercising jurisdiction over application of this Code

ampacity. The current-carrying capacity, expressed in amperes, of an electric conductor under stated thermal conditions.

anchorage. A secure point of attachment to which the fall protection system is connected

apparatus. Means all electrical devices such as machines, transformers, capacitors, regulators, reclosures, switchgear, electric transmission and distribution lines, underground cable and fittings etc., which are used for the generation, transmission, distribution lines, utilization of electrical energy.

appliance. Current-conducting; energy-consuming equipment, fixed or portable; for example, heating, cooking, and small motor-operated equipment

approved. As used in this code means approval by concerned Organization Head /Competent Authority.

area or district. The specified area, circle, zone or district under the jurisdiction of respective utility for operational control.

area lighting. An electrical installation that provides lumens on public or private property.

NOTE: Area lighting installations under the exclusive control of a utility are covered by the PETSAC-2014. All other area lighting installations are covered by industry practices.

authorized person. A person who has been authorized by the controlling utility or its designated representative to perform specified duties in, on, or in the vicinity of utility facilities, as applicable.

automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence—as, for example, a change in current strength; not manual; without personal intervention. Remote control that requires personal intervention is not automatic, but manual.

backfill. Materials such as sand, crushed stone, or soil, that are placed to fill an excavation.

ballast section (railroads). The section of material, generally trap rock, which provides support under railroad tracks.

barricade. Is a temporary obstruction, such as a rope or fence, erected to limit the distance the public can approach to a protected area.

barrier. Is a temporary non-conducting obstacle that is placed to limit the distance workers can reach or approach to anything that is at a different electric potential from themselves.

bonding. The electrical interconnection of conductive parts, e.g., cable sheaths, armors or enclosures, designed to maintain a common electrical potential.

broadcasting systems. Television and radio systems are typically designed as cellular telecommunication systems, with a few major exceptions. Telecommunication is directed one way and the radio frequency

antennas providing the television or radio coverage transmits on a lower frequency, thus creating a longer wave length. In addition, the transmission energy is considerably higher than for a cellular system enabling the signal to reach all receivers in the populated areas. Due to the high output energy and long wavelength, fewer transmission stations are required.

cable. A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

cable jacket. A protective covering over the insulation, core, or sheath of a cable

cable sheath. A conductive protective covering applied to cables.

NOTE: A cable sheath may consist of multiple layers, of which one or more is conductive.

cable television network. Means any system comprising head-end and distribution network for provision of Cable TV services, telephone or the internet service or all of these services to end users / the subscribers.

cable terminal. A device that provides insulated egress for the conductors. *Syn: termination.*

caution notice. Means a notice attached to a dead or faulty electrical apparatus to prevent, such equipment being made live.

charged. The item has acquired a charge either because it is live or because it has become charged by other means such as by static or induction charging, or has retained or regained a charge due to capacitance effects even though it may be disconnected from the rest of the system.

circuit. A conductor or system of conductors through which an electric current is intended to flow

circuit breaker. A switching device capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal conditions such as those of short circuit.

clearance. The clear distance between two objects measured surface to surface, and usually filled with a gas such as air.

climbing. The vertical movement (ascending and descending) and horizontal movement to access or depart the worksite.

cold work. Commencement of work in facility adjacent to electrically connected facility or facility not electrically commissioned.

common use. Simultaneous use by two or more utilities of the same kind

telecommunication lines. *See: lines.*

competent authority. Means a person, body, committee, board nominated by the organization for the purpose of this code.

conductor.

1. A material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current.
2. **bare conductor.** A metallic conductor without a covering.

3. **bundled conductor.** An assembly of two or more conductors used as a single conductor and employing spacers to maintain a predetermined configuration. The individual conductors of this assembly are called *sub-conductors*.
4. **covered conductor.** A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.
5. **fiber-optic conductor.** See: **fiber-optic cable—communication or fiber-optic cable—supply.**
6. **grounded conductor.** A conductor that is intentionally grounded, either solidly or through a non-interrupting current-limiting device.
7. **grounding conductor.** A conductor that is used to connect the equipment or the wiring system with a grounding electrode or electrodes.
8. **insulated conductor.** A conductor covered with a dielectric (other than air) having a rated insulating strength equal to or greater than the voltage of the circuit in which it is used.
9. **lateral conductor.** A wire or cable entirely supported on one structure and extending in a general horizontal, vertical, or diagonal direction to make connection to line conductors, service drops, equipment, or other facilities supported on the same structure. Lateral conductors may be attached directly to the structure or supported away from the structure.
10. **line conductor.** (Overhead supply or telecommunication lines.) A wire or cable intended to carry electric currents, extending along the route of the line, supported by poles, towers, or other structures, but not including vertical or lateral conductors.
11. **open conductor.** A type of electric supply or telecommunication line construction in which the conductors are (a) bare, covered, or insulated, (b) do not have grounded shielding, and (c) are individually supported at the structure either directly or with insulators. *Syn: open wire.*
12. **vertical conductor.** Either a wire or cable riser attached to a pole or a vertical portion of a lateral conductor.

Certified Minimum Qualification . Means Basic diploma/3-year diploma (electrical/electronic/telecom) from recognized Government of Pakistan (federal/provincial) institutes and all such other certifications approved by the concerned authority from time to time;

Certified Telecommunication and Terminal Equipment Installer (Certificate). Means a person who has been issued a certificate for installation of telecommunication and terminal equipment by the concerned authority;

conductor shielding. An envelope that encloses the conductor of a cable and provides an equipotential surface in contact with the cable insulation

conduit. A structure containing one or more ducts.

NOTE: Conduit may be designated as iron-pipe conduit, tile conduit, etc. If it contains only one duct, it is called *single-duct conduit*; if it contains more than one duct, it is called *multiple-duct conduit*, usually with the number of ducts as a prefix, e.g., *two-duct multiple conduit*.

conduit system. Any combination of duct, conduit, conduits, manholes, handholes, and/or vaults joined to form an integrated whole.

current-carrying part. A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

danger. Means danger to health or danger to life or limb from shock, burn, or other injury to persons.

danger notice. Means a notice attached to a live electrical apparatus, calling attention to the danger of touching or interfering with apparatus.

dead. Means de-energized and earthed.

de-energized. Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means.

NOTE: De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

delivery point. The point at which one utility delivers energy or signals to other utility.

department. The department of public utilities.

designated person. A qualified person designated to perform specific duties under the conditions existing.
Syn: designated employee.

designated competent person / authorized person. A competent person appointed by the employer, organization or competent authority; preferably in writing, to undertake certain specific responsibilities and duties, which may include the issue and/or receipt of safety documents such as permits-to-work. The person must be competent by way of training, qualifications and/or experience and knowledge of the system to be worked on.

disconnected. Equipment (or a part of an electrical system) that is not connected to any source of electrical energy.

disconnecting or isolating switch. A mechanical switching device used for changing the connections in a circuit or for isolating a circuit or equipment from a source of power at no-load condition.

duct. A single enclosed raceway for conductors or cable.

earth. Means the conducting mass of the earth or of any conductor in direct electrical connection with earth. [UK uses the term “Earth” whereas USA uses the term “Ground”]

earthed. Means connected to earth in such a manner as will ensure at all times an immediate discharge of electrical energy.

earthing connection. Means a metallic conductor for connecting electrical equipment to earth.

earthing system. Means an electrical system in which all the conductors are earthed.

effectively grounded (grounded effectively). Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the building up of voltages which may result in undue hazard to connected equipment or to persons.

effectively grounded neutral conductor: A conductor that is intentionally connected to the source transformer neutral directly or through an impedance to limit ground-to-phase fault current and has not less than four grounds in each 1.6 km (1.0 mi) of line. The conductor shall be of sufficient size to carry the available fault current and permit prompt operation of circuit protective devices.

electric inspector. Means the Electric Inspector appointed by competent authority.

electric supply equipment. Equipment that produces, modifies, regulates, controls, or safeguards a supply of electric energy. *Syn: supply equipment.*

electric supply lines. *See: lines.*

electric supply station. Any building, room, or separate space within which electric supply equipment is located and the interior of which is accessible, as a rule, only to qualified persons. This includes generating stations and substations, including their associated generator, storage battery, transformer, and switchgear rooms or enclosures.

1. **generating station.** A plant wherein electric energy is produced by conversion from some other form of energy (e.g., chemical, nuclear, solar, mechanical, or hydraulic) by means of suitable apparatus. This includes all generating station auxiliaries and other associated equipment required for the operation of the plant. Not included are stations producing power exclusively for use with telecommunications systems.
2. **substation.** An enclosed assemblage of equipment, e.g., switches, circuit breakers, buses, and transformers, under the control of qualified persons, through which electric energy is passed for the purpose of switching or modifying its characteristics.
3. **switching station.** *See: substation.*

electrical insulation. Is any non-conducting material that provides adequate dielectric strength to withstand the electrical stresses existing between objects at different potentials.

employed. Means an employee who is in receipt of wages, salary or -pay in return for services rendered to department.

enclosed. Surrounded by case, cage, or fence designed to protect the contained equipment and limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects.

energized. Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity. *Syn: live.*

equipment. A general term including fittings, devices, appliances, fixtures, apparatus, and similar terms used as part of or in connection with an electric supply or telecommunications system.

exclusive control. Generally covers installation, ownership, restricted access, operation, and maintenance by qualified and authorized persons.

exclusive control of utility. Where (a) energized facilities are separated from public access by a spatial or a physical barrier and accessible only to qualified personnel authorized by the serving utility, and (b) the utility is responsible for connection/disconnection of such facilities to/from energized sources of energy or signals.

exposed. Not isolated or guarded and accessible to humans and tools.

fall arrest system. The assemblage of equipment, such as a line-worker's body belt, aerial belt, or full body harness in conjunction with a connecting means, with or without an energy absorbing device, and an anchorage to limit the forces a worker can experience during a fall.

fall prevention system. A system, which may include a positioning device system, intended to prevent a worker from falling from an elevation.

fall protection program. A program intended to protect workers from injury due to falls from elevations.

fall protection system (hardware). Consists of either a fall prevention system or a fall arrest system

feeder. Is the cable connecting the transmitting or receiving antenna with the transmit or receive equipment.

fiber-optic cable—telecommunication. A fiber optic cable meeting the requirements for a telecommunication line and located in the telecommunication space of overhead or underground facilities

fiber-optic cable—supply. A fiber-optic cable located in the supply space of overhead or underground facilities.

fire-proofing (of cables). The application of a fire-resistant covering

generating station. *See: electric supply station.*

grounded. Connected to or in contact with earth or connected to some extended conductive body that serves instead of the earth.

grid station: *See: substation.*

grounded effectively. *See: effectively grounded.*

grounded system. A system of conductors in which at least one conductor or point is intentionally grounded, either solidly or through a non-interrupting current-limiting device

guard. Means to protect a worker from injury in a hazardous area.

guarded. Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats or platforms, designed to limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects.

NOTE: Wires that are insulated but not otherwise protected are not normally considered to be guarded.

handhole. An access opening, provided in equipment or in a below-the-surface enclosure in connection with underground lines, into which personnel reach but do not enter, for the purpose of installing, operating, or maintaining equipment or cable or both.

harness. A component with a design of straps that is fastened about the worker in a manner so as to contain the torso and distribute the fall arrest forces over at least the upper thighs, pelvis, chest, and shoulders with means for attaching it to other components and subsystems.

NOTE: Wherever the word *harness* is used in this Code, it refers to full body harness.

hazard. Any unsafe act or unsafe condition that may lead to injury of person or damage to property.

hot or live” (or “alive”). Means electrically energized as distinguished from “dead” or “de-energized”.

hot work. Commencement of work on an equipment which is in a live facility or itself alive.

in service. Lines and equipment are considered in service when connected to the system and intended to be capable of delivering energy or telecommunication signals, regardless of whether electric loads or signaling apparatus are presently being served from such facilities.

insulated. Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

NOTE: When any object is said to be *insulated*, it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is, within the purpose of these rules, uninsulated.

insulated working support or insulated tool. Is a support or tool insulated from earth or other potential by an insulating material.

insulating. Is a term used to describe a device or medium made from a material having the required - electrical insulation.

insulating gloves. Means rubber gloves 11 kV rated to be worn with leather protectors.

insulating gloves method of working. Is performing work when workers wear insulating protective equipment as insulation between themselves and energized equipment on which work is being performed.

insulating protective equipment. Is protective equipment made of rubber or other approved insulating material used during work on energized lines or equipment.

insulation (as applied to cable). Insulating material used to insulate the conductor from other conductors or conducting parts or from ground

insulation shielding. An envelope that encloses the insulation of a cable and provides an equipotential surface in contact with the cable insulation

insulator. Insulating material to support a conductor physically, and electrically separate it from another conductor or object.

isolated. Equipment (or part of an electrical system) which is disconnected and separated by a safe distance (the isolating gap) from all sources of electrical energy in such a way that the disconnection is secure, i-e it cannot be re-energized accidentally or inadvertently.

isolated by elevation. Elevated sufficiently so that persons may safely walk underneath

isolator. *See: disconnecting or isolating switch.*

jacket. A protective covering over the insulation, core, or sheath of a cable

joint use. Simultaneous use by two or more utilities

lanyard. A flexible line or webbing, rope, wire rope, or strap that generally has a connector at each end for connecting the line-worker's body belt, aerial belt, or full body harness to an energy absorbing device, lifeline, or anchorage.

lightning arrester. *See: surge arrester.*

limited access highways. As used herein, limited access highways are fully controlled highways where access is controlled by a governmental authority for purposes of improving traffic flow and safety. Fully controlled access highways have no grade crossings and have carefully designed access connections.

lines.

1. **telecommunication lines.**

- a. **located in the telecommunication space.** The conductors and their supporting or containing structures, equipment, and apparatus that are used for public or private signal or telecommunications service, and which operate at potentials not exceeding 400 V to ground or 750 V between any two points of the circuit, and the transmitted power of which does not exceed

150 W. When operating at not more than 90 V ac or 150 V dc, no limit is placed on the transmitted power of the system. Under specified conditions, telecommunication cables may include telecommunication circuits exceeding the preceding limitation where such circuits are also used to supply power solely to telecommunications equipment. Fiber-optic cables are considered as telecommunication lines, regardless of whether they are installed in the telecommunication space or supply space in accordance with applicable rules,

NOTE: Public or private telephone, telegraph, railroad-signal, data, clock, fire, police-alarm, cable-television, and other systems conforming with the above are included. Lines used for signaling purposes, but not included under the above definition, are considered as supply lines of the same voltage and are to be so installed. Traffic signal light lines are considered as supply lines, not telecommunication lines.

- b. **located in the supply space.** Telecommunication lines located in the supply space and meeting Rules 6.3.5.1 and , may (a) operate at any voltage, (b) include supply circuits of any voltage, or (c) be included within a supply conductor or cable operating at any voltage.
2. **electric supply lines.** Those wires, conductors, and cables used to transmit electric or light energy and their necessary supporting or containing structures, equipment, and apparatus that are used to provide public or private electric supply or lighting service.

Signal lines of more than 400 V and traffic signal lines of any voltage are always considered as supply lines within the meaning of the rules, and signal lines of less than 400 V may be considered as supply lines, if so run and operated throughout.

Although fiber-optic lines are considered as telecommunication lines, regardless of whether they are installed in the telecommunication space or supply space in accordance with applicable rules, electric supply conductors to light amplifier, etc., are considered as supply lines, unless contained within a telecommunication cable in accordance with the definition of telecommunication lines and applicable rules.

3. **joint-use lines.** Overhead or underground lines containing or supporting facilities of two or more utilities. Lines containing or supporting facilities delivering two or more types of service by the same owner, such as electricity and lighting supply service or telephone and CATV telecommunication service, are not considered as joint-use lines, unless also accompanied by one or more lines of another utility.

Syn: supply lines.

line superintendent. Means an authorized person responsible for patrolling and repair of lines, equipment & switches.

line-worker's body belt. A belt that consists of a belt strap and D-rings and which may include a cushion section or a tool saddle.

live. *See: energized.*

manhole. A subsurface enclosure that personnel may enter and which is used for the purpose of installing, operating, and maintaining submersible equipment and cable

manhole cover. A removable lid that closes the opening to a manhole or similar subsurface enclosure

manhole grating. A grid that provides ventilation and a protective cover for a manhole opening.

manual. Capable of being operated by personal intervention.

minimum approach distance. The closest distance a qualified employee is permitted to approach either an

energized or a grounded object, as applicable for the work method being used.

multi-grounded/multiple grounded system. A system of conductors in which a neutral conductor is intentionally grounded solidly at specified intervals. A multigrounded or multiple grounded system may or may not be effectively grounded. *See: effectively grounded.*

neutral conductor. A system conductor other than a phase conductor that provides a return path for current to the source. Not all systems have a neutral conductor. An example is an ungrounded delta system containing only three energized phase conductors.

nominal voltage. Of circuit or system is the rated voltage assigned for convenient designation between phase conductors of a three-phase line, or the two conductors of a single phase line, whether or not one of the conductors is earthed.

out of service. Lines and equipment are considered out of service when disconnected from the system and when not intended to be capable of delivering energy or telecommunications signals.

overhead ground wire. *See: shield wire.*

overvoltage. Voltage between two points of a system that is greater than the highest value appearing between the same two points under normal service conditions. Over voltages include, but are not limited to, switching impulse (switching surge) over voltages and temporary (transient) over voltages.

owner. A party that possesses the exclusive right to hold, use, benefit-from, enjoy, convey, transfer, and otherwise dispose of an asset or property.

pad-mounted equipment. A general term describing enclosed equipment, the exterior of which enclosure is at ground potential, positioned on a surface-mounted pad.

permit to work (PTW). Means a form of declaration signed and given by one authorized person to another person to carry out work on any electrical/telecom equipment or lines or cable as per instructions.

personal insulating protective equipment. Is insulating protective equipment worn by a person during work on energized lines or equipment.

personal protective equipment. Is protective equipment worn by a person during work.

positioning device system. A system of equipment or hardware that, when used with its line-worker's body belt or full body harness, allows a worker to be supported on an elevated vertical surface, such as a pole or tower, and work with both hands free.

positioning strap. A strap with snaphook(s) to connect to the D-rings of a line-worker's body belt or full body harness.

premises. The land and buildings of a user located on the user side of the service point (sometimes called the *utility-user network point of demarcation* for telecommunication wiring) to electric supply, telecommunication, or signal premises wiring.

premises wiring (system). Interior and exterior wiring, including power, lighting, control, telecommunication, and other signal circuit wiring together with all their associated hardware, fittings, and wiring devices, both permanently and temporarily installed either (a) from the service point or premises power source to the outlets, or (b) where there is no service point, from and including the non-utility power source to the outlets.

Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, motor control centers, and similar equipment, nor does it include utility equipment and wiring on the utility side of the service point.

prestressed-concrete structures. Concrete structures that include metal tendons that are tensioned and anchored either before or after curing of the concrete.

pulling iron. An anchor secured in the wall, ceiling, or floor of a manhole or vault to attach rigging used to pull cable.

pulling tension. The longitudinal force exerted on a cable during installation.

qualified. Having been trained in and having demonstrated adequate knowledge of the installation, construction, or operation of lines and equipment and the hazards involved, including identification of and exposure to electric supply and telecommunication lines and equipment in or near the workplace. An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training, and who is under the direct supervision of a qualified person, is considered to be a qualified person for the performance of those duties.

qualified climber. A worker who, by reason of training and experience, understands the methods and has routinely demonstrated proficiency in climbing techniques and familiarity with the hazards associated with climbing.

raceway. Any channel designed expressly and used solely for holding conductors, wires and cables. *See :duct.*

random separation. Installed with less than 300 mm (12 in) separation and without deliberate separation.

remotely operable (as applied to equipment). Capable of being operated from a position external to the structure in which it is installed or from a protected position within the structure.

restricted access. Where exclusive control is maintained.

roadway. The portion of highway, including shoulders, for vehicular use. *See also: shoulder; traveled way.*

NOTE: A divided highway has two or more roadways.

sag.

1. The distance measured vertically from a conductor to the straight line joining its two points of support. Unless otherwise stated in the rule, the sag referred to is the sag at the midpoint of the span. See Figure 2-1.
2. **initial unloaded sag.** The sag of a conductor prior to the application of any external load.
3. **final sag.** The sag of a conductor under specified conditions of loading and temperature applied, after it has been subjected for an appreciable period to the loading prescribed for the clearance zone in which it is situated, or equivalent loading, and the loading removed. Final sag shall include the effect of inelastic deformation.
4. **final unloaded sag.** The sag of a conductor after it has been subjected for an appreciable period to the loading prescribed for the clearance zone in which it is situated, or equivalent loading, and the loading removed. Final unloaded sag shall include the effect of inelastic deformation.
5. **total sag.** The distance measured vertically from the conductor to the straight line joining its two points of support, under conditions of ice loading equivalent to the total resultant loading for the clearance zone in which it is located.

6. **maximum total sag.** The total sag at the midpoint of the straight line joining the two points of support of the conductor.
7. **apparent sag of a span.** The maximum distance between the wire in a given span and the straight line between the two points of support of the wire, measured perpendicularly from the straight line. See Figure D-1 below.
8. **sag of a conductor at any point in a span.** The distance measured vertically from the particular point in the conductor to a straight line between its two points of support.
9. **apparent sag at any point in the span.** The distance, at the particular point in the span, between the wire and the straight line between the two points of support of the wire, measured perpendicularly from the straight line.

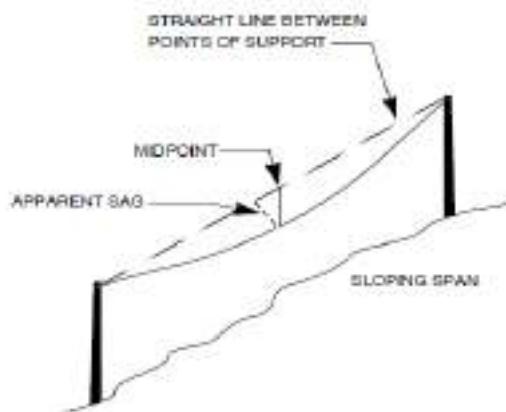


Figure 2-1: Sag and apparent sag

separation. The distance between two objects, measured surface to surface, and usually filled with a solid or liquid material.

service drop. The overhead conductors between the electric supply or telecommunication line and the building or structure being served as service line.

service point. The point of connection between the facilities of the serving utility and the premises wiring

NOTE: The service point is the point of demarcation between the serving utility and the premises wiring. The service point is the point on the wiring system where the serving utility wiring ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the utility's condition of service.

Because the location of the service point is generally determined by the utility, the service-drop conductors and the service-lateral conductors may or may not be part of the service covered by relevant rules. For these types of conductors to be covered, they must be physically located on the premises wiring side of the service point. If the conductors are located on the utility side of the service point, they are not covered by relevant rules definition of service conductors and are therefore not covered by relevant rules.

Based on the definitions of the term *service point* and *service conductors*, any conductor on the serving utility side of the service point generally is not covered by relevant rules. For example, a typical suburban residence has an overhead service drop from the utility pole to the house. If the utility specifies that the service point is at the point of attachment of the service drop to the house, the service-drop conductors are not considered service conductors because the service drop is not on the premises wiring side of the service point. Alternatively, if the utility specifies that the service point is "at the pole," and the service-drop conductors are not under utility control, relevant rules would apply to the service drop.

Exact location for a service point may vary from utility to utility, as well as from occupancy to occupancy.

shield wire (also referred to as overhead ground wire, static wire, or surge-protection wire). A wire or wires, strung parallel to and above phase conductors to protect the power system from lightning strikes.

shoulder. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles for emergency use and for lateral support of base and surface course.

side-wall pressure. The crushing force exerted on a cable during installation.

single-grounded system/ungrounded system. A system of conductors in which one conductor is intentionally grounded solidly at a specific location, typically at the source.

spacer cable. A type of electric supply-line construction consisting of an assembly of one or more covered conductors, separated from each other and supported from a messenger by insulating spacers.

spacing. The distance between two objects measured center to center.

span length. The horizontal distance between two adjacent supporting points of a conductor.

span wire. An auxiliary suspension wire that serves to support one or more trolley contact conductors or a light fixture and the conductors that connect it to a supply system.

static wire. *See: shield wire.*

structure conflict. A line so situated with respect to a second line that the overturning of the first line will result in contact between its supporting structures or conductors and the conductors of the second line, assuming that no conductors are broken in either line.

substation. *See: electric supply station.*

supervised installation. Where conditions of maintenance and supervision ensure that only qualified persons monitor and service the system.

supply equipment. *See: electric supply equipment.*

supply station. *See: electric supply station.*

supported facility. Any component of an overhead line system that is supported on, but is not intended to provide structural strength to the supporting structure or mechanical support system.

NOTE: Examples of supported facilities include, but are not limited to, components such as conductors, line hardware, equipment hanger brackets, and switches.

supporting structure. The main supporting unit (usually a pole or tower) used to support supply and/or telecommunication conductors, cables, and equipment.

NOTE: A supporting structure may consist of a single or multiple pole arrangement or a pre-cast concrete structure that supports supply and/or telecommunication conductors, cables, and equipment at a line location.

1. **readily climbable.** A supporting structure having sufficient handholds or footholds so that the structure can be climbed easily by an average person without using a ladder, tools or devices, or extraordinary physical effort.

2. **not readily climbable.** A supporting structure not meeting the definition of a readily climbable structure, including but not limited to the following:
 - a. Supporting structures, including poles and tower legs, with handholds or footholds arranged so that there is not less than 2.45 m (8 ft) between either: (1) the lowest handhold or foothold and ground or other accessible surface, or (2) the two lowest handholds or footholds. Diagonal braces on towers are not considered to be handholds or footholds except at their points of attachment.
 - b. guy wires

surge arrester. A protective device for limiting surge voltages.

surge-protection wire. *See: shield wire.*

susceptiveness. The characteristics of a telecommunication circuit, including its connected apparatus, that determine the extent to which it is adversely affected by inductive fields.

switch. A device for opening and closing or for changing the connection of a circuit.

switchboard. A type of switchgear assembly that consists of one or more panels with electric devices mounted thereon, and associated framework.

tag. Accident prevention tag (DANGER, PEOPLE AT WORK, etc.) of a distinctive appearance used for the purpose of personnel protection to indicate that the operation of the device to which it is attached is restricted. A tag is issued and placed on the switch of respective device after issuance of PTW.

telecommunication systems. Telecommunication is the common description for technology enabling two-way telecommunication between parties located at distances from each other. Telecommunication also comprises one-way telecommunication technology such as television and radio broadcasting.

termination. *See: cable terminal.*

transferring (as applied to fall protection). The act of moving from one distinct object to another (e.g., between an aerial device and a structure).

transformer vault. An isolated enclosure either above or below ground with fire-resistant walls, ceiling, and floor, in which transformers and related equipment are installed, and which is not continuously attended during operation. *See also: vault.*

transitioning (as applied to fall protection). The act of moving from one location to another on equipment or a structure.

traveled way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and full-time parking lanes.

ungrounded system. A system of conductors in which no conductor or point is intentionally grounded, - either solidly or through a noninterrupting current-limiting device.

ungrounded system. *See: single-grounded system/ungrounded system.*

unloaded tension.

1. **initial.** The longitudinal tension in a conductor prior to the application of any external load.

2. **final.** The longitudinal tension in a conductor after it has been subjected for an appreciable period to the loading prescribed for the loading district in which it is situated, or equivalent loading, and the loading removed. Final unloaded tension shall include the effect of inelastic deformation (creep).

utility. An organization responsible for the engineering and supervision (design, construction, operation, and maintenance) of a public or private electric supply, telecommunication, area lighting, street lighting, signal, or railroad utility system.

1. **public utility.** A public utility is an entity that performs or provides one or more utility services for the benefit of multiple customers (at retail, wholesale, or both), including utilities formed for a singular purpose (including but not limited to providing street and outdoor lighting, municipal traffic signal control, or distributed generation). Public utilities include investor-owned, municipality/government-owned, cooperative-owned utility, public utility districts, irrigation districts, lighting districts, traffic signal or other signal utilities, and similar utilities.
2. **private utility.** A private utility is an entity that (a) performs or provides one or more utility services to its own facilities, such as a large industrial complex, large campus, military complex, railroad system trolley system, or extensive gas or oil field through its own electric supply, telecommunication, street and area lighting, or signal system and/or generate or transmits power that is delivered to another utility.

NOTE: Although many private utilities only operate a distribution level system, others operate generation and transmission systems.

utility interactive system. An electric power production system that is operating in parallel with and capable of delivering energy to a utility electric supply system.

utilization equipment. An electrical installation that uses electric or light energy for electronic, electromechanical, chemical, heating, lighting, testing, telecommunication, signaling or similar purposes on the premises wiring side of the service point.

NOTE: Utilization equipment and premises wiring on the load side of the service point is intended to be performed under the NEC, regardless of whether a utility has exclusive control.

vault. A structurally solid enclosure, including all sides, top, and bottom, that is (1) associated with an underground electric supply or telecommunication system, (2) located either (a) above or below ground or (b) in a building, and (3) where entry is limited to personnel qualified to install, maintain, operate, or inspect the equipment or cable enclosed. The enclosure may have openings for ventilation, personnel access, cable entrance, and other openings required for operation of equipment in the vault.

voltage.

1. The effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.
2. **voltage of circuit not effectively grounded.** The highest nominal voltage available between any two conductors of the circuit.

NOTE: If one circuit is directly connected to and supplied from another circuit of higher voltage (as in the case of an autotransformer), both are considered to be of the higher voltage, unless the circuit of the lower voltage is effectively grounded, in which case its voltage is not determined by the circuit of higher voltage. Direct connection implies electric connection as distinguished from connection merely through electromagnetic or electrostatic induction.

3. **voltage of a constant-current circuit.** The highest normal full-load voltage of the circuit.
4. **voltage of an effectively grounded circuit.** The highest nominal voltage available between any conductor of the circuit and ground unless otherwise indicated.
5. **voltage to ground of:**
 - a. **a grounded circuit.** The highest nominal voltage available between any conductor of the circuit and that point or conductor of the circuit that is grounded.
 - b. **an ungrounded circuit.** The highest nominal voltage available between any two conductors of the circuit concerned.
6. **voltage to ground of a conductor of:**
 - a. **a grounded circuit.** The nominal voltage between such conductor and that point or conductor of the circuit that is grounded.
 - b. **an ungrounded circuit.** The highest nominal voltage between such conductor and any other conductor of the circuit concerned.

voltage levels. Voltage levels are defined as

	IEEE Std. 141	IEC Std. 60038
1. Low voltage	120 V to 600 V	≤ 1000 V
2. Medium voltage	2.4 kV to 69 kV	1 kV to 35 kV
3. High voltage	115 kV to 230 kV	35 kV to 230 kV
4. Extra high voltage	345 kV to 765 kV	230 kV to 800 kV
5. Ultra high voltage	-	1050 kV to 1200 kV

wire gages. Throughout these rules the American Wire Gage (AWG), formerly known as Brown & Sharpe (B&S), is the standard gage for copper, aluminum, and other conductors, excepting only steel conductors, for which the Steel Wire Gage (Steel WG) is used.

worksite (as applied to fall protection). The location on the structure or equipment where, after the worker has completed the climbing (horizontally and vertically), the worker is in position to perform the assigned work or task.

SECTION 3

ADMINISTRATION AND ENFORCEMENT

3.1 Compliance Requirements

1. All installations, operation and maintenance of equipment and facilities in electric supply and telecommunication utilities shall be in accordance with PETSAC-2014.
2. These provisions shall be applicable to all new installations, extensions and retrofitting related to electrical and telecommunication facilities or environment.
3. In case of existing installations, whether maintenance or replacement, such installation is required to be in compliance with this Code.
4. All the management of the utility companies shall comply with this Code.

3.2 Administrative Requirements

1. The implementation and enforcement of this Code shall be through a statutory notification by the Government of Pakistan through Ministry of Law and Justice.
2. All relevant regulators shall ensure compliance and implementations of this Code through necessary regulations, orders and directives.
3. All utility companies shall comply with this Code by adopting or amending their relevant byelaws or rules for implementation.

3.3 Compliance Documents

1. The concerned regulators shall prepare a road map not later than six (6) months after issuance of notification of PETSAC-2014 to ensure implementation and compliance.
2. The concerned utility companies shall prepare a road map not later than one (1) year after issuance of notification of PETSAC-2014 to ensure adoption and compliance.
3. All major or minor accidents shall be recorded by the concerned utility and reported within a maximum of forty five (45) days to the following:
 - a. The respective regulator
 - b. The concerned labor department

3.4 Supplementary Information

1. This Code shall be reviewed and updated, after two (2) years of implementation and thereafter every five (5) years or earlier on the basis of data and feedback received from the concerned regulators, by the Standing Committee of PETSAC-2014 at Pakistan Engineering Council.
2. The concerned authority may require supplementary information necessary to verify compliance with this Code, such as calculations, worksheets, compliance forms, manufacturer's literature, or other data.

SECTION 4

GROUNDING METHODS FOR ELECTRIC SUPPLY AND TELECOMMUNICATION FACILITIES

4.1 Purpose and scope of rules

4.1.1 Purpose

The purpose of this Section is to provide practical methods of grounding, as one of the means of safeguarding employees and the public from injury that may be caused by electrical potential.

4.1.2 Scope

This Section covers methods of protective grounding of supply and telecommunication conductors and equipment. The rules requiring grounding are in other parts of this Code. For rules requiring conductors or equipment to be effectively grounded, methods described in this section shall be used and the definition of effectively grounded shall be met.

These rules do not cover the grounded return of electric railways nor those lightning protection wires that are normally independent of supply or telecommunication wires or equipment.

4.2 Point of connection of grounding conductor

4.2.1 Direct-current systems that are required to be grounded

4.2.1.1 750 V and below

Connection shall be made only at supply stations. In three-wire dc systems, the connection shall be made to the neutral.

4.2.1.2 Over 750 V

Connection shall be made at both the supply and load stations. The connection shall be made to the neutral of the system. The ground or grounding electrode may be external to or remotely located from each of the stations.

One of the two stations may have its grounding connection made through surge arresters provided the other station neutral is effectively grounded as described above.

EXCEPTION: Where the stations are not geographically separated as in back-to-back converter stations, the neutral of the system should be connected to ground at one point only.

4.2.2 Alternating current systems that are required to be grounded

4.2.2.1 750 V and below

The point of the grounding connection on a wye-connected three-phase four-wire system, or on a single-phase three-wire system, shall be the neutral conductor. On other one-, two-, or three-phase systems with an associated lighting circuit or circuits, the point of grounding connection shall be on the common circuit conductor associated with the lighting circuits.

The point of grounding connection on a three-phase three-wire system, whether derived from a delta-connected or an ungrounded wye-connected transformer installation not used for lighting, may be any of the circuit conductors, or it may be a separately derived neutral.

The grounding connections shall be made at the source, and at the line side of all service equipment.

4.2.2.2 Over 750 V

A. Non-shielded (bare or covered conductors or insulated non-shielded cables)

Grounding connection shall be made at the neutral of the source. Additional connections may be made, if desired, along the length of the neutral, where this is one of the system conductors.

B. Shielded

(1) Surge-arrester cable-shielding interconnection

Cable-shielding grounds shall be bonded to surge-arrester grounds, where provided, at points where underground cables are connected to overhead lines.

(2) Cable without insulating jacket

Connection shall be made to the neutral of the source transformer and at cable termination points.

(3) Cable with insulating jacket

Additional bonding and connections between the cable insulation shielding or sheaths and the system ground are recommended. Where multi-grounded shielding cannot be used for electrolysis or sheath-current reasons, the shielding sheaths and splice-enclosure devices shall be insulated for the voltage that may appear on them during normal operation.

Bonding transformers or reactors may be substituted for direct ground connection at one end of the cable.

4.2.2.3 Separate grounding conductor

If a separate grounding conductor is used as an adjunct to a cable run underground, it shall be connected either directly or through the system neutral to the source transformers, source transformer accessories, and cable accessories where these are to be grounded. This grounding conductor shall be located in the same direct burial or conduit run as the circuit conductors. If run in duct of magnetic material, the grounding conductor shall be run in the same duct as the circuit conductors.

EXCEPTION: The grounding conductor for a circuit that is installed in a magnetic duct need not be in the same duct if the duct containing the circuit is bonded to the separate grounding conductor at both ends.

4.2.3 Messenger wires and guys

4.2.3.1 Messenger wires

Messenger wires required to be grounded shall be connected to grounding conductors at poles or structures at maximum intervals as listed below:

- a. Where messenger wires are adequate for system grounding conductors (Rules 4.3.3.1, 4.3.3.2, and 4.3.3.5), four connections in each 1.6 km (1 mi).
- b. Where messenger wires are not adequate for system grounding conductors, eight connections in each 1.6 km (1 mi), exclusive of service grounds.

4.2.3.2 Guys

Guys that are required to be grounded shall be connected to one or more of the following:

- a. A grounded metallic supporting structure.
- b. An effective ground on a nonmetallic supporting structure.
- c. A line conductor that has at least four ground connections in each mile of line in addition to the ground connections at individual services.

4.2.3.3 Common grounding of messengers and guys on the same supporting structure

- a. Where messengers and guys on the same supporting structure are required to be grounded, they shall be bonded together and grounded by connection to:
 - (1) One grounding conductor that is grounded at that structure, or to
 - (2) Separate grounding conductors or grounded messengers that are bonded together and grounded at that structure, or to
 - (3) One or more grounded line conductors or grounded messengers that are (i) bonded together at this structure or elsewhere and (ii) multi-grounded elsewhere at intervals as specified in Rules 4.2.3.1 and 4.2.3.2.
- b. At common crossing structures, messengers and guys that are required to be grounded shall be bonded together at that structure and grounded in accordance with Rule 4.2.3.3a.

EXCEPTION: This rule does not apply to guys that are connected to an effectively grounded overhead static wire.

4.2.4 Current in grounding conductor

Ground connection points shall be so arranged that under normal circumstances there will be no objectionable flow of current over the grounding conductor. If an objectionable flow of current occurs over a grounding conductor due to the use of multi-grounds, one or more of the following should be used:

1. Determine the source of the objectionable ground conductor current and take action necessary to reduce the current to an acceptable level at its source.
2. Abandon one or more grounds.
3. Change location of grounds.
4. Interrupt the continuity of the grounding conductor between ground connections.
5. Subject to the approval of the administrative authority, take other effective means to limit the current.

The system ground of the source transformer shall not be removed.

Under normal system conditions a grounding conductor current will be considered objectionable if the electrical or telecommunication system's owner/operator deems such current to be objectionable, or if the presence and/or electrical characteristics of the grounding conductor current is in violation of rules and regulations governing the electrical system, as set forth by the authority having jurisdiction to promulgate such rules.

The temporary currents set up under abnormal conditions while the grounding conductors are performing their intended protective functions are not considered objectionable. The conductor shall have the capability of conducting anticipated fault current without thermal overloading or excessive voltage buildup. Refer to Rule 4.3.3.

NOTE: Some amount of current will always be present on the grounding conductors of an operating AC electrical system.

4.2.5 Fences

Fences that are required to be grounded by other parts of this Code shall be designed to limit touch, step, and transferred voltages in accordance with industry practices.

NOTE: IEEE Std. 80TM-2000 [see Appendix-A] is one source that may be utilized to provide guidance in meeting these requirements.

The grounding connections shall be made either to the grounding system of the enclosed equipment or to a separate ground.

1. Fences shall be grounded at each side of a gate or other opening.
2. Gates shall be bonded to the grounding conductor, jumper, or fence.
3. A buried bonding jumper shall be used to bond across a gate or other opening in the fence, unless a non-conducting fence section is used.
4. If barbed wire strands are used above the fence fabric, the barbed wire strands shall be bonded to the grounding conductor, jumper, or fence.
5. When fence posts are of conducting material, the grounding conductor shall be connected to the fence post or posts, as required, with suitable connecting means.
6. When fence posts are of non-conducting material, suitable bonding connection shall be made to the fence mesh strands and the barbed wire strands at each grounding conductor point.

4.3 Grounding conductor and means of connection

4.3.1 Composition of grounding conductors

In all cases, the grounding conductor shall be made of copper or other metals or combinations of metals that will not corrode excessively during the expected service life under the existing conditions and, if practical, shall be without joint or splice. If joints are unavoidable, they shall be so made and maintained as to not materially increase the resistance of the grounding conductor and shall have appropriate mechanical and corrosion-resistant characteristics. For surge arresters and ground detectors, the grounding conductor or conductors shall be as short, straight, and free from sharp bends as practical. Metallic electrical equipment cases or the structural metal frame of a building or structure may serve as part of a grounding conductor to an acceptable grounding electrode.

In no case shall a circuit-opening device be inserted in the grounding conductor or connection except where its operation will result in the automatic disconnection from all sources of energy of the circuit leads connected to the equipment so grounded.

EXCEPTION 1: For dc systems over 750 V, grounding conductor circuit-opening devices shall be permitted for changing between a remote electrode and a local ground through surge arresters.

EXCEPTION 2: Temporary disconnection of grounding conductors for testing purposes, under competent supervision, shall be permitted.

EXCEPTION 3: Disconnection of a grounding conductor from a surge arrester is allowed when accomplished by means of a surge-arrester dis-connector.

NOTE: The base of the surge arrester may remain at line potential following operation of the dis-connector.

4.3.2 Connection of grounding conductors

Connection of the grounding conductor shall be made by a means matching the characteristics of both the grounded and grounding conductors, and shall be suitable for the environmental exposure.

These means include brazing, welding, mechanical and compression connections, ground clamps, and ground straps. Soldering is acceptable only in conjunction with lead sheaths.

4.3.3 Ampacity and strength

For bare grounding conductors, the short time ampacity is the current that the conductor can carry for the time during which the current flows without melting or affecting the design characteristics of the conductor. For insulated grounding conductors, the short time ampacity is the current that the conductor can carry for the applicable time without affecting the design characteristics of the insulation. Where grounding conductors at one location are paralleled, the increased total current capacity may be considered.

4.3.3.1 System grounding conductors for single-grounded systems

The system grounding conductor or conductors for a system with single-system grounding electrode or set of electrodes, exclusive of grounds at individual services, shall have a short time ampacity adequate for the fault current that can flow in the grounding conductors for the operating time of the system-protective device. If this value cannot be readily determined, continuous ampacity of the grounding conductor or conductors shall not be less than the full-load continuous current of the system supply transformer or other source of supply.

4.3.3.2 System grounding conductors for multi-grounded alternating current systems

The system grounding conductors for an AC system with grounds at more than one location exclusive of grounds at individual services shall have continuous total ampacities at each location of not less than one-fifth that of the conductors to which they are attached. (See also Rule 4.3.3.8).

4.3.3.3 Grounding conductors for instrument transformers

The grounding conductor for instrument cases and secondary circuits for instrument transformers shall not be smaller than AWG No. 12 copper or shall have equivalent short time ampacity (see Appendix C for cross reference of AWG and other gauges).

4.3.3.4 Grounding conductors for primary surge arresters

The grounding conductor or conductors shall have adequate short time ampacity under conditions of excess current caused by or following a surge. Individual arrester grounding conductors shall be no smaller than AWG No. 6 copper or AWG No. 4 aluminum.

EXCEPTION: Arrester grounding conductors may be copper-clad or aluminum-clad steel wire having not less than 30% of the conductivity of solid copper or aluminum wire of the same diameter, respectively.

Where flexibility of the grounding conductor, such as adjacent to the base of the arrester, is vital to its proper operation, a suitably flexible conductor shall be employed.

4.3.3.5 Grounding conductors for equipment, messenger wires, and guys

A. Conductors

The grounding conductors for equipment, raceways, cable, messenger wires, guys, sheaths, and other metal enclosures for wires shall have short time ampacities adequate for the available fault current and operating time of the system fault-protective device. If no overcurrent or fault protection is provided, the ampacity of the grounding conductor shall be determined by the design and operating conditions of the circuit, but shall not be less than that of AWG No. 8 copper. Where the adequacy and continuity of the conductor enclosures and their attachment to the equipment enclosures is assured, this path can constitute the equipment grounding conductor.

B. Connections

Connections of the grounding conductor shall be to a suitable lug, terminal, or device not disturbed in normal inspection, maintenance, or operation.

4.3.3.6 Fences

The grounding conductor for fences required to be grounded by other parts of this Code shall meet the requirements of Rule 4.3.3.5 or shall be steel wire not smaller than Steel WG No. 5.

4.3.3.7 Bonding of equipment frames and enclosures

Where required, a low-impedance metallic path shall be provided to conduct fault current back to the grounded terminal of the local supply. Where the supply is remote, the metallic path shall interconnect the equipment frames and enclosures with all other non-energized conducting components within reach and shall additionally be connected to ground as outlined in Rule 4.3.3.5. Short time ampacities of bonding conductors shall be adequate for the duty involved.

4.3.3.8 Ampacity limit

No grounding conductor need have greater ampacity than either:

- a. The phase conductors that would supply the ground fault current, or
- b. The maximum current that can flow through it to the ground electrode or electrodes to which it is attached. For a single grounding conductor and connected electrode or electrodes, this would be the supply voltage divided by the electrode resistance (approximately).

4.3.3.9 Strength

All grounding conductors shall have mechanical strength suitable for the conditions to which they may reasonably be subjected.

Furthermore, unguarded grounding conductors shall have a tensile strength not less than that of AWG No. 8 soft-drawn copper, except as noted in Rule 4.3.3.

4.3.4 Guarding and protection

1. Single-grounded systems: Guarding is required for grounding conductors for single-grounded systems unless the installation is not readily accessible to the public.
2. Multi-grounded systems: Grounding conductors of multi-grounded systems need not to be guarded.

3. Where guarding is required, grounding conductors shall be protected by guards suitable for the exposure to which they may be reasonably be subjected. The guards should extend for not less than 2.45 m (8 ft) above the ground or platform from which the grounding conductors are accessible to the public.
4. Where guarding is not required, grounding conductors, installed in area of exposure to mechanical damage, shall be protected by being substantially attached closely to the surface of the pole or other structure and, where practical, on the portion of the structure having least exposure.
5. Guards used for grounding conductors of lightning-protection equipment shall be of non-metallic materials if the guard completely encloses the grounding conductor or is not bonded at both ends to the grounding conductor.

4.3.5 Underground

1. Grounding conductors laid directly underground shall be laid slack or shall be of sufficient strength to allow for earth movement or settling that is normal at the particular location.
2. Direct-buried uninsulated joints or splices in grounding conductors shall be made with methods suitable for the application and shall have appropriate corrosion resistance, required permanence, appropriate mechanical characteristics, and required ampacity. The number of joints or splices should be the minimum practical.
3. Grounding cable insulation shielding systems shall be interconnected with all other accessible grounded power supply equipment in manholes, handholes, and vaults.

EXCEPTION: Where cathodic protection or shield cross-bonding is involved, interconnection may be omitted.

4. Looped magnetic elements such as structural steel, piping, reinforcing bars, etc., should not separate grounding conductors from the phase conductors of circuits they serve.
5. Metals used for grounding, in direct contact with earth, concrete, or masonry, shall have been proven suitable for such exposure.

NOTE 1: Under present technology, aluminum has not generally been proven suitable for such use.

NOTE 2: Metals of different galvanic potentials that are electrically interconnected may require protection against galvanic corrosion.

6. Sheath transposition connections (cross-bonding)
 - a. Where cable insulating shields or sheaths, which are normally connected to ground, are insulated from ground to minimize shield circulating currents, they shall be insulated from personnel contact at accessible locations. Transposition connections and bonding jumpers shall be insulated for nominal 600 V service, unless the normal shielding voltage exceeds this level, in which case the insulation shall be ample for the working voltage to ground.
 - b. Bonding jumpers and connecting means shall be sized and selected to carry the available fault current without damaging jumper insulation or sheath connections.

4.3.6 Common grounding conductor for circuits, metal raceways, and equipment

Where the ampacity of a supply system grounding conductor is also adequate for equipment grounding requirements, this conductor may be used for the combined purpose. Equipment referred to includes the frames and enclosures of supply system control and auxiliary components, conductor raceways, cable shields, and other enclosures.

4.4 Grounding electrodes

The grounding electrode shall be permanent and adequate for the electrical system involved. A common electrode or electrode system shall be employed for grounding the electrical system and the conductor enclosures and equipment served by that system. This may be accomplished by interconnecting these elements at the point of connection of grounding conductor, Rule 4.2.

Grounding electrodes shall be one of the following:

4.4.1 Existing electrodes

Existing electrodes consist of conducting items installed for purposes other than grounding:

4.4.1.1 Metallic water piping system

Extensive metallic underground cold water piping systems may be used as grounding electrodes.

EXCEPTION: Water systems with nonmetallic, non-current-carrying pipe or insulating joints are not suitable for use as grounding electrodes.

NOTE: Such systems normally have very low resistance to earth and have been extensively used in the past.

4.4.1.2 Local systems

Isolated buried metallic cold water piping connecting to wells having sufficiently low measured resistance to earth may be used as grounding electrodes.

NOTE: Care should be exercised to ensure that all parts that might become disconnected are effectively bonded together.

4.4.1.3 Steel reinforcing bars in concrete foundations and footings

The reinforcing bar system of a concrete foundation or footing that is not insulated from direct contact with earth, and that extends at least 900 mm (3 ft) below grade, constitutes an effective and acceptable type of grounding electrode. Where steel supported on this foundation is to be used as a grounding conductor (tower, structure, etc.), it shall be interconnected by bonding between anchor bolts and reinforcing bars or by cable from the reinforcing bars to the structure above the concrete.

The normally applied steel ties are considered to provide adequate bonding between bars of the reinforcing cage.

NOTE: Where reinforcing bars in concrete are not suitably connected to a metal structure above the concrete, and the latter structure is subjected to grounding discharge currents (even connected to another electrode), there is likelihood of damage to the intervening concrete from ground-seeking current passing through the semiconducting concrete.

4.4.2 Made electrodes

4.4.2.1 General

Where made electrodes are used, they shall, as far as practical, penetrate permanent moisture level and below the frostline. Made electrodes shall be of metal or combinations of metals that do not corrode excessively under the existing conditions for the expected service life.

All outer surfaces of made electrodes shall be conductive, that is, not having paint, enamel, or other covering of an insulating type.

4.4.2.2 Driven rods

- a. Driven rods may be sectional; the total length shall be not less than 2.44 m (8 ft). Iron, zinc-coated steel, or steel rods shall have a diameter of not less than 15.87 mm (0.625 in). Copper-clad, stainless steel, or stainless steel-clad rods shall have a diameter of not less than 12.7 mm (0.5 in).
- b. Longer rods or multiple rods may be used to reduce the ground resistance. Spacing between multiple rods should not be less than 1.8 m (6 ft).

EXCEPTION: Other diameters or configurations may be used if their suitability is supported by a qualified engineering study.

- c. Driven depth shall be not less than 2.45 m (8 ft). The upper end shall be flush with or below the ground level unless suitably protected.

EXCEPTION 1: Where rock bottom is encountered, driven depth may be less than 2.45 m (8 ft), or other types of electrode may be employed.

EXCEPTION 2: When contained within pad-mounted equipment, vaults, manholes, or similar enclosures, the driven depth may be reduced to 2.3 m (7.5 ft).

4.4.2.3 Buried wire, strips, or plates

In areas of high soil resistivity or shallow bedrock, or where lower resistance is required than attainable with driven rods, one or more of the following electrodes may be more useful:

A. Wire

Bare wires 4 mm (0.162 in) in diameter or larger, conforming to Rule 4.3.5-5, buried in earth at a depth not less than 450 mm (18 in) and not less than 30 m (100 ft) total in length, laid approximately straight, constitute an acceptably made electrode. (This is frequently designated a counterpoise.) The wire may be in a single length or may be several lengths connected at ends or at some point away from the ends. The wire may take the form of a network with many parallel wires spaced in two-dimensional array, referred to as a grid.

EXCEPTION 1: Where rock bottom is encountered, burial depth may be less than 450 mm (18 in).

EXCEPTION 2: Other lengths or configurations may be used if their suitability is supported by a qualified engineering study.

B. Strips

Strips of metal not less than 3.0 m (10 ft) in total length and with total (two sides) surface not less than 0.47 m² (5 ft²) buried in soil at a depth not less than 450 mm (18 in) constitute an acceptably made electrode. Ferrous metal electrodes shall be not less than 6 mm (0.25 in) in thickness and nonferrous metal electrodes not less than 1.5 mm (0.06 in).

NOTE: Strip electrodes are frequently useful in rocky areas where only irregularly shaped pits are practical to excavate.

C. Plates or sheets

Metal plates or sheets having not less than 0.185 m^2 (2 ft^2) of surface exposed to the soil, and at a depth of not less than 1.5 m (5 ft), constitute an acceptable made electrode. Ferrous metal electrodes shall not be less than 6 mm (0.25 in) in thickness and nonferrous metal electrodes not less than 1.5 mm (0.06 in).

4.4.2.4 Pole-butt plates and wire wraps

A. General

In areas of very low soil resistivity there are two constructions, described in specifications B and C below, that may provide effective grounding electrode functions although they are inadequate in most other locations. Where these have been proven to have adequately low earth resistance by the application of Rule 4.6, two such electrodes may be counted as one made electrode and ground for application of Rules 4.2.3.1-a, 4.2.3.1-b, 4.6.3, and 4.7.3; however, these types shall not be the sole grounding electrode at transformer locations.

B. Pole-butt plates

Subject to the limitations of Rule 4.4.2.4-A, a pole-butt plate on the base of a wooden pole, possibly folded up around the base of the pole butt, may be considered an acceptable electrode in locations where the limitations of Rule 4.6 are met. The plates shall be not less than 6 mm (1/4 in) thick if of ferrous metal and not less than 1.5 mm (0.06 in) thick if of nonferrous metal. Further, the plate area exposed to the soil shall be not less than 0.046 m^2 (0.5 ft^2).

C. Wire wrap

Subject to the limitations of Rule 4.4.2.4-A, made electrodes may be wire attached to the pole previous to the setting of the pole. The wire shall be of copper or other metals that will not corrode excessively under the existing conditions and shall have a continuous bare or exposed length below ground level of not less than 3.7 m (12 ft), shall extend to the bottom of the pole, and shall not be smaller than AWG No. 6.

4.4.2.5 Concentric neutral cable

Systems employing extensive [30 m (100 ft) minimum length] buried bare concentric neutral cable in contact with the earth may employ the concentric neutral as a grounding electrode. The concentric neutral may be covered with a semi-conducting jacket that has a radial resistivity not exceeding $100 \text{ m}\Omega$ and that will remain essentially stable in service. The radial resistivity of the jacket material is that value calculated from measurements on a unit length of cable, of the resistance between the concentric neutral and a surrounding conducting medium. Radial resistivity equals resistance of unit length times the surface area of jacket divided by the average thickness of the jacket over the neutral conductors. All dimensions are to be expressed in meters.

4.4.2.6 Concrete-encased electrodes

A metallic wire, rod, or structural shape, meeting Rule 4.3.5-5 and encased in concrete, that is not insulated from direct contact with earth, shall constitute an acceptable ground electrode. The concrete depth below grade shall be not less than 300 mm (1 ft), and a depth of 750 mm (2.5 ft) is recommended. Wire shall be no smaller than AWG No. 4 if copper, or 9 mm (3/8 in) diameter or AWG No. 1/0 if steel. It shall be not less than 6.1 m (20 ft) long, and shall remain entirely within the concrete except for the external connection. The conductor should be run as straight as practical.

The metal elements may be composed of a number of shorter lengths arrayed within the concrete and connected together (e.g., the reinforcing system in a structural footing).

EXCEPTION: Other wire length or configurations may be used if their suitability is supported by a qualified engineering study.

NOTE 1: The lowest resistance per unit wire length will result from a straight wire installation.

NOTE 2: The outline of the concrete need not be regular, but may conform to an irregular or rocky excavation.

NOTE 3: Concrete-encased electrodes are frequently more practical or effective than driven rods or strips or plates buried directly in earth.

4.4.2.7 Directly embedded metal poles

Directly embedded steel poles shall constitute an acceptable electrode, if all of the following requirements are met:

- a. Backfill around the pole is native earth, concrete, or other conductive material
- b. Not less than 1.5 m (5.0 ft) of the embedded length is exposed directly to the earth, without nonconductive covering

EXCEPTION: Other lengths, configurations, or type metal may be used if their suitability is supported by a qualified engineering study.

NOTE 1: Aluminum installed below ground is not considered as an acceptable electrode. Weathering steel may not be an acceptable material for this application.

NOTE 2: There are structural and corrosion concerns that should be investigated prior to using metal poles as grounding electrodes. See Rules 6.6 and 6.7.

4.5 Method of connection to electrode

4.5.1 Ground connections

The grounding connection shall be as accessible as practical and shall be made to the electrode by methods that provide the required permanence, appropriate mechanical characteristics, corrosion resistance, and required ampacity such as:

1. An effective clamp, fitting, braze, or weld.
2. A bronze plug that has been tightly screwed into the electrode.
3. For steel-framed structures, employing a concrete-encased reinforcing bar electrode, a steel rod similar to the reinforcing bar shall be used to join, by welding, a main vertical reinforcing bar to an anchor bolt. The bolt shall be substantially connected to the baseplate of the steel column supported on that footing. The electrical system may then be connected (for grounding) to the building frame by welding or by a bronze bolt tapped into a structural member of that frame.
4. For non-steel frame structures employing a concrete-encased rod or wire electrode, an insulated copper conductor of size meeting the requirements of Rule 4.3.3 (except not smaller than AWG No. 4) shall be connected to the steel rod or wire using a cable clamp suitable for steel cable. This clamp and all the bared portion of the copper conductor, including ends of exposed strands within the concrete, shall be completely covered with mastic or sealing compound before concrete is poured. The copper conductor end shall be brought to or out of the concrete surface at the required location for connection to the electrical system. If the copper wire is carried beyond the surface of the concrete, it shall be no smaller than AWG No. 2.

Alternately, the copper wire may be brought out of the concrete at the bottom of the hole and carried external to the concrete for surface connection.

4.5.2 Point of connection to piping systems

1. The point of connection of a grounding conductor to a metallic water piping system shall be as near as is practical to the water-service entrance to the building or near the equipment to be grounded and shall be accessible. If a water meter is between the point of connection and the underground water pipe, the metallic water piping system shall be made electrically continuous by bonding together all parts between the connection and the pipe entrance that may become disconnected, such as meters and service unions.
2. Made grounds or grounded structures should be separated by 3.0 m (10 ft) or more from pipelines used for the transmission of flammable liquids or gases operating at high pressure [1030 kPa (150 lb/in²) or greater] unless they are electrically interconnected and cathodically protected as a single unit. Grounds within 3.0 m (10 ft) of such pipelines should be avoided or shall be coordinated so that hazardous ac conditions will not exist and cathodic protection of the pipeline will not be nullified.

RECOMMENDATION: It is recommended that calculations or tests be used to determine the required separation of ground electrodes for high-voltage direct-current (HVDC) systems from flammable liquid or high-pressure gas pipelines.

NOTE: Ground electrodes for HVDC systems over 750 V may require greater separation.

4.5.3 Contact surfaces

If any coating of non-conducting material, such as enamel, rust, or scale, is present on electrode contact surfaces at the point of connection, such a coating shall be thoroughly removed where required to obtain the requisite good connection. Special fittings so designed as to make such removal of non-conducting coatings unnecessary may also be used.

4.6 Ground resistance requirements

4.6.1 General

Grounding systems shall be designed to minimize hazard to personnel and shall have resistances to ground low enough to permit prompt operation of circuit protective devices. Grounding systems may consist of buried conductors and grounding electrodes.

4.6.2 Supply stations

Supply stations may require extensive grounding systems consisting of multiple buried conductors, grounding electrodes, or interconnected combinations of both. Grounding systems shall be designed to limit touch, step, mesh, and transferred potentials in accordance with industry practices.

NOTE: IEEE Std 80-2000 [see Appendix-A] is one source that may be utilized to provide guidance in meeting these requirements.

4.6.3 Multi-grounded systems

The neutral, which shall be of sufficient size and ampacity for the duty involved, shall be connected to a made or existing electrode at each transformer location and at a sufficient number of additional points with made or existing electrodes to total not less than four grounds in each 1.6 km (1 mile) of the entire line, not including grounds at individual services.

RECOMMENDATION: This rule may be applied to shield wire(s) grounded at the source and which meet the multi-grounding requirements of this rule.

EXCEPTION: Where underwater crossings are encountered, the requirement of made electrodes to total not less than four grounds in each 1.6 km (1 mile) of the entire line does not apply for the underwater portion if the neutral is of sufficient size and capacity for the duty involved and the requirements of Rule 4.2.1.2 are met.

NOTE 1: Multi-grounded systems extending over a substantial distance are more dependent on the multiplicity of grounding electrodes than on the resistance to ground of any individual electrode. Therefore, no specific values are imposed for the resistance of individual electrodes.

NOTE 2: The intent is to ensure that grounding electrodes are distributed at approximately 400 m (1/4 mile) or smaller intervals, although some intervals may exceed 400 m (1/4 mile).

4.6.4 Single-grounded (uni-grounded or delta) systems

The ground resistance of an individual made electrode used for a single-grounded system should meet the requirements of Rule 4.6.1 and should not exceed 25Ω . If a single electrode resistance cannot meet these requirements, then other methods of grounding as described in Rule 4.4.2 shall be used to meet the requirements of Rule 4.6.1.

4.7 Separation of grounding conductors

4.7.1 Separation of grounding conductors and electrodes

Except as permitted in Rule 4.7.2, grounding conductors from equipment and circuits of each of the following classes shall be run separately to the grounding electrode for each of the following classes:

1. Surge arresters of circuits over 750 V and frames of any equipment operating at over 750 V.
2. Lighting and power circuits under 750 V.
3. Shield wires of power circuits.
4. Lightning rods, unless attached to a grounded metal supporting structure.

Alternatively, the grounding conductors shall be run separately to a sufficiently heavy ground bus or system ground cable that is well connected to ground at more than one place.

4.7.2 Grounding conductor of equipment

The grounding conductors of the equipment classes detailed in Rules 4.7.1-1, 4.7.1-2, and 4.7.1-3 may be interconnected utilizing a single grounding conductor, provided:

1. There is a direct-earth grounding connection at each surge-arrester location, and
2. The secondary neutral or the grounded secondary phase conductor is common with or connected to a primary neutral or a shield wire meeting the grounding requirements of Rule 4.7.3.

4.7.3 Grounding of primary and secondary circuits

Primary and secondary circuits utilizing a single conductor as a common neutral shall have at least four ground connections on such conductor in each 1.6 km (1 mi) of line, exclusive of ground connections at customers' service equipment.

4.7.4 Ungrounded or single-grounded systems and multi-grounded systems

4.7.4.1 Ungrounded or single-grounded systems

Where the secondary neutral is not interconnected with the primary surge-arrester grounding conductor as in Rule 4.7.2, interconnection may be made through a spark gap or device that performs an equivalent function. The gap or device shall have a 50 Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV. At least one other grounding connection on the secondary neutral shall be provided with its grounding electrode located at a distance of not less than 6.1 m (20 ft) from the surge-arrester grounding electrode in addition to customer's grounds at each service entrance. The primary grounding conductor, or the secondary grounding conductor, shall be insulated for 600 V.

NOTE: For single-grounded systems, also see Rules 4.3.3.1, 4.3.4, and 4.6.4.

4.7.4.2 Multi-grounded systems

On multi-grounded systems, the primary and secondary neutrals should be interconnected according to Rule 4.7.2. However, where it is necessary to separate the neutrals, interconnection of the neutrals shall be made through a spark gap or a device that performs an equivalent function. The gap or device shall have a 50 Hz breakdown voltage not exceeding 3 kV. At least one other grounding connection on the secondary neutral shall be provided with its grounding electrode located at a distance not less than 1.80 m (6 ft) from the primary neutral and surge-arrester grounding electrode in addition to the customer's grounds at each service entrance. Where the primary and secondary neutrals are not directly interconnected, (a) the primary grounding conductor, or the secondary grounding conductor, or both, shall be insulated for 600 V, and (b) the secondary grounding conductor shall be guarded according to Rule 4.3.4-2.

NOTE 1: A difference of voltage can exist where primary and secondary neutrals are not directly interconnected. For example, where metallic equipment is bonded to the secondary grounding conductor and is installed on the same pole, the primary grounding conductor would be insulated.

NOTE 2: Cooperation of all telecommunications and supply utilities, customers of these utilities, and others may be necessary to obtain effective isolation between primary and secondary neutrals.

- A. Where separate electrodes are used for system isolation, separate grounding conductors shall be used. Where multiple electrodes are used to reduce grounding resistance, they may be bonded together and connected to a single grounding conductor.
- B. Made electrodes used for grounding surge arresters of ungrounded supply systems operated at potentials exceeding 15 kV phase to phase should be located at least 6.1 m (20 ft) from buried telecommunication cables. Where lines with lesser separations are to be constructed, reasonable advance notice should be given to the owners or operators of the affected systems.
- C. Bonding of telecommunication systems to electric supply systems.

Where both electric supply systems and telecommunication systems are grounded on a joint use structure, either a single grounding conductor shall be used for both systems or the electric supply and telecommunication grounding conductors shall be bonded together, except where separation is required by Rule 4.7.1. Where the electric supply utility is maintaining isolation between primary and secondary neutrals, the telecommunication system ground shall be connected only to the primary grounding conductor.

4.8 Additional requirements for grounding and bonding of telecommunication apparatus

Where required to be grounded by other parts of this Code, telecommunication apparatus shall be grounded in the following manner.

See *NOTE 2* in Rule 4.7.4.2.

4.8.1 Electrode

The grounding conductor shall be connected to an acceptable grounding electrode as follows:

1. Where available and where the supply service is grounded to an acceptable electrode, as described in Rule 4.4, to the grounded metallic supply service conduit, service equipment enclosure, grounding electrode conductors, or grounding electrode conductors' metal enclosure.
2. Where the grounding means of Rule 4.8.1-1 is not available, to a grounding electrode as described in Rule 4.4.1.
3. Where the grounding means of Rule 4.8.1-1 or 4.8.1-2 are not available, to a grounding electrode as described in Rule 4.4.2.

EXCEPTION: A variance to Rule 4.4.2.2 is allowed for this application. Iron or steel rods may have a cross-sectional dimension of not less than 13 mm (.50 in) and a length of not less than 1.50 m (5 ft). The driven depth shall be 1.50 m (5 ft), subject to *EXCEPTION 1* of Rule 4.4.2.2.

4.8.2 Electrode connection

The grounding conductor shall preferably be made of copper (or other material that will not corrode excessively under the prevailing conditions of use) and shall not be less than AWG No. 6 in size. The grounding conductor shall be attached to the electrode by means of a bolted clamp or other suitable methods.

NOTE: For requirements on proper materials, methods, and precautions to be taken in the selection and application of grounding and bonding, refer to Rules 4.3.2 and 4.5.

4.8.3 Bonding of electrodes

A bond not smaller than AWG No. 6 copper or equivalent shall be placed between the telecommunication grounding electrode and the supply system neutral grounding electrode where separate electrodes are used at the structure or building being served. All separate electrodes shall be bonded together except where separation is required as per Rule 4.7.

RECOMMENDATION: If water piping is used as a bonding means, care must be taken to assure that the metallic path is continuous between electrodes.

NOTE 1: See NEC Article 800-100(D) for corresponding requirements.

NOTE 2: The bonding together of all separate electrodes limits potential differences between them and between their associated wiring systems.

SECTION 5

SAFETY RULES FOR THE INSTALLATION, OPERATION AND MAINTENANCE OF ELECTRIC SUPPLY SUBSTATIONS AND EQUIPMENT

5.1 Purpose and scope of rules

5.1.1 Purpose

The purpose of this Section is the practical safeguarding of persons during the installation, operation, or maintenance of substations and their associated equipment.

5.1.2 Scope

Section 5 of this Code covers the electric supply conductors and equipment, along with the associated structural arrangements in electric substations that are accessible only to qualified personnel. It also covers the conductors and equipment employed primarily for the utilization of electric power when such conductors and equipment are used by the utility in the exercise of its function as a utility.

5.1.3 Application of rules

The general requirements for application of these rules are contained in Rule 1.5.

5.1.4 Referenced sections

The Introduction (Section 1), Definitions (Section 2), Administration and enforcement (Section 3), and Grounding methods (Section 4) shall apply to the requirements of Section 5.

5.2 Specific requirements for substations

The rules presented herein are applicable to installation, maintenance and operation of all substations as per Rule 1.5. The owner shall ensure that the spirit of National Disaster Management Act 2010 (Act No.XXIV of 2010). The substation is defined as “electric supply station” in Section 2.

NOTE: National Disaster Management Act 2010; Act No. XXIV of 2010 requires certain level of policies, plans and guidelines for disaster management.

5.2.1 Site selection

The site for new substation shall be selected so as to ensure that all foreseeable hazards are accounted for. Existing substation shall be evaluated as per Rule 1.5 for potential hazards and accordingly planning shall be undertaken by the owner to safeguard against potential hazards. The location shall be such that the substation is built in area which does not pose threat to environment.

5.2.1.1 Geology and geotechnical considerations

The substation site shall have sound geology and geotechnical settings. Sites vulnerable to landslides, rockslides, near faults, in area with potential to be washed by rivers and all other such factors shall be considered.

NOTE: Building Code of Pakistan-Seismic Provisions 2007 should be followed.

5.2.1.2 Consideration of natural hazards

The substation shall be so designed that all natural hazards are considered in planning of installation of a new substations. Existing substations shall also be evaluated as per Rule 1.5 against all natural hazards and planning should be initiated to address safeguarding against these hazards.

5.2.1.3 Consideration of manmade hazards

The substations shall be so designed to be resilient to all types of manmade hazards. The design shall ensure that all manmade hazards are addressed while planning new substations. Existing substations shall be evaluated as per Rule 1.5 for potential manmade hazards and mitigation measures shall be planned to address them. The manmade hazards are of various types and are not limited to the following:

- a. Chemical attack due to waste from industry or any other such sources
- b. Fire
- c. Blasts
- d. Vehicular accidents

5.2.2 Installation consideration against natural hazards

5.2.2.1 General requirements

The substations shall be designed to cater for all foreseeable loads. The design shall ensure all relevant codes are complied with including Building Code of Pakistan-Seismic Provisions and Building Code of Pakistan – Energy Provisions 2011.

5.2.2.2 Seismic design

Substations shall be designed to withstand seismic forces generated as result of ground shaking. The seismic hazard defined in Building Code of Pakistan-Seismic Provisions shall be taken as minimum ground shaking. All the components of substations shall be so designed that they are able to withstand these forces and the substation continues to fulfill the functional requirements without any major interruption.

A. Seismic hazard

The seismic hazard defined in Building Code of Pakistan-Seismic Provisions shall be the basis of design of new substations and evaluation of existing ones. As minimum the 475-years return period seismic hazard map shall be used. However, substations in close vicinity of active faults may be designed for higher seismic hazard established by site specific seismic hazard analysis. It should ensure that appropriate seismic hazard is considered.

B. Structural safety

All buildings and their allied structures in substations shall satisfy as minimum the provisions of Building Code of Pakistan-Seismic Provisions. Electrical components and their allied structures shall meet the minimum requirements as per Rules 5.2.2.2-C pertaining to “Seismic Performance Criteria for Electrical Substation Equipment”.

NOTE: Building Code of Pakistan-Seismic Provisions 2007 provide minimum requirements Existing substations shall be evaluated for any deficiencies of structural system and/or strength and accordingly measures shall be adopted to mitigate those shortcomings.

NOTE: Acceptable techniques of Non-destructive Evaluation can be applied; ACI 318R-02 Chapter 20 “Strength Evaluation of Existing Structures” can be used wherever necessary, ASCE 31 “Seismic

Evaluation of Existing Buildings" and ASCE 41 "Seismic Rehabilitation of Existing Buildings" may be considered wherever necessary.

C. Seismic performance criteria for electrical substation equipment

The substation shall have satisfactory performance during and after an earthquake which shall depend on survival, without malfunction, of equipment installed in the substation. Not only shall individual equipment be properly engineered, but also their anchorage, service and interconnections must be well designed. For critical areas within the substation, it may be prudent to have back-up facilities and protected spares in the event of failure due to earthquake-causing ground motion.

In order to design structures and qualify electrical equipment, three qualification levels are defined as "low", "moderate" and "high". These levels are correlated to Building Code of Pakistan in following manner. The owner shall ensure the desired qualification level for equipment.

Seismic loads shall be superimposed on other pre-existing loads or other load that may occur due to earthquake loads.

Table 5-1: Seismic zoning and corresponding qualification levels

Seismic Zoning ^①	Ground Acceleration	Qualification Level	
		Low and Medium Voltage	High and Extra High Voltage
Zone-1	0.05 to 0.08g	Low	Low
Zone-2A and Zone-2B	0.08 to 0.24g	Low/Moderate ^②	Moderate
Zone-3 and Zone-4	0.24 to > 0.32g Or > 0.24	Low/Moderate ^②	High

^① These seismic zonings are taken from Table 2.2 Building Code of Pakistan-Seismic Provisions 2007.

^② The owner shall decide the Qualification Level depending on the rating of substation.

NOTE: IEEE Recommended Practice for Seismic Design of Substations, IEEE Std. 693 -2005 and Building Code of Pakistan-Seismic Provisions 2007.

1. Qualification levels

Qualification Level Low: Equipment that is qualified in this level is said to be seismically qualified to the low seismic level specified in Table 5-1. The low seismic level represents the performance that can be expected when good construction and seismic installation practices are used, but when no special consideration is given to the seismic performance of the equipment.

Qualification Level Moderate: The substation that are located in seismic zone 2A, and 2B, their Equipment should be qualified in this level, and should use the moderate Required Response Spectrum (RRS) as given in Figure 5-1 below. The equipment should be called seismically qualified to the "moderate" seismic level.

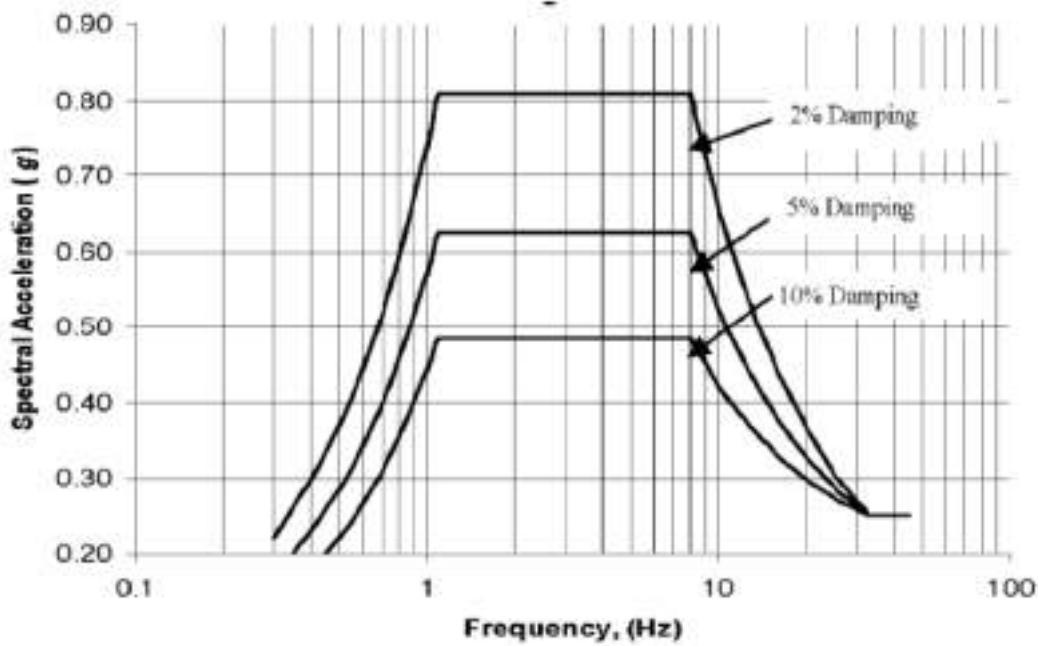


Figure 5-1: Response Spectrum 0.25g for level “medium”

Spectral Accelerations, S_a (g), for Frequencies, f (Hz):

$$S_a = 0.572 \beta f \quad \text{for } 0.0 \leq f \leq 1.1$$

$$S_a = 0.625 \beta \quad \text{for } 1.1 \leq f \leq 8.0$$

$$S_a = (6.6 \beta - 2.64) / f - 0.2 \beta + 0.33 \quad \text{for } 8.0 \leq f \leq 33$$

$$S_a = 0.25 \quad \text{for } f > 33$$

$$\beta = (3.21 - 0.68 \ln(d)) / 2.1156, \text{ where } d \text{ is the percent damping (2, 5, 10, etc.) and } d \leq 20\%.$$

Qualification Level High: The substations that are located in seismic zones 3 and 4, their equipment that is qualified in this level, shall use the high RRS as given in Figure 5-2 below. The equipment shall be called seismically qualified to the “high” seismic level.

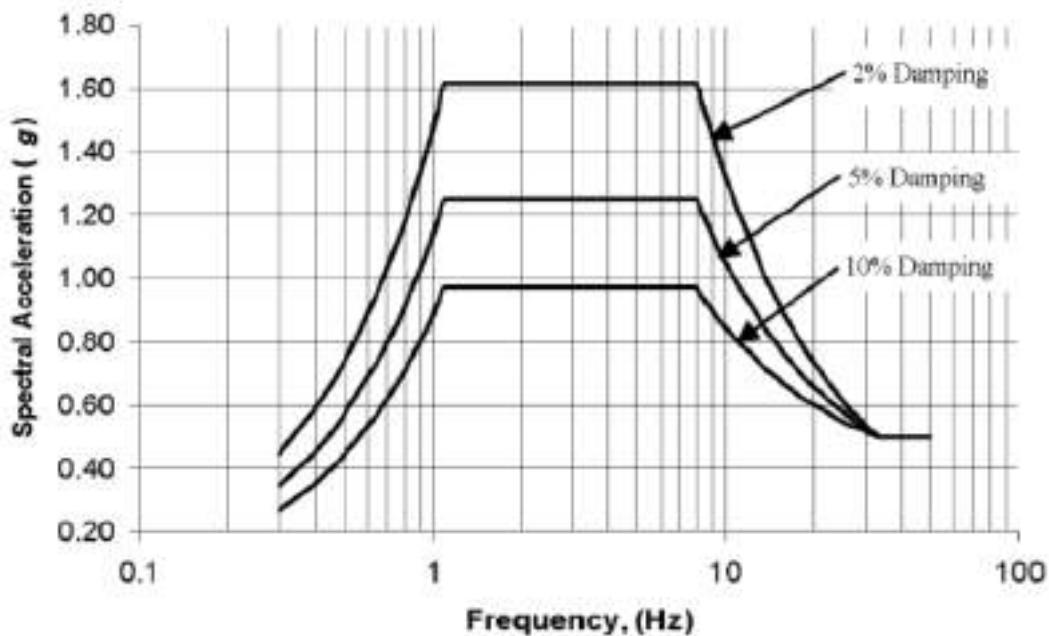


Figure 5-2: Response Spectrum 0.5g for level “high”

Spectral Accelerations, S_a (g), for Frequencies, f (Hz):

$$S_a = 1.144 \beta f \quad \text{for } 0.0 \leq f \leq 1.1$$

$$S_a = 1.25 \beta \quad \text{for } 1.1 \leq f \leq 8.0$$

$$S_a = (13.2 \beta - 5.28) / f - 0.4 \beta + 0.66 \quad \text{for } 8.0 \leq f \leq 33$$

$$S_a = 0.5 \quad \text{for } f > 33$$

$$\beta = (3.21 - 0.68 \ln(d)) / 2.1156, \text{ where } d \text{ is the percent damping (2, 5, 10, etc.) and } d \leq 20\%.$$

NOTE: IEEE Recommended Practice for Seismic Design of Substations, IEEE Std. 693 -2005 and Building Code of Pakistan-Seismic Provisions 2007

2. Selection of qualification levels

The substation classified into “low” level from Table 5-1 may only need to demonstrate in their design calculation to have accounted for these minimum level of design forces, unless a case-specific installation raises concerns.

The substations that fall into “moderate” level from Table 5-1 should ensure that their equipment and anchorages along with interconnections, if any, satisfy the design forces. This conformance should be demonstrated by two means. One by design calculation and secondly by “Qualification Testing of Equipment by Group”. Neither of the two means be avoided.

The substation that belongs to “high” level from Table 5-1 shall ensure that their equipment and anchorages along with interconnections if any shall be able to withstand the design forces. This conformance shall be demonstrated by two means. One by design calculation

and secondly by “Qualification Testing of Equipment Individually”. Neither of the two means be avoided.

5.2.2.3 Safety consideration for flood

The substations that are in vicinity of rivers or water body shall be investigated for suitable frequency of flood. A detailed analysis for minimum of 100-years return period shall be considered and if required a higher return period may be considered. The effect of climate change shall also be accounted for.

5.2.2.4 Safety Consideration for Wind

The substations shall be designed to withstand wind forces. Buildings, electrical equipment installed outdoors and allied structures shall be designed to resist design forces.

NOTE: Building Code of Pakistan-Seismic Provision 2007, Division III “Wind Design” provides the details on design for wind.

5.2.3 Safety consideration for manmade hazards

The substation shall be designed to resist forces imposed by manmade hazards. While considering the level of hazard for design of new substations or assessment of existing substations, social and economic impact shall be taken into account in case of non-functionality of substations and associated impacts on the security and defense of the area. Vulnerability studies shall be undertaken and corresponding measures shall be adopted.

5.2.4 Instrumentation of substations

5.2.4.1 Seismic instrumentation

Critical substations in seismic zone 3 and 4 may be instrumented for monitoring seismic activity. Instrumentation may be such that free field ground motion may be recorded along with response of critical components of substations. Suitable instrumentation may be used with data recorders that have sufficient storage capacity to record earthquake time histories of all data channels of multiple events.

The instrumentation installed on structures, electrical equipment etc. may be planned while considering the importance of that component being instrumented.

5.2.4.2 Instrumentation for wind, temperature, relative humidity and rain

The owner may ensure the availability of recording environmental data on substations on regular basis. This may include recording wind, temperature, relative humidity and rain. All such records may be maintained throughout the design life of the substations. The data may be used in maintenance operations of existing substation and can be helpful for planning of new ones.

5.3 Protective arrangements in electric supply substations

5.3.1 General requirements

5.3.1.1 Enclosure of equipment

A. Types of enclosures

Rooms and spaces in which electric supply conductors or equipment are installed shall be so arranged with fences, screens, partitions, or walls to form an enclosure as to limit the

likelihood of entrance of unauthorized persons or interference by them with equipment inside. Entrances not under observation of an authorized person shall be kept locked.

A safety sign shall be displayed at each entrance. For fenced substations, a safety sign shall be displayed on each side of the fenced enclosure.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007, and ANSI Z535.5-2007 contain information regarding safety signs.

Metal fences, when used to enclose substations having energized electric conductors or equipment, shall have a height not less than 2.13 m (7 ft) overall and shall be grounded in accordance with Section 4.

The requirements for fence height may be satisfied with any one of the following:

- a. Fence fabric, 2.13 m (7 ft) or more in height.
- b. A combination of 1.80 m (6 ft) or more of fence fabric and an extension utilizing three or more strands of barbed wire to achieve an overall height of the fence of not less than 2.13 m (7 ft).
- c. Other types of construction, such as nonmetallic material, that presents equivalent barriers to climbing or other unauthorized entry.

B. Safety clearance zone

Fences or walls, when installed as barriers for unauthorized personnel, shall be located such that exposed live parts are outside the safety clearance zone depending on the type of barrier, as follows:

- a. A metal chain-link fence or equivalent barrier, as illustrated in Figure 5-3, shall have an R-value equal to or greater than that specified in Table 5-2.
- b. Where an impenetrable barrier is used, such as fence, partition, or wall with no openings through which sticks or other objects can be inserted, the sum of the values of R1 and H (barrier height) as illustrated in Figure 5-4 shall be equal to or greater than the sum of dimension (R) as specified in Table 5-2 plus 1.5 m (5.0 ft). the impenetrable barrier does not have to cover the entire wall or fence, only those portions that would not be in compliance with the dimensions of Figure 5-3 and Table 5-2, having a width such that the minimum distance from the outer edge of impenetrable barrier to the nearest live parts shall be equal to or greater than the dimension (R).

EXCEPTION: The safety clearance zone requirement is not applicable to internal fences within a substation perimeter.

5.3.1.2 Rooms and spaces

All rooms and spaces in which electric supply equipment is installed shall comply with the following requirements:

A. Construction

They shall be as much as practical non-combustible.

NOTE: This rule is not intended to prevent wood poles from being used to support conductors or equipment in electric supply stations.

B. Use

They should be as much as practical free from combustible materials, dust, and fumes and shall not be used for manufacturing or for storage.

EXCEPTION 1: Material, equipment, and vehicles essential for maintenance of the installed equipment may be stored if guarded or separated from live parts as required by Rule 5.4.5.

EXCEPTION 2: Material, equipment, and vehicles related to station, transmission and distribution construction, operation, or maintenance work may be stored in the station if located in an area separated from the station electric supply equipment by a fence meeting the requirements of Rule 5.3.1.1

EXCEPTION 3: Material, equipment, and vehicles related to station, transmission and distribution construction, operation, or maintenance work in progress may be temporarily located in a storage space meeting all of the following requirements:

- (a) Guarded or separated from live parts as required by Rule 5.4.5
- (b) Station exits continue to meet the requirements of Rule 5.3.4
- (c) Station working space continues to meet the requirements of Rule 5.4.6
- (d) Access is limited to qualified personnel and persons escorted by qualified personnel.
- (e) The storage location and content is such that the risk of fire does not unreasonably jeopardize station operation.

(For battery areas, see Rule 5.6; for guarding, see Rule 5.4.5; for auxiliary equipment in classified locations, see Rule 5.4.6.4.

C. Ventilation

There should be sufficient ventilation to maintain operating temperatures within ratings, arranged to minimize accumulation of airborne contaminants under any operating conditions.

D. Moisture and weather

They should be dry. In outdoor stations or stations in wet tunnels, subways or other moist or high-humidity locations, the equipment shall be suitably designed to withstand the prevailing atmospheric conditions.

5.3.1.3 Electric equipment

All stationary equipment shall be supported and secured in a manner consistent with reasonably expected conditions of service. Consideration shall be given to the fact that certain heavy equipment, such as transformers, can be secured in place by their weight. However, equipment that generates dynamic forces during operation may require appropriate additional measures.

5.3.1.4 Monitoring

CCTV cameras should be installed in substations for the surveillance and monitoring of entrance of unauthorized persons.

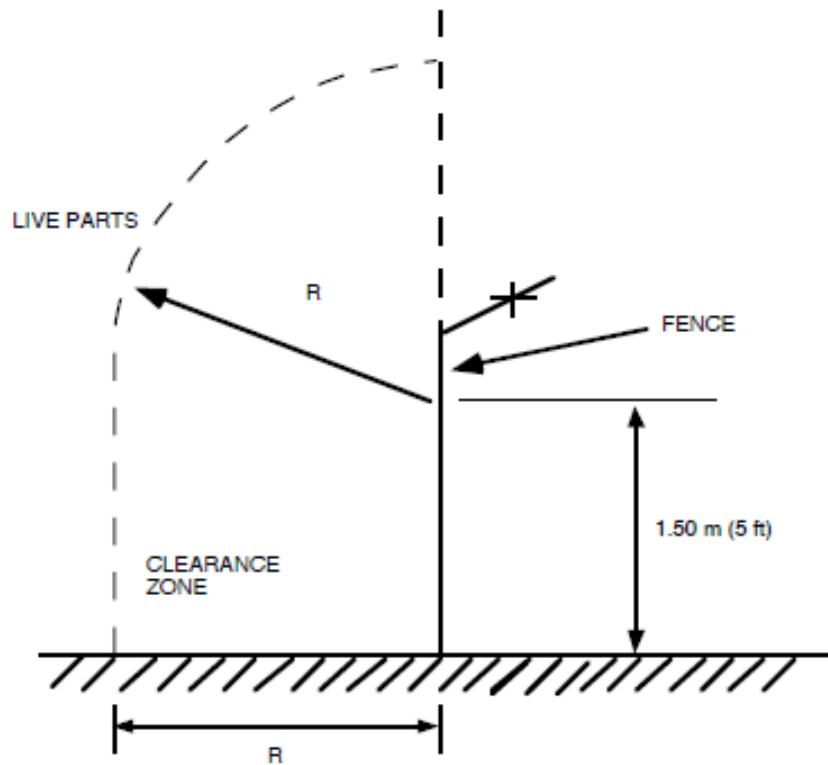
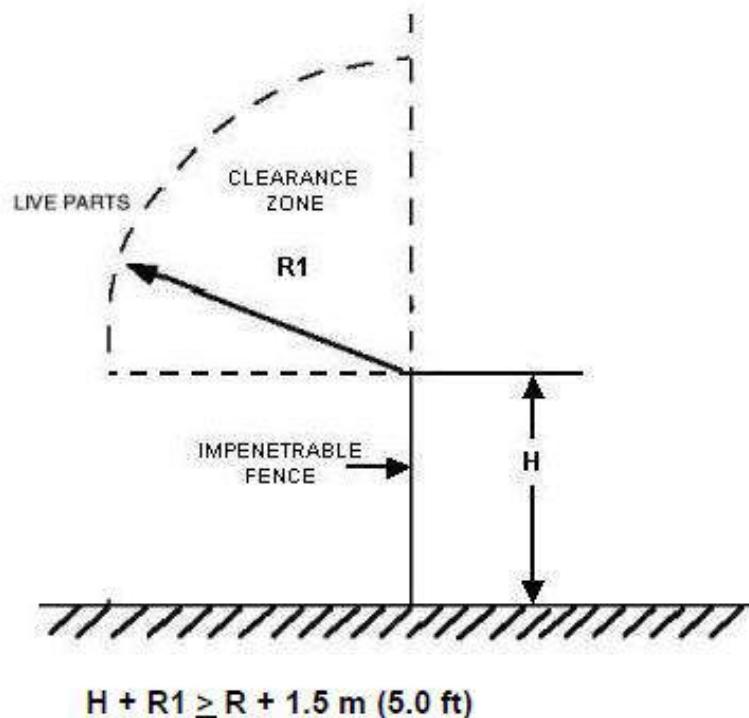


Figure 5-3: Safety clearance to substation fences



$$H + R1 \geq R + 1.5 \text{ m (5.0 ft)}$$

Figure 5-4: Two Safety clearance to substation impenetrable fence

Table 5-2: Values for use with Figure 5-3

Nominal voltage between phases (kV)	Typical BIL (kV)	Dimension "R"	
		m	ft
0.151-7.2	95	3.0	10.0
11	95	3.1	10.1
13.8	110	3.1	10.1
23	150	3.1	10.3
33	200	3.2	10.6
34.5	200	3.2	10.6
46	250	3.3	10.9
66	350	3.5	11.6
69	350	3.5	11.6
115	550	4.0	13.0
132	650	4.2	13.7
138	650	4.2	13.7
161	750	4.4	14.3
220	1050	5.0	16.4
345	1175	5.3	17.3
345	1300	5.5	18.3
500	1550	6.0	19.8
500	1800	6.6	21.5
765	2050	7.1	23.4

5.3.2 Illumination

5.3.2.1 Under normal conditions

1. Outdoor lightning is required at unattended stations. Portable lighting may be used during such times that personnel perform work in the station at night.
2. Rooms and spaces shall have provisions for artificial illumination. Illumination levels not less than those listed in Table 5-3 are recommended for safety to be maintained on the task.

5.3.2.2 Emergency lighting

1. A separate emergency source of illumination with automatic initiation, from an independent generator, storage battery, or other suitable source, shall be provided in every attended station.
2. Emergency lighting of 11 lux (1 footcandle) shall be provided in exit paths from all areas of attended stations. Consideration must be given to the type of service to be rendered, whether of short or long duration. The minimum duration shall be 1-1/2 h. It is recommended that emergency circuit wiring shall be kept independent of all other wiring and equipment.

5.3.2.3 Fixtures

Arrangements for permanent fixtures and plug receptacles shall be such that portable cords need not be brought into dangerous proximity to live or moving parts. All lighting shall be controlled and serviced from safely accessible locations.

5.3.2.4 Attachment plugs and receptacles for general use

Portable conductors shall be attached to fixed wiring only through separable attachment plugs that will disconnect all poles by one operation. Receptacles installed on two- or three-wire single-phase, ac branch circuits shall be of the grounding type. Receptacles connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable.

5.3.2.5 Receptacles in damp or wet locations

All 230V AC permanent receptacles shall either be provided with ground-fault interrupter (GFI) protection or be on a grounded circuit that is tested at such intervals as experience has shown to be necessary.

Table 5-3: Illumination levels

Location	Lux	footcandles
Generating station (interior)		
Highly critical areas occupied most of the time ^①	270	25
Areas occupied most of the time ^②	160	15
Critical areas occupied infrequently ^③	110	10
Areas occupied infrequently ^④	55	5
Generating station (exterior)		
Building pedestrian main entrance	110	10
Critical areas ^⑤	55	5
Areas occupied occasionally by pedestrians ^⑥	22	2
Areas occupied occasionally by vehicles ^⑦	11	1
Areas occupied infrequently ^⑧	5.5	0.5
Remote areas ^⑨	2.2	0.2
Substation		
Control building interior	55	5
General exterior horizontal and equipment vertical	22	2
Remote areas ^⑩	2.2	0.2

^① Such as: Chemical laboratory, large centralized control room 1.68 m (66 in) above floor, section of duplex facing away from operator, bench boards (horizontal level), dispatch boards — horizontal plane (desk level), dispatch boards — vertical face of board [1.22 m (48 in) above floor, facing operator] — system load dispatch room.

^② Such as: Ordinary control room 1.68 m (66 in) above floor, secondary dispatch room, turbine room.

- ③ Such as: Auxiliaries, battery area, boiler feed pumps, tanks, compressors, gage area, burner platforms, hydrogen and carbon dioxide manifold area, screen house, power switchgear, telephone equipment room, turbine bay sub-basement, visitors' gallery, water treating area.
- ④ Such as: Air-conditioning equipment, air preheater and fan floor, ash sluicing, boiler platforms, cable room, circulator, or pump bay, coal conveyor, crusher, feeder, scale area, pulverizer, fan area, transfer tower, condensers, de-aerator floor, evaporator floor, heater floors, area inside duplex switchboards, rear of all switchboard panels (vertical), precipitators, soot or slag blower platform, steam headers and throttles, piping tunnels or galleries.
- ⑤ Such as: Coal unloading dock (loading or unloading zone), coal unloading car dumper, gate house conveyor entrance, fuel-oil delivery headers, platforms — boiler, turbine deck.
- ⑥ Such as: Catwalks, coal unloading tipple, conveyors, secondary building entrances.
- ⑦ Such as: Oil storage tanks, roadway between or along buildings.
- ⑧ Such as: Coal unloading barge storage area, roadway not bordered by buildings.
- ⑨ Such as: cinder dumps, fence, open yard.
- ⑩ Such as: Fence, open yard.

5.3.3 Floors, floor openings, passageways, and stairs

5.3.3.1 Floors

Floors shall have even surfaces and afford secure footing. Slippery floors or stairs should be provided with antislip covering.

5.3.3.2 Passageways

Passageways, including stairways, shall be unobstructed and shall, where practical, provide at least 2.13 m (7 ft) head room. Where the preceding requirements are not practical, the obstructions should be painted, marked, or indicated by safety signs, and the area properly lighted.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007, and ANSI Z535.5-2007 contain information regarding safety signs.

5.3.3.3 Railings

All floor openings without gratings or other adequate cover and raised platforms and walkways in excess of 300 mm (1 ft) in height shall be provided with railings. Openings in railings for units such as fixed ladders, cranes, and the like shall be provided with adequate guards such as grates, chains, or sliding pipe sections.

5.3.3.4 Stair guards

All stairways consisting of four or more risers shall be provided with handrails.

NOTE: For additional information, see ANSI A1264.1-1995 [Appendix A].

5.3.3.5 Top rails

All top rails shall be kept unobstructed for a distance of 75 mm (3 in) in all directions except from below at supports.

5.3.4 Exits

5.3.4.1 Clear exits

Each room or space and each working space about equipment shall have a means of exit, which shall be kept clear of all obstructions.

5.3.4.2 Double exits

If the plan of the room or space and the character and arrangement of equipment are such that an accident would be likely to close or make inaccessible a single exit, a second exit shall be provided.

5.3.4.3 Exit doors

Exit doors shall swing out and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

EXCEPTION: This rule does not apply to exit doors in buildings and rooms containing low-voltage, non-explosive equipment, and to gates in fences for outdoor equipment installations.

5.3.5 Fire-extinguishing equipment

Fire-extinguishing equipment approved for the intended use shall be conveniently located and conspicuously marked.

EXCEPTION: This rule does not apply to unmanned, outdoor substations that do not contain a control building or similar building. This rule is not intended to require permanently installed fire extinguishers or fire extinguishment system in all substations or in all areas of large, complex stations.

5.4 Installation and maintenance of equipment

5.4.1 General requirements

- A. All electric equipment shall be constructed, installed, and maintained so as to safeguard personnel as far as practical.
- B. The rules of this section are applicable to both ac and dc supply stations.

5.4.2 Periodic Inspections

5.4.2.1 In-service equipment

Electric equipment shall be inspected and maintained at such intervals as recommended by manufacturer or experience has shown to be necessary. Equipment or wiring found to be defective shall be put in good order or permanently disconnected.

5.4.2.2 Idle equipment

Infrequently used equipment or wiring shall be inspected and tested before use to determine its fitness for service. Idle equipment energized but not connected to a load shall be inspected and maintained at such intervals as experience has shown to be necessary.

5.4.2.3 Emergency equipment

Equipment and wiring maintained for emergency service shall be inspected and tested at such intervals as experience has shown to be necessary to determine its fitness for service.

5.4.2.4 New equipment

New equipment shall be inspected and tested before being placed in service. New equipment shall be tested in accordance with standard industry practices.

5.4.2.5 Data and record keeping

The owner shall maintain complete log of periodic inspections for all equipment.

5.4.2.6 Cable layout maps and route identification

The owner shall maintain up to date cable layout maps and shall accordingly mark the cables routes on ground.

5.4.3 Guarding shaft ends, pulleys, belts, and suddenly moving parts

5.4.3.1 Mechanical transmission machinery

The methods for safeguarding pulleys, belts, and other equipment used in the mechanical transmission of power shall be in accordance with ANSI/ASME B15.1-2000.

5.4.3.2 Suddenly moving parts

Parts of equipment that move suddenly in such a way that persons in the vicinity are likely to be injured by such movement shall be guarded or isolated.

5.4.4 Protective grounding

5.4.4.1 Protective grounding or physical isolation of non-current-carrying metal parts

All electric equipment shall have the exposed non-current-carrying metal parts, such as frames of generators and switchboards, cases of transformers, switches, and operating levers, effectively grounded or physically isolated. All metallic guards including rails, screen fences, etc., about electric equipment shall be effectively grounded.

5.4.4.2 Grounding method

All grounding that is intended to be a permanent and effective protective measure, such as surge arrester grounding, grounding of circuits, equipment, or wire raceways, shall be made in accordance with the methods specified in Section 4 of this Code.

NOTE: For additional information, see IEEE Std 80-2000 [Appendix A].

5.4.4.3 Provision for grounding equipment during maintenance

Electric equipment or conductors normally operating at more than 400 V between conductors, on or about which work is occasionally done while isolated from a source of electric energy by disconnecting or isolating switches only, shall be provided with some means for grounding, such as switches, connectors, or a readily accessible means for connecting a portable grounding conductor.

5.4.4.4 Grounding methods for direct-current systems

On DC systems 48 V and above, the DC system shall be grounded in accordance with the methods specified in Section 4 of this Code.

5.4.5 Guarding live parts

5.4.5.1 Where required

1. Guards shall be provided around all live parts operating above 400 V phase-to-phase without an adequate insulating covering, unless their location gives sufficient horizontal or vertical clearance or a combination of these clearances to limit the likelihood of accidental human contact, and the location of the live parts is in compliance with the Safety Clearance Zone requirements of Rule 5.3.1.1-B. Clearances from live parts to any permanent supporting surface for workers shall equal or exceed either of those shown in Table 5-4 and illustrated in Figure 5-5.

EXCEPTION: Where supplemental protection is used in accordance with Rule 5.4.5.3-C, the requirements to guard do not apply.

2. Parts over or near passageways through which material may be carried, or in or near spaces such as corridors, storerooms, and boiler rooms used for nonelectrical work, shall be guarded or given clearances in excess of those specified such as may be necessary to secure reasonable safety. The guards shall be substantial and completely shield or enclose the live parts without openings. In spaces used for nonelectrical work, guards should be removable only by means of tools or keys.
3. Each portion of parts of indeterminate potential, such as telephone wires exposed to induction from high-voltage lines, ungrounded neutral connections, ungrounded frames, ungrounded parts of insulators or surge arresters, or ungrounded instrument cases connected directly to a high-voltage circuit, shall be guarded in accordance with Rule 5.4.5.1-1 on the basis of the maximum voltage that may be present on the surface of that portion. The vertical clearance above any permanent supporting surface for workers to the bottom of such part shall be not less than 2.60 m (8.5 ft) unless it is enclosed or guarded in accordance with Rule 5.4.5.3 or Rule 5.4.5.3-G.

5.4.5.2 Strength of guards

Guards shall be sufficiently strong and shall be supported rigidly and securely enough to limit the likelihood of them being displaced or dangerously deflected by a person slipping or falling against them.

5.4.5.3 Types of guards

A. Location or physical isolation

Live parts in compliance with the Rule 5.3.1.1-B Safety Clearance Zone requirements and having clearances equal to or greater than specified in Table 5-4 are guarded by location. Parts are guarded by isolation when all entrances to enclosed spaces, runways, fixed ladders, and the like are kept locked, barricaded, or roped off, and safety signs are posted at all entrances.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007, and ANSI Z535.5-2007 contain information regarding safety signs.

B. Shields or enclosures

Guards less than 100 mm (4 in) outside of the guard zone shall completely enclose the parts from contact up to the heights listed in column 2 of Table 5-4. They shall be not closer to the live parts than listed in column 4 of Table 5-4, except when suitable insulating material is used with circuits of less than 2500 V to ground. If more than 100 mm (4 in) outside the guard zone, the guards shall extend at least 2.60 m (8.5 ft) above the floor. Covers or

guards, which must at any time be removed while the parts they guard are live, shall be so arranged that they cannot readily be brought into contact with live parts.

C. Supplemental barriers or guards within substations

If the vertical distance in Table 5-4 cannot be obtained, railings or fences may be used. Railings or fences, if used, shall be not less than 1.07 m (3.5 ft) high and shall be located at a horizontal distance of at least 900 mm (3 ft) [and preferably not more than 1.20 m (4 ft)] from the nearest point of the guard zone that is less than 2.60 m (8.5 ft) above the floor or grade (see Figure 5-6).

NOTE: It is preferred that the railing or fence be located as close as practical to the parts, while providing a sufficient clear distance to the side of the guard zone to allow appropriate working room with expected tools (such as hot sticks) and working methods—see Rule 5.4.6 and Rule {refer Section 9 work rules Energized conductors}.

D. Mats

Mats of rubber or other suitable insulating material complying with ASTM D 178-88 may be used at switchboards, switches, or rotating machinery as supplementary protection.

E. Live parts below supporting surfaces for persons

The supporting surfaces for persons above live parts shall be without openings. Toe boards at least 150 mm (6 in) high and handrails shall be provided at all edges.

F. Insulating covering on conductors or parts

Conductors and parts may be considered as guarded by insulation if they have either of the following:

- a. Insulation covering of a type and thickness suitable for the voltage and conditions under which they are expected to be operated, and if operating above 2500 V to ground, having metallic insulation shielding or semiconducting shield in combination with suitable metallic drainage that is grounded to an effective ground.

EXCEPTION: Non-shielded insulated conductors listed by a qualified testing laboratory shall be permitted for use up to 8000 V (phase to phase) when the conductors meet the requirements of the NEC, Article 310-6.

- b. Barriers or enclosures that are electrically and mechanically suitable for the conditions under which they are expected to be operated.

G. Taut-string distances

Vertical clearances to energized parts or parts of intermediate potential as required by Rule 5.4.5.1 that are set back from the edge of equipment or other barriers to clear reaching distance may be composed of the vertical distance of the top of the equipment or barrier above the nearest permanent supporting surface (such as a step, foundation pad, etc.) plus the shortest diagonal or horizontal clearance from the edge of the top side of the equipment or barrier to the part with a vertical component of a tout string distance not less than 1.5 m (5 ft), as shown in Figure 5-7.

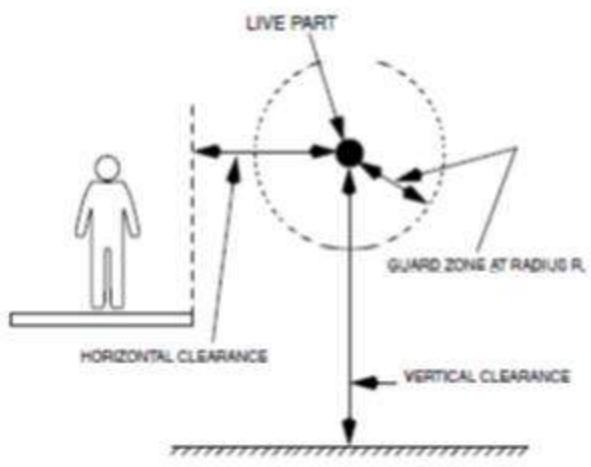


Figure 5-5: Clearance from live parts

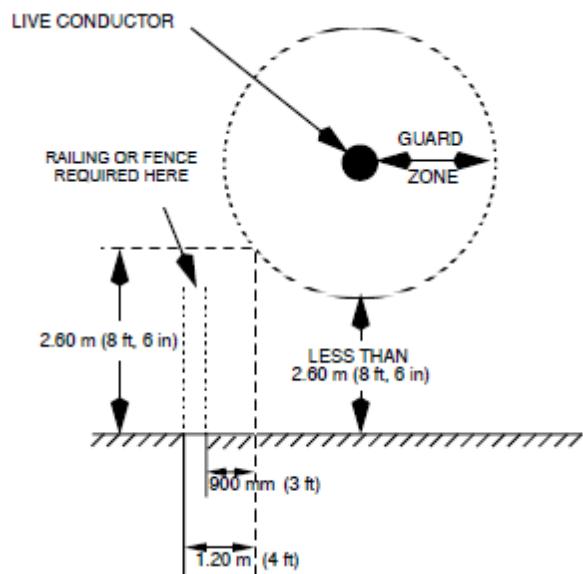


Figure 5-6: Railings or fences used as guards

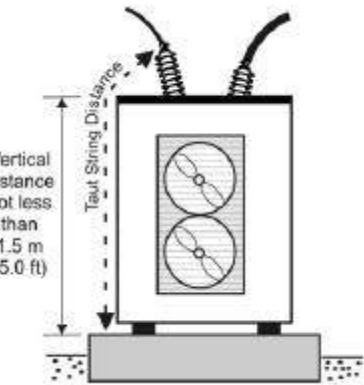


Figure 5-7: Taut-string measurement of vertical clearance to energized parts of equipment or behind barriers

Table 5-4: Clearances from live parts

PART A—Low, medium, and high voltages (based on BIL factors)

Column 1 Maximum design voltage between phases	Column C Basic impulse insulation level ^⑤ (BIL)	Column 2 Vertical clearance of unguarded parts ^①	Column 3 Horizontal clearance of unguarded parts ^①	Column 4 Clearance guard to live parts ^①
				thick border
kV	kV	m	m	mm
0.3	—	Not specified	Not specified	Not specified
0.6	—	2.64	1.02	50
2.4	—	2.67	1.02	76
7.2	95	2.69	1.02	101
15 ^⑥	95	2.69	1.02	101
15	110	2.74	1.07	152
25	125	2.77	1.09	177
25	150	2.82	1.14	228
35 ^⑥	200	2.90	1.22	304
48	250	3.00	1.32	406
72.5 ^⑥	250	3.00	1.32	406
72.5	350	3.18	1.50	584
121	350	3.18	1.50	584
121	550	3.53	1.85	939
145 ^⑥	350	3.18	1.50	584
145	550	3.53	1.85	939
145	650	3.71	2.03	1117
169	550	3.53	1.85	939
169	650	3.71	2.03	1117
169	750	3.91	2.24	1320
242 ^⑥	550	3.53	1.85	939
242	650	3.71	2.03	1117
242	750	3.91	2.24	1320
242	900	4.19	2.51	1600
242	1050	4.52	2.84	1930

Table 5-4 Clearances from live parts

PART B—Extra-high voltages (based on switching-surge factors)⁽²⁾

Column 1	Column A	Column B	Column 2	Column 3	Column 4
Maximum design voltage between phases	Switching - surge factor ⁽³⁾ per unit ⁽⁴⁾	Switching surge line to ground ⁽⁴⁾	Vertical clearance of unguarded parts ⁽¹⁾	Horizontal clearance of unguarded parts ⁽¹⁾	Clearance guard to live parts ⁽¹⁾
kV		kV	m	M	m
362	2.2 or below	650	4.7	3.0	2.13
362	2.3	680	4.9	3.2	2.3
362	2.4	709	5.0	3.4	2.45
362	2.5	739	5.2	3.6	2.6
362	2.6	768	5.4	3.7	2.8
362	2.7	798	5.6	3.9	3
362	2.8	828	5.8	4.1	3.2
362	2.9	857	6.0	4.3	3.4
362	3.0	887	6.1	4.5	3.6
550 ⑥	1.8 or below	808	5.7	4.1	3.2
550	1.9	853	5.9	4.3	3.4
550	2.0	898	6.2	4.6	3.6
550	2.1	943	6.6	4.9	4.0
550	2.2	988	6.9	5.2	4.3
550	2.3	1033	7.2	5.5	4.6
550	2.4	1078	7.5	5.8	4.9
550	2.5	1123	7.9	6.2	5.3
550	2.6	1167	8.2	6.6	5.6
550	2.7	1212	8.6	7.0	6.0
800	1.5	980	6.8	5.1	4.2
800	1.6	1045	7.3	5.6	4.7
800	1.7	1110	7.8	6.1	5.2
800	1.8	1176	8.3	6.6	5.7
800	1.9	1241	8.8	7.2	6.2
800	2.0	1306	9.4	7.7	6.8
800	2.1	1372	10.0	8.3	7.4
800	2.2	1437	10.6	8.9	8.0
800	2.3	1502	11.2	9.5	8.6
800	2.4	1567	11.8	10	9.2

Table 5-4 Clearances from live parts

PART C — Extra-high voltages (based on BIL factors)^②

Column 1	Column C	Column 2	Column 3	Column 4
Maximum design voltage between phases	Basic impulse insulation level ^⑤ (BIL) ^④	Vertical clearance of unguarded parts ^①	Horizontal clearance of unguarded parts ^①	Clearance guard to live parts ^①
kV	kV	m	m	m
362	1050	4.7	3.0	2.13
362	1300	5.2	3.6	2.6
550	1550	5.7	4.1	3.2
550	1800	6.2	4.6	3.6
800	2050	6.8	5.2	4.2

Table 5-4 Clearances from live parts

PART D — High voltage direct current (based on transient overvoltage)

Column 1	Column A	Column B	Column 2	Column 3	Column 4
Maximum design voltage conductor to ground	Transient overvoltage per unit ^(④)	Transient overvoltage line to ground ^(④)	Vertical clearance of unguarded parts ^(①)	Horizontal clearance of unguarded parts ^(①)	Clearance guard to live parts ^(①)
kV		kV	m	m	m
250	1.5 or below	375	3.81	2.13	1.22
250	1.6	400	3.89	2.22	1.3
250	1.7	425	3.97	2.3	1.38
250	1.8	450	4.05	2.38	1.46
400	1.5 or below	600	4.54	2.87	1.95
400	1.6	640	4.67	3	2.08
400	1.7	680	4.88	3.21	2.29
400	1.8	720	5.12	3.45	2.53
500	1.5 or below	750	5.29	3.62	2.7
500	1.6	800	5.6	3.92	3.01
500	1.7	850	5.96	4.29	3.37
500	1.8	900	6.35	4.67	3.76
600	1.5 or below	900	6.35	4.67	3.76
600	1.6	960	6.73	5.06	1.14
600	1.7	1020	7.13	5.45	4.54
600	1.8	1080	7.57	5.89	4.97
750	1.5 or below	1125	7.9	6.23	5.31
750	1.6	1200	8.44	6.76	5.85
750	1.7	1275	9.06	7.38	6.47
750	1.8	1350	9.72	8.04	7.13

^(①) Interpolate for intermediate values. The clearances in column 4 of this table are solely for guidance in installing guards without definite engineering design and are not to be considered as a requirement for such engineering design. For example, the clearances in the tables above are not intended to refer to the clearances between live parts and the walls of the cells, compartments, or similar enclosing structures. They do not apply to the clearances between bus bars and supporting structures nor to clearances between the blade of a disconnecting switch and its base. However, where surge-protective devices are applied to protect the live parts, the vertical clearances, column 2 of Table 5-4 Part A may be reduced provided the clearance is not less than 2.6 m plus the electrical clearance between energized parts and ground as limited by the surge-protective devices.

^(②) Clearances shall satisfy either switching-surge or BIL duty requirements, whichever are greater.

^(③) Switching-surge factor—an expression of the maximum switching-surge crest voltage in terms of the maximum operating line-to-neutral crest voltage of the power system.

④ The values of columns A, B, and C are power system design factors that shall correlate with selected clearances. Adequate data to support these design factors should be available.

⑤ The selection of station BIL shall be coordinated with surge-protective devices when BIL is used to determine clearance. BIL—basic impulse insulation level—for definition and application, see IEEE Std. 1313-1993 (Appendix-A).

⑥ Values are the max design value of the nominal voltages of 11 kV, 33 kV, 66 kV, 132 kV, 220 kV and 500 kV.

5.4.6 Working space about electric equipment

5.4.6.1 Working space (400V or less)

Access and working space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment.

A. Clear spaces

Working space required by this section shall not be used for storage. When normally enclosed energized parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be guarded.

B. Access and entrance to working space

At least one entrance shall be provided to give access to the working space about electric equipment.

C. Working space

The working space in the direction of access to energized parts operating at 400 V or less that require examination, adjustment, servicing, or maintenance while energized shall be not less than indicated in Table 5-5. In addition to the dimensions shown in Table 5-5, the working space shall be not less than 750 mm (30 in) wide in front of the electric equipment. Distances shall be measured from the energized parts if such are exposed or from the enclosure front or opening if such are enclosed. Concrete, brick, or tile walls shall be considered grounded.

D. Headroom working space

The headroom of working spaces about switchboards or control centers shall be not less than 2.13 m (7 ft).

E. Front working space

In all cases where there are energized parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than 900 mm (3 ft).

5.4.6.2 Working space over 400V

Working space shall be in accordance with Table 5-4.

Table 5-5: Working space

Voltage to ground (V)	Clear distance					
	Condition 1		Condition 2		Condition 3	
	Mm	Ft	mm	Ft	mm	ft
0 - 400	900	3	1070	3-1/2	1200	4

Where the *conditions* are as follows:

1. Exposed energized parts on one side and no energized or grounded parts on the other side of the working space, or exposed energized parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not over 300 V shall not be considered energized parts.
2. Exposed energized parts on one side and grounded parts on the other side.
3. Exposed energized parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

EXCEPTION: Working space shall not be required in back of assemblies, such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

5.4.6.3 Equipment for work on energized parts

When it is necessary for personnel to move themselves, material, or tools within the guard zone of unguarded energized parts, protective equipment shall be provided.

This protective equipment shall be periodically inspected, tested, and kept in a safe condition. Protective equipment shall be rated for not less than the voltage involved. Refer to Appendix-A for a list of specifications for equipment.

5.4.6.4 Classified locations

Electrical installations in classified areas shall meet the requirements of the NEC, Articles 500 through 517. Areas classified in accordance with NEC Article 500 shall comply with the requirements of that Article and A. through L. below. Areas classified with the optional Zone method in accordance with NEC Article 505 shall comply with the requirements of that article.

A. Coal-handling areas

1. Unventilated spaces inside or above coal-storage silos or bunkers, or other enclosed coal storage and coal-handling spaces where methane may accumulate in explosive or ignitable mixtures as defined in Article 500-5 of the NEC, are Class I, Division 1, Group D locations. Electric equipment in other locations in which flammable gases or vapors may exist shall be in accordance with the NEC, Article 500-5, or the locations shall be adequately ventilated.
2. Adequate ventilation exists when the method of ventilation will limit the likelihood of accumulation of significant quantities of vapor-air concentrations from exceeding 25% of the lower flammable limit.
3. Tunnels beneath stockpiles or surge piles; spaces inside, above, or below coal-storage silos or bunkers; or other enclosed coal-storage or coal-handling spaces or areas shall be Class II, Group F, Division 1 or Division 2 locations as determined by the NEC.

4. Enclosed sections where only wet coal is handled, or enclosed sections so cut off as to be free from dangerous amounts of coal dust, are not classified. Coal shall be considered to be wet if enough water sprays are installed and maintained to limit the atmospheric concentration of total entrapped volatiles to 8% or less (See ASTM D 3175 for coal and coke dusts).
5. Locations having completely dust-tight pulverized fuel systems designed and installed in compliance with NFPA 8503-1997 shall not be considered classified.
6. Portable lamps for use in fuel bunkers or bins shall be suitable for Class II, Division 1 locations.
7. Sparking electric tools shall not be used where combustible dust or dust clouds are present.
8. An equipment grounding conductor shall be carried with the power conductors and serve to ground the frames of all equipment supplied from that circuit. The origin of the grounding conductor shall be:
 - a. Ungrounded delta or wye-transformer frame ground.
 - b. Grounded delta or wye-transformer grounded secondary connection.
 - c. Resistance grounded wye—the grounded side of the grounding resistor.
9. Ungrounded systems should be equipped with a ground-fault indicating device to give both a visual and audible alarm upon the occurrence of a ground fault in the system.

B. Flammable and combustible liquids

1. Flammable liquid shall mean a liquid having a flash point below 38 °C (100 °F) and having a vapor pressure not exceeding 275 kPa (40 lb/in²) (absolute) at 38 °C (100 °F) and shall be known as a Class I liquid.
2. Combustible liquid shall mean a liquid having a flash point greater than or equal to 38 °C (100 °F) and having a vapor pressure not exceeding 275 kPa (40 lb/in²) (absolute) at 38 °C (100 °F).
3. Class I liquids are subdivided as follows:
 - a. Class IA includes those having flash points below 23 °C (73 °F) and having a boiling point below 38 °C (100 °F).
 - b. Class IB includes those having flash points below 23 °C (73 °F).
 - c. Class IC includes those having flash points at or above 23 °C (73 °F) and below 38 °C (100 °F).
4. Combustible liquids are subdivided as follows:
 - a. Class II includes those having flash points equal to or greater than 38 °C (100 °F) but less than 60 °C (140 °F).
 - b. Class IIIA includes those having flash points equal to or greater than 60 °C (140 °F) but less than 93 °C (200 °F).
 - c. Class IIIB includes those having flash points greater than or equal to 93 °C (200 °F).

C. Flammable liquid storage area

Electric wiring and equipment located in flammable liquid storage areas shall be installed in accordance with applicable sections of NFPA 30-2000 and the relevant industrial practices.

D. Loading and unloading facilities for flammable and combustible liquids

Electric equipment located in the area shall be installed in accordance with applicable sections of NFPA 30-2000 and the NEC.

E. Gasoline-dispensing stations

Electric equipment installed in areas used for dispensing flammable liquids shall be installed in accordance with applicable sections of NFPA 30A-2000 and the NEC.

F. Boilers

When storing, handling, or burning fuel oils that have flash points below 38 °C (100 °F) the installation shall conform to NFPA 30-2000 and the NEC.

NOTE: Attention must be given to electrical installations in areas where flammable vapors or gases may be present in the atmosphere. Typical locations are burner areas, fuel-handling equipment areas, fuel-storage areas, pits, sumps, and low spots where fuel leakage or vapors may accumulate. The NEC, Article 500 provides for classifying such areas and defines requirements for electrical installations in the areas so classified. The burner front piping and equipment shall be designed and constructed to eliminate hazardous concentrations of flammable gases that exist continuously, intermittently, or periodically under normal operating conditions. Providing the burners are thoroughly purged before removal for cleaning, burner front maintenance operations will not cause hazardous concentrations of flammable vapors to exist frequently. With such provisions, the burner front is not normally classified more restrictively than Class I, Division 2.

G. Gaseous hydrogen systems for supply equipment

1. Outdoor storage areas shall not be located beneath electric power lines.
2. Safety considerations at specific storage areas.

Electric equipment shall be suitable for Class I, Division 2 locations:

- a. Within 4.6 m (15 ft) of outdoor storage spaces
 - b. Within adequately ventilated separate buildings or special rooms for storing hydrogen
 - c. Within 7.6 m (25 ft) of a hydrogen storage space in an adequately ventilated building used for other purposes
3. Space around elements of the generator hydrogen seal oil system shall not be considered classified for electrical installation except where external venting is not provided in the bearing drain system.

4. Spaces around the hydrogen piping system beyond the point where the hydrogen storage system connects to distribution piping shall not be considered classified for electrical installations, outside the boundaries established in Rule 5.4.6.4-G2a and Rule 5.4.6.4-G2c.

H. Liquid hydrogen systems

1. Electric wiring and equipment located within 900 mm (3 ft) of a point where connections are regularly made and disconnected shall be in accordance with the NEC, Article 501, Class I, Group B, Division 1 locations.
2. Except as provided in Paragraph 1, electric wiring and equipment located within 7.6 m (25 ft) of a point where connections are regularly made and disconnected or within 7.6 m (25 ft) of a liquid hydrogen storage container, shall be in accordance with the NEC, Article 501, Class I, Group B, Division 2 locations. When equipment approved for Class I, Group B atmospheres is not commercially available, the equipment may be (1) purged or ventilated in accordance with NFPA 496-1998, (2) intrinsically safe, or (3) approved for Class I, Group C atmospheres. This requirement does not apply to electric equipment that is installed on mobile supply trucks or tank cars from which the storage container is filled.

I. Sulfur

1. Electric wiring and equipment located in areas where sulfur dust is in suspension in explosive or ignitable mixtures during normal operations shall be suitable for Class II, Division 1, Group G.

J. Oxygen

1. Bulk oxygen installations are not defined as classified locations.

K. Liquefied petroleum gas (LPG)

Electric equipment and wiring installed in areas used for handling, storage, or utilization of LPG shall be installed in accordance with applicable sections of NFPA 58-2001, NFPA 59-2001, and the NEC.

L. Natural gas (methane)

Electric equipment and wiring installed in areas used for handling, storage, or utilization of natural gas shall be installed in accordance with applicable sections of NFPA 59A-1990 and the NEC.

NOTE: NFPA 497M-1997 [B61] and API RP500, 7 January 1998 [B18], provide additional guidelines for classifying these areas.

5.4.6.5 Identification

Electric equipment and devices shall be identified for safe use and operation. The identification shall be as nearly uniform as practical throughout any one station. Identification marks shall not be placed on removable covers or doors that could be interchanged.

5.4.6.6 Mobile hydrogen equipment

Mobile hydrogen supply units being used to replenish a hydrogen system shall be bonded both to the grounding system and to the grounded parts of the hydrogen system.

5.5 Rotating equipment

Rotating equipment includes generators, motors, motor generators, and rotary converters.

5.5.1 Speed control and stopping devices

5.5.1.1 Automatic overspeed trip device for prime movers

When harmful overspeed can occur, prime movers driving generating equipment shall be provided with automatic overspeed trip devices in addition to their governors.

5.5.1.2 Manual stopping devices

An operator-initiated stopping device shall be provided for any machine that drives an electric power generator or rotary uninterruptible power supply (motor-generator). The operator-initiated stopping device shall be accessible to the operator during normal operation. Manual controls to be used in emergency for machinery and electric equipment shall be located so as to provide protection to the operator in the event of such emergency.

5.5.1.3 Speed limit for motors

Machines of the following types shall be provided with speed-limiting devices unless their inherent characteristics or the load and the mechanical connection thereto are such as to safely limit the speed.

1. Separately excited dc motors
2. Series motors

5.5.1.4 Adjustable-speed motors

Adjustable-speed motors, controlled by means of field regulation, shall, in addition to the provisions of Rule 5.5.1.3 be so equipped and connected that the field cannot be weakened sufficiently to permit dangerous speed.

5.5.1.5 Protection of control circuits

Where speed-limiting or stopping devices and systems are electrically operated, the control circuits by which such devices are actuated shall be protected from mechanical damage. Such devices and systems should be of the automatic tripping type.

5.5.2 Motor control

All motors arranged such that an unexpected starting of the motor might create an exposure of personnel to injury shall have the motor control circuit designed to block unintended re-energization of the motor after a power supply interruption of a duration sufficient for moving equipment to become stationary. The motor control shall be such that an operator must take some action to restart the motor, or automatic restarting shall be preceded by warning signals and a time delay sufficient for personnel action to limit the likelihood of injury. This requirement does not apply to those motors with an emergency use and where the opening of the circuit may cause less safe conditions.

5.5.3 Short-circuit protection

Means shall be provided to automatically disconnect an electric motor from the supply source in the event of high-magnitude short-circuit currents within the motor.

5.6 Storage batteries

5.6.1 General

The provisions of this section are intended to apply to all stationary installations of storage batteries.

For operating precautions, see Section 9 {relevant Work Rules in this Code}.

Space shall be provided around batteries for safe inspection, maintenance, testing, and cell replacement and space left above the cells to allow for operation of lifting equipment when required, addition of water, and taking measurements.

5.6.2 Location

Storage batteries shall be located within a protective enclosure or area accessible only to qualified persons. A protective enclosure can be a battery room, control building, or a case, cage, or fence that will protect the contained equipment and limit the likelihood of inadvertent contact with energized parts.

5.6.3 Ventilation

The battery area shall be ventilated, either by a natural or powered ventilation system to limit hydrogen accumulation to less than an explosive mixture. Failure of a continuously operated or automatically controlled powered ventilation system required by design to limit hydrogen accumulation to less than an explosive mixture shall be annunciated.

5.6.4 Racks

Racks refer to frames designed to support cells or trays. Racks shall be firmly anchored, preferably to the floor. Anchoring to both walls and floors is not recommended. Racks made of metal shall be grounded.

5.6.5 Floors in battery areas

Floors of battery areas should be of an acid-resistive material, painted with acid-resistive paint, or otherwise protected. Provision should be made to contain spilled electrolyte.

5.6.6 Illumination for battery areas

Lighting fixtures shall be protected from physical damage by guards or isolation. Receptacles and lighting switches should be located outside of battery areas.

5.6.7 Service facilities

- A. Proper eye protection and clothing shall be provided in the battery area during battery maintenance and installation and shall consist of the following:
 1. Goggles or face shield
 2. Acid-resistant gloves
 3. Protective aprons and overshoes
 4. Portable or stationary water facilities or neutralizing agent for rinsing eyes and skin

- B. Safety signs inside and outside of a battery room or in the vicinity of a battery area, prohibiting smoking, sparks, or flame shall be provided.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007, and ANSI Z535.5 2007 contain information regarding safety signs.

5.7 Transformers and regulators

5.7.1 Current-transformer secondary circuits protection including 400 V and above

Secondary circuits, when in the vicinity of primary circuits 400 V and exceeding should be adequately protected by means of conduit, covering or any such suitable protection methods. Exceptions are the short lead lengths at the terminals of the transformer.

Any metallic covering, used for protection, shall be effectively grounded, taking in consideration to circulating currents.

Current transformers shall have provision for shorting the secondary terminals.

5.7.2 Grounding secondary circuits of instrument transformers

The secondary circuits of instrument transformers shall be effectively grounded where functional requirements permit.

5.7.3 Location and arrangement of power transformers and regulators

5.7.3.1 Outdoor installations

1. Power transformers and regulators shall be so installed that all energized parts are enclosed or guarded so as to minimize the likelihood of inadvertent contact in compliance with Rule 5.4.5. All protective casing shall be effectively grounded or guarded.
2. The installation of liquid-filled transformers shall utilize one or more of the following methods to minimize fire hazards. The method to be applied shall be according to the degree of the fire hazard. Recognized methods are the use of less flammable liquids, space separation, fire-resistant barriers, automatic extinguishing systems, absorption beds, and enclosures.

The amount and characteristics of liquid contained should be considered in the selection of space separation, fire-resistant barriers, automatic extinguishing systems, absorption beds, and enclosures that confine the liquid of a ruptured transformer tank, all of which are recognized as safeguards.

5.7.3.2 Indoor installations

1. Voltage regulators and transformers of 50 kVA and above containing an appreciable amount of flammable liquid and installed indoors shall have well ventilated rooms or vaults separated from the balance of the building by fire walls.

Doorways to the interior of the building shall be equipped with fire doors and shall have means of containing the liquid.

2. Transformers or voltage regulators of the dry type or containing a nonflammable liquid or gas may be installed in a building without a fireproof enclosure.

When installed in a building used for other than station purposes, the case or the enclosure shall be designed to keep the energized parts within the effectively grounded, in accordance with Rule 5.4.4, case or enclosure, to prevent any likelihood of inadvertent contact by persons.

The pressure-relief vent of a unit containing a non-biodegradable liquid shall be furnished with a means for absorbing toxic gases.

3. Transformers containing less flammable liquid may be installed in a supply station building in such a way as to minimize the fire hazards. The fire protection method shall be employed with due consideration to the amount and characteristics of the liquid contained, the type of the electrical protection and tank venting system.

5.7.4 Short-circuit protection of power transformers

Power transformers shall be provided with means to automatically disconnect the source of supply of short circuit current due to fault within the transformer.

The devices for automatic disconnection of transformer, either locally or remotely, may include:

1. Relays
2. Circuit breaker
3. Circuit switcher
4. Fuses
5. Thyristor blocking
6. Other reasonable methods

The automatic disconnection includes generator electric field source together with the source of mechanical energy in case of fault in generator step-up transformer or station auxiliary transformer.

Disconnection of a single phase rather than all three phases to isolate the fault is acceptable.

EXCEPTION: Instrument transformers, neutral grounding transformers, regulating transformers, and other transformers specifically for control, protection, or metering.

5.8 Conductors

5.8.1 Application

Conductors shall be suitable for the location, use, and voltage. Conductors shall have ampacity that is adequate for the application.

5.8.2 Electrical protection

5.8.2.1 Overcurrent protection required

Conductors and insulation shall be protected against excessive heating by the design of the system and by overcurrent, alarm, indication, or trip devices.

5.8.2.2 Grounded conductors

Conductors normally grounded for the protection of persons shall be arranged without overcurrent protection or other means that could interrupt their continuity to ground.

5.8.2.3 Insulated power cables

Insulated power cable circuits shall be provided with short-circuit protection that will isolate the short circuit from the supply.

5.8.3 Mechanical protection and support

- A. All conductors shall be adequately supported by suitable means to withstand the displacement effects of forces caused by the expected maximum short-circuit current.

Where supported conductors extend outside the substation, then all such conductors and the respective supports shall comply with the grades of construction, strength, and loading requirements of Section 6 of this Code.

- B. Where conductors, conductor insulation, or conductor supports may be subjected to mechanical damage then all adequate means such as casing, armor shall be employed to limit the likelihood of damage or disturbance.

5.8.4 Isolation

All non-shielded insulated conductors of more than 2500 V to ground and bare conductors of more than 150 V to ground shall be isolated by elevation (installation at suitable height) or guarded in accordance with Rule 5.4.5

Non-shielded, insulated, and jacketed conductors may be installed in accordance with Rule 5.4.5.3-F.

5.8.5 Insulated conductor terminations

5.8.5.1 Insulation

Ends and joints of insulated conductors shall have insulating covering, which is same as other portion of the conductor.

5.8.5.2 Metal-sheathed or shielded cable

Insulation of the conductors, where leaving the metal sheath or shield, shall be protected from mechanical damage, moisture, and excessive electrical stress.

5.9 Circuit breakers, reclosers, switches, and fuses

5.9.1 Arrangement

Circuit breakers, reclosers, switches, and fuses shall be so installed as to be accessible only to persons qualified for operation and maintenance. Walls, barriers, latched doors, location,

isolation, or other means shall be provided to protect persons from energized parts or arcing. Conspicuous markings (such as numbers/letters/symbols) shall be provided on each device and at any remote operating points so as to facilitate identification by employees authorized to operate the device. No device identification shall be duplicated within the same supply station. When the contact parts of a switching device are not normally visible, the device shall be equipped with an indicator to show all normal operating positions.

5.9.2 Application

Circuit breakers, circuit switchers, reclosers, switches, and fuses should be utilized with due regard to their assigned ratings of voltage and continuous and momentary currents. Devices that are intended to interrupt fault current shall be capable of safely interrupting the maximum short-circuit current they are intended to interrupt, and for the circumstances under which they are designed to operate. The interrupting capacity should be reviewed prior to each significant system change.

5.9.3 Circuit breakers, reclosers, and switches containing oil and gas

Circuit-interrupting devices containing flammable liquids shall be adequately segregated from other equipment and buildings to limit damage in the event of an explosion or fire. Segregation may be provided by spacing, by fire-resistant barrier walls, or by metal cubicles. Gas-relief vents should be equipped with oil-separating devices or piped to a safe location. Means shall be provided to control oil that could be discharged from vents or by tank rupture. This may be accomplished by absorption beds, pits, drains, or by any combination thereof. Buildings or rooms housing this equipment shall be of fire-resistant construction.

5.9.4 Switches and disconnecting devices

5.9.4.1 Capacity

Switches shall be of suitable voltage and ampere rating for the circuit in which they are installed. Switches used to break load current shall be marked with the current that they are rated to interrupt.

5.9.4.2 Provisions for disconnecting

Switches and disconnectors shall be so arranged that they can be locked in the open and closed positions, or plainly tagged where it is not practical to install locks (See Section 9 relevant Work Rules in this Code). For devices that are operated remotely and automatically, the control circuit shall be provided with a positive disconnecting means near the apparatus to limit the likelihood of accidental operation of the mechanism.

5.9.5 Disconnection of fuses

Fuses in circuits of more than 230 V to ground or more than 15 A shall be classified as disconnecting fuses or be so arranged that before handling:

- A. The fuses can be disconnected from all sources of electric energy, or
- B. The fuses can be conveniently removed by means of insulating handles.

Fuses can be used to disconnect from the source when they are so rated.

5.10 Switchgear and metal-enclosed bus

5.10.1 Switchgear assemblies

5.10.1.1 General requirements for all switchgear

1. To minimize movement, all switchgear shall be secured in a manner consistent with conditions of service and applicable manufacturer's instructions.
2. Cable routed to switchgear shall be supported to minimize forces applied to conductor terminals.
3. Piping containing liquids, or corrosive or hazardous gases, shall not be routed in the vicinity of switchgear unless suitable barriers are installed to protect the switchgear from damage in the event of a pipe failure.
4. Switchgear shall not be located where foreign flammable or corrosive gases or liquids routinely and normally are discharged. Companion equipment such as transformers and switchgear are not considered foreign.
5. Switchgear should not be installed in a location that is still specifically under active construction, especially where welding and burning are required directly overhead. Special precautions should be observed to minimize impingement of slag, metal filings, moisture, dust, or hot particles.

EXCEPTION: Switchgear may be installed in a general construction area if suitable temporary protection is provided to minimize the risks associated with general construction activities.

6. Precautions shall be taken to protect energized switchgear from damage when maintenance is performed in the area.
7. Switchgear enclosure surfaces shall not be used as physical support for any item unless specifically designed for that purpose.
8. Enclosure interiors shall not be used as storage areas unless specifically designed for that purpose.
9. Metal instrument cases shall be grounded and enclosed in covers that are metal and grounded, or are of insulating material.
10. Vermin proofing of all switchgear and control panels shall be provided.
11. For attended substations suitable air conditioning shall be provided in switchgear rooms.

5.10.1.2 Metal-enclosed power switchgear

1. Switchgear shall not be located within 7.6 m (25 ft) horizontally indoors or 3.0 m (10 ft) outdoors of storage containers, vessels, utilization equipment, or devices containing flammable liquids or gases.

EXCEPTION: If an intervening barrier, designed to mitigate the potential effects of flammable liquids or gases, is installed, the distances listed above do not apply.

NOTE: Rule 5.10.1.2-1 is not intended to apply to the power transformer(s) supplying the switchgear.

2. Enclosed switchgear rooms shall have at least two means of egress, one at each extreme of the area, not necessarily in opposite walls. Doors shall swing out and be equipped

with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

EXCEPTION: One door may be used when required by physical limitations if means are provided for unhampered exit during emergencies.

3. Space shall be maintained in front of switchgear to allow breakers to be removed and turned without obstruction.
4. Space shall be maintained in the rear of the switchgear to allow for door opening to at least 90 degrees open, or a minimum of 900 mm (3 ft) without obstruction when removable panels are used.
5. Permanently mounted devices, panelboards, etc., located on the walls shall not encroach on the space requirements in Rule 5.10.1.2-4.
6. Where columns extend into the room beyond the wall surface, the face of the column shall not encroach on the space requirements in Rule 5.10.1.2-4.
7. Low-voltage cables or conductors, except those to be connected to equipment within the compartment, shall not be routed through the medium- or high-voltage divisions of switchgear unless installed in rigid metal conduit or isolated by rigid metal barriers.
8. Low-voltage conductors routed from medium- or high-voltage sections of switchgear shall terminate in a low-voltage section before being routed external to the switchgear.
9. Conductors entering switchgear shall be insulated for the higher operating voltage in that compartment or be separated from insulated conductors of other voltage ratings.
10. Switchgear enclosures shall be suitable for the environment in which they are installed.
11. A safety sign shall be placed in each cubicle containing more than one high-voltage source.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007, and ANSI Z535.5-2007 contain information regarding safety signs.

12. The location of control devices shall be readily accessible to personnel. Instruments, relays, and other devices requiring reading or adjustments should be so placed that work can readily be performed from the working space.

5.10.1.3 Dead-front power switchboards

Dead-front power switchboards with uninsulated rear connections shall be installed in rooms or spaces that are capable of being locked, with access limited to qualified personnel.

5.10.1.4 Motor control centers

1. Motor control centers shall not be connected to systems having higher short circuit capability than the bus bracing can withstand. Where current-limiting fuses are employed on the source side of the bus, the bus bracing and breaker-interrupting rating are determined by the peak let through characteristic of the current-limiting fuse.
2. A safety sign shall be placed in each cubicle containing more than one voltage source.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007, and ANSI Z535.5-2007 contain information regarding safety signs.

5.10.1.5 Control switchboards

1. Cabinets containing solid-state logic devices, electron tubes, or relay logic devices such as boiler analog, burner safety, annunciators, computers, inverters, precipitator logic, soot blower control, load control, telemetering, totalizing microwave radio, etc., are covered under these rules.
2. Where carpeting is installed in rooms containing control switchboards, it shall be of an antistatic type and shall minimize the release of noxious, corrosive, caustic, or toxic gas under any condition.
3. Layout of the installation shall provide adequate clearance in front of, or rear of, panels if applicable, to allow meters to be read without use of stools or auxiliary devices.
4. Where personnel access to control panels, such as benchboards, is required, cables shall be routed through openings separate from the personnel opening. Removable, sliding, or hinged panels are to be installed to close the personnel opening when not in use.

5.10.2 Metal-enclosed bus

5.10.2.1 General requirements for all types of bus

1. Busways shall be installed only in accessible areas.
2. Busways, unless specifically approved for the purpose, shall not be installed: where subject to severe physical damage or corrosive vapors; in hoistways; in any classified hazardous location; outdoors or in damp locations.
3. Dead ends of busway shall be closed.
4. Busways should be marked with the voltage and current rating for which they are designed, in such manner as to be visible after installation.

5.10.2.2 Isolated-phase bus

1. The minimum clearance between an isolated-phase bus and any magnetic material shall be the distance recommended by the manufacturer to avoid overheating of the magnetic material.
2. Nonmagnetic conduit should be used to protect the conductors for bus-alarm devices, thermocouples, space heaters, etc., if routed within the manufacturer's recommended minimum distance to magnetic material and parallel to isolated-phase bus enclosures.
3. When enclosure drains are provided for isolated-phase bus, necessary piping shall be provided to divert water away from electrical equipment.
4. Wall plates for isolated-phase bus shall be nonmagnetic, such as aluminum or stainless steel.
5. Grounding conductors for isolated-phase bus accessories should not be routed through ferrous conduit.

5.11 Surge arresters

5.11.1 General requirements

If arresters are required, they shall be located as close as practical to the equipment they protect.

NOTE: See IEEE Std. C62.1™-1989 [B55] and IEEE Std. C62.11™-1999 [B56] for additional information.

5.11.2 Indoor locations

Arresters, if installed inside of buildings, shall be enclosed or shall be located well away from passageways and combustible parts.

5.11.3 Grounding conductors

Grounding conductors shall run as directly as practical between the arresters and ground. Such conductors be of low impedance, ample current-carrying capacity and shall be grounded in accordance with the methods outlined in Section 4.

5.11.4 Installation

Arresters shall be installed in such a manner and location that neither the expulsion of gases nor the arrester disconnector is directed upon live parts in the vicinity.

SECTION 6

SAFETY RULES FOR OVERHEAD LINES

6.1 Purpose and scope of rules

6.1.1 Purpose

The purpose of this section is the practical safeguarding of persons during the installation, operation, or maintenance of overhead electric supply and telecommunication lines and their associated equipment.

6.1.2 Scope

This section covers supply conductors and equipment in overhead lines. It covers the associated structural arrangements of such systems and the extension of such systems into buildings. The rules include requirements for spacing, clearances, and strength of construction. They do not cover installations in electric supply stations except as required by Rule 5.8.3-A.

NOTE 1: Section 9 (relevant Work Rules) contains the approach distances and work rules required of supply employers and their employees working on or near supply lines and equipment.

NOTE 2: The approach distances to energized parts, and other requirements applicable to the activities of utility or non-utility construction personnel, and others in close proximity to existing supply lines are governed by the statutes or regulations of the electric utilities.

6.1.3 Application of rules

The general requirements for application of these rules are contained in Rule 1.5. However, when a structure is replaced, the arrangement of equipment shall conform to Rule 6.4.9.3.

6.2 General requirements

6.2.1 Referenced sections

The Introduction (Section 1), Definitions (Section 2), Grounding methods (Section 4) and Appendix-A (bibliography), shall apply to the requirements of this section.

6.2.2 Induced voltages

Rules covering supply-line influence and telecommunication-line susceptiveness have not been detailed in this Code. Cooperative procedures are recommended in the control of voltages induced from proximate facilities. Therefore, reasonable advance notice should be given to owners or operators of other proximate facilities that may be adversely affected by new construction or changes in existing facilities.

NOTE: Additional information about supply-line influence and telecommunication-line susceptiveness may be obtained from IEEE Std. 776™ (1992) and IEEE Std. 1137™ (1991).

6.2.3 Accessibility

All parts that must be examined or adjusted during operation shall be arranged so as to be accessible to authorized persons by the provision of adequate climbing spaces, working spaces, working facilities, and clearances between conductors.

6.2.4 Inspection and tests of lines and equipment

6.2.4.1 When in service

A. Initial compliance with rules

Lines and equipment shall comply with these safety rules when placed in service.

B. Inspection

Lines and equipment shall be inspected at such intervals as experience has shown to be necessary.

NOTE: It is recognized that inspections may be performed in a separate operation or while performing other duties, as desired.

C. Tests

When considered necessary, lines and equipment shall be subjected to practical tests to determine required maintenance.

D. Inspection Record

Any conditions or defects affecting compliance with this Code revealed by inspection or tests, if not promptly corrected, shall be recorded; such records shall be maintained until the conditions or defects are corrected.

E. Corrections

- a. Lines and equipment with recorded conditions or defects that would reasonably be expected to endanger life or property shall be promptly corrected, disconnected, or isolated.
- b. Other conditions or effects shall be designated for correction.

6.2.4.2 When out of service

A. Lines infrequently used

Lines and equipment infrequently used shall be inspected or tested as necessary before being placed into service.

B. Lines temporarily out of service

Lines and equipment temporarily out of service shall be maintained in a safe condition.

C. Lines permanently abandoned

Lines and equipment permanently abandoned shall be removed or maintained in a safe condition.

6.2.5 Grounding of circuits, supporting structures, and equipment

6.2.5.1 Methods

Grounding required by these rules shall be in accordance with the applicable methods given in Section 4.

6.2.5.2 Circuits

A. Common neutral

A conductor used as a common neutral for primary and secondary circuits shall be effectively grounded.

B. Other neutrals

Primary line, secondary line, and service neutral conductors shall be grounded.

EXCEPTION: Circuits designed for ground-fault detection and impedance-current-limiting devices.

C. Other conductors

Line or service conductors, other than neutral conductors, that are intentionally grounded, shall be grounded.

D. Surge arresters

Where the operation of surge arresters is dependent upon grounding, they shall be grounded.

E. Use of earth as part of circuit

- a. Supply circuits shall not be designed to use the earth normally as the sole conductor for any part of the circuit.
- b. Monopolar operation of a bipolar HVDC system is permissible for emergencies and limited periods for maintenance.

6.2.5.3 Non-current-carrying parts

NOTE: Nothing in Rule 6.2.5.3 limits a portion(s) of a guy or span wire from being insulated and another portion(s) being effectively grounded.

A. General

Metal or metal-reinforced supporting structures, including lamp posts; metal conduits and raceways; cable sheaths; messengers; metal frames, cases, and hangers of equipment; and metal switch handles and operating rods shall be effectively grounded.

EXCEPTION 1: Unless both of the following conditions apply (isolated or guarded in a well-defined operating area), the following items shall be grounded. If the decision is made to ground all new items above the 2.45 m level, the rules does not require retrofitting existing ungrounded items

- a. Frames, cases, and hangers of equipment and switch handles and operating rods that are 2.45 m or more above readily accessible surfaces or are otherwise isolated or guarded and
- b. The practice of not grounding such items has been a uniform practice over a well-defined operating area.

NOTE: Typical practice is to ground existing items whenever significant work is done on existing structures.

EXCEPTION 2: This rule does not apply to isolated or guarded equipment cases in certain specialized applications, such as series capacitors where it is necessary that equipment cases be either ungrounded or connected to the circuit. Such equipment cases shall be considered as energized and shall be suitably identified.

EXCEPTION 3: This rule does not apply to equipment cases, frames, equipment hangers, conduits, messengers, raceways, and cable sheaths enclosing or supporting only telecommunication conductors, provided they are not exposed to contact with open supply conductors of over 300 V.

B. Anchor guys and span guys

Anchor guys and span guys shall be effectively grounded as specified in Rule 4.2.3.2.

EXCEPTION: Where one or more guy insulators meeting the requirements of Rules 6.8.9.1 and Rule 6.2.5.3-D or 6.2.5.3-E are inserted in an anchor guy or span guy, the guy is not required to be grounded.

NOTE: For the purpose of this rule, if a span guy and its associated anchor guy are bonded together, they may be considered as one guy.

C. Span wires carrying luminaires or traffic signals

Span wires carrying luminaires or traffic signals shall be effectively grounded.

EXCEPTION: Where one or more span-wire insulators meeting the requirements of Rules 6.8.9.2 and 6.2.5.3-E are inserted in a luminaire or traffic signal span wire, the span wire is not required to be grounded.

D. Use of insulators in anchor guys

Where insulators are used in lieu of grounding in anchor guys in accordance with Rule 6.2.5.3-B, insulators shall be installed as follows:

- a. Insulator(s) shall be positioned so as to limit the likelihood of any portion of an anchor guy, including any conductive components or the insulator(s), becoming energized within 2.45 m of the ground level in the event that the anchor guy becomes slack or breaks below the lowest guy insulator.
- b. Insulators shall be positioned so as to limit the likelihood of any anchor guy becoming a conductive path between: (1) an energized conductor or rigid live part and (2) a conductor of another circuit, rigid part, or equipment in the event that the anchor guy becomes slack.
- c. Insulators shall be positioned so as to limit the likelihood that the insulators will become ineffective in the event that any anchor guy sags down upon another anchor guy, span guy, or span wire.

E. Use of insulators in span guys, and span wires supporting luminaires or traffic signals

Where insulators are used in lieu of grounding in span guys, or in span wires supporting luminaires or traffic signals in accordance with Rule 6.2.5.3-B or 6.2.5.3-C, insulators shall be installed as follows:

- a. Insulator(s) shall be positioned so as to limit the likelihood of any portion of a span guy or a span wire becomes energized within 2.45 m of the ground level in the event that the span guy or span wire becomes slack.
- b. Insulators shall be positioned so as to limit the likelihood of a span guy or a span wire becoming a conductive path between: (1) any energized conductor or rigid live part, and (2) a conductor of another circuit, rigid part, or equipment in the event that the span guy or span wire becomes slack.
- c. Insulators shall be positioned so as to limit the likelihood that the insulators will become ineffective in the event that any span guy or span wire sags down upon another anchor guy, span guy, or span wire.

F. Use of insulators in span wires supporting energized trolley or electric railroad contact conductors

- a. All span wires supporting energized trolley or electric railroad contact conductors, including bracket span wires, shall have a suitable insulator (in addition to an insulated hanger if used) inserted between each point of support of the span wire and the trolley or electric railroad contact conductor supported.

EXCEPTION 1: Single insulators, as provided by an insulated hanger, may be permitted when the span wire or bracket is supported on wood poles supporting only trolley, railway feeder, or telecommunication conductors used in the operation of the railway concerned.

EXCEPTION 2: Insulators are not required if the span wire is effectively grounded.

EXCEPTION 3: This rule does not apply to insulated feeder taps used as span wires.

- b. In case insulated hangers are not used, the insulator shall be located so as to limit the likelihood of having the energized part of the span wire within 2.45 m of the ground level in the event of a broken wire.

G. Insulators used to limit galvanic corrosion

An insulator in the guy strand used exclusively for the limitation of galvanic corrosion of metal in ground rods, anchors, anchor rods, or pipe in an effectively grounded system shall meet there requirements of Rule 6.8.9.1-Ac and shall be installed such that (a) the upper portion of a guy has been effectively grounded according to Rule 6.2.5.3, and (b) the top of insulators used to limit galvanic corrosion shall be installed at an elevation below exposed energized conductors and parts.

NOTE: See Rule 6.8.9.1-Ba.

H. Multiple messengers on the same structure

Telecommunication cable messengers exposed to power contacts, power induction, or lightning, shall be bonded together at intervals specified in Rule 4.2.3.1.

6.2.6 Arrangement of switches

6.2.6.1 Accessibility

Switches or their control mechanisms shall be installed so as to be accessible to authorized persons.

6.2.6.2 Indicating open or closed position

Switch position shall be visible or clearly indicated.

6.2.6.3 Locking

Switch-operating mechanisms that are accessible to unauthorized persons shall have provisions for locking in each operational position and shall be locked or otherwise secured except during operation or testing.

NOTE: See relevant Work Rules in Section 9.

6.2.6.4 Uniform position

The handles or control mechanisms for all switches throughout any system should have consistent positions when opened and uniformly different positions when closed in order to minimize operating errors. Where this practice is not followed, the switches should be marked to minimize mistakes in operation.

6.2.6.5 Local/Remote option

Remotely controlled, automatic transmission, or distribution overhead line switching devices shall have local provisions to render remote or automatic controls inoperable.

6.2.7 General

6.2.7.1 Supporting structures

A. Protection of structures

a. Mechanical damage

Appropriate physical protection shall be provided for supporting structures in parking lots, in alleys, or next to driveways subject to vehicular traffic abrasion that would materially affect their strength.

This rule does not require protection or marking of structural components located outside of the traveled ways of roadways or established parking areas.

NOTE: Experience has shown that it is not practical to protect structures from contact by out-of-control vehicles operating outside of established traveled ways. See Rule 6.4.2.2 for structure clearances to roadways.

b. Fire

Supporting structures shall be placed and maintained so as to be exposed as little as is practical to brush, grass, rubbish, or building fires.

c. Attached to bridges

Supporting structures attached to bridges for the purpose of carrying open supply conductors exceeding 600 V shall be posted with appropriate safety signs.

NOTE: ANSI Z535.1 (2006), ANSI Z535.2 (2007), ANSI Z535.4 (2007), ANSI contains information regarding safety symbols to be used in place of a safety word message.

B. Readily climbable supporting structures

- a. Readily climbable supporting structures, such as closely latticed poles, towers, or bridge attachments, carrying open supply conductors, which are adjacent to roads, regularly traveled pedestrian thoroughfares, or places where persons frequently gather (such as schools or public playgrounds), shall be equipped with barriers to inhibit climbing by unqualified persons or posted with appropriate safety signs.

EXCEPTION: This rule does not apply where access to the supporting structure is limited by a fence meeting the height requirements of Rule 5.3.1.1-A.

NOTE: ANSI Z535.1 (2006), ANSI Z535.2 (2007), ANSI Z535.4 (2007), contains information regarding safety signs. ANSI Z535.3 (2007) contains information regarding safety symbols to be used in place of a safety word message.

- b. Steps

Steps permanently installed on supporting structures shall not be less than 2.45 m from the ground or other accessible surface.

Where steps are temporarily installed less than 2.45 m from the ground or other accessible surface, structures shall be attended or barriers to inhibit climbing by unqualified persons shall be installed.

EXCEPTION 1: This rule does not apply where supporting structures are isolated.

EXCEPTION 2: This rule does not apply where access to the supporting structure is limited by a fence meeting the height requirements of Rule 5.3.1.1-A.

- c. Standoff brackets

Standoff brackets on supporting structures shall be arranged so that there is not less than 2.45 m between either:

- (1) The lowest bracket and ground or other accessible surface, or
- (2) The two lowest brackets.

EXCEPTION: This rule does not apply where supporting structures are isolated.

C. Identification

Supporting structures, including those on bridges, on which supply or telecommunication conductors are maintained shall be so constructed, located, marked, or numbered so as to facilitate identification by employees authorized to work thereon.

D. Attachments, decorations, and obstructions

No attachment of any kind to a supporting structure of a utility line (including lighting and metering structures) shall be allowed without the concurrence of the structure owner. Non-utility attachments shall also have concurrence of the occupation(s) of the space in which the attachment is made.

- a. No attachment shall cause any portion of the resulting installation to be in noncompliance with the clearance, grounding, strength, or other requirements of the PETSAC-2014.
- b. Attachments shall neither obstruct the climbing space nor present a climbing hazard to utility personnel. Through bolts shall be properly trimmed. Vines, nails, tacks, or other items which may interfere with climbing should be removed before climbing.

6.2.7.2 Unusual conductor supports

Where line conductors are attached to structures other than those used solely or principally for their support, all rules shall be complied with as far as they apply. Such additional precautions as may be deemed necessary by the administrative authority shall be taken to avoid damage to the structures or injury to the persons using them. The supporting of conductors on trees and roofs should be avoided.

6.2.7.3 Protection and marking of guys

1. The ground end of anchor guys exposed to pedestrian traffic shall be provided with a substantial and conspicuous marker.

NOTE: Visibility of markers can be improved by the use of color or color patterns that provide contrast with the surroundings.

2. Where an anchor is located in an established parking area, the guy shall either be protected from vehicle contact or marked.
3. This rule does not require protection or marking of anchor guys located outside of the traveled ways of roadways or established parking areas.

NOTE: Experience has shown that it is not practical to protect guys from contact by out of control vehicles operating outside of established traveled ways. See Rule 6.4.2.3 for clearances of structures adjacent to roadways.

6.2.8 Vegetation management

6.2.8.1 General

1. Vegetation that may damage ungrounded supply conductors should be pruned or removed. Vegetation management should be performed as experience has shown to be necessary.

NOTE 1: Factors to consider in determining the extent of vegetation management required include, but are not limited to: line voltage class, species' growth rates and failure characteristics, right-of-way limitations, the vegetation's location in relation to the conductors, the potential combined movement of vegetation and conductors during routine winds, and sagging of conductors due to elevated temperatures or icing.

NOTE 2: It is not practical to prevent all tree-conductor contacts on overhead lines.

2. Where pruning or removal is not practical, the conductor should be separated from the tree with suitable materials or devices to avoid conductor damage by abrasion and grounding of the circuit through the tree.

6.2.8.2 At line crossings, railroad crossings, limited-access highway crossings, or navigable waterways requiring crossing permits.

The crossing span and the adjoining span on each side of the crossing should be kept free from overhanging or decayed trees or limbs that otherwise might fall into the line.

6.3 Relations between various classes of lines and equipment

6.3.1 Relative levels

6.3.1.1 Standardization of levels

The levels at which different classes of conductors are to be located should be standardized by agreement of the utilities concerned.

6.3.1.2 Relative levels: supply and telecommunication conductors

1. Preferred levels

Where supply and telecommunication conductors cross each other or are located on the same structures, the supply conductors should be carried at the higher level.

EXCEPTION: This rule does not apply to trolley feeders, which may be located for convenience approximately at the level of the trolley-contact conductor.

2. Special construction for supply circuits, the voltage of which is 600 V or less and carrying power not in excess of 5 kW

Where all circuits are owned or operated by one party or where cooperative consideration determines that the circumstances warrant and the necessary coordinating methods are employed, single-phase ac or two-wire dc circuits carrying a voltage of 600 V or less between conductors, with transmitted power not in excess of 5 kW, when involved in the joint use of structures with telecommunication circuits, may be installed in accordance with footnote 1 of Table 6-18, under the following conditions:

- a. That such supply circuits are of covered conductor not smaller than AWG No. 8 medium hard-drawn copper or its equivalent in strength, and the construction otherwise conforms to the requirements for supply circuits of the same class.
- b. That the supply circuits are placed on the end and adjacent pins of the lowest through signal support arm and that a 750 mm climbing space be maintained from the ground up to a point at least 600 mm above the supply circuits. The supply circuits shall be rendered conspicuous by the use of insulators of different form or color from others on the pole line or by stenciling the voltage on each side of the support arm between the pins carrying each supply circuit, or by indicating the voltage by means of metal characters.
- c. That there shall be a vertical clearance of at least 600 mm between the support arm carrying these supply circuits and the next support arm above. The other pins on the support arm carrying the supply circuits may be occupied by telecommunication circuits used in the operation or control of signal system or other supply system if owned, operated, and maintained by the same company operating the supply circuits.
- d. That such supply circuits shall be equipped with arresters and fuses installed in the supply end of the circuit and where the signal circuit is ac, the protection shall be installed on the secondary side of the supply transformer. The arresters shall be designed so as to break down at approximately twice the voltage between the wires of the circuit, but the breakdown voltage of the arrester need not be less than

1 kV. The fuses shall have a rating not in excess of approximately twice the maximum operating current of the circuit, but their rating need not be less than 10 A. The fuses likewise in all cases shall have a rating of at least 600 V, and where the supply transformer is a step-down transformer, shall be capable of opening the circuit successfully in the event the transformer primary voltage is impressed upon them.

- e. Such supply circuits in cable meeting the requirements of Rule 6.4.1.3-1, 6.4.1.3-2 or 6.4.1.3-3 may be installed below telecommunication attachments, with not less than 400 mm vertical separation between the supply cable and the lowest telecommunication attachment. Telecommunication circuits other than those used in connection with the operation of the supply circuits shall not be carried in the same cable with such supply circuits.
- f. Where such supply conductors are carried below telecommunication conductors, transformers and other apparatus associated therewith shall be attached only to the sides of the support arm in the space between and at no higher level than such supply wires.
- g. Lateral runs of such supply circuits carried in a position below the telecommunication space shall be protected through the climbing space by wood molding or equivalent covering, or shall be carried in insulated multiple-conductor cable, and such lateral runs shall be placed on the underside of the support arm.

6.3.1.3 Relative levels:

Supply lines of different voltage classifications (0 to 750 V, over 750 V to 8.7 kV, over 8.7 kV to 22 kV, over 22 kV to 50 kV, and over 50 kV)

A. At crossings or conflicts

Where supply conductors of different voltage classifications cross each other or structure conflict exists, the higher-voltage lines should be carried at the higher level.

B. On structures used only by supply conductors

Where supply conductors of different voltage classifications are on the same structures, relative levels should be as follows:

- a. Where all circuits are owned by one utility, the conductors of higher voltage should be placed above those of lower voltage.
- b. Where different circuits are owned by separate utilities, the circuits of each utility may be grouped together, and one group of circuits may be placed above the other group provided that the circuits in each group are located so that those of higher voltage are at the higher levels and that any of the following conditions is met:
 - (1) A vertical clearance of not less than that required by Table 6-18 is maintained between the nearest line conductors of the respective utilities.
 - (2) Conductors of a lower voltage classification placed at a higher level than those of a higher classification shall be placed on the opposite side of the structure.
 - (3) Ownership and voltage are prominently displayed.

6.3.1.4 Identification of overhead conductors

All conductors of electric supply and telecommunication lines should, as far as is practical, be arranged to occupy uniform positions throughout, or shall be constructed, located, marked, numbered, or attached to distinctive insulators or cross-arms, so as to facilitate identification by employees authorized to work thereon. This does not prohibit systematic transposition of conductors.

6.3.1.5 Identification of equipment on supporting structures

All equipment of electric supply and telecommunication lines should be arranged to occupy uniform positions throughout or shall be constructed, located, marked, or numbered so as to facilitate identification by employees authorized to work thereon.

6.3.2 Avoidance of conflict

Two separate lines, either of which carries supply conductors, should be so separated from each other that neither conflicts with the other.

EXCEPTION: If elimination of conflict is not practical, should be so separated as far as practical and shall be built to the grade of construction required by Rule 6.5 for a conflicting line, or the two lines shall be combined on the same structure.

6.3.3 Joint use of structures

Joint use of structures should be considered for circuits along highways, roads, streets, and alleys. The choice between joint use of structures and separate lines shall be determined through cooperative consideration of all the factors involved, including the character of circuits, the total number and weight of conductors, tree conditions, number and location of branches and service drops, structure conflicts, availability of right-of-way, etc. Where such joint use is mutually agreed upon, it shall be subject to the appropriate grade of construction specified in Rule 6.5.

6.3.4 Telecommunications protective requirements

6.3.4.1 Where required

Where telecommunication apparatus is handled by other than qualified persons, it shall be protected by one or more of the means listed in Rule 6.3.4.2 if such apparatus is permanently connected to lines subject to any of the following:

1. Lightning
2. Contact with supply conductors whose voltage to ground exceeds 300 V
3. Transient rise in ground potential exceeding 300 V
4. Steady-state induced voltage of a hazardous level

Where telecommunication cables will be in the vicinity of supply stations where large ground currents may flow, the effect of these currents on telecommunication circuits should be evaluated.

NOTE: Additional information may be obtained from IEEE Stds 487TM-2007 and IEEE Std. 1590TM-2003.

6.3.4.2 Means of protection

Where telecommunication apparatus is required to be protected Rule 6.3.4.1, protective means adequate to withstand the voltage expected to be impressed shall be provided by insulation, protected where necessary by surge arresters used in conjunction with fusible elements. Severe conditions may require the use of additional devices such as auxiliary arresters, drainage coils, neutralizing transformers, or isolating devices.

6.3.5 Telecommunication circuits located within the supply space and supply circuits located within the telecommunication space

6.3.5.1 Telecommunication circuits located in the supply space

1. Telecommunication circuits located in the supply space shall be installed and maintained only by personnel authorized and qualified to work in the supply space in accordance with the applicable rules (see relevant work rules of Section 9).
2. Telecommunication circuits located in the supply space shall meet the following clearance requirements, as applicable:
 - a. Insulated telecommunication cables supported by an effectively grounded messenger shall have the same clearances as neutrals meeting Rule 6.4.1.5 from telecommunication circuits located in the telecommunication space and from supply conductors located in the supply space. See Rules 6.4.6 and 6.4.9.
 - b. Fiber-optic cables located in the supply space shall meet the requirements of Rule 6.4.1.5.
 - c. Open-wire telecommunication circuits permitted by other rules to be in the supply space shall have the same clearances from telecommunication circuits located in the telecommunication space and from other circuits located in the supply space as required by Rule 6.4.6 for ungrounded open supply conductors of 0–750 V.

EXCEPTION: Service drops meeting Rules 6.3.5.1-3a and 6.3.5.1-3b may originate in the supply space on a line structure or in the span and terminate in the telecommunication space on the building or structure being served.

3. Telecommunication circuits located in the supply space in one portion of the system may be located in the telecommunication space in another portion of the system if the following requirements are met:
 - a. Where the telecommunication circuit is, at any point, located above an energized supply conductor or cable, the telecommunication circuit shall be protected by fuseless surge arresters, drainage coils, or other suitable devices to limit the normal telecommunication circuit voltage to 400 V or less to ground.

NOTE: The grades of construction for telecommunication conductors with inverted levels apply.

- b. Where the telecommunication circuit is always located below the supply conductors, the telecommunication protection shall meet the requirements of Rule 6.3.4.

- c. The transition(s) between the supply space and the telecommunication space shall occur on a single structure; no transition shall occur between line structures.

EXCEPTION: Service drops meeting Rules 6.3.5.1-3a and 6.3.5.1-3b may originate in the supply space on a line structure or in the span and terminate in the telecommunication space on the building or structure being served.

- d. The construction and protection shall be consistently followed throughout the extent of such section of the telecommunications system.

6.3.5.2 Supply circuits used exclusively in the operation of telecommunication circuits

Circuits used for supplying power solely to apparatus forming part of a telecommunications system shall be installed as follows:

1. Open-wire circuits shall have the grades of construction, clearances, insulation, etc., prescribed elsewhere in these rules for supply or telecommunication circuits of the voltage concerned.
2. Special circuits operating at voltages in excess of 90 V ac or 150 V dc and used for supplying power solely to telecommunications equipment may be included in telecommunication cables under the following conditions:
 - a. Such cables shall have a conductive sheath or shield that is effectively grounded, and each such circuit shall be carried on conductors that are individually enclosed with an effectively grounded shield.
 - b. All circuits in such cables shall be owned or operated by one party and shall be maintained only by qualified personnel.
 - c. Supply circuits included in such cables shall be terminated at points accessible only to qualified personnel.
 - d. Telecommunication circuits brought out of such cables, if they do not terminate in a repeater station or terminal office, shall be protected or arranged so that in the event of failure within the cable, the voltage on the telecommunication circuit will not exceed 400 V to ground.
 - e. Terminal apparatus for the power supply shall be so arranged that the live parts are inaccessible when such supply circuits are energized.

EXCEPTION: The requirements of Rule 6.3.5.2-2 do not apply to telecommunication circuits where the transmitted power does not exceed 150 W.

6.3.6 Electric railway construction

6.3.6.1 Trolley-contact conductor fastenings

All overhead trolley-contact conductors shall be supported and arranged so that the breaking of a single contact conductor fastening will not allow the trolley conductor live span wire, or current carrying connection, to come within 3.0 m (measured vertically) from the ground, or from any platform accessible to the general public.

Span-wire insulation for trolley-contact conductors shall comply with Rule 6.8.9.2.

6.3.6.2 High-voltage contact conductors

Trolley-contact conductors energized at more than 750 V shall be suspended in such a way that, if broken at one point, the conductor will not come within 3.6 m (measured vertically) of the ground, or any platform accessible to the public.

6.3.6.3 Third rails

Third rails shall be protected by adequate guards composed of wood or other suitable insulating material.

EXCEPTION: This rule does not apply where third rails are on fenced right-of-way.

6.3.6.4 Prevention of loss of contact at railroad crossings at grade

At crossings at grade with other railroads or other electrified railway systems, contact conductors shall be arranged as set forth in the following specifications 1, 2, 3, 4, and 5, following whichever apply:

1. Where the crossing span exceeds 30 m catenary construction shall be used for overhead trolley-contact conductors.
2. When pole trolleys, using either wheels or sliding shoes, are used:
 - a. The trolley-contact conductor shall be provided with live trolley guards of suitable construction; or
 - b. The trolley-contact conductor should be at a uniform height above its own track throughout the crossing span and the next adjoining spans. Where it is not practical to maintain a uniform height, the change in height shall be made in a gradual manner.

EXCEPTION: Rule 6.3.6.4 does not apply where the crossing is protected by signals or interlocking.

3. When collectors of the pantograph type are used, the contact conductor and track through the crossing should be maintained in a condition where the rocking of pantograph-equipped cars or locomotives will not de-wire the pantograph. If this cannot be done, auxiliary contact conductors shall be installed. Wire height shall conform to Rule 6.3.6.4.
4. Where two electrified tracks cross:
 - a. When the trolley-contact conductors are energized from different supply circuits, or from different phases of the same circuit, the trolley-conductor crossover shall be designed to insulate both conductors from each other. The design shall not permit either trolley collector to contact any conductor or part energized at a different voltage than at which it is designed to operate.
 - b. Trolley-contact crossovers used to insulate trolley conductors of the same voltage but of different circuit sections shall be designed to limit the likelihood of both sections being simultaneously contacted by the trolley collector.

5. When third rail construction is used, and the length of the third rail gap at the crossings is such that a car or locomotive stopping on the crossing can lose propulsion power, the crossing shall be protected by signals or interlocking.

6.3.6.5 Guards under bridges

Trolley guards of suitable construction shall be provided where the trolley-contact conductor is so located that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

6.4 Clearances

6.4.1 General

6.4.1.1 Application

This section covers all clearances, including climbing spaces, involving overhead supply and telecommunication lines.

A. Permanent and temporary installations

The clearances of Rule 6.4 are required for permanent and temporary installations.

B. Emergency installations

The clearances required in Rule 6.4 may be decreased for emergency installations if the following conditions are met.

NOTE: See Rule 1.6.

- a. Open supply conductors of 0 to 750 V and supply cables meeting Rule 6.4.1.3; and telecommunication conductors and cables, guys, messengers, and neutral conductors meeting Rule 6.4.1.5-1 shall be suspended not less than 4.8 m above areas where trucks are expected, or 2.70 m above areas limited to pedestrians or restricted traffic only where vehicles are not expected during the emergency, unless Rule 6.4 permits lesser clearances.

For the purpose of this rule, trucks are defined as any vehicle exceeding 2.5 m in height. Areas not subject to truck traffic are areas where truck traffic is neither normally encountered nor reasonably anticipated or is otherwise limited.

Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals., vehicles, or other mobile units exceeding 2.5 m in height are prohibited by regulation or permanent terrain configurations or are otherwise neither normally encountered nor reasonably anticipated or are otherwise limited.

- b. Vertical clearances of open supply conductors above 750 V shall be increased above the applicable value of Rule 6.4.1.1-Ba as appropriate for the voltage involved and the given local conditions.

- c. Reductions in horizontal clearances permitted by this rule shall be in accordance with accepted good practice for the given local conditions during the term of the emergency.
- d. Supply and telecommunication cables may be laid directly on grade if they are guarded or otherwise located so that they do not unduly obstruct pedestrian or vehicular traffic and are appropriately marked. Supply cables operating above 600 V shall meet either Rule 6.4.1.3 or Rule 7.6.1-B.
- e. No clearance is specified for areas where access is limited to qualified personnel only.

C. Measurement of clearance and spacing

Unless otherwise stated, all clearances shall be measured from surface to surface and all spacings shall be measured center to center. For clearance measurement, live metallic hardware electrically connected to supply line conductors and telecommunication equipment connected to telecommunication line conductors shall be considered a part of the line conductors. Metallic bases of potheads, surge arresters, and similar devices shall be considered a part of the supporting structure.

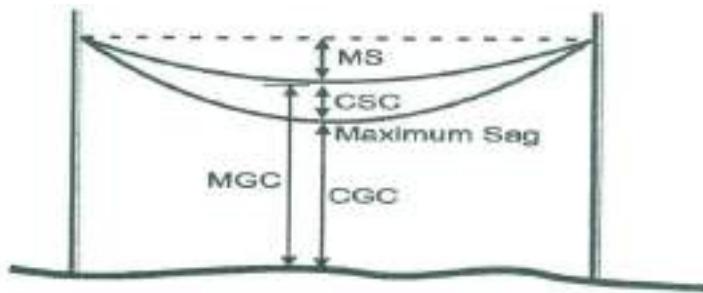
D. Rounding of calculation results

Unless otherwise specified in a table or rule within Rule 6.4, clearance specifications that require a calculation to determine the required clearances shall have the resultant of the calculation rounded up to the same level of decimal places as the basic value shown in the rule or table, regardless of the numbers of significant digits of individual values required to be used in the calculation.

If a calculated clearance is allowed a reduction by footnotes or *EXCEPTIONS*, the resultant calculation shall be rounded up before the reduction is applied, and the resultant calculation after the reduction is applied shall also be rounded up.

EXCEPTION 1: when determining a clearance at specified conditions based on field measurements, the resultant calculation shall be rounded down.

Example: Rounding of calculated grounds clearance at maximum sag



MGC = measured ground clearance = 5.69 m

MS = measured sag @ 28°C conductor temperature = 0.66 m

CSC = calculated sag change from 28°C to maximum sag due to thermal or ice loading = 0.77 m

CGC = calculated ground clearance at maximum sag = 4.92m

= 4.9 m when rounded down to the next 0.1 m

Actual clearance aboveground was measured to be 5.69 m when the conductor was measured to be at 28 °C. The sag at that conductor temperature was measured to be 0.66 m. The measured sag, conductor temperature, and span length were used in sag and tension software to calculate the change in sag from the measured condition to the maximum sag produced by either ice loading or maximum conductor temperature. The change in sag from the measured conditions to the maximum sag condition was calculated to be 0.77 m. Thus, the ground clearance when the maximum sag is calculated to be 5.69 m - 0.77 m = 4.92 m

Since the clearances of Table 6-3 are specified in 0.1 m increments, the calculated clearance 4.92 m must be rounded down to the next lower 0.1 m 4.9 m and compared to the required clearance to determine if the code requirements are met. For example, if this conductor was an effectively grounded supply neutral conductor meeting Rule 6.4.1.5-1, crossing a field, it would meet the 4.7 m required for neutral over a field when a final sag that is required by Table 6-3, row 4, other lands. However if the conductor were a primary voltage supply conductor of 7200 V to ground , the clearance would not meet the 5.6 m required at maximum sag by the same table and row for that voltage.

EXCEPTION 2: Rules or table with values in millimeter are shown in units of 5 mm; as a result, resultant of calculations to be expressed in millimeters shall be rounded up to the next multiple of 5 mm.

6.4.1.2 Ice and wind loading for clearances

1. Three general degrees of loading due to weather conditions are recognized and are designated as clearance zones 1, 2, and 3.

NOTE: The localities are classified in the different zones according to the relative simultaneous prevalence of the wind velocity and thickness of ice that accumulates on wires. Zone 3 is for places where little, if any, ice accumulates on wires.

2. Table 6-1 shows the radial thickness of ice to be used in calculating sags for clearance purposes. See applicable clearance rules in Rule 6.4.
 3. Ice and wind loads are specified in Rule 6.4.1.2-1.
 - a. Where a cable is attached to a messenger, the specified loads shall be applied to both cable and messenger.
 - b. In determining wind loads on a conductor or cable without ice covering, the assumed projected area shall be that of a smooth cylinder whose outside diameter is the same as that of the conductor or cable. The force coefficient (shape factor) for cylindrical surfaces is assumed to be 1.0.
- NOTE:* Experience has shown that as the size of multi-conductor cable decreases, the actual projected area decreases, but the roughness factor increases and offsets the reduction in projected area.
- c. An appropriate mathematical model shall be used to determine the wind and weight loads on ice-coated conductors and cables. In the absence of a model developed in accordance with Rule 6.4.1.2-5, the following mathematical model shall be used:

- (1) On a conductor, lashed cable, or multiple-conductor cable, the coating of ice shall be considered to be a hollow cylinder touching the outer strands of the conductor or the outer circumference of the lashed cable or multiple-conductor cable.
 - (2) On bundled conductors, the coating of ice shall be considered as individual hollow cylinders around each sub-conductor.
 - d. It is recognized that the effects of conductor stranding or of non-circular cross section may result in wind and ice loadings more or less than those calculated according to assumptions stated in Rules 6.4.1.2-3b and 6.4.1.2-3c. No reduction in these loadings is permitted unless testing or a qualified engineering study justifies a reduction.
4. Table 6.2 shows the radial thickness of ice, wind pressures, temperatures, and additive constants to be used in calculating inelastic deformation. The load components shall be determined as follows:
- a. Vertical load component
- The vertical load on a wire, conductor, or messenger shall be its own weight plus the weight of conductors, spacers, or equipment that it supports, ice covered where required by Rule 6.4.1.2-1 and Table 6-2.
- b. Horizontal load component
- The horizontal load shall be the horizontal wind pressure determined under Rule 6.4.1.2-1 and Table 6-2, applied at right angles to the direction of the line using the projected area of the conductor or messenger and conductors, spacers, or equipment that it supports, ice covered where required by Rule 6.4.1.2-1 and Table 6-2.
- NOTE:* The projected area of the conductor or messenger is equal to the diameter of the conductor or messenger, plus ice if appropriate, multiplied by the span length (see Rule 6.6.3.2-D). See Rule 6.6.2.1-2 for force coefficient value of different surface shapes.
- c. Total load
- The total load on each wire, conductor, or messenger shall be the resultant of components in a) and b) above, calculated at the applicable temperature in Table 6-2, plus the corresponding additive constant in Table 6-2.
5. Final sag calculations shall include the effects of inelastic deformation due to both (a) initial and subsequent combined ice and wind loading, and (b) long-term material deformation (creep). See applicable sag definitions. Ice is assumed to weigh 913 kg/m³.

6.4.1.3 Supply cables

For clearance purposes, supply cables, including splices and taps, conforming to any of the following requirements are permitted lesser clearances than open conductors of the same voltage. Cables should be capable of withstanding tests applied in accordance with an applicable standard.

1. Cables that are supported on or cabled together with an effectively grounded bare messenger or neutral, or with multiple concentric neutral conductors, where any associated neutral conductor(s) meet(s) the requirements of Rule 6.4.1.5-1 and where the cables also meet one of the following:
 - a. Cables of any voltage having an effectively grounded continuous metal sheath or shield.

- b. Cables designed to operate on a multi-grounded system at 22 kV or less and having semiconducting insulation shielding in combination with suitable metallic drainage.
- 2. Cables of any voltage, not included Rule 6.4.1.3-1, covered with a continuous auxiliary semiconducting shield in combination with suitable metallic drainage and supported on and cabled together with an effectively grounded bare messenger.
- 3. Insulated, nonshielded cable operated at not over 5 kV phase to phase, or 2.9 kV phase to ground, supported on and cabled together with an effectively grounded bare messenger or neutral.

6.4.1.4 Covered conductors

Covered conductors shall be considered bare conductors for all clearance requirements except that clearance between conductors of the same or different circuits, including grounded conductors, may be reduced below the requirements for open conductors when the conductors are owned, operated, or maintained by the same party and when the conductor covering provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact between conductors or between conductors and the grounded conductor. Intermediate spacers may be used to maintain conductor clearance and to provide support.

6.4.1.5 Neutral conductors

- 1. Neutral conductors that are effectively grounded throughout their length and associated with circuits of 0 to 22 kV to ground may have the same clearances as guys and messengers.
- 2. All other neutral conductors of supply circuits shall have the same clearances as the phase conductors of the circuit with which they are associated.

6.4.1.6 Fiber-optic cable

- 1. Fiber-optic—supply cable
 - a. Cable defined as “fiber-optic—supply” supported on a messenger that is effectively grounded throughout its length shall have the same clearance from telecommunications facilities as required for a neutral conductor meeting Rule 6.4.1.5-1.
 - b. Cable defined as “fiber-optic—supply” that is entirely dielectric, or supported on a messenger that is entirely dielectric, shall have the same clearance from telecommunications facilities as required for a neutral conductor meeting Rule 6.4.1.5-1.
 - c. Fiber-optic—supply cables supported on or within messengers not meeting Rule 6.4.1.6-1a or 6.4.1.6-1b shall have the same clearances from telecommunications facilities required for such messengers.
 - d. Fiber-optic—supply cables supported on or within a conductor(s), or containing a conductor(s) or cable sheath(s) within the fiber-optic cable assembly shall have the same clearances from telecommunications facilities required for such conductors. Such clearance shall be not less than that required under Rule 6.4.1.6-1a, 6.4.1.6-1b, or 6.4.1.6-1c, as applicable.
 - e. Fiber-optic—supply cables meeting Rule 6.3.5.1-3 are considered to be telecommunication cables when located in the telecommunication space.

2. Fiber-optic—telecommunication cable

Cable defined as “fiber-optic—telecommunication” shall have the same clearance from supply facilities as required for a telecommunication messenger.

6.4.1.7 Alternating- and direct-current circuits

The rules of this section are applicable to both ac and dc circuits. For dc circuits, the clearance requirements shall be the same as those for ac circuits having the same crest voltage to ground.

NOTE: Although the corresponding crest voltage for a common sinusoidal ac circuit may be calculated by multiplying its rms value by 1.414 (square root of 2), this may not be appropriate for other type ac circuits. An example of the latter is represented by non-sinusoidal power supplies such as used in some coaxial cable type telecommunication systems.

6.4.1.8 Constant-current circuits

The clearances for constant-current circuits (such as series lighting circuits) shall be determined on the basis of their normal full-load voltage.

6.4.1.9 Maintenance of clearances and spacings

The clearances and spacing required shall be maintained at the values and under the conditions specified in Rule 6.4. The clearances of Rule 6.4 are not intended to be maintained during the course of or as a result of abnormal events such as, but not limited to, actions of others or weather events in excess of those described under Rule 6.4. Utilities are responsible for correcting known non-compliant conditions in accordance with Rule 6.2.4.1-D or Rule 6.2.4.1-E as applicable

NOTE: See Rule 1.5 to determine the applicable edition.

Table 6-1: Ice thickness for purposes of calculating clearances

	Clearance zone (for use with Rules 6.4.3, 6.4.4, 6.4.5 and 6.4.6)		
	Zone 1	Zone 2	Zone 3
Radial thickness of ice(mm)	12.5	6.4	0

Table 6-2: Ice, wind pressures, temperatures, and additive constants for purposes of calculating final inelastic deformation

	Clearance zone (for use with Rules 6.4.3, 6.4.4, 6.4.5 and 6.4.6)		
	Zone 1 Heavy ice	Zone 2 Moderate ice	Zone 3 No ice
Radial thickness of ice (mm)	12.5	6.4	0
Horizontal wind pressure (kg/m^2)	19	19	43
Temperature ($^\circ\text{C}$)	-20	-10	-1~+10
Constant to be added to the resultant (kg/m^2)	0.44	0.29	0.073

6.4.2 Clearances of supporting structures from other objects

Supporting structures, support arms, anchor guys, and equipment attached thereto, and braces shall have the following clearances from other objects. The clearance shall be measured between the nearest parts of the objects concerned.

6.4.2.1 From fire hydrants

Not less than 1.2 m.

EXCEPTION 1: Where conditions do not permit, a clearance of not less than 900 mm is allowed.

EXCEPTION 2: Clearances in Rule 6.4.2.1 may be reduced by agreement with the local fire authority and the pole owner.

6.4.2.2 From streets, roads, and highways

1. Where there are curbs: supporting structures, support arms, anchor guys, or equipment attached thereto, up to 4.6 m above the road surface shall be located a sufficient distance from the street side of the curbs to avoid contact by ordinary vehicles using and located on the traveled way. For a redirection curb, such distance shall be not less than 150 mm. For paved or concrete swale-type curbs, such facilities shall be located behind the curb.
2. Where there are no curbs, supporting structures should be located a sufficient distance from the roadway to avoid contact by ordinary vehicles using and located on the traveled way.
3. Location of overhead utility installations on roads, streets, or highways with narrow rights-of way or closely abutting improvements are special cases that must be resolved in a manner consistent with the prevailing limitations and conditions.
4. Where a governmental authority exercising jurisdiction over structure location has issued a permit for, or otherwise approved, specific locations for supporting structures, that permit or approval shall govern.

6.4.2.3 From railroad tracks

Where railroad tracks are parallel to or crossed by overhead lines, all portions of the supporting structures, support arms, anchor guys, and equipment attached thereto less than 6.6 m above the nearest track rail shall have horizontal clearances not less than the values required by Rule 6.4.2.3-1 or 6.4.2.3-2 for the situation concerned.

NOTE: See Rule 6.4.5.9.

1. Not less than 3.6 m from the nearest track rail.

EXCEPTION 1: A clearance of not less than 2.13 m may be allowed where the supporting structure is not the controlling obstruction, provided sufficient space for a driveway is left where cars are loaded or unloaded.

EXCEPTION 2: Supports for overhead trolley-contact conductors may be located as near their own track rail as conditions require. If very close, however, permanent screens on cars will be necessary to protect passengers.

EXCEPTION 3: Where necessary to provide safe operating conditions that require an uninterrupted view of signals, signs, etc., along tracks, the parties concerned shall cooperate in locating structures to provide the necessary clearance.

EXCEPTION 4: At industrial sidings, a clearance of not less than 2.13 m shall be permitted, provided sufficient space is left where cars can be loaded or unloaded.

2. The clearances of Rule 6.4.2.3-1 may be reduced by agreement with the railroad(s).

6.4.3 Vertical clearances of wires, conductors, cables, and equipment above ground, roadway, rail, or water surfaces

6.4.3.1 Application

The vertical clearances specified in Rule 6.4.3.2-A apply under the following conductor temperature and loading conditions, whichever produces the largest final sag:

1. 50 °C, no wind displacement
2. The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C, with no wind displacement
3. 0 °C, no wind displacement, with radial thickness of ice, if any, specified in Table 6-1 for the zone concerned

EXCEPTION: The conductor temperature and loading condition for trolley and electrified railroad contact conductors shall be 15 °C, no wind displacement, final unloaded sag, or initial unloaded sag in cases where these facilities are maintained approximately at initial unloaded sags.

NOTE: The phase and neutral conductors of a supply line are normally considered separately when determining the sag of each due to temperature rise.

6.4.3.2 Clearance of wires, conductors, cables, equipment, and support arms mounted on supporting structures

A. Clearance to wires, conductors, and cables

The vertical clearance of wires, conductors, and cables aboveground in generally accessible places, roadway, rail, or water surfaces, shall be not less than that shown in Table 6-3.

B. Clearance to unguarded rigid live parts of equipment

The vertical clearance above ground, roadway, or water surfaces for unguarded rigid live parts such as potheads, transformer bushings, surge arresters, and short lengths of supply conductors connected thereto, which are not subject to variation in sag, shall be not less than that shown in Table 6-4. For clearances of drip loops of service drops, see Table 6-3.

C. Clearance to support arms, switch handles, and equipment cases

The vertical clearance of switch handles, equipment cases, support arms, platforms, and braces that extend beyond the surface of the structure shall be not less than that shown in Table 6-4. These clearances do not apply to internal structural braces for latticed towers, X-braces between poles, and pole-type push braces.

D. Street and area lighting

- a. The vertical clearance of street and area lighting luminaires shall be not less than that shown in Table 6-4. For this purpose, grounded luminaire cases and brackets shall be considered as effectively grounded equipment cases; ungrounded luminaire cases and brackets shall be considered as a rigid live part of the voltage contained.

EXCEPTION: This rule does not apply to post-top mounted luminaires with grounded or entirely dielectric cases.

- b. Insulators, as specified in Rule 6.8.9.1, should be inserted at least 2.45 m from the ground in metallic suspension ropes or chains supporting lighting units of series circuits.

6.4.3.3 Additional clearances for wires, conductors, cables, and unguarded rigid live parts of equipment

Greater clearances than specified by Rule 6.4.3.2 shall be provided where required by Rule 6.4.3.3-A.

A. Voltages exceeding 22 kV

- a. For voltages between 22 and 470 kV, the clearance specified in Rule 6.4.3.2-A (Table 6-3) or Rule 6.4.3.2-B (Table 6-4) shall be increased at the rate of 10 mm per kilovolt in excess of 22 kV. For voltages exceeding 470 kV, the clearance shall be determined by the method given in Rule 6.4.3.4. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

EXCEPTION: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required above are permitted for systems with known maximum switching-surge factors (see Rule 6.4.3.4).

- b. For voltages exceeding 50 kV, the additional clearance specified in Rule 6.4.3.3-Aa shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
- c. For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means as required to limit the steady-state current due to electrostatic effects to 5 mA rms if the largest anticipated truck, vehicle, or equipment under the line were short-circuited to ground. The size of the anticipated truck, vehicle, or equipment used to determine these clearances may be less than but need not be greater than that limited by federal, state, or local regulations governing the area under the line. For this determination, the conductors shall be at final unloaded sag at 50 °C.

6.4.3.4 Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 6.4.3.2 and 6.4.3.3 may be reduced for circuits with known switching-surge factors, but shall be not less than the alternate clearance, which is computed by adding the reference height from Rule 6.4.3.4-B to the electrical component of clearance from Rule 6.4.3.4-C.

A. Sag conditions of line conductors

The vertical clearance shall be maintained under the conductor temperature and loading condition given in Rule 6.4.3.1.

B. Reference heights

The reference height shall be selected from Table 6-5.

C. Electrical component of clearance

- a. The electrical component (D) shall be computed using the following equations. Selected values of D are listed in Table 6-6.

$$D = 1.00 \left[\frac{V \cdot (PU) \cdot a}{500K} \right]^{1.667} bc \quad (m)$$

Where

V = maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

c = 1.2, the margin of safety

K = 1.15, the configuration factor for conductor-to-plane gap

b. The value of D shall be increased 3% for each 300 m in excess of 450 m above mean sea level.

c. For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means as required to limit the steady state current due to electrostatic effects to 5 mA, rms, if the largest anticipated truck, vehicle, or equipment under the line were short-circuited to ground. The size of the anticipated truck, vehicle, or equipment used to determine these clearances may be less than but need not be greater than that limited by federal, state, or local regulations governing the area under the line. For this determination, the conductors shall be at final unloaded sag at 50 °C.

D. Limit

The alternate clearance shall be not less than the clearance given in Table 6-3 computed for 98 kV ac to ground in accordance with Rule 6.4.3.4-C.

Table 6-3: Vertical clearance of wires, conductors, and cables above ground, roadway, rail, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 6.4.3.1, 6.4.3.2-A, 6.4.3.3-Aa, and 6.4.3.4-D)

Nature of surface underneath wires, conductors, or cables	Insulated telecommunication conductors and cables; messengers; overhead shield/surge-protection wires; grounded guys; ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9-1 exposed to 0 to 300V ^{⑥⑪⑯} neutral conductors meeting Rule 6.4.1.5; supply cables meeting Rule 6.4.1.3-1 (m)	Noninsulated telecommunication conductors; supply cables of 0 to 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 (m)	Supply cables over 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3; open supply conductors, 0 to 750V ^⑩ ; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9-1 exposed to over 300V to 750V ^{⑥⑯} (m)	Open supply conductors, over 750V to 22 kV; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9-1 exposed to 750V to 22kV ^{⑥⑯} (m)	Trolley and electrified railroad contact conductors and associated span or messenger wires
	0 to 750V to ground (m)	Over 750V to 22 kV to ground (m)			
Where wires, conductors, or cables over or overhang					
1. Track rails of railroads (except electrified railroads using overhead trolley conductors) ^{②⑯} _⑯	7.2	7.3	7.5	8.1	6.7 ^④ _④
2. Roads, streets, and other areas subject to truck traffic ^⑯	4.7	4.9	5.0	5.6	5.5 ^⑤ _⑤
3. Driveways, parking lots, and alleys ^⑯	4.7 ^{⑦⑯}	4.9 ^{⑦⑯}	5.0 ^⑦	5.6	5.5 ^⑤ _⑤

4. Other areas traversed by vehicles, such as cultivated, grazing, forest, and orchard lands, industrial sites, commercial sites, etc. ⁽²⁵⁾	4.7	4.9	5.0	5.6	-	-
5. Spaces and ways subject to pedestrians or restricted traffic only ⁽⁹⁾	2.9	3.6 ⁽⁸⁾	3.8 ⁽⁸⁾	4.4	4.9	5.5
6. Water areas not suitable for sailboating or where sailboating is prohibited ⁽²¹⁾	4.0	4.4	4.6	5.2	-	-

Table 6-3: (Continued)
Vertical clearance of wires, conductors, and cables above ground, roadway, rail, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems.

See Rules 6.4.3.1, 6.4.3.2-A, 6.4.3.3-Aa, and 6.4.3.4-D)

Nature of surface underneath wires, conductors, or cables	Insulated telecommunication conductors and cables; messengers; overhead shield/surge-protection wires; grounded guys; ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9-1 exposed to 0 to 300V⑥⑪⑯ neutral conductors meeting Rule 6.4.1.5; supply cables meeting Rule 6.4.1.3-1 (m)	Non-insulated telecommunication conductors; supply cables of 0 to 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 (m)	Supply cables over 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3; open supply conductors, 0 to 750V; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9-1 exposed to over 300V to 750V⑥⑯⑯ (m)	Open supply conductors, over 750V to 22 kV; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9-1 exposed to 750V to 22kV⑥⑯⑯ (m)	Trolley and electrified railroad contact conductors and associated span or messenger wires	
					0 to 750V to ground (m)	Over 750V to 22 kV to ground (m)
Where wires, conductors, or cables over or overhang						
7. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of ⑯⑰⑲⑳⑳						
a. Less than 0.08 km ²	5.3	5.5	5.6	6.2	-	-

b. Over 0.08 to 0.8 km ²	7.8	7.9	8.1	8.7	-	-
c. Over 0.8 to 8 km ²	9.6	9.8	9.9	10.5	-	-
d. Over 8 km ²	11.4	11.6	11.7	12.3	-	-
8. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sail boats	Clearance above ground shall be 1.5 m greater than in 7 above, For the type of water areas served by the launching sites					
Where wires, conductors, or cables run along and within the limits of Highways or other road rights-of-way but do not overhang the roadway						
9. Roads, streets, or alleys	4.7 (24)	4.9	5.0	5.6	5.5⑤	6.1⑤
10. Roads where it is unlikely that vehicles will be crossing under the line	4.1 (10)(12)	4.3(10)	4.4(10)	5.0	5.5⑤	6.1⑤

NOTE: The clearance value shown in the table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table B-1 to the applicable reference components of Table B-2a of Appendix B.

(1) Where subways, tunnels, or bridges require it, less clearance above ground or rails than required by Table 6-3 may be used locally. The trolley and electrified railroad contact conductor should be graded very gradually from the regular construction down to the reduced elevation.

(2) For wires, conductors, or cables crossing over mine, logging, and similar railways that handle only cars lower than standard freight cars, the clearance may be reduced by an amount equal to the difference in height between the highest loaded car handled and 6.1 m, but the clearance shall not be reduced below that required for street crossings.

(3) Does not include neutral conductors meeting Rule 6.4.1.5-1.

(4) In communities where 6.3 m has been established, this clearance may be continued if carefully maintained. The elevation of the contact conductor should be the same in the crossing and next adjacent spans. (See Rule 6.3.6.4-2 for conditions that must be met where uniform height above rail is impractical.)

(5) In communities where 4.9 m has been established for trolley and electrified railroad contact conductors 0 to 750 V to ground, or 5.5 m for trolley and electrified railroad contact conductors exceeding 750 V, or where local conditions make it impractical to obtain in the clearance given in the table, these reduced clearances may be used if carefully maintained.

(6) These clearance values also apply to guy insulators.

(7) Where the height of a residential building does not permit its service drop(s) to meet these values, the clearances over residential driveways only may be reduced to the following:

	(m)
(a) Insulated supply service drops limited to 300 V to ground	3.8
(b) Insulated drip loops of supply service drops limited to 300 V to ground	3.2
(c) Supply service drops limited to 150 V to ground and meeting Rule 6.4.1.3-1 or 6.4.1.3-3	3.6
(d) Drip loops only of service drops limited to 150 V to ground and meeting Rule 6.4.1.3-1 or 6.4.1.3-3	3.0
(e) Insulated telecommunication service drops	3.5

(8) Where the height of a residential building does not permit its service drop(s) to meet these values, the clearances may be reduced to the following:

	(m)
(a) Insulated supply service drops limited to 300 V to ground	3.2
(b) Insulated drip loops of supply service drops limited to 300 V to ground	3.2

(c) Supply service drops limited to 150 V to ground and meeting Rule 6.4.1.3-1 or 6.4.1.3-3	3.0
(d) Drip loops only of supply service drops limited to 150 V to ground and meeting Rule 6.4.1.3-1 or 6.4.1.3-3	3.0
⑨ Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horses or other large animals, vehicles, or other mobile units exceeding a total height of 2.45 m, are prohibited by regulation or permanent terrain configurations, or are otherwise not normally encountered nor reasonably anticipated.	
⑩ Where a supply or telecommunication line along a road is located relative to fences, ditches, embankments, etc., so that the ground under the line would not be expected to be traveled except by pedestrians, the clearances may be reduced to the following values:	
(m)	
(a) Insulated telecommunication conductor and telecommunication cables	2.9
(b) Conductors of other telecommunication circuits	2.9
(c) Supply cables of any voltage meeting Rule 6.4.1.3-1 and neutral conductors meeting Rule 6.4.1.5-1	2.9
(d) Insulated supply conductors limited to 300 V to ground	3.8
(e) Insulated supply cables limited to 150 V to ground meeting Rule 6.4.1.3-2 or 6.4.1.3-3	3.1
(f) Grounded guys, guys meeting Rule 6.8.9-1 and 6.2.5.3-E exposed to 0 to 300 V	2.9

- ⑪ No clearance from ground is required for anchor guys not crossing tracks, rails, streets, driveways, roads, or pathways.
- ⑫ This clearance may be reduced to 4.0 m for telecommunication conductors and guys.
- ⑬ Where this construction crosses over or runs along alleys, driveways, or parking lots not subject to truck traffic this clearance may be reduced to 4.6 m.
- ⑭ The portion(s) of span guys between guy insulators and the Portion (s) of anchor guys above guy insulators that are not grounded shall have Clearances based on the highest values to which they may be exposed due to slack conductor or guy.
- ⑮ The portion of anchor guys below the lowest insulator meeting Rule 6.8.9-1 and 6.2.5.3-E may have the same clearance as grounded guys.
- ⑯ Adjacent to tunnels and overhead bridges that restrict the height of loaded rail cars to less than 6.1 m, these clearances may be reduced by the difference between the highest loaded rail car handled and 6.1 m, if mutually agreed to by the parties at interest.
- ⑰ For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high water level.
- ⑱ For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.
- ⑲ The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1.6 km-long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.
- ⑳ Where an overwater obstruction restricts vessel height to less than the applicable reference height given in Table 6-3, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height, except that the reduced clearance shall be not less than that required for the surface area on the line-crossing side of the obstruction.
- ㉑ Where the concerned and relevant authority has issued a crossing permit, clearances of that permit shall govern, provided that the permit complies the minimum requirements of this code.
- ㉒ See Rule 6.4.5.9 for the required horizontal and diagonal clearances to rail cars.
- ㉓ For the purpose of this rule, trucks are defined as any vehicle exceeding 2.45 m in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.
- ㉔ Telecommunication cables and conductors may have a clearance of 5.1 m where poles are back of curbs or other deterrents to vehicular traffic.
- ㉕ The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table B-1 to the applicable Reference Component of Table B-2a of Appendix B.

(26) When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 4.8 m.

Table 6-4:
Vertical clearance of equipment cases, support arms, platforms, braces and unguarded rigid live parts above ground, roadway, or water surfaces

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations, See the definitions section for voltages of other systems.

See Rules 6.4.3.1, 6.4.3.2-A, 6.4.3.3-Aa, and 6.4.3.4-D

Nature of surface below	Nonmetallic or effectively grounded support arms, switch handles, platforms, braces, and equipment cases (m)	Unguarded rigid live parts of 0 to 750V and ungrounded cases that contain equipment connected to circuits of not more than 750V (m)	Unguarded rigid live parts of over 750V to 22 kV and ungrounded cases that contain equipment connected to circuits of over 750V to 22 kV (m)
1. Where rigid parts overhang			
a. Roads, streets, and other areas subject to truck traffic ⁽⁴⁾	4.6	4.9	5.5
b. Driveways, parking lots, and alleys	4.6	4.9 ⁽⁶⁾	5.5
c. Other areas traversed by vehicles such as cultivated, grazing, forest, and orchard lands, industrial areas, commercial areas, etc. ⁽³⁾	4.6 ⁽⁷⁾	4.9	5.5
d. Spaces and ways subject pedestrians or restricted traffic only ⁽⁵⁾	3.4 ⁽⁷⁾	3.6 ⁽¹⁾	4.3
2. Where rigid parts are along and within the limits of highways or other road rights-of-way but do not overhang the roadway			
a. Roads, streets, and alleys	4.6 ⁽⁷⁾	4.9	5.5
b. Roads where it is unlikely that vehicles will be crossing under the line	4.0 ⁽⁷⁾	4.3 ⁽²⁾	4.9
3. Water areas not suitable for sailboating or where sailboating is prohibited ⁽⁸⁾	4.3	4.4	4.6

(1) For insulated live parts limited to 150 V to ground, this value may be reduced to 3.0 m.

(2) Where a supply line along a road is limited to 300 V to ground and is located relative to fences, ditches, embankments, etc., so that the ground under the line would not be expected to be traveled except by pedestrians, this clearance may be reduced to 3.6 m.

(3) This footnote not used in this edition.

(4) For the purpose of this rule, trucks are defined as any vehicle exceeding 2.45 m in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

⑤ Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding 2.45 m in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

⑥ This clearance may be reduced to the following values for driveways, parking lots, and alleys not subject to truck traffic:

	(m)
(a) Insulated live parts limited to 300 V to ground	3.6
(b) Insulated live parts limited to 150 V to ground	3.0
⑦ Effectively grounded switch handles and supply or telecommunication equipment cases (such as fire alarm boxes, control boxes, telecommunication terminals, meters or similar equipment cases) may be mounted at a lower level for accessibility, provided such cases do not unduly obstruct a walkway.	

NOTE: See also Rule 6.4.5.10-Bc.

⑧ Where the concerned and relevant authority has issued a crossing permit, clearances of that permit shall govern, provided that the permit complies the minimum requirements of this code.

Table 6-5: Reference Heights
(See Rule 6.4.3.4-B)

Nature of surface underneath lines	(m)
a. Track rails of railroads (except railroads using overhead trolley conductors) ①	6.7
b. Streets, alleys, roads, driveways, and parking lots	4.3
c. Spaces and ways subject to pedestrians or restricted traffic only ②	3.0
d. Other lands, such as cultivated, grazing, forest, and orchard, that is traversed by vehicles	4.3
e. Water areas not suitable for sailboating or where sailboating is prohibited	3.8
f. Water areas not suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with unobstructed surface area ③④	
(1) Less than 0.08 km ² (20 acres)	4.9
(2) Over 0.08 to 0.8 km ² (20 to 200 acres)	7.3
(3) Over 0.8 to 8 km ² (200 to 2000 acres)	9.0
(4) Over 8 km ² (2000 acres)	11.0
g. In public or private land and water areas posted for rigging or launching sailboats, the reference height shall be 1.5 m greater than in "f" above, for the type of water areas serviced by the launching site	

① See Rule 6.4.5.9 for the required horizontal and diagonal clearances to rail cars.

② Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding 2.45 m in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

③ For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high water level. For other waters, the surface area shall be that enclosed by its annual high-water mark, and clearances shall be based on the normal flood level. The clearances over rivers, streams, and canals shall be based upon the largest surface area of any 1600 m long segment that includes the crossing. The clearance over a canal or similar waterway providing access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

④ Where an overwater obstruction restricts vessel height to less than the applicable reference height, the required clearance may be reduced by the difference between the reference height and the overwater obstruction height, except that the reduced clearance shall not be less than that required for the surface area on the line-crossing side of the obstruction.

Table 6-6: Electrical component of clearance in Rule 6.4.3.4-Ca

[This clearance shall be increased at the rate of 1% per 100 m excess of 450 m above mean sea level. Increase clearance to limit electrostatic effects in accordance with Rules 6.4.3.1 and 6.4.3.4-Cc]

Maximum operating voltage phase to phase (kV)	Switching-surge factor (per unit)	Switching surge (kV)	Electrical Component of clearance (m)
242	3.54 or less	700 or less	2.17①
362	2.37 or less	700 or less	2.17①
550	1.56 or less	700 or less	2.17①
	1.90	853	3.1
	2.0	898	3.3
	2.2	988	3.9
	2.4	1079	4.5
	2.6	1168	5.1
800	1.6	1045	4.3
	1.8	1176	5.2
	2.0	1306	6.2
	2.1 or more	1372 or more	6.7②

① Shall be not less than that required by Rule 6.4.3.4-D, including the altitude correction for lines above 1000 m elevation as specified in Rule 6.4.3.3-Aa.

② Shall be not less than that required by Rule 6.4.3.1 and 6.4.3.2.

6.4.4 Clearances between wires, conductors, and cables carried on different supporting structures

6.4.4.1 General

Crossings should be made on a common supporting structure, where practical. In other cases, the clearance between any two crossing or adjacent wires, conductors, or cables carried on different supporting structures shall be not less than that required by Rules 6.4.4.2 and 6.4.4.3 at any location in the spans. The clearance shall be not less than that required by application of a clearance envelope developed under Rule 6.4.4.1-B to the positions on or within conductor movement envelopes developed under Rule 6.4.4.1-A at which the two wires, conductors, or cables would be closest together. For purposes of this determination, the relevant positions of the wires, conductors, or cables on or within their respective conductor movement envelopes are those that can occur when (1) both are simultaneously subjected to the same ambient air temperature and wind loading conditions, and (2) each is subjected individually to the full range of its icing conditions and applicable design electrical loading.

Figure 6-1 is a graphical illustration of the application of Rule 6.4.4.1. Alternate methods that assure compliance with these rules may be used.

A. Conductor movement envelope

a. Development

The conductor movement envelope shall be developed from the locus of the most displaced conductor positions defined below and shown in Figure 6-2:

(1) 15 °C, no wind displacement, at both initial unloaded and final unloaded sag (conductor positions A and C).

(2) With the wire, conductor, or cable displaced from rest by a 290 Pa wind at both initial and final sag at 15 °C. The displacement of the wire, conductor, or cable shall include deflection of suspension insulators and flexible structures (conductor positions B and D).

EXCEPTION: Where the entire span is so close to a building, terrain feature, or other obstacle as to be sheltered from the wind flowing across the line in either direction, the wind pressure may be reduced to a 190 Pa wind. Trees are not considered to shelter a line.

(3) Final sag at one of the following loading conditions, whichever produces the largest sag (conductor position E):

(a) 50 °C, no wind displacement,

(b) The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C, with no wind displacement, or

(c) 0 °C, no wind displacement, with radial thickness of ice, if any, specified in Table 6-1 for the zone concerned.

b. Sag increase

No sag increase for either high operating temperatures or ice loading is required for trolley and electrified railroad contact conductors. Rule 6.4.4.1-Aa3 does not apply to these conductors.

B. Clearance envelope

The clearance envelope shown in Figure 6-3 shall be determined by the horizontal clearance (H) required by Rule 6.4.4.2 and the vertical clearance (V) required by Rule 6.4.4.3.

6.4.4.2 Horizontal clearance

1. The voltage between line Clearance requirements

The horizontal clearance between adjacent wires, conductors, or cables carried on different supporting structures shall be not less than 1.50 m. For voltages between the wires, conductors, or cables exceeding 22 kV, additional clearance of 10 mm per kV over 22 kV shall be provided. All clearances for lines over 50 kV shall be based on the maximum operating voltages.

Conductors of different circuits shall be the greater of the following:

- (1) The phasor difference between the conductors involved.

NOTE: A phasor relationship of 180° is considered appropriate where the actual phasor relationship is unknown.

- (2) The phase-to-ground voltage of the higher-voltage circuit.

EXCEPTION: The horizontal clearance between anchor guys of different supporting structures may be reduced to 150 mm and may be reduced to 600 mm between other guys, span wires, and neutral conductors meeting Rule 6.4.1.5-1.

2. For voltages exceeding 50 kV, the additional clearance specified in Rule 6.4.4.2-1 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
3. Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground.

The clearances specified in Rule 6.4.4.2-1 may be reduced for circuits with known switching-surge factors, but shall be not less than the alternate clearance derived from the computations required in Rules 6.4.6.2-Ca and 6.4.6.2-Cb.

6.4.4.3 Vertical clearance

1. Clearance requirements

The vertical clearance between any crossing or adjacent wires, conductors, or cables carried on different supporting structures shall be not less than that shown in Table 6-7.

EXCEPTION: No vertical clearance is required between wires, conductors, or cables that are electrically interconnected at the crossing.

2. Voltages exceeding 22 kV

- a. The clearance given in Table 6-7 shall be increased by the sum of the following:

For the upper-level conductors between 22 and 470 kV, the clearance shall be increased at the rate of 10 mm per kV in excess of 22 kV. For the lower-level conductors exceeding 22 kV, the additional clearance shall be computed at the same rate. For voltages exceeding 470 kV, the clearance shall be determined by the method given in Rule 6.4.4.3-3. The additional clearance shall be computed using the maximum operating voltage if above 50 kV and nominal voltage if below 50 kV.

EXCEPTION: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required above are permitted for systems with known switching-surge factors. (See Rule 6.4.4.3-3.)

- b. For voltages exceeding 50 kV, the additional clearance specified in Rule 6.4.4.3-2a shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
3. Alternate clearances for voltage exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 6.4.4.3-1 and 6.4.4.3-2 may be reduced where the higher-voltage circuit has a known switching-surge factor, but shall be not less than the alternate clearance, which is computed by adding the reference height from Rule 6.4.4.3-3a to the electrical component of clearance from Rule 6.4.4.3-3b. For these computations, telecommunication conductors and cables, guys, messengers, neutral

conductors meeting Rule 6.4.1.5-1, and supply cables meeting Rule 6.4.1.3-1 shall be considered at zero voltage.

a. Reference heights

The reference height shall be selected from Table 6-9.

b. Electrical component of clearance

- (1) The electrical component (D) shall be computed using the following equations. Selected values of D are listed in Table 6.8.

$$D = 1.00 \left[\frac{[V_H \cdot (PU) + V_L]a}{500K} \right]^{1.667} bc \quad (\text{m})$$

Where

VH = higher-voltage circuit maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

VL = lower-voltage circuit maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = higher-voltage circuit maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

c = 1.2, the margin of safety

K = 1.4, the configuration factor for conductor-to-conductor gap

- (2) The value of D calculated by Rule 6.4.4.3-3b1 shall be increased 3% for each 300 m in excess of 450 m above mean sea level.

c. Limit

The alternate clearance shall be not less than the clearance required by Rules 6.4.4.3-1 and 6.4.4.2 with the lower-voltage circuit at ground potential.

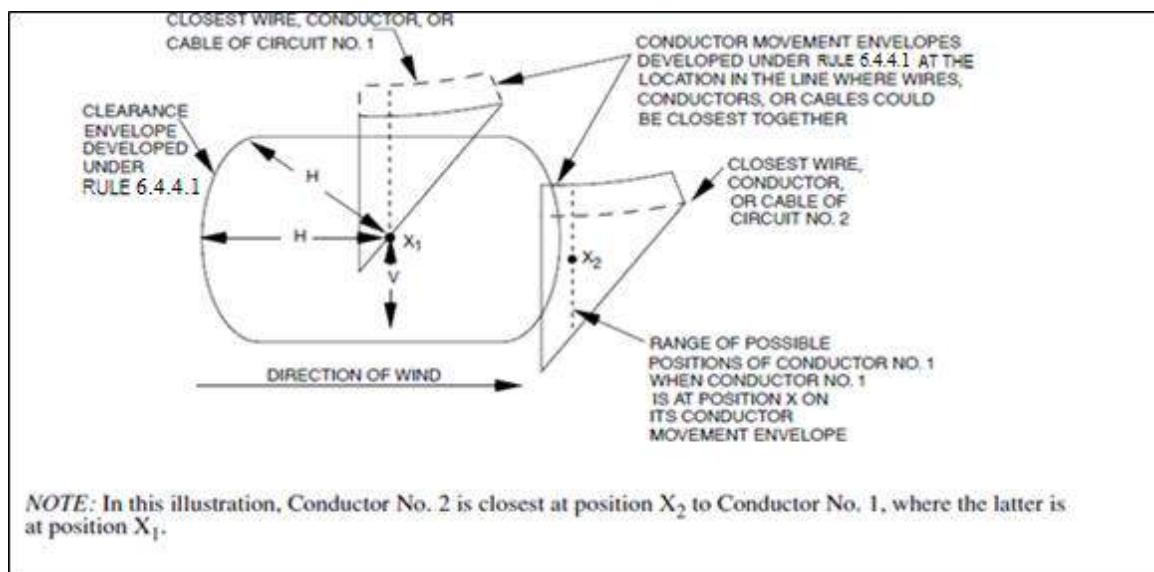


Figure 6-1: Use of clearance envelope and conductor movement envelopes to determine applicable clearance

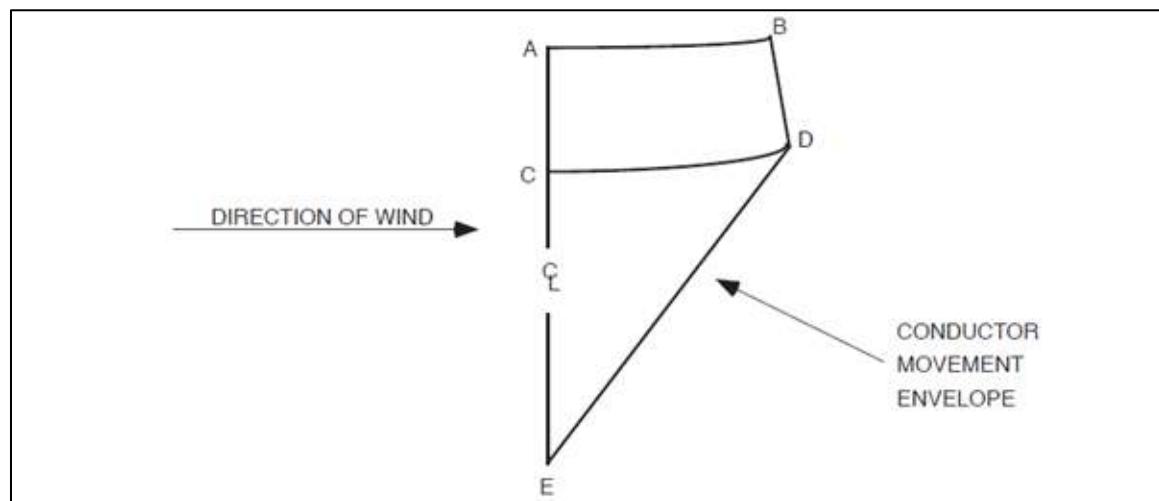


Figure 6-2: Conductor movement envelope

Point	Conductor temperature	Sag	Ice loading	Wind displacement ⁽¹⁾
A	15 °C ⁽²⁾	Initial	None	None
B	15 °C ⁽²⁾	Initial	None	290 Pa ⁽²⁾
C	15 °C ⁽²⁾	Final	None	None
D	15 °C ⁽²⁾	Final	None	290 Pa ⁽²⁾
E ₁ ^{(1) (2)}	The greater of 50 °C or maximum operating temperature	Final	None	None
E ₂ ^{(1) (2)}	0 °C	Final	As applicable	None

- ① The direction of the wind shall be that which produces the minimum distance between conductors. The displacement of the wires, conductors, or cables includes the deflection of suspension insulators and flexible structures.
- ② Where the entire span is so close to a building, terrain feature, or other obstacle as to be sheltered from the wind flowing across the line in either direction, the wind pressure may be reduced to a 19 kg/m^2 wind. Trees are not considered to shelter a line.
- ③ Point E shall be determined by whichever of the conditions described under E1 and E2 produces the greatest sag.
- ④ Line D-E shall be considered to be straight unless the actual concavity characteristics are known.
- ⑤ When one conductor movement envelope is lower than that of the other conductor, the lower envelope shall be developed with points A, B, C, and D at a conductor temperature equal to the ambient temperature used in determining E of the upper conductor movement envelope.

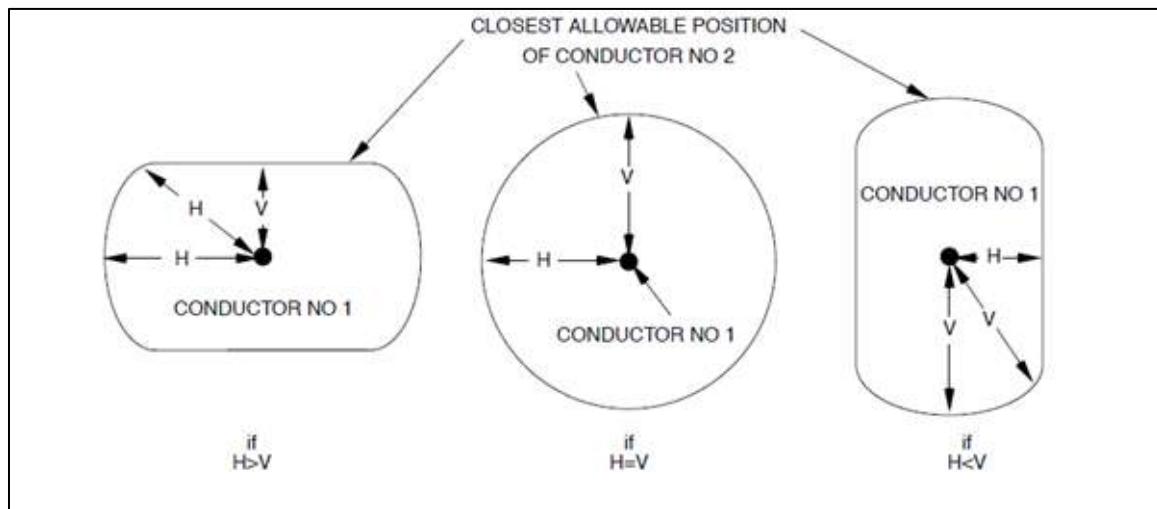


Figure 6-3: Clearance envelope

Table 6-7:

Vertical clearance between wires, conductors, and cables carried on different supporting structures

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See Rules 6.4.4.1, 6.4.4.3-1 and 6.4.4.3-2a)

Lower level	Upper level				
	Effectively grounded supply guys⑦, span wires and messengers, neutral conductors meeting Rule 6.4.1.5-1, and overhead shield/surge protection wires (m)	Supply cables meeting Rules 6.4.1.3-1, and supply cables of 0 to 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 (m)	Open supply conductors , 0 to 750V ⑥ and supply cables over 750 meeting Rules 6.4.1.3-2 or 6.4.1.3-3 (m)	Open supply conductors , over 750V to 22 kV (m)	
1. Effectively grounded supply guys⑦, span wires and messengers, neutral conductors meeting Rule 6.4.1.5-1, and overhead shield/surge protection wires	0.60①②	0.60①②	0.60②	0.60	0.60
2. Effectively grounded telecommunication guys⑦, span wires and messengers, telecommunication conductors and cables	0.60①②	0.60①	0.60	1.20⑧	1.50⑤
3. Supply cables meeting Rules 6.4.1.3-1, and supply cables of 0 to 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3	0.60	0.60	0.60	0.60	0.60
4. Open supply conductors, 0 to 750V⑥ and supply cables over 750 meeting Rules 6.4.1.3-2 or 6.4.1.3-3	1.20⑨	0.60	0.60	0.60	0.60
5. Open supply conductors, over 750V	1.50⑤⑨	0.60	0.60⑨	0.60⑨	0.60

to 22 kV					
6. Trolley and electrified railroad contact conductors and associated span and messenger wires	1.20③	1.20③	1.20③	1.20③④	1.80

- ① No clearance is specified between guys or span wires that are electrically interconnected.
- ② The clearance of telecommunication conductors and their guy, span, and messenger wires from each other in locations where no other classes of conductors are involved may be reduced by mutual consent of the parties concerned, except for fire-alarm conductors and conductors used in the operation of railroads.
- ③ Trolley and electrified railroad contact conductors of more than 750 V should have at least 1.80 m of clearance. This clearance should also be provided over lower-voltage trolley and electrified railroad contact conductors unless the crossover conductors are beyond reach of a trolley pole leaving the trolley-contact conductor or are suitably protected against damage from trolley poles leaving the trolley-contact conductor.
- ④ Trolley and electrified railroad feeders are exempt from this clearance requirement for contact conductors if they are of the same nominal voltage and of the same system.
- ⑤ This clearance may be reduced to 1.20 m where supply conductors of 750 V to 8.7 kV cross a telecommunication line more than 1.83 m horizontally from a telecommunications structure.
- ⑥ Does not include neutral conductors meeting Rule 6.4.1.5-1.
- ⑦ These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
- ⑧ This clearance may be reduced to 0.60 m for supply service drops.
- ⑨ In general, this type of crossing is not recommended.

Table 6-8: Clearance between supply wires, conductors, and cables in Rules 6.4.4.1 and 6.4.4.3-3b1

(This clearance shall be increased 3% for each 300 m in excess of 450 m above mean sea level)

Higher voltage circuit		Lower voltage circuit						
Maximum operating voltage phase to phase (kV)	Switching surge factor (per unit)	Maximum operating voltage phase to phase (kV)						
		121 (m)	145 (m)	169 (m)	242 (m)	362 (m)	550 (m)	800 (m)
242	3.3 or less	1.78①	1.84	1.91	2.16			
362	2.4	2.48①	2.48①	2.48①	2.48①	2.86		
	2.6	2.48①	2.48①	2.48①	2.67	3.2		
	2.8	2.49	2.58	2.67	3.0	3.5		
	3.0	2.76①	2.86①	3.0	3.3	3.8		
550	1.8	3.6①	3.6①	3.6①	3.6①	3.6①	4.2	
	2.0	3.6①	3.6①	3.6①	3.6①	3.8①	4.7	
	2.2	3.6①	3.6①	3.6①	3.8	4.3	5.2	
	2.4	3.8	3.9	4.0	4.3	4.8	5.8	
	2.6	4.1②	4.2②	4.4②	4.8②	5.4	6.3	
800	1.6	5.0①	5.0①	5.0①	5.0①	5.0①	5.6	6.9
	1.8	5.0①	5.0①	5.0①	5.0①	5.4	6.4	7.8
	2.0	5.0①	5.2	5.3	5.6	6.3	7.3	8.7
	2.2	5.5②	5.7②	5.8②	6.2②	6.9②	8.0②	9.4②

① Shall be not less than that required by Rule 6.4.4.3-3c, including the altitude correction for lines above 1000 m elevation as specified in Rule 6.4.4.3-2b.

② Need not be greater than the values specified in Rules 6.4.4.3-1 and 6.4.4.3-2.

Table 6-9: Reference heights

(See Rule 6.4.4.3-3a.)

Reference height	(m)
(1) Supply lines	0
(2) Telecommunication lines	0.60

6.4.5 Clearance of wires, conductors, cables, and equipment from buildings, bridges, rail cars, swimming pools, and other installations

6.4.5.1 Application

In each of Rule 6.4.5.2, 6.4.5.3, and 6.4.5.4, horizontal clearance requirements are specified for two conditions: (1) the conductor without wind displacement (at rest), and (2) the conductor with wind displacement. In each case, the clearance requirements for both conditions shall be satisfied.

A. Vertical and horizontal clearances (no wind displacement)

The vertical and horizontal clearances specified in Rules 6.4.5.2, 6.4.5.3, 6.4.5.4, 6.4.5.5, 6.4.5.6, and 6.4.5.9 apply under whichever conditions of the following conductor temperature and loading conditions produces the closest approach. Rules 6.4.5.1-Aa, 6.4.5.1-Ab, and 6.4.5.1-Ac apply above and alongside subject installations; Rule 6.4.5.1-Ad applies below and alongside subject installations.

- a. 50 °C, no wind displacement, final sag.
- b. The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C, no wind displacement, final sag.
- c. 0 °C, no wind displacement, final sag, with radial thickness of ice, if any, specified in Table 6-1 for the zone concerned.
- d. The minimum conductor temperature for which the line is designed, no wind displacement, initial sag.

EXCEPTION: Vertical or lateral conductors or cables attached directly to the surface of a supporting structure in accordance with other rules are not subject to the provisions of this rule.

NOTE: The phase and neutral conductors of a supply line are normally considered separately when determining the sag of each due to temperature rise.

B. Horizontal clearances (with wind displacement)

Where consideration of horizontal displacement under wind conditions is required, the wires, conductors, or cables shall be considered to be displaced from rest toward the installation by a 290 Pa wind at final sag at 15 °C. The displacement of a wire, conductor or cable shall include deflection of suspension insulators. The displacement of a wire, conductor, or cable shall also include deflection of a flexible structure if the highest wire, conductor, or cable attachment is 18 m or more above grade.

EXCEPTION: Where the entire span is so close to a building, terrain feature, or other obstacle as to be sheltered from the wind flowing across the line in either direction, the wind pressure may be reduced to a 190 Pa wind. Trees are not considered to shelter a line.

C. Transition between horizontal and vertical clearances

The horizontal clearance governs above the level of the roof or top of an installation to the point where the diagonal equals the vertical clearance requirement. Similarly, the horizontal clearance governs above or below projections from buildings, signs, or other installations to the point where the diagonal equals the vertical clearance requirement. From this point the transitional clearance shall equal the vertical clearance as shown in Figures 6-4(a) and 6-4(b). This rule should not be interpreted as restricting the installation of a trolley-contact conductor over the approximate center line of the track it serves.

EXCEPTION: When the horizontal clearance is greater than the vertical clearance, the vertical clearance governs beyond the roof or top of an installation, or projections from an installation, to the point where the diagonal equals the horizontal clearance requirement, as shown in Figure 6-4(c).

6.4.5.2 Clearances of wires, conductors, and cables from other supporting structures

Wires, conductors, or cables of one line passing near a lighting support, traffic signal support, or a supporting structure of a second line, without being attached thereto, shall have clearance from any part of such structure not less than the following:

NOTE: Skip-span construction: Lines where upper conductors are not attached to intermediate poles.

A. Horizontal clearances

- a. A horizontal clearance, without wind, of 1.50 m for voltages up to 50 kV.

EXCEPTION: For effectively grounded guys and messengers, insulated telecommunication conductors and cables, neutrals meeting Rule 6.4.1.5-1, and cables of 300 V or less to ground meeting the requirements of Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3, the horizontal clearance may be reduced to 900 mm.

- b. When the following conductors and cables are displaced from rest under the wind conditions of Rule 6.4.5.1-B, horizontal clearances from such conductors or cables to other supporting structures shall be not less than those shown below:

Conductor or cable	Horizontal clearance require when displaced by wind (m)
Open supply conductors, 0 to 750 V①	1.1
6.4.1.3-2 cable, above 750 V	1.1
6.4.1.3-3 cable, above 750 V	1.1
Open supply conductors, over 750 V to 22 kV	1.4

① Does not include neutral conductors meeting Rule 6.4.1.5-1.

B. Vertical clearances

A vertical clearance of 1.40 m for voltages below 22 kV and a vertical clearance of 1.70 m for voltages between 22 kV and 50 kV. *EXCEPTIONS 1 and 2* shall not be applied cumulatively.

EXCEPTION 1: For effectively grounded guys and messengers, insulated telecommunication conductors and cables, and neutrals meeting Rule 6.4.1.5-1 and for cables of 300 V or less to ground meeting the requirements of Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3, the vertical clearance may be reduced to 600 mm.

EXCEPTION 2: The vertical clearances may be reduced by 600 mm if both of the following conditions are met:

- (a) The wires, conductors, or cables above and the supporting structure of another line below are operated and maintained by the same utility

(b) Employees do not work above the top of the supporting structure unless:

- (1) The upper circuit is de-energized and grounded per relevant Rule (Section 9 Work rules) or temporarily insulated or repositioned, or
- (2) Other equivalent measures are taken.

NOTE: Clearances of wires, conductors, and cables from adjacent line structure guy wires are given in Rule 6.4.4.

6.4.5.3 Clearances of wires, conductors, cables, and rigid live parts from buildings, signs, billboards, chimneys, radio and television antennas, tanks, and other installations except bridges

A. Vertical and horizontal clearances

a. Clearances

Unguarded or accessible wires, conductors, cables, or rigid live parts may be located adjacent to buildings, signs, billboards, chimneys, radio and television antennas, tanks, and other installations and any projections therefrom. The vertical and horizontal clearances of such rigid and non-rigid parts shall be not less than the values given in Table 6-10 when at rest under the conditions specified in Rule 6.4.5.1-A. These facilities may be installed beside, over or under buildings, building projections and other installations, as illustrated in Figures 6-4(a), 6-4(b), and 6.4(c).

b. Horizontal clearances under wind displacement conditions

When the following conductors and cables are displaced from rest under the wind conditions of Rule 6.4.5.1-2, horizontal clearances from such conductors or cables to buildings, signs, billboards, chimneys, radio and television antennas, and other installations shall be not less than those shown below:

Conductor or cable	Horizontal clearance required when displaced by wind (m)
Open supply conductors, 0 to 750 V ^①	1.1
6.4.1.3-2 cable, above 750 V	1.1
6.4.1.3-3 cable, above 750 V	1.1
Open supply conductors, over 750 V to 22 kV	1.4

^① Does not include neutral conductors meeting Rule 6.4.1.5-1.

B. Guarding of supply conductors and rigid live parts

Where the clearances set forth in Table 6-10 cannot be obtained, supply conductors and rigid live parts shall be guarded. Supply cables meeting Rule 6.4.1.3-1a are considered to be guarded within the meaning of this rule.

C. Supply conductors attached to buildings or other installations

Where the permanent attachment of supply conductors of any class to a building or other installation is necessary for an entrance, such conductors shall meet the following requirements over or along the installation to which the conductors are attached:

- a. Energized service drop conductors, including splices and taps, shall be insulated or covered in accordance with the following:

- (1) For 0 to 750V, Rule 6.4.1.3 or 6.4.1.4
- (2) For over 750 V, Rule 6.4.1.3-1

This rule does not apply to neutral conductors meeting Rule 6.4.1.5-1.

- b. Conductors of more than 300 V to ground shall not be carried along or near the surface of the installation unless they are guarded or made inaccessible.
- c. Wires or cables attached to and run along side the installation shall have clearances from the surface of the installation not less than 75 mm.

EXCEPTION: For open supply circuits of 0 to 750 V and supply cables of all voltages meeting Rule 6.4.1.3-1, 6.4.1.3-2 or 6.4.1.3-3, the clearance at the attachment points may be reduced to 25mm. No clearance from the served structure is specified for such conductors anywhere else in the span where they are physically restrained by a suitable bracket from abrasion against the served structure.

- d. Service-drop conductors, including drip loops shall have a clearance of not less than the following:
- (1) 3.0 m vertical clearance from the highest point of roofs, balconies, porches, or attached decks over which they pass

EXCEPTION 1: For clearance above railings, walls, or parapets around balconies, decks, or roofs, use the clearances required for row 1b(1) of Table 6-10. For such clearances where an outside stairway exists to provide access to such balconies, decks, or roofs, use the clearances required for row 2b(2), Table 6-10.

EXCEPTION 2: Where the voltage between conductors meeting Rule 6.4.1.4 does not exceed 300 V, or where the voltage of cables meeting Rule 6.4.1.3-2 or 6.4.1.3-3 does not exceed 750 V, or where the cable meets Rule 6.4.1.3-1, and the roof, balcony, porch, or attached deck is not readily accessible, the clearance over the roof, balcony, porch, or attached deck including the drip loop shall be not less than either of the following:

- (a) 900 mm
- (b) 457 mm for a horizontal distance of 1.8 m from an approved raceway or support located not more than 1.2 m from the edge of the roof and not less than 900 mm for the remainder of the horizontal distance that the cable or conductor passes over the roof or balcony

A roof, balcony, porch, or attached deck is considered readily accessible to pedestrians if it can be casually accessed through a doorway, window, ramp, stairway, or permanently mounted ladder by a person, on foot, who neither exerts extraordinary physical effort nor employs tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its

bottom rung is 2.45 m or more from the ground or other permanently installed accessible surface.

NOTE: See Figure 6-5.

(2) 900 mm in any direction from windows, doors, porches, fire escapes, or similar locations.

(3) EXCEPTION 1: This does not apply to service-drop conductors meeting Rule 6.4.1.3-3 above the top level of a window.

(4) EXCEPTION 2: This does not apply to windows that are not designed to open.

D. Telecommunication conductors attached to buildings or other installations

Telecommunication conductors and cables may be attached directly to buildings or other installations.

E. Ladder space

Where buildings or other installations exceed three stories [or 15 m] in height, overhead lines should be arranged where practical so that a clear space or zone at least 1.8 m wide will be left either adjacent to the building or beginning not over 2.45 m from the building to facilitate the raising of ladders where necessary for firefighting.

EXCEPTION: This requirement does not apply where it is the unvarying rule of the local fire departments to exclude the use of ladders in alleys or other restricted places that are generally occupied by supply conductors and cables.

6.4.5.4 Clearance of wires, conductors, cables, and unguarded rigid live parts from bridges

A. Vertical and horizontal clearances

a. Clearances

Unguarded or accessible wires, conductors, cables, or rigid live parts may be located adjacent to or within a bridge structure. The vertical and horizontal clearances of such rigid and non-rigid parts shall be not less than the values given in Table 6-11 when at rest under the conditions specified in Rule 6.4.5.1-A, as illustrated in Figures 6-4(a) and 6-4(b).

EXCEPTION: This rule does not apply to insulated telecommunication cables, effectively grounded guys, span wires, and surge protection wires; neutrals meeting Rule 6.4.1.5-1; and supply cables meeting Rule 6.4.1.3-1.

b. Horizontal clearances under wind displacement conditions

When the following conductors and cables are displaced from rest under the wind conditions of Rule 6.4.5.1-B, horizontal clearances from such conductors or cables to bridges shall be not less than those shown below:

Conductor or cable	Horizontal clearance require when displaced by wind (m)
Open supply conductors, 0 to 750 V ^①	1.1
6.4.1.3-2 cable, above 750 V	1.1
6.3.1.3-3 cable, above 750 V	1.1
Open supply conductors, over 750 V to 22 kV	1.4

① Does not include neutral conductors meeting Rule 6.4.1.5-1.

B. Guarding trolley-contact conductors located under bridges

a. Where guarding is required

Guarding is required where the trolley-contact conductor is located so that a trolley pole leaving the conductor can make simultaneous contact between it and the bridge structure.

b. Nature of guarding

Guarding shall consist of a substantial inverted trough of non-conducting material located above the contact conductor, or of other suitable means of limiting the likelihood of contact between the trolley support and the bridge structure.

6.4.5.5 Clearance of wires, conductors, cables, or unguarded rigid live parts installed over or near swimming areas with no wind displacement

A. Swimming pools

Where wires, conductors, cables, or unguarded rigid live parts are over a swimming pool or the surrounding area, the clearances in any direction shall be not less than those shown in Table 6-12 and illustrated in Figure 6-6.

EXCEPTION 1: This rule does not apply to a pool fully enclosed by a solid or screened permanent structure.

EXCEPTION 2: This rule does not apply to telecommunication conductors and cables, effectively grounded surge-protection wires, neutral conductors meeting Rule 6.4.1.5-1, guys and messengers, supply cables meeting Rule 6.4.1.3-1, and supply cables of 0 to 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 when these facilities are 3 m or more horizontally from the edge of the pool, diving platform, diving tower, water slide, or other fixed, pool-related structures.

NOTE: For PET SAC-2014 clearance purposes, spas (including whirlpools, hot-tubs, Jacuzzis, or other similar installations not suitable for swimming) are not considered as swimming pools covered by Rule 6.4.5.5, Table 6-12. Note that this rule and table refer to swimming areas and swimming pools. Table 6-10 clearance allow for use of skimmer and rescue poles.

Spas, etc., not suitable for swimming, are usually installed as part of the building or a similar installation. Clearances for such installations are found in Table 6-10. Vertical clearance should be from the highest point of the installation upon which people can stand. See row 1, Buildings, in Table 6-10 for installations that are part of buildings, such as a raised spa on an open deck. See row 2, other installations, in Table 6-10 for free-standing installations.

For portable wading pools, see Table 6-3, row 5.

B. Beaches and waterways restricted to swimming

Where rescue poles are used by lifeguards at supervised swimming beaches, the vertical and horizontal clearances shall be not less than those shown in Table 6-12. Where rescue poles are not used, the clearances shall be as specified in Rule 6.4.3.

C. Waterways subject to water skiing

The vertical clearance shall be the same as that specified in Rule 6.4.3.

6.4.5.6 Clearances of wires, conductors, cables, and rigid live parts from grain bins

A. Grain bins loaded by permanently installed augers, conveyers, or elevator systems

All portions of grain bins that are expected to be loaded by the use of a permanently installed auger, conveyer, or elevator system shall be considered as a building or other installation under Rule 6.4.5.3 for the purpose of determining appropriate clearances of wires, conductors, cables, and rigid live parts. In addition, the following clearances shall also apply without wind displacement. See Figure 6-7(a).

- a. A clearance of not less than 5.5 m in all directions above the grain bin shall be maintained from each probe port in the grain bin roof for all wires, conductors, and cables.
- b. A horizontal clearance of not less than 4.6 m shall be maintained between grain bins and open supply conductors, 0 to 22 kV. This clearance does not apply to a neutral conductor meeting Rule 6.4.1.5-1.

B. Grain bins loaded by portable augers, conveyers, or elevators (with no wind displacement)

- a. The clearance of wires, conductors, cables, and rigid live parts from grain bins that are expected to be loaded by the use of a portable auger, conveyer, or elevator shall be not less than the values illustrated in Figure 6-7(b).

EXCEPTION: Clearances of the following items on the nonloading side of grain bins shall be not less than those required by Rule 6.4.5.3 for clearances from buildings:

- (a) Support arms; effectively grounded equipment cases
 - (b) Insulated telecommunication conductors and cables, messengers, surge-protection wires, grounded guys, neutral conductors meeting Rule 6.4.1.5-1, and supply cables meeting Rule 6.4.1.3-1.
 - (c) Supply cables of 0 to 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3
- b. Any side of a grain bin is considered to be a nonloading side if it is so designated, or if it is so closely abutting another structure or obstruction, or so close to a public road or other right-of-way that a portable auger, conveyor, or elevator is not reasonably anticipated to be used over that side or portion to fill the grain bin.

- c. Where an agreement excludes the use of portable augers, conveyors, or elevators from a designated portion of a grain bin, such portion is considered to be a nonloading side.

6.4.5.7 Additional clearances for voltages exceeding 22 kV for wires, conductors, cables, and unguarded rigid live parts of equipment.

Greater clearances than specified in Rules 6.4.5.2, 6.4.5.3, 6.4.5.4, 6.4.5.5, 6.4.5.6, and 6.4.5.10 shall be provided where required as follows:

1. For voltages between 22 and 470 kV, the clearance specified in Rules 6.4.5.2, 6.4.5.3, 6.4.5.4, 6.4.5.5, 6.4.5.6, and 6.4.5.10 shall be increased at the rate of 10 mm per kV in excess of 22 kV. For voltages exceeding 470 kV, the clearance shall be determined by the method given in Rule 6.4.5.8. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

EXCEPTION 1: Where a clearance value is given for the 22 kV to 50 kV range, the voltage adder of Rule 6.4.5.7-1 applies to the voltage in excess of 50 kV.

EXCEPTION 2: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required above are permitted for systems with known maximum switching-surge factor. (See Rule 6.4.5.8)

2. For voltages exceeding 50 kV, the additional clearance specified in Rule 6.4.5.7-1 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
3. For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means, as required, to limit the steady-state current due to electrostatic effects to 5 mA, rms, if an ungrounded metal fence, building, sign, billboard, chimney, radio or television antenna, tank or other installation, or any ungrounded metal attachments thereto, were short-circuited to ground. For this determination, the conductor shall be at final unloaded sag at 50 °C or the maximum conductor temperature for which the line is designed to operate.

6.4.5.8 Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 6.4.5.2, 6.4.5.3, 6.4.5.4, 6.4.5.5, 6.4.5.6, 6.4.5.7 and 6.4.5.10 may be reduced for circuits with known switching-surge factors, but shall be not less than the alternate clearance, which is computed by adding the reference distance from Rule 6.4.5.8-B to the electrical component of clearance from Rule 6.4.5.8-C.

A. Sag conditions of line conductors

The vertical, horizontal, and diagonal clearances shall be maintained under the conductor temperature and loading conditions given in Rule 6.4.5.1.

B. Reference distances

The reference distance shall be selected from Table 6-14.

C. Electrical component of clearance

- a. The electrical component (D) shall be computed using the following equations. Selected values of D are listed in Table 6-13.

$$D = 1.00 \left[\frac{V.(PU).a}{500K} \right]^{1.667} bc \quad (\text{m})$$

where

V = maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

c = the margin of safety:

1.2 for vertical clearances

1.0 for horizontal clearances

K = 1.15, the configuration factor for conductor-to-plane gap

- b. The value of D shall be increased 3% for each 300 m in excess of 450 m above mean sea level.

D. Limit

The alternate clearance shall be not less than the clearance of Rule 6.4.5.2, Table 6-10, 6-11, or 6-12, as applicable, computed for 98 kV ac rms to ground by Rule 6.4.5.7-1.

6.4.5.9 Clearance of wires, conductors, and cables to rail cars

Where overhead wires, conductors, or cables run along railroad tracks, the clearance in any direction shall be not less than that shown in Figure 6-8. The values of V and H are as defined as follows:

V = vertical clearance from the wire, conductor, or cable above the top of the rail as specified in Rule 6.4.3 minus 6.1 m, the assumed height of the rail car

H = horizontal clearance from the wire, conductor, or cable to the nearest rail, which is equal to the required vertical clearance above the rail minus 4.6 m as computed by the lesser of the following:

1. Rules 6.4.3.2-A and 6.4.3.3-A

2. Rule 6.4.3.4

These clearances are computed for railroads handling standard rail cars as common carriers in interchange service with other railroads. Where wires, conductors, or cables run along mine, logging, and similar railways that handle only cars smaller than standard freight cars, the value of H may be reduced by one-half the difference between the width of a standard rail car (3.3 m) and the width of the narrower car.

6.4.5.10 Clearance of equipment mounted on supporting structures

A. Clearance to unguarded rigid live parts of equipment

The horizontal and vertical clearances of unguarded rigid live parts such as potheads, transformer bushings, surge arresters, and short lengths of supply conductors connected thereto, which are not subject to variation in sag, shall be not less than those required by Rule 6.4.5.3 or 6.4.5.4, as applicable.

B. Clearance to equipment cases

Equipment shall be mounted so that clearances are not less than that given by Rules 6.4.5.10-Ba, 6.4.5.10.Bb, and 6.4.5.10-Bc.

- a. Effectively grounded equipment cases may be located on or adjacent to buildings, bridges, or other structures provided that clearances for unguarded rigid live parts of such equipment, as specified in Rule 6.4.5.10-A, are maintained.
- b. Equipment cases that are not effectively grounded shall be located so that the clearances of Rule 6.4.5.3 or 6.4.5.4, as applicable, are maintained.
- c. Equipment cases shall be located so as not to serve as a means of approach to unguarded rigid live parts by unqualified persons.

NOTE: Rule 6.4.5.10 is not subject to the loading conditions of Rule 6.4.5.1.

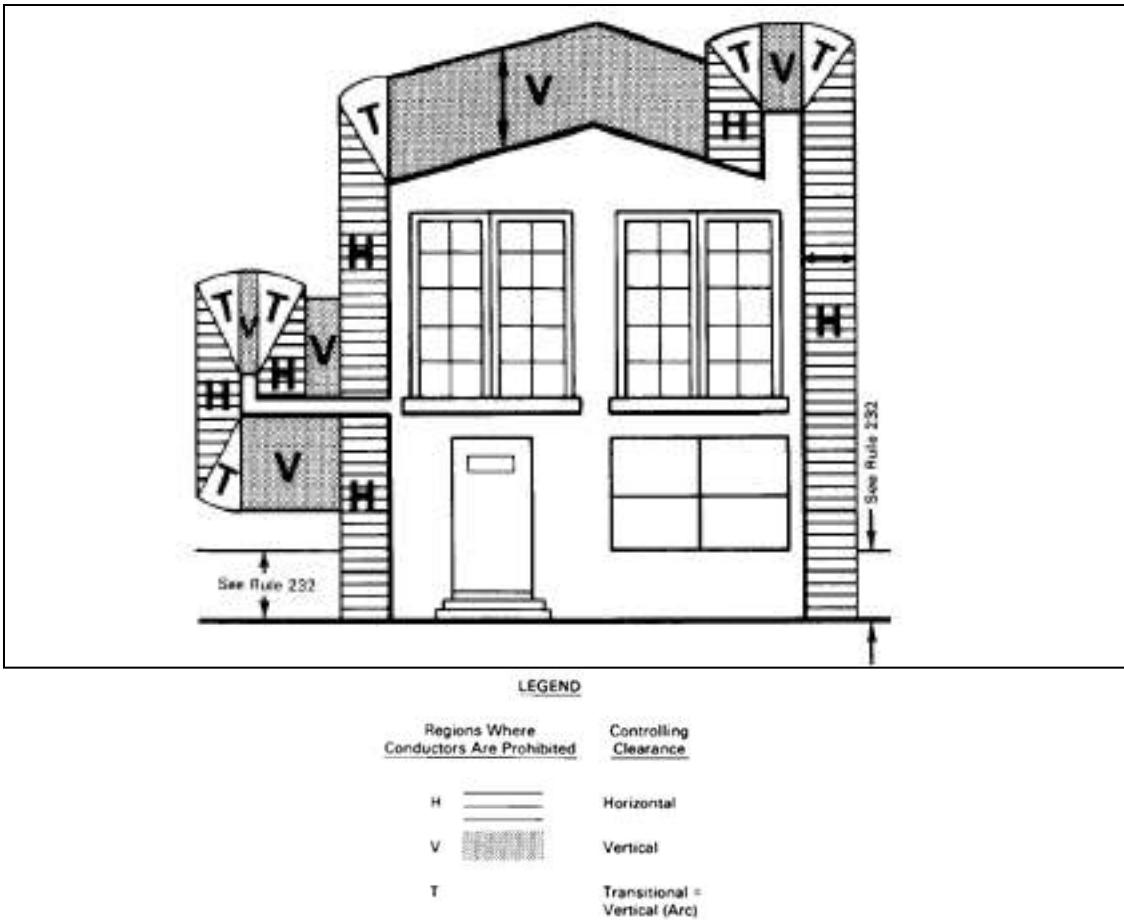


Figure 6-4 (a): Clearance diagram for building

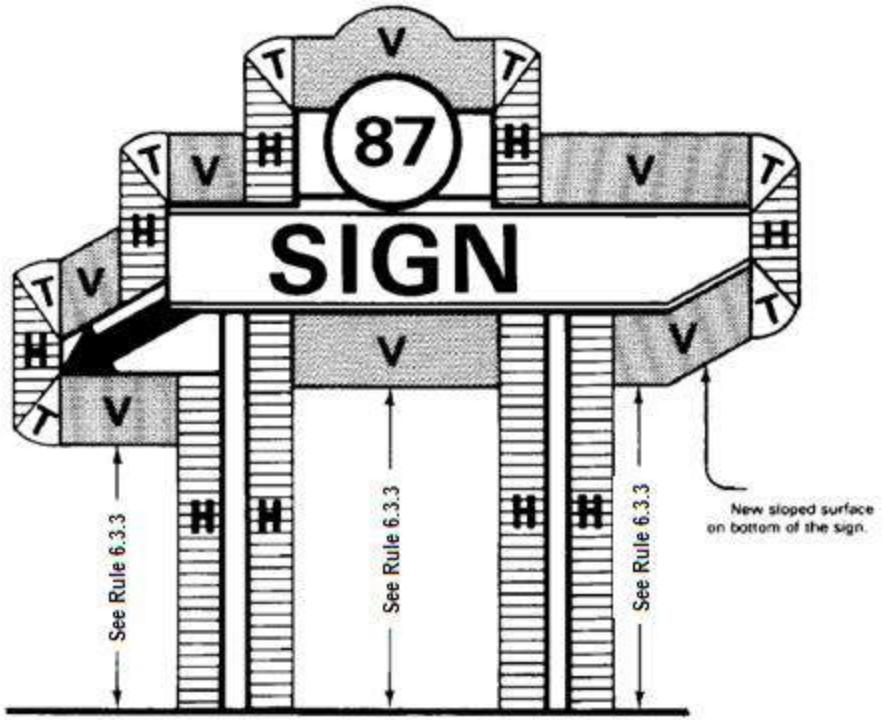


Figure 6-4 (b): Clearance diagram for other structures

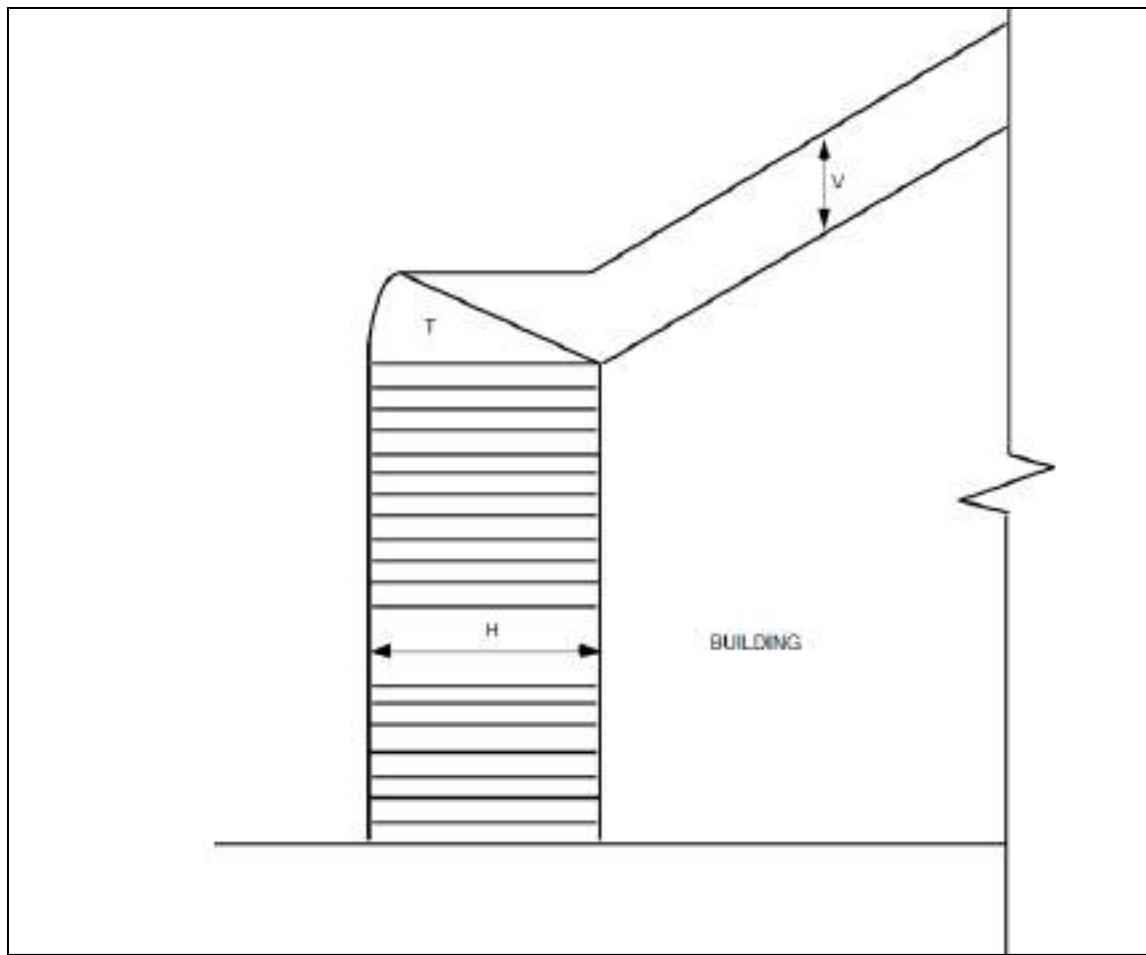
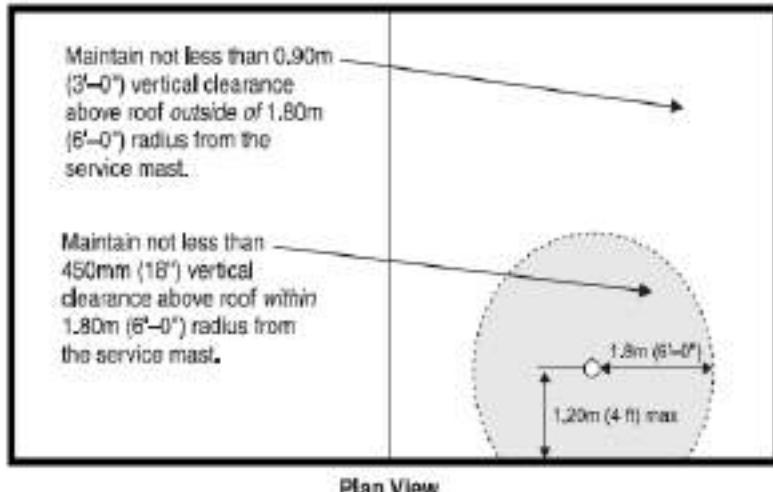
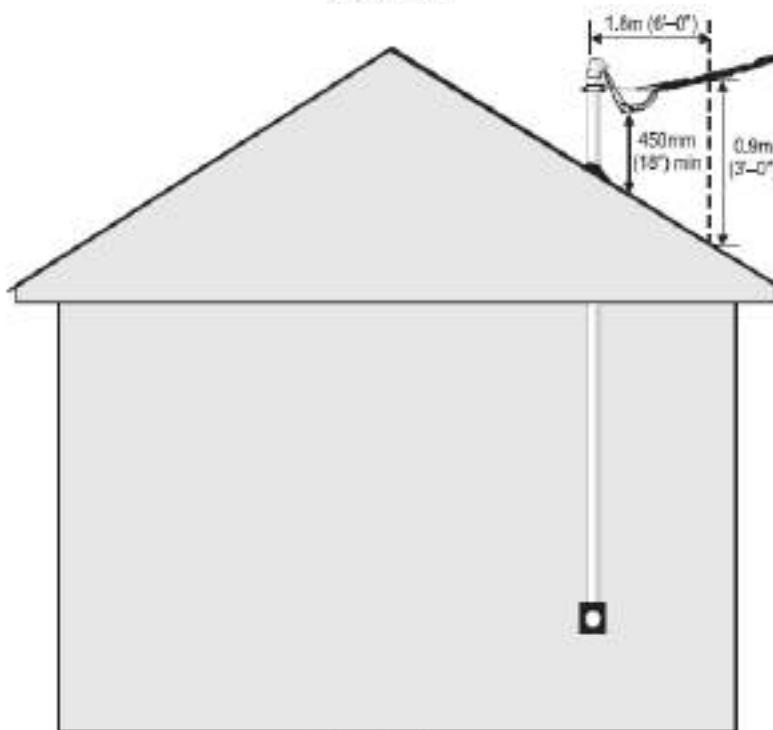


Figure 6-4 (c): Transitional clearance when H is greater than V



Plan View



Elevation View

Figure 6-5: Clearances of service drop terminating on support mast

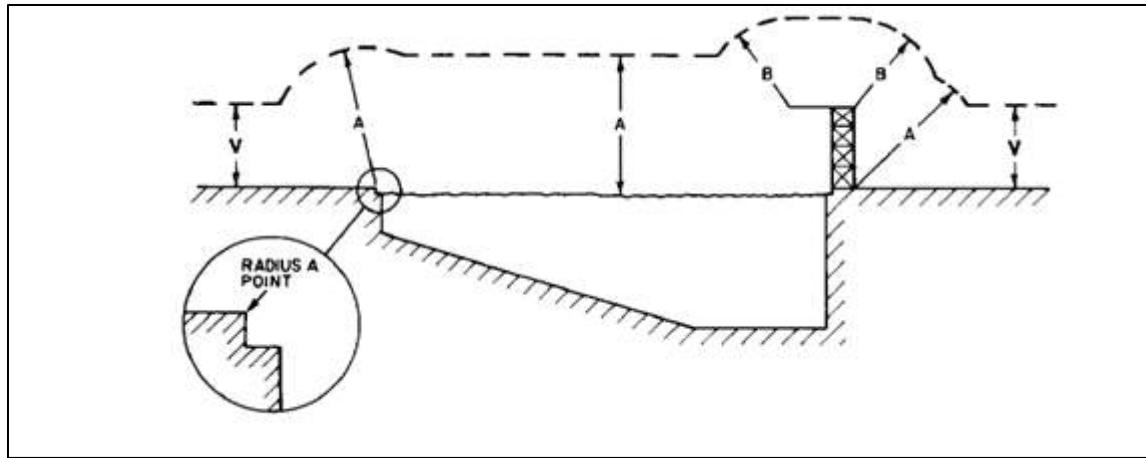


Figure 6-6: Swimming pole clearances

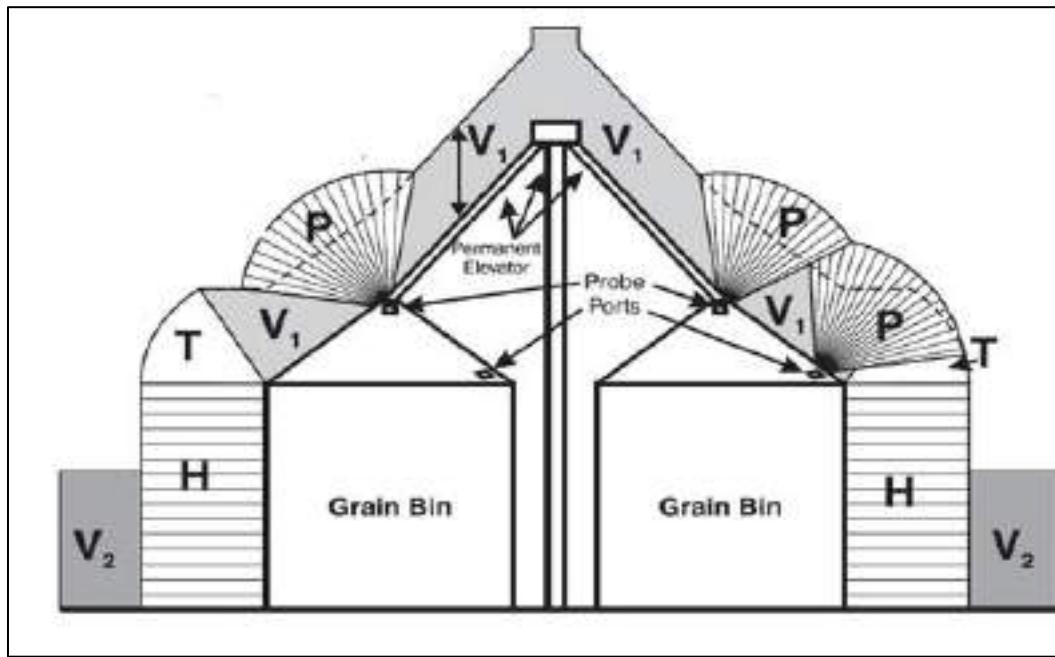


Figure 6-7 (a): Clearance envelope for grain bins filled by permanently installed augers, conveyors or elevators

Legend

P = probe clearance 5.5 m required by Rule 6.4.5.6-Aa

H = horizontal clearance 4.6 m required by Rule 6.4.5.6-Ab

T = transitional clearance

V₁ = vertical clearance above a building required by Rule 6.4.5.3 (Table 6-10)

V₂ = vertical clearance above a building required by Rule 6.4.4.2 (Table 6-3 or Table 6-4)

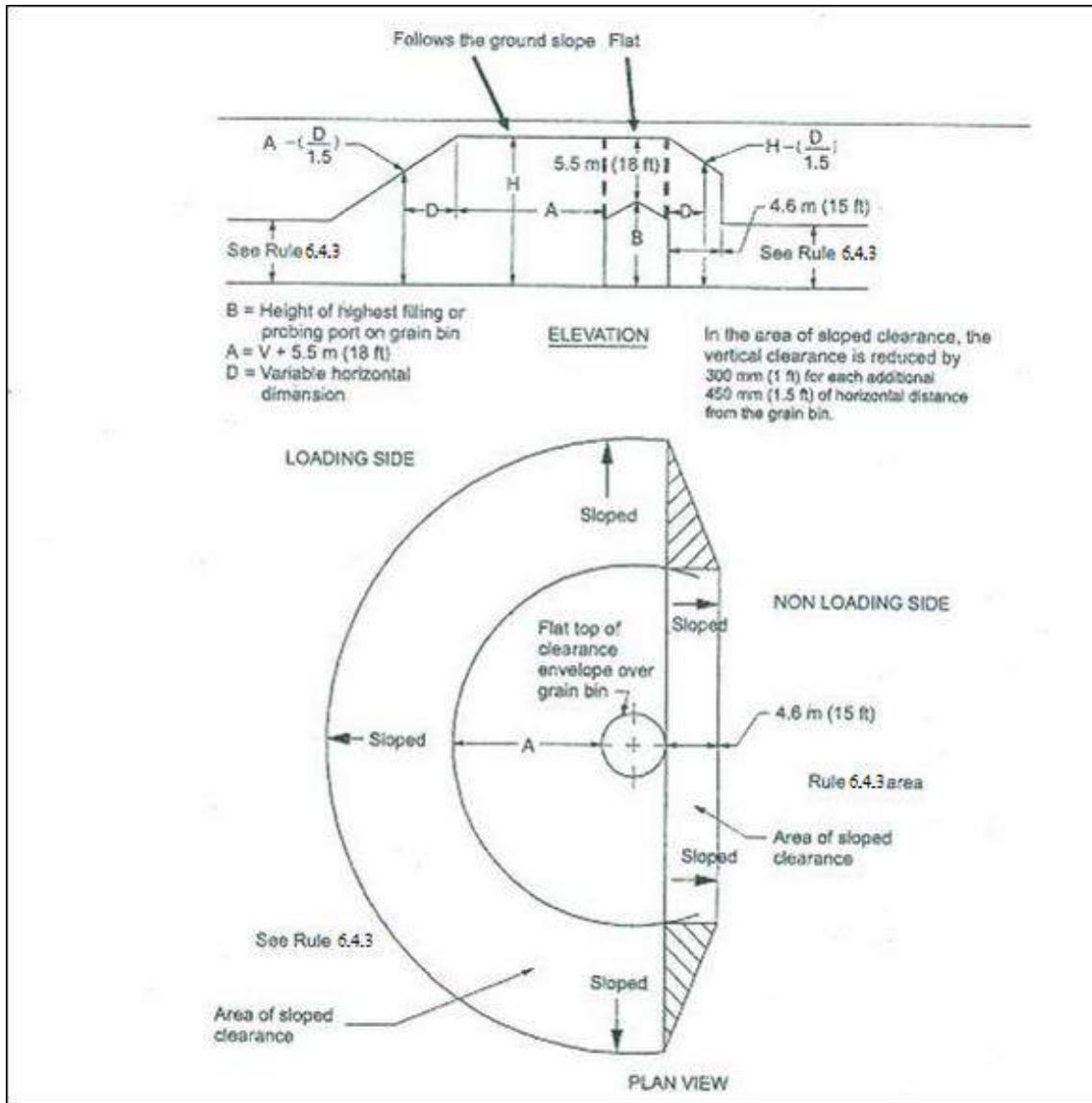


Figure 6-7 (b): Clearance envelope for grain bins filled by portable augers, conveyors or elevators

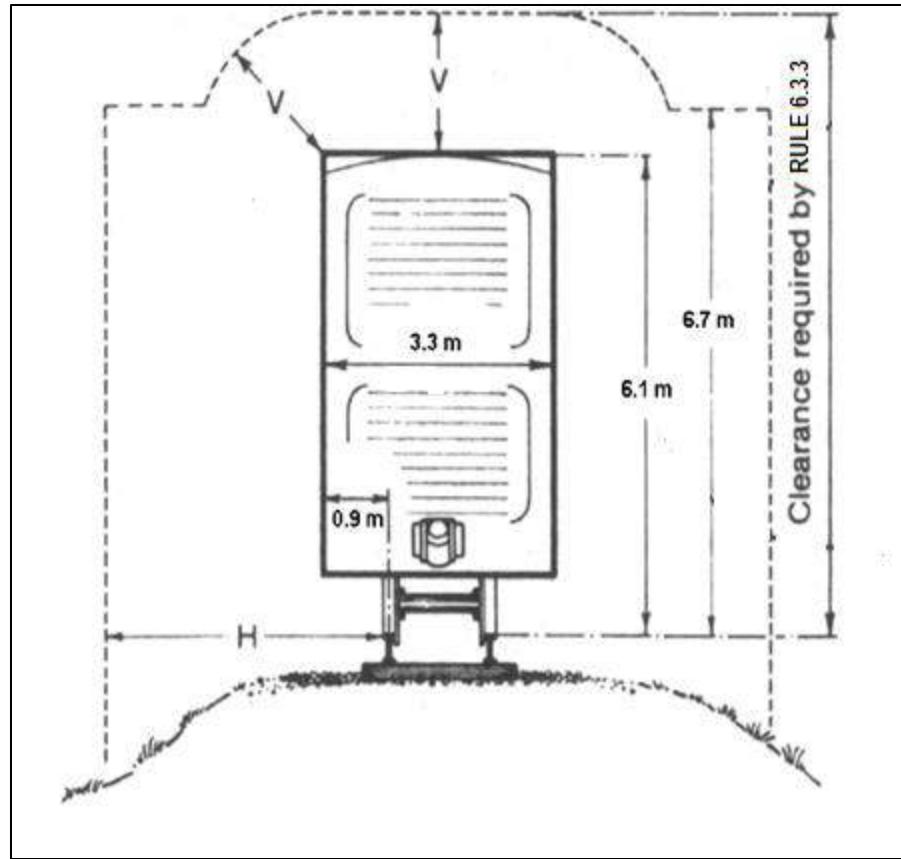


Figure 6-8: Rail car clearances

Table 6-10: Clearance of wires, conductors, cables and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below:

See Rules 6.4.5.1, 6.4.5.3-Aa, 6.4.5.3-B and 6.4.5.8-D)

Clearance of	Insulated telecommunication conductors and cables; messengers; overhead shield/surge-protection wires; grounded guys; ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed to 0 to 300V⑪⑯ neutral conductors meeting Rule 6.8.9.1; supply cables meeting Rule 6.4.1.3-1 (m)	Supply cables of 0 to 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated telecommunication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed open supply conductors of over 300V to 750V⑤⑯ (m)	Supply cables over 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3; open supply conductor s, 0 to 750V⑬ (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed to over 750V to 22 kV⑤⑯ (m)	Open supply conductors, over 750V to 22 kV (m)
1. Buildings						
a. Horizontal						
1) To walls, projections, and guarded windows	1.40①②⑦	1.50①②	1.50①②	1.70①②⑨	2.00①②	2.30①②⑩
2) To unguarded windows⑧	1.40	1.50	1.50	1.70⑨	2.00	2.30⑩
3) To balconies and areas readily accessible to pedestrians③	1.40	1.50	1.50	1.70⑨	2.00	2.30⑩
b. Vertical ⑫						
1) Over or under roofs	0.90	1.07	3.0	3.2	3.6	3.8

or projections not readily accessible to pedestrians③						
2) Over or under balconies, porches, decks, and roofs readily accessible to pedestrians③	3.2	3.4	3.4	3.5	4.0	4.1

Table 6-10: (Continued)

Clearance of wires, conductors, cables and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below:

See Rules 6.4.5.1, 6.4.5.3-Aa, 6.4.5.3-B and 6.4.5.8-D)

Clearance of	Insulated telecommunication conductors and cables; messengers; overhead shield/surge-protection wires; grounded guys; ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed to 0 to 300V⑪⑯ neutral conductors meeting Rule 6.8.9.1; supply cables meeting Rule 6.4.1.3-1 (m)	Supply cables of 0 to 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated telecommunication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed open supply conductors of over 300V to 750V⑮⑯ (m)	Supply cables over 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3; open supply conductors, 0 to 750V⑯ (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed to over 750V to 22 kV⑯⑯ (m)	Open supply conductors, over 750V to 22 kV (m)
	3) Over roads, ramps, decks, and loading docks accessible to vehicles but not subject to truck traffic⑯	3.2	3.4	3.4	3.5	4.0

4) Over roofs, ramps, decks, and loading docks accessible to truck traffic⑥⑯	^	4.9	4.9	5.0	5.5	5.6
2. Signs, chimneys, billboards, radio and television antennas, flagpoles and flags, banners, tanks, and other installations not classified as buildings or bridges⑮						
a. Horizontal④						
1) To portions that area readily accessible to pedestrians③	1.40	1.50	1.50	1.70	2.00	2.30

Table 6-10: (Continued)

Clearance of wires, conductors, cables and unguarded rigid live parts adjacent but not attached to buildings and other installations except bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below:

See Rules 6.4.5.1, 6.4.5.3-Aa, 6.4.5.3-B and 6.4.5.8-D)

Clearance of	Insulated telecommunication conductors and cables; messengers; overhead shield/surge-protection wires; grounded guys; ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed to 0 to 300V⑪⑯ neutral conductors meeting Rule 6.8.9.1; supply cables meeting Rule 6.4.1.3-1 (m)	Supply cables of 0 to 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated telecommunication conductors; ungrounded equipment cases, 0 to 750 V; and ungrounded portion of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed open supply conductors of over 300V to 750V⑤⑯ (m)	Supply cables over 750V meeting Rule 6.4.1.3-2 or 6.4.1.3-3; open supply conductors , 0 to 750V⑬ (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E and 6.8.9.1 exposed to over 750V to 22 kV⑤⑯ (m)	Open supply conductors, over 750V to 22 kV (m)
2) To portions that are not readily accessible to pedestrians③	0.90	1.07	1.50①②	1.70①②⑨	2.00①②	2.30①②⑩
b. Vertical						
1) Over or under catwalks and other surfaces upon which personnel walk	3.2	3.4	3.4	3.5	4.0	4.1
2) Over or under other portions of such installations④	0.90	1.07	1.70	1.80	2.30	2.45

Note: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table B-1 to the applicable reference component of Table B-2b of Appendix B.

- ① Where buildings, sign, chimney, antenna, tank, or other installation does not require maintenance such as painting, washing, changing of sign letters, or other operations that would require persons to work or pass between wires, conductors, cables, or unguarded rigid live parts and structures, the clearance may be reduced by 0.60 m.
- ② Where available space will not permit this value, the clearance may be reduced by 0.60 m wires, provided the wires, conductors, or cables including splices and taps, and unguarded rigid live parts have a covering that provides sufficient dielectric strength to limit the likelihood of a short circuit in a case of momentary contact with structure or building.
- ③ A roof, balcony, or area is considered readily accessible to pedestrians if it can be casually accessed through a doorway, ramp, window, stairway, or permanently mounted ladder by a person on foot who neither exerts extraordinary physical effort nor employs tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its bottom rung is 2.45m or more from the ground or other permanently installed accessible surface.
- ④ The required clearances shall be to the closest approach of motorized signs or moving portions of installations covered by Rule 6.4.5.3.
- ⑤ The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy above guy insulators that are not grounded shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
- ⑥ For the purpose of this rule, trucks are defined as any vehicle exceeding 2.45 m in height.
- ⑦ This clearance may be reduced to 75 mm for the grounded portions of guys.
- ⑧ Windows not designed to open may have the clearances permitted for walls and projections.
- ⑨ The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.07 m; see Rule 6.4.5.3-Ab.
- ⑩ The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.07 m; see Rule 6.4.5.3-Ab.
- ⑪ The portion of anchor guys below the lowest insulator meeting Rules 6.8.9.1 and 6.2.5.3-E may have the same clearance as grounded guys.
- ⑫ For clearance above railings, walls, or parapets around balconies, decks, or roofs, use the clearances required for row 1b(1). For such clearances where an outside stairway exists to provide access to such balconies, decks, or roofs, use the clearances required for row 2b(2).
- ⑬ Does not include neutral conductors meeting Rule 6.4.1.5-1.
- ⑭ The clearance values also apply to guy insulators.
- ⑮ It is presumed that a flag or banner is fully extended but that there is no deflection or displacement of the flagpole or other supporting structure due to wind and that the conductors, cables, or rigid live parts are not displaced by the wind. The specified clearance is measured to the point of maximum displacement of the banner or flag towards the overhead utility facility.
- ⑯ When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 4.3 m.

Table 6-11: Clearance of wires, conductors, cables, and unguarded rigid live parts from bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below:

See Rules 6.4.5.1, 6.4.5.4-Aa and 6.4.5.8-D)

	Unguarded rigid live parts, 0 to 750 V; noninsulated telecommunication conductors; supply cables of 0 to 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3⑦ ungrounded equipment cases, 0 to 750 V; ungrounded portions of guys meeting Rules 6.2.5.3-D, 6.2.5.3-E, and 6.8.9.1 exposed to open supply conductors over 300 V to 750V④⑪ (m)	Supply cables over 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3⑦; open supply conductors, 0 to 750 V⑩ (m)	Open supply conductors, over 750 V to 22 kV (m)	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22 kV; ungrounded portions of guys meeting Rules 6.4.1.3-2, 6.4.1.3-3, and 6.8.9.1 exposed to open supply conductors of over 750 V to 22 kV④⑪ (m)
1. Clearance over bridges①				
a. Attached③	0.90	1.07	1.70	1.50
b. Not attached	3.0	3.2	3.8	3.6
2. Clearance beside, under or within bridge structure⑥				
a. Readily accessible portion of any bridge including wing, walls, and bridge attachments①				
(1) Attached	0.90	1.07⑧	1.70⑨	1.5
(2) Not attached	1.50	1.70⑧	2.30⑨	2.00
b. Ordinarily inaccessible portions of bridges (other than brick, concrete, or masonry) and from abutments②				
(1) Attached③⑤	0.90	1.07⑧	1.70⑨	1.5
(2) Not attached④⑤	1.20	1.40⑧	2.00⑨	1.80

- ① Where over traveled ways on or near bridges, the clearances of Rule 6.4.3 apply also.
- ② Bridges seats of steel bridges carried on masonry, brick, or concrete abutments that require frequent access for inspection shall be considered as readily accessible portions.
- ③ Clearance from supply conductors to supporting arms and brackets attached to bridges shall be the same as specified in Table 6-21 (Rule 6.4.6.5-A) if the supporting arms and brackets are owned, operated, or maintained by the same utility.
- ④ the portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not grounded shall have clearances based on the highest voltage to which they may be exposed due to slack conductor or guy.
- ⑤ Where conductors passing under bridges are adequately guarded against contact by unauthorized persons and can be de-energized and grounded per relevant Rule (Section 9 Work Rules) for maintenance of the bridge, clearances of the conductors from the bridge, at any point, may have the clearances specified in Table 6-21 for clearance from surfaces of support arms plus one-half the final unloaded sag of the conductor at that point.
- ⑥ Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.
- ⑦ Where permitted by the bridge owner, supply cables may be run in rigid conduit attached directly to the bridge. Refer to Part 3 for installation rules.
- ⑧ The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.07m; see Rule 6.4.5.4-Ab.
- ⑨ The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 1.40 m; see Rule 6.4.5.4-Ab.
- ⑩ Does not include neutral conductors meeting Rule 6.4.1.5-1.
- ⑪ These clearance values also apply to guy insulators.

Table 6-12: Clearance of wires, conductors, cables, or unguarded rigid live parts over or near swimming pools

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. Clearances are with no wind displacement except where stated in the footnotes below:

See Rules 6.4.5.1, 6.4.5.5-A, 6.4.5.5-B and 6.4.5.8-D)

	Insulated telecommunication conductors and cables; measures; overhead shield/surge-protection wires; grounded guys; ungrounded portions of guys meeting Rules 6.4.1.3-2, and 6.4.1.3-3 exposed 0 to 300 V^{②④} neutral conductors meeting Rule 6.8.9.1; supply cables meeting Rule 6.4.1.3-1 (m)	Unguarded rigid live parts, 0 to 750 V; noninsulated telecommunication conductors; supply cables of 0 to 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3 ungrounded equipment cases, 0 to 750 V; ungrounded portions of guys meeting Rules 6.4.1.3-2, 6.4.1.3-3, and 6.8.9.1 exposed to open supply conductors over 300 V to 750V^{①④} (m)	Supply cables over 750 V meeting Rule 6.4.1.3-2 or 6.4.1.3-3; open supply conductors, 0 to 750 V^③ (m)	Unguarded rigid live parts, over 750 V to 22 kV, ungrounded portions of guys meeting Rules 6.4.1.3-2, 6.4.1.3-3, and 6.8.9.1 exposed to over 750 V to 22 kV^{①④} (m)	Open supply conductors, over 750 V to 22 kV (m)
A.	Cle arance if any direction from the water level, edge of pool, base of diving platform , or anchore d raft	6.6	6.9	7.0	7.5
B.	Cle arance if any direction of the diving platform , tower, water slide, or	4.3	4.4	4.6	5.1
					5.2

other fixed, pool related structure s					
V. Vertical clearanc e over adjacent land	Clearance shall be as required by Rule 6.4.3.				

NOTE 1: A, B, and V are shown in Figure 6-3.

NOTE 2: The clearance values shown in this table are computed by adding the applicable Mechanical and Electrical (M & E) value of Table-B to the applicable Reference Component of Table B-2b of Appendix B.

- ① The portion(s) of span guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not grounded shall have clearances based on the highest voltage to which they may be exposed due to slack conductor or guy.
- ② The portion of anchor guys below the lowest insulator meeting Rules 6.8.9.1 and 6.4.1.3-3 may have the same clearance as ground guys.
- ③ Does not include neutral conductors meeting Rule 6.4.1.5-1.
- ④ These clearance values also apply to guy insulators.

Table 6-13: Electrical component of clearance of buildings, bridges, and other installations

[This clearance shall be increased 3% for each 300 m in excess of 450 m above mean sea level.

See Rule 6.4.5.8-Ca and 6.4.5.8-Cb.]

Maximum operating voltage phase to phase (kV)	Switching surge factor (per unit)	Switching surge (kV)	Electrical Component of Clearances	
			Vertical (m)	Horizontal (m)
242	2.0	395	0.84	0.70
	2.2	4.5	0.98	0.82
	2.4	474	1.14	0.95
	2.6	514	1.30	1.08
	2.8	553	1.47	1.22
	3.0	593	1.64	1.37
362	1.8	532	1.38	1.15
	2.0	591	1.64	1.37
	2.2	650	1.92	1.60
	2.4	709	2.22	1.85
	2.6	768	2.53	2.11
	2.8	828	2.87	2.39
550	3.0	887	3.3	2.68
	1.6	719	2.27	1.86
	1.8	808	2.76	2.30
	2.0	898	3.3	2.74
	2.2	988	3.9	3.3
	2.4	1079	4.5	3.8
800	2.6	1168	5.1	4.3
	1.6	1045	4.3	3.6
	1.8	1176	5.2	4.3
	2.0	1306	6.2	5.2
	2.2	1437	7.2	6.0
	2.4	1568	8.4	7.0

**Table 6-14: Reference Distances
(See Rule 6.4.5.8-B)**

Reference Distance	Vertical (m)	Horizontal (m)
a. Building	2.70	0.90
b. Signs, chimneys, radio and television antennas, tanks, and other installations not classified as bridges or buildings	2.70	0.90
c. Superstructure of bridges①②	2.70	0.90
d. Supporting structures of another line	1.80	1.50
e. Dimension A of Figure 6-6	5.50	-
f. Dimension B of Figure 6-6	4.30	4.30

- ① Where over traveled ways on or near bridges, the clearances of Rule 6.4.3 apply also.
- ② Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.

6.4.6 Clearance for wires, conductors, or cables carried on the same supporting structure

6.4.6.1 Application of rule

A. Multiconductor wires or cables

Cables, and duplex, triple, or paired conductors supported on insulators or messengers meeting Rule 6.4.1.3 or 6.4.1.4, whether single or grouped, for the purposes of this rule are considered single conductors even though they may contain individual conductors not of the same phase or polarity.

B. Conductors supported by messengers or span wires

Clearances between individual wires, conductors, or cables supported by the same messenger, or between any group and its supporting messenger, or between a trolley feeder, supply conductor, or telecommunication conductor, and their respective supporting span wires, are not subject to the provisions of this rule.

C. Line conductors of different circuits

- a. Unless otherwise stated, the voltage between line conductors of different circuits shall be the greater of the following:

- (1) The phasor difference between the conductors involved

NOTE: A phasor relationship of 180° is considered appropriate where the actual phasor relationship is unknown.

- (2) The phase-to-ground voltage of the higher-voltage circuit

- b. When the circuits have the same nominal voltage, either circuit may be considered to be the higher-voltage circuit.

6.4.6.2 Horizontal clearance between line conductors

A. Fixed supports

Line conductors attached to fixed supports shall have horizontal clearances from each other not less than the larger value required by either Rule 6.4.6.2-Aa or 6.4.6.2-Ab for the situation concerned. Voltage is between the two conductors for which the clearance is being determined except for railway feeders, which are to ground.

EXCEPTION 1: The pin spacing at buckarm construction may be reduced as specified in Rule 6.4.7.6 to provide climbing space.

EXCEPTION 2: Grade N need meet only the requirements of Rule 6.4.6.2-Aa

EXCEPTION 3: These clearances do not apply to cables meeting Rule 6.4.1.3 or covered conductors of the same circuit meeting Rule 6.4.1.4.

EXCEPTION 4: For voltages to ground exceeding 98 kV ac or 139 kV dc, clearances less than those required by a and b below are permitted for systems with known maximum switching-surge factors. (See Rule 6.4.6.2-C)

- a. Horizontal clearance between line conductors of the same or different circuits

Clearances shall be not less than those given in Table 6-15.

- b. Clearance according to sags

The clearance at the supports of line conductors of the same or different circuits of Grade B or C shall be not less than the values given by the following formulas, at a conductor temperature of 15 °C, at final unloaded sag, no wind. For the purpose of this rule, the line conductor clearances are between the surfaces of the conductors only, not including armor rods, tie wires, or other fasteners. The requirements of Rule 6.4.6.2-Aa apply if they give a greater clearance than this rule.

Using the applicable formula with a fixed conductor clearance to determine maximum allowable sag for the conductor clearance, the resultant maximum sag shall be rounded down.

EXCEPTION: No requirement is specified for clearance between conductors of the same circuit when rated above 50 kV.

In the following, S is the apparent sag in millimeters of the conductor having the greater sag, and the clearance is in millimeters. Voltage (kV) is the voltage between the conductors.

$$(1) \text{ For line conductors smaller than AWG No. 2: clearance} = 7.6 \text{ mm/(kV)} + 20.4 \sqrt{S - 610}$$

(Table 6-16 shows selected values up to 46 kV.)

$$(2) \text{ For line conductors of AWG No. 2 or larger: clearance} = 7.6 \text{ mm/(kV)} + 8 \sqrt{(2.12S)}$$

(Table 6-17 shows selected values up to 46 kV.)

- (3) For voltages exceeding 814 kV, the clearance shall be determined by the alternate method given by Rule 6.4.6.2-C.
- (4) The clearance for voltages exceeding 50 kV specified in Rule 6.4.6.2-Ab1 and 6.4.6.2-Ab2 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level. All clearances for lines over 50 kV shall be based on the maximum operating voltage.

B. Suspension insulators

Where suspension insulators are used and are not restrained from movement, the clearance between conductors shall be increased so that one string of insulators may swing transversely throughout a range of insulator swing up to its maximum design swing angle without reducing the values given in Rule 6.4.6.2-A. The maximum design swing angle shall be based on a 290 Pa wind on the conductor at final sag at 15 °C. This may be reduced to a 190 Pa wind in areas sheltered by buildings, terrains, or other obstacles. Trees are not considered to shelter a line. The displacement of the wires, conductors, and cables shall include deflection of flexible structures and fittings, where such deflection would reduce the horizontal clearance between two wires, conductors, or cables.

C. Alternate clearances for different circuits where one or both circuits exceed 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 6.4.6.2-A and 6.4.6.2-B may be reduced for circuits with known switching-surge factors but shall be not less than the clearances derived from the following computations. For these computations, telecommunication conductors and cables, guys, messengers, neutral conductors meeting Rule 6.4.1.5-1, and supply cables meeting Rule 6.4.1.3-1 shall be considered line conductors at zero voltage.

a. Clearance

- (1) The alternate clearance shall be maintained under the expected loading conditions and shall be not less than the electrical clearance between conductors of different circuits computed from the following equation. For convenience, clearances for typical system voltages are shown in Table 6-18.

$$D = 1.00 \left[\frac{V_{L-L} \cdot (PU) \cdot a}{500K} \right]^{1.667} b \quad (\text{m})$$

where

V_{L-L} = maximum ac crest operating voltage in kilovolts between phases of different circuits or maximum dc operating voltage between poles of different circuits. If the phases are of the same phase and voltage magnitude, one phase conductor shall be considered grounded

PU = maximum switching-surge factor expressed in per-unit peak operating voltage between phases of different circuits and defined as a switching surge level between phases for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker

operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations

b = 1.03, the allowance for nonstandard atmospheric conditions

K = 1.4, the configuration factor for a conductor-to-conductor gap

- (2) The value of D shall be increased 3% for each 300 m in excess of 450 m above mean sea level.

b. Limit

The clearance derived from Rule 6.4.6.2-Ca shall not be less than the basic clearances given in Table 6-15 computed for 169 kV ac.

6.4.6.3 Vertical clearance between line conductors at the support

All wires, conductors, and cables located at different levels on the same supporting structure shall have vertical clearances not less than the following:

A. Basic clearance for conductors of same or different circuits

- a. Between supply lines of the same or different circuits

The clearance requirements given in Table 6-19 shall apply to supply line wires, conductors, or cables of 0 to 50 kV attached to supports. No value is specified for clearances between conductors of the same circuit exceeding 50 kV, between cables meeting Rule 6.4.1.3-3 and neutral conductors meeting Rule 6.3.1.5-1 of the same utility, or between ungrounded open supply conductors 0 to 50 kV of the same phase and circuit of the same utility.

- b. Between supply lines and telecommunication lines

The clearance requirements given in Table 6-19 shall apply.

- c. Between telecommunication lines located in the telecommunication space

The clearance and spacing requirements of Rule 6.4.6.8 shall apply to telecommunication lines located in the telecommunication space.

- d. Between telecommunication lines located in the supply space

The clearance requirements of Table 6-19 shall apply to telecommunication lines located in the supply space.

EXCEPTION 1: Line wires, conductors, or cables on vertical racks or separate brackets placed vertically and meeting the requirements of Rule 6.4.6.7 may have spacing as specified in that rule.

EXCEPTION 2: Where telecommunication service drops cross under supply conductors on a common crossing structure, the clearance between the telecommunication conductor and an effectively grounded supply conductor may be reduced to 100 mm provided the clearance between the telecommunication conductor and supply conductors not effectively grounded meets the requirements of Rule 6.4.6.3 as appropriate.

EXCEPTION 3: Supply service drops of 0 to 750 V running above and parallel to telecommunication service drops may have a clearance of not less than 300 mm at any point in the span including the point of their attachment to the building or structure being served provided that the non-grounded conductors are insulated and that the clearance as otherwise required by this rule is maintained between the two service drops at the pole.

EXCEPTION 4: This rule does not apply to conductors of the same circuit meeting Rule 6.4.1.4.

B. Additional clearances

Greater clearances than those required (by Rule 6.4.6.3-A) and given in Table 6-19 shall be provided under the following conditions. The increases are cumulative where more than one is applicable.

a. Voltage related clearances

- (1) For voltages between 50 and 814 kV, the clearance between line wires, conductors, or cables of different circuits shall be increased 10 mm per kilovolt in excess of 50 kV.

EXCEPTION: For voltages to ground exceeding 98 kV ac or 139 kV dc, clearances less than those required above are permitted for systems with known switching-surge factors. (See Rule 6.4.6.3-C.)

EXAMPLES: Calculations of clearances required by Rule 6.4.6.3-Ba for a 69.7 kV maximum operating voltage phase-to-ground conductor above a 7.2 kV phase to ground conductor, assuming conductors are 180° out of phase.

Rule 6.4.6.3-Ba: Clearance required at support

- (a) Same utility [basic clearance = 0.41 m]:

$$\text{SI Units: } \{0.41 + [(50 - 8.7) \cdot 0.01]\} + [(69.7 + 7.2 - 50) \cdot 0.01] = 1.09 \text{ m. No rounding required in this example.}$$

- (b) Different utilities [basic clearance = 1.00 m]:
SI Unit: $\{1.00 + [(50 - 8.7) \times 0.01]\} + [(69.7 + 7.2 - 50) \times 0.01] = 1.68 \text{ m. No rounding required in this example.}$

- (2) The increase in clearance for voltages in excess of 50 kV specified in Rule 6.4.6.3-Ba(1) shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
- (3) All clearances for lines over 50 kV shall be based on the maximum operating voltage.
- (4) No value is specified for clearances between conductors of the same circuit.

b. Sag-related clearances

- (1) Line wires, conductors, and cables supported at different levels on the same structures shall have vertical clearances at the supporting structures so adjusted that the clearance at any point in the span shall be not less than any of the following:

- (a) For voltages less than 50 kV between conductors, 75% of that required at the supports by Table 6-19.
- (b) For voltages more than 50 kV between conductors, use the value as calculated by the following appropriate formula:

If the basic value is 0.41 m: 0.62 m plus 10 mm per kV in excess of 50 kV.

If the basic value is 1.0 m: 1.08 m plus 10 mm per kV in excess of 50 kV.

The increase in clearance for voltages in excess of 50 kV specified in Rule 6.4.6.3-Bb(1)(b) shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.

All clearances for lines over 50 kV shall be based on the maximum operating voltage.

EXAMPLES: Calculations of clearances required by Rule 6.4.6.3-Bb(1)(b) for a 69.7 kV maximum operating voltage phase-to-ground conductor above a 7.2 kV phase-to-ground conductor, assuming conductors are 180 degrees out of phase.

Rule 6.4.6.3-Bb(1)(b): Clearance required at any point in the span

- i. Same utility [basic clearance = 0.41m]:

$$\{0.41 + [(50 - 8.7) \times 0.01]\} \times 0.75 + [(69.7 + 7.2 - 50) \times 0.01] = 0.89 \text{ m. No rounding required in this example.}$$

- ii. Different utilities [basic clearance = 1.00 m]:

$$\{1.00 + [(50 - 8.7) \times 0.01]\} \times 0.75 + [(69.7 + 7.2 - 50) \times 0.01] = 1.33 \text{ m. No rounding required in this example.}$$

EXCEPTION 1: For Rules 6.4.6.3-Bb(1)(a) and 6.4.6.3-Bb(1)(b), neutral conductors meeting Rule 6.4.1.5-1, fiber-optic supply cables meeting Rule 6.4.1.6-Aa or 6.4.1.6-Ab, insulated telecommunication cables located in the supply space and supported by an effectively grounded messenger, and supply cables meeting Rule 6.4.1.3-1 (including their support brackets) in the supply space running above and parallel to telecommunication cables in the telecommunications space where the supply neutral or messenger is bonded to the telecommunication messenger at intervals specified in Rule 4.2.3, may have a clearance of 300 mm at any point in the span provided that a clearance of 0.75 m is maintained between the supply space conductors and cables and the telecommunication space cables at the supporting poles. Bonding is not required for entirely dielectric cables meeting Rule 6.4.1.6-Ab.

EXCEPTION 2: For Rules 6.4.6.3-Bb(1)(a) and 6.4.6.3-Bb(1)(b), when all parties involved are in agreement, for supply conductors of different utilities, vertical clearance at any point in the span need not exceed 75% of the values required at the supports for the same utility by Table 6-19.

- (c) For purposes of this determination the vertical clearances required in Rule 6.4.6.3-Bb(1)(a) and 6.4.6.3-Bb(1)(b) apply to the following conductor temperature and loading conditions whichever produces the greater vertical clearance at the structure when:

- i. The upper conductor is at final sag at 50 °C or the maximum operating temperature for which the line is designed to operate and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, or

EXCEPTION: Rule 6.4.6.3-Bb(1)(c) does not apply to conductors of the same utility when the upper and lower conductors are the same circuit, the same size and type, installed at the same sag and tension, and will be without electrical loading simultaneously.

- ii. The upper conductor is at final sag at 0°C with the radial thickness of ice, if any, specified in Table 6-1 for the zone concerned and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, and without ice loading.

EXCEPTION: Rule 6.4.6.3-Bb(1)(c) does not apply where experience in an area has shown that different ice conditions do not occur between the upper and lower conductors.

If both *EXCEPTIONs* in Rule 6.4.6.3-Bb(1)(c) can be used, then Rule 6.4.6.3-Bb does not apply, see Rule 1.4c.

- (2) Sags should be readjusted when necessary to accomplish the foregoing, but not reduced sufficiently to conflict with the requirements of Rule 6.7.2.7.8-A. In cases where conductors of different sizes are strung to the same sag for the sake of appearance or to maintain unreduced clearance throughout storms, the chosen sag should be such as will keep the smallest conductor involved in compliance with the sag requirements of Rule 6.7.2.7.8-A.
- (3) For span lengths in excess of 45 m, vertical clearance at the structure between open supply conductors and telecommunication cables or conductors shall be adjusted so that under conditions of conductor temperature of 15 °C, no wind displacement and final unloaded sag, no open supply conductor of over 750 V but less than 50 kV shall be lower in the span than a straight line joining the points of support of the highest telecommunication cable or conductor.

EXCEPTION: Effectively grounded supply conductors associated with systems of 50 kV or less need meet only the provisions of Rule 6.4.6.3-Bb(1).

C. Alternate clearances for different circuits where one or both exceed 98 kV ac, or 139 kV dc to ground

The clearances specified in Rules 6.4.6.3-A and 6.4.6.3-B may be reduced for circuits with known switching-surge factors, but shall not be less than the crossing clearances required by Rule 6.4.4.3-C.

D. Telecommunication worker safety zone

The clearances specified in Rules 6.4.6.3 and 6.4.9 create a *telecommunication worker safety zone* between the facilities located in the supply space and facilities located in the telecommunication space, both at the structure and in the span between structures. Except as allowed by Rules 6.4.9.3, 6.4.9.4, and 6.4.10, no supply or telecommunication facility shall be located in the telecommunication worker safety zone.

6.4.6.4 Diagonal clearance between line wires, conductors, and cables located at different levels on the same supporting structure

No wire, conductor, or cable may be closer to any other wire, conductor, or cable than defined by the dashed line in Figure 6-12, where V and H are determined in accordance with other parts of Rule 6.4.6.

6.4.6.5 Clearances in any direction at or near a support from line conductors to supports, and to vertical or lateral conductors, service drops, and span, or guy wires, attached to the same support

A. Fixed supports

Clearances shall be not less than those given in Table 6-20.

EXCEPTION: For voltages exceeding 98 kV ac to ground or 139 kV dc to ground, clearances less than those required by Table 6-16 are permitted for systems with known switching-surge factor. (See Rule 6.4.6.5-C)

NOTE 1: For clearances in any direction from supply line conductors to telecommunication antennas in the supply space attached to the same supporting structure, see Rule 6.4.6.9.

NOTE 2: For antennas in the telecommunication space, see Rule 6.4.7.4-1 and 6.4.9.

B. Suspension insulators

Where suspension insulators are used and are not restrained from movement, the clearance shall be increased so that the string of insulators may swing transversely throughout a range of insulator swing up to its maximum design swing angle without reducing the values given in Rule 6.4.6.5-A. The maximum design swing angle shall be based on a 290 Pa wind on the conductor at final sag at 65 °C. This may be reduced to a 190 Pa wind in areas sheltered by buildings, terrain, or other obstacles. Trees are not considered to shelter a line. The displacement of the wires, conductors, and cables shall include deflection of flexible structures and fittings, where such deflection would reduce the clearance.

C. Alternate clearances for voltages exceeding 98 kV ac to ground or 139 kV dc to ground

The clearances specified in Rules 6.4.6.5-A and 6.4.6.5-B may be reduced for circuits with known switching-surge factors but shall not be less than the following:

1. Alternate clearances to anchor guys, surge-protection wires, and vertical or lateral conductors

The alternate clearances shall be not less than the crossing clearances required by Rule 6.4.4.2-B and Rules 6.4.4.3-3a and 6.4.4.3-3b for the conductor voltages concerned. For the purpose of this rule, anchor guys and surge-protection wires shall be assumed to be at ground potential. The limits of Rule 6.4.6.5-C shall apply to the clearance derived from Rules 6.4.4.3-3a and 6.4.4.3-3b.

2. Alternate clearance to surface of support arms and structures

(1) Alternate clearance

(a) Basic computation

The alternate clearances shall be maintained under the expected loading conditions and shall be not less than the electrical clearances computed from the following equation. For convenience, clearances for typical system voltages are shown in Table 6-21.

$$D = 1.00 \left[\frac{V.(PU).a}{500K} \right]^{1.667} b \quad (\text{m})$$

where

V = maximum ac crest operating voltage to ground or maximum dc operating voltage to ground in kilovolts

PU = maximum switching-surge factor expressed in per-unit peak voltage to ground and defined as a switching-surge level for circuit breakers corresponding to 98% probability that the maximum switching surge generated per breaker operation does not exceed this surge level, or the maximum anticipated switching-surge level generated by other means, whichever is greater

a = 1.15, the allowance for three standard deviations with fixed insulator supports

= 1.05, the allowance for one standard deviation with free swinging manipulators

b = 1.03, the allowance for nonstandard atmospheric conditions

K = 1.2, the configuration factor for conductor-to-tower window

(b) Atmospheric correction

The value of D shall be increased 3% for each 300 m in excess of 450 m above mean sea level.

(2) Limits

The alternate clearance shall not be less than the clearance of Table 6-20 for 169 kV ac. The alternate clearance shall be checked for adequacy of clearance to workers and increased, if necessary, where work is to be done on the structure while the circuit is energized. (Also see Section 9).

6.4.6.6 Clearances between circuits of different voltage classifications located in the supply space on the same support arm

Circuits of any one voltage classification (0 to 750 V, over 750 V to 8.7 kV, over 8.7 kV to 22 kV, and over 22 kV to 50 kV) may be maintained in the supply space on the same support arm with supply circuits of the next consecutive voltage classification only under

one or more of the five following conditions. For purposes of these determinations, a neutral conductor shall be considered as having the same voltage classification as the circuit with which it is associated:

1. If they occupy positions on opposite sides of the structure
2. If in bridge-arm or sidarm construction, the clearance is not less than the climbing space required for the higher voltage concerned and provided for in Rule 6.4.7.
3. If the higher-voltage conductors occupy the outer positions and the lower-voltage conductors occupy the inner positions
4. If series lighting or similar supply circuits are ordinarily dead during periods of work on or above the support arm concerned
5. If the two circuits concerned are telecommunication circuits (located in the supply space in accordance with Rule 6.3.5.1, or one circuit is such a telecommunication circuit and the other is a supply circuit of less than 8.7 kV, provided they are installed as specified in Rule 6.4.6.6-1 or 6.4.6.6-2.

6.4.6.7 Conductor spacing: vertical racks or separate brackets

Conductors or cables may be carried on vertical racks or separate brackets other than wood placed vertically on one side of the structure and securely attached thereto with less clearance between the wires, conductors, or cables than specified in Rule 6.4.6.3 if all the following conditions are met:

1. All wires, conductors, and cables are owned and maintained by the same utility, unless by agreement between all parties involved.
2. The voltage shall be not more than 750 V, except supply cables and conductors meeting Rule 6.4.1.3-1 or 6.4.1.2-2, which may carry any voltage.
3. Conductors shall be arranged so that the vertical spacing shall be not less than the conditions specified in Rule 6.4.6.3-Bb(1)(c).

EXCEPTION 1: A supporting neutral conductor of a supply cable meeting 6.4.1.3-3 or an effectively grounded messenger of a supply cable meeting Rule 6.4.1.3-1 or 6.4.1.3-2 may attach to the same insulator or bracket as a neutral conductor meeting Rule 6.4.1.5-1, so long as the clearances of Rule 6.4.6.3-Bb(1)(c).are maintained in mid-span and the insulated energized conductors are positioned away from the open supply neutral at the attachment.

EXCEPTION 2: No mid-span clearance is required where supply cables meeting Rule 6.4.1.3-3 are service drops meeting Rule 6.4.5.3-Ca are attached to the neutral conductor meeting Rule 6.4.1.5-1, anywhere in the span.

6.4.6.8 Clearance and spacing between telecommunication conductors, cables, and equipment

1. The spacing between messengers supporting telecommunication cables should be not less than 300 mm except by agreement between the parties involved including the pole owner(s).
2. The clearances between the conductors, cables, and equipment of one telecommunication utility to those of another, anywhere in the span, shall be not less than 100 mm, except by agreement between the parties involved including the pole owner(s).

6.4.6.9 Clearances in any direction from supply line conductors to telecommunication antennas in the supply space attached to the same supporting structure

A. General

Telecommunication antennas located in the supply space shall be installed and maintained only by personnel authorized and qualified to work in the supply space in accordance with the applicable rules of Section 9 Work rules. See also Rule 6.3.5.1.

B. Telecommunication antenna

The clearance between a telecommunication antenna operated at a radio frequency of 3 kHz to 300 GHz including any associated conductive mounting hardware, and a supply line conductor shall be not less than the value given in Table 6-20, row 1c.

NOTE 1: The antenna functions as a rigid, vertical, or lateral open wire telecommunication conductor.

NOTE 2: Clearances shown in Table 6-20 are not intended to apply to personnel working in the vicinity of telecommunication antennas. See relevant Rule of Section 9 Work Rules.

C. Equipment case that supports or is adjacent to a telecommunication antenna

The clearance between an equipment case that supports a telecommunication antenna and a supply line conductor shall be not less than the value given in Table 6-20, Row 4a.

D. Vertical or lateral telecommunication conductors and cables attached to a telecommunication antenna

The clearance between a supply line conductor and the vertical or lateral telecommunication conductor and cable attached to a telecommunication antenna shall be not less than the value given in Rule 6.4.10.

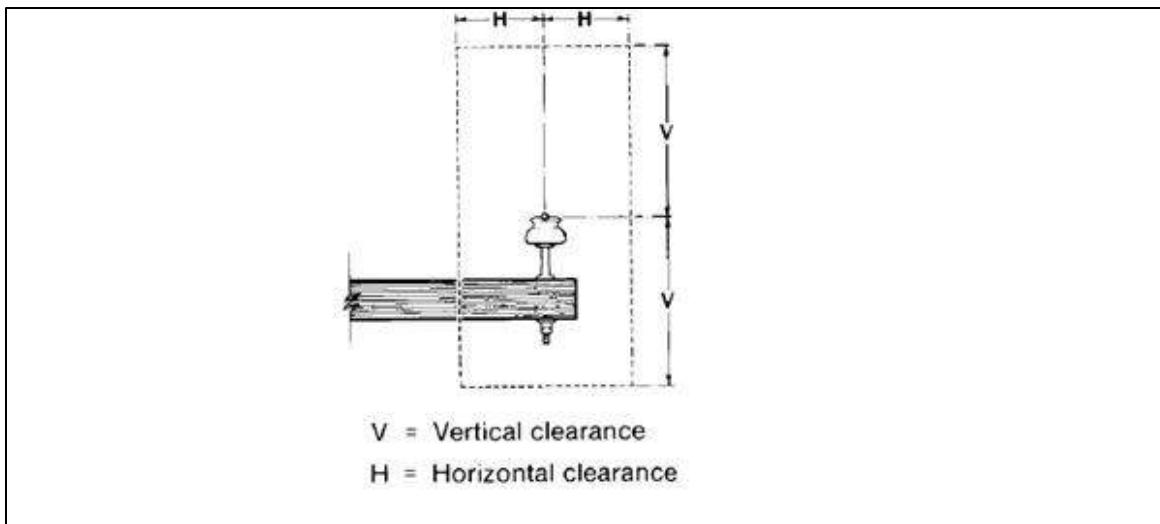


Figure 6-9: Clearance diagram for energized conductor

Table 6-15: Horizontal clearance between wires, conductors, or cables at supports
 (All voltages are between conductors involved except for railway feeders, which are to ground.
 See also Rules 6.4.6.1, 6.4.6.2Aa, and 6.4.6.2-Cb.)

Class of Circuit	Clearance (mm)	Notes
Open telecommunication conductors	150	Does not supply at conductor transposition point.
	75	Permitted where pin spacing less than 150 mm have been in regular use. Does not apply at conductor transposition points.
Railway feeders: 0 to 750 V, AWG No. 4/0 or larger 0 to 750 V, smaller than AWG No. 4/0 Over 750 V to 8.7 kV	150 300 300	Where 250 mm to 300 mm clearance has already been established by practice, it may be continued, subject to the provisions of Rule 6.4.6.2Ab, for conductors having apparent sags not over 900 mm and for voltages not exceeding 8.7 kV.
Supply conductor of the same circuit: 0 to 8.7 kV Over 8.7 kV to 50 kV Above 50 kV	300 plus 10 per kV in excess of 8.7 kV No value specified	
Supply conductor of the same circuit: 0 to 8.7 kV Over 8.7 kV to 50 kV	300 plus 10 per kV in excess of	For all voltages above 50 kV, the additional clearance shall be increased 3% for each 300 m in

Above 50 kV to 814 kV	8.7 kV 715 plus 10 per kV in excess of 50 kV	excess of 1000 m above mean sea level. All clearance for voltages above 50 kV shall be based on the maximum operating voltage.
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Table 6-16: Horizontal clearance between line conductors smaller than AWG No. 2 at supports, based on sags
 [See also Rules 6.4.6.1 and 6.4.6.2-Ab]

Voltage between conductors (kV)	Sag (mm)							
	915	1220	1830	2440	3050	4570	6095	But not less than①
	Horizontal clearance (mm)							
2.4	375	525	735	895	1030	1305	1530	300
4.16	390	540	745	905	1040	1320	1545	300
12.47	455	600	810	970	1150	1380	1610	340
13.2	460	605	815	975	1100	1385	1615	345
13.8	465	610	820	980	1115	1390	1620	355
14.4	470	615	825	985	1120	1395	1625	360
24.94	550	695	905	1065	1200	1475	1705	465
34.5	620	770	975	1135	1270	1550	1775	560
46	710	855	1065	1225	1360	1635	1865	675

① Clearance determined by Table 6-15, Rule 6.4.6.2Aa.

NOTE: Clearance = $7.6 \text{ per kV} + 20.4 \sqrt{S - 610}$, where S is the sag in millimeters.

**Table 6-17: Horizontal clearance between line conductors AWG No. 2 or
Larger at supports, based on sags**
[See also Rules 6.4.6.1 and 6.4.6.2Ab]

Voltage between conductors (kV)	Sag (mm)							
	915	1220	1830	2440	3050	4570	6095	But not less than①
Horizontal clearance (mm)								
2.4	375	430	520	595	665	810	930	300
4.16	385	440	530	610	675	820	945	300
12.47	450	505	595	675	740	885	1005	340
13.2	455	510	600	680	745	890	1010	345
13.8	460	515	605	685	750	895	1015	355
14.4	465	520	610	685	755	900	1020	360
24.94	545	600	690	765	835	980	1100	465
34.5	615	670	765	840	910	1050	1175	560
46	705	760	850	925	995	1140	1260	675

① Clearance determined by Table 6-15, Rule 6.4.6.2Aa.

NOTE: Clearance = $7.6 \text{ per kV} + 8 \sqrt{2.12S}$, where S is the sag in millimeters.

Table 6-18: Electrical clearance in Rule 6.4.6.2Ca-1

[This clearance shall be increased 3% for each 300 m]

In excess of 450 m above mean sea level]

Maximum operating voltage phase to phase (kV)	Switching surge factor (per unit)	Switching surge (kV)	Electrical Component of Clearances (m)
242	2.6 or less	890 or less	1.94
	2.8	958	2.20
	3.0	1027	2.47
	3.2 or more	1095 or more	2.65①
362	1.8	893 or less	2.06
	2.0	1024	2.46
	2.2	1126	2.88
	2.4	1228	3.4
	2.6	1330	3.8
	2.7 or more	1382 or more	3.9①
550	1.6	1245	3.4
	1.8	1399	4.2
	2.0	1555	5.0
	2.2	1711	5.8①
800	2.3	1789 or more	5.8
	1.6	1810	6.4
	1.8	2037	7.8
	1.9 or more	2149 or more	8.3①

① Need not be greater than specified in Rules 6.4.6.1A and 6.4.6.2B.

Table 6-19: Vertical clearance between conductors at supports

[When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. When calculating clearance values within the table, all voltages are between the conductors involved. See the definitions section for voltages of other systems. See also Rules 6.4.6.1, 6.4.6.3-A, 6.4.6-B, and 6.4.6.6.]

Conductors and cables usually at lower level	Conductors and cables usually at upper level			
	Supply cables meeting Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3; neutral conductors meeting Rule 6.4.1.5.1; telecommunications cables meeting Rule 6.3.5.1-2 (m)	Open supply conductors		
		0 to 8.7kV ⁽¹¹⁾ (m)	Over 8.7 kV to 50 kV	
1. Telecommunication conductors and cables				
a. Located in the telecommunication space	1.00 ⁽¹⁾ ⁽⁵⁾	1.00	1.00	1.00 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV
b. Located in the supply space	0.41 ⁽⁹⁾ ⁽¹⁰⁾	0.41 ⁽¹⁰⁾	1.00 ⁽¹⁰⁾	1.00 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV
2. Supply conductors and cables				
a. Open conductors 0 to 750V ⁽¹¹⁾ supply cables meeting Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3; neutral conductors meeting Rule 6.4.1.5-1	0.41 ⁽⁸⁾ ⁽⁹⁾	0.41 ⁽²⁾	0.41 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV	1.00 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV
b. Open conductors over 750V to 8.7 kV		0.41 ⁽²⁾	0.41 plus 0.01 per kV ⁽⁴⁾ ⁽⁶⁾ in excess of 8.7 kV	1.00 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV
c. Open conductors over 8.7 to 22 kV				
(1) If worked on energized with live-line tools and adjacent circuits are neither de-energized nor covered with shields or protectors			0.41 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV	1.00 plus 0.01 per kV ⁽⁶⁾ in excess of 8.7 kV
(2) If not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live-line tools not requiring line workers to go between			0.41 plus 0.01 per kV ⁽³⁾ ⁽⁶⁾ in excess of 8.7 kV	1.00 plus 0.01 per kV ⁽³⁾ ⁽⁶⁾ in excess of 8.7 kV

live wires				
d. Open conductors exceeding 22 kV, but not exceeding 50 kV			0.41 plus 0.01 per kV ^{③⑥} in excess of 8.7 kV	1.00 plus 0.01 per kV ^{③⑥} in excess of 8.7 kV

- ① Where supply circuits of 600 V or less, with transmitted power of 5000 W or less, are run below telecommunication circuits in accordance with Rule 6.3.1.2-2, the clearance may be reduced to 0.41m.
- ② Where conductor are operated by different utilities, a vertical clearance of not less than 1.00 m is recommended.
- ③ Where values do not apply to conductors of the same circuit or circuits being carried on adjacent conductor supports.
- ④ May be reduced to 0.41 m where conductors are not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live-line tools not requiring line workers to go between live wires.
- ⑤ May be reduced to 0.75 m for supply neutrals meeting Rule 6.4.1.5-1, fiber-optic supply cables on an effectively grounded messenger meeting Rule 6.4.1.6-1a, entirely dielectric fiber-optic supply cables meeting Rule 6.4.1.6-1b, insulated commutation cables located in the supply space and supported by an effectively grounded messenger, and cables meeting Rule 6.4.1.3-1 where the supply neutral or messenger is bonded to the telecommunication messenger at intervals specified in Rule 4.2.2. Bonding is not required for entirely dielectric cables meeting Rule 6.4.1.6-1b.
- ⑥ The greater of phase difference or phase-to-ground voltage; see Rule 6.4.6.1-C.
- ⑦ See examples of calculations in Rules 6.4.6.3-Ba and 6.4.6.3-Bb.
- ⑧ No clearance is specified between supply cables meeting rule 6.4.1.3-3 and neutral conductors meeting Rule 6.4.1.5-1 of the same utility. See Rule 6.4.6.7.
- ⑨ No clearance is specified between neutral conductors meeting Rule 6.4.1.5-1 and insulated telecommunication cables located in the supply space and supported by an effectively grounded messenger. The cable messenger may be attached to the neutral at the pole or in the span, provided that the cable is positioned away from the neutral to prevent abrasion damage. If the cable messenger is not attached to the neutral in the span, mid span spacing shall be not less than that specified in Rule 6.4.6.7.
- ⑩ No clearance is specified between fiber-optic supply cables (FOSC) meeting Rule 6.4.1.6-1b and supply cables and supply cables and conductors. The FOSC may be attached to a supply conductor or cable at the pole or in the span, provided that the FOSC is positioned away from the supply conductor or cable to prevent abrasion damage. If the FOSC is not attached to the neutral in the span, mid span spacing shall be not less than that specified in Rule 6.4.6.7.
- ⑪ Does not include neutral conductors meeting Rule 6.4.1.5-1.

Table 6-20: Clearance in any direction from line conductors at or near a support to supports, and to vertical or lateral conductors, service drops, span or guy wires, and to telecommunications antennas attached to the same support
[See also Rules 6.4.6.1, 6.4.6.5-A, 6.4.6.5-C2(2), and 6.4.6.9]

Clearance of line conductors from	Communication lines in general (mm)	Communication lines on jointly used structures (mm)	Supply lines Circuit phase-to-phase voltage			
			Neutral conductors meeting Rule 6.4.1.5-1 (mm)	0 to 8.7 kV ^⑭ (mm)	Over 8.7 kV to 50 kV (mm)	Over 50 kV to 814 kV ^{⑮⑯} (mm)
1. Vertical and lateral conductors at the support						
a. Of the same circuit	75	75	75	75	75 plus 6.5 per kV in excess of 8.7 kV	No value specified
b. Of other circuit ^⑫	75	75	75	150 ^⑮	150 plus 10 per kV in excess of 8.7 kV	580 plus 10 per kV in excess of 50 kV
c. Telecommunication antennas ^⑯	75	75	75	150 ^⑮	150 plus 10 per kV in excess of 8.7 kV	580 plus 10 per kV in excess of 50 kV
2. Span or guy wires^⑪, or messengers attached to same structure at or near the support						
a. When parallel to line	75 ^⑰	150 ^{⑱⑰}	150 ^{⑱⑰}	300 ^⑲	300 plus 10 per kV in excess of 8.7 kV	740 plus 10 per kV in excess of 50 kV
b. Anchor guys	75 ^⑰	150 ^{⑱⑰}	150 ^{⑱⑰}	150 ^⑲	150 plus 6.5 per kV in excess of 8.7 kV	410 plus 6.5 per kV in excess of 50 kV
c. All other	3 ^⑰	150 ^{⑱⑰}	150 ^{⑱⑰}	150 ^⑲	150 plus 10 per kV in excess of 8.7 kV	580 plus 10 per kV in excess of 50 kV

Table 20 : (Continued)

Clearance in any direction from line conductors at or near a support to supports, and to vertical or lateral conductors, service drops, span or guy wires, and to telecommunications antennas attached to the same support

Clearance of line conductors from	Communication lines in general (mm)	Communication lines on jointly used structures (mm)	Supply lines Circuit phase-to-phase voltage			
			Neutral conductors meeting Rule 6.4.1.5-1 (mm)	0 to 8.7 kV ^⑯ (mm)	Over 8.7 kV to 50 kV (mm)	Over 50 kV to 814 kV ^{⑭⑮} (mm)
3. Surface of support arms at the support	75 ^⑰	75 ^⑰	75 ^{⑰⑯}	75 ^⑰	75 plus 5 per kV in excess of 8.7 kV	280 plus 5 per kV in excess of 50 kV
4. Surface of structures at the support						
a. On jointly used structures	-	125 ^⑰	125 ^{⑰⑯}	125 ^{⑰⑮}	125 plus 5 per kV in excess of 8.7 kV	300 plus 5 per kV in excess of 50 kV
b. All other	75 ^⑰	-	-	75 ^⑰	75 plus 5 per kV in excess of 8.7 kV	280 plus 5 per kV in excess of 50 kV
5. Service drops in the span^⑯						
a. Telecommunication	300	300	750 ^⑯	750	750 plus 10 per kV in excess of 8.7 kV	1200 plus 10 per kV in excess of 50 kV
b. Supply	N/A	750	300	300	300 plus 10 per kV in excess of 8.7 kV	750 plus 10 per kV in excess of 50 kV

① For guy wires, if practical. For clearances between span wires and telecommunication conductors, see Rule 6.4.9.3

On jointly used structures, guys that pass within 300 mm of supply conductors, and also pass within 300 mm of telecommunication cables, shall be protected with a suitable insulating covering where the guy passes the supply conductors, unless the guy is effectively grounded or insulated with a strain insulator at a point below the lowest supply conductor and above the highest telecommunication cable.

The clearance from an insulated or effectively grounded guy to a telecommunication cable may be reduced to 75 mm when abrasion protection is provided on the guy or telecommunication cable.

② Telecommunication conductors may be attached to supports on the sides or bottom of crossarms or surfaces of poles with less clearance.

- ③ This clearance applies only to supply conductors at the support below telecommunication conductors, on jointly used structures.

Where supply conductors are above telecommunication conductors, this clearance may be reduced to 75 mm.

- ④ All clearances for line over 50 kV shall be based on the maximum operating voltage. For voltages exceeding 814 kV, the clearance shall be determined by the alternate method given by Rule 6.4.6.5-C
- ⑤ For supply circuits of 0 to 750 V, this clearance may be reduced to 75 mm.
- ⑥ A neutral conductor meeting Rule 6.4.1.5-1 may be attached directly to the structure surface.
- ⑦ Guys and messengers may be attached to the same strain plates or to the same through bolts.
- ⑧ For open supply circuits of 0 to 750 V and supply cables of all voltages meeting Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3, this clearance may be reduced to 25 mm. No clearance is specified for phase conductors of such cables where they are physically restrained by a suitable bracket from abrasion against the pole.
- ⑨ The additional clearance for voltages in excess of 50 kV specified in Table 6-20 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
- ⑩ Where the circuit is effectively grounded and the neutral conductor meets Rule 6.4.1.5-1, phase-to-neutral voltage shall be used to determine the clearance from the surface of support arms and structures.
- ⑪ These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
- ⑫ Phase-to-phase voltages shall be determined according to Rule 6.4.6.1-C.
- ⑬ These clearances apply to telecommunication antennas operated at a radio frequency of 3 kHz to 300 GHz. Also see Rules 6.4.6.9-D, 6.4.9. and 6.4.10
- ⑭ Does not include neutral conductors meeting Rule 6.4.1.5-1
- ⑮ These services drop values apply anywhere in the span but not at the support. For vertical clearances at the support, see Table 6-19.

NOTE: These values were derived from Table 6-19 and Rule 6.4.6.3-Bb(1)(a).

- ⑯ This value may be reduced to 300 mm if the supply neutral and telecommunication are electrically bonded together.

Table 6-21: Clearance in any direction from line conductor to supports

Maximum operating voltage phase to phase (kV)	Switching surge factor (per unit)	Switching surge (kV)	Computed Clearance to supports	
			Fixed (m)	Free swinging at Maximum angle (m)
242	2.4	474	0.88	0.88①
	2.6	514	1.01	0.88①
	2.8	553	1.14	0.98
	3.0	593	1.24②	1.10
	3.2	632	1.24②	1.22
362	1.6	473	0.88①	0.88①
	1.8	532	1.07	0.92
	2.0	591	1.27	1.09
	2.2	650	1.49	1.28
	2.4	709	1.72	1.48
550	2.5	739	1.84	1.59
	1.6	719	1.76	1.51
	1.8	808	2.14	1.84
	2.0	898	2.55	2.19
	2.2	988	2.78②	2.57
800	1.6	1045	3.3	2.82
	1.8	1176	4.0	3.5
	1.9	1241	4.1②	3.8
	2.0	1306	4.1②	4.1②

① Shall be not less than that required by Rule 6.4.6.5-C2(2), including the altitude correction for lines as specified in Footnote 9 of Table 6-20.

② Need not be greater than specified in Rule 6.4.6.5-A and 6.4.6.5-B.

Table 6-22: Vertical spacing between conductors supported on vertical racks or separate brackets

Span length		Vertical spacing between conductors	
(m)	(ft)	(mm)	(in)
0 to 45	0 to 150	100	4
Over 45 to 60	Over 150 to 200	150	6
Over 60 to 75	Over 200 to 250	200	8
Over 75 to 90	Over 250 to 300	300	12

EXCEPTION: The vertical spacing between open wire conductors may be reduced where the conductors are held apart by intermediate spacers, but may not be less than 100 mm (4 in).

6.4.7 Climbing space

The following requirements apply only to portions of structures that workers ascend.

6.4.7.1 Location and dimensions

1. A climbing space having the horizontal dimensions specified in Rule 6.4.7.5 shall be provided past any conductors, support arms, or other parts.
2. The climbing space need be provided on one side or corner of the support only.

3. The climbing space shall extend vertically past any conductor or other part between levels above and below the conductor as specified in Rules 6.4.7.5, 6.4.7.6, 6.4.7.7 and 6.4.7.9, but may otherwise be shifted from any side or corner of the support to any other side or corner.

6.4.7.2 Portions of supporting structures in climbing space

Portions of the supporting structure, when included in one side or corner of the climbing space, are not considered to obstruct the climbing space.

6.4.7.3 Support arm location relative to climbing space

RECOMMENDATION: Support arms should be located on the same side of the pole.

EXCEPTION: This recommendation does not apply where double crossarms are used on any pole or where crossarms on any pole are not all parallel.

6.4.7.4 Location of equipment relative to climbing space

1. All supply and telecommunication equipment such as transformers, regulators, capacitors, cable terminals (potheads), amplifiers, loading coils, antennas, surge arresters, switches, etc., when located below conductors or other attachments, shall be mounted outside of the climbing space.
2. All exposed ungrounded conductive parts of luminaires and their supports that are not insulated from current-carrying parts shall be maintained at not less than 500 mm from the surface of their supporting structure.

EXCEPTION 1: This may be reduced to 125 mm if located on the side of the structure opposite the designated climbing space.

EXCEPTION 2: This does not apply where the equipment is located at the top or other vertical portion of the structure that is not subject to climbing.

6.4.7.5 Climbing space between conductors

Climbing space between conductors shall be not less than the horizontal dimensions specified in Table 6-23. These dimensions are intended to provide a clear climbing space of 600 mm while the conductors bounding the climbing space are covered with temporarily installed protective covering rated for the voltage involved. The climbing space shall be provided both along and across the line and shall be projected vertically not less than 1.0 m above and below the limiting conductors. Where telecommunication conductors are above supply conductors of more than 8.7 kV to ground or 15 kV line to line, the climbing space shall be projected vertically at least 1.50 m above the highest supply conductors.

EXCEPTION 1: This rule does not apply if it is the unvarying practice of the employers concerned to prohibit employees from ascending beyond the conductors or equipment of a given line or structure unless the conductors or equipment are de-energized and grounded per relevant work Rules of section 9.

EXCEPTION 2: For supply conductors carried on a structure in a position below telecommunications facilities in the manner permitted in Rule 6.3.1.2-b, the climbing space need not extend more than 600 mm above such supply space.

EXCEPTION 3: If the conductors are owned, operated, or maintained by the same utility, the climbing space may be provided by temporarily moving the line conductors using live-line tools.

6.4.7.6 Climbing space on buckarm construction

Method of providing climbing space on buckarm construction

The full width of climbing space shall be maintained on buckarm construction and shall extend vertically in the same position at least 1.0 m [or 1.50 m where required by Rule 6.4.7.5] above and below any limiting conductor.

A six-pin crossarm having pin spacing of 370 mm may be used to provide a 750 mm climbing space on one corner of a junction pole by omitting the pole pins on all arms, and inserting pins midway between the remaining pins so as to give a spacing of 185 mm, provided that all of the following conditions are met:

1. Circuits are less than 8.7 kV to ground or 15 kV line to line
2. Span lengths do not exceed 45 m
3. Sags do not exceed 380 mm for wires of AWG No. 2 and larger sizes, or 750 mm for wires smaller than AWG No. 2
4. Each conductor on the end of every arm is tied to the same side of its insulator
5. The spacing on the next pole is not less than 370 mm

6.4.7.7 Climbing space past longitudinal runs not on support arms

The full width of climbing space shall be provided past longitudinal runs and shall extend vertically in the same position from 1.0 m below the run to a point 1.0 m above [or 1.50 m where required by Rule 6.4.7.5]. The width of climbing space shall be measured from the longitudinal run concerned. Longitudinal runs on racks, or cables on messengers, are not considered as obstructing the climbing space if the location, size, and quantity of the cables permit qualified workers to climb past them. This does not apply where telecommunication conductors are above the longitudinal runs concerned.

EXCEPTION 1: If a supply longitudinal run is placed on the side or corner of the supporting structure where climbing space is provided, the width of climbing space shall be measured horizontally from the center of the structure to the nearest supply conductors on support arms, under both of the following conditions:

- (a) Where the longitudinal run consists of neutral conductors meeting Rule 6.4.1.5-1, open supply conductors carrying not more than 750 V, or supply cables and conductors meeting Rule 6.4.1.3, all voltages; and is supported close to the structure as by brackets, racks, or pins close to the structure
- (b) Where the nearest supply conductors on support arms are parallel to and on the same side of the structure as the longitudinal run and within 1.20 m above or below the run

EXCEPTION 2: For supply conductors carried on a structure in a position below telecommunications facilities in the manner permitted in Rule 6.3.1.2b the climbing space need not extend more than 600 mm above such supply space.

EXCEPTION 3: A service drop less than 750 V and meeting Rule 6.4.1.3 is not considered to obstruct the climbing space if all conductors concerned are covered by rubber protective equipment or otherwise guarded as an unvarying practice before workers climb past them, provided that such a service drop is (1) not closer to the longitudinal run at the point of attachment than the diameter of the pole plus 125 mm measured horizontally, and (2) not closer than 950 mm measured horizontally to

the longitudinal run at a point 750 mm on the run measured from the point of attachment at the pole. See Figure 6-10

6.4.7.8 Climbing space past vertical conductors

Vertical runs physically protected by suitable conduit or other protective covering and securely attached without spacers to the surface of the line structure are not considered to obstruct the climbing space.

6.4.7.9 Climbing space near ridge-pin conductors

The climbing space specified in Table 6-23 shall be provided above the top support arm to the ridge-pin conductor but need not be carried past it.

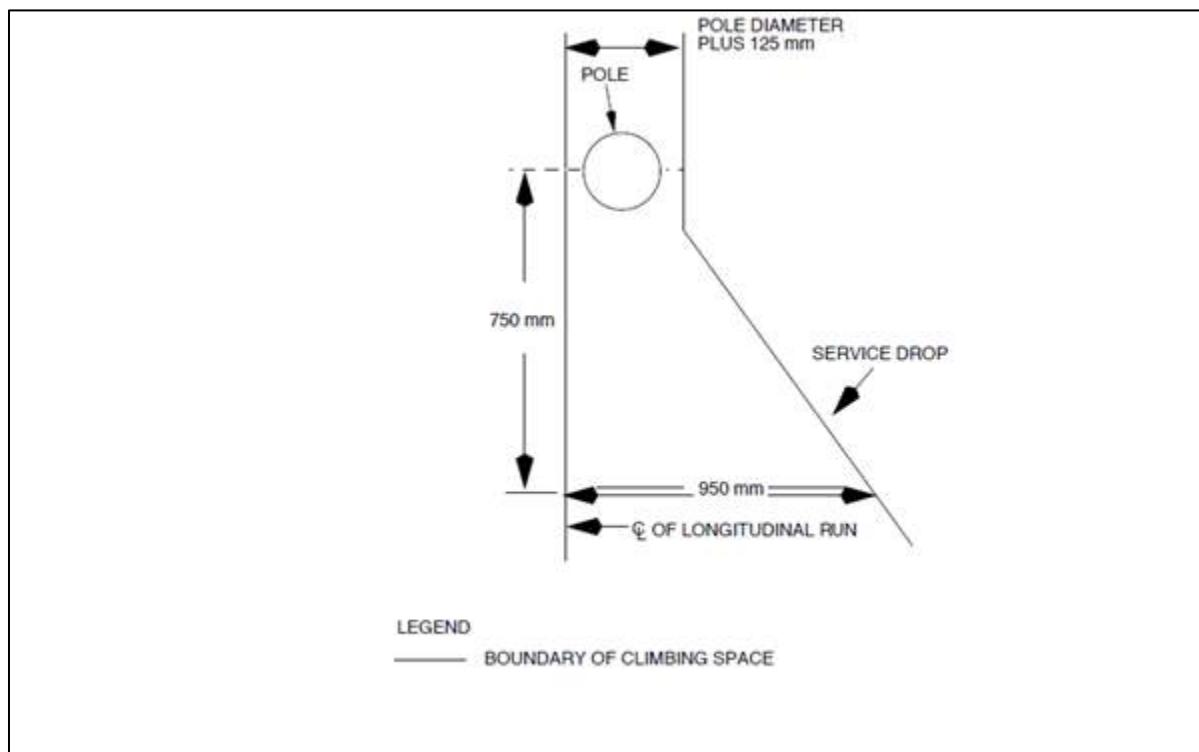


Figure 6-10: Rule 6.4.7.7, *Exception 3*

Table 6-23: Horizontal clearance between conductors bounding the climbing space

[All voltages are between the two conductors bounding the climbing space except for telecommunication conductors, which are voltage to ground. Where the two conductors are in different circuits, the voltage between conductors shall be the arithmetic sum of the voltages of each conductor to ground for a grounded circuit, or phase to phase for an ungrounded conductor.

See also Rule 6.4.7.5

Character of conductors adjacent to climbing space	Voltage of conductors	Horizontal clearance between conductors bounding the climbing space			
		On structure used solely by		On jointly used structures	
		Telecommunication Conductors (m)	Supply Conductors (m)	Supply Conductors above Telecommunication Conductors (m)	Telecommunication Conductors above Supply Conductors① (m)
1. Telecommunication conductors	0 to 150 V	0.60			0.60
	Exceeding 150 V				
2. Supply cables meeting 6.4.1.3-1	All voltages				
3. Supply cables meeting 6.4.1.3-2 or 6.4.1.3-3	All voltages	-	0.60	0.60	0.75
4. Open supply line conductors and supply cables meeting 6.4.1.3	0 to 750 V	-	0.60	0.60	0.75
	750 V to 15 kV	-	0.75	0.75	0.75
	15 kV to 28 kV	-	0.90	0.90	0.90
	28 kV to 38 kV	-	1.00	1.00	
	38 kV to 50 kV	-	1.17	1.17	
	50 kV to 73 kV	-	1.40	1.40	
	Exceeding 73 kV	-	>1.40		

① This relation of levels in general is not desirable and should be avoided.

② climbing space shall be the same as required for the supply conductors immediately above, with a maximum of 0.75 m except that a climbing space of 0.41 m across the line may be employed for telecommunication cables or conductors where the only supply conductors at a higher level are secondaries (0 to 750 V) supplying airport or airway

marker lights or crossing over the telecommunication line and attached to the pole top or to a pole-top extension fixture.

- ③ Attention is called on the operating requirements of relevant Work Rules in Section 9, of this code.

6.4.8 Working space

6.4.8.1 Location of working spaces

Working spaces shall be provided on the climbing face of the structure at each side of the climbing space.

6.4.8.2 Dimensions of working spaces

A. Along the support arm

The working space shall extend from the climbing space to the outmost conductor position on the support arm.

B. At right angles to the support arm

The working space shall have the same dimension as the climbing space (see Rule 6.4.7.5). This dimension shall be measured horizontally from the face of the support arm.

C. Vertically

The working space shall have a height not less than that required by Rule 6.4.6 for the vertical separation of line conductors carried at different levels on the same support.

6.4.8.3 Location of vertical and lateral conductors relative to working spaces

The working spaces shall not be obstructed by vertical or lateral conductors. Such conductors shall be located on the opposite side of the pole from the climbing side or on the climbing side of the pole at a distance from the support arm at least as great as the width of climbing space required for the highest voltage conductors concerned. Vertical conductors enclosed in suitable conduit may be attached on the climbing side of the structure.

6.4.8.4 Location of buckarms relative to working spaces

Buckarms may be used under any of the following conditions, provided the climbing space is maintained. Climbing space may be obtained as in Rule 6.4.7.6.

A. Standard height of working space

Lateral working space of the height required by Table 6-19 shall be provided between the crossing or tap line conductors attached to the buckarm and the main line conductors. This may be accomplished by increasing the spacing between the line support arms, as shown in Figure 6-11.

B. Reduced height of working space

Where no circuits exceeding 8.7 kV to ground or 15 kV line to line are involved and the clearances of Rules 6.4.6.2.Aa and 6.4.6.2.Ab are maintained, conductors supported on buckarms may be placed between line conductors having normal vertical spacing, even though such buckarms obstruct the normal working space, provided that a working space of not less than 450 mm in height is maintained either above or below line conductors and buckarm conductors.

EXCEPTION: The above working space may be reduced to 300 mm if both of the following conditions exist:

- (a) Not more than two sets of the line arms and buckarms are involved
- (b) Working conditions are rendered safe by providing rubber protective equipment or other suitable devices to insulate and cover line conductors and equipment that are not being worked upon

6.4.8.5 Guarding of energized equipment

Exposed energized parts of equipment such as switches, circuit breakers, surge arresters, etc., shall be enclosed or guarded if all of the following conditions apply:

1. The equipment is located below the top conductor support
2. The equipment is located on the climbing side of the structure
3. The requirements of {relevant rule in Section 9 Work Rules} be met

6.4.8.6 Working clearances from energized equipment

All parts of equipment such as switches, fuses, transformers, surge arresters, luminaires and their support brackets, etc., or other connections that may require operation or adjustment while energized and exposed at such times, shall be so arranged with respect to each other, other equipment, vertical and lateral conductors, and portions of the supporting structure, including supporting platforms or structural members, that in adjustment or operation no portion of the body, including the hands, need be brought closer to any exposed energized parts or conductors than permitted in relevant rule in Section 9 Work Rules.

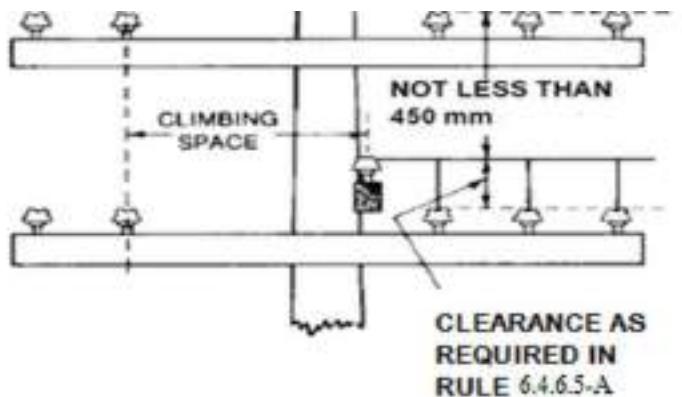


Figure 6-11: Obstruction of working space by buckarm

6.4.9 Vertical clearance between certain telecommunications and supply facilities located on the same structure

6.4.9.1 Equipment

For the purpose of measuring clearances under this rule, equipment shall be taken to mean noncurrent-carrying metal parts of equipment, including metal supports for cables or conductors, metal support braces that are attached to metal supports or are less than 25 mm from transformer cases or hangers that are not effectively grounded, and metal or nonmetallic supports or braces associated with telecommunication cables or conductors. Antennas shall be considered equipment for the purpose of measuring clearances under this rule.

6.4.9.2 Clearances in general

Vertical clearances between supply conductors and telecommunications equipment, between telecommunication conductors and supply equipment, and between supply and telecommunications equipment shall be as specified in Table 6-24, except as provided in Rule 6.4.9.3 and 6.4.9.4.

6.4.9.3 Clearances for span wires or brackets

Span wires or brackets carrying luminaires, traffic signals, or trolley conductors shall have at least the vertical clearances in millimeters or inches from telecommunications equipment set forth in Table 6-25.

6.4.9.4 Clearance of drip loops of luminaire or traffic signal brackets

If a drip loop of conductors entering a luminaire, luminaire bracket, or a traffic signal bracket is above a telecommunication cable, the lowest point of the loop shall be at least 300 mm above telecommunication cable, through bolt, or other exposed conductive objects.

EXCEPTION: The above clearance may be reduced to 75 mm if the loop is covered by a suitable nonmetallic covering that extends at least 50 mm beyond the loop.

6.4.9.5 Telecommunication worker safety zone

The clearances specified in Rules 6.4.6.2 and 6.4.9 create a telecommunication worker safety zone between the facilities located in the supply space and facilities located in the telecommunication space, both at the structure and in the span between structures. Except as allowed by Rules 6.4.9.3, 6.4.9.4, and 6.4.10, no supply or telecommunication facility shall be located in the telecommunication worker safety zone.

Table 6-24: Vertical clearance between supply conductors and telecommunications equipment, between telecommunication conductors and supply equipment, and between supply and telecommunications equipment

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See also Rule 6.4.9.2)

Supply voltage (kV)	Vertical Clearance (m)
1. Grounded conductor and messenger hardware and supports	0.75
2. 0 to 8.7	1.00①
3. Over 8.7	1.00 plus 0.01 per kV① In excess of 8.7 kV

- ① Where non-current-carrying parts of supply equipment are effectively grounded and the associated neutral meeting Rule 6.4.1.5-1 or supply cables meeting Rule 6.4.1.3-1 (including the support brackets) are bonded to telecommunication messengers at intervals meeting Rule 4.2.3 throughout well-defined areas and where telecommunication is at lower levels, clearance may be reduced to 0.75 m.

Table 6-25: Vertical clearance of span wires and brackets from telecommunication lines
[See also Rule 6.4.9.3.]

	Carrying luminaires or traffic signals		Carrying trolley conductor	
	Not effectively grounded (m)	Effectively grounded (m)	Not effectively grounded (m)	Effectively grounded (m)
Above telecommunication support arms	500①	500①	500①	500①
Below telecommunication support arms	1000③	600	600	600
Above messengers carrying telecommunication cables	500①	100	300	100
Below messengers carrying telecommunication cables	1000④	100	300	100
From terminal box of telecommunication cable	500①	100	300②	100
From telecommunication brackets, bridle wire rings, or drive hooks	410①	100	100	100

- ① This may be reduced to 300 mm for either span wires or metal parts of brackets at points 1.0 m or more from the structure surface.
- ② Where it is not practical to obtain a clearance of 300 mm from terminal boxes of telecommunication cables, all metal parts of terminals shall have the greatest possible clearance from fixtures or span wires including all supporting screws and bolts of both attachments.
- ③ This may be reduced to 600 mm for luminaires and traffic signals operating at less than 150 V to ground.
- ④ This may be reduced to 500 mm for luminaires and traffic signals operating at less than 150 V to ground.

6.4.10 Clearance of vertical and lateral facilities from other facilities and surfaces on the same supporting structure

Vertical and lateral conductors shall have the clearances required by this rule from other facilities or surfaces on the same supporting structure.

6.4.10.1 General

1. Grounding conductors, surge-protection wires, neutral conductors meeting Rule 6.4.1.5-1, insulated telecommunication conductors and cables, supply cables meeting Rule 6.4.1.3-1 or 7.6.1-B, insulated supply cables of 0 to 750 V, or conduits may be placed directly on the supporting structure. These conductors, wires, cables, and conduits shall be securely attached to the surface of the structure. Cables not in conduit shall be installed in such a manner as to avoid abrasion at the point of attachment.
2. Installation of supply cable and telecommunication cable in same duct or U-guard type covering
 - a. Supply cables 0 to 600 V may be installed together in the same duct or U-guard, if all of the cables are operated and maintained by the same utility.

- b. Supply cables exceeding 600 V meeting Rule 6.4.1.3-1 or 7.6.1-C may be installed together in the same duct or U-guard if all of the cables are operated and maintained by the same utility.
 - c. Supply cables 0 to 600 V and supply cables exceeding 600 V meeting Rule 6.4.1.3-1 or 7.6.1-B may be installed together in the same duct or U-guard if all of the cables are operated and maintained by the same utility.
 - d. Supply cables shall not be installed in the same duct or U-guard with telecommunication cables unless all of the cables are operated and maintained by the same utility.
 - e. Telecommunication cables may be installed together in the same duct or U-guard provided all utilities involved are in agreement.
3. Paired telecommunication conductors in rings may be attached directly to a structure or messenger.
 4. Insulated supply circuits of 600 V or less and not exceeding 5000 W may be placed in the same cable with control circuits with which they are associated.
 5. The term nonmetallic covering as used in Rule 6.4.10 refers to material other than a cable jacket that provides an additional barrier against physical contact.
 6. Where guarding and protection are required by other rules, either conduit or U-guards may be used.

6.4.10.2 Location of vertical or lateral conductors relative to climbing spaces, working spaces, and pole steps

Vertical or lateral conductors shall be located so that they do not obstruct climbing spaces, or lateral working spaces between line conductors at different levels, or interfere with the safe use of pole steps.

EXCEPTION: This rule does not apply to portions of the structure that workers do not ascend while the conductors in question are energized.

NOTE: See Rule 6.4.7.8 for vertical runs in conduit or other protective covering.

6.4.10.3 Conductors not in conduit

Conductors not encased in conduit shall have the same clearances from conduits as from other surfaces of structures.

6.4.10.4 Guarding and protection near ground

1. Where within 2.45 m of the ground, or other areas readily accessible to the public, all vertical conductors and cables shall be guarded.

EXCEPTION: This guarding may be omitted from grounding conductors used to ground multi-grounded circuits or equipment (telecommunications or supply); telecommunication cables or conductors; armored cables; or conductors used solely to protect structures from lightning.

2. Where guarding is required by Rule 6.4.10.4-1, either conduit or U-guards may be used. A backing plate shall be used with a U-guard unless the U-guard fits tightly to the supporting structure surface.

3. When guarding is not required, conductors and cables shall be securely attached to the surface of the structure or to standoff brackets and located, where practical, on the portion of the structure having the least exposure to mechanical damage.
4. Guards that completely enclose grounding conductors of lightning-protection equipment shall be of nonmetallic materials or shall be bonded at both ends to the grounding conductor.

6.4.10.5 Requirements for vertical and lateral supply conductors on supply line structures or within supply space on jointly used structures

A. General clearances

In general, clearances shall be not less than the values specified in Table 6-26 or Rule 6.4.6.5.

B. Special cases

The following requirements apply only to portions of a structure that workers ascend while the conductors in question are energized.

a. General

If open-line conductors are within 1.20 m of the pole, vertical conductors shall be run in one of the following ways:

- (1) The clearance between open vertical conductors and pole-surface shall be not less than that given in Table 6-27 within the zone specified in the table.
- (2) Within the zone above and below open supply conductors as given in Table 6-27, vertical and lateral conductors or cables attached to the surface of the structure shall be enclosed in nonmetallic conduit or protected by non-metallic covering.

EXCEPTION: This conduit or covering may be omitted from grounding conductors, surge-protection wires, neutral conductors meeting Rule 6.4.1.5-1 supply cables meeting Rule 6.4.1.3.1-1, and jacketed multiple-conductor supply cables of 0 to 750V, where such conductors or cable are not in the climbing space.

For the purpose of this exception, a jacketed multiple-conductor cable is a cable with a jacket enclosing the entire cable assembly.

b. Conductors to luminaires

On structures used only for supply lines or on jointly used structures where the luminaire bracket is 1.0 m or more above all telecommunication attachments, open wires may be run from the supply line arm directly to the head of a luminaire, provided the clearances of Table 6-26 are obtained and the open wires are securely supported at both ends.

6.4.10.6 Requirements for vertical and lateral telecommunication conductors on telecommunication line structures or within the telecommunication space on jointly used structures

A. Clearances from telecommunication conductors

The clearances of uninsulated vertical and lateral telecommunication conductors from other telecommunication conductors (except those in the same ring run) and from guy, span, or messenger wires shall be not less than those given in Rule 6.4.6.5-A, Table 6-20.

B. Clearances from supply conductors

The vertical clearance of vertical and lateral insulated telecommunication conductors shall be not less than 1.0 m from any supply conductors (other than vertical runs or luminaire leads) of 8.7 kV or less, or 1.0 m plus 10 mm per kV over 8.7 to 50 kV. The additional clearance of Rule 6.4.6.2-B is applicable when the voltage exceeds 50 kV.

EXCEPTION 1: May be reduced to 0.75 m from supply neutrals meeting Rule 6.4.1.5-1, cables meeting Rule 6.4.1.3, and fiber optic-supply cables where the supply neutral or messenger is bonded to the telecommunication messenger.

EXCEPTION 2: These clearances do not apply where the supply circuits involved are those carried in the manner specified in Rule 6.3.1.2-2.

6.4.10.7 Requirements for vertical supply conductors and cables passing through telecommunication space on jointly used line structures

A. Guarding—General

Vertical supply conductors or cables attached to the structure shall be guarded with suitable conduit or covering from 1.0 m above the highest telecommunication attachment to 1.80 m below the lowest telecommunication attachment, except as allowed by Rule 6.4.9.4.

EXCEPTION 1: This conduit or covering may be omitted from neutral conductors meeting Rule 6.4.1.5-1, supply cables meeting Rule 6.4.1.3-1, and jacketed multiple-conductor supply cables of 0 to 750 V, where such conductors or cable are not in the climbing space.

For the purpose of this exception, a jacketed multiple-conductor cable is a cable with a jacket enclosing the entire cable assembly.

EXCEPTION 2: This conduit or covering may be omitted from supply grounding conductors where there are no trolley or ungrounded traffic signal attachments, or ungrounded street lighting fixtures located below the telecommunication attachment, provided:

- (a) The grounding conductor is directly (metallically) connected to a conductor which forms part of an effective grounding system,
- (b) The grounding conductor has no connection to supply equipment between the grounding electrode and the effectively grounded conductor unless the supply equipment has additional connections to the effectively grounded conductor, and
- (c) The grounding conductor is bonded to grounded telecommunication facilities at that structure.

B. Cables and conductors in conduit or covering

Cables and conductors of all voltages may be run in a nonmetallic conduit or covering or in a grounded metallic conduit or covering in accordance with Rule 6.4.10.1-1 Where

a metallic conduit or covering is not bonded to grounded telecommunications facilities at that structure, such metal conduit or covering shall have a nonmetallic covering from 1.0 m above the highest telecommunication attachment to 1.80 m below the lowest telecommunication attachment.

C. Protection near trolley, ungrounded traffic signal, or ungrounded luminaire attachments

Vertical supply conductors or cables attached to the structure shall be guarded with suitable nonmetallic conduit or covering on structures that carry a trolley or ungrounded traffic signal attachment or an ungrounded luminaire that is attached below the telecommunication cable. The cable shall be protected with nonmetallic covering from 1.0 m above the highest telecommunication wire to 1.80 m below the lowest trolley attachment or ungrounded luminaire fixture or ungrounded traffic signal attachment.

D. Aerial services

Where supply cables are used as aerial services, the point where such cables leave the structure shall be at least 1.0 m above the highest or 1.0 m below the lowest telecommunication attachment. Within the telecommunication space, all splices and connections in the energized phase conductors shall be insulated.

E. Clearance from through bolts and other metal objects

Vertical runs of supply conductors or cables shall have a clearance of not less than 50 mm from exposed through bolts and other exposed metal objects attached thereto that are associated with telecommunication line equipment.

EXCEPTION: Vertical runs of effectively grounded supply conductors may have a clearance of 25 mm.

6.4.10.8 Requirements for vertical telecommunication conductors passing through supply space on jointly used structures

All vertical runs of telecommunication conductors passing through supply space shall be installed as follows:

A. Metal-sheathed telecommunication cables

Vertical runs of metal-sheathed telecommunication cables shall be covered with suitable nonmetallic material, where they pass trolley feeders or other supply line conductors. This nonmetallic covering shall extend from a point 1.0 m above the highest trolley feeders or other supply conductors, to a point 1.80 m below the lowest trolley feeders or other supply conductors, but need not extend below the top of any mechanical protection that may be provided near the ground.

EXCEPTION 1: Telecommunication cables may be run vertically on the pole through space occupied by railroad signal supply circuits in the lower position, as permitted in Rule 6.3.1.2-2 without covering within the supply space.

EXCEPTION 2: Covering is not required in the supply space on metallic or concrete supporting structures.

EXCEPTION 3: Where the cable terminates at an antenna in the supply space meeting Rule 6.4.6.6 the nonmetallic covering need only extend to the antenna.

B. Telecommunication conductors

Vertical runs of insulated telecommunication conductors shall be covered with suitable nonmetallic material, to the extent required for metal-sheathed telecommunication cables in Rule 6.4.10.8-A, where such conductors pass trolley feeders or supply conductors.

EXCEPTION 1: Telecommunication conductors may be run vertically on the structure through space occupied by railroad-signal supply circuits in the lower position, as permitted in Rule 6.3.1.2-2 without covering within the supply space.

EXCEPTION 2: Covering is not required in the supply space on metallic or concrete supporting structures.

C. Telecommunication grounding conductors

Vertical telecommunication grounding conductors shall be covered with suitable nonmetallic material between points at least 1.80 m below and 1.0 m above any trolley feeders or other supply line conductors by which they pass.

EXCEPTION 1: Telecommunication grounding conductors may be run vertically on the structure though space occupied by railroad-signal supply circuits in the lower position, as permitted in Rule 6.3.1.2-2, without covering within the supply space.

EXCEPTION 2: Covering is not required in the supply space on metallic or concrete supporting structures.

D. Clearance from through bolts and other metal objects

Vertical runs of telecommunication conductors or cables shall have a clearance of one-eighth of the pole circumference but not less than 50 mm from exposed through bolts and other exposed metal objects attached thereto that are associated with supply line equipment.

EXCEPTION: Vertical runs of effectively grounded telecommunication cables may have a clearance of 25 mm.

6.4.10.9 Operating rods

Effectively grounded or insulated operating rods of switches are permitted to pass through the telecommunication space, but shall be located outside of the climbing space.

6.4.10.10 Additional rules for standoff brackets

1. Standoff brackets may be used to support the conduit(s). Cable insulation appropriate for the intended service is required; non-metallic conduit shall not be used to meet basic insulation requirements.

NOTE: See Rule 6.2.7.1-B.

2. Standoff brackets may be used to support the following types of cable enclosed within a single outer jacket or sheath (cable only without conduit):
 - a. Telecommunication
 - b. Rule 6.4.1.3-1 supply (any voltage)
 - c. Supply less than 750 V

NOTE: See Rule 6.2.7.1-B.

Table 6-26: Clearance of open vertical and lateral conductors
 (Circuit phase-to-phase voltage. See also Rules 6.4.10.5-A and 6.4.10.5-Bb.)

Clearance of open vertical and lateral conductors	Neutral conductors meeting Rule 6.4.1.5-1	0 to 8.7 kV ^⑦ (mm)	Over 8.7 kV to 50 kV (mm)	Over 50 kV ^④ (mm)
From surfaces of supports	Not specified ^①	75 ^②	75 plus 5 per kV in excess of 8.7 kV ^⑥	280 plus 5 per kV in excess of 50 kV
From span, guy, and messenger wire ^⑤	75	150	75 plus 5 per kV in excess of 8.7 kV ^③	280 plus 5 per kV in excess of 50 kV ^③

- ① A neutral conductor meeting Rule 6.4.10.5-A may be attached directly to the structure surface.
- ② For supply circuits of 0 to 750 V, this clearance may be reduced to 25 mm.
- ③ Multiplier may be reduced to 6.5 mm/kV for anchor guys.
- ④ The additional clearance for voltages in excess of 50 kV specified in Table 6.26 shall be increased 3% for each 300 m in excess of 1000 m above mean sea level.
- ⑤ These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.
- ⑥ Where the circuit neutral is effectively grounded and the neutral conductor meets Rule 6.4.1.5-1, phase-to-neutral voltage shall be used to determine the clearance from the surface of support arms and structures.
- ⑦ Does not include neutral conductors meeting Rule 6.4.1.5-1.

Table 6-27: Clearance between open vertical conductors and pole surface

[Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. See the definitions section for voltages of other systems. See also Rules 6.4.10.5-Ba(1) and 6.4.10.5-Ba(2)]

Voltage (kV)	Distance above and below open supply conductors where clearances apply (m)	Clearance between vertical Conductor and pole surface (mm)
0 to 22①	1.80	480
22 to 30	1.80	560
30 to 50	1.80	760

① Does not include neutral conductors meeting Rule 6.4.1.5-1.

6.5 Grades of construction

6.5.1 General

- A. The grades of construction are specified in this section on the basis of the required strengths for safety. Where two or more conditions define the grade of construction required, the grade used shall be the highest one required by any of the conditions.
- B. For the purposes of this section, the voltage values for direct-current circuits shall be considered equivalent to the rms values for alternating-current circuits.

6.5.2 Application of grades of construction to different situations

6.5.2.1 Supply cables

For the purposes of these rules, supply cables are classified by two types as follows:

Type 1—Supply cables conforming to Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3 shall be installed in accordance with Rule 6.7.2.7

Type 2—All other supply cables are required to have the same grade of construction as open-wire conductors of the same voltage.

6.5.2.2 Order of grades

The relative order of grades for supply and telecommunication conductors and supporting structures is B, C, and N, with Grade B being the highest.

6.5.2.3 At crossings

Wires, conductors, or other cables of one line are considered to be at crossings when they cross over another line, whether or not on a common supporting structure, or when they cross over or overhang a railroad track, the traveled way of a limited access highway, or navigable waterways requiring waterway crossing permits. Joint-use or collinear construction in itself is not considered to be at crossings.

A. Grade of upper line

Conductors and supporting structures of a line crossing over another line shall have the grade of construction specified in Rules 6.5.2.3-A, 6.5.3, and 6.5.4.

B. Grade of lower line

Conductors and supporting structures of a line crossing under another line need only have the grades of construction that would be required if the line at the higher level were not there.

C. Multiple crossings

- a. Where a line crosses in one span over two or more other lines, or where one line crosses over a span of a second line, which span in turn crosses a span of a third line, the grade of construction of the uppermost line shall be not less than the highest grade that would be required of either one of the lower lines when crossing the other lower line.
- b. Where telecommunication conductors cross over supply conductors and railroad tracks in the same span, the grades of construction shall be in accordance with Grade B construction. It is recommended that the placing of telecommunication conductors above supply conductors generally be avoided unless the supply conductors are trolley-contact conductors and their associated feeders.

6.5.2.4 Conflicts

The grade of construction of the conflicting structure shall be as required by Rule 6.5.4.1-4.

6.5.3 Grades of construction for conductors

The grades of construction required for conductors are given in Tables 6-28. For the purpose of these tables certain classes of circuits are treated as follows:

6.5.3.1 Constant-current circuit conductors

The grade of construction for conductors of a constant-current supply circuit shall be based on the open circuit voltage rating of the transformer supplying such circuit. The grade of construction shall be not less than that required in Table 6-28 for a supply conductor of the same voltage.

6.5.3.2 Railway feeder and trolley-contact circuit conductors

Railway feeder and trolley-contact circuit conductors shall be considered as supply conductors for the purpose of determining the required grade of construction.

6.5.3.3 Telecommunication circuit conductors and cables

Telecommunication circuit conductors and cables shall have a grade of construction not less than (a) that required by Table 6-28, or (b) the highest grade of construction required for any conductors or cables located below.

6.5.3.4 Fire-alarm circuit conductors

Fire-alarm circuit conductors shall meet the strength and loading requirements of telecommunication circuit conductors.

6.5.3.5 Neutral conductors of supply circuits

Supply-circuit neutral conductors, which are effectively grounded throughout their length and are not located above supply conductors of more than 750 V to ground, shall have the same grade of construction as supply conductors of not more than 750 V to ground, except that they need not meet any insulation requirements. Other neutral conductors shall have the same

grade of construction as the phase conductors of the supply circuits with which they are associated.

6.5.3.6 Surge-protection wires

Surge-protection wires shall be of the same grade of construction as the supply conductors with which they are associated.

**Table 6-28: Grades of construction for conductors and cables alone, at crossing,
or on the same structures with other conductors and cables**

(The voltages listed in this table are phase-to-ground values for: effectively grounded ac circuits, two-wire grounded circuits, or center-grounded dc circuits; otherwise phase-to-phase values shall be used. The grade of construction for supply conductors and cables, as indicated across the top of the table, shall also meet the requirements for any lines at lower levels except when otherwise noted. Placing of telecommunication conductors and cables at higher levels at crossings or on jointly used poles in a telecommunication space above supply conductors or cables should generally be avoided, unless the supply conductors are trolley-contract conductors and their associated feeders)

Conductors, cables, tracks, and rights-of-way at lower levels	Conductors and cables at higher levels ^①						
	Supply conductor					Telecommunication conductors and cables	
	0 to 750 V	751 to 22 kV		Exceeding 22 kV			
	Open or Cable	Open	Cable	Open	Cable	Open or cable	
Exclusive private rights-of-way	N	N ^②		N ^②		N	
Common or public rights-of-way	N	C N		C ^③ C		N	
Railroad tracks and limited-access highways ^④ , and navigable waterways requiring waterway crossing permits	B	B	B	B	B	B	
Supply conductors, 0 to 750 V, open or cable	N	C	N	C ^③	C	B, C, or N; see Rule 6.5.3.3	
750 V to 22 kV Open	C ^④	C C		C ^③ C			
Cable	N	C N		C ^③ C			
Exceeding 22 kV Open	B ^④	B B		C ^③ C			
Cable	C ^④	C	N	C ^③	C	B, C, or N; see Rule 6.5.3.3	
Telecommunication Conductors; open or cable, located in the supply space ^⑤	B, C, or N; see Rule 6.5.3.3						
Telecommunication conductor: open or cable ^⑥	N	B ^{⑥⑦}	C	B ^⑦	C	B, C, or N; see Rule 6.5.3.3	

- ① The words *open* and *cable* appearing in the headings have the following meanings as applied to supply conductors: cable means the type 1 cables described in Rule 6.5.2.1 open means Type 2 cables described in Rules 6.5.2.1 and open wire.
- ② Lines that can fall outside the exclusive private rights-of-way shall comply with the grades specified for lines not on exclusive private rights-of-way.
- ③ Grade B construction shall be used if the supply circuits will not be promptly de-energized, both initially and following subsequent breaker operations, in the event of a contact with lower supply conductors or other grounded objects.
- ④ If the wires are service drops, they may have Grade N sizes and tensions as set forth in Table 6-38.
- ⑤ Grade N construction may be used where the telecommunication conductors consist only of not more than one insulated twisted-pair or parallel-lay conductor, or where service drops only are involved.
- ⑥ Grade C construction may be used if the voltage does not exceed 5.0 kV phase to phase or 2.9 kV phase to ground.
- ⑦ Grade C construction may be used if both of the following conditions or fulfilled:
- (a) The supply voltage will be promptly removed from the telecommunications plant by de-energization or other means, both initially and following subsequent circuit-breaker operations in the event of a contact with the telecommunications plant.
 - (b) The voltage and current impressed on the telecommunications plant in the event of a contact with the supply conductors are not in excess of the safe operating limit of the telecommunications-protective devices.
- ⑧ Not used in this edition.
- ⑨ Telecommunication circuits located below supply conductors shall not affect the grade of construction of the supply circuits.
- ⑩ There is no intent to require Grade B over ordinary streets and highways.

6.5.4 Grades of construction for line supports

6.5.4.1 Structures

The grade of construction shall be that required for the highest grade of conductors supported except as modified by the following:

1. The grade of construction of jointly used structures, or structures used only by telecommunication lines, need not be increased merely because the telecommunication wires carried on such structures cross over trolley-contact conductors of 0 to 750 V to ground.
2. Structures carrying supply service drops of 0 to 750 V to ground shall have a grade of construction not less than that required for supply line conductors of the same voltage.
3. Where the telecommunication lines cross over supply conductors and a railroad in the same span and Grade B is required by Rule 6.5.2.3-Cb for the telecommunication conductors, due to the presence of railroad tracks, the grade of the structures shall be B.
4. The grade of construction required for a conflicting structure (first circuit) shall be determined from the requirements of Rule 6.5.3 for crossings. The conflicting structure's conductors (first circuit) shall be assumed to cross the other circuit's conductors (second circuit) for the purposes of determining the grade of construction required for the conflicting structure.

NOTE: The resulting structure grade requirement could result in a higher grade of construction for the structure than for the conductors carried thereon.

6.5.4.2 Crossarms and support arms

The grade of construction shall be that required for the highest grade of conductors carried by the arm concerned except as modified by the following:

1. The grade of construction of arms carrying only telecommunication conductors need not be increased merely because the conductors cross over trolley-contact conductors of 0 to 750 V to ground.
2. Arms carrying supply service drops of 0 to 750 V to ground shall have a grade of construction not less than that required for supply line conductors of the same voltage.
3. Where telecommunication lines cross over supply conductors and a railroad in the same span and Grade B is required by Rule 6.5.2.3-Cb for the telecommunication conductors due to the presence of railroad tracks, the grade of the arm shall be B.

6.5.4.3 Pins, armless construction brackets, insulators, and conductor fastenings

The grade of construction for pins, armless construction brackets, insulators, and conductor fastenings shall be that required for the conductor concerned except as modified by the following:

1. The grade of construction need not be increased merely because the supported conductors cross over trolley-contact conductors of 0 to 750 V to ground.
2. Supply service drops of 0 to 750 V to ground require only the same grade of construction as supply line conductors of the same voltage.
3. When Grade B construction is required by Rule 6.5.2.3-Cb for the telecommunication conductors due to the presence of railroad tracks, Grade B construction shall be used when supporting telecommunication lines that cross over supply conductors and a railroad in the same span.
4. When telecommunication conductors are required to meet Grade B or C, only the requirements for mechanical strength for these grades are required.
5. Insulators for use on open conductor supply lines shall meet the requirements of Rule 6.8 for all grades of construction.

6.6 Loadings for Grades B and C

6.6.1 Loading requirements

6.6.1.1 General

1. It is necessary to assume the wind and ice loads that may occur on a line. Three weather loadings are specified in Rules 6.6.1.2, 6.6.1.3, and 6.6.1.4. Where all three rules apply, the required loading shall be the one that has the greatest effect.
2. Where construction or maintenance loads exceed those imposed by Rule 6.6.1.1-1, the assumed loadings shall be increased accordingly. When temporary loads, such as lifting of equipment, stringing operations, or a worker on a structure or its component, are to be imposed on a structure or component, the strength of the structure or component

should be taken into account or other provisions should be made to limit the likelihood of adverse effects of structure or component failure.

NOTE: Other provisions could include cranes that can support the equipment loads, guard poles and spotters with radios, and stringing equipment capable of promptly halting stringing operations.

3. It is recognized that loadings actually experienced in certain areas in each of the loading zones may be greater, or in some cases, may be less than those specified in these rules. In the absence of a detailed loading analysis, using the same respective statistical methodologies used to develop the maps in Rule 6.6.1.3 or 6.6.1.4, no reduction in the loadings specified therein shall be made without the approval of the administrative authority.
4. The structural capacity provided by meeting the loading and strength requirements of Rules 6.6 and 6.7 provides sufficient capability to resist earthquake ground motions.

6.6.1.2 Combined ice and wind loading

Three general degrees of loading due to weather conditions are recognized and are designated as heavy, medium and light loading.

NOTE: The localities are classified in the different loadings according to the relative simultaneous prevalence of the wind velocity and thickness of ice that accumulates on wires. Light loading is for places where little, if any, ice accumulates on wires.

Table 6-29 shows the radial thickness of ice and the wind pressures to be used in calculating loads. Ice is assumed to weigh 913 kg/m³.

6.6.1.3 Extreme wind loading

If no portion of a structure or its supported facilities exceeds 18 m above ground or water level, the provisions of this rule are not required, except as specified in Rule 6.7.2.1-Ac 6.7.2.1-Be, or 6.7.2.1-Cd. Where a structure or its supported facilities exceeds 18 m above ground or water level the structure and its supported facilities shall be designed to withstand the extreme wind load associated with the Basic Wind Speed of 45 m/s. The wind pressures calculated shall be applied to the entire structure and supported facilities without ice. The following formula shall be used to calculate wind load.

$$\text{Load in newtons} = 0.613 \cdot (\text{Vm/s})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f A(\text{m}^2)$$

where

0.613	Velocity-pressure numerical coefficient reflects the mass density of air for the standard atmosphere, i.e., temperature of 15°C and sea level pressure of 760 mm of mercury. The numerical coefficient 0.613 metric shall be used except where sufficient climatic data are available to justify the selection of a different value of this factor for a design application
k_z	Velocity pressure exposure coefficient, as defined in Rule 6.6.1.3-A, Table 6-30
V	Basic wind speed, 3 s gust wind speed in m/s at 10 m above ground

G_{RF}	Gust response factor, as defined in Rule 6.6.1.3-B
I	Importance factor, 1.0 for utility structures and their sported facilities
C_f	Force coefficient (shape factor) as defined in Rules 6.6.2.1-2 and 6.6.3.2
A	Projected wind area, m^2

The wind pressure parameters (k_z , V , and GRF) are based on open terrain with scattered obstructions (Exposure Category C as defined in ASCE 7-05). Exposure Category C is the basis of the PETSAC-2014 extreme wind criteria. Topographical features such as ridges, hills, and escarpments may increase the wind loads on site-specific structures. A Topographic Factor, k_z , from ASCE 7-05, may be used to account for these special cases.

NOTE: Special wind regions—Although the wind speed defined herein above is valid for most regions of the country, but the wind blowing over mountain ranges or through gorges or river valleys can develop speeds that are substantially higher than the value indicated.

A. Velocity pressure exposure coefficient, k_z

The velocity pressure exposure coefficient, k_z , is based on the height, h , to the center-of-pressure of the wind area for the following load applications:

- a. k_z for the structure is based on 0.67 of the total height, h , of the structure above ground line.

NOTE: In Table 6-30, for $h \leq 75$ m, the structure k_z values are adjusted for the wind load to be determined at the center-of-pressure of the structure assumed to be at 0.67 h . The wind pressure is assumed uniformly distributed over the structure face normal to the wind.

- b. k_z for the wire is based on the height, h , of the wire at the structure.

In special terrain conditions (i.e., mountainous terrain and canyon) where the height of the wire above ground at mid-span may be substantially higher than at the structure, engineering judgment may be used in determining an appropriate value for the wire k_z .

- c. k_z for a specific height on a structure or component is based on the height, h , to the center-of pressure of the wind area being considered.

The formulas shown in Table 6-30 shall be used to determine all values of k_z .

EXCEPTION: The selection values of k_z tabulated in Table 6-30 may be used instead of calculating the values.

B. Gust response factor, GRF

- a. The structure gust response factor, GRF, is determined using the total structure height, h . When calculating a wind load at a specific height on a structure, the structure guest response factor, GRF, determined using the total structure height, h , shall be used.

- b. The wire gust response factor is determined using the height of the wire at the structure, h , and the design wind span, L . Wire attachment points that are 18 m or less above ground or water level must be considered if the total structure height is greater than 18 m above ground or water.

In special terrain conditions (i.e., mountainous terrain ad canyon) where the height of the wire aboveground at mid-span substantially higher than at the attachment point, engineering judgment may be used in determining an appropriate value for the wire GRF.

- c. The gust response factor, GRF, to be used on components, such as antennas, transformers, etc., shall be the structure gust response factor determined in Rule 6.6.1.3-Ba.

Selected values of the structure and wire gust response factors are tabulated in Table 6-31. The structure and wire gust response factors may also be determined using the formulas in Table 6-31. For values of $h > 75$ m and $L > 600$ m, the G_{RF} shall be determined using the formulas in Table 6-31.

NOTE: Where structure heights are 50 m or less and spans are 600 m or less, the combined product of k_z and GRF may be conservatively taken as 1.15 it is desired to simplify calculations.

6.6.1.4 Extreme ice with concurrent wind loading

If no portion of a structure or its supported facilities exceeds 18 m above ground or water level, the provisions of this rule are not required. Where a structure or its supported facilities exceeds 18 m above ground or water level, the structure and its supported facilities shall be designed to withstand the ice and wind load associated with the Uniform Ice Thickness and Concurrent Wind Speed. The wind pressures for the concurrent wind speed shall be as indicated in Table 6-32. The wind pressures calculated shall be applied to the entire structure and supported facilities without ice and to the iced wire diameter determined in accordance with Rule 6.6.2.

Ice is assumed to weigh 913 kg/m³.

1. For Grade B, the radial thickness of ice shall be multiplied by a factor of 1.00.
2. For Grade C, the radial thickness of ice shall be multiplied by a factor of 0.80.
3. The concurrent wind shall be applied to the projected area resulting from Rules 6.6.1.4-1 and 6.6.1.4-2 multiplied by a factor of 1.00.

Table 6-29: Ice, wind pressure, and temperatures

	Heavy Loading Areas	Medium Loading Areas	Light Loading Areas
Radial thickness of ice (mm)	12.5	6.5	0
Horizontal wind pressure (kg/m ²)	19	19	43
Temperature (°C)	-20	-10	-1~ +10

Table 6-30 : Velocity pressure exposure coefficient k_z

Height, h (m)	k _z (structure)	k _z (wire, specified height on the structure, and component)
≤ 10	0.9	1.0
> 10 to 15	1.0	1.1
> 15 to 25	1.1	1.2
> 25 to 35	1.2	1.3
> 35 to 50	1.3	1.4
> 50 to 75	1.4	1.5
> 75	Use formulas	Use formulas

Formulas:

Structure	$k_z = 2.01 \cdot 0.67 \cdot h/275^{(2/9.5)}$ $k_z = 1.85$	$h \leq 275\text{m}$ $h \leq 275\text{m}$
Wire, specified height on the structure, and Component	$k_z = 2.01 \cdot (h/275)^{(2/9.5)}$ $k_z = 2.01$	$h \leq 275\text{m}$ $h \leq 275\text{m}$

h = Structure, specified height on the structure, and component and wire height as defined in Rule 6.6.1.3-A

Minimum $k_z = 0.85$

Formulas are for exposure Category C, ASCE 7-05

NOTE: Calculations in this table are based on the maximum values in the stated ranges.

Table 6-31: Structure and wire gust response factors, GRF

Height	Structure	Wire G_{RF}, span length, L (m)						
		≤75	75<L ≤150	150<L ≤225	225<L ≤300	300<L ≤450	450<L ≤600	L >600
≤10	1.00	0.91	0.86	0.79	0.75	0.72	0.69	①
>10 to 15	0.96	0.87	0.82	0.76	0.73	0.70	0.67	①
>15 to 25	0.93	0.85	0.80	0.75	0.71	0.69	0.66	①
>20 to 35	0.89	0.82	0.78	0.73	0.70	0.68	0.65	①
>35 to 50	0.86	0.81	0.77	0.72	0.69	0.67	0.64	①
>50 to 75	0.83	0.79	0.75	0.71	0.68	0.66	0.63	①
>75	①	①	①	①	①	①	①	①

Formulas:

Where:

Structure $G_{RF} = [1 + (2.7 \cdot E_s \cdot B_s^{0.5})]/k_v^2$ E_w = Wire exposure factor

Wire $G_{RF} = [1 + (2.7 \cdot E_w \cdot B_w^{0.5})]/k_v^2$ E_s = Structure exposure factor

$E_s = 0.346 \cdot [10/(0.67 \cdot h)]^{1/7}$ B_w = Dimensionless response term corresponding to the quasi-static background wind loads on the structure

$E_w = 0.346 \cdot (10/h)^{1/7}$ B_s = Dimensionless response term corresponding to the quasi-static background wind loads on the structure

$B_s = 1/(1+0.56 \cdot (0.67 \cdot h))^{6/7}$ $k_v = 1.43$

$B_w = 1/(1+0.8 \cdot L/67)$ h = Structure or wire height, as defined in Rule 6.6.1.3-B, in meters

L = Design wind span, in meters

Formulas are for Exposure Category C, ASCE 7-05

① For heights greater than 75 m and/or spans greater than 600 m, the formulas shall be used.

Table 6-32: Wind speed conversions to pressure
 To be used only with the extreme ice with concurrent wind loading of Rule 6.6.1.4

Wind speed (mph)	Horizontal wind pressure
	kg/m ²
30	11
40	19
50	31
60	44

6.6.2 Conductor loading

6.6.2.1 General

Ice and wind loads are specified in Rule 6.6.1.

1. Where a cable is attached to a messenger, the specified loads shall be applied to both cable and messenger.
2. In determining wind loads on a conductor or cable without ice covering, the assumed projected area shall be that of a smooth cylinder whose outside diameter is the same as that of the conductor or cable. The force coefficient (shape factor) for cylindrical surfaces is assumed to be 1.0.

EXCEPTION: The force coefficient (shape factor) of 1.0 may be reduced for the bare conductor (without radial ice) if wind tunnel tests or a qualified engineering study justifies a reduction.

NOTE: Experience has shown that as the size of multi-conductor cable decreases, the actual projected area decreases, but the roughness factor increases and offsets the reduction in projected area.

3. An appropriate mathematical model shall be used to determine the wind and weight loads on ice-coated conductors and cables. In the absence of a model developed in accordance with Rule 6.6.2.1-4, the following mathematical model shall be used:
 - a. On a conductor, lashed cable, or multiple-conductor cable, the coating of ice shall be considered to be a hollow cylinder touching the outer strands of the conductor or the outer circumference of the lashed cable or multiple-conductor cable.
 - b. On bundled conductors, the coating of ice shall be considered as individual hollow cylinders around each subconductor.
4. It is recognized that the effects of conductor stranding or of non-circular cross section may result in wind and ice loadings more or less than those calculated according to assumptions stated in Rules 6.6.2.1-2 and 6.6.2.1-3. No reduction in these loadings is permitted unless testing or a qualified engineering study justifies a reduction.

6.6.2.2 Load components

The load components shall be determined as follows:

- 1. Vertical load component**

The vertical load on a wire, conductor, or messenger shall be its own weight plus the weight of conductors, spacers, or equipment that it supports, ice covered where required by Rule 6.6.1.

- 2. Horizontal load component**

The horizontal load shall be the horizontal wind pressure determined under Rule 6.6.1 applied at right angles to the direction of the line using the projected area of the conductor or messenger and conductors, spacers, or equipment that it supports, ice covered where required by Rule 6.6.1.

NOTE: The projected area of the conductor or messenger is equal to the diameter of the conductor or messenger, plus ice if appropriate, multiplied by the span length (see Rule 6.6.3.2-D). See Rule 6.6.2.1-2 for force coefficient values of different surface shapes.

- 3. Total load**

The total load on each wire, conductor, or messenger shall be the resultant of components 1 and 2 above, calculated at the applicable temperature in Table 6-33, plus the corresponding constant in Table 6-33. In all cases the conductor or messenger tension shall be computed from this total load.

Table 6-33: Temperatures and constants

	Loading (for use with Rule 6.6.1.2)		
	Heavy Loading Areas	Medium Loading Areas	Light Loading Areas
Temperature (°C)	-20	-10	-1
Constant to be added to the resultant (all conductors)①(kg/m^2)	0.44	0.29	0.073

① For cable arrangements supported by a messenger using spacers or rings and where each conductor or cable is separately loaded with ice and wind as described in Rule 6.6.2.1-3b as opposed to being analyzed with the ice and wind applied to a hollow cylinder touching the outer strands of the conductors as described in Rule 6.6.2.1-3a, the constant specified here shall be added to the resultant load of each component conductor and the messenger.

6.6.3 Loads on line supports

6.6.3.1 Assumed vertical loads

The vertical loads on poles, towers, foundations, crossarms, pins, insulators, and conductor fastenings shall be their own weight plus the weight that they support, including all wires and cables, in accordance with Rules 6.6.2.1 and 6.6.2.2-1, together with the effect of any difference in elevation of supports. Loads due to radial ice shall be computed on wires, cables, and messengers, but need not be computed on supports.

6.6.3.2 Assumed transverse loads

The total transverse loads on poles, towers, foundations, crossarms, pins, insulators, and conductor fastenings shall include the following:

A. Transverse loads from conductors and messengers

The transverse loads from conductors and messengers shall be the horizontal load determined by Rule 6.6.2.

EXCEPTION: In medium- and heavy-loadings, where supporting structures carry ten or more conductors on the same crossarm, not including cables supported by messengers, and where the horizontal pin spacing does not exceed 380 mm (15 in), the transverse wind load may be calculated on two-thirds of the total number of such conductors if at least ten conductors are used in the calculations.

B. Wind loads on structures

The transverse load on structures and equipment shall be computed by applying, at right angles to the direction of the line, the appropriate horizontal wind pressure determined under Rule 6.6.1. This load shall be calculated using the projected surfaces of the structures and equipment supported thereon, without ice covering. The following force coefficient (shape factors) shall be used.

a. Cylindrical structures and components

Wind loads on straight or tapered cylindrical structures or structures composed of numerous narrow relatively flat panels that combine to form a total cross section that is circular or elliptical in shape shall be computed using a force coefficient (shape factor) of 1.0.

b. Flat surfaced (not latticed) structures and components

Wind loads on structures or components, having solid or enclosed flat sided cross sections that are square or rectangular, with rounded corners, shall be computed using a force coefficient (shape factor) of 1.6.

c. Latticed structures

Wind loads on square or rectangular latticed structures or components shall be computed using a force coefficient (shape factor) of 3.2 on the sum of the projected areas of the members of the front face if structural members are flat surfaced or 2.0 if structural surfaces are cylindrical. The total, however, need not exceed the load that would occur on a solid structure of the same outside dimension.

EXCEPTION: The force coefficient (shape factor) listed under Rules 6.6.3.2-Ba, 6.6.3.2-Bb, and 6.6.3.2-Bc may be reduced if wind tunnel tests or a qualified engineering study justifies a reduction.

C. At angles

Where a change in direction of wires occurs, the loads on the structure, including guys, shall be the vector sum of the transverse wind load and the wire tension load. In calculating these loads, a wind direction shall be assumed that will give the maximum resultant load. Proper reduction may be made to the loads to account for the reduced wind pressure on the wires resulting from the angularity of the application of the wind on the wire.

D. Span lengths

The calculated transverse load shall be based on the average of the two spans adjacent to the structure concerned.

6.6.3.3 Assumed longitudinal loading

A. Change in grade of construction

The longitudinal loads on supporting structures, including poles, towers, and guys at the ends of sections required to be of Grade B construction, when located in lines of lower than Grade B construction, shall be taken as an unbalanced pull in the direction of the higher grade section equal to the larger of the following values:

- a. Conductors with rated breaking strength of 13.3 kN or less The unbalanced tension shall be the tension of two-thirds, but not fewer than two, of the conductors having a rated breaking strength of 13.3 kN or less. The conductors selected shall produce the maximum stress in the support.

EXCEPTION: Where there are one or two conductors having rated breaking strength of 13.3 kN or less, the load shall be that of one conductor.

- b. Conductors with rated breaking strength of more than 13.3 kN. The pull resulting from one conductor when there are eight or less conductors (including overhead ground wires) having rated breaking strength of more than 13.3 kN, and the pull of two conductors when there are more than eight conductors. The conductors selected shall produce the maximum stress in the support.

B. Jointly used poles at crossings over railroads, telecommunication lines, or limited access highways

Where a joint line crosses a railroad, a telecommunication line, or a limited access highway, and Grade B is required for the crossing span, the tension in the telecommunication conductors of the joint line shall be considered as limited to one-half their rated breaking strength, provided they are smaller than Stl WG No. 8 if of steel, or AWG No. 6 if of copper.

C. Deadends

The longitudinal load on a supporting structure at a deadend shall be an unbalanced pull equal to the tensions of all conductors and messengers (including overhead ground wires); except that with spans in each direction from the dead-end structure, the unbalanced pull shall be the difference in tensions.

D. Unequal spans and unequal vertical loads

The structure should be capable of supporting the unbalanced longitudinal load created by the difference in tensions in the wires in adjacent spans caused by unequal vertical loads or unequal spans.

E. Stringing loads

Consideration should be given to longitudinal loads that may occur on the structure during wire stringing operations.

F. Longitudinal capability

It is recommended that structures having a longitudinal strength capability be provided at reasonable intervals along the line.

G. Telecommunication conductors on unguyed supports at railroad and limited access highway crossings.

The longitudinal load shall be assumed equal to an unbalanced pull in the direction of the crossing of all open-wire conductors supported, the pull of each conductor being taken as 50% of its rated breaking strength in the heavy loadings, 33-1/3% in the medium loadings, and 22-1/4% in the light-loadings.

6.6.3.4 Simultaneous application of loads

Where a combination of vertical, transverse, or longitudinal loads may occur simultaneously, the structure shall be designed to withstand the simultaneous application of these loads.

NOTE: Under the extreme wind conditions of Rule 6.6.1.3, an oblique wind may require greater structural strength than that computed by Rules 6.6.3.2 and 6.6.3.3.

6.6.4 Load factors for structures, crossarms, support hardware, guys, foundations, and anchors

Loads in Rule 6.6.1.2, the extreme wind loading condition in Rule 6.6.1.3, and the extreme ice with concurrent wind condition in Rule 6.6.1.4 shall be multiplied by the load factors in Table 6-34.

Table 6-34: Load factors for structures^①, crossarms, support hardware^②, guys, foundations, and anchors to be used with the strength factors of Table 6-35

Load Factors			
	Grade B	Grade C	
		At crossings ^⑥	Elsewhere
Rule 6.6.1.2 loads (Combined ice and wind loadings) Vertical loads ^③	1.50	1.90 ^⑤	1.90 ^⑤
Transverse loads Wind Wire tension	2.50 1.65 ^②	2.20 1.30 ^④	1.75 1.30 ^④
Longitudinal loads In general At deadends	1.10 1.65 ^②	No requirement 1.30 ^④	No requirement 1.30 ^④
Rule 6.6.1.3 load (Extreme wind) Wind loads All other loads	1.00 1.00	0.87 ^⑦ 1.00	0.87 ^⑦ 1.00
Rule 6.6.1.4 loads (Extreme ice with concurrent wind)	1.00	1.00	1.00

^① Includes pole.

^② For guys and anchors associated with structures supporting telecommunication conductors and cables only, this factor may be reduced to 1.33.

^③ Where vertical loads significantly reduce the stress in a structure member, a vertical load factor of 1.0 should be used for the design of such member. Such member shall be designed for the worst case loading.

^④ For metal or prestressed concrete, portions of structures, crossarms, guys, foundations, and anchors, use a value of 1.10.

^⑤ For metal prestressed concrete, or fiber-reinforced polymer portions of structures and crossarms, guys, foundations, and anchors, use a value of 1.50.

^⑥ This applies only where a line crosses another supply or telecommunication line (see Rule 6.5.2.3 and Table 6-28).

^⑦ For wind velocities above 160 km/hour, a factor of 0.75 may be used.

^⑧ Support hardware does not include insulators. See Rule 6.8 for insulator strength and loading requirements.

6.7 Strength requirements

6.7.1 General

6.7.1.1 Preliminary assumptions

1. It is recognized that deformation, deflections, or displacement of parts of the structure may change the effects of the loads assumed. In the calculation of stresses, allowance may be made for such deformation, deflection, or displacement of supporting structures including poles, towers, guys, crossarms, pins, conductor fastenings, and insulators when the effects can be evaluated. Such deformation, deflection, or displacement should be calculated using Rule 6.6.1 loads prior to application of the load factors in Rule 6.6.4. For crossings or conflicts, the calculations shall be subject to mutual agreement.

NOTE: Depending upon the characteristics of the structural material, significant sustained (everyday) stress (such as stresses produced by gravity or tension loads) can decrease the strength during the expected life of the material and may require guying or bracing to be able to meet the required strength capability.

2. It is recognized that new materials may become available. While these materials are in the process of development, they must be tested and evaluated. Trial installations are permitted where the requirements of Rule 1.5.1-2 are met.

6.7.1.2 Application of strength factors

1. Supporting structures and structural components shall be designed to withstand the appropriate loads multiplied by the load factors in Rule 6.6 without exceeding their strength multiplied by the strength factors in Table 6-35.

EXCEPTION: For insulators, see Rule 6.8 for strength and loading requirements.

NOTE 1: The latest edition of the following document may be used for providing information for determining the 5% lower exclusion limit strength of a FRP structure or component for use with an appropriate strength factor (Table 6-35) and the specified PETSAC loads and load factors (Table 6-34): ASCE-111, Reliability-Based Design of Utility Pole Structures.

NOTE 2: The latest edition (unless a specific edition is referenced) of the documents (Appendix-A) are among those available for determining structure design capacity with the specified PETSAC-2014 loads, load factors, and strength factors:

2. Where strength factors are not defined in Rule 6.7.2, a strength factor of 0.80 shall be used for the extreme wind loading conditions specified in Rule 6.6.1.3 and for the extreme ice with concurrent wind specified in Rule 6.6.1.4 for all supported facilities.

6.7.2 Grades B and C construction

6.7.2.1 Supporting structures

The strength requirements for supporting structures may be met by the structures alone or with the aid of guys or braces or both.

A. Metal, prestressed-, and reinforced-concrete structures

- a. These structures shall be designed to withstand the loads in Rule 6.6.3 multiplied by the appropriate load factors in Table 6-34 without exceeding the permitted stress.

- NOTE:* When determining required strength for axial loads, buckling needs to be considered.
- b. The permitted stress shall be the strength multiplied by the strength factors in Table 6-35 (where guys are used, see Rule 6.7.2.3).
 - c. All structures including those below 18 m shall be designed to withstand, without conductors, the extreme wind load in Rule 6.6.1.3 applied in any direction on the structure and any supported facilities and equipment that may be in place prior to installation of conductors.
 - d. Spliced and reinforced structures

Reinforcements or permanent splices to a supporting structure are permitted provided they develop the required strength of the structure.

B. Wood structures

Wood structures shall be of material and dimensions to meet the following requirements:

- a. Wood structures shall be designed to withstand the loads in Rule 6.6.1.3 multiplied by the appropriate load factors in Table 6-34 without exceeding the permitted stress level at the point of maximum stress.

EXCEPTION 1: When installed, unguyed naturally grown wood poles 16.8 m or less in total length, acting as single-based structures or unbraced multiple-pole structures, shall meet the requirements of Rule 6.7.2.1-Ba without exceeding the permitted stress level at the ground line. However, all guyed poles, regardless of length, shall meet the requirements of Rule 6.7.2.1-Ba without exceeding the permitted stress level at points of attachment for guy and guy struts.

EXCEPTION 2: At a Grade B crossing, in a straight section of line, wood structures complying with the transverse strength requirements of Rule 6.7.2.1-Ba without the use of transverse guys, shall be considered as having the required longitudinal strength, providing the longitudinal strength is comparable to the transverse strength of the structure. This EXCEPTION does not modify the requirements of this rule for deadends.

EXCEPTION 3: At a Grade B crossing of a supply line over a highway or a telecommunication line where there is an angle in the supply line, wood structures shall be considered as having the required longitudinal strength if all of the following conditions are met:

- (a) The angle is not over 20 degrees.
- (b) The angle structure is guyed in the plane of the resultant of the conductor tensions. The tension in this guy under the loading in Rule 6.7.2.1-Ba multiplied by a load factor of 2.0 shall not exceed the rated breaking strength multiplied by the strength factor in Table 6-35.
- (c) The angle structure has sufficient strength to withstand, without guys, the transverse loading of Rule 6.6.3 multiplied by the appropriate load factors in Table 6-34 which would exist if there were no angle at that structure without exceeding the permitted stress level.

NOTE: When determining a fiber stress for axial loads, buckling needs to be considered.

- b. Permitted stress level

- (1) Natural wood pole

The permitted stress level of natural wood poles of various species meeting the requirements of ANSI O5.1-2008 shall be determined by multiplying the designated fiber strength set forth in that standard by the appropriate strength factors in Table 6-35.

(2) Sawn or laminated wood structural members, crossarms, and braces.

The permitted stress level of sawn or laminated wood structural members, crossarms, and braces meeting the requirements of ANSI O5.2-2006 [B16] or ANSI O5.3-2008 [B17] shall be determined by multiplying the appropriate designated fiber stress set forth in the respective standard, by the appropriate strength factors in Table 6-35.

c. Strength of guyed poles

Guyed poles shall be designed as columns, resisting the vertical component of the tension in the guy plus any other vertical loads.

d. Spliced and reinforced poles

Reinforcements or permanent splices at any section along the pole are permitted provided they develop the required strength of the pole.

- e. All structures including those below 18 m shall be designed to withstand, without conductors, the extreme wind load in Rule 6.6.1.3 applied in any direction on the structure and any supported facilities and equipment which may be in place prior to installation of conductors.

C. Fiber-reinforced polymer structures

- a. These structures shall be designed to withstand the loads in Rule 6.6.3 multiplied by the appropriate load factors in Table 6-34 without exceeding the permitted load.

NOTE: When determining a fiber stress for axial loads, buckling needs to be considered.

- b. The permitted load shall be the 5th percentile strength (i.e., “5% lower exclusion limit”) or less, multiplied by the strength factors in Table 6-35 (where guys are used, see Rule 6.7.2.3).

c. Spliced and reinforced poles

Reinforcements or permanent splices to a supporting pole are permitted provided they develop the required strength of the pole.

- d. All structures including those below 18 m shall be designed to withstand, without conductors, the extreme wind load in Rule 6.6.1.3 applied in any direction on the structure and any supported facilities and equipment which may be in place prior to installation of conductors.

D. Transverse strength requirements for structures where side guying is required, but can be installed only at a distance

Grade B: If the transverse strength requirements of this section cannot be met except by the use of side guys or special structures, and where it is physically impractical to employ

side guys, the transverse strength requirements may be met by side-guying the line at each side of, and as near as practical to, the crossing, or other transversely weak structure, and with a distance between such side-guyed structures of not over 250 m, provided that:

- a. The side-guyed structures for each such section of 250 m or less shall be designed to withstand the calculated transverse load due to wind on the supports and ice-covered conductors, on the entire section between side-guyed structures.
- b. The line between such side-guyed structures shall be substantially in a straight line and the average span between the side-guyed structures shall not exceed 45 m.
- c. The entire section between the structures with the required transverse strength shall comply with the highest grade of construction concerned in the given section, except as to the transverse strength of the intermediate poles or towers.

Grade C: The above provisions do not apply to Grade C.

E. Longitudinal strength requirements for sections of higher grade in lines of a lower grade construction

- a. Methods of providing longitudinal strength

Grade B: The longitudinal strength requirements for sections of line of higher grade in lines of a lower grade (for assumed longitudinal loading, see Rule 6.6.3) may be met by placing a structure of the required longitudinal strength at each end of the higher grade section.

Where this is impractical, the structures of the required longitudinal strength may be located away from the section of higher grade, within 150 m on each side and with not more than 250 m between the structures of the required longitudinal strength. This is permitted provided the following conditions are met:

- (1) The structures and the line between them meet the requirements for transverse strength and stringing of conductors of the highest grade occurring in the section, and
- (2) The line between the structures of the required longitudinal strength is approximately straight or suitably guyed.

The longitudinal strength requirement of the structures may be met by using guys.

Grade C: The above provisions do not apply to Grade C.

- b. Flexible supports

Grade B: When supports of the section of higher grade are capable of considerable deflection in the direction of the line, it may be necessary to increase the clearances required in Rule 6.4 or to provide line guys or special reinforcements to reduce the deflection.

Grade C: The above provision does not apply to Grade C.

6.7.2.2 Strength of foundations, settings, and guy anchors

Foundations, settings, and guy anchors shall be designed or be determined by experience to withstand the loads in Rule 6.6.3 multiplied by the load factors in Table 6-34 without exceeding the permitted load. The permitted load shall be equal to the strength multiplied by the strength factors in Table 6-35.

NOTE 1: Excessive movement of foundations, settings, and guy anchors or errors in settings can reduce clearances or structure capacity.

NOTE 2: Soil saturation can have an adverse effect on the strengths of foundations, settings, and guy anchors.

6.7.2.3 Strength of guys and guy insulators

The strength requirements for guys and guy insulators are covered under Rules 6.7.4 and 6.8.9.1-Ac respectively.

A. Metal and prestressed-concrete structures

Guyss shall be considered as an integral part of the structure.

B. Wood and reinforced-concrete structures

When guys are used to meet the strength requirements, they shall be considered as taking the entire load in the direction in which they act, the structure acting as a strut only, except for those structures considered to possess sufficient rigidity so that the guy can be considered an integral part of the structure.

NOTE: Excessive movement of guys can reduce clearances or structure capacity.

C. Fiber-reinforced polymer structures

When guys are used to meet the strength requirements, the guys shall be considered as taking the entire load in the direction in which they act, as if the structure is acting as a strut only, except for those structures considered to possess sufficient rigidity so that the guys can be considered an integral part of the structure.

NOTE: Excessive movement of guys can reduce clearances or structure capacity.

6.7.2.4 Crossarms and braces

A. Concrete and metal crossarms and braces

Crossarms and braces shall be designed to withstand the loads in Rule 6.6.3 multiplied by the load factors in Table 6-34 without exceeding the permitted load. The permitted load shall be equal to the strength multiplied by the strength factors in Table 6-34.

B. Wood crossarms and braces

- a. Strength

(1) Crossarms and braces shall be designed to withstand the loads in Rule 6.6.3 multiplied by the load factors in Table 6-34 without exceeding their permitted stress.

(2) The permitted stress level of solid sawn or laminated wood crossarms and braces shall be determined by multiplying their ultimate fiber stress by the strength factors in Table 6-35.

b. Material and size

Wood crossarms and braces of selected wood shall have a cross section of not less than those in Table 6-35. Crossarms of other species may be used provided they have equal strength.

C. Fiber-reinforced polymer crossarms and braces

Crossarms and braces shall be designed to withstand the loads in Rule 6.6.3 multiplied by the load factors in Table 6-34 without exceeding the permitted load. The permitted load shall be the 5th percentile strength (i.e., “5% lower exclusion limit”) or less, multiplied by the strength factors in Table 6-35.

D. Crossarms and braces of other materials

Crossarms and braces should meet the strength requirements of Rule 6.7.2.4-B.

E. Additional requirements

a. Longitudinal strength

(1) General

(a) Crossarms shall be designed to withstand a load of 3.1 kN applied at the outer conductor attachment point without exceeding the permitted stress level for wood crossarms or the permitted load for crossarms of other materials, as applicable.

(b) At each end of a transversely weak section, as described in Rule 6.7.2.1-D the longitudinal load shall be applied in the direction of the weak section.

(2) Methods of meeting Rule 6.7.2.4-Ba(1)

Grade B: Where conductor tensions are limited to a maximum of 9.0 kN per conductor, double wood crossarms having cross sections in Table 6-31 and properly assembled will comply with the longitudinal strength requirements in Rule 6.7.2.4-Ba(1).

Grade C: This requirement is not applicable.

(3) Location

At crossings, crossarms should be mounted on the face of a pole away from the crossing, unless special bracing or double crossarms are used.

b. Bracing

Crossarms shall be supported by bracing, if necessary, to support expected loads, including line personnel working on them. Crossarm braces used only to sustain unbalanced vertical loads need only to be designed for these unbalanced vertical loads.

c. Double crossarms, brackets, or equivalent support assembly

Grade B: Where pin-type construction is used, double wood crossarms, each crossarm having the strength required by Rule 6.7.2.4-Ba(1), or a support assembly equivalent in strength to double wood crossarms shall be used at each crossing structure, at ends of joint use or conflict sections, at deadends, and at corners where the angle of departure from a straight line exceeds 20 degrees. Under similar conditions, where a bracket supports a conductor operated at more than 750 V to ground and there is no crossarm below, double brackets or a support assembly equivalent in strength to double wood crossarms shall be used.

EXCEPTION: The above does not apply where telecommunication cables or conductors cross below supply conductors and either are attached to the same pole, or where supply conductors are continuous and of uniform tension in the crossing span and each adjacent span. This exception does not apply to railroad crossings and limited access highways except by mutual agreement.

Grade C: The above requirement is not applicable.

6.7.2.5 Insulators

The strength requirements for insulators are covered under Rules 6.8.8 and 6.8.9.

6.7.2.6 Strength of pin-type or similar construction and conductor fastenings

A. Longitudinal strength

a. General

Pin-type or similar construction and ties or other conductor fastenings shall be designed to withstand the applicable longitudinal loads in Rule 6.6.3, multiplied by the load factors for longitudinal loads in Table 6-34, or 3.1 kN applied at the pin, whichever is greater.

b. Method of meeting Rule 6.7.2.6-Aa

Grade B: Where conductor tensions are limited to 9.0 kN and such conductors are supported on pin insulators, double wood pins and ties or their equivalent will be considered to meet the requirements of Rule 6.7.2.6-Aa.

Grade C: No requirement.

c. At deadends and at ends of higher grade construction in line of lower grade

Grade B: Pins and ties or other conductor fastenings connected to the structure at a deadend or at each end of the higher grade section shall be designed to withstand an unbalanced pull due to the conductor load in Rule 6.6.2 multiplied by the load factors in Rule 6.6.4.

Grade C: This requirement is not applicable except for deadends.

- d. At ends of transverse sections described in Rule 6.7.2.1-D

Grade B: Pins and ties or other conductor fastenings connected to the structure at ends of the transverse section as described in Rule 6.7.2.1-D shall be designed to withstand the unbalanced pull in the direction of that transverse section under the load in Rule 6.6.3 multiplied by the load factors in Rule 6.6.4.

Grade C: No requirement.

B. Double pins and conductor fastenings

Grade B: Double pins and conductor fastenings shall be used where double crossarms or brackets are required by Rule 6.7.2.4-D.

EXCEPTION: The above does not apply where telecommunication cables or conductors cross below supply conductors and either are attached to the same pole, or where supply conductors are continuous and of uniform tension in a crossing span and each adjacent span. This exception does not apply in the case of railroad crossings and limited access highway crossings except by mutual agreement.

Grade C: No requirement.

C. Single supports used in lieu of double wood pins

A single conductor support and its conductor fastening, when used in lieu of double wood pins, shall develop strength equivalent to double wood pins and their conductor fastenings as specified in Rule 6.7.2.6-Aa.

6.7.2.7 Armless construction

A. General

Open conductor armless construction is a type of open conductor supply line construction in which conductors are individually supported at the structure without the use of crossarms.

B. Insulating material

Strength of insulating material shall meet the requirements of Rule 6.7.

C. Other components

Strengths of other components shall meet the requirements of Rules 6.7.1 and 6.7.2.

6.7.2.8 Open supply conductors and overhead shield wires

A. Tensions

- a. The supply conductor and overhead shield wire tensions shall be not more than 60% of their rated breaking strength for the load of Rule 6.6.1.2 in Rule 6.6.2 multiplied by a load factor of 1.0. If Rules 6.6.1.3 and 6.6.1.4 are applicable, the supply conductor and overhead shield wire tensions for these loading cases shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 6.6.1.3 and 6.6.1.4 in Rule 6.6.2 multiplied by a load factor of 1.0.

- b. The tension at the applicable temperature listed in Table 6-33, without external load, shall not exceed the following percentages of their rated breaking strength:

Initial unloaded tension 35%

Final unloaded tension 25%

EXCEPTION 1: The initial and final unloaded tension limits may be used at higher temperatures not to exceed 15°C if (a) vibration control devices or self-damping conductors are appropriately used, or (b) a qualified engineering study, manufacturer's recommendation, or experience indicated aeolian vibration damage is not likely to occur.

EXCEPTION 2: In the case of conductors with a generally triangular cross section, such as cables composed of three wires, the final unloaded tension at the applicable temperature listed in Table 6-33 shall not exceed 30% of the rated breaking strength of the conductor.

NOTE: The above limitations may not protect the conductor or facilities from damage due to aeolian vibration.

B. Splices, taps, dead-end fittings, and associated attachment hardware

- a. Splices should be avoided in crossings and adjacent spans. If it is impractical to avoid such splices, they shall have sufficient strength to withstand the maximum tension resulting from the loads of Rule 6.6.1.2 in Rule 6.6.2 multiplied by a load factor of 1.65. If Rules 6.6.1.3 and 6.6.1.4 are applicable, splices shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 6.6.1.3 and 6.6.1.4 in Rule 6.6.2 multiplied by a load factor of 1.0.
- b. Taps should be avoided in crossing spans but, if required, shall be of a type that will not impair the strength of the conductors to which they are attached.
- c. Dead-end fittings, including the associated attachment hardware, shall have sufficient strength to withstand the maximum tension resulting from the loads of Rule 6.6.1.2 in Rule 6.6.2 multiplied by a load factor of 1.65. If Rules 6.6.1.3 and 6.6.1.4 are applicable, deadend fittings shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 6.6.1.3 and 6.6.1.4 in Rule 6.6.2 multiplied by a load factor of 1.0.

C. Trolley-contact conductors

In order to provide for wear, no trolley-contact conductor shall be installed of less size than AWG No. 0, if of copper, or AWG No. 4, if of silicon bronze.

6.7.2.9 Supply cable messengers

Messengers shall be stranded and shall not be stressed beyond 60% of their rated breaking strength under the loads of Rule 6.6.1.2 in Rule 6.6.2 multiplied by a load factor of 1.0. If Rules 6.6.1.3 and 6.6.1.4 are applicable, messengers shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 6.6.1.3 and 6.6.1.4 in Rule 6.6.2 multiplied by a load factor of 1.0.

NOTE: There are no strength requirements for cables supported by messengers.

6.7.2.10 Open-wire telecommunication conductors

Open-wire telecommunication conductors in Grade B or C construction shall have the tensions in Rule 6.7.2.8-A for supply conductors of the same grade.

EXCEPTION: Where supply conductors are trolley-contact conductors of 0 to 750 V to ground, WG No. 12 Stl may be used for telecommunication conductors for spans of 0 to 30 m, and Stl WG No. 9 may be used for spans of 38 to 45 m.

6.7.2.11 Telecommunication cables and messengers

A. Telecommunication cables

- a. There are no strength requirements for telecommunication cables supported by messengers. See Rule 6.7.2.11-B for the strength requirements for messengers supporting telecommunication cables.
- b. Self-supporting cables shall not be stressed beyond the limits stated in Rule 6.7.2.1-D
- c. For paired metallic telecommunication conductors, see Rule 6.7.2.12.

B. Messenger

The messenger shall not be stressed beyond 60% of its rated breaking strength under the loads of Rule 6.7.1.2 in Rule 6.6.2 multiplied by a load factor of 1.0. If Rules 6.6.1.3 and 6.6.1.4 are applicable, messengers shall not be stressed beyond 80% of their rated breaking strength under the loads of Rules 6.6.1.3 and 6.6.1.4 multiplied by a load factor of 1.0.

6.7.2.12 Paired metallic telecommunication conductors

A. Paired conductors supported on messenger

- a. Use of messenger

A messenger may be used for supporting paired conductors in any location, but is required for paired conductors crossing over trolley-contact conductors of more than 7.5 kV to ground.

- b. Tension of messenger

Messenger used for supporting paired conductors required to meet Grade B construction because of crossing over trolley-contact conductors shall meet the tension requirements for Grade B.

- c. Size and sag of conductors

There are no requirements for paired conductors when supported on messenger.

B. Paired conductors not supported on messenger

- a. Above supply lines

Grade B: Tensions shall not exceed those in Rule 6.7.2.8-A for supply conductors of similar grade.

Grade C: Sizes and tensions

Spans 0 to 30 m —No requirements.

Each conductor shall have a rated breaking strength of not less than 0.75 kN.

Spans 30 to 45 m — Tensions shall not exceed those required for Grade B telecommunication conductors.

Spans exceeding 45 m—Tensions shall not exceed those required for Grade C supply conductors. (See Rule 6.7.2.8-A)

- b. Above trolley-contact conductors

Grade B: Sizes and tensions

Spans 0 to 30 m—No size requirements. Tensions shall not exceed those of Rule 6.7.2.8-A

Spans exceeding 30 m—Each conductor shall have a rated breaking strength of not less than 0.75 kN. Tensions shall not exceed those of Rule 6.7.2.8-A

Grade C: Sizes and tensions

Spans 0 to 30 m —No requirements.

Spans exceeding 30 m —No tension requirements.

Each conductor shall have a rated breaking strength of not less than 0.75 kN.

6.7.2.13 Support and attachment hardware

The strength required for all support and attachment hardware not covered by Rule 6.7.2.6 or 6.7.2.8-B shall be not less than the load times the appropriate load factor given in Rule 6.6 and the load factor shall not be less than 1.0. For appropriate strength factors, see Rule 6.7.1.2.

6.7.2.14 Climbing and working steps and their attachments to the structure

The strength required for all climbing devices (includes steps, ladders, platforms and their attachments) shall be capable of supporting 2.0 times the maximum intended load. Unless otherwise quantified by the owner, the maximum intended load shall be assumed to be 1.36 kg, which includes the weight of the lineman, harness, tools, and equipment being supported by the lineman.

NOTE: See IEEE Std 1307TM-2004 [B55].

Table 6-35: Strength factors for structures^①, crossarms, braces, support hardware, guys, foundations, and anchors

[It is recognized that structures will experience some level of deterioration after installation, depending upon materials, maintenance, and service conditions. The table values specify strengths required at installation. Footnotes specify deterioration allowed, if any. When new or changed facilities add loads to existing structures (a) the strength of the structure when new shall have been great enough to support the additional loads and (b) the strength of the deteriorated structure shall exceed the strength required at replacement. If either (a) or (b) cannot be met, the structure must be replaced, augmented, or rehabilitated.]

	Grade B	Grade C
Strength factors for use with loads of Rule 6.6.1.2 (combined ice and wind loadings)		
Metal and prestressed-concrete structures, crossarms, and braces ^⑥	1.0	1.0
Wood and reinforced-concrete structures, crossarms, and braces ^{②④}	0.65	0.85
Fiber-reinforced polymer structures, crossarms, and braces ^⑥	1.0	1.0
Support hardware	1.0	1.0

Guy wire ^{⑤⑥}	0.9	0.9
Guy anchor and foundation ^⑥	1.0	1.0
Strength factors for use with loads of Rules 6.6.1.3 (extreme wind) and 6.6.1.4 (extreme ice with concurrent wind loadings)		
Metal and prestressed-concrete structures, crossarms, and braces ^⑥	1.0	1.0
Wood and reinforced-concrete structures, crossarms, and braces ^{③④}	0.75	0.75
Fiber-reinforced polymer structures, crossarms, and braces ^⑥	1.0	1.0
Support hardware	1.0	1.0
Guy wire ^{⑤⑥}	0.9	0.9
Guy anchor and foundation ^⑥	1.0	1.0

(1) Includes poles.

(2) Wood and reinforced concrete structures shall be replaced or rehabilitated when deterioration reduces the structure strength to 2/3 of that required when installed. When new or changed facilities modify loads on existing structures, the required strength shall be based on the revised loadings. If a structure or component is replaced, it shall meet the strength required by Table 6-350. Rehabilitated portions of structures shall have strength greater than 2/3 of that required when installed.

(3) Wood and reinforced structures shall be replaced or rehabilitated when deterioration reduces the structure strength to 3/4 of that required when installed. When new or changed facilities modify loads on existing structures, the required strength shall be based on the revised loadings. If a structure or component is replaced, it shall meet the strength required by Rule 6.7.2.8-A. If a structure or component is rehabilitated, rehabilitated portions of structures shall have strength greater than 3/4 of that required when installed.

(4) Where a wood or reinforced concrete structure is built for temporary service, the structure strength may be reduced to values as low as those permitted by footnotes (2) and (3) provided the structure strength does not decrease below the minimum required during the planned life of the structure.

(5) For guy insulator requirements, see Rule 6.8.9.

(6) Deterioration during service shall not reduce strength capability below the required strength.

Table 5-36 : Dimensions of crossarm cross section of selected wood

Crossarm length	mm:	Grades of construction	
		Grade B	Grade C
1.20 m or less	mm:	75 x 100	70 x 95
2.45 m	mm:	80 x 110	75 x 100
3.0 m	mm:	80 x 110	75 x 100

6.7.3 Grade N construction

The strength of Grade N construction need not be equal to or greater than Grade C.

6.7.3.1 Poles

Poles used for lines for which neither Grade B nor C is required shall be of initial size or guyed or braced to withstand expected loads, including line personnel working on them.

6.7.3.2 Guys

The general requirements for guys are covered in Rules 6.7.4 and 6.8.9.1.

6.7.3.3 Crossarm strength

Crossarms shall be securely supported by bracing, if necessary, to withstand expected loads, including line personnel working on them.

NOTE: Double crossarms are generally used at crossings, unbalanced corners, and dead ends, in order to permit conductor fastenings at two insulators to limit the opportunity for slipping, although single crossarms might provide sufficient strength. To secure extra strength, double crossarms are frequently used, and crossarm guys are sometimes used.

6.7.3.4 Supply line conductors

A. Size

Supply-line conductors shall be not smaller than the sizes listed in Table 6-37.

RECOMMENDATION: It is recommended that these sizes for copper and steel not be used in spans longer than 45 m for the heavy-loadings, and 53 m for the medium- and light-loadings.

6.7.3.5 Service drops

A. Size of open-wire service drops

- a. Not over 750 V.

Service drops shall be as required by (1) or (2):

- (1) Spans not exceeding 45 m

Sizes shall be not smaller than those in Table 6-38.

- (2) Spans exceeding 45 m

Sizes shall be not smaller than 8 AWG.

- b. Exceeding 750 V

Sizes of service drops of more than 750 V shall be not less than required for supply line conductors of the same voltage.

B. Tension of open-wire service drops

The tension of the service drop conductors shall not exceed the strength of the conductor attachment or its support under the expected loads.

C. Cabled service drops

Service conductors may be grouped together in a cable, provided the following requirements are met:

- a. Size

The size of each conductor shall be not less than required for drops of separate conductors (Rule 6.7.3.5-A).

- b. Tension of cabled service drops

The tension of the service drop conductors shall not exceed the strength of the conductor attachment or its support under the expected loads.

6.7.3.6 Trolley-contact conductors

In order to provide for wear, trolley-contact conductors shall be not smaller than size AWG No. 0, if of copper, or AWG No. 4, if of silicon bronze.

6.7.3.7 Telecommunication conductors

There are no specific requirements for Grade N telecommunication line conductors or service drops.

6.7.3.8 Street and area lighting equipment

The lowering rope or chain for luminaires arranged to be lowered for examination or maintenance shall be of a material and strength designed to withstand climatic conditions and to sustain the luminaire safely.

6.7.3.9 Insulators

The strength requirements for insulators are covered under Rules 6.8.7 and 6.8.9.

Table 6-37: Sizes for Grade N supply line conductors

Material	Required AWG ^① or Stl WG ^②
Soft copper	6
Medium or hard drawn copper	8
Steel	9
Stranded aluminum:	
EC	2
ACSR	4
ALLOY	4
ACAR	2

^① Copper or aluminum.

^② Steel.

Table 6-38: Sizes of service drops of 750 V or less

(Voltages of trolley-contact conductors are voltage to ground.)

AWG used for aluminum and copper wires; Stl WG used for steel wire.)

Situation	Copper wire			
	Soft-drawn	Medium or Hard drawn	Steel wire	EC aluminum wire ^②
Along	10	12	12	4
Concerned with telecommunication conductor	10	12	12	4
Over supply conductors of				
0 to 750 V	10	12	12	4
750 V to 8.7 kV ^①	8	10	12	4
Exceeding 8.7 kV ^①	6	8	9	4
Over trolley-contact conductor				
0 to 750 V	8	10	12	4
Exceeding 750 V ac or dc	6	8	9	4

^① Installation of service drops of not more than 750 V above supply lines of more than 750 V should be avoided where practical.

^② ACSR or high-strength aluminum alloy conductor size shall be not less than No. 6.

6.7.4 Guying and bracing

6.7.4.1 Where used

When the loads are greater than can be supported by the structure alone, additional strength shall be provided by the use of guys, braces, or other suitable construction. Such measures shall also be used where necessary to limit the increase of sags in adjacent spans and provide sufficient strength for those supports on which the loads are sufficiently unbalanced, for example, at corners, angles, dead ends, large differences in span lengths, and changes of grade of construction.

6.7.4.2 Strength

Guy wires shall be designed to withstand the loads in Rule 6.6.3 multiplied by the load factors in Table 6-34 without exceeding the permitted load. The permitted load shall be equal to the strength multiplied by the strength factors in Table 6-35. For guy wires conforming to ASTM Standards, the minimum breaking strength value therein defined shall be the rated breaking strength required in this Code.

NOTE: For protection and marking of guys, see Rule 6.2.7.3 Point of attachment

The guy or brace should be attached to the structure as near as is practical to the center of the conductor load to be sustained. However, on lines exceeding 8.7 kV, the location of the guy or brace may be adjusted to minimize the reduction of the insulation offered by nonmetallic support arms and supporting structures.

6.7.4.3 Guy fastenings

Guy wires having a rated breaking strength of 9.0 kN or more and that are subject to small radius bends should be stranded and should be protected by suitable guy thimbles or their equivalent. Any guy having a design loading of 44.5 kN or more wrapped around cedar or similar softwood poles should be protected by the use of suitable guy shims.

Where there is a tendency for the guy to slip off the shim, guy hooks or other suitable means of limiting the likelihood of this action should be used. Shims are not necessary in the case of supplementary guys, such as storm guys.

6.7.4.4 Electrolysis

Where anchors and rods are subject to electrolysis, suitable measures should be taken to minimize corrosion from this source.

6.7.4.5 Anchor rods

1. Anchor rods should be installed so as to be in line with the pull of the attached guy when under load.

EXCEPTION: This is not required for anchor rods installed in rock or concrete.

2. The anchor and rod assembly shall have an ultimate strength not less than that required of the guy(s) by Rule 6.7.4.2.

6.8 Line insulation

6.8.1 Application of rule

These requirements apply only to open-conductor supply lines.

NOTE 1: See Rule 6.5.4.3-5.

NOTE 2: See Rule 6.5.3.5 for insulation requirements for neutral conductors.

6.8.2 Material and marking

Insulators for operation of supply circuits shall be made of wet-process porcelain or other material that will provide equivalent or better electrical and mechanical performance. Insulators for use at or above 2.3 kV between conductors shall be marked by the maker with its name or trademark and an identification mark or markings that will permit determination of the electrical and mechanical properties. The marking shall be applied so as not to reduce the electrical or mechanical strength of the insulator.

NOTE: The identifying marking can be either a catalog number, trade number, or other means so that properties of the unit can be determined either through catalogs or other literature.

6.8.3 Ratio of flashover to puncture voltage

Insulators shall be designed so that the ratio of their rated low-frequency dry-flashover voltage to low-frequency puncture voltage is in conformance with applicable American National Standards. When a standard does not exist, this ratio shall not exceed 75%.

The applicable American National Standards are as follows:

ANSI C29.1-1988

ANSI C29.2-1992

ANSI C29.3-1986

ANSI C29.4-1989

ANSI C29.5-1984

ANSI C29.6-1996

ANSI C29.7-1996

EXCEPTION: Insulators specifically designed for use in areas of high atmospheric contamination may have a rated low-frequency dry-flashover voltage not more than 80% of their low-frequency puncture voltage.

6.8.4 Insulation level

The rated dry flashover voltage of the insulator or insulators, when tested in accordance with ANSI C29.1-1988, shall be not less than that shown in Table 6-39, unless based on a qualified engineering study. Higher insulation levels than those shown in Table 6-39, or other effective means, shall be used where severe lightning, high atmospheric contamination, or other unfavorable conditions exist. Insulation levels for system voltages in excess of those shown shall be based on a qualified engineering study.

Table 6-39: Insulation level requirements

Nominal voltage (between phases) (kV)	Rated dry Flashover voltage Of insulators ^① (kV)	Nominal voltage (between phases) (kV)	Rated dry Flashover voltage Of insulators ^① (kV)
0.75	5	115	315
2.4	20	132	390

6.9	39	138	390
11	55	161	445
13.2	55	220	640
23.0	75	230	640
33	100	345	830
34.5	100	500	965
46	125	765	1145
66	175		
69	175		

① Interpolate for intermediate values.

6.8.5 Factory tests

Each insulator or insulating part thereof for use on circuits operating at or above 2.3 kV between conductors shall be tested by the manufacturer in accordance with applicable American National Standards, or, where such standards do not exist, other good engineering practices to ensure their performance.

The applicable American National Standards are listed in Rule 6.8.3.

6.8.6 Special insulator applications

6.8.6.1 Insulators for constant-current circuits

Insulators for use on constant-current circuits shall be selected on the basis of the rated full-load voltage of the supply transformer.

6.8.6.2 Insulators for single-phase circuits directly connected to three-phase circuits

Insulators used on single-phase circuits directly connected to three-phase circuits (without intervening isolating transformers) shall have an insulation level not less than that required for the three-phase circuit.

6.8.7 Mechanical strength of insulators

Insulators shall withstand all applicable loads specified in Rules 6.6.1, 6.6.2, and 6.6.3 except those of Rules 6.6.1.3 and 6.6.1.4-D without exceeding the percentages of their strength rating for the respective insulator type shown in Table 6-35. Proper allowance should be made for the loads in Rules 6.6.3 and 6.6.1.4.

Table 6-40: Allowed percentages of strength ratings

Insulator type	Percent	Strength or load rating①	Reference standard
Ceramic			
Suspension type②	50%	Combined mechanical and electrical strength	ANSI C29.1-1988 (R2002) and ANSI C29.2-1992 (R1999)
Line post	40%	Cantilever strength	ANSI XC29.7-1996 (R2002)
	50%	Tension, Compression Strength	
Station post	40%	Cantilever strength	ANSI C29.9-1983 (R2002) (B9)
	50%	Tension, compression, or torsion strength	

Station cap and pin	40%	Cantilever tension, compression, or torsion-strength	ANSI C29.8-1985 (R2002) (B8)
Pin	40%	Cantilever strength	ANSI C29.5-1984 (R2002) and ANSI C29.6-1996 (R2002)
Spool	50%	Transverse strength	ANSI C29.3-1986 (R2002)
Nonceramic			
Suspension type②	50%	Specified mechanical load (SML)	ANSI C29.12-1997 (R2002) (B12) and ANSI C29.13-2000 (B13)
Line post	40%	Specified cantilever strength load (SCL)	ANSI C29.17-2002 (B14) and
	50%	Specified tensile load (STL)	ANSI C29.18-2003 (B15)
Station post	40%	All strength ratings	See Footnote 4
Pin	See Footnote 3	Cantilever strength	See Footnote 4
Spool	See Footnote 3	Transverse strength	See Footnote 4

① All strengths shall be those supplied by the respective manufacturers.

② Suspension type includes deadend applications.

③ This percentage shall be supplied by the manufacturer.

④ Industry standards do not currently exist.

6.8.8 Aerial cable systems

6.8.8.1 Electrical requirements

1. Covered or insulated conductors not meeting the requirements of Rule 6.4.1.3-1, 6.4.1.3-2, or 6.4.1.3-3 shall be considered as bare conductors for all insulation requirements.
2. The insulators or insulating supports shall meet the requirements of Rule 6.8.4.
3. The systems shall be so designed and installed as to minimize long-term deterioration from electrical stress.

6.8.8.2 Mechanical requirements

1. Insulators other than spacers used to support aerial cable systems shall meet the requirements of Rule 6.8.8.
2. Insulating spacers used in spacer cable systems shall withstand the loads specified in Rule 6.6 (except those of Rules 6.6.1.3 and 6.6.1.4) without exceeding 50% of their rated ultimate strength.

6.8.9 Guy and span insulators

6.8.9.1 Insulators

A. Properties of guy insulators

Where guy insulators are used in accordance with Rule 6.2.5.3-B, the guy insulators shall meet the following requirements:

a. Material

Insulators shall be made of wet-process porcelain, wood, fiber-reinforced polymer, or other material of suitable mechanical and electrical properties.

b. Electrical strength

The guy insulator shall have a rated dry flashover voltage at least double, and a rated wet flashover voltage at least as high as, the nominal line voltage between conductors of the guyed circuit. The dry and wet flashover values shall be determined according to the Low-Frequency Dry and Low-Frequency Wet Withstand Voltage Tests specified in ANSI C29.1. Fiber-reinforced polymer plastic guy insulators, or guy insulators of other suitable materials, that can reasonably be expected to be degraded by ultraviolet light shall be protected against UV degradation. A guy insulator may consist of one or more units.

c. Mechanical strength

The rated ultimate strength of the guy insulator shall be at least equal to the required strength of the guy in which it is installed.

B. Galvanic corrosion and BIL insulation

a. Limitation of galvanic corrosion

An insulator in the guy strand used exclusively to limit galvanic corrosion of metal in ground rods, anchors, anchor rods, or pipe in an effectively grounded system shall not be classified as a guy insulator and shall not reduce the mechanical strength of the guy.

NOTE: See Rule 6.2.5.3-G.

b. BIL insulation

An insulator in the guy strand used exclusively to meet BIL requirements for the structure in an effectively grounded system, as shown in Figure 6-12, shall not be classified as a guy insulator, provided mechanical strength of the insulator meets Rule 6.8.9.1-Ac and either of the following provisions is met:

- (1) The guy is otherwise insulated to meet the requirements of Rule 6.2.5.3-D and 6.8.9.1-A.
- (2) Anchor guys are grounded below the insulator in accordance with Rules 4.2.3.2 and 6.2.5.3.

6.8.9.2 Properties of span-wire insulators

Where span-wire insulators are used in accordance with Rule 6.2.4, the span-wire insulators shall meet the following requirements:

A. Material

Insulators shall be made of wet-process porcelain, wood, fiber-reinforced, or other material of suitable mechanical and electrical properties.

B. Insulation level

The insulation level of span-wire insulators shall meet the requirements of Rule 6.8.5.

A hanger insulator, where used to provide single insulation as permitted by Rule 6.8.9 shall meet the requirements of Rule 6.8.5.

C. Mechanical strength

The rated ultimate strength of the span-wire insulator shall be at least equal to the required strength of the span wire in which it is located.

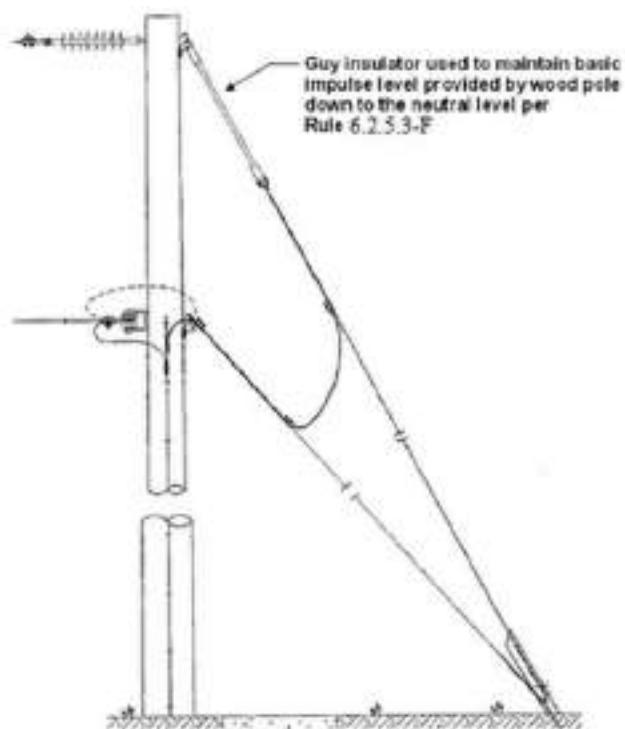


Figure 6-12: Insulator used for BIL insulation

SECTION 7

SAFETY RULES FOR THE INSTALLATION AND MAINTENANCE OF UNDERGROUND ELECTRIC SUPPLY AND TELECOMMUNICATION LINES

7.1 Purpose and Scope

7.1.1 Purpose

The purpose of this code is to detail the requirements for safe installation, operation and maintenance of underground or buried supply and telecommunication cables and associated equipment.

7.1.2 Scope

It covers supply and telecommunication cables and equipment in underground or buried systems having Utility function. It covers new installations, additions and extensions in existing installations. It also covers the cables and equipment employed primarily for the utilization of electric power when such cables and equipment are used by the utility in the exercise of its function as a utility. It does not cover installations in electric supply stations, domestic, commercial and Industrial buildings not doing any function of Utility.

7.2 General Requirements Applying to Underground Lines

7.2.1 Referenced Section

The Introduction (Section 1), Definitions (Section 2), Grounding methods (Section 4), Substations (Section 5), Overhead Lines (Section 6) and Appendix-A (bibliography), shall apply to the requirements of this section.

7.2.2 Installation and maintenance

- A. Persons responsible for underground facilities shall be able to indicate the location of their facilities without any difficulty.
- B. Reasonable advance notice should be given to owners or operators of other proximate facilities that may be adversely affected by new construction or changes in existing facilities.
- C. For emergency installations, supply and telecommunication cables should be laid directly on grade if they are guarded or otherwise located so that they do not unduly obstruct pedestrian or vehicular traffic and are appropriately marked. Supply cables operating above 400 V shall meet Rule 7.6.1-B.

7.2.3 Accessibility

All parts that must be examined or adjusted during operation shall be arranged so as to be accessible to authorized persons by the provision of adequate working spaces, working facilities and clearances.

7.2.4 Inspection and tests of lines and equipment

7.2.4.1 When in service

A. Initial compliance with OSHA Electrical safety Standard.

Lines and equipment shall comply with these safety Sections upon being placed in service.

B. Inspection

Accessible lines and equipment shall be inspected by the responsible party at such intervals as experience has shown to be necessary.

C. Tests

When considered necessary, lines and equipment shall be subjected to practical tests to determine their conditions for troubleshooting or replacements.

D. Inspection of Records

If any condition or defect found during inspection or tests which is not promptly removed or corrected, shall be recorded. Such records shall be maintained until the use of equipment.

E. Corrections

- a. Lines and equipment with recorded conditions or defects that would reasonably be inspected to endanger life or property shall be promptly corrected, disconnected, or isolated.
- b. Other conditions or defects shall be designated for corrections.

7.2.4.2 When out of service

A. Lines infrequently used

Lines and equipment infrequently used shall be inspected or tested as necessary before being placed into service.

B. Lines temporarily out of service

Lines and equipment temporarily out of service shall be maintained in a safe condition.

C. Lines permanently abandoned

Lines and equipment permanently abandoned shall be removed or maintained in a safe condition.

7.2.5 Grounding of circuits & equipment

7.2.5.1 Methods

The methods to be used for grounding of circuits and equipment should be as per Section 4 of this code.

7.2.5.2 Conductive parts to be grounded

Cable sheaths and shields (except conductor shields), equipment frames and cases (including pad-mounted devices), and conductive lighting poles shall be effectively grounded. Conductive-material ducts and riser guards that enclose electric supply lines or are exposed to contact with open supply conductors shall be effectively grounded.

7.2.5.3 Circuits

A. Neutrals

Primary neutrals, secondary and service neutrals, and common neutrals shall be effectively grounded.

EXCEPTION: Circuits designed for ground-fault detection and impedance current-limiting devices.

B. Other conductors

Conductors, other than neutral conductors, that are intentionally grounded, shall be effectively grounded.

C. Surge arresters

Surge arresters shall be effectively grounded.

D. Use of earth as part of circuit

- a. Supply circuits shall not be designed to use the earth normally as the sole conductor for any part of the circuit.
- b. Monopolar operation of a bipolar HVDC system is permissible for emergencies and limited periods for maintenance.

7.2.6 Telecommunications protective requirements

7.2.6.1 Where required

Where telecommunications apparatus is handled by other than qualified persons, it shall be protected by one or more of the means listed in Rule 7.2.6.2 if such apparatus is permanently connected to lines subject to any of the following:

1. Lightning
2. Possible contact with supply conductors with voltages exceeding 300 V
3. Transient rise in ground potential exceeding 300 V
4. Steady-state induced voltage of a level that may cause personal injury

NOTE: When telecommunication cables will be in the vicinity of supply stations where large ground currents may flow, the effect of these currents on telecommunication circuits should be evaluated.

7.2.6.2 Means of protection

Where telecommunications apparatus is required to be protected under Rule 7.2.6.1, protective means adequate to withstand the voltage expected to be impressed shall be provided by insulation, protected where necessary by surge arresters. Severe conditions may require the use of additional devices such as auxiliary arresters, drainage coils, neutralizing transformers, or isolating devices.

7.2.7 Induced voltage

Sections covering supply-line influence and telecommunication-line susceptibility have not been detailed in this Code. Cooperative procedures are recommended to minimize steady-state voltages induced from proximate facilities. Therefore, reasonable advance notice should be given to owners or operators of other known proximate facilities that may be adversely affected by new construction or changes in existing facilities.

7.3 Underground Conduit Systems

NOTE 1: While it is often the practice to use duct and conduit interchangeably, duct, as used herein, is a single enclosed raceway for conductors or cable; conduit is a structure containing one or more ducts; and conduit system is the combination of conduit, conduits, manholes, handholes, and/or vaults joined to form an integrated whole.

NOTE 2: For cables installed in a single duct not part of a conduit system: see Rule 7.6.1-G.

7.3.1 Location

7.3.1.1 Routing

A. General

- a. Conduit systems should be subject to the least disturbance practical. Conduit systems extending parallel to other subsurface structures should not be located directly over or under other subsurface structures. If this is not practical, the section on separation, as stated in Rule 7.3.1.2, should be followed.
- b. Conduit alignment should be such that there are no protrusions that would be harmful to the cable.
- c. Where bends are required, the bending radius shall be sufficiently large to limit the likelihood of damage to cable being installed in the conduit.

B. Natural hazards

Routes through unstable soils such as mud, shifting soil, etc., or through highly corrosive soils, should be avoided. If construction is required in these soils, the conduit should be constructed in such a manner as to minimize movement or corrosion or both.

C. Highways and streets

Where conduit must be installed longitudinally under the roadway, it should be installed in the shoulder. If this is not practical, the conduit should be installed within the limits of one lane of traffic.

D. Bridges and tunnels

The conduit system shall be located so as to limit the likelihood of damage by traffic. It should be located to provide safe access for inspection or maintenance of both the structure and the conduit system.

E. Crossing railroad tracks

- a. The top of the conduit system should be located not less than 900 mm (36 in) below the top of the rails of a street railway or 1.27 m (50 in) below the top of the rails of a railroad. Where unusual conditions exist or where proposed construction would interfere with existing installations, a greater depth than specified above may be required.

EXCEPTION: Where this is impractical, or for other reasons, this separation may be reduced by agreement between the parties concerned. In no case, however, shall the top of the conduit or any conduit protection extend higher than the bottom of the ballast section that is subject to working or cleaning.

- b. At crossings under railroads, manholes, handholes, and vaults should not, where practical, be located in the roadbed.

F. Submarine crossing

Submarine crossings should be routed, installed, or both so they will be protected from erosion by tidal action or currents. They should not be located where ships normally anchor.

7.3.1.2 Separation from other underground installations

A. General

The separation between a conduit system and other underground structures paralleling it should be as large as necessary to permit maintenance of the system without damage to the paralleling structures. A conduit that crosses over another subsurface structure shall have a separation sufficient to limit the likelihood of damage to either structure. These separations should be determined by the parties involved.

EXCEPTION: When conduit crosses a manhole, vault, or subway tunnel roof, it may be supported directly on the roof with the concurrence of all parties involved.

B. Separations between supply and telecommunication conduit systems

Conduit systems to be occupied by telecommunication conductors shall be separated from conduit systems to be used for supply systems by not less than

- a. 75 mm (3 in) of concrete
- b. 100 mm (4 in) of masonry
- c. 300 mm (12 in) of well-tamped earth

EXCEPTION: Lesser separations may be used where the parties concur.

C. Sewers, sanitary and storm

- a. If conditions require a conduit to be installed parallel to and directly over a sanitary or storm sewer, it may be done provided both parties are in agreement as to the method.
- b. Where a conduit run crosses a sewer, it shall be designed to have suitable support on each side of the sewer to limit the likelihood of transferring any direct load onto the sewer.

D. Water lines

Conduit should be installed as far as is practical from a water main in order to protect it from being undermined if the main breaks. Conduit that crosses over a water main shall be designed to have suitable support on each side as required to limit the likelihood of transferring any direct loads onto the main.

E. Gas and other lines that transport flammable material

Conduit should have sufficient separation from gas and other lines that transport flammable material to permit the use of pipe maintenance equipment. Conduit shall not enter the same manhole, handhole, or vault with gas or other lines that transport flammable material.

F. Steam lines

Conduit should be installed so as to limit the likelihood of detrimental heat transfer between the steam and conduit systems.

7.3.2 Excavation and backfill

7.3.2.1 Trench

The bottom of the trench should be undisturbed, tamped, or relatively smooth earth. Where the excavation is in rock, the conduit should be laid on a protective layer of clean tamped backfill.

7.3.2.2 Quality of backfill

All backfill should be free of materials that may damage the conduit system.

RECOMMENDATION: Backfill within 150 mm (6 in) of the conduit should be free of solid material greater than 100 mm (4 in) in maximum dimension or with sharp edges likely to damage it. The balance of backfill should be free of solid material greater than 200 mm (8 in) in maximum dimension. Backfill material should be adequately compacted.

7.3.3 Ducts and joints

7.3.3.1 General

1. Duct material shall be corrosion-resistant and suitable for the intended environment.
2. Duct materials, the construction of the conduit, or both shall be designed so that a cable fault in one duct would not damage the conduit to such an extent that it would cause damage to cables in adjacent ducts.
3. The conduit system shall be designed to withstand external forces to which it may be subjected by the surface loadings set forth in Rule 7.3.4.1, except that impact loading may be reduced one third for each 300 mm (12 in) of cover so no impact loading need be considered when cover is 900 mm (3 ft) or more.
4. The internal surface of the duct shall be free of sharp edges or burrs, which could damage supply cable.

7.3.3.2 Installation

A. Restraint

Conduit, including terminations and bends, should be suitably restrained by backfill, concrete envelope, anchors, or other means to maintain its design position under stress of installation procedures, cable pulling operations, and other conditions such as settling and hydraulic or frost uplift.

B. Joints

Ducts shall be joined in a manner so as to limit solid matter from entering the conduit line. Joints shall form a sufficiently continuous smooth interior surface between joining duct sections so that supply cable will not be damaged when pulled past the joint.

C. Externally coated pipe

When conditions are such that externally coated pipe is required, the coating shall be corrosion resistant and should be inspected, tested, or both, to see that the coating is continuous and intact prior to backfill. Precautions shall be taken to prevent damage to the coating when backfilling.

D. Building walls

Conduit installed through a building wall shall have internal and external seals intended to limit the likelihood of the entrance of gas into the building. The use of seals may be supplemented by gas-venting devices in order to minimize building up of positive gas pressures in the conduit.

E. Bridges

- a. Conduit installed in bridges shall include the capability to allow for expansion and contraction of the bridge.
- b. Conduits passing through a bridge abutment should be installed so as to avoid or resist any shear due to soil settlement.
- c. Conduit of conductive material installed on bridges shall be effectively grounded.

F. In vicinity of manholes

Conduit should be installed on compacted soil or otherwise supported when entering a manhole to limit the likelihood of detrimental shear stress on the conduit at the point of manhole entrance.

7.3.4 Manholes, handholes and vaults

7.3.4.1 Strength

Manholes, handholes, and vaults shall be designed to sustain all expected loads that may be imposed upon the structure. The horizontal design loads, vertical design loads, or both shall consist of dead load, live load, equipment load, impact, load due to water table, frost, and any other load expected to be imposed upon the structure, to occur adjacent to the structure, or both. The structure shall sustain the combination of vertical and lateral loading that produces the maximum shear and bending moments in the structure.

1. In roadway areas, the live load shall consist of the weight of a moving tractor-semitrailer truck illustrated in Figure 7-1. The vehicle wheel load shall be considered applied to an area as indicated in Figure 7-2. In the case of multilane pavements, the structure shall sustain the combination of loadings that results in vertical and lateral structure loadings that produce the maximum shear and bending moments in the structure.

NOTE: Loads imposed by equipment used in road construction may exceed loads to which the completed road may be subjected.

2. In designing structures not subject to vehicular loading, the design live load shall be not less than 14.5 kPa (300 lb/ft²).
3. Live loads shall be increased by 30% for impact.
4. When hydraulic, frost, or other uplift will be encountered, the structure shall either be of sufficient weight or so restrained as to withstand this force. The weight of equipment installed in the structure is not to be considered as part of the structure weight.
5. Where pulling iron facilities are furnished, they should be installed to withstand twice the expected load to be applied to the pulling iron.

7.3.4.2 Dimensions

Manholes shall meet the following requirements: A clear working space sufficient for performing the necessary work shall be maintained. The horizontal dimensions of the clear working space shall be not less than 900 mm (3 ft). The vertical dimensions shall be not less than 1.83 m (6 ft) except in manholes where the opening is within 300 mm (1 ft), horizontally, of the adjacent interior side wall of the manhole.

EXCEPTION 1: Where one boundary of the working space is an unoccupied wall and the opposite boundary consists of cables only, the horizontal working space between these boundaries may be reduced to 750 mm (30 in.).

EXCEPTION 2: In manholes containing only telecommunication cables, equipment, or both, one horizontal dimension of the working space may be reduced to not less than 600 mm (2 ft), provided the other horizontal dimension is increased so that the sum of the two dimensions is at least 1.83 m (6 ft).

7.3.4.3 Manhole access

1. Round access openings in a manhole containing supply cables shall be not less than 650 mm (26 in) in diameter. Round access openings in any manhole containing telecommunication cables only, or manholes containing supply cables and having a fixed ladder that does not obstruct the opening, shall be not less than 600 mm (24 in) in diameter. Rectangular access openings should have dimensions not less than 650 mm × 560 mm (26 in × 22 in).
2. Openings shall be free of protrusions that will injure personnel or prevent quick egress.
3. Manhole openings shall be located so that safe access can be provided. When in the highway, they should be located outside of the paved roadway when practical. They should be located outside the area of street intersections and crosswalks whenever practical to reduce the traffic hazards to the workers at these locations.
4. Personnel access openings should be located so that they are not directly over the cable or equipment. When these openings interfere with curbs, etc., they can be located over the cable if one of the following is provided:
 - a. A conspicuous safety sign

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, ANSI Z535.4-2007 contain information regarding safety signs.

- b. A protective barrier over the cable
 - c. A fixed ladder
5. Any manhole greater than 1.25 m (4 ft) in depth shall be designed so it can be entered by means of a ladder or other suitable climbing device. Equipment, cable, and hangers are not suitable climbing devices.

7.3.4.4 Covers

1. Manholes and handholes, when not being worked in, shall be securely closed by covers of sufficient weight or proper design so they cannot be easily removed without tools.
2. Covers should be suitably designed or restrained so that they cannot fall into manholes or protrude into manholes sufficiently far to contact cable or equipment.
3. Strength of covers and their supporting structure shall be at least sufficient to sustain the applicable loads of Rule 7.3.4.1

7.3.4.5 Vault and utility tunnel access

1. Access openings shall be located so that safe access can be provided.
2. Personnel access openings in vaults should be located so that they are not directly over or do not directly open into equipment or cable. In vaults, other types of openings (not personnel access) may be located over equipment to facilitate work on, replacement, or installation of equipment.
3. Where accessible to the public, access doors to utility tunnels and vaults shall be locked unless qualified persons are in attendance to restrict entry by unqualified persons. When vaults and utility tunnels contain exposed live parts, a prominent safety sign shall be visibly posted before entering the vault.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007, and ANSI Z535.4-2007 contain information regarding safety signs.

4. Such doors shall be designed so that a person on the inside may exit when the door is locked from the outside.

EXCEPTION: This Section does not apply where the only means of locking is by padlock and the latching system is so arranged that the padlock can be closed on the latching system to prevent locking from the outside. Clearance of energized parts and controls from penetrable ventilation openings.

5. Clearance of energized parts and controls from penetrable ventilation openings

Where ventilation openings in an above ground vault are not protected with louvers or baffles that limit the opportunity for penetration from outside the vault by sticks or other objects, energized parts and controls that are not guarded shall be located so as to have a clearance from the outside of the ventilation opening not less than that required by the safety clearance zone of Rule 5.3.1.1- B and Table 5-2.

7.3.4.6 Ladder requirements

Fixed ladders shall be corrosion-resistant. Portable ladders shall be used in accordance with relevant rule of Section 9 Work Rules.

RECOMMENDATION: Ladders should conform to ANSI A14.1-1994, ANSI A14.2-1990, ANSI A14.3-1992, or ANSI A14.5-1992.

7.3.4.7 Drainage

Where drainage is into sewers, suitable traps or other means should be provided to limit the likelihood of sewer gas entering into manholes, vaults, or tunnels.

7.3.4.8 Ventilation

Adequate ventilation to open air shall be provided for manholes, vaults, and tunnels, having an opening into enclosed areas used by the public. Where such enclosures house transformers, switches, regulators, etc., the ventilating system shall be cleaned at necessary intervals.

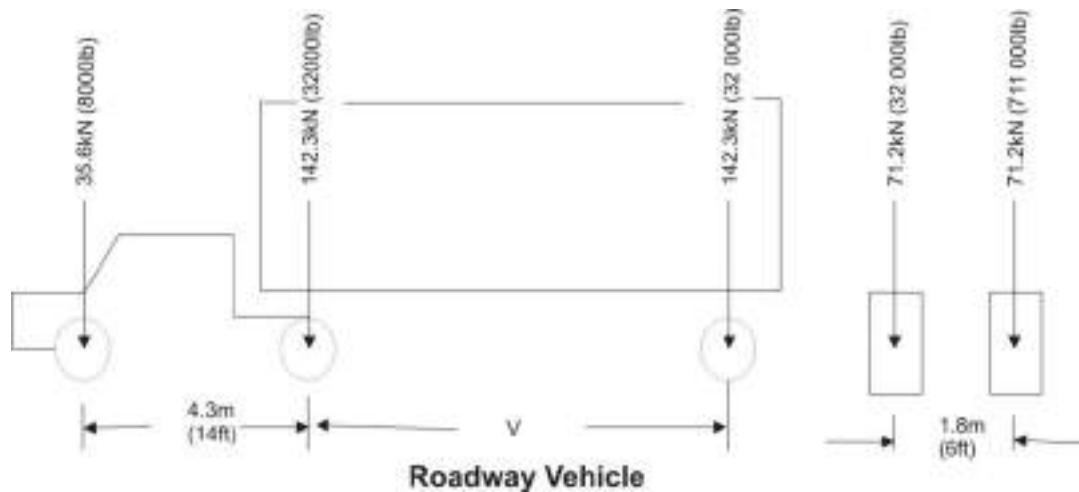
EXCEPTION: This does not apply to enclosed areas under water or in other locations where it is impractical to comply.

7.3.4.9 Mechanical protection

Supply cables and equipment should be installed or guarded in such a manner as to avoid damage by objects falling or being pushed through the grating.

7.3.4.10 Identification

Manhole and handhole covers should have an identifying mark that will indicate ownership or type of utility.



V=Variable spacing, 4.3m to 9.0m (14ft to 30ft), inclusive. Spacing to be used is that which results in vertical and lateral structure loading that produces the maximum shear and bending moments in the structure.

Figure 7-1: Roadway vehicle load

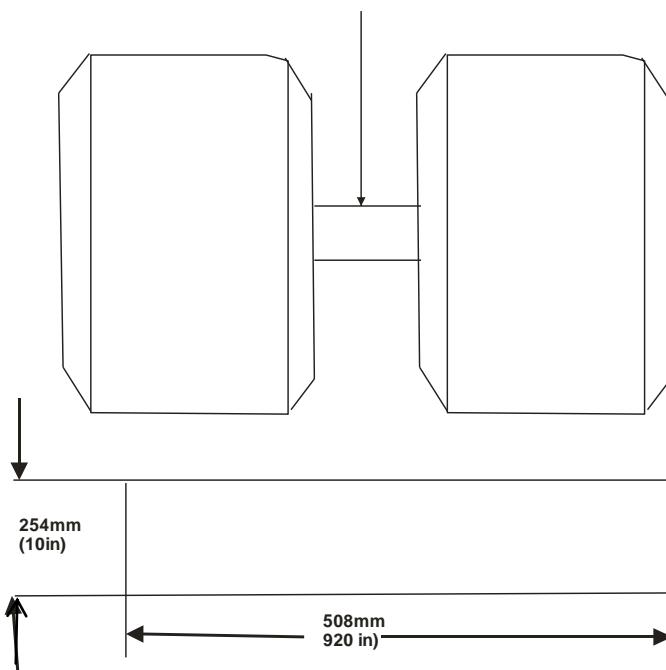


Figure 7-2: Wheel load area

7.4 Supply Cable

7.4.1 General

RECOMMENDATION: Cables used shall be manufactured and tested in accordance with the standards issued by a recognized international organization such as British Standard Specifications (BSS), International Electro-technical Commission (IEC) or any other international/national relevant standard.

- A. The design and construction of conductors, insulation, separation sheath, jacket and shielding shall include consideration of mechanical, thermal, environmental, and electrical stresses that are expected during installation and operation
- B. Cables shall be designed and manufactured to retain the specified dimensions and structural integrity during manufacture, reeling, storage, handling and installation.
- C. Cable shall be designed and constructed in such a manner that each component is protected from harmful effects of other components
- D. The conductor, insulation and shielding shall be designed to withstand the effects of the expected magnitude and duration of fault current, except in the immediate vicinity of the fault.

7.4.2 Sheaths and jackets

Separation sheaths, jackets, or both shall be provided when necessary to protect the insulation or shielding from moisture, termite or other adverse environmental conditions.

7.4.3 Shielding

7.4.3.1 General

- 1. Conductor shielding should, and insulation shielding shall, be provided as specified by an applicable document issued by a nationally recognized cable standardization organization.

NOTE: Typical cable standardization organizations include: BSS, IEC or any other relevant national/international standard.

EXCEPTION: Shielding is not required for short jumpers that do not contact a grounded surface within enclosures or vaults, provided the jumpers are guarded or isolated.

- 2. Insulation shielding may be sectionalized provided that each section is effectively grounded.

7.4.3.2 Material

- 1. The shielding system may consist of semi conducting materials, nonmagnetic metal, or both. The shielding adjacent to the insulation shall be designed to remain in intimate contact with the insulation under all operating conditions.
- 2. Shielding material shall either be designed to resist excessive corrosion under the expected operating conditions or shall be protected.

7.4.4 Cable accessories and joints

- A. Cable accessories and joints shall be designed to withstand the mechanical, thermal, environmental and electrical stresses expected during operation.
- B. Cable accessories and joints shall be designed and constructed in such a manner that each component of the cable and joint is protected from harmful effects of the other components.
- C. Cable accessories and joints shall be designed and constructed to maintain the structural integrity of the cables to which they are applied and to withstand the magnitude and duration of the fault current expected during operation, except in the immediate vicinity of the fault.
- D. For insulating joints, see Rule 7.4.3.1-2.

7.5 Cable in Underground Structures

7.5.1 General

- A. Rule 7.4.3 shall apply to supply cable in underground structures.
- B. On systems operating above 2 kV to ground, the design of the conductors or cables installed in nonmetallic conduit should consider the need for an effectively grounded shield, a sheath, or both.

7.5.2 Installation

7.5.2.1 General

- 1. Bending of the supply cable during handling, installation and operation shall be controlled to avoid damage to the insulation, shielding or jacket and ultimately result in cable failure. It is therefore very important that the cable is not bent sharply. The minimum bending radius must be followed as given in the relevant cable standard.
- 2. Pulling tensions and sidewall pressures on the supply cable should be limited to avoid damage. The maximum allowable pulling force is dependent on the cable conductor material.
 - a. The maximum allowable pulling force in Kg is 6 times the conductor cross sectional area in mm² for copper and 3 times the cross sectional area for aluminum.
 - b. For multi core cables, the maximum tension can be increased by number of cores in the cable, provided pulling eye is attached to each conductor.

If the pulling force so calculated is more than 2000Kgs then it is desirable to limit it to 2000Kgs only.

Maximum side wall pressure is given by the formula:

Max. side wall pressure = Max .pulling force in Kg / Min. bending radius in Meters

Anyhow, in any case, the maximum side wall pressure shall not exceed 500 kg/m.

- 3. Ducts should be cleaned of foreign material that could damage the supply cable during pulling operations.
- 4. Cable Lubricants shall not be detrimental to cable or conduit systems.
- 5. On slopes or vertical runs consideration should be given to restraining cables to limit the likelihood of downhill movement.
- 6. Supply cable shall not be installed in the same duct with telecommunication cables unless all of the cables are operated and maintained by the same utility.
- 7. Telecommunication cables may be installed together in the same duct provided the telecommunication cables are shielded and all utilities involved are in agreement.

7.5.2.2 Cable in manholes and vaults

A. Supports

- a. Cable supports shall be designed to withstand both live and static loading and should be compatible with the environment.
- b. Supports shall be provided to maintain specified clearance between cables.

- c. Horizontal runs of supply cables shall be supported at least 75 mm (3 in) above the floor, or shall be suitably protected.

EXCEPTION: This Section does not apply to grounding or bonding conductors.

- d. The installation should allow cable movement without destructive concentration of stresses. The cable should remain on supports during operation.

NOTE: Special protection may be necessary at the duct entrance.

B. Clearance

- a. Adequate working space shall be provided in accordance with Rule 7.3.4.2.
- b. Between supply and telecommunications facilities (cable, equipment, or both):
 - (1) Where cable, equipment, or both are to be installed in a joint-use manhole or vault, it shall be done only with the concurrence of all parties concerned.
 - (2) Supply and telecommunication cables should be racked from separate walls. Crossings should be avoided.
 - (3) Where supply and telecommunication cables must be racked from the same wall, the supply cables should be racked below the telecommunication cables.
 - (4) Supply and telecommunications facilities shall be installed to permit access to either without moving the other.
 - (5) Clearances shall be not less than those specified in Table 7-1.

C. Identification

7.5.2.2.C.1. General

- (1) Cables shall be permanently identified by tags or otherwise at each manhole or other access opening of the conduit system.

EXCEPTION: This requirement does not apply where the position of a cable, in conjunction with diagrams or maps supplied to workers, gives sufficient identification.

- (2) All identification shall be of a corrosion-resistant material suitable for the environment.
- (3) All identification shall be of such quality and located so as to be readable with auxiliary lighting.

7.5.2.2.C.2. Joint-use manholes and vaults

Cables in a manhole or vault that are operated and maintained by different utilities shall be permanently identified by markings or tags denoting the utility name and type of cable use.

Table 7-1: Clearance between supply and telecommunications facilities in joint-use manholes and vaults

Phase- to-phase supply voltage	Surface to surface clearance	
	(mm)	(in)
0 to 15000 V	150	6
15001 to 50,000 V	230	9
50001 to 120000 V	300	12
120001 to above V	600	24

EXCEPTION 1: These clearances do not apply to grounding conductors

EXCEPTION 2: These clearances may be reduced by mutual agreement between parties concerned when suitable barriers or guards are installed.

7.5.3 Grounding and bonding

- A. Cable and joints with bare metallic shields, sheaths, or concentric neutrals that are exposed to personnel contact shall be effectively grounded.
- B. Cable sheaths or shields that are connected to ground at a manhole shall be bonded or connected to a common ground.
- C. Bonding and grounding leads shall be of a corrosion-resistant material suitable for the environment or suitably protected.

7.5.4 Fire-proofing

Although fireproofing is not a requirement, it may be provided in accordance with each utility's normal service reliability practice to provide protection from external fire.

7.5.5 Telecommunication cables containing special supply circuits

- A. Special circuits operating at voltages in excess of 90 V ac or 150 V dc and used for supplying power solely to telecommunications equipment may be included in telecommunication cables under the following conditions:
 - 1. Such cables shall have a conductive sheath or shield that shall be effectively grounded and each such circuit shall be carried on conductors that are individually enclosed with an effectively grounded shield.
 - 2. All circuits in such cables shall be owned or operated by one party and shall be maintained only by qualified personnel.
 - 3. Supply circuits included in such cables shall be terminated at points accessible only to qualified employees.
 - 4. Telecommunication circuits brought out of such cables, if they do not terminate in a repeater station or terminal office, shall be protected or arranged so that in event of a failure within the cable, the voltage on the telecommunication circuit will not exceed 400 V to ground.
 - 5. Terminal apparatus for the power supply shall be so arranged that live parts are inaccessible when such supply circuits are energized.
 - 6. Such cables shall be identified, and the identification shall meet the pertinent requirements of Rule 7.5.2.2-C.

EXCEPTION: The requirements of Rule 7.5.5-A do not apply to telecommunication circuits where the transmitted power does not exceed 150 W.

7.6 Direct Buried Cable

Note: The term duct or ducts as used in this section refers to duct(s) not part of conduit system.

7.6.1 General

- A. Rule 7.4 shall apply to direct-buried supply cable.
- B. Cables operating above 600 V to ground shall have a continuous metallic shield, sheath, or concentric neutral that is effectively grounded.

EXCEPTION: At a splice or joint, the current path of the metallic shield, sheath, or neutral shall be made continuous but need not be concentric.

- C. Cables meeting Rule 7.6.1-B of the same supply circuit may be buried with no deliberate separation.
- D. Cables of the same circuit operating below 600 V to ground and without an effectively grounded shield or sheath shall be placed in close proximity (no intentional separation) to each other.
- E. Telecommunication cables containing special circuits supplying power solely to telecommunications equipment shall comply with the requirements of Rules 7.5.5-A1 through Rule 7.5.5-A5
- F. All direct-buried jacketed supply cable meeting Rule 7.6.1-B and all direct-buried telecommunication cables shall be legibly marked as follows:

The appropriate identification symbol shown in Figure 7-3 shall be indented or embossed in the outermost cable jacket at a spacing of not more than 1 m (40 in). The symbol may be separate or sequentially combined with other data, or symbols, or both, printed on the jacket. If the symbol is sequentially combined, it shall be separated as indicated in Figure 7-3. The rule in this section shall also apply to supply and telecommunication cables installed in duct that is not part of conduit system

RECOMMENDATION: If color coding is used as an additional method of identifying cable, the American Public Works Association Uniform Color Code for marking underground utility lines is recommended.

EXCEPTION 1: Cables with jackets that cannot be effectively marked in accordance with Rule 7.6.1-F need not be marked.

- G. The rules in this section shall also apply to supply and telecommunication cables installed in duct that is not part of a conduit system.

RECOMMENDATION: If color coding is used as a method of identifying the duct, the American Public Works Association Uniform Color Code for marking underground utility lines is recommended.

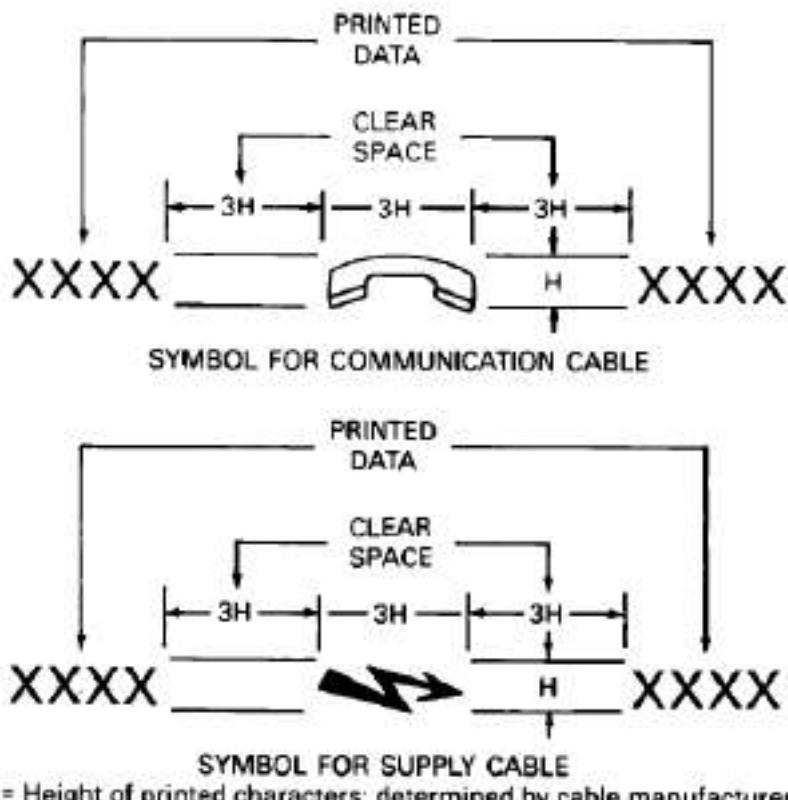


Figure 7-3: Symbols for identification of buried cables

7.6.2 Location and routing

7.6.2.1 General

1. Cables should be located so as to be subject to the least disturbance practical. When cables are to be installed parallel to and directly over or under other subsurface structures, the sections on separation in Rule 7.6.4 and Rules 7.6.5 as applicable, shall be followed.
2. Cables should be installed in as straight and direct a line as practical. Where bends are required, the bending radius shall be sufficiently large to limit the likelihood of damage to the cable being installed.
3. Cable systems should be routed so as to allow safe access for construction, inspection, and maintenance.
4. The location of structures in the path of the projected cable route shall, as far as practical, be determined prior to trenching, plowing, or boring operation.

7.6.2.2 Natural hazards

Routes through unstable soil such as mud, shifting soils, corrosive soils, or other natural hazards should be avoided. If burying is required through areas with natural hazards, the cables shall be constructed and installed in such a manner as to protect them from damage. Such protective measures should be compatible with other installations in the area.

7.6.2.3 Other conditions

A. Swimming pools (in-ground)

Supply cable should not be installed within 1.5 m (5 ft) horizontally of a swimming pool or its auxiliary equipment. If 1.5 m (5 ft) is not attainable, supplemental mechanical protection shall be provided.

NOTE: For aboveground pools, see Rule 7.6.2.3-Cb.

B. Buildings and other structures

Cable should not be installed directly under the foundations of buildings or other structures. Where a cable must be installed under such a structure, the foundation shall be suitably supported to limit the likelihood of transfer of a detrimental load onto the cable.

C. Railroad tracks

- a. The installation of cable longitudinally under the ballast section for railroad tracks should be avoided. Where cable must be installed longitudinally under the ballast section of a railroad, it should be located at a depth of not less than 1.27 m (50 in) below the top of the rail.

EXCEPTION: Where this is impractical, or for other reasons, this clearance may be reduced by agreement between the parties concerned.

NOTE: Where unusual conditions exist or where proposed construction would interfere with existing installations, a greater depth than specified above would be required.

- b. Where a cable crosses under railroad tracks, the same clearances indicated in Rules 7.3.1.1-E shall apply.

D. Highways and streets

The installation of cable longitudinally under traveled surfaces of highways and streets should be avoided. When cable must be installed longitudinally under the roadway, it should be installed in the shoulder or, if this is not practical, within the limits of one lane of traffic to the extent practical.

E. Submarine crossings

Submarine crossings should be routed, installed, or both, so they will be protected from erosion by tidal action or currents. They should not be located where ships normally anchor.

7.6.3 Installation

7.6.3.1 Trenching

A. Direct buried cable

The bottom of the trench receiving direct-buried cable should be relatively smooth, undisturbed earth; well-tamped earth; or sand. When excavation is in rock or rocky soils, the cable should be laid on a protective layer of well-tamped backfill. Backfill within 100 mm (4 in) of the cable should be free of materials that may damage the cable. Backfill should be adequately compacted. Machine compaction should not be used within 150 mm (6 in) of the cable.

B. Cable in Duct

For cable installed in a duct, the bottom of the trench should be undisturbed, tamped or relatively smooth earth. Where the excavation is in rock, the duct should be laid on a protective layer of clean tamped backfill. All backfill should be free of materials that may damage the duct.

7.6.3.2 Plowing

1. Plowing in of cable in soil containing rock or other solid material should be done in such a manner that the solid material will not damage the cable, either during the plowing operation or afterward.
2. The design of cable-plowing equipment and the plowing-in operation should be such that the cable will not be damaged by bending, side-wall pressure, or excessive cable tension.

7.6.3.3 Boring

Where a cable system is to be installed by boring and the soil and surface loading conditions are such that solid material in the region may damage the cable, the cable shall be adequately protected.

7.6.3.4 Depth of burial

1. The distance between the top of a cable and the surface under which it is installed (depth of burial) shall be sufficient to protect the cable from damage imposed by expected surface usage.
2. Burial depths as indicated in Table 7-2 are considered adequate for supply cables or conductors, except as noted in a, b, or c following:
 - a. In areas where frost conditions could damage cables, greater burial depths than indicated above may be desirable.
 - b. Lesser depths than indicated above may be used where supplemental protection is provided. The supplemental protection should be sufficient to protect the cable from damage imposed by expected surface usage.
 - c. Where the surface under which a cable is to be installed is not to final grade, the cable should be placed so as to meet or exceed the requirements indicated above, both at the time of installation and subsequent thereto.

7.6.3.5 Supply cables

Supply cables shall not be installed in the same duct with telecommunication cables unless all of the cables are operated and maintained by the same utility.

7.6.3.6 Telecommunication cables.

Telecommunication cables may be installed together in the same duct provided all utilities involved are in agreement.

**Table 7-2: Supply cable or conductor burial depth
(Rule 7.6.3.4)**

Voltage (Phase to phase)	Depth of Burial	
	(mm)	(in)
0 to 600 V	600	24
601 to 50000 V	750	30
50001 and above V	1070	42

EXCEPTION: Where conflicts with other underground facilities exist, street and area lighting cables operating at not more than 150 V to ground may be buried at a depth not less than 450 mm (18 in).

7.6.4 Deliberate separations – equal to or greater than 300 mm (12 in) from underground structures or other cables

7.6.4.1 General

1. These Sections apply to a radial separation of supply and telecommunication cables or conductors from each other and from other underground structures such as sewers, water lines, gas and other lines that transport flammable material, building foundations, steam lines, etc., when separations equal to or greater than 300 mm (12 in).

NOTE: For radial separation less than 300 mm (12 in) see Rule 7.6.5

2. The radial separation should be adequate to permit access to and maintenance of either facility to limit damage to the other.

7.6.4.2 Crossings

1. Where a cable crosses under another underground structure, the structure shall be suitably supported to limit the likelihood of transferring of a detrimental load onto the cable system.
2. Where a cable crosses over another underground structure, the cable shall be suitably supported to limit the likelihood of transferring a detrimental load onto the structure.
3. Adequate support may be provided by installing the facilities with sufficient vertical separation.

7.6.4.3 Parallel facilities

Where a cable system is to be installed directly over and parallel to another underground structure(or another underground structure installed directly over and parallel to a cable), it may be done providing all parties are in agreement as to the method. Adequate vertical separation shall be maintained to permit access to and maintenance of either facility without damage to the other cables.

7.6.4.4 Thermal protection

Cable should be installed with sufficient separation from other underground structures, such as steam or cryogenic lines, to avoid thermal damage to the cable. Where it is not practical to provide adequate clearance, a suitable thermal barrier shall be placed between the two facilities.

7.6.5 Random separation – separation less than 300 mm (12 in) from underground structures or other cables

7.6.5.1 General

1. These Sections apply to a radial separation of supply and telecommunication cables or conductors from each other and from other underground structures when the radial separation between them will be less than 300 mm (12 in).
2. Radial separation of supply and telecommunications cables or conductors from steam lines, gas, and other lines that transport flammable material shall be not less than 300 mm (12 in) and shall meet Rule 7.6.4.

EXCEPTION: For supply cables operating at not more than 300V between conductors, the radial separation may be less than the required by Rule 7.6.5.1-2, provided supplemental mechanical protection is used to limit the likelihood of detrimental heat transfer to steam lines, gas and other lines that transport flammable material due to a cable fault. Agreement to the reduced separation by all utilities involved is required.

3. Supply circuits operating above 300 V to ground or 600 V between conductors shall be so constructed, operated, and maintained that when faulted, they shall be promptly de-energized initially or following subsequent protective device operation (phase-to-ground faults for grounded circuits, phase-to-phase faults for ungrounded circuits).
4. Telecommunication cables and conductors, and supply cables and conductors buried in random separation may be treated as one system when considering separation from other underground structures or facilities.

7.6.5.2 Supply cables or conductors

The cables or conductors of a supply circuit and those of another supply circuit may be buried together at the same depth with no deliberate separation between facilities, provided all parties involved are in agreement.

7.6.5.3 Telecommunication cables or conductors

The cables or conductors of a telecommunication circuit and those of another telecommunication circuit may be buried together and at the same depth with no deliberate separation between facilities, provided all parties involved are in agreement.

7.6.5.4 Supply and telecommunication cables or conductors

Supply cables or conductors and telecommunication cables or conductors may be buried together at the same depth, with no deliberate separation between facilities, provided all parties involved are in agreement and the applicable Rules in Rule 7.6.5.4-Aa are met and either Rule 7.6.5.4-Ab, Rule 7.6.5.4-Ac or Rule 7.6.5.4-Ad met.

EXCEPTION: Entirely dielectric fiber-optic telecommunication cables may be buried together at the same depth with no deliberate separation from supply cables or conductors provided all parties involved are in agreement and Rule 7.6.5.4-Aa, Rule 7.6.5.4-Ab, Rule 7.6.5.4-Ac and Rule 7.6.5.4-Ad are met.

A. General

- a. Grounded supply systems shall not be operated in excess of 22000 V to ground.
- b. Ungrounded supply systems shall not be operated in excess of 5300 V phase to phase.
- c. Cables of an ungrounded supply system operating above 300 V shall be of effectively grounded concentric shield construction. Such cables shall be maintained in close proximity to each other.
- d. Ungrounded supply circuits operating above 300 V between conductors and in random separation with telecommunication conductors shall be equipped with a ground-fault indication system.
- e. Telecommunication cables and telecommunication service wire having metallic conductors or metallic components shall have a continuous metallic shield under the outer jacket.

EXCEPTION: This requirement does not apply to Rule 7.6.5-4

- f. Telecommunications-protective devices shall be adequate for the voltage and currents expected to be impressed on them in the event of contact with the supply conductors.
- g. Adequate bonding shall be provided between the effectively grounded supply conductor or conductors and the telecommunication cable shield or sheath at intervals that should not exceed 300 m (1000 ft).
- h. In the vicinity of supply stations where large ground currents may flow, the effect of these currents on telecommunication circuits should be evaluated before telecommunication cables are placed in random separation with supply cables.

B. Grounded bare or semiconducting jacketed neutral supply cables

- a. A supply facility operating above 300 V to ground shall include a bare or semiconducting jacketed grounded conductor in continuous contact with the earth. This conductor, adequate for the expected magnitude and duration of the fault current that may be imposed, shall be one of the following:
 - (1) A sheath, an insulation shield, or both
 - (2) Multiple concentric conductors closely spaced circumferentially
 - (3) A separate conductor in contact with the earth and in close proximity to the cable, where such cable or cables also have a grounded sheath or shield not necessarily in contact with the earth. The sheath, shield, or both, as well as the separate conductor, shall be adequate for the expected magnitude and duration of the fault currents that may be imposed.

NOTE: This is applicable when a cable in nonmetallic duct is considered as a direct-buried cable installation and random separation is desired.

EXCEPTION: Where buried cable passes through a short section of conduit such as under a roadway, the contact with earth of the grounded conductor can be omitted, provided the grounded conductor is continuous through the conduit.

- b. The bare conductor or conductors in contact with the earth shall be of suitable corrosion resistant material. The conductor covered by a semiconducting jacket shall be compatible with the jacketing compound.

NOTE: Experience has shown that in many geographic areas, bare concentric copper neutral conductors experience severe corrosion.

- c. The radial resistivity of the semiconducting jacket shall be not more than $100 \Omega \cdot m$ and shall remain essentially stable in service. The radial resistivity of the jacket material is that value calculated from measurements on a unit length of cable, of the resistance between the concentric neutral and a surrounding conducting medium. Radial resistivity is equal to the resistance of a unit length times the surface area of the jacket divided by the average thickness of the jacket over the neutral conductors. All dimensions are to be expressed in meters.

C. Insulating jacketed grounded neutral supply cables

Each phase conductor of a multi-grounded supply system operating above 300 V to ground and having an overall insulating jacket shall have an effectively grounded copper concentric conductor meeting all of the following requirements:

- a. A conductance not less than one half that of the phase conductor
- b. Adequate for the expected magnitude and duration of fault current that may be imposed
- c. Grounded in accordance with Rule 7.2.5 except that the grounding interval required by Rule 4.6.3 shall be not less than eight in each 1.6 km (1 mile) of the random buried section, not including grounds at individual services

D. Insulating jacketed grounded neutral supply cables in nonmetallic duct

Insulating jacketed grounded neutral supply cables meeting the Rule 7.6.5.4-C, when installed in nonmetallic duct, may be random-laid with telecommunication cables.

7.6.5.5 Supply and telecommunication cables or conductors and non-metallic water and sewer lines

1. Supply cables and conductors and non-metallic water and sewer lines may be buried together with no deliberate separation between facilities and at the same depth, provided all parties involved are in agreement.
2. Telecommunication cables and conductors and non-metallic water and sewer lines may be buried together with no deliberate separation between facilities and at the same depth, provided all parties involved are in agreement.
3. Supply cables or conductors, telecommunication cables or conductors, non-metallic water and sewer lines may be buried together with no deliberate separation between facilities and at the same depth, provided the applicable sections in Rule 7.6.5.4-D are met and all parties involved are in agreement.

7.6.6 Additional Rules for duct not part of a conduit system

- A. Duct material shall be corrosion-resistant and suitable for the intended environment.
- B. The internal surface of the duct shall be free of sharp edges or burrs, which could damage the supply or telecommunication cable.
- C. Ducts shall be joined in a manner so as to limit solid matter from entering the duct line. Joints shall form a sufficiently continuous smooth interior surface between joining duct sections so that the supply or telecommunication cable will not be damaged when pulled past the joints.
- D. Ducts installed through a building wall shall have internal and external seals intended to limit the likelihood of the entrance of gas into the building. The use of seals may be supplemented by gas-venting devices in order to limit the buildup of positive gas pressures in the conduit.

7.7 Risers

7.7.1 General

- A. Mechanical protection for supply conductors or cables shall be provided as required by Rule 6.4.10.4. This protection should extend at least 300 mm (1 ft) below ground level.
- B. Supply conductors or cable should rise vertically from the cable trench with only such deviation as necessary to permit a reasonable cable-bending radius.
- C. Exposed conductive pipes or guards containing supply conductors or cables shall be grounded in accordance with Rule 7.2.5.
- D. Moisture resistant cable termination should be installed near the pole at the top of riser. The cable termination should be bent from top to bottom to prevent rain water entering the cable.

7.7.2 Installation

- A. The installation should be designed so that water does not stand in riser pipes above the frost line.
- B. Conductors or cables shall be supported in a manner designed to limit the likelihood of damage to conductors, cables, or terminals.
- C. Where conductors or cables enter the riser pipe or elbow, they shall be installed in such a manner that shall minimize the possibility of damage due to relative movement of the cable and pipe.

7.7.3 Pole risers – additional requirements

- A. Risers should be located on the pole in the safest available position with respect to climbing space and exposure to traffic damage.
- B. The number, size, and location of riser ducts or guards shall be limited to allow adequate access for climbing.

7.7.4 Pad-mounted Installations

- A. Supply conductors or cables rising from the trench to transformers, switchgear, or other equipment mounted on pads shall be so placed and arranged that they will not bear on the edges of holes through the pad nor the edges of bends or other duct work below the pad.
- B. Cable entering pad-mounted equipment shall be maintained substantially at adequate depth for the voltage class until it becomes protected by being directly under the pad, unless other suitable mechanical protection is provided.

7.8 Supply Cable Terminations

7.8.1 General

- A. Cable terminations shall be designed and constructed to meet the requirements of Rule 7.4.4.
- B. Riser terminations not located within a vault, pad-mounted equipment, or similar enclosure shall be installed in a manner designed to ensure that the clearance specified in Sections 5 and 6 of this Code are maintained.
- C. A cable termination shall be designed to limit the likelihood of moisture penetration into the cable where such penetration is detrimental to the cable.
- D. Where clearances between parts at different potentials are reduced below those adequate for the voltage and BIL (basic impulse insulation level), suitable insulating barriers or fully insulated terminals shall be provided to meet the required equivalent clearances.

7.8.2 Support at terminations

- A. Cable terminations shall be installed in a manner designed to maintain their installed position.
- B. Where necessary, cable shall be supported or secured in a manner designed to limit the likelihood of the transfer of damaging mechanical stresses to the termination, equipment, or structure.

7.8.3 Identification

Suitable circuit identification shall be provided for all terminations.

EXCEPTION: This requirement does not apply where the position of the termination, in conjunction with diagrams or maps supplied to workers, gives sufficient identification.

7.8.4 Clearances in enclosures or vaults

- A. Adequate electrical clearances of supply terminations shall be maintained, both between conductors and between conductors and ground, consistent with the type of terminator used.
- B. Where exposed live parts are in an enclosure, clearances or insulating barriers adequate for the voltages and the design BIL shall be provided.
- C. Where a termination is in a vault, un-insulated live parts are permissible provided they are guarded or isolated.

7.8.5 Grounding

- A. All exposed conducting surfaces of the termination device, other than live parts and equipment to which it is attached, shall be effectively grounded, bonded, or both.
- B. Conductive structures supporting cable terminations shall be effectively grounded.

EXCEPTION: Grounding, bonding, or both is not required where the above parts are isolated or guarded.

7.9 Equipment

7.9.1 General

- A. Equipment includes:
 1. Buses, transformers, switches, etc., installed for the operation of the electric supply system
 2. Repeaters, loading coils, etc., installed for the operation of the telecommunications system
 3. Auxiliary equipment, such as sump pumps, convenience outlets, etc., installed incidental to the presence of the supply or telecommunications systems
- B. Where equipment is to be installed in a joint-use manhole, it shall be done with the concurrence of all parties concerned.
- C. Supporting structures, including racks, hangers, or pads and their foundations, shall be designed to sustain all loads and stresses expected to be imposed by the supported equipment including those stresses caused by its operation.
- D. Pad-mounted equipment, pedestals, and other aboveground enclosures, should be located not less than 1.2 m (4 ft) from fire hydrants.

EXCEPTION 1: Where conditions do not permit a clearance of 1.2 m (4 ft), a clearance of not less than 900 mm (3 ft) is allowed.

EXCEPTION 2: Clearance as given in Rules 7.9.1-D may be reduced by agreement with the local fire authority and the equipment owner.

7.9.2 Design

- A. The expected thermal, chemical, mechanical, and environmental conditions at the location shall be considered in the design of all equipment and mountings.
- B. All equipment, including auxiliary devices, shall be designed to withstand the effects of normal, emergency, and fault conditions expected during operation.
- C. Switches shall be provided with clear indication of contact position, and the handles or activating devices clearly marked to indicate operating directions.

RECOMMENDATION: The handles or control mechanism of all switches throughout the system should operate in a like direction to open and in a uniformly different direction to close in order to minimize errors.
- D. Remotely controlled or automatic devices shall have local provisions to render remote or automatic controls inoperable if such operation may result in a hazard to the worker.
- E. Enclosures containing fuses and interrupter contacts shall be designed to withstand the effects of normal, emergency, and fault conditions expected during operation.
- F. When tools are to be used to connect or disconnect energized devices, space or barriers shall be designed to provide adequate clearance from ground or between phases.

G. Pad-mounted and other aboveground equipment

1. Pad-mounted and other aboveground equipment shall have an enclosure that is either locked or otherwise secured against unauthorized entry.
2. Access to exposed live parts in excess of 600 V shall require two separate conscious acts. The first shall be the opening of a door or barrier that is locked or otherwise secured against unauthorized entry as required by Rule 7.9.2-G1. The second act shall be either the opening of a door or the removal of a barrier.

RECOMMENDATION: A prominent and appropriate safety sign should be visible when the first door or barrier is opened or removed.

NOTE: ANSI Z535.1-2006, ANSI Z535.2-2007, ANSI Z535.3-2007 and ANSI Z535.4-2006, contain information regarding safety signs.

7.9.3 Location in underground structures

- A. Equipment shall not obstruct personnel access openings in manholes or vaults, nor shall it impede egress by persons working in the structures containing the equipment.
- B. Equipment shall not be installed closer than 200 mm (8 in) to the back of fixed ladders and shall not interfere with the proper use of such ladders.
- C. Equipment should be arranged in a manhole or vault to permit installation, operation, and maintenance of all items in such structures.
- D. Switching devices that have provision for manual or electrical operation shall be operable from a safe position. This may be accomplished by use of portable auxiliary devices, temporarily attached.
- E. Equipment should not interfere with drainage of the structure.
- F. Equipment shall not interfere with the ability to ventilate any structure or enclosure.

7.9.4 Installation

- A. Provisions for lifting, rolling to final position, and mounting shall be adequate for the weight of the device.
- B. Live parts shall be guarded or isolated to limit the likelihood of contact by persons in a normal position adjacent to the equipment.
- C. Operating levers, inspection facilities, and test facilities shall be visible and readily accessible when equipment is in final location without moving permanent connections.
- D. Live parts shall be isolated or protected from exposure to conducting liquids or other material expected to be present in the structure containing the equipment.
- E. Operating controls of supply equipment, readily accessible to unauthorized personnel, shall be secured by bolts, locks, or seals.

7.9.5 Grounding and bonding

- A. Cases and enclosures made of conductive material shall be effectively grounded or guarded.
- B. Guards constructed of conductive material shall be effectively grounded.

Bonding should be provided between all aboveground metallic power and telecommunications apparatus (pedestals, terminals, apparatus cases, transformer cases, etc.) that are separated by a distance of 1.8 m (6 ft) or less. For the purpose of this Section, pole grounds are not required to be bonded to the telecommunication enclosures.

7.9.6 Identification

Where transformers, regulators, or other similar equipment operate in multiple, tags, diagrams, or other suitable means shall be used to indicate that fact.

7.10 Installation in Tunnels

7.10.1 General

- A. The installation of supply and telecommunications facilities in tunnels shall meet the applicable requirements contained elsewhere in Section 7 of this Code as supplemented or modified by this section.
- B. Where the space occupied by supply or telecommunications facilities in a tunnel is accessible to other than qualified persons, or where supply conductors do not meet the requirements of Section 7 of this Code for cable systems, the installation shall be in accordance with the applicable requirements of Section 6 of this Code.
- C. All parties concerned must be in agreement with the design of the structure and designs proposed for installations within it.

7.10.2 Environment

- A. When the tunnel is accessible to the public or when workers must enter the structure to install, operate, or maintain the facilities in it, the design shall provide a controlled safe environment including, where necessary, barriers, detectors, alarms, ventilation, pumps, and adequate safety devices for all facilities. Controlled safe environment shall include the following:
 - 1. Design to avoid poisonous or suffocation atmosphere
 - 2. Design to protect persons from pressurized lines, fire, explosion, and high temperatures
 - 3. Design to avoid unsafe conditions due to induced voltages
 - 4. Design to limit the likelihood of hazards due to flooding
 - 5. Design to ensure egress; two directions for egress shall be provided for all points in tunnels
 - 6. Working space, in accordance with Rule 7.3.4.2 , the boundary of which shall be not less than 600 mm (2 ft) from a vehicular operating space or from exposed moving parts of machinery
 - 7. Safeguards designed to protect workers from hazards due to the operation of vehicles or other machinery in tunnels
 - 8. Unobstructed walkways for workers in tunnels
- B. A condition of occupancy in multiple-use tunnels by supply and telecommunications facilities shall be that the design and installation of all facilities is coordinated to provide a safe environment for the operation of supply facilities, telecommunications facilities, or both. Safe environment for facilities shall include the following:
 - 1. Means to protect equipment from harmful effects of humidity or temperature
 - 2. Means to protect equipment from harmful effects of liquids or gases
 - 3. Coordinated design and operation of corrosion-control systems.

SECTION 8

SAFETY RULES FOR TELECOMMUNICATION FACILITIES

8.1 Purpose and Scope

8.1.1 Purpose

The purpose of this section is the safeguarding of persons during installation, operation and maintenance of telecommunication systems.

8.1.2 Scope

This section covers the safety requirements for telecommunication systems including wireless and wireline infrastructures such as telephone exchanges, base stations, mobile switching centers, base station controllers, access networks (including copper, fiber optic and coaxial cables), overhead and underground telecommunication lines, terminal equipment and cable television networks.

This section also covers compliance of telecommunication installations with safety limits for human exposure to electromagnetic fields (EMFs) produced by telecommunication equipment in the frequency range 9 kHz to 300 GHz.

8.2 Referenced Section

The Introduction (Section 1), Definitions (Section 2), Administration and Enforcement (Section 3) Grounding methods (Section 4), Substations (Section 5), Overhead Lines (Section 6), Underground Lines (Section 7), Telecommunication facilities (Section 8) and Appendix-A (bibliography), shall apply to the requirements of this section.

8.3 Grounding Methods for Telecommunication Systems

Refer to Section 4 of this Code for further details on grounding methods.

8.3.1 Grounding of telecom feeder

1. All telecom feeders and transceivers (transmitting and receiving devices) shall be grounded at the lowest possible point on the tower or mast.
2. the grounding shall not take place at a point where there is mechanical strain on the feeder such as on a bend;
3. A suitable 14 mm clearance hole on the mast steelwork shall be near to the earth point on the feeder;
4. The connection shall be made as follows:
 - a. remove 40 mm band of the PVC jacket from each feeder, taking great care not to damage the outer conductor;
 - b. clean off any tar or other compound using a suitable non-inflammable non-toxic solvent;
 - c. wrap two layers of braid around the feeder outer and secure with a stainless steel jubilee clip taking care not to crush the outer. This braid should be aluminum for aluminum feeders, and copper braid for copper feeders;
 - d. if aluminum braid is used, this may be bolted directly to a cleaned part of the tower galvanised surface;
 - e. if copper braid is used, proceed as follows:

- i. tin the end of the copper braid, and join to a suitable length of 25 mm x 3 mm aluminium tape using two M10 galvanised nuts, bolts and spring washers;
- ii. bolt the aluminium tape to a cleaned part of the tower galvanised surface.
- iii. the connections to the feeders must be covered with several layers of Denso tape;
- iv. if copper braid is used, all of the copper braid, and all of the joints to aluminium tape should also be covered with several layers of Denso tape;
- v. keep aluminium tape as straight (free of bends and kinks) as is practicable.

8.3.2 Earthing arrangements for UHF and VHF transmitting aerial towers generally high and medium powered stations

Following procedures shall be adopted;

Earth rods and plates: two per leg for;

1. Low/medium soil resistivity (clay/arable land); radial conductors with lengths: 1/2 tower height shown as in Figure 8-1.
2. High soil resistivity sites (sand or rock etc.); additional radial conductor lengths shown in the Figure 8-1.

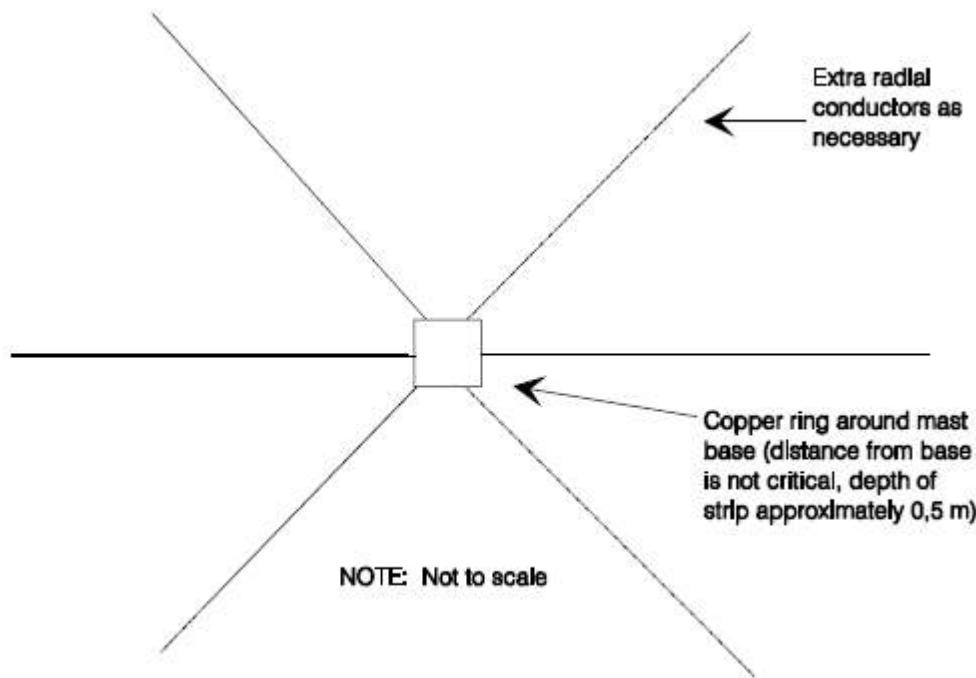


Figure 8-1: Layout of buried copper conductors

8.3.3 Earthing arrangements for UHF, VHF and SHF transmitter towers generally low powered stations

Following procedures shall be adopted;

1. For sites on clay and arable land; one earth rod or earth plate at each leg of tower (only).

2. For sites on sand or rock; one earth rod or plate at each leg of tower and four 25 mm x 3 mm (1" x 1/6") conductors shown as in Figure 8-2.
3. For sites on solid rock (in mountainous terrain);
 - a. Four 25 mm x 3 mm radial conductors shown in Figure 8-2;
 - b. Three or four 25 mm x 3 mm radial conductors shown in Figure 8-2.

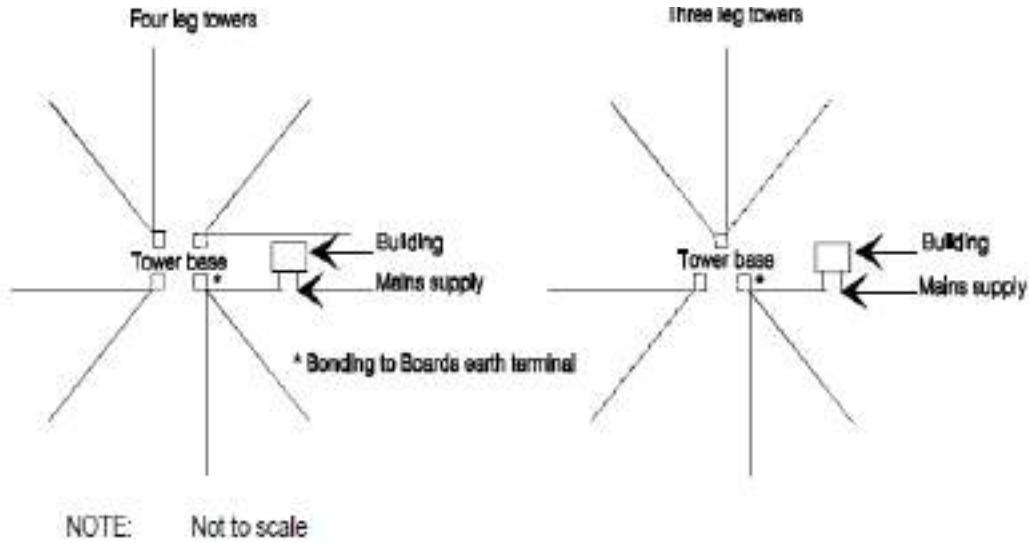


Figure 8-2: Site conditions b and c layout of buried copper conductors

8.3.4 Arrangement for earthing telecom and broadcasting towers

The Figure 8-3 illustrates earthing arrangement for telecom and broadcasting towers and buildings.

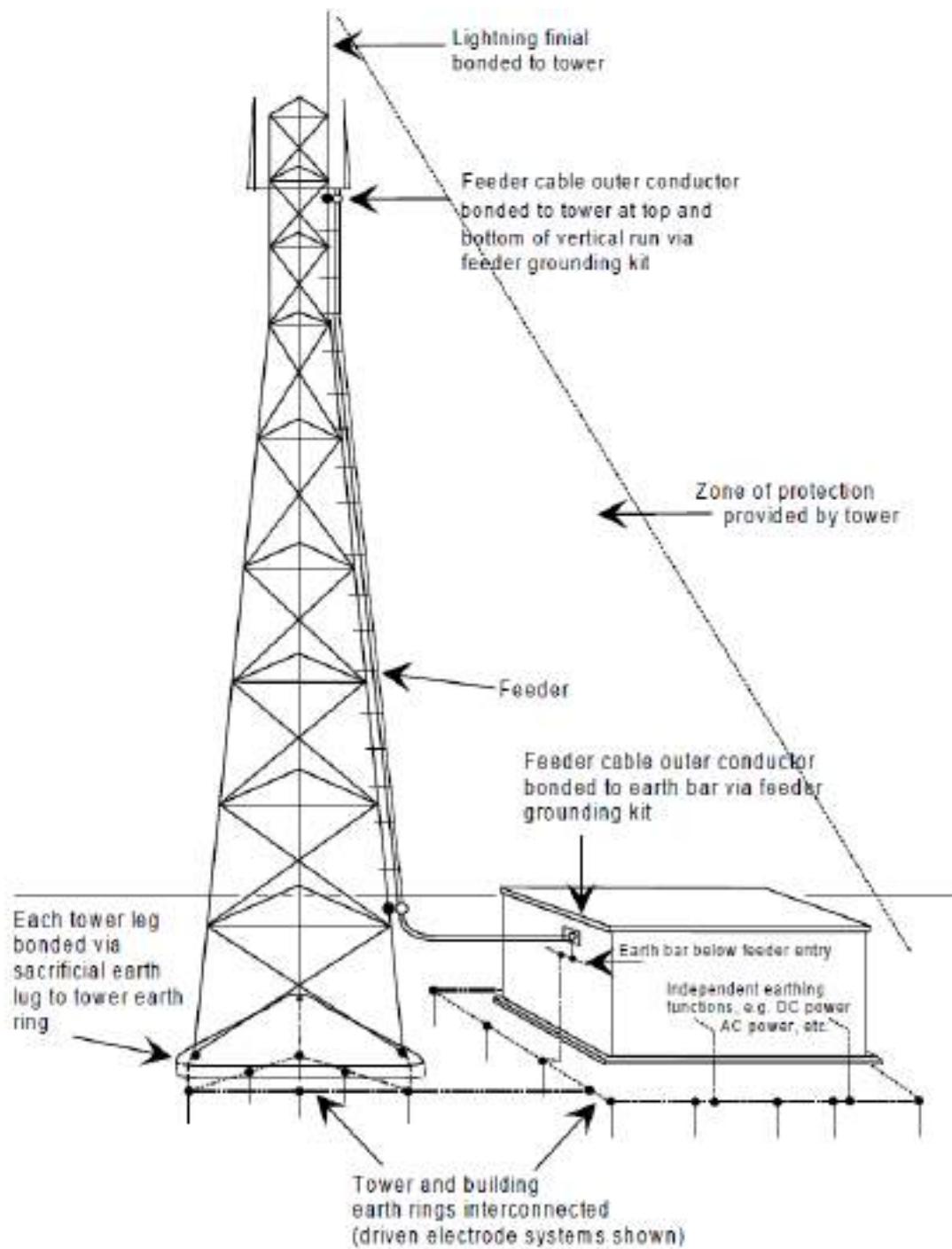


Figure 8-3: Earthing for telecom and broadcasting towers and buildings

8.4 Protection of Telecom Exchanges and Transmission Equipment

Telecom operators shall take all necessary steps for protection of equipment from the following;

1. Overtvoltages
2. Overcurrents
3. Lightning

In areas exposed to frequent and serious disturbances (lightning, power lines, soil of low conductivity), the telecom operator shall use protective devices between the cable conductors and the equipment to which they are connected, preferably on the Main Distribution Frame (MDF). The protective devices shall be fitted to the line side of the MDF to avoid the need to carry discharge currents in the MDF jumper field and to expose as little of the MDF wiring and terminal strips as possible to mains voltage in the event that a mains voltage line contact causes a series protective device to disconnect the line.

In less exposed locations, with low levels and frequency of disturbances (voltages and current) where the risks do not exceed those resulting from the residual effects for exposed regions, no protective devices shall be required.

8.5 Safety Requirements for Cable Television Distribution Networks

8.5.1 Reference levels, length of subscriber drop and grade of distribution cable

A Cable Television Operator shall maintain a specific grade of distribution cable in relation to the number of subscribers covered. The following shall be the reference levels:

Table 8-1: Grade of distribution cable versus number of subscribers

Number of subscribers terminal connected to the distribution cable	Grade of distribution cable
Up to and including 5000	RG-11 / ½ inch TFC
Above 5000	½ inch TFC / Fiber Optics

The cable TV operator shall ensure that the subscriber drop is clamped properly to walls, poles, as the case may be and shall not cause nuisance to the subscriber, public and environment.

A Cable Television Operator shall adopt distribution cable specification given in Table 8-2 for the subscriber drop:

Table 8-2: Distribution cable specification for the subscriber drop

Number of subscribers on the drop	Length of the subscriber's drop without using an amplifier in the drop①	Grade of distribution cable
1	Up to 30 meters	RG-6

2 to 4	Up to 30 meters	RG-7
1 to 4	30 to 100 meters	RG-11
5 and more	Up to 100 meters	RG-11

① In all other conditions an amplifier shall be used in the subscriber's drop.

8.5.2 Reference Frequency Band

A Cable Television Operator shall use PAL B/G television system on its cable system. The frequency bands mentioned in Table 8-3 shall be used:

Table 8-3: Frequency bands

Standard Band	Standard Channel Identification	Frequency (MHz.)①
VHF (Low)	E2-E4	48 – 68
VHF (Low)	X, Y, Z	69 – 88
VHF (Mid)	S1-S10	108 – 174
VHF (High)	E5-E12	175 – 230
VHF (Super)	S11-S20	231 – 300
VHF (Hyper)	S21-S41	303 - 469
VHF (Ultra High)	E21-E69	471 - 861

① The audio center frequency of the audio carrier shall be 4.5 to 5.5 MHz above the frequency of the visual/video carrier at the output of the modulating or processing equipment of a cable system and at the subscriber end of the subscriber's drop.

8.5.3 Permissible Signal Leakage Levels

1. A Cable Television Operator shall ensure that the signal leakage from a cable television system shall be within the limits specified in Table 8-4:

Table 8-4: Signal leakage reference limits

Frequencies(MHz.)	Signal leakage limit (μ V/meter)	Distance (meters)
Upto and including 54	15	30
Over 54	20	3

2. The carrier-to-noise ratio for each television channel received at subscriber's end of the subscriber's drop shall not be less than 45 dB.

8.5.4 System/Equipment Layout and Location

1. A Cable Television Operator shall establish the head-end facilities in an area which is easily accessible to its subscribers and which does not cause nuisance to people living in residential areas. Provided that no objection certificate (NOC) has been obtained from the relevant authorities, where required
2. A Cable Television Operator shall ensure that the distribution cable does not become nuisance to the public and does not pose a hazard to people, animals and the environment, besides the security of the medium itself.

- a. In case where the distribution cable has to be buried under ground, the specifications given in Table 8-5 shall be complied with:

Table 8-5: Buried distribution cable standard

Area	Standard
In case of public areas, where the distribution cable has to be buried under road, footpaths etc.	PVC pipes shall be used which shall be buried at least one foot below the ground level.
In all other areas	The distribution cable shall be passed in trenches with bricks on three sides (two sides and on top) and is filled with sand.

- b. In case where the medium has to be laid overhead, the Cable Television Operator shall ensure that the distribution cable is installed at a sufficient height, out of reach of people and vehicles passing under it and that it is properly clamped to the poles. The clearance of the distribution cable shall at least as per Table 8-6.

Table 8-6: Minimum ground clearance of distribution cable

In case:	Minimum Ground Clearance	
	m	ft
Where vehicles, people, animal etc pass under it	4.27	14
All other areas	3.35	11

Provided that High Tension electricity poles (11 kV and above) shall not be used for the purpose of laying the cable television distribution cable.

Provided further that in case of using electricity/telephone/railway poles, care shall be taken that disturbance from external sources i.e. electricity, telephone lines etc. does not cause interference in the distribution cable which may result in the inferior quality of service to the subscribers. The clearance mentioned in Table 8-7 shall be maintained between the lines and the distribution cable.

Table 8-7: Clearance between the distribution cable and the lines

In case:	Minimum clearance between the distribution cable and the lines	
	(m)	(ft)
Where the distribution cable has to be strung on Low Tension live lines poles(400/230 V)	0.91	3
Where the distribution cable has to be strung on telecommunication lines.	0.61	2

NOTE 1: A Cable Television Operator shall ensure that its cable system does not cause interference or harm to the equipment of subscribers and other systems that may be connected to its system.

NOTE 2: In case of an expansion/construction of the cable system, the Cable Television Operator shall ensure that the work is undertaken only after obtaining proper permission/ NOC from the relevant authorities in case of digging roads and using other utilities poles etc.

8.5.5 Scalability of Cable Television Distribution System

A Cable Television Operator shall install a system which is scalable and can cater for the future growth of the subscribers and television channels.

8.5.6 Safety Measures

1. A Cable Television Operator shall take all necessary steps to ensure the safety of its equipment, personnel/staff, own building, surrounding buildings and environment. The safety measure shall include the following, but are not limited to:
 - a. Provision of fire-fighting equipment
 - b. Use of standard quality cables for electricity and cable system.
2. A Cable Television Operator shall ensure that line isolators are installed at both ends of the main distribution system, to prevent stray electrical charges from getting on to the cable system and causing danger to the subscriber's equipment and people.
3. The cable TV operators shall ensure that cables or other installations do not become a nuisance to the public and do not pose a hazard to people.
4. The cable operator shall make provisions for installing cables at all utility poles at sufficient height.

8.6 Environmental, Health, and Safety In Telecommunications Infrastructures

The section is regarding EHS for telecommunications infrastructure such as fixed line and wireless voice and data transmission infrastructure, including long distance terrestrial and submarine cables (e.g. fiber optic cables), as well as radio and television broadcasting, and associated telecommunications and broadcasting installations and equipment.

8.6.1 Environment

Environmental issues in telecommunications primarily include the following:

8.6.1.1 Terrestrial Habitat Alteration

Terrestrial and aquatic habitats may be altered primarily during the construction of telecommunications infrastructure depending on the type of infrastructure component and proposed location.

Potential impacts to habitat is more significant during construction and installation of linear infrastructure, such as long distance fixed line cables, as well as access roads to other types of infrastructure along previously undeveloped land.

Measures to prevent and control impacts to terrestrial habitats during construction of the right-of-way includes:

1. Site fixed line infrastructure (e.g. fiber optic cable) and other types of linear infrastructure rights-of-way, access roads, lines, and towers should avoid critical habitat through use of existing utility and transport corridors, whenever possible;
2. Avoidance of construction activities during the breeding season and other sensitive

- seasons or times of day;
- 3. Revegetation of disturbed areas with native plant species;

8.6.1.2 Avian Collisions

The height of television and radio transmission towers poses a fatal risk to birds mainly through collisions.

The likelihood of avian collisions increases with the height and design of the telecommunications tower (e.g. guyed towers represent a higher potential for collisions), the presence of tower lighting (which attracts some species of birds at night or during low light conditions), and, most importantly, the tower location with regard to flyways or migration corridors.

Prevention and control measures to minimize avian collisions include:

1. Siting towers to avoid critical habitats (e.g. nesting grounds, heronries, rookeries, foraging corridors, and migration corridors);
2. Avoiding the cumulative impact of towers by collocating antennae on existing towers or other fixed structures (especially cellular telephone telecommunication antennae), designing new towers structurally and electrically to accommodate future users, and removing towers no longer in use;
3. To the extent feasible, limiting the tower height and giving preference to non-guyed tower construction designs (e.g. using lattice structures or monopoles);
4. If guy wired towers are located near critical bird habitats or migratory routes, installing visibility enhancement objects (e.g. marker balls, bird deterrents, or diverters) on the guy wires;
5. Limiting the placement and intensity of tower lighting systems to those required to address aviation safety.

8.6.1.3 Aquatic Habitat Alteration

Depending on their location, the installation of fixed line components, including shore approaches for long distance fiber optic cables, and access roads to transmission towers and other fixed infrastructure, may require construction of corridors crossing aquatic habitats with the potential to disrupt watercourses, wetlands, coral reefs, and riparian vegetation.

Measures to prevent and control impacts to aquatic habitats include:

1. Site power transmission towers and substations to avoid critical aquatic habitat such as watercourses, wetlands, and riparian areas, as well as fish spawning habitat, and critical fish over-wintering habitat, whenever possible;
2. Maintaining fish access when road crossings of watercourses are unavoidable by utilizing clear pan bridges, open-bottom culverts, or other approved methods;
3. Minimizing clearing and disruption to riparian vegetation;

8.6.1.4 Marine Habitat Alteration

Long distance telecommunications cables (e.g. fiber optic cables) may reach across ocean stretches. Cables are typically installed using a cable-laying vessel and a remotely operated, underwater vehicle. Issues associated with marine habitat alteration include disruption to intertidal vegetation and marine life, including marine mammals, and sedimentation resulting in turbidity and reductions in water quality.

Measures to prevent and control impacts to marine habitats include:

1. Locating and siting cable routes, and shore access, to avoid critical marine habitats, such as coral reefs and breeding grounds;
2. Burying submarine cables when traversing sensitive intertidal habitat;

3. Monitoring cable laying path for presence of marine mammals;
4. Avoiding laying of submarine cable during fish and marine mammals breeding periods, calving periods, and spawning seasons.

8.6.1.5 Visual Impacts

The visual impacts from tower and antennae equipment may depend on the perception of the local community as well as the aesthetic value assigned to the scenery (e.g. scenic and tourism areas).

Measures to prevent, minimize and control the visual impacts include:

1. Minimizing construction of additional towers through co-location of proposed antennae in existing towers or existing structures such as buildings or power transmission towers;
2. Use of tower and antennae camouflaging or disguising alternatives (e.g. masts or towers designed to look as trees);
3. Taking into account public perception about aesthetic issues by consulting with the local community during the siting process of antenna towers.

8.6.1.6 Hazardous Materials and Waste

Telecommunications processes do not normally require the use of significant amounts of hazardous materials. However, the operation of certain types of switching and transmitting equipment may require the use backup power systems consisting of a combination of batteries (typically lead-acid batteries) and diesel-fueled backup generators for electricity. Operations and maintenance activities may also result in the generation of electronic wastes (e.g. nickel-cadmium batteries and printed circuit boards from computer and other electronic equipment as well as backup power batteries). The operation of backup generators and service vehicles may also result in the generation of used tires, and waste oils and used filters. Transformer equipment may potentially contain Polychlorinated Biphenyls (PCBs) while cooling equipment may contain refrigerants (potential Ozone Depleting Substances [ODSs]).

The hazardous materials management actions include:

1. Implementing fuel delivery procedures and spill prevention and control plans applicable to the delivery and storage of fuel for backup electric power systems, preferably providing secondary containment and overfill prevention for fuel storage tanks;
2. Implementing procedures for the management of lead acid batteries, including temporary storage, transport and final recycling by a licensed facility;
3. Ensuring that new support equipment does not contain PCBs or ODSs. PCBs from old equipment should be managed as a hazardous waste;
4. Purchasing electronic equipment that meets international phase out requirements for hazardous materials contents and implementing procedures for the management of waste from existing equipment.

Considering the implementation of a take-back program for consumer equipment such as cellular telephones and their batteries.

8.6.1.7 Emissions to air

The following measures shall be taken to minimize and control emissions from telecommunications facilities:

1. Implementation of vehicle fleet and power generator emissions management strategies

- and avoiding the use of backup power generators as a permanent power source, if feasible;
2. Substitution in use of chlorofluorocarbons (CFCs) in cooling and fire-suppression systems, using contractors who are properly trained or certified in the management of CFCs.

8.6.1.8 Noise

The principal source of noise in telecommunication facilities is associated with the operation of backup power generators. If the noise level exceeds 85 dBA on a time-weighted average, a hearing conservation program is required. The actual exposure limits are given in Table 8-8.

Noise management action includes the use of noise suppression shields and mufflers, as well as the location of noise generating sources away from residential or other noise-sensitive receptors.

Table 8-8 : Noise level exposure limit

Noise Level	Exposure Limit
90 dBA	8.0 Hours
92 dBA	6.0 Hours
95 dBA	5.0 Hours
97 dBA	3.0 Hours
100 dBA	2.0 Hours
102 dBA	1.5 Hours
105 dBA	1.0 Hours
110 dBA	30 Minutes
115 dBA	15 Minutes

8.6.2 Occupational health and safety

Occupational health and safety issues in telecommunications projects primarily include the following:

Excavation, construction, and repair of some components of a telecommunications system may result in workers' exposure to existing aboveground or underground utilities, including aerial or buried electric transmission lines or buried natural gas and petroleum pipelines. Identification and location of all relevant existing underground utilities should be undertaken prior to any excavation and trenching activities.

8.6.2.1 Electrical Safety

Telecommunications workers may be exposed to occupational hazards from contact with live power lines during construction, maintenance, and operation activities.

Prevention and control measures associated with live power lines include:

1. Only allowing trained and certified workers to install, maintain, or repair electrical equipment;
2. Deactivating and properly grounding live power distribution lines before work is performed on, or in close proximity to, the lines;
3. Ensuring that live-wire work is conducted by trained workers with strict

- adherence to specific safety and insulation standards. Qualified or trained employees working on transmission or distribution systems should be able to achieve the following:
- a. Distinguish live parts from other parts of the electrical system
 - b. Determine the voltage of live parts
 - c. Understand the minimum approach distances outlined for specific live line voltages
 - d. Ensure proper use of special safety equipment and procedures when working near, or on, exposed energized parts of an electrical system
4. Workers should not approach an exposed, energized or conductive part even if properly trained unless:
 - a. The worker is properly insulated from the energized part with gloves or other approved insulation; or
 - b. The energized part is properly insulated from the worker and any other conductive object; or
 - c. The worker is properly isolated and insulated from any other conductive object (live-line work)
 5. Where maintenance and operation is required within minimum setback distances, specific training, safety measures, personal safety devices, and other precautions should be defined in a health and safety plan;
 6. Measures to prevent, minimize, and control injuries related to electric shock include:
 - a. All electrical installations should be performed by certified personnel and supervised by an accredited person. Certification for such work should include theoretical as well as practical education and experience;
 - b. Strict procedures for de-energizing and checking of electrical equipment should be in place before any maintenance work is conducted. If de-energizing is not possible, electrical installations should be moved or insulated to minimize the hazardous effects;
 - c. Prior to excavation works, all existing underground cable installations should be identified and marked. Drawings and plans should indicate such installations;
 - d. All electrical installations or steel structures, such as masts or towers, should be grounded to provide safety as the electrical current chooses the grounded path for electrical discharge. In cases where maintenance work has to be performed on energized equipment, a strict safety procedure should be in place and work should be performed under constant supervision;
 - e. Personnel training should be provided in revival techniques for victims of electric shock.

8.6.2.2 Optical fiber safety

Workers involved in fiber optic cable installation or repair may be at risk of permanent eye damage due to exposure to laser light during cable connection and inspection activities.

Workers may also be exposed to minute or microscopic glass fiber shards that can penetrate human tissue through skin or eyes, or by ingestion or inhalation. Optical fiber installation activities may also pose a risk of fire due to the presence of flammable materials in high-powered laser installation areas.

Measures to prevent, minimize, and control injuries related to fiber optic cables installation and maintenance include:

1. Worker training on specific hazards associated with laser lights, including the various classes of low and high power laser lights, and fiber management;
2. Preparation and implementation of laser light safety and fiber management procedures which include:
 - a. Switching off laser lights prior to work initiation, when feasible
 - b. Use of laser safety glasses during live optical fiber systems installation
 - c. Prohibition of intentionally looking into the laser or fiber end or pointing it at another person
 - d. Restricting access to the work area, placing warning signs and labeling of areas with potential for exposure to laser radiation, and providing adequate background lighting to account for loss of visibility with the use of protective eyewear
 - e. Inspecting the work area for the presence of flammable materials prior to the installation of high-powered laser lights
3. Implementation of a medical surveillance program with initial and periodic eye examinations;
4. Avoiding exposure to fibers through use of protective clothing and separation of work and eating areas.

8.6.2.3 Elevated and overhead work

The assembly of towers and installation of antennae can pose a physical hazard to workers using lifts and elevated platforms and those located below due to the potential for falling objects.

The management strategies include:

1. The area around which elevated work is taking place should be barricaded to prevent unauthorized access. Working under other personnel should be avoided;
2. Hoisting and lifting equipment should be rated and maintained and operators trained in their use. Elevating platforms should be maintained and operated according to established safety procedures that include such aspects as equipment and use of fall protection measures (e.g. railings), movement of location only when the lift is in a retracted position, repair by qualified individuals, and the use of effective locks to avoid unauthorized use by untrained individuals;
3. Ladders should be used according to pre-established safety procedures including proper placement, climbing, standing, and the use of extensions.

8.6.2.4 Fall protection

Workers may be exposed to occupational hazards when working at elevation during construction, maintenance, and operation activities. Prevention and control measures for working at height include:

1. Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others;
2. Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters (m) above the working surface, but sometimes extended to 7m, depending on the activity). The fall protection system should be appropriate for the tower structure and necessary movements, including ascent, descent, and moving from point to point;
3. Installation of fixtures on tower components to facilitate the use of fall protection systems;
4. Provision of an adequate work-positioning device system for workers.

- Connectors on positioning systems should be compatible with the tower components to which they are attached;
5. Safety belts should be of not less than 16 millimeters (mm) (5/8 inch) two-in-one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibers become evident;
 6. When operating power tools at height, workers should use a second (backup) safety strap.

8.6.2.5 Confined spaces

The type of confined spaces encountered in telecommunications projects varies, but may include underground fixed line infrastructure co-located with other underground infrastructure in urban areas. Telecommunications facility operators should develop and implement confined space entry procedures.

8.6.2.6 Motor vehicle safety

The geographically dispersed nature of the infrastructure of some telecommunications operators may require the frequent use of ground transportation for maintenance activities. Under these circumstances, companies should prepare and implement motor vehicle safety programs to protect the safety of its workers and the communities in which they operate.

8.6.2.7 Electromagnetic fields (EMF)

Telecommunications workers typically have a higher exposure to EMF than the general public due to working in proximity to transmitting antennas emitting radio waves and microwaves. Radio wave strength is generally much greater from radio and television broadcast stations than from cellular phone telecommunication base transceiver stations. Microwave and satellite system antennas transmit and receive highly concentrated directional beams at even higher power levels.

Occupational EMF exposure should be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

1. Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities;
2. Training of workers in the identification of occupational EMF levels and hazards;
3. Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers;
4. Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the Institute of Electrical and Electronics Engineers (IEEE). Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g. 50 percent). Action plans to address occupational exposure may include deactivation of transmission equipment during maintenance activities, limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, use of shielding materials; or installation of ladders or other climbing devices inside the mast or towers, and behind the transmission beams. Table 8-9 shows the reference levels.

Table 8-9 : ICNIRP reference levels (unperturbed rms values)

Type of exposure	Frequency range	Electric field strength (V/m)	Magnetic field strength (A/m)	Equivalent plane wave power density S_{eq} (W/m ²)
Occupational exposure	Up to 1 Hz	–	2×10^5	–
	1-8 Hz	20 000	$2 \times 10^5/f^2$	–
	8-25 Hz	20 000	$2 \times 10^4/f$	–
	0.025-0.82 kHz	$500/f$	$20/f$	–
	0.82-65 kHz	610	24.4	–
	0.065-1 MHz	610	$1.6/f$	–
	1-10 MHz	$610/f$	$1.6/f$	–
	10-400 MHz	61	0.16	10
	400-2000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$f/40$
	2-300 GHz	137	0.36	50
General public	Up to 1 Hz	–	2×10^4	–
	1-8 Hz	10 000	$2 \times 10^4/f^2$	–
	8-25 Hz	10 000	$5 000/f$	–
	0.025-0.8 kHz	$250/f$	$4/f$	–
	0.8-3 kHz	$250/f$	5	–
	3-150 kHz	87	5	–
	0.15-1 MHz	87	$0.73/f$	–
	1-10 MHz	$87f^{1/2}$	$0.73/f$	–
	10-400 MHz	28	0.073	2
	400-2000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$f/200$
	2-300 GHz	61	0.16	10

NOTE 1 – f is as indicated in the frequency range column.

NOTE 2 – For frequencies between 100 kHz and 10 GHz, the averaging time is 6 minutes.

NOTE 3 – For frequencies up to 100 kHz, the peak values can be obtained by multiplying the rms value by $\sqrt{2} (\approx 1.414)$. For pulses of duration t_p , the equivalent frequency to apply should be calculated as $f = 1/(2t_p)$.

NOTE 4 – Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 MHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz, it is suggested that the peak equivalent plane-wave power density, as averaged over the pulse width, does not exceed 1000 times the S_{eq} limit, or that the field strength does not exceed the field strength exposure levels given in the table.

NOTE 5 – For frequencies exceeding 10 GHz, the averaging time is $68/f^{1.05}$ minutes (f in GHz).

8.6.2.8 Compliance of mobile handsets

Mobile handsets or other radiating devices operating in the frequency range of 300 MHz to 3 GHz and used against the head, shall comply with the ICNIRP safety limits as given in Table 8-8 by applying the measurement procedures for SAR in IEC 62209 (2004).

The following Table 8-10 shows the basic limits.

Table 8-10 : ICNIRP basic limits

Type of exposure	Frequency range	Current density for head and trunk (mA/m ²) (rms)	Whole-body average SAR (Watt/kg)	Localized SAR (head and trunk) (Watt/kg)	Localized SAR (limbs) (Watt/kg)
Occupational	Up to 1 Hz	40	—	—	—
	1-4 Hz	40/f	—	—	—
	4 Hz-1 kHz	10	—	—	—
	1-100 kHz	f/100	—	—	—
	100 kHz-10 MHz	f/100	0.4	10	20
	10 MHz-10 GHz	—	0.4	10	20
General public	Up to 1 Hz	8	—	—	—
	1-4 Hz	8/f	—	—	—
	4 Hz-1 kHz	2	—	—	—
	1-100 kHz	f/500	—	—	—
	100 kHz-10 MHz	f/500	0.08	2	4
	10 MHz-10 GHz	—	0.08	2	4

NOTE 1 – f is the frequency in Hertz.

NOTE 2 – Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm² perpendicular to the current direction.

NOTE 3 – All SAR values are to be averaged over any 6-minute period.

NOTE 4 – The localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.

8.6.2.9 Antenna installation, operation directions and safety procedures

1. Roof-mounted antennas shall be elevated at least of twenty five feet (25ft) above the height of people who may have to be on the rooftop.
2. Radiating surface of all roof-mounted antennas shall be kept twenty five feet (25ft) away from the public places including roof access points, telephone service points.
3. All roof-mounted directional antennas shall be placed near the roof periphery and be pointed away from the building.
4. The large aperture antennas (lower maximum radio frequency) and small aperture antennas (lower visual impact) shall be considered especially for installations on building roofs.
5. Precautions should be taken when designing co-location sites, where multiple antennas owned by different operators are on the same structure, particularly those sites that include high-power broadcast (FM/TV) antennas.

8.6.2.10 Requirements for installation of telecommunication towers/ antennas

All telecom operators shall ensure compliance to the following:

1. The hazard light on top of structure/tower for the safety of aviation should be installed with the following features:
 - a. red color;
 - b. visible at aerial distance of at least three (3) Kilo meters;
 - c. omni directional; and
 - d. blinking of light during day shall be at the rate of four (4) seconds on time and two (2) seconds off
2. The tower should have two colors namely red and white.
3. Information about the site shall be made known by putting a plate in red color on the structure/tower. The following information shall be engraved on plate:
 - a. company name;
 - b. site ID (assigned by company);
 - c. height of tower (tallest mechanical structure at the site; from base of the structure and not just the tower);
 - d. date of Installation;
 - e. Emergency contact number (24x7); and Contact No. of concerned regulatory Authority.
 - f. Contact No. of nearest fire brigade
 - g. Warning to keep the passer by or someone living in the vicinity away from the site as its prolonged exposure can be hazardous and injurious to health.
4. The plate shall be:
 - a. installed at height of five (5) feet from base of tower;
 - b. made of stainless steel material or an alloy of good quality and strength;
 - c. weather resistant;
 - d. 1'x 1' (ft) in dimensions: and firmly, fixed with at least one leg.

8.6.2.11 Work practices standards

1. Individuals working at antenna sites shall be trained and informed about the presence of RF energy, the potential for exposure and the steps that shall be taken to reduce their exposure.
2. Each exposed worker shall be asked to sign a document provided by the operator (not its contractor or sub-contractor) which clearly identifies the possible hazards and safety precautions to be taken.
3. In case where the radio frequency radiation at a site exceeds the permissible limits for general public, the site shall immediately be shut down and posted with appropriate signs of warning till the time the issue is rectified and cleared by the concerned regulatory authority.
4. In case where the situation specified in Rule 8.7.5-3 of this code arises, which shall only be in exceptional circumstances, the complete plan with supporting information shall be submitted to the concerned regulatory authority prior to the increase in energy levels, regarding, the time, technical specifications, and justification for such increase.
5. All antennas shall be presumed to remain active at all times
6. All operators shall take necessary preventive measures and safety precautions for the protection of their workers including the following: -
 - a. A minimum distance often feet (10) between the antenna and their workers.
 - b. A facility to power down (or shut down) the transmitters in the areas which exceed the guidelines for controlled (occupational) exposures.

- c. All telecom operators shall ensure wearing of a protective gear kit by their workers and that the workers are appropriately communicated to keep moving when working in close proximity of the site.

8.6.2.12 Requirements for Installation of Telecommunication and Terminal Equipment

1. Objective and Applicability

This section covers the following;

- a. Minimum standard of qualification that is required to be possessed by the Telecommunication and Terminal Equipment Installer to install quality telecom equipment.
- b. Telecommunication wiring, which enables the occupiers with uninterrupted access to multi-play telecom services or broadband using latest technologies.
- c. All Installations (both wired and wireless) have to be laid through a Certified Telecommunication and Terminal Equipment Installer.
- d. Access Networks consisting of wireless, wire/cable (Coaxial, Copper, Fiber) and telecommunication equipment connecting essentials laying within the Premises, other than plug into socket, including but not limited to Network Termination Point (NTP) at a Premises.

Note: Guidelines issued by relevant Regulator may be referred, where applicable.

2. Telecom Operator's obligation

- a. A telecom operator shall not provide any telecommunication service at a premise where the telecommunication equipment is not installed by a Certified Telecommunication (Terminal and Equipment) Installer in accordance with the standards prescribed in this section of the code.
- b. All Local Loop (Fixed Local Loop & Wireless Local Loop) telecom operators shall be required to obtain a Certificate from the concerned authority if any equipment is required to be installed at the customer Premises.
- c. The Network Termination Point shall be securely fixed at the closest customer Premises from the outside plant. If the terminal equipment is provided by the telecom operators, the NTP shall be extended upto the terminal box. The telecom operators shall maintain all NTP termination and installation records for the duration of the service.

3. Premises Owner's Obligation

Premises Telecommunication Installations shall be the responsibility of the Premises owner.

4. Telecommunication and Terminal Equipment Installer's Obligations

- a. The Certified Telecommunication and Terminal Equipment Installer shall be responsible for following, as and where applicable:
 - i. Wiring shall be as per international standards specified at Appendix-D
 - ii. Wiring shall be properly terminated at Network Termination Point.
 - iii. When a telecom cabling is placed alongside an AC electrical power cable inside a wall space or in the ceiling space, it may have a minimum separation of 50.4 mm (2 in), or shall be passed through a separate PVC pipe.
 - iv. When there is a requirement for the telecom cable for voice, data and video to cross the power cable it shall always cross at right angle.
 - v. There shall be a clear separation of 2 inches between:
 - 1) Separation from power conduits.
 - 2) Separation and barriers within raceways; and
 - 3) Separation within outlet boxes or compartments.
 - vi. The voltage shall not be injurious to occupants, it shall be safe and secure from normal electrical power.
 - vii. Shall verify that the attenuation and signal losses are minimum.
 - viii. That the Telecom room (TR) and building entrance facility (BEF) have enough accommodation for cabling and equipment and additional space is available for future requirements. Passive equipment like patch panels shall have 50 % free ports.
 - ix. General environment requirements shall be adhered which includes sufficient power requirements, power backup, humidity, ventilation and HVAC etc.
- b. The Certified Telecommunication and Terminal Equipment Installer shall execute a written agreement with the Premises owner after completion of the installation work to verify satisfactory completion of the installation work in accordance with this code. A copy of the agreement shall be retained by the Certificate holder and the Premises owner.
- c. No Person, other than the holder of a Certificate shall advertise or otherwise claim to be an authorized Certificate holder or qualified to perform or carry out such Installation work.

Note: The application for the grant of certificate shall be submitted to the concerned regulatory authority.

8.6.3 Community Health and Safety

Examples community health and safety issues identified during the construction phase include exposure to construction vehicles and transports, and exposure to dust, noise and vibrations caused by constructions works.

Operational phase occupational hazards associated with telecommunications projects include:

8.6.3.1 Structural and site access issues

Communities may be exposed to structural safety issues in the event of structural failure of masts or towers. These same sites may also attract unauthorized persons interested in climbing these structures, also representing a risk to their safety.

Measures to manage site safety issues include:

1. Design and installation of tower structures and components according to good international industry practice¹⁸, taking into account the potential frequency and magnitude of natural hazards;
2. Erection of fences in combination with other institutional controls and management approaches, such as the posting of signs forbidding entry and

- placement of guards to protect the premises surrounding the site;
3. Equipping masts or towers with anti-climbing devices to preclude unauthorized climbing.

8.6.3.2 Aircraft navigation safety

Antenna towers, if located near an airport or known flight paths, can impact aircraft safety directly through collision or indirectly through radar interference. Aircraft collision impacts can be mitigated by:

1. Avoiding the siting of towers close to airports and outside of known flight path envelopes;
2. Consultation with regulatory air traffic authorities prior to installation, in accordance with air traffic safety regulations.

8.6.3.3 Driver Safety and Cellular Phones

Telecommunications companies who provide cellular phone service have little or no influence over the safe use of these devices by their clients. However, to the extent feasible, companies should promote the safe use of cellular telephones through such methods as customer information campaigns which may include distribution of information at the time of customer service sign-up or by mail with billing information, or through public advertising campaigns.

8.7 Work Environment Rules for Telecommunication Facilities

8.7.1 Application

1. This section sets forth safety and health standards that apply to the work conditions, practices, means, methods, operations, installations and processes performed at telecommunications centers and at telecommunications field installations, which are located outdoors or in building spaces used for such field installations. Center work includes the installation, operation, maintenance, rearrangement, and removal of telecommunications equipment and other associated equipment in telecommunications switching centers. Field work includes the installation, operation, maintenance, rearrangement, and removal of conductors and other equipment used for signal or telecommunication service, and of their supporting or containing structures, overhead or underground, on public or private rights of way, including buildings or other structures.
2. These standards do not apply:
 - a. To construction work
 - b. To installations under the exclusive control of electric utilities used for the purpose of telecommunications or metering, or for generation, control, transformation, transmission, and distribution of electric energy, which are located in buildings used exclusively by the electric utilities for such purposes, or located outdoors on property owned or leased by the electric utilities or on public highways, streets, roads, etc., or outdoors by established rights on private property.
 - c. Operations which involve construction work are subject to all the applicable standards defined by PEC.

8.7.2 General

8.7.2.1 For buildings containing telecommunication centers

1. **Illumination.** Lighting in telecommunication centers shall be provided in an adequate amount such that continuing work operations, routine observations, and the passage of employees can be carried out in a safe and healthful manner. Certain specific tasks in centers, such as splicing cable and the maintenance and repair of equipment frame lineups, may require a higher level of illumination. In such cases, the employer shall install permanent lighting or portable supplemental lighting to attain a higher level of illumination shall be provided as needed to permit safe performance of the required task.
2. **Working surfaces.** Guard rails and toe boards may be omitted on distribution frame mezzanine platforms to permit access to equipment. This exemption applies only on the side or sides of the platform facing the frames and only on those portions of the platform adjacent to equipped frames.
3. **Working spaces.** Maintenance aisles, or wiring aisles, between equipment frame lineups are working spaces and are not an exit route.
4. **Special doors.** When blast proof or power actuated doors are installed in specially designed hard site security buildings and spaces, they shall be designed and installed so that they can be used as a means of egress in emergencies.
5. **Equipment Machinery and machine guarding.** When power plant machinery in telecommunications centers is operated with commutes and couplings uncovered, the adjacent housing shall be clearly marked to alert personnel to the rotating machinery.

8.7.2.2 Battery handling

1. Eye protection devices which provide side as well as frontal eye protection for employees shall be provided when measuring storage battery specific gravity or handling electrolyte and the employer shall ensure that such devices are used by the employees. The employer shall also ensure that acid resistant gloves and aprons shall be worn for protection against spattering. Facilities for quick drenching or flushing of the eyes and body shall be provided unless the storage batteries are of the enclosed type and equipped with explosion proof events, in which case sealed water rinse or neutralizing packs may be substituted for the quick drenching or flushing facilities. Employees assigned to work with storage batteries shall be instructed in emergency procedures such as dealing with accidental acid spills.
2. Electrolyte (acid or base, and distilled water) for battery cells shall be mixed in a well ventilated room. Acid or base shall be poured gradually, while stirring, into the water. Water shall never be poured into concentrated (greater than 75 percent) acid solutions. Electrolyte shall never be placed in metal containers nor stirred with metal objects.
3. When taking specific gravity readings, the open end of the hydrometer shall be covered with an acid resistant material while moving it from cell to cell to avoid splashing or throwing the electrolyte.

8.7.2.3 First Aid Kit

Employers should provide employees with readily accessible, adequate, and appropriate first aid supplies as mentioned in Table 8-11.

Table 8-11 : Basic Fill Contents for First Aid Kit

Item and Minimum Size or Volume	Minimum Quantity
Absorbent Compress, 32 sq. in. (No side smaller than 4")	1
Adhesive Bandages, 1" x 3"	16
Adhesive Tape, 5 yd.	1
Antiseptic, .5g application	10
Burn Treatment, .5g application	6
Medical Exam Gloves	2 pairs.
Sterile Pads, 3" x 3"	4
Triangular bandage, 40" x 40" x 56"	1

8.7.2.4 Hazardous materials

Highway mobile vehicles and trailers stored in garages may be equipped to carry more than one LP-gas container, but the total capacity of LP-gas containers per work vehicle stored in garages shall not exceed 100 pounds of LP-gas. All container valves shall be closed when not in use.

8.7.2.5 Compressed gas

When using or transporting nitrogen cylinders in a horizontal position, special compartments, racks, or adequate blocking shall be provided to prevent cylinder movement. Regulators shall be removed or guarded before a cylinder is transported.

8.7.2.6 Support structures

No employee, or any material or equipment, may be supported or permitted to be supported on any portion of a pole structure, platform, ladder, walkway or other elevated structure or aerial device unless the employer ensures that the support structure is first inspected by a competent person and it is determined to be adequately strong, in good working condition and properly secured in place.

8.7.2.7 Approach distances to exposed energized overhead power lines and parts

The employer shall ensure that no employee approaches or takes any conductive object closer to any electrically energized overhead power lines and parts than prescribed in Table 8-12, unless

1. The employee is insulated or guarded from the energized parts (insulating gloves rated for the voltage involved shall be considered adequate insulation).
2. The energized parts are insulated or guarded from the employee and any other conductive object at a different potential.

- The power conductors and equipment are de-energized and grounded.

Table 8-12: Approach Distances to Exposed Energized Overhead Power Lines and Parts

Voltage range (phase to phase, RMS)	Approach Distance	
	(Meters)	(inches)
300 V and less	0.025	1
Over 300V, not over 750V	0.305	12
Over 750V not over 2 kV	0.457	18
Over 2 kV, not over 15 kV	0.610	24
Over 15 kV, not over 37 kV	0.914	36
Over 37 kV, not over 87.5 kV	1.067	42
Over 87.5 kV, not over 121 kV	1.219	48
Over 121 kV, not over 140 kV	1.372	54

8.7.2.8 Illumination of field work

Whenever natural light is insufficient to adequately illuminate the worksite, artificial illumination shall be provided to enable the employee to perform the work safely.

8.7.3 Training

Employers shall provide training in the various precautions and safe practices described in this section and shall insure that employees do not engage in the activities to which this section applies until such employees have received proper training in the various precautions and safe practices required by this section. However, where the employer can demonstrate that an employee is already trained in the precautions and safe practices required by this section prior to his employment, training need not be provided to that employee in accordance with this section. Where training is required, it shall consist of on-the-job training or classroom-type training or a combination of both. The employer shall certify that employees have been trained by preparing a certification record which includes the identity of the person trained, the signature of the employer or the person who conducted the training, and the date the training was completed. The certification record shall be prepared at the completion of training and shall be maintained on file for the duration of the employee's employment. The certification record shall be made available upon request to the competent/concerned Authority. Such training shall, where appropriate, include the following subjects:

- Recognition and avoidance of dangers relating to encounters with harmful substances and animal, insect, or plant life.
- Procedures to be followed in emergency situations
- First aid training, including instruction in artificial respiration.

8.7.4 Employee protection in public work areas

- Before work is begun in the vicinity of vehicular or pedestrian traffic which may endanger employees, warning signs and/or flags or other traffic control devices shall be placed conspicuously to alert and channel approaching traffic. Where further protection is needed, barriers shall be utilized. At night, warning lights shall be prominently displayed, and excavated areas shall be enclosed with protective barricades.

2. If work exposes energized or moving parts that are normally protected, danger signs shall be displayed and barricades erected, as necessary, to warn other personnel in the area.
3. The employer shall insure that an employee finding any crossed or fallen wires which create or may create a hazardous situation at the work area:
 - a. Remains on guard or adopts other adequate means to warn other employees of the danger.
 - b. Has the proper authority notified at the earliest practical moment.

8.7.5 Tools and personal protective equipment—generally

Personal protective equipment, protective devices and special tools needed for the work of employees shall be provided and the employer shall ensure that they are used by employees. Before each day's use the employer shall ensure that these personal protective devices, tools, and equipment are carefully inspected by a competent person to ascertain that they are in good condition.

8.7.6 Rubber insulating equipment.

1. Rubber insulating equipment designed for the voltage levels to be encountered shall be provided and the employer shall ensure that they are used by employees as required by this section.
2. The employer is responsible for the periodic retesting of all insulating gloves, blankets, and other rubber insulating equipment. This retesting shall be electrical, visual and mechanical. Retesting intervals mentioned in Table 8-13 shall apply:

Table 8-13: Retesting interval of insulating gloves

Gloves, blankets, and other insulating equipment	Natural rubber	Synthetic rubber
	Months	
New	12	18
Re-issued	9	15

3. Gloves and blankets shall be marked to indicate compliance with the retest schedule, and shall be marked with the date the next test is due. Gloves found to be defective in the field or by the tests set forth in Rule 8.7.6-2 of this section shall be destroyed by cutting them open from the finger to the gauntlet.

8.7.7 Personal climbing equipment

8.7.7.1 General

1. Safety belts and straps shall be provided and the employer shall ensure their use when work is performed at positions more than 4 feet above ground, on poles, and on towers, except as provided in Rules 8.7.14-7 and 8.7.14-8 of this section.
2. The employer shall ensure that all safety belts and straps are inspected by a competent person prior to each day's use to determine that they are in safe working condition.

8.7.7.2 Telecommunication lineman's body belts, safety straps, and lanyards

1. General Requirements

- a. Hardware for lineman's body belts, safety straps, and lanyards shall be drop forged or pressed steel and shall have a corrosion resistant finish. Surfaces shall be smooth and free of sharp edges. Production samples of lineman's safety straps, body belts and lanyards shall be approved by a nationally recognized testing laboratory, as having been tested in accordance with and as meeting the requirements of this Rule.

- b. All buckles shall withstand a 2,000-pound tensile test with a maximum permanent deformation no greater than one sixty-fourth inch.
- c. D rings shall withstand a 5,000-pound tensile test without cracking or breaking.
- d. Snap hooks shall withstand a 5,000-pound tensile test, or shall withstand a 3,000-pound tensile test and a 180° bend test. Tensile failure is indicated by distortion of the snap hook sufficient to release the keeper; bend test failure is indicated by cracking of the snap hook.

2. Specific requirements

- a. All fabric used for safety straps shall be capable of withstanding an A.C. dielectric test of not less than 25,000 volts per foot "dry" for 3 minutes, without visible deterioration.
- b. All fabric and leather used shall be tested for leakage current. Fabric or leather may not be used if the leakage current exceeds 1 milli ampere when a potential of 3,000 volts is applied to the electrodes positioned 12 inches apart.
- c. In lieu of alternating current tests, equivalent direct current tests may be performed.
- d. The cushion part of the body belt shall:
 - i. Contain no exposed rivets on the inside. This provision does not apply to belts used by craftsmen not engaged in line work.
 - ii. Be at least three inches in width
 - iii. Be at least five thirty-seconds (5/32) inch thick, if made of leather
 - iv. Reserved
 - v. Suitable copper, steel, or equivalent liners shall be used around the bars of D rings to prevent wear between these members and the leather or fabric enclosing them.
 - vi. All stitching shall be done with a minimum 42-pound weight nylon or equivalent thread and shall be lock stitched. Stitching parallel to an edge may not be less than three-sixteenths (3/16) inch from the edge of the narrowest member caught by the thread. The use of cross stitching on leather is prohibited.
 - vii. The keepers of snap hooks shall have a spring tension that will not allow the keeper to begin to open when a weight of 2 1/2 pounds or less is applied, but the keepers shall begin to open when a weight of four pounds is applied. In making this determination, the weight shall be supported on the keeper against the end of the nose.
 - viii. Safety straps, lanyards, and body belts shall be tested in accordance with the following procedure:-
 - 1) Attach one end of the safety strap or lanyard to a rigid support, and the other end to a 250-pound canvas bag of sand.
 - 2) Allow the 250-pound canvas bag of sand to free fall 4 feet when testing safety straps and 6 feet when testing lanyards. In each case, the strap or lanyard shall stop the fall of the 250-pound bag.
 - 3) Failure of the strap or lanyard shall be indicated by any breakage or slippage sufficient to permit the bag to fall free from the strap or lanyard.
 - 4) Failure of the strap or lanyard shall be indicated by any breakage or slippage sufficient to permit the bag to fall free from the strap or lanyard.
 - 5) The entire "body belt assembly" shall be tested using on D ring. A safety strap or lanyard shall be used that is capable of passing the "impact loading test" described in Rule 8.7.7.2-2(d)(ii) of this section and attached as required in Rule 8.7.7.2-2(d)(i) of this section. The body belt shall be secured to the 250-pound bag of sand at a point which simulates the waist of a man and shall be dropped as stated in Rule 8.9.7.2-2(d)(ii)

of this section. Failure of the body belt shall be indicated by any breakage or slippage sufficient to permit the bag to fall free from the body belt.

3. Pole climbers

- a. Pole climbers may not be used if the gaffs are less than 1 1/4 inches in length as measured on the underside of the gaff. The gaffs of pole climbers shall be covered with safety caps when not being used for their intended use.
- b. The employer shall ensure that pole climbers are inspected by a competent person for the following conditions: Fractured or cracked gaffs or leg irons, loose or dull gaffs, broken straps or buckles. If any of these conditions exist, the defect shall be corrected before the climbers are used.
- c. Pole climbers shall be inspected as required in this Rule 8.7.7.2-3 before each day's use and a gaff cut-out test performed at least weekly when in use.
- d. Pole climbers may not be worn when:
 - i. Working in trees (specifically designed tree climbers shall be used for tree climbing),
 - ii. Working on ladders,
 - iii. Working in an aerial lift,
 - iv. Driving a vehicle, nor
 - v. Walking on rocky, hard, frozen, brushy or hilly terrain.

8.7.8 Ladders

1. The employer shall ensure that no employee nor any material or equipment may be supported or permitted to be supported on any portion of a ladder unless it is first determined, by inspections and checks conducted by a competent person that such ladder is adequately strong, in good condition, and properly secured in place.
2. The spacing between steps or rungs permanently installed on poles and towers shall be no more than 18 inches (36 inches on any one side). This requirement also applies to fixed ladders on towers, when towers are so equipped. Spacing between steps shall be uniform above the initial unstepped section, except where working, standing, or access steps are required. Fixed ladder rungs and step rungs for poles and towers shall have a minimum diameter of 5/8". Fixed ladder rungs shall have a minimum clear width of 12 inches. Steps for poles and towers shall have a minimum clear width of 4 1/2 inches. The spacing between detachable steps may not exceed 30 inches on any one side, and these steps shall be properly secured when in use.
3. Portable wood ladders intended for general use may not be painted but may be coated with a translucent nonconductive coating. Portable wood ladders may not be longitudinally reinforced with metal.
4. Portable wood ladders that are not being carried on vehicles and are not in active use shall be stored where they will not be exposed to the elements and where there is good ventilation
5. The rolling ladders used in telecommunications centers shall have a minimum inside width, between the side rails, of at least eight inches.
6. Climbing ladders or stairways on scaffolds used for access and egress shall be affixed or built into the scaffold by proper design and engineering, and shall be so located that their use will not disturb the stability of the scaffold. The rungs of the climbing device shall be equally spaced, but may not be less than 12 inches nominal nor more than 16 inches nominal apart.
7. Horizontal end rungs used for platform support may also be utilized as a climbing device if such rungs meet the spacing requirement of this Rule 8.7.8.6, and if there is sufficient clearance between the rung and the edge of the platform to afford an adequate handhold. If a portable ladder is affixed to the scaffold, it shall be securely attached and shall have rungs meeting the spacing requirements of this Rule 8.7.8.6. Clearance shall be provided in the

- back of the ladder of not less than 6 inches from center of rung to the nearest scaffold structural member.
8. When a ladder is supported by an aerial strand, and ladder hooks or other supports are not being used, the ladder shall be extended at least 2 feet above the strand and shall be secured to it (e.g. lashed or held by a safety strap around the strand and ladder side rail). When a ladder is supported by a pole, it shall be securely lashed to the pole unless the ladder is specifically designed to prevent movement when used in this application.
 9. The following requirements apply to metal manhole ladders.
 - a. Metal manhole ladders shall be free of structural defects and free of accident hazards such as sharp edges and burrs. The metal shall be protected against corrosion unless inherently corrosion-resistant.
 - b. These ladders may be designed with parallel side rails or with side rails varying uniformly in separation along the length (tapered), or with side rails flaring at the base to increase stability.
 - c. The spacing of rungs or steps shall be on 12-inch centers.
 - d. Connections between rungs or steps and side rails shall be constructed to insure rigidity as well as strength.
 - e. Rungs and steps shall be corrugated, knurled, dimpled, coated with skid-resistant material, or otherwise treated to minimize the possibility of slipping.
 - f. Ladder hardware shall meet the strength requirements of the ladder's component parts and shall be of a material that is protected against corrosion unless inherently corrosion-resistant. Metals shall be so selected as to avoid excessive galvanic action.

8.7.9 Other tools and personal protective equipment

8.7.9.1 Head protection

Head protection shall be provided whenever there is exposure to possible high voltage electrical contact, and the employer shall ensure that the head protection is used by employees.

8.7.9.2 Eye protection

Eye protection shall be provided and the employer shall ensure its use by employees here foreign objects may enter the eyes due to work operations such as but not limited to:

1. Drilling or chipping stone, brick or masonry, reeking concrete or pavement, etc. by hand tools (sledgehammer, etc.) or power tools such as pneumatic drills or hammers;
2. Working on or round high speed emery or other grinding wheels unprotected by guards;
3. Cutting or chipping terra cotta ducts, tile, etc.;
4. Working under motor vehicles requiring hammering;
5. Cleaning operations using compressed air, steam, or sand blast;
6. Acetylene welding or similar predations where sparks are thrown off;
7. Using powder actuated stud drivers;
8. Tree pruning or cutting underbrush;
9. Handling battery cells and solutions, such as taking battery readings with a hydrometer and thermometer;
10. Removing or rearranging strand or open wire; and
11. Performing lead sleeve wiping and while soldering.

8.7.9.3 Tent heaters

Flame-type heaters may not be used within ground tents or on platforms within aerial tents unless:

1. The tent covers are constructed of fire resistant materials.

2. Adequate ventilation is provided to maintain safe oxygen levels and avoid harmful buildup of combustion products and combustible gases.

8.7.9.4 Torches

Torches may be used on aerial splicing platforms or in buckets enclosed by tents provided the tent material is constructed of fire resistant material and the torch is turned off when not in actual use. Aerial tents shall be adequately ventilated while the torch is in operation.

8.7.9.5 Portable power equipment

Nominal 220V, or less, portable generators used for providing power at work locations do not require grounding if the output circuit is completely isolated from the frame of the unit.

8.7.9.6 Vehicle-mounted utility generators

Vehicle-mounted utility generators used for providing nominal 220V AC or less for powering portable tools and equipment need not be grounded to earth if all of the following conditions are met:

1. One side of the voltage source is solidly strapped to the metallic structure of the vehicle.
2. Grounding-type outlets are used, with a “grounding” conductor between the outlet grounding terminal and the side of the voltage source that is strapped to the vehicle;
3. All metallic encased tools and equipment that are powered from this system are equipped with three-wire cords and grounding-type attachment plugs, except as designated in Rule 8.7.9.7 of this section.

8.7.9.7 Portable lights, tools, and appliances

Portable lights, tools, and appliances having noncurrent-carrying external metal housing may be used with power equipment described in Rule 8.9.9.5 of this section without an equipment grounding conductor. When operated from commercial power such metal parts of these devices shall be grounded, unless these tools or appliances are protected by a system of double insulation, or its equivalent. Where such a system is employed, the equipment shall be distinctively marked to indicate double insulation.

8.7.9.8 Soldering devices

Rounding shall be omitted when using soldering irons, guns or wire-wrap tools on telecommunications circuits.

8.7.9.9 Lead work

The wiping of lead joints using melted solder, gas fueled torches, soldering irons or other appropriate heating devices, and the soldering of wires or other electrical connections do not constitute the welding, cutting and brazing. When operated from commercial power the metal housing of electric solder pots shall be grounded. Electric solder pots may be used with the power equipment described in Rule 8.9.9.5 of this section without a grounding conductor. The employer shall ensure that wiping gloves or cloths and eye protection are used in lead wiping operations. A drip pan to catch hot lead drippings shall also be provided and used.

8.7.10 Vehicle-mounted material handling devices and other mechanical equipment

8.7.10.1 General.

1. The employer shall ensure that visual inspections are made of the equipment by a competent person each day the equipment is to be used to ascertain that it is in good condition.
2. The employer shall ensure that tests shall be made at the beginning of each shift by a competent person to insure the vehicle brakes and operating systems are in proper working condition.

8.7.10.2 Scrapers, loaders, dozers, graders and tractors

1. All rubber-tired, self propelled scrapers, rubber-tired front end loaders, rubber-tired dozers, agricultural and industrial tractors, crawler tractors, crawler-type loaders, and motor graders, with or without attachments, that are used in telecommunications work shall have rollover protective structures.
2. Eye protection shall be provided and the employer shall ensure that it is used by employees when working in areas where flying material is generated.

8.7.10.3 Vehicle-mounted elevating and rotating work platforms

These devices shall not be operated with any conductive part of the equipment closer to exposed energized power lines than the clearances set forth in Table-8.12 of this section.

8.7.10.4 Derrick trucks and similar equipment.

1. This equipment shall not be operated with any conductive part of the equipment closer to exposed energized power lines than the clearances set forth in Table 8-12 of this section.
2. When derricks are used to handle poles near energized power conductors, these operations shall comply with the requirements contained in Rules 8.7.2.7 and 8.7.14.11 of this section.
3. Moving parts of equipment and machinery carried on or mounted on telecommunications line trucks shall be guarded. This may be done with barricades as specified in Rule 8.7.4.2 of this section.
4. Derricks and the operation of derricks shall comply with the following requirements:
 - a. Manufacturer's specifications, load ratings and instructions for derrick operation shall be strictly observed.
 - b. Rated load capacities and instructions related to derrick operation shall be conspicuously posted on a permanent weather-resistant plate or decal in a location on the derrick that is plainly visible to the derrick operator.
 - c. Prior to derrick operation the parking brake must be set and the stabilizers extended if the vehicle is so equipped. When the vehicle is situated on a grade, at least two wheels must be chocked on the downgrade side.
 - d. Only persons trained in the operation of the derrick shall be permitted to operate the derrick.
 - e. The employer shall ensure that the derrick and its associated equipment are inspected by a competent person at intervals set by the manufacturer but in no case less than once per year. Records shall be maintained including the dates of inspections, and necessary repairs made, if corrective action was required.
 - f. Modifications or additions to the derrick and its associated equipment that alter its capacity or affect its safe operation shall be made only with written certification from the manufacturer, or other equivalent entity, such as a nationally recognized testing laboratory, that the modification results in the equipment being safe for its

- intended use. Such changes shall require the changing and posting of revised capacity and instruction decals or plates. These new ratings or limitations shall be as provided by the manufacturer or other equivalent entity.
- g. Wire rope used with derricks shall be of improved plow steel or equivalent.
 - h. Wire rope shall be taken out of service, or the defective portion removed, when any of the following conditions exist:
 - i. The rope strength has been significantly reduced due to corrosion, pitting, or excessive heat.
 - ii. The thickness of the outer wires of the rope has been reduced to two-thirds or less of the original thickness.
 - iii. There are more than six broken wires in any one rope lay
 - iv. There is excessive permanent distortion caused by kinking, crushing, or severe twisting of the rope.

8.7.11 Materials handling and storage

8.7.11.1 Poles.

When working with poles in piles or stacks, work shall be performed from the ends of the poles as such as possible, and precautions shall be taken for the safety of employees at the other end of the pole. During pole hauling operations, all loads shall be secured to prevent displacement. Lights, reflectors and/or flags shall be displayed on the end and sides of the load as necessary. The requirements for installation, removal, or other handling of poles in pole lines are prescribed in Rule 8.7.14 of this section which pertains to overhead lines. In the case of hoisting machinery equipped with a positive stop load holding device, it shall be permissible for the operator to leave his position at the controls (while a load is suspended) for the sole purpose of assisting in positioning the load prior to landing it. Prior to unloading steel, poles, cross arms, and similar material, the load shall be thoroughly examined to ascertain that the load has not shifted, that binders or stakes have not broken, and that the load is not otherwise hazardous to employees.

8.7.11.2 Cable reels

Cable reels in storage shall be checked or otherwise restrained when there is a possibility that they might accidentally roll from position.

8.7.12 Cable fault locating and testing

1. Employees involved in using high voltages to locate trouble or test cables shall be instructed in the precautions necessary for their own safety and the safety of other employees.
2. Before the voltage is applied, cable conductors shall be isolated to the extent practicable. Employees shall be warned, by such techniques as briefing and tagging at all affected locations, to stay clear while the voltage is applied.

8.7.13 Grounding for employee protection—pole lines

8.7.13.1 Power conductors.

Electric power conductors and equipment shall be considered as energized unless the employee can visually determine that they are bonded to one of the grounds listed in Rules 8.7.13.4 & 8.7.13.5 of this section.

8.7.13.2 Nonworking open wire

Nonworking open wire telecommunications lines shall be bonded to one of the rounds listed in Rules 8.7.13.4 & 8.7.13.5 of this section.

8.7.13.3 Vertical power conduit, power ground wires and street light fixtures

1. Metal power conduit on joint use poles, exposed vertical power ground wires, and street light fixtures which are below telecommunications attachments or less than 20 inches above these attachments, shall be considered energized and shall be tested for voltage unless the employee can visually determine that they are bonded to the telecommunications suspension strand or cable sheath.
2. If no hazardous voltage is shown by the voltage test, a temporary bond shall be placed between such street light fixture, exposed vertical power grounding conductor, or metallic power conduit and the telecommunications cable strand. Temporary bonds used for this purpose shall have sufficient conductivity to carry at least 500 amperes for a period of one second without fusing.

8.7.13.4 Suitable protective grounding

Acceptable grounds for protective grounding are as follows:

A vertical ground wire which has been tested, found safe, and is connected to a power system multi grounded neutral or the grounded neutral of a power secondary system where there are at least three services connected;

8.7.13.5 Telecommunications cable sheath or shield and its supporting strand where the sheath/shield is

1. Bonded to an underground or buried cable which is connected to a central office ground,
2. Bonded to an underground metallic piping system, or
3. Bonded to a power system multi grounded neutral or grounded neutral of a power secondary system which has at least three services connected; Guys which are bonded to the grounds specified in Rules 8.9.13.4 and 8.9.13.5 of this section and which have continuity uninterrupted by an insulator; and
4. If all of the preceding grounds are not available, arrays of driven ground rods where the resultant resistance to ground will be low enough to eliminate danger to personnel or permit prompt operation of protective devices.

8.7.13.6 Attaching and removing temporary bonds

When attaching grounds (bonds), the first attachment shall be made to the protective ground. When removing bonds, the connection to the line or equipment shall be removed first. Insulating gloves shall be worn during these operations.

8.7.13.7 Temporary grounding of suspension strand

1. The suspension strand shall be grounded to the existing rounds listed in Rules 8.7.13.4 & 8.7.13.5 of this section when being placed on jointly used poles or during thunderstorm activity.
2. Where power crossings are encountered on non-joint lines, the strand shall be bonded to an existing ground listed in Rules 8.7.13.4 & 8.7.13.5 of this section as close as possible to the crossing. This bonding is not required where crossings are made on a common crossing pole unless there is an upward change in grade at the pole.
3. Where roller-type bonds are used, they shall be restrained so as to avoid stressing the electrical connections.
4. Bonds between the suspension strand and the existing ground shall be at least No. 6AWG copper.
5. Temporary bonds shall be left in place until the strand has been tensioned, dead-ended, and permanently grounded.
6. The requirements of Rules 8.7.13.7-1 through 8.9.13.7-5 of this section do not apply to the installation of insulated strand.

8.7.13.8 Antenna work-radio transmitting stations 3–30 MHZ

1. Prior to grounding a radio transmitting station antenna, the employer shall insure that the rigger in charge:
 - a. Prepares a danger tag signed with his signature,
 - b. Requests the transmitting technician to shut down the transmitter and to ground the antenna with its grounding switch,
 - c. Is notified by the transmitting technician that the transmitter has been shutdown
 - d. Tags the antenna ground switch personally in the presence of the transmitting technician after the antenna has been grounded by the transmitting technician.
2. Power shall not be applied to the antenna, nor shall the grounding switch be opened under any circumstances while the tag is affixed.
 - a. Where no grounding switches are provided, grounding sticks shall be used, one on each side of line, and tags shall be placed on the grounding sticks, antenna switch, or plate power switch in a conspicuous place.
 - b. When necessary to further reduce excessive radio frequency pickup, ground sticks or short circuits shall be placed directly on the transmission lines near the transmitter in addition to the regular grounding switches.
 - c. In other cases, the antenna lines may be disconnected from ground and the transmitter to reduce pickup at the point in the field.
3. All radio frequency line wires shall be tested for pickup with an insulated probe before they are handled either with bare hands or with metal tools.
4. The employer shall insure that the transmitting technician warn the riggers about adjacent lines which are, or may become energized.
5. The employer shall insure that when antenna work has been completed, the rigger in charge of the job returns to the transmitter, notifies the transmitting technician in charge that work has been completed, and personally removes the tag from the antenna ground switch.

8.7.14 Overhead lines

8.7.14.1 Handling suspension strand.

1. The employer shall insure that when handling cable suspension strand which is being installed on poles carrying exposed energized power conductors, employees shall wear insulating gloves and shall avoid body contact with the strand until after it has been tensioned, dead-ended and permanently grounded.
2. The strand shall be restrained against upward movement during installation:
 - a. On joint-use poles, where there is an upward change in grade at the pole, and
 - b. On non-joint-use poles, where the line crosses under energized power conductors.

8.7.14.2 Need for testing wood poles

Unless temporary guys or braces are attached, the following poles shall be tested in accordance with Rule (8.9.14-3) of this section and determined to be safe before employees are permitted to climb them:

1. Dead-end poles, except properly braced or guyed “Y” or “T” cable junction poles,
2. Straight line poles which are not storm guyed and where adjacent span lengths exceed 165 feet,
3. Poles at which there is a downward change in grade and which are not guyed or braced corner poles or cable junction poles
4. Poles which support only telephone drop wire
5. Poles which carry less than ten telecommunication line wires. On joint use poles, one power line wire shall be considered as two telecommunication wires for purposes of this Rule 8.7.14.2-5.

8.7.14.3 Methods for testing wood poles

One of the following methods or an equivalent method shall be used for testing wood poles:

1. Rap the pole sharply with a hammer weighing about 3 pounds, starting near the ground line and continuing upwards circumferentially around the pole to a height of approximately 6 feet. The hammer will produce a clear sound and rebound sharply when striking sound wood. Decay pockets will be indicated by a dull sound and/or a less pronounced hammer rebound. When decay pockets are indicated, the pole shall be considered unsafe. Also, prod the pole as near the ground line as possible using a pole prod or a screwdriver with a blade at least 5 inches long. If substantial decay is encountered, the pole shall be considered unsafe.
2. Apply a horizontal force to the pole and attempt to rock it back and forth in a direction perpendicular to the line. Caution shall be exercised to avoid causing power wires to swing together. The force may be applied either by pushing with a pike pole or pulling with a rope. If the pole cracks during the test, it shall be considered unsafe.

8.7.14.4 Unsafe poles or structures

Poles or structures determined to be unsafe by test or observation may not be climbed until made safe by guying, bracing or other adequate means. Poles determined to be unsafe to climb shall, until they are made safe, be tagged in a conspicuous place to alert and warn all employees of the unsafe condition.

8.7.14.5 Test requirements for cable suspension strand

1. Before attaching a splicing platform to a cable suspension strand, the strand shall be tested and determined to have strength sufficient to support the weight of the platform and the employee. Where the strand crosses above power wires or railroad tracks it may not be tested but shall be inspected in accordance with Rule 8.7.14.6 of this section.
2. The following method or an equivalent method shall be used for testing the strength of the strand:

A rope, at least three-eighths inch in diameter, shall be thrown over the strand. On joint lines, the rope shall be passed over the strand using tree pruner handles or a wire raising tool. If two employees are present, both shall grip the double rope and slowly transfer their entire weight to the rope and attempt to raise themselves off the ground. If only one employee is present, one end of the rope which has been passed over the strand shall be tied to the bumper of the truck, or other equally secure anchorage. The employee then shall grasp the other end of the rope and attempt to raise himself off the ground.

8.7.14.6 Inspection of strand

Where strand passes over electric power wires or railroad tracks, it shall be inspected from an elevated working position at each pole supporting the span in question. The strand may not be used to support any splicing platform, scaffold or cable car, if any of the following conditions exist:

1. Corrosion so that no galvanizing can be detected,
2. One or more wires of the strand are broken,
3. Worn spots, or
4. Burn marks such as those caused by contact with electric power wires.

8.7.14.7 Outside work platforms

Unless adequate railings are provided, safety straps and body belts shall be used while working on elevated work platforms such as aerial splicing platforms, pole platforms, ladder platforms and terminal balconies.

8.7.14.8 Other elevated locations

Safety straps and body belts shall be worn when working at elevated positions on poles, towers or similar structures, which do not have adequately guarded work areas.

8.7.14.9 Installing and removing wire and cable.

Before installing or removing wire or cable, the pole or structure shall be guyed, braced, or otherwise supported, as necessary, to prevent failure of the pole or structure.

8.7.14.10 Avoiding contact with energized power conductors or equipment.

When cranes, derricks, or other mechanized equipment are used for setting, moving, or removing poles, all necessary precautions shall be taken to avoid contact with energized power conductors or equipment.

8.7.14.11 Handling poles near energized power conductors.

1. Joint use poles may not be set, moved, or removed where the nominal voltage of open electrical power conductors exceeds 34.5kV phase to phase (20kV to ground).
2. Poles that are to be placed, moved or removed during heavy rains, sleet or wet snow in joint lines carrying more than 8.7kV phase to phase voltage (5kV to ground) shall be guarded or otherwise prevented from direct contact with overhead energized power conductors.
3. In joint lines where the power voltage is greater than 750 volts but less than 34.5kV phase to phase (20 kV to ground), wet poles being placed, moved or removed shall be insulated with either a rubber insulating blanket, a fiberglass box guide, or equivalent protective equipment.
 - a. In joint lines where the power voltage is greater than 8.7 kV phase to phase (5kV to ground) but less than 34.5kV phase to phase (20 kV to ground), dry poles being placed, moved, or removed shall be insulated with either a rubber insulating blanket, a fiberglass box guide, or equivalent protective equipment.
 - b. Where wet or dry poles are being removed, insulation of the pole is not required if the pole is cut off 2 feet or more below the lowest power wire and also cut off near the ground line.
4. Insulating gloves shall be worn when handling the pole with either hands or tools, when there exists a possibility that the pole may contact a power conductor.
5. The guard or insulating material used to protect the pole shall meet the appropriate 3 minute proof test voltage requirements.
6. When there exists a possibility of contact between the pole or the vehicle-mounted equipment used to handle the pole, and an energized power conductor, the following precautions shall be observed:
 - a. When on the vehicle which carries the derrick, avoid all contact with the ground, with persons standing on the ground, and with all grounded objects such as guys, tree limbs, or metal sign posts. To the extent feasible, remain on the vehicle as long as the possibility of contact exists.
 - b. When it is necessary to leave the vehicle, step onto an insulating blanket and break all contact with the vehicle before stepping off the blanket and onto the ground. As a last resort, if a blanket is not available, the employee may jump cleanly from the vehicle.
 - c. When it is necessary to enter the vehicle, first step onto an insulating blanket and break all contact with the ground, grounded objects and other persons before touching the truck or derrick.

8.7.14.12 Working position on poles

Climbing and working are prohibited above the level of the lowest electric power conductor on the pole (exclusive of vertical runs and street light wiring), except:

1. Where telecommunications facilities are attached above the electric power conductors, and a rigid fixed barrier is installed between the electric power facility and the telecommunications facility, or
2. Where the electric power conductors are cabled secondary service drops carrying less than 300 volts to ground and are attached 40 inches or more below the telecommunications conductors or cables.

8.7.14.13 Metal tapes and ropes.

1. Metal measuring tapes, metal measuring ropes, or tapes containing conductive strands may not be used when working near exposed energized parts.
2. Where it is necessary to measure clearances from energized parts, only nonconductive devices shall be used.

8.7.15 Underground lines

The provisions of this Rule apply to the guarding of manholes and street openings, and to the ventilation and testing for gas in manholes and unvented vaults, where telecommunications field work is performed on or with underground lines.

8.7.15.1 Guarding manholes and street openings.

1. When covers of manholes or vaults are removed, the opening shall be promptly guarded by a railing, temporary cover, or other suitable temporary barrier which is appropriate to prevent an accidental fall through the opening and to protect employees working in the manhole from foreign objects entering the manhole.
2. While work is being performed in the manhole, a person with basic first aid training shall be immediately available to render assistance if there is cause for believing that a safety hazard exists, and if the requirements contained in Rules 8.7.4.1 and 8.7.15.1-1 of this section do not adequately protect the employee(s). Examples of manhole worksite hazards which shall be considered to constitute a safety hazard include, but are not limited to:
 - a. Manhole worksites where safety hazards are created by traffic patterns that cannot be corrected by provisions of Rule 8.7.4.1 of this section.
 - b. Manhole worksites that are subject to unusual water hazards that cannot be abated by conventional means.
 - c. Manhole worksites that are occupied jointly with power utilities as described in Rule 8.7.15.3 of this section.

8.7.15.2 Requirements prior to entering manholes and unvented vaults

1. Before an employee enters a manhole, the following steps shall be taken:
 - a. The internal atmosphere shall be tested for combustible gas and, except when continuous forced ventilation is provided, the atmosphere shall also be tested for oxygen deficiency.
 - b. When unsafe conditions are detected by testing or other means, the work area shall be ventilated and otherwise made safe before entry.
2. An adequate continuous supply of air shall be provided while work is performed in manholes under any of the following conditions:
 - a. Where combustible or explosive gas vapors have been initially detected and subsequently reduced to a safe level by ventilation,
 - b. Where organic solvents are used in the work procedure,
 - c. Where open flame torches are used in the work procedure,

- d. Where the manhole is located in that portion of a public right of way open to vehicular traffic and/or exposed to a seepage of gas or gases, or
 - e. Where a toxic gas or oxygen deficiency is found.
3. The requirements of Rules 8.7.15.2-1 and 8.7.15.2-2 of this section do not apply to work in central office cable vaults that are adequately ventilated. The requirements of Rules 8.7.15.2-1 and 8.7.15.2-2 of this section apply to work in unvented vaults.

8.7.15.3 Joint power and telecommunication manholes

While work is being performed in a manhole occupied jointly by an electric utility and a telecommunication utility, an employee with basic first aid training shall be available in the immediate vicinity to render emergency assistance as may be required. The employee whose presence is required in the immediate vicinity for the purposes of rendering emergency assistance is not to be precluded from occasionally entering a manhole to provide assistance other than in an emergency. The requirement of this Rule 8.7.15.3 does not preclude a qualified employee, working alone, from entering for brief periods of time, a manhole where energized cables or equipment are in service, for the purpose of inspection, housekeeping, taking readings, or similar work if such work can be performed safely.

1. **Ladders.** Ladders shall be used to enter and exit manholes exceeding 4 feet in depth.
2. **Flames.** When open flames are used in manholes, the following precautions shall be taken to protect against the accumulation of combustible gas:
 - a. A test for combustible gas shall be made immediately before using the open flame device, and at least once per hour while using the device; and
 - b. A fuel tank (e.g., acetylene) may not be in the manhole unless in actual use.

8.7.16 Microwave Transmission

8.7.16.1 Eye protection

Employers shall insure that employees do not look into an open waveguide which is connected to an energized source of microwave radiation.

8.7.16.2 Hazardous area

Accessible areas associated with microwave telecommunication systems where the electromagnetic radiation level exceeds the radiation protection given in 8.6 shall be posted as described in that section. The lower half of the warning symbol shall include the following: Radiation in this area may exceed hazard limitations and special precautions are required. Obtain specific instruction before entering.

8.7.16.3 Protective measures

When an employee works in an area where the electromagnetic radiation exceeds the radiation protection guide, the employer shall institute measures that insure that the employee's exposure is not greater than that permitted by the radiation guide. Such measures shall include, but not be limited to those of an administrative or engineering nature or those involving personal protective equipment.

8.7.17 Tree Trimming—electrical hazards

8.7.17.1 General

1. Employees engaged in pruning, trimming, removing, or clearing trees from lines shall be required to consider all overhead and underground electrical power conductors to be energized with potentially fatal voltages, never to be touched (contacted) either directly or indirectly.

2. Employees engaged in line-clearing operations shall be instructed that:
 - a. A direct contact is made when any part of the body touches or contacts an energized conductor, or other energized electrical fixture or apparatus.
 - b. An indirect contact is made when any part of the body touches any object in contact with an energized electrical conductor, or other energized fixture or apparatus.
 - c. An indirect contact can be made through conductive tools, tree branches, trucks, equipment, or other objects, or as a result of telecommunications wires, cables, fences, or guy wires being accidentally energized.
 - d. Electric shock will occur when an employee, by either direct or indirect contact with an energized conductor, energized tree limb, tool, equipment, or other object, provides a path for the flow of electricity to a grounded object or to the ground itself. Simultaneous contact with two energized conductors will also cause electric shock which may result in serious or fatal injury.
3. Before any work is performed in proximity to energized conductors, the system operator/owner of the energized conductors shall be contacted to ascertain if he knows of any hazards associated with the conductors which may not be readily apparent. This rule does not apply when operations are performed by or on behalf of, the system operator/owner.

8.7.17.2 Working in proximity to electrical hazards

1. Employers shall ensure that a close inspection is made by the employee and by the foremen or supervisor in charge before climbing, entering, or working around any tree, to determine whether an electrical power conductor passes through the tree, or passes within reaching distance of an employee working in the tree. If any of these conditions exist either directly or indirectly, an electrical hazard shall be considered to exist unless the system operator/owner has caused the hazard to be removed by de-energizing the lines, or installing protective equipment.
2. Only qualified employees or trainees, familiar with the special techniques and hazards involved in line clearance, shall be permitted to perform the work if it is found that an electrical hazard exists.
3. During all tree working operations aloft where an electrical hazard of more than 750V exists, there shall be a second employee or trainee qualified in line clearance tree trimming within normal voice telecommunication.
4. Where tree work is performed by employees qualified in line-clearance tree trimming and trainees qualified in line-clearance tree trimming, the clearances from energized conductors given in Table 8-14 shall apply.

Table 8-14: Minimum working distances from energized conductors for line-clearance tree trimmers and line-clearance tree-trimmer trainees

Voltage range (phase to phase) (kilovolts)	Minimum working distance	
	(m)	(ft)
2.1 to 11.0	0.61	2 ft. 0 in.
11.0 to 35.0	0.71	2 ft. 4 in.
35.1 to 46.0	0.76	2 ft. 6 in.
46.1 to 72.5	0.91	3 ft. 0 in.
72.6 to 121.0	1.02	3 ft. 4 in.
121.0 to 145.0	1.07	3 ft. 6 in.
161.0 to 169.0	1.12	3 ft. 8 in.
220.0 to 242.0	1.52	5 ft. 0 in.
345.0 to 362.0	2.13	7 ft. 0 in.
500.0 to 552.0	3.35	11 ft. 0 in.

700.0 to 765.0	4.57	15 ft. 0 in.
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5. Branches hanging on an energized conductor may only be removed using appropriately insulated equipment.
6. Rubber footwear, including lineman's overshoes, shall not be considered as providing any measure of safety from electrical hazards.
7. Ladders, platforms, and aerial devices, including insulated aerial devices, may not be brought in contact with an electrical conductor. Reliance shall not be placed on their dielectric capabilities.
8. When an aerial lift device contacts an electrical conductor, the truck supporting the aerial lift device shall be considered as energized.

8.7.17.3 Storm work and emergency conditions

1. Since storm work and emergency conditions create special hazards, only authorized representatives of the electric utility system operator/ owner and not telecommunication workers may perform tree work in these situations where energized electrical power conductors are involved.
2. When an emergency condition develops due to tree operations, work shall be suspended and the system operator/owner shall be notified immediately.

8.8 Clearance

For clearance safety rules between telecommunication facilities and electric supply lines, refer to Rule 6.4 of this Code.

SECTION 9

SAFETY RULES FOR WORK ENVIRONMENT

9.1 Purpose and Scope

9.1.1 Purpose

The purpose of this section is to provide practical work rules as one of the means of safeguarding employees and the public from injury. It is not the intent of these rules to require unreasonable steps to comply; however, all reasonable steps shall be taken.

9.1.2 Scope

This Section covers work rules to be followed in the installation, operation and maintenance of electric supply and telecommunication systems.

9.1.3 Referenced Section

The Introduction (Section 1), Definitions (Section 2), Grounding methods (Section 4), Substations (Section 5), Overhead Lines (Section 6), Underground Lines (Section 7), Telecommunication Facilities (Section 8) and Appendix-A (bibliography), shall apply to the requirements of this section.

9.2 Safety accountability and responsibility

9.2.1 Responsibility of the Employer (CEO, MD or equivalent)

- a. Shall be responsible to ensure compliance with the PETSAC-2014 and all relevant safety laws or regulations of the land
- b. Provide a safe working environment/conditions as outlined in this code for each employee/individual working in his organization
- c. Establish a dedicated safety department/section appropriate in size to activities of the organization/company for implementing and maintaining the PETSAC-2014.
- d. Adopt a systemic approach for safety management by outlining safety policy , safety goals and objectives for the organization/company and ensuring provision of resources to achieve these
- e. Encouraging employees to reduce the number of occupational safety and health hazards at their places of duty
- f. Acquire, maintain, and mandate use of safety equipment, personal protective equipment, and devices reasonably necessary to protect employees
- g. Maintain records of all accidents and illnesses within the scope of PETSAC for proper evaluation and necessary corrective action
- h. Monitor safety performance and record Safety Performance of the organization/company
- i. Maintain and provide safety data to authorities as mandated by regulations, acts and laws

- j. Defines rules and responsibilities of managers and supervisors
- k. The employer shall ensure that an assessment is performed to determine potential exposure to an electric arc for employees who work on or near energized lines, parts, or equipment.

If the assessment determines potential employee exposure, clothing made from acetate, nylon, polyester, or polypropylene shall not be worn, unless arc rated.

If the assessment determines a potential employee exposure greater than 2 cal/cm² exists (see Neal, Bingham, and Doughty), the employer shall:

- a. Perform a detailed arc hazard analysis to determine the effective arc rating of clothing or a clothing system to be worn by employees working on or near energized lines, parts, or equipment at voltages 50 V to 800 000 V.
The arc hazard analysis shall include a calculation of the estimated arc energy based on the available fault current, the duration of the arc (cycles), and the distance from the arc to the employee.
- b. Require employees to wear clothing or a clothing system with an effective arc rating not less than the anticipated level of arc energy.

EXCEPTION: If the clothing or clothing system required by this rule has the potential to create additional or greater hazards than the possible exposure to the heat energy of the electric arc, then clothing or a clothing system with an effective arc rating less than that required by this rule may be worn.

NOTE 1: Assessments performed to determine potential exposure to an electric arc consider the affected employee's assigned tasks and/or work activities.

NOTE 2: A clothing system (multiple layers) that includes an outer layer of flame resistant material and an inner layer of non-flame resistant natural fiber material has been shown to block more heat than a single layer. The effect of the combination of these multiple layers may be referred to as the effective arc rating (e.g., EBT, ATPV).

NOTE 3: Engineering controls can be utilized to reduce arc energy levels and work practices can be utilized to reduce exposure levels.

9.2.2 Responsibility of managers and supervisors

Managers/Supervisors ensure that:-

- a. Employees and/or contractors engaged to do electrical work should have appropriate knowledge of safety rules and procedures to carry out the task and Supervisors are competent to supervise the work
- b. The safety procedures/instructions are documented and all concerned aware of them.
- c. Clearly define the roles and responsibilities of the persons under them including those of any contractors who may be employed.
- d. Workers are aware of limitations of their work allowed under the safety rules. Those carrying out complex work shall be instructed to carry the safety procedures/instructions with them.
- e. All workers follow the safety rules and control measures identified in risk assessments

9.2.3 Responsibility of the employee/Individual

Each employee is required to:-

- a. comply with safety standards, rules, regulations, instructions and orders issued pursuant to this code which are applicable to his/her own actions and conduct namely:
 - (a) Personal safety
 - (b) Fellow employee's safety
 - (c) Protection to the public
 - (d) Protection to department property.
- b. Be fully informed of the contents of the Safety Code and amendments therein from time to time, and apply it to his/her work.
- c. Report any unsafe conditions to the immediate supervisor before attempting any work, if the immediate supervisor is unavailable for any reason, report any unsafe conditions to the next higher level of management.

9.3 General

9.3.1 Safety organization

Every electrical and telecom entity shall have a dedicated safety department appropriate in size to its activities:

- a. Organization comprising of one (1) to twenty-five (25) persons – minimum one (1) manager safety who may be doing another job in addition to managing safety
- b. Organization comprising of more than twenty-five (25) up to hundred (100) persons – minimum one dedicated safety manager supported by adequate staff
- c. Organization comprising of more than hundred (100) persons – a dedicated safety department appropriate to the nature and activities of the entity.

9.3.2 Safety framework

Each organization shall have a written safety framework. The framework shall be specific to the safety requirements of the organization, and shall:

- a. Include commitment to safety by the employer
- b. Be widely circulated and communicated to all employees
- c. Must be reviewed from time to time
- d. Signed off by the employer/accountable manager

9.3.3 Safety risk management

Organizations shall have a safety risk management program appropriate to the nature of their activities, capable of identifying hazards before they turn into accidents. The program shall comprise of at least following considerations:

- a. Hazard identification

- b. Risk assessment
- c. Risk mitigation

9.3.4 Safety assurance

Organization shall have a safety assurance program, capable of providing safety oversight of its activities. The program shall have following accountabilities:

- a. Safety performance monitoring and measurement
- b. Management of change
- c. Continual improvement

9.3.5 Safety promotion

Organization shall have a safety promotion program, capable of identifying its safety training needs, providing training to its employees and maintaining two way channel of telecommunication including feedback. The program shall comprise of:

- a. Safety Management System Planning
- b. Education and Training
- c. Safety telecommunication.

9.3.6 Personal Protective Equipment

It is the responsibility of the employer to provide Personal Protective Equipment (PPE) / Special Protective Equipment (SPE) to each employee/gang (as the case may be) which is appropriate to the nature of job. The PPE/SPE shall be inspected from time to time to ascertain its condition and serviceability. Employees shall be trained in the use of PPE/SPE.

9.4 Accident Reporting and Investigating

All accidents must be thoroughly investigated by qualified accident investigators. The purpose of investigation should not be to apportion blame but the intent should be to find out the “root cause” of the accident and suggest appropriate corrective and preventive measures to avoid recurrence

- a. It is the responsibility of the accountable manager/employer to ensure a system for accident/incident reporting, investigating and analysis.
- b. In addition, the concerned utility shall report all fatal, non-fatal and other major accidents to the relevant regulator within defined timeline and prescribed format.
- c. The regulator shall provide a comprehensive outcome of reported cases to PEC Working Group to analyze for future refinement in this Code.

9.4.1 Fatal/Non-Fatal Accidents

- a. In cases where the Fatal/Near-fatal accident results or is likely to have resulted in loss of life or grievous injury, an immediate inquiry shall be made to investigate if similar hazardous conditions exist in other areas, if found so, work shall be stopped before hazard is mitigated.
- b. In case of fatal accidents to persons, an immediate report shall be made as per prescribed manner.

9.4.2 Hazards and Hazard Reporting

In order to prevent accidents from happening:

- a. Each organization shall have a system for hazard reporting. This system will have provision for internal hazard reporting for own employees as well as external reporting for all those who are affected by the organizations activities.
- b. The system shall also ensure that reported hazards are timely and effectively addressed.
- c. In case where a hazard cannot be removed or corrected immediately, adequate safety precautions shall be taken for the interim period.

9.4.3 Public Safety

Every reasonable effort shall be made to protect public from hazards arising out of the activities of the organization, especially:

- a. When work is in progress on public places by the use of signs, barricades or personal warning.
- b. When work is conducted along public streets or high-ways, pedestrian and vehicular traffic shall be warned in compliance with applicable standards.
- c. Where necessary, open manholes, ditches and excavations shall be barricaded or be substantially covered to prevent pedestrians, animals or vehicles from falling into them.
- d. During the night, dark locations or conditions of low visibility warning lights and/or barricades shall be placed at obstructions, excavation or opening which are likely to cause injury to employees or to the public.
- e. When working on customers' premises or public property, every effort shall be made to avoid hazards to customers or public and their property. Excess material and scrap shall be removed when the job is completed.
- d. In case where a hazard cannot be removed or corrected immediately, adequate safety precautions shall be taken for the interim period.

9.4.4 Qualifications of employees

- a. Employees whose duties require working on or in the vicinity of energized equipment or lines shall perform only those tasks for which they are trained, equipped, authorized, and so directed.
Inexperienced employees shall: (a) work under the direction of an experienced and qualified person at the site, and (b) perform only directed tasks.
- b. Employees operating mechanized equipment shall be qualified to perform those tasks.
- c. If an employee is in doubt as to the safe performance of any assigned work, the employee shall request instructions from the employee's supervisor or person in charge.
- d. Employees who do not normally work on or in the vicinity of electric supply lines and equipment but whose work brings them into these areas for certain tasks shall proceed with this work only when authorized by a qualified person.
- e. In case where a hazard cannot be removed or corrected immediately, adequate safety

precautions shall be taken for the interim period.

9.4.5 Safeguarding oneself and others

1. Employees shall heed safety signs and signals and warn others who are in danger or in the vicinity of energized equipment or lines.
2. Employees shall report promptly to the proper authority any of the following:
 - a. Line or equipment defects such as abnormally sagging wires, broken insulators, broken poles, or lamp supports
 - b. Accidentally energized objects such as conduits, light fixtures, or guys
 - c. Other defects that may cause a dangerous condition
3. Employees whose duties do not require them to approach or handle electric equipment and lines shall keep away from such equipment or lines and should avoid working in areas where objects and materials may be dropped by persons working overhead.
4. Employees who work on or in the vicinity of energized lines shall consider all of the effects of their actions, taking into account their own safety as well as the safety of other employees on the job site, or on some other part of the affected electric system, the property of others, and the public in general.
5. No employee shall approach or bring any conductive object, without a suitable insulating handle, closer to any exposed energized part than allowed by Rule 9.8.2 or Rule 9.9.2, as applicable.

Note: Employees should exercise care when extending metal ropes, tapes, or wires parallel to and in the proximity of energized high-voltage lines because of induced voltages. When it is necessary to measure clearances from energized objects, only devices approved for the purpose shall be used. In case where a hazard cannot be removed or corrected immediately, adequate safety precautions shall be taken for the interim period.

9.4.6 Energized or unknown conditions

Employees shall consider electric supply equipment and lines to be energized, unless they are positively known to be de-energized. Before starting work, employees shall perform preliminary inspections or tests to determine existing conditions. Operating voltages of equipment and lines should be known before working on or in the vicinity of energized parts.

9.4.7 Ungrounded metal parts

Employees shall consider all ungrounded metal parts of equipment or devices such as transformer cases and circuit breaker housings, to be energized at the highest voltage to which they are exposed, unless these parts are known by test to be free from such voltage.

9.4.8 Arcing conditions

Employees should keep all parts of their bodies as far away as practical from switches, brushes, commutators, circuit breakers, or other parts at which arcing may occur during operation or handling.

9.4.9 Liquid-cell batteries

1. Employees shall ascertain that battery areas are adequately ventilated before performing work.
2. Employees should avoid smoking, using open flames, or using tools that may produce sparks in the vicinity of liquid-cell batteries.
3. Employees shall use eye and skin protection when handling an electrolyte.

4. Employees shall not handle energized parts of batteries unless necessary precautions are taken to avoid short circuits and electrical shocks.

9.4.10 Tools and protective equipment

Employees shall use the personal protective equipment, the protective devices, and the special tools provided for their work. Before starting work, these devices and tools shall be carefully inspected to make sure that they are in good condition.

a. Clothing

1. Employees shall wear clothing suitable for the assigned task and the work environment.
2. When employees will be exposed to an electric arc, clothing or a clothing system shall be worn in accordance with Rule 9.2.1-k.
3. When working in the vicinity of energized lines or equipment, employees should avoid wearing exposed metal articles

b. Ladders and supports

1. Employees shall not support themselves, or any material or equipment, on any portion of a tree, pole structure, scaffold, ladder, walkway, or other elevated structure or aerial device, etc., without it first being determined, to the extent practical, that such support is adequately strong, in good condition, and properly secured in place
2. Portable wood ladders intended for general use shall not be painted except with a clear non-conductive coating, nor shall they be longitudinally reinforced with metal.
3. Portable metal ladders intended for general use shall not be used when working on or in the vicinity of energized parts.
4. If portable ladders are made partially or entirely conductive for specialized work, necessary precautions shall be taken to ensure that their use will be restricted to the work for which they are intended.

c. Fall protection

1. At elevated locations above 3 m (10 ft), climbers shall be attached to equipment or structures by a fall protection system while at the worksite, at a rest site, in aerial devices, helicopters, cable carts, and a boatswain's chair.
2. Qualified climbers may be permitted to be unattached to equipment or structures while climbing, transferring, or transitioning across obstacles on structures. Unqualified climbers shall be attached while performing these activities.
3. Fall protection equipment shall be inspected before use by the employee to ensure that the equipment is in safe working condition.
4. Fall arrest equipment shall be attached to a suitable anchorage.
5. The employee shall determine that all components of the fall protection system are properly engaged and that the employee is secure in the line-worker's body belt, harness, or any other fall protection system.

NOTE: Climbers need to be aware of accidental disengagement of fall protection components. Accidental disengagement is the sudden, unexpected release of a positioning strap snap hook from the D-ring of the line-worker's body belt without the user directly manipulating the latch of the snap hook. In general, there are two primary reasons for this occurrence.

- (i) Foreign objects may open the latch of the snap hook during normal use. It is possible for the snap hook to come in contact with such things as hand lines, guy wires, or other apparatus. These items may place pressure on the latch, causing the snap hook to separate from the D-ring without the user's knowledge. This could cause an accident. The worker must take care to keep the snap hooks away from any potential causes of

release. Locking snaphooks reduce the possibility of this occurrence.

- (ii) Roll-out is the sudden separation of the snaphook/D-ring combination when the snaphook is twisted in the D-ring, but the user does not deliberately open the latch. This occurs when a twist is introduced into a positioning strap with a snaphook/D-ring combination that is incompatible. However, compatible hardware, when properly maintained, will not separate in this fashion.
- 6. Snaphooks shall be dimensionally compatible with the member to which they are connected so as to prevent unintentional disengagement of the connection.

NOTE: The possibility exists for some snaphooks to roll out of D-rings. Attachment of a mismatched or multiple snap hooks to a single D-ring should be avoided. Multiple locking snaphooks may be attached to a single D-ring if they have been evaluated in the combination to be used. Locking snaphooks reduce the potential for roll-out.

- (i) Disengagement through contact of the snaphook keeper with the connected member may be prevented by the use of a locking snaphook.
- (ii) Hardware compatibility can be verified. Simply attach the snaphook to the D-ring, then roll the snaphook placing the latch towards the body of the D-ring. This is similar to the action that occurs when the strap is twisted. If the rivet falls beyond the edge of the inside of the D-ring, placing pressure on the latch, the hardware is not compatible, and a roll-out potential exists.
- (iii) Other factors may increase the potential for accidental disengagement even if the hardware is compatible (e.g., foreign objects carried on the D-rings, condition of the snaphook, the shape of the D-ring).
- 7. Snaphooks shall not be connected to each other.
- 8. One hundred percent leather positioning straps or non-locking snaphooks shall not be used.
- 9. Wire rope lanyards shall be used in operations where the lanyard is subject to being cut. Wire rope lanyards shall not be used in the vicinity of energized lines or equipment.

d. Fire extinguishers

In fighting fires or in the vicinity of exposed energized parts of electric supply systems, employees shall use fire extinguishers or materials that are suitable for the purpose. If this is not possible, all adjacent and affected equipment should first be de-energized.

e. Machines or moving parts

Employees working on normally moving parts of remotely controlled equipment shall be protected against accidental starting by proper tags installed on the starting devices, or by locking or blocking where practical. Employees shall, before starting any work, satisfy themselves that these protective devices have been installed. When working or in the vicinity of automatically or remotely operated equipment such as circuit breakers that may operate suddenly, employees shall avoid being in a position where they might be injured from such operation.

f. Fuses

When fuses must be installed or removed with one or both terminals energized, employees shall use special tools or gloves insulated for the voltage involved. When installing expulsion-type fuses, employees shall wear personal eye protection and take precautions to stand clear of the exhaust path of the fuse barrel.

g. Cable reels

Cable reels shall be securely blocked so they cannot roll or rotate accidentally.

h. Street and area lighting

1. The lowering rope or chain, its supports, and fastenings shall be examined periodically.
2. A suitable device shall be provided by which each lamp on series-lighting circuits of more than 300 V may be safely disconnected from the circuit before the lamp is handled.

EXCEPTION: This rule does not apply where the lamps are always worked on from suitable insulated platforms or aerial lift devices, or handled with suitable insulated tools, and treated as under full voltage of the circuit concerned.

i. Telecommunication antennas

When working in the vicinity of telecommunication antennas operating in the range up to 300 GHz, workers shall not be exposed to radiation levels that exceed those set forth by the regulatory authority having jurisdiction.

9.5 Rigging & Hoisting

- a. Chain hoists, derricks, cranes and other hoisting equipment shall be inspected at regular intervals. It will be operated by persons who are qualified and competent to operate it and posses a valid permit to operate it.
- b. Any hoisting equipment found defective shall be immediately tagged as unsafe and not used until repaired.
- c. Before the load is lifted, a strain should be taken on the cable and the hitch and slings rechecked for security.
- d. When there is a danger of the load being suddenly released the hooks shall be snubbed with wire or shackles.
- e. Before operating crane, derrick or other hoisting equipment, the operator shall sound warning and accept only one person's signal to start raising, lowering or swinging load however, the operator shall stop immediately upon signal from any one.
- f. Before moving a loaded or unloaded crane in close proximity to overhead electric lines, the boom or load shall be lowered sufficiently to provide the following clearance:

Below 50 kV	1.25 m
50 kV-230 kV	3 m
Above 230 kV	5 m
- g. When making heavy lifts, Outriggers shall be used to prevent overturning. The outrigger shall rest on a secure and firm surface.
- h. Extreme caution shall be used when working near cables or ropes under tension. Never place oneself within the angle formed by ropes or cables under tension.
- i. Employees shall familiarize themselves with the proper knots, ties and hitches, safe working loads for ropes, cables, slings and fittings and proper methods of hooking and slinging required in their work.
- j. Particular care shall be exercised to see that cables, chains, and other hoisting equipment are not unduly stressed by improper use.

- k. Chains shall not be spliced or joined by make shift means such as open links, bolts, or wire. New links shall be inserted by some competent person.
- l. Wire ropes or cables should not be allowed to kink as this weakens their basic strength .
- m. When applying U-bolt clips to cables, the proper number and spacing shall be used and the base shall bear on the pulling side of the loop.
- n. The rating of hooks, rings, clevises and other fittings used on chains or cables shall exceed the carrying capacity of the chain or cable.
- o. Fiber rope shall be properly cared for to retain its strength and lasting quality by use of the following precautions:
 - 1. Where a rope sling passes over sharp edges, pads shall be used to protect the fibers against cutting and undue stress.
 - 2. Do not use too small a pulley or a pulley with rough surfaces or broken edges.
 - 3. Do not let rope slip on winch drum of a mechanically or hydraulic driven winch or lie idle on moving drum unnecessarily.
 - 4. Do not place kinked rope under stress.
 - 5. Do not allow rope to unravel; finish the ends.
 - 6. Do not tie knots where splices should be used,
 - 7. Do not allow ropes to become oil-soaked or exposed to acid, corrosive substances, remain dirty and exposed to extremes of weather
- p. Synthetic Web Slings:
 - 1. Protect slings from sharp edges.
 - 2. Do not allow slings to become oil soaked or exposed to acid or corrosive substances.
 - 3. Do not allow slings to remain exposed to weather and Sunlight any longer than necessary.
 - 4. The safe working load as marked on each sling shall not be exceeded.
 - 5. Check sling before use for cuts, burns and scrapes and replace if defective.

9.6 Overhead line operating procedures

Employees working on or with overhead lines shall observe the following rules in addition to applicable rules contained elsewhere in Rules 9.8 to 9.9.

- a. Setting, moving, or removing poles in or near energized electric supply lines
 - 1. When setting, moving, or removing poles in or in the vicinity of energized lines, precautions shall be taken to avoid direct contact of the pole with the energized conductors. Employees shall wear suitable insulating gloves or use other suitable means where voltages may exceed rating of gloves in handling poles where conductors energized at potentials above 750 V can be contacted. Employees performing such work shall not contact the pole with un-insulated parts of their bodies.
 - 2. Contact with trucks, or other equipment that is not being used to set, move, or remove

poles in or in the vicinity of energized lines shall be avoided by employees standing on the ground or in contact with grounded objects unless employees are wearing suitable protective equipment.

- b. Checking structures before climbing
 1. Before climbing poles, ladders, scaffolds, or other elevated structures, employees shall determine, to the extent practical, that the structures are capable of sustaining the additional or unbalanced stresses to which they will be subjected.
 2. Where there are indications that poles and structures may be unsafe for climbing, they shall not be climbed until made safe by guying, bracing, or other means.
- c. Installing and removing wires or cables
 1. Precautions shall be taken to prevent wires or cables that are being installed or removed from contacting energized wires or equipment. Wires or cables that are not bonded to an effective ground and which are being installed or removed in the vicinity of energized conductors shall be considered as being energized.
 2. Sag of wire or cables being installed or removed shall be controlled to prevent danger to pedestrian and vehicular traffic.
 3. Before installing or removing wires or cables, the strains to which poles and structures will be subjected shall be considered and necessary action taken to prevent failure of supporting structures.
 4. Employees should avoid contact with moving winch lines, especially in the vicinity of sheaves, blocks, and take-up drums.
 5. Employees working on or in the vicinity of equipment or lines exposed to voltages higher than those guarded against by the safety appliances provided shall take steps to be assured that the equipment or lines on which the employees are working are free from dangerous leakage or induction or have been effectively grounded.

9.7 Underground line operating procedures

Employees working on or with underground lines shall observe the following rules in addition to applicable rules contained elsewhere in Rules 9.8 to 9.9.

- a. Guarding manhole and street openings

When covers of manholes, handholes, or vaults are removed, the opening shall be promptly protected with a barrier, temporary cover, or other suitable guard.
- b. Testing for gas in manholes and unventilated vaults
 1. The atmosphere shall be tested for combustible or flammable gas(es) before entry.
 2. Where combustible or flammable gas(es) are detected, the work area shall be ventilated and made safe before entry.
 3. Unless forced continuous ventilation is provided, a test shall also be made for oxygen deficiency.
 4. Provision shall be made for an adequate continuous supply of air.

NOTE: The term *adequate* includes evaluation of both the quantity and quality of the air.
- c. Flames
 1. Employees shall not smoke in manholes.

2. Where open flames must be used in manholes or vaults, extra precautions shall be taken to ensure adequate ventilation.
 3. Before using open flames in an excavation in areas where combustible gases or liquids may be present, such as in the vicinity of gasoline service stations, the atmosphere of the excavation shall be tested and found safe or cleared of the combustible gases or liquids.
 4. When a torch or open flame is used (as in heat shrink splicing) in proximity to a visibly exposed gas or other line(s) that transport flammable material, adequate air space or a barrier shall be provided to protect the gas or line(s) that transport flammable material from the heat source.
- d. Excavation
1. Cables and other buried utilities in the immediate vicinity shall be located, to the extent practical, prior to excavating.
 2. When using guided boring or directional drilling methods, existing utilities should be exposed by the personnel performing the boring operation where the bore path crosses such facilities. See IEEE Std. 1333TM-1994.
 3. Hand tools used for excavating in the vicinity of energized supply cables shall be equipped with handles made of nonconductive material. See IEEE Std. 1333-1994.
 4. Mechanized equipment should not be used to excavate in close proximity to cables and other buried utilities.
 5. If a gas or line that transports flammable material is broken or damaged, employees shall:
 - i. Leave the excavation open
 - ii. Extinguish flames that could ignite the escaping gas or fuel
 - iii. Notify the proper authority
 - iv. Keep the public away until the condition is under control
 6. When a worker is required to perform tasks in trenches or excavations where a cave-in hazard exists or the trench or excavation is in excess of 1.5 m (5 ft) in depth, shoring, sloping, or shielding methods shall be used to provide employee protection.
- e. Identification
1. When underground facilities are exposed, they should be identified and shall be protected as necessary to avoid damage.
 2. Where multiple cables exist in an excavation, cables other than the one being worked on shall be protected as necessary.
 3. Before cutting into a cable or opening a splice, the cable should be identified and verified to be the proper cable.
 4. When multiple cables exist in an excavation, the cable to be worked on shall be positively identified.
- f. Operation of power-driven equipment
- Employees should avoid being in manholes where power-driven rodding equipment is in operation.

9.8 Additional rules for telecommunications employee

9.8.1 General

Telecommunications employees shall observe the following rules in addition to the rules

contained in Rule 9.4.

9.8.2 Approach to energized conductors or parts

- A. No employee shall approach, or bring any conductive object, within the distances to any exposed energized part as listed in Table 9-1. When repairing storm damage to telecommunication lines that are joint use with electric supply lines at that or another point, employees shall:
 1. Treat all such supply and telecommunication lines as energized to the highest voltage to which they are exposed, or
 2. Assure that the supply lines involved are de-energized and grounded in accordance with Rule 9.4.6.
- B. Altitude correction
The distances in Table 9-1 shall be used at elevations below 3600 m (12 000 ft). Altitude correction factors as indicated in Table 9-4 shall be applied above that altitude. Altitude correction factors shall be applied only to the electrical component of the minimum approach distance.
- C. When repairing underground telecommunication lines that are joint use with damaged electric supply cables, employees shall:
 1. Treat all such supply and telecommunication lines as energized to the highest voltage to which they are exposed, or
 2. Assure that the supply lines involved are de-energized and grounded in accordance with Rule 9.9.

Table 9-1: Telecommunication work minimum approach distances

(See Rule 9.8.2 in its entirety.)

Voltage range phase-to-phase (rms) ^①	Distance to employee at altitudes from sea level to 3600 m		
0 to 50 V ^②	Not specified		
51 to 300 V ^②	Avoid contact		
301 to 750 V ^②	0.32 m		
751 to 15 kV	0.64 m		
15.1 kV to 36 kV	0.91 m		
36.1 kV to 46 kV	1.07 m		
46.1 kV to 72.5 kV	1.22 m		
At altitudes from			
Voltage range phase-to-phase (rms) ^①	Sea level to 900 m	901 m to 1800 m	1801 m to 3600 m
72.6 kV to 121 kV	1.43 m	1.49 m	1.63 m
121.1 kV to 145 kV	1.60 m	1.70 m	1.85 m
146.1 kV to 169 kV	1.78 m	1.88 m	2.08 m

169.1 kV to 242 kV	2.29 m	2.44 m	2.72 m
242.1 kV to 362 kV	3.70 m	3.96 m	4.50 m
362.1 kV to 420 kV	4.55 m	4.88 m	5.54 m
420.1 kV to 550 kV	5.38 m	5.77 m	6.58 m
550.1 kV to 800 kV	7.19 m	7.72 m	8.84 m

- ① For single-phase lines off three-phase systems, use the phase-to-phase voltage of that system.
- ② For single-phase systems, use the highest voltage available.
- ③ Distances listed are for standard atmospheric conditions. The data used to calculate Table 9-1 was derived from test data taken under standard atmospheric conditions for dry and clean insulators. Standard atmospheric conditions are defined as temperatures above freezing, wind less than 24 km per hr, and normal barometric pressure with unsaturated and uncontaminated air.
- ④ The data used to formulate values in this table for voltages above 72.5 kV was obtained from IEEE Std 516-2009 using phase-to-ground exposure with the maximum T values of 3.5 for 72 kV to 420 kV , 3.0 for 420 kV to 550 kV, and 2.5 for 800 kV aC_{21.1} tool factor. A 2 ft distance was added to the calculated values: one foot is added for inadvertent movement (as per IEEE Std 516-2009) plus one extra foot added for telecommunications worker over an electrical worker.

9.8.3 Joint-use structures

When working on jointly used poles or structures, employees shall not approach closer than distances specified in Table 9-1 and shall not position themselves above the level of the lowest electric supply conductor exclusive of vertical runs and street lighting.

EXCEPTION: On voltages 140 kV and below, this rule does not apply where telecommunications facilities are attached above electric supply conductors if a rigid fixed barrier has been installed between the supply and telecommunications facilities.

9.8.4 Attendant on surface at joint-use manhole

While personnel are in a joint-use manhole, an employee shall be available on the surface in the immediate vicinity to render assistance as may be required.

9.8.5 Sheath continuity

Metallic or semiconductive sheath continuity shall be maintained by bonding across the opening, or by equivalent means, when working on buried cable or on cable in manholes.

9.9 Additional rules for electrical supply employees

9.9.1 General

Electrical Supply employees shall observe the following rules in addition to the rules contained in Rule 9.4.5

9.9.2 Energized conductors or parts

Employees shall not approach within the reach or extended reach, or knowingly permit others to approach, any exposed ungrounded part normally energized except as permitted by this rule.

9.9.2.1 Minimum approach distance to energized lines or parts

1. Employees shall not approach or bring any conductive object within the minimum approach distance listed in Table 9-2 or 9-5 or distance as determined by an engineering analysis to exposed parts unless one of the following is met:
 - i. The line or part is de-energized and grounded per Rule 9.12.4.
 - ii. The employee is insulated from the energized line or part. Electrical protective equipment insulated for the voltage involved, such as tools, rubber gloves, or rubber gloves with sleeves, shall be considered effective insulation for the employee from the energized line or part being worked on.
 - iii. The energized line or part is insulated from the employee and from any other line or part at a different voltage.
 - iv. The employee is performing barehand live-line work according to Rule 9.14.

NOTE 1: IEEE Std. 516-2009 contains information that may be used to perform an engineering analysis to determine minimum approach distances.

NOTE 2: Minimum Approach distance calculated under this rule for 0.301 kV to 0.750 kV contain the electrical component plus 0.30 m (1ft) for inadvertent movement. Voltages above 72.5 kV contain the electrical component plus 0.31 m (1ft) for inadvertent movement.

NOTE 3: Methodology for calculating minimum approach distances were taken from IEEE Std. 516-2009.

NOTE 4: The voltage ranges are contained in ANSI C84.1-1995, Table 1.

2. Precautions for approach—Voltages from 51 V to 300 V

Employees shall not contact exposed energized parts operating at 51 V to 300 V, unless the provisions of Rule 9.9.2.1-1 are met.

3. Precautions for approach—Voltages from 301 V to 72.5 kV

At voltages from 301 V to 72.5 kV, employees shall be protected from phase-to-phase and phase-to-ground differences in voltage. See Table 9-2 for the minimum approach distances to live parts.

- i. When exposed grounded lines, conductors, or parts are in the work area, they shall be guarded or insulated.
- ii. When the Rubber Glove Work Method is employed, rubber insulating gloves, insulated for the maximum use voltage as listed in Table 9-5, shall be worn whenever employees are within the reach or extended reach of minimum approach distances listed in Table 9-2, supplemented by one of the following two protective methods:
 - (i) The employee shall wear rubber insulating sleeves, insulated for the maximum use voltage as listed in Table 9-5, in addition to the rubber insulating gloves.

EXCEPTION: When work is performed on electric supply equipment energized at 750 V or less, rubber sleeves are not required if only the live parts being worked on are exposed.

- (ii) All exposed energized lines or parts, other than those temporarily exposed to perform work and maintained under positive control, located within maximum reach or extended reach of the employee's work position, shall be covered with insulating protective equipment.

EXCEPTION: When work is being performed on parts energized between 300 V and 750 V within enclosed spaces, (e.g., control panels and relay cabinets),

insulating or guarding of all exposed grounded lines, conductors, or parts in the work area is not required provided that employees use insulated tools and/or gloves and that exposed grounded lines, conductors, or parts are covered to the extent feasible.

- iii. When the Rubber Glove Work Method is employed at voltages above 15 kV phase-to-phase, supplementary insulation (e.g. insulated aerial device or structure-mounted insulating work platform), tested for the voltage involved shall be used to support the worker.
- iv. Cover-up equipment used to insulate phase-to-phase exposure shall be rated for not less than the phase-to-phase voltage of the circuit(s) in the work area. All other cover-up equipment shall be rated for not less than the phase-to-ground voltage of the circuit(s). The determination of whether phase-to-phase or phase-to-ground exposure exists shall be based on factors such as but not limited to: work rules, conductor spacing, worker position, and task being performed.
- v. Cover-up equipment, when used, shall be applied to the exposed facilities as the employee first approaches the facilities from any direction, be that from the structure or from an aerial device, and shall be removed in the reverse order. This protective cover-up shall extend beyond the reach of the employee's anticipated work position or extended reach distance.

4. Precautions for approach - Voltage above 72.5 kV

The minimum approach distance for live work is determined by the requirements in Rule 9.9.2.1-4a or 9.9.2.1-4b. If the requirements in Rule 9.9.2.1-4b cannot be met in their entirety, Rule 9.9.2.1-4a shall be used.

- a. For work on exposed parts operating at phase-to-phase voltage above 72.5 kV, where the maximum approach distance at the worksite has not been determined by an engineering analysis, the ac live work minimum approach distances in Table 9-2, or Table 9-3 shall be used providing all the following conditions are met:

- I. While live work is being performed, any switching performed on the line is done with circuit breakers.
- II. At 242 kV and below, automatic instantaneous or high-speed reclosing is disabled, and
- III. Above 420 kV, either closing resistors or surge arrestors (or a combination of both) are being used to limit switching overvoltages.

NOTE: It is recommended to lock reclosing during live work on all voltages.

- b. For work on exposed parts operating at phase-to-phase voltage above 72.5 kV, where the minimum approach distances have been determined by engineering analysis, the live work minimum approach distance may be used with the determined value, providing that all of the following conditions are met.

EXCEPTION: If a temporary (transient) overvoltage control device (TTOCD), as defined in Rule 9.9.2.1-5, has been installed adjacent to the worksite to limit the maximum anticipated overvoltage (TOV), the value of the maximum anticipated per unit overvoltage factor (T) used to determine the live work minimum approach distance shall be the T value determined in Rule 9.9.2.1-5 plus 0.2 p.u. When installing or removing the TTOCD adjacent to the worksite, minimum approach distance determined by Rule 9.9.2.1-4a shall be used.

- i. The minimum approach distances determined by the engineering shall reflect actual operating conditions.

- ii. Automatic reclosing shall be disabled at all terminals of the line on which live work is being performed.

EXCEPTION: If required for system stability, one high-speed automatic reclose may be permitted, providing that the circuit interrupters or isolating devices to be reclosed cannot produce at the worksite an overvoltage value exceeding the value of the T being used at the worksite. This value shall be determined from an engineering analysis.

- iii. The altitude corrections according to Rule 9.9.2.1-6b shall be used when the elevation of the worksite is above 900 m (3000 ft) above sea level.
- iv. For dc work, the relative humidity at the worksite shall be less than 85%.

5. Temporary (transient) overvoltage control device (TTOCD)

TTOCD, which are designed and tested for installation adjacent to the worksite to limit the TOV at the worksite, may be used to obtain a lower value of T.

An engineering analysis, including laboratory testing, of the TTOCD shall be performed to determine and identify the range of spark over voltages. The withstand and sparkover characteristics of a TTOCD are determined by sparkover probability data for the particular protective gap geometry, gap distance, and conductor bundle geometry. The TOV rating for the TTOCD device shall be determined from test data and shall be the voltage at which the device sparks over 50% of the time. The T_{TTOCD} is calculated by dividing the TOV rating of the device by nominal peak voltage rounded-up to one decimal place.

As an example of determining T_{TTOCD} , for a line operating at 345 kV, using TTOCD which has been installed adjacent to the worksite to limit the maximum worksite T_{TTOCD} , having a TOV rating of 510 kV:

$$T_{TTOCD} = 510 / ((362 \times 1.414) / 1.732)$$

$$T_{TTOCD} = 510 / 295.53 = 1.72 \text{ or } 1.8$$

6. Altitude correction

The distances in Tables 9-2, 9-3, and 9-4 shall be used at elevations below 900 m (3000 ft). Above that altitude, the minimum approach distance shall be increased by:

- a. Multiplying the electrical component of the minimum approach distance by the applicable altitude correction factors of Table 9-4, and
- b. Adding the result to the values for inadvertent movement values as follows:

$$0.31 \text{ kV to } 0.750 \text{ kV} = 0.3 \text{ m (1ft)}$$

$$0.751 \text{ kV to } 72.5 \text{ kV} = 0.5 \text{ m (2 ft)}$$

$$72.6 \text{ kV to } 800 \text{ kV} = 0.3 \text{ m (1ft)}$$

NOTE: The electrical component of clearance included in Tables 9-2, 9-3 is the table value less the value for inadvertent movement for that voltage.

9.9.2.2 Additional approach requirements

1. The clear insulation distance associated with insulators shall be the shortest straight-line air-gap distance from the nearest energized part to the nearest grounded part.
2. When working on insulators under live work procedures employing rubber gloves or live-line tools, the clear insulation distance shall be not less than the straight-line distance in air required by Rule 9.9.2.1-4.

3. Work may be performed at the grounded end of an open switch if all of the following conditions are met:

- a. The air-gap distance of the switch shall not be reduced in any manner. This distance shall be not less than the minimum approach distances determined by Rules 9.9.2.1-2, 9.9.2.1-3, and 9.9.2.1-4 less the inadvertent movement values. The inadvertent movement values of Rule 49.9.2.1-7(a) are not required in this distance.
- b. The minimum approach distance to the energized part of the switch shall be not less than that required by Rules 9.9.2.1-2, 9.9.2.1-3, and 9.9.2.1-4.

4. Special rules for working on insulator assemblies operating above 72.5 kV

- a. When work is to be performed at the ground end of an insulator assembly, the minimum approach distance to the nearest energized part may equal the straight-line distance measured along the insulators.
- b. For suspension insulator assembly installations (see ANSI C29.2-1992) operating above 72.5 kV (ac), the first insulator at the grounded end may be temporarily shorted out as part of the work procedure. Before temporarily shorting out any insulator units, as part of the work procedure, each of the insulator units in the string shall be tested to determine the number and location of any failed units.

EXCEPTION: For voltages at 230 kV (ac) and above, up to three insulator units may be temporarily shorted out as part of the work procedure, provided that the minimum approach distance requirements of Rule 9.9.2.1-4 are met.

- c. When performing live work employing the barehand technique on installations operating above 72.5 kV (ac), the first insulator at the energized (hot) end of a suspension insulator assembly (see ANSI C29.2-1992) may be shorted out during the work. Before temporarily shorting out any insulator units, as part of the work procedure, each of the insulator units in the string shall be tested to determine the number and location of any failed units.

EXCEPTION: For voltages at 230 kV (ac) and above, up to three insulator units may be temporarily shorted out as part of the work procedure, provided that the minimum approach distance requirements of Rule 9.9.2.1-4 are met.

- (1) The minimum approach distance to the grounded end of the insulator assembly may be equal to the straight-line distance from the nearest energized part to the closest grounded part across the insulators.
- (2) The straight-line insulation distance shall be not less than the values required by Rule 9.9.2.1-4.

9.9.2.3 Live-line tool clear insulation length

A. Clear live-line tool length

The clear live-line tool distance shall be not less than the distance measured longitudinally along the live-line tool from the conductive part at the working end of the tool and any part of the employee. Distances for conducting sections (such as metallic splices and hardware) shall be subtracted from the clear live-line length. The clear live-line tool length shall equal or exceed the values for the minimum approach distance with tools required by rule 9.9.2.1-4 for the indicated voltage ranges. The minimum clear live-line tool distance shall be the distance measured longitudinally along the live-line tool from the conductive part at the working end of the tool to any part of the employee.

B. Live-line conductor support tool length

Conductor support tools such as link sticks, strain carriers, and insulator cradles may be used provided that the clear insulating distance is at least as long as the insulator string or the maximum distance specified in Rule 9.9.2.1-4. When installing this equipment, the employee shall maintain the minimum approach distance required equal to the clear insulating length for the support tools.

NOTE: Conductive components of tools disturb the field in the gap and decrease the insulation value of the tool more than the linear subtraction of the length(s) of the conductive components.

Table 9-2: AC live work minimum approach distance^④
(See Rule 9.9.2 in its entirety.)

Voltage in kilovolts phase-to-phase ^{①②③}	Distance to employee ^④			
	Phase-to-phase		Phase-to-phase	
	(m)	(ft-in)	(m)	(ft-in)
0 to 0.050	Not specified		Not specified	
0.051 to 0.300	Avoid contact		Avoid contact	
0.301 to 0.750	0.32	1-1	0.32	1-1
0.751 to 15	0.64	2-2	0.67	2-3
15.1 to 36.0	0.73	2-5	0.84	2-10
36.1 to 46.0	0.79	2-7	0.94	3-1
46.1 to 72.5	0.89	2-11	1.15	3-9
Distance to employee from energized part ^{④⑤⑥⑩}				
Voltage in kilovolts phase-to-phase	Without tools Phase-to-ground		With tools Phase-to-ground ^{⑦⑨}	
	(m)	(ft-in)	(m)	(ft-in)
	0.94	3-1	1.01	3-4
72.6 to 121	1.07	3-7	1.15	3-10
121.1 to 145	1.20	4-0	1.29	4-3
146.1 to 169	1.58	5-3	1.71	5-8
169.1 to 242	2.56	8-5	2.75	9-1
242.1 to 362	3.38	11-1	3.61	11-11
362.1 to 550	4.54	14-11	4.82	15-10
550.1 to 800				

- ① For single-phase systems, use the highest voltage available.
- ② For single-phase lines off three phase systems, use the phase-to-phase voltage of the system.

③ Inadvertent movement factors used in these tables are as follows:

0.31 kV to 0.750 kV = 0.3 m (1ft)

0.751 kV to 72.5 kV = 0.5 m (2 ft)

72.6 kV to 800 kV = 0.3 m (1ft)

- ④ Distances listed are for standard atmospheric conditions. The data used to formulate this table was obtained from test data taken with standard atmospheric conditions. Standard atmospheric conditions are defined as temperatures above freezing, wind less than 15 mi per hr or 24 km per hr, unsaturated air, normal barometer, uncontaminated air, and clean and dry insulators.

- ⑤ For voltages the voltage above 72.5 kV, distances are based on altitudes below 900 m (3000 ft) above sea level. For altitudes above 900 m (3000 ft), Rule 9.9.2.1-6 applies.

- ⑥ Distances were calculated using the following TOV values:

72.6 kV to 800 kV = 0.3

362.1 kV to 550 kV = 2.4

- 550.1 kV to 800 kV = 2.0
- ⑦ Distances for live-line tools in the air gap were calculated by adding a tool factor to the electrical component (IEEE 516 C₂ 1.1 tool factor).
- ⑧ Phase-to-phase live-line tool in the air gap values are not available. If this situation exists, an engineering evaluation should be performed.
- ⑨ *With tools* means a live-line tool bridging the air gap to the employee from the energized part.
- ⑩ For barehand work where the employee is at line potential, this distance is to an object at a different potential.

Table 9-3: DC live work minimum approach distance.

(See Rule 9.9.2 in its entirety.)

Maximum pole-to-pole Voltage in kilovolts ^{①②③}	Distance to employee			
	Pole-to-ground			
	(m)	(ft-in)		
0 to 0.050	Not specified			
0.051 to 0.300	Avoid contact			
0.301 to 0.750	0.32	1-1		
0.751 to 5	0.64	2-2		
5.1 to 72.5	0.89	2-11		
Maximum pole-to-ground Voltage in kilovolts ^{①②③}	Distance to employee from energized part			
	Without tools Phase-to-ground	With tools ^④ Phase-to-ground		
(m)	(ft-in)	(m)	(ft-in)	
2.6 to 250	1.28	4-3	1.37	4-7
250.1 to 400	1.95	6-5	2.11	7-0
400.1 to 500	2.61	8-7	2.81	9-3
500.1 to 600	3.39	11-2	3.62	11-11
600.1 to 750	4.79	15-9	5.08	16-8

- ① For voltages above 72.6 kV, distance were calculated using a TOV value of 1.8.
- ② The data used to calculate these tables was obtained from test data taken with standard atmospheric conditions. Standard atmospheric conditions are defined as temperatures above freezing, wind less than 15 mi per hr or 24 km per hr, unsaturated air, normal barometer, uncontaminated air, and clean and dry insulators. If standard atmospheric conditions do not exist, extra care must be taken.
- ③ For voltages above 72.5 kV, distances are based on altitudes below 900 m (3000 ft) above sea level. For altitudes above 900 m (3000 ft), Rule 9.9.2.1-6 applies.
- ④ Distances for live-line tools in the air gap were calculated by adding a tool factor to the electrical component (IEEE 516 C₂ 1.1 tool factor)

Table 9-4: Altitude correction factor

Altitude		Correction factor
(m)	(ft)	
Sea level to 900	Sea level to 3000	1.00
901 to 1,200	3001 to 4000	1.02
1201 to 1500	4001 to 5000	1.05
1501 to 1800	5001 to 6000	1.08
1801 to 2100	6001 to 7000	1.11
2101 to 2400	7001 to 8000	1.14
2401 to 2700	8001 to 9000	1.17
2701 to 3000	9001 to 10000	1.20
3001 to 3600	10001 to 12000	1.25
3601 to 4200	12001 to 14000	1.30

(See Rule 9.9.2 in its entirety.)

**Table 9-5:
Maximum use
voltage for rubber
insulating
equipment**

Class of equipment	maximum use voltage ^①
00	500
0	1000
1	7500
2	17000
3	26500
4	36000

- ① The maximum use voltage is the ac voltage (rms) rating of the protective equipment that designates the maximum nominal design voltage of the energized system that may be safely worked. The nominal design voltage is equal to the phase-to-phase voltage on multiphase circuits.

EXCEPTION 1: If there is no multiphase exposure in a system area (at the worksite) and the voltage exposure is limited to the phase (polarity on dc systems) to ground potential, the phase (polarity on dc systems) to ground potential shall be considered to be the nominal design voltage.

EXCEPTION 2: If electric equipment and devices are insulated, isolated, or both, such that the multiphase exposure on a grounded wye circuit is removed and if supplemental insulation (e.g., insulated aerial device or structure-mounted insulating work platform) is used to insulate the employee from ground, then the nominal design voltage may be considered as the phase-to-ground voltage on that circuit.

9.10 Switching control procedures

9.10.1 Designated person

Designated person shall:

1. Keep informed of operating conditions affecting the safe and reliable operation of the system.
2. Maintain a suitable record showing operating changes in such conditions.
3. Issue or deny authorization for switching, as required, for safe and reliable operation.

9.10.2 Specific work

Authorization from the designated person shall be secured before work is begun on or in the vicinity of station equipment, transmission, or interconnected feeder circuits and where circuits are to be de-energized at stations. The designated person shall be notified when such work ceases.

EXCEPTION 1: In an emergency, to protect life or property, or when telecommunication with the designated person is difficult because of storms or other causes, any qualified employee may make repairs on or in the vicinity of the equipment or lines covered by this rule without special authorization if the qualified employee can clear the trouble promptly with available help in compliance with the remaining rules. The designated person shall thereafter be notified as soon as possible of the action taken.

EXCEPTION 2: Suspension of normal rule or rules under disaster conditions: Where catastrophic service disruptions occur (e.g., earthquake, hurricane) and where multiple employer crews may be imported to assist in service restorations, the normal use of Rule 9.10 procedures may be suspended provided that:

- (a) Each individual involved in system repairs is informed of the suspension of normal rules.
- (b) Employees are required to observe all requirements of Rules 9.11 and 9.12, including protection Designated from step and touch potentials.
- (c) Equipment used to de-energize or re-energize circuits at designated points of control (e.g., station breakers) is operated in conformance with Rules 9.10.1 and 9.10.4.
- (d) Tagging requirements under Rule 9.12.3, for this *EXCEPTION*, shall include, and may be limited to, designated points of control.

9.10.3 Operations at stations

Qualified employees shall obtain authorization from the designated person before switching sections of circuits.

In the absence of specific operating schedules, employees shall secure authorization from the designated person before opening and closing supply circuits or portions thereof or starting and stopping equipment affecting system operation at stations.

EXCEPTION 1: Sections of distribution circuits are excepted if the designated person is notified as soon as possible after the action is taken.

EXCEPTION 2: In an emergency, to protect life or property, any qualified employee may open circuits and stop moving equipment without special authorization if, in the judgment of the qualified employee, this action will promote safety, but the designated person shall be notified as soon as possible of such action, with reasons therefore.

9.10.4 Re-energizing after work

Instructions to re-energize equipment or lines that have been de-energized by permission of the designated person shall not be issued by the designated person until all employees who requested the line to be de-energized have reported clear. Employees who have requested equipment or lines de-energized for other employees or crews shall not request that equipment or lines be re-energized until all of the other employees or crews have reported clear. The same procedure shall be followed when more than one location is involved.

9.10.5 Tagging electric supply circuits associated with work activities

1. Equipment or circuits that are to be treated as de-energized and grounded per Rule 9.12.4 shall have suitable tags attached to all points where such equipment or circuits can be energized.
2. When the automatic reclosing feature of a reclosing device is disabled during the course of work on energized equipment or circuits, a tag shall be placed at the reclosing device location.

EXCEPTION: If the automatic reclosing feature of a reclosing device is disabled by a Supervisory Control and Data Acquisition System (SCADA), the system shall provide for the following:

- a. At the SCADA operating point
 - i) A signal is received by the SCADA operator confirming that the disabling operation has occurred at the reclosing device location, and
 - ii) A readily visible tag or electronic display is used to inform any potential SCADA operator that a disabling operation has been initiated, and
 - iii) The tag or electronic display is removed before action is taken to re-enable the automatic reclosing feature.
- b. At the reclosing device location
 - i) The reclosing feature is disabled in such a manner as to prevent manual override of the normal control by any potential on-site operator, or
 - ii) A signal, flag, or other display is used in such a manner as to alert any potential on-site operator that the reclosing feature has been disabled.

- c. The required tags shall be placed to clearly identify the equipment or circuits on which work is being performed.

9.10.6 Restoration of service after automatic trip

1. When circuits or equipment upon which tags have been placed open automatically, the circuits or equipment shall be left open until reclosing has been authorized.
2. When circuits open automatically, local operating rules shall determine in what manner and how many times they may be closed with safety.

9.10.7 Repeating oral messages

Each employee receiving an oral message concerning the switching of lines and equipment shall immediately repeat it back to the sender and obtain the identity of the sender. Each employee sending such an oral message shall require it to be repeated back by the receiver and secure the latter's identity.

9.11 Work on energized lines and equipment

9.11.1 General requirements

1. When working on energized lines and equipment, one of the following shall be applied:
 - a. Insulate employee from energized parts
 - b. Isolate or insulate the employee from ground and grounded structures, and potentials other than the one being worked on
2. Employees shall not place dependence for their safety on the covering (nonrated insulation) of wires. All precautions (see Rule 9.9) for working on energized parts shall be observed.
3. All employees working on or in the vicinity of lines or equipment exposed to voltages higher than those guarded against by the safety protective equipment provided shall assure themselves that the equipment or lines on which they are working are free from dangerous leakage or induction, or have been effectively grounded.
4. Cutting into insulating coverings of energized conductors
 - a. A supply cable to be worked on as de-energized that cannot be positively identified or determined to be de-energized shall be pierced or severed at the work location with a tool designed for the purpose.
 - b. Before cutting into an energized supply cable, the operating voltage shall be determined and appropriate precautions taken for handling conductors at that voltage.
 - c. When the insulating covering on energized wires or cables must be cut into, the employee shall use a tool designed for the purpose. While doing such work, suitable eye protection and insulating gloves with protectors shall be worn. Employees shall exercise extreme care to prevent short-circuiting conductors when cutting into the insulation.
5. Metal measuring tapes, and tapes or ropes containing metal threads or strands, shall not be used closer to exposed energized parts than the distance specified in Rule 9.9.2.1. Care should be taken when extending metallic ropes or tapes parallel to and in the proximity of high-voltage lines because of the effect of induced voltages.
6. Equipment or material of a non-insulating substance that is not bonded to an effective ground and which extends into an energized area, and which could approach energized equipment closer than the distance specified in Rule 9.9.2.1, shall be treated as though it is energized at the same voltage as the line or equipment to which it is exposed.

9.11.2 Requirement for assisting employee

In inclement weather or at night, no employee shall work alone outdoors on or dangerously in the vicinity of energized conductors or parts of more than 750 V between conductors.

EXCEPTION: This shall not preclude a qualified employee, working alone, from cutting trouble in the clear, switching, replacing fuses, or similar work if such work can be performed safely.

9.11.3 Opening and closing switches

Manual switches and disconnectors shall always be closed by a continuous motion. Care should be exercised in opening switches to avoid serious arcing

9.11.4 Working position

Employees should avoid working on equipment or lines in any position from which a shock or slip will tend to bring the body toward exposed parts at a potential different than the employee's body. Work should, therefore, generally be done from below, rather than from above.

9.11.5 Protecting employees by switches and disconnectors

When equipment or lines are to be disconnected from any source of electric energy for the protection of employees, the switches, circuit breakers, or other devices designated and designed for operation under the load involved at sectionalizing points shall be opened or disconnected first. When re-energizing, the procedure shall be reversed.

9.11.6 Making connections

In connecting de-energized equipment or lines to an energized circuit by means of a conducting wire or device, employees should first attach the wire to the de-energized part. When disconnecting, the source end should be removed first. Loose conductors should be kept away from exposed energized parts.

9.11.7 Switchgear

Switchgear shall be de-energized and grounded per Rule 9.12.4 prior to performing work involving removal of protective barriers unless other suitable means are provided for employee protection. The personnel safety features in switchgear shall be replaced after work is completed.

9.11.8 Current transformer secondaries

The secondary of a current transformer shall not be opened while energized. If the entire circuit cannot be properly de-energized before working on an instrument, a relay, or other section of a current transformer secondary circuit, the employee shall bridge the circuit with jumpers so that the current transformer secondary will not be opened.

9.11.9 Capacitors

Before employees work on capacitors, the capacitors shall be disconnected from the energizing source, short-circuited, and grounded. Any line to which capacitors are connected shall be short-circuited and grounded before it is considered de-energized. Since capacitor units may be connected in series-parallel, each unit shall be shorted between all insulated terminals and the capacitor tank before handling. Where the tanks of capacitors are on ungrounded racks, the racks shall also be grounded. The internal resistor shall not be

depended upon to discharge capacitors.

9.11.10 Gas-insulated equipment

Employees working on gas-insulated cable systems or circuit breakers shall be instructed concerning the special precautions required for possible presence of arcing by-products of sulfur hexafluoride (SF_6).

NOTE: By-products resulting from arcing in sulfur-hexafluoride (SF_6) gas-insulated systems are generally toxic and irritant. Gaseous by-products can be removed for maintenance on the compartments by purging with air or dry nitrogen. The solid residue that must be removed is mostly metallic fluoride. This fine powder absorbs moisture and produces fluorides of sulfur and hydrofluoric acid, which are toxic and corrosive.

9.11.11 Attendant on surface

While electric supply personnel are in a manhole, an employee shall be available on the surface in the immediate vicinity to render assistance from the surface. This shall not preclude the employee on the surface from entering the manhole to provide short-term assistance.

EXCEPTION: This shall not preclude a qualified employee, working alone, from entering a manhole where energized cables or equipment are in service, for the purpose of inspection, housekeeping, taking readings, or similar work if such work can be performed safely

9.11.12 Unintentional grounds on delta circuits

Unintentional grounds on delta circuits shall be removed as soon as practical.

9.12 De-energizing equipment or lines to protect employees

9.12.1 Application of rule

1. When employees must depend on others to operate switches or otherwise de-energize circuits on which they are to work, or must secure special authorization before they operate such switches themselves, the precautionary measures that follow shall be taken in the order given before work is begun.
2. If the employee under whose direction a section of a circuit is disconnected is in sole charge of the section and of the means of disconnection, those portions of the following measures that pertain to dealing with the designated person may be omitted.
3. Records shall be kept on all contractual utility interactive systems on any electric supply lines. When these lines are de-energized according to Rule 9.12.3, the utility interactive system shall be visibly disconnected from the lines.

9.12.2 Employee's request

The employee in charge of the work shall apply to the designated person to have the particular section of equipment or lines de-energized, identifying it by position, letter, color, number, or other means.

9.12.3 Operating switches, disconnectors, and tagging

The designated person shall direct the operation of all switches and disconnectors through which electric energy may be supplied to the particular section of equipment and lines to be de-energized, and shall direct that such switches and disconnectors be rendered inoperable and tagged. If switches that are controlled automatically or remotely or both can be rendered inoperable, they shall be tagged at the switch location. If it is

impractical to render such switches and disconnectors inoperable, then these remotely controlled switches shall also be tagged at all points of control. A record shall be made when placing the tag, giving the time of disconnection, the name of the person making the disconnection, the name of the employee who requested the disconnection, and the name or title or both, of the designated person.

9.12.4 Employee's protective grounds

When all the switches and disconnectors designated have been operated, rendered inoperable where practical, and tagged in accordance with Rule 9.12.3, and the employee has been given permission to work by the designated person, the employee in charge should immediately proceed to make the employee's own protective grounds or verify that adequate grounds have been applied (see Rule 9.13) on the disconnected lines or equipment. During the testing for potential and/or application of grounds, distances not less than those shown in Tables 9-2, as applicable, shall be maintained.

Temporary protective grounds shall be placed at such locations and arranged in such a manner that affected employees are protected from hazardous differences in electrical potential.

NOTE: Hazardous touch and step potentials may exist around grounded equipment or between separately grounded systems. Additional measures for worker protection may include barriers, insulation, work practices, isolation or grounding mats.

The distance in Table 9-2, as applicable, shall be maintained from ungrounded conductors at the work location. Where the making of a ground is impractical, or the conditions resulting therefrom are more hazardous than working on the lines or equipment without grounding, the ground may be omitted by special permission of the designated person.

EXCEPTION: Alternative work methods such as isolation of equipment, lines, and conductors from all sources including induced voltages may be employed when the employer has assured worker protection from hazardous differences in electrical potential.

9.12.5 Proceeding with work

1. After the equipment or lines have been de-energized and grounded per Rule 9.12.4, the employee in charge, and those under the direction of the employee in charge, may proceed with work on the de-energized parts.
Equipment may be re-energized for testing purposes only under the supervision of the employee in charge and subject to authorization by the designated person.
2. Each additional employee in charge desiring the same equipment or lines to be de-energized and grounded per Rule 9.12.4 for the protection of that person, or the persons under direction, shall follow these procedures to secure similar protection.

9.12.6 Reporting clear—Transferring responsibility

1. The employee in charge, upon completion of the work and after ensuring that all persons assigned to this employee in charge are in the clear, shall remove protective grounds and shall report to the designated person that all tags protecting that person may be removed.
2. The employee in charge who received the permission to work may, if specifically permitted by the designated person, transfer the permission to work and the responsibility for persons by personally informing the affected persons of the transfer.

9.12.7 Removal of tags

1. The designated person shall then direct the removal of tags and the removal shall be

reported back to the designated person by the persons removing them. Upon the removal of any tag, there shall be added to the record containing the name of the designated person or title or both, and the person who requested the tag, the name of the person requesting removal, the time of removal, and the name of the person removing the tag.

2. The name of the person requesting removal shall be the same as the name of the person requesting placement, unless responsibility has been transferred according to Rule 9.12.6.

9.12.8 Sequence of re-energizing

Only after all protective grounds have been removed from the circuit or equipment and after protective tags have been removed in accordance with Rule 9.12.6 at a specific location, may the designated person direct the operation of switches and dis-connectors at that location.

9.13 Protective grounds

Extreme caution shall be exercised that the proper sequence of installing and removing protective grounds is followed

9.13.1 Installing grounds

When placing protective grounds on a previously energized part, the following sequence and precautionary measures shall be observed.

EXCEPTION: In certain situations, such as when grounding conductors are supported on some high-voltage towers, it may be appropriate to perform the voltage test before bringing the grounding device into the work area.

9.13.1.1 Current-carrying capacity of grounds

The grounding device shall be of such size as to carry the induced current and anticipated fault current that could flow at the point of grounding for the time necessary to clear the line.

NOTE: Refer to ASTM F-855-04[B24] for specifications for protective grounding equipment.

9.13.1.2 Initial connections

Before grounding any previously energized part, the employee shall first securely connect one end of the grounding device to an effective ground. Grounding switches may be employed to connect the equipment or lines being grounded to the actual ground connections.

9.13.1.3 Test for voltage

The previously energized parts that are to be grounded shall be tested for voltage except where previously installed grounds are clearly in evidence. The employee shall keep every part of the body at the required distance by using insulating handles of proper length or other suitable devices.

9.13.1.4 Completing grounds

- a. If the part shows no voltage, the grounding may be completed.
- b. If voltage is present, the source shall be determined to ensure that presence of this voltage does not prohibit completion of the grounding.
- c. After the initial connections are made to ground, the grounding device shall next be brought into contact with the previously energized part using insulating handles or

other suitable devices and securely clamped or otherwise secured thereto. Where bundled conductor lines are being grounded, grounding of each subconductor should be made. Only then may the employee come within the distances from the previously energized parts specified in Rule 9.9.2.1 or proceed to work upon the parts as upon a grounded part.

9.13.2 Removing grounds

1. The employee shall first remove the grounding devices from the de-energized parts using insulating tools or other suitable devices.
2. In the case of multiple ground cables connected to the same grounding point, all phase connections shall be removed before removing any of the ground connections.

EXCEPTION: If the application of Rule 9.13.2-2 produces a hazard such as unintentional contact of the ground with ungrounded parts, then the grounds may be removed individually from each phase and ground connection.

3. The connection of the protective ground to the effective ground shall be removed last.

NOTE 1: Hazards due to electric and magnetic field induction may exist when de-energized conductors, cables, and equipment are in proximity to other energized circuits.

NOTE 2: IEEE Std. 1048TM-1990 and IEEE Std. 1246TM-2002 contain additional information for personal protective grounding.

9.14 Live work

All employees using live work practices shall observe the following rules in addition to applicable rules contained elsewhere in Rule 9.9.

The distances specified in Table 9-2, or Table 9-3 shall be maintained from all grounded objects and from other conductors, lines, and equipment having a potential different from that to which conductive equipment and devices are bonded in order to maintain the equipotentially energized work environment in an isolated state.

9.14.1 Training

Employees shall be trained in live work practices, which include rubber glove, hot stick, or barehand method, before being permitted to use these techniques on energized lines.

9.14.2 Equipment

1. Insulated aerial devices, ladders, and other support equipment used in live work shall be evaluated for performance at the voltages involved. Tests shall be conducted to ensure the equipment's integrity. Insulated aerial devices used in barehand work shall be tested before the work is started to ensure the integrity of the insulation. See applicable references in Section 3, specifically IEEE Std. 516-2009 and ANSI/SIA A92.2-1992.
2. Insulated aerial devices and other equipment used in this work shall be maintained in a clean condition.
3. Tools and equipment shall not be used in a manner that will reduce the overall insulating strength of the insulated aerial device.

9.14.3 Clearance insulation distance

When working on insulators under live-line procedures, the clear insulation distance shall

be not less than the distances required by Tables 9-2 and 9-3.

9.14.4 Bonding and shielding for barehand method

1. A conductive bucket liner or other suitable conducting device shall be provided for bonding the insulated aerial device to the energized line or equipment.
2. The employee shall be bonded to the insulated aerial device by use of conducting shoes, leg clips, or other suitable means.
3. Adequate electrostatic shielding in the form of protective clothing that has been evaluated for electrical performance shall be provided and used where necessary.
NOTE: Electrostatic shielding—Evaluation of protective clothing designed for this purpose is covered in IEEE Std 516-2009.
4. Before the employee contacts the energized part to be worked on, the aerial device shall be bonded to the energized conductor by means of a positive connection.

9.15 Protection against arcing and other damage while installing and maintaining insulators and conductors

In installing and maintaining insulators and conductors, precautions shall be taken to limit the opportunity for, as far as is practical, any damage that might render the conductors or insulators liable to fall. Precautions shall also be taken to prevent, as far as is practical, any arc from forming and to prevent any arc that might be formed from injuring or burning any parts of the supporting structures, insulators, or conductors.

9.16 Equipment operators

1. The employers shall ensure followings regarding equipment operators.
 - a. shall have proper permit/license from competent authority for operating the equipment they are operating
 - b. shall be medically fit as required by law to operate the equipment
 - c. shall periodically undergo a medical and competency check as required by applicable law or in absence of relevant law a reasonable period as determined by the employer
2. The operator shall ensure:
 - a. defective equipment is reported so that it is corrected before use
 - b. observance of operating instructions and applicable rules
 - c. his condition is reported to his superior if not fit for duty
 - d. Loading/operation of equipment does not exceed the rated capacity.
 - e. unauthorized persons do not ride the equipment
 - f. Ensure when not in use the equipment is parked in a safe manner

9.16.1 Equipment

The employers shall ensure following regarding equipment:

- a. shall be kept in good operating condition
- b. any unsafe conditions of the equipment are corrected before use.
- c. Valid permit/license regarding fitness and operating the equipment are maintained
- d. Appropriate safety equipment required for safe operation is available on the equipment
- e. Any special checks or calibration required for safe operation of the equipment is completed by competent agency on time
- f. Hazardous parts, assemblies or components which can cause accidents must be appropriately marked to provide adequate caution.

9.17 Emergency Response

All electrical and telecommunication entities must have emergency response system to address hazardous conditions arising out of routine as well as non-routine activities.

Appendix-A

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Appendix-B

Table B-1

Group	Category	R/NR (ft)	G/O (ft)	M (ft)	E (ft)	M&E (ft)	M&E (mm/ m)
I	Support arms	1.0 ¹	0.0 ¹	1.0	0.0	1.0	305 mm
	Effectively grounded equipment cases	1.0 ¹	0.0 ¹	1.0	0.0		
II	Insulated communication conductors and cables	—/1.5	0.0 ¹	1.5	0.0	1.5	455 mm
	Messengers	—/1.5	0.0 ¹	1.5	0.0		
	Surge protection wires	—/1.5	0.0 ¹	1.5	0.0		
	Grounded guys	—/1.5	0.0 ¹	1.5	0.0		
	230E1	—/1.5	0.0 ¹	1.5	0.0		
	230C1	—/1.5	0.0 ¹	1.5	0.0		
III	URLP, 0 V to 750 V	1.0 ¹	—/0.5	1.5	0.5	2.0	610 mm
	Noninsulated communication conductors	—/1.5	—/0.5	2.0	0.0		
	230C2, 0 V to 750 V	—/1.5	0.0 ¹	1.5	0.5		
	230C3, 0 V to 750 V	—/1.5	0.0 ¹	1.5	0.5		
	Ungrounded cases of equipment at 0 to 750 V	1.0 ¹	—/0.5	1.5	0.5		
IV	230C2, greater than 750 V	—/1.5	0.0 ¹	1.5	1.0*	2.5	760 mm
	230C3, greater than 750 V	—/1.5	0.0 ¹	1.5	1.0*		
	Open supply conductors, 0 to 750 V ⁽¹⁾	—/1.5	0.0 ¹	2.0	0.5*		
	230E2	—/1.5	0.0 ¹	2.0	0.5*		
V	URLP, greater than 750 V to 22 kV	1.0 ¹	—/0.5	1.5	2.5	4.0	1.2 m
	Ungrounded cases of equipment at greater than 750 V to 22 kV	1.0 ¹	—/0.5	1.5	2.5		
VI	Open supply conductors, greater than 750 V to 22 kV	—/1.5	—/0.5	2.0	2.5	4.5	1.37 m

NOTE 1: The portion (s) of guys between guy insulators and the portion(s) of anchor guys above guy insulators that are not grounded have clearances based on the highest voltage to which they are exposed
NOTE an asterick (*) beside a value indicates an exception to the legend

⁽¹⁾ Does not include neutral conductors meeting Rule 6.4.1.5-1.

Table B-2b

Table	Item	Ref (mm/m)	Ref (ft)
234-1	1. Buildings		
	a. Horizontal		
	(1) Walls, projections, and guarded windows	915 mm	3.0
	(2) Unguarded windows	915 mm	3.0
	(3) Balconies and areas accessible to pedestrians	915 mm	3.0
	b. Vertical		
	(1) Roofs/projections not accessible to pedestrians	2.44 m	8.0
	(2) Balconies and roofs accessible to pedestrians	2.74 m	9.0
	(3) Roofs—vehicles not over 2.4 m (8 ft)	2.74 m	9.0
	(4) Roofs—vehicles over 2.4 m (8 ft)	4.3 m	14.0
	2. Signs, chimneys, billboards, antennas, tanks, etc.		
	a. Horizontal	915 mm	3.0
	b. Vertical over or under	1.07 m	3.5
234-2	1. Over bridges		
	a. Attached	305 mm	1.0
	b. Not attached	2.44 m	8.0
	2. Beside, under, or within bridge structure		
	a. Accessible		
	(1) Attached	305 mm	1.0
	(2) Not attached	915 mm	3.0
	b. Inaccessible		
	(1) Attached	305 mm	1.0
	(2) Not attached	610 mm	2.0
234-3	1. From water level, edge of pool, etc.	6.25 m	20.5
	2. From diving platform or tower	3.8 m	12.5

Vertical Clearances now apply at the maximum conductor sag conditions, such as outlined in Rule 6.4.3.1 rather than at a 15° C (60°F) conductor temperature conditions as used in the 1987 Edition. This is illustrated in Figure 6-4(a); 5.6m (18.5ft) is required for open supply conductors, over 750 V to 22 kV, over roads, for any sag conditions or span length.

Appendix-C

CROSS REFERENCE OF AWG AND OTHER GAUGES

Gage No.	AWG		SWG		Gage No.	AWG		SWG	
	inches	mm	inches	mm		inches	mm	inches	mm
0	0.3249	8.25	0.324	8.23	23	0.0226	0.574	0.024	0.610
1	0.2893	7.35	0.300	7.62	24	0.0201	0.511	0.022	0.559
2	0.2576	6.54	0.276	7.01	25	0.0179	0.455	0.020	0.508
3	0.2294	5.83	0.252	6.40	26	0.0159	0.404	0.0180	0.457
4	0.2043	5.19	0.232	5.89	27	0.0142	0.61	0.0164	0.417
5	0.1819	4.62	0.212	5.38	28	0.0126	0.320	0.0148	0.376
6	0.162	4.11	0.192	4.88	29	0.0113	0.287	0.0136	0.345
7	0.1443	3.67	0.176	4.47	30	0.0100	0.254	0.0124	0.315
8	0.1285	3.26	0.160	4.06	31	0.0089	0.226	0.0116	0.295
9	0.1144	2.91	0.144	3.66	32	0.0080	0.203	0.0108	0.274
10	0.1019	2.59	0.128	3.25	33	0.0071	0.180	0.0100	0.254
11	0.0907	2.3	0.116	2.95	34	0.0063	0.160	0.0092	0.234
12	0.0808	2.05	0.104	2.64	35	0.0056	0.142	0.0084	0.213
13	0.0720	1.83	0.092	2.34	36	0.0050	0.127	0.0076	0.193
14	0.0641	1.63	0.080	2.03	37	0.0045	0.114	0.0068	0.173
15	0.0571	1.45	0.072	1.83	38	0.0040	0.102	0.0060	0.152
16	0.0508	1.29	0.064	1.63	39	0.0035	0.089	0.0052	0.132
17	0.0453	1.15	0.056	1.42	40	0.0031	0.079	0.0048	0.122
18	0.0403	1.02	0.048	1.22	41	0.0028	0.071	0.0044	0.112
19	0.0359	0.912	0.040	1.02	42	0.0025	0.064	0.0040	0.102
20	0.032	0.813	0.036	0.914	43	0.0022	0.056	0.0036	0.091
21	0.0285	0.724	0.032	0.813	44	0.0020	0.051	0.0032	0.081
22	0.0253	0.643	0.028	0.711	45	0.0018	0.046	0.0028	0.071

Appendix-D

Telecommunication Installer Requirement Specifications

The Installer is required to possess the following relevant skill set:

- A. Should be aware of International standards for:
 - a. Residential telecommunication Infrastructure (e.g. EIA/TIA 570B etc)
 - b. Commercial Building for
 - i. Telecommunication Pathways and Spaces(e.g. TIA 569B etc) and,
 - ii. Telecommunication Wiring Standard (e.g. EIA/ TIA 568).
 - c. Telco on-premise wiring.
 - d. Public Network OSP Cabling.
- B. Should have good knowledge of the network topologies.
- C. Should be aware of the latest wired and wireless Access layer technologies, for instance LAN CAT & Fiber optic terminations, WiFi, RFIDs.
- D. Should have a sound knowledge of the Earthing requirements.
- E. Aware of high voltage telecom equipment safety requirements.
- F. Aware of exposure to hazardous wireless equipment.
- G. All standards defined by ITU and other organizations etc. form time to time.

