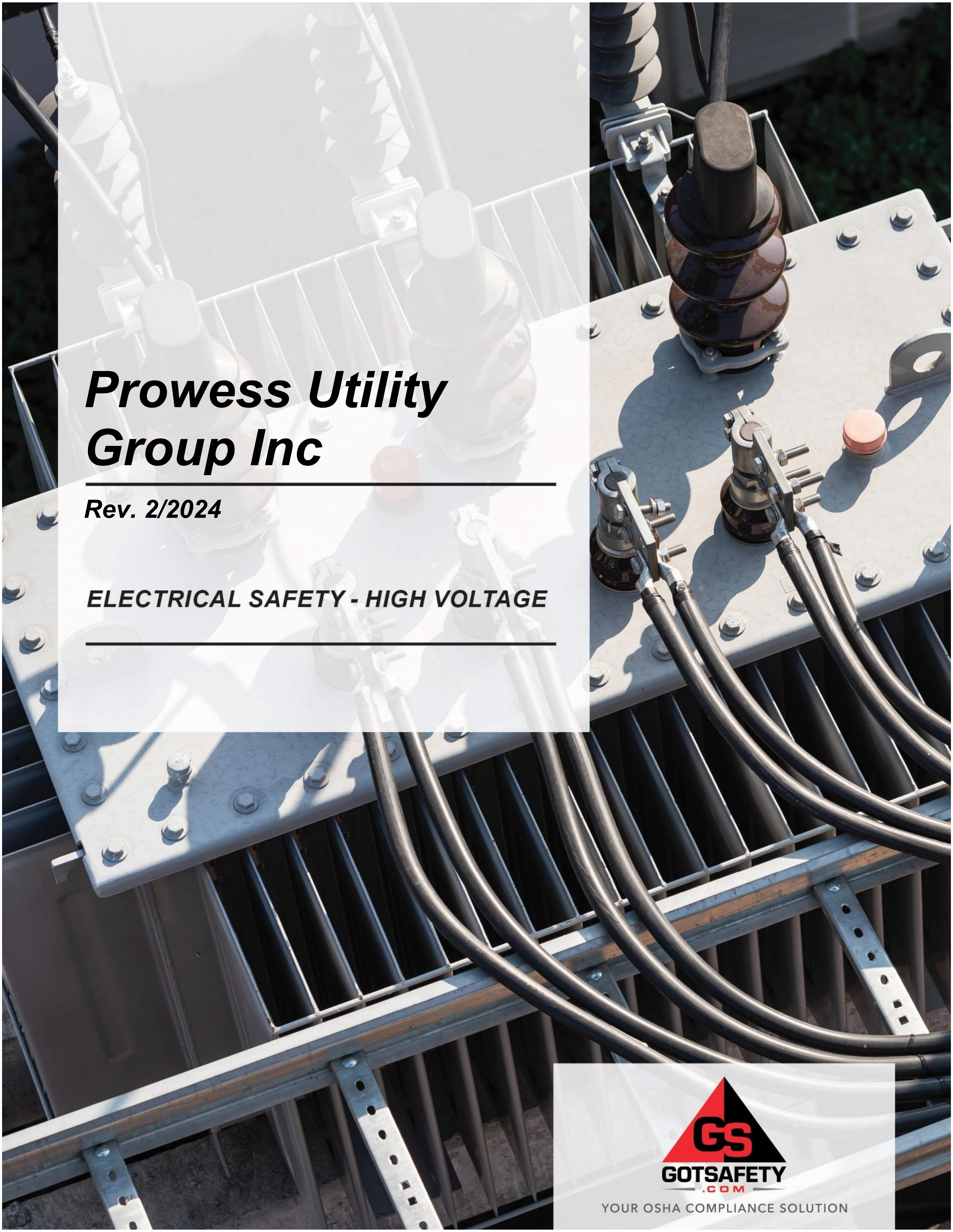

Prowess Utility Group Inc

Rev. 2/2024

ELECTRICAL SAFETY - HIGH VOLTAGE

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1 OBJECTIVE

Prowess Utility Group Inc has developed and implemented this High-Voltage Electrical Safety Program to provide the minimum safety requirements to our employees. These safety orders will assist in the elimination of accidents which may result from the operation, installation, removal, use and maintenance of electrical equipment and tools.

The High-Voltage Electrical Safety Program requirements will apply to all electrical installations and electrical equipment operating or intended to operate on systems of more than 600 volts between conductors and to all work performed directly on or in proximity to such electrical installations, equipment or systems in all places of employment in the State of California as defined in Article 36 of the Labor Code.

2 PROGRAM ADMINISTRATOR

Prowess Utility Group Inc has designated Julian Alcaide for the implementation of the High-Voltage Electrical Safety Program. Julian Alcaide is responsible for:

- Identifying work areas, processes, or tasks that could potentially expose employees to electrical hazards;
- Enforcing methods of exposure control; and
- Maintaining, reviewing, and updating the High-Voltage Electrical Safety Program when necessary.

3 PURPOSE OF ELECTRICAL SAFETY

Electricity can be very dangerous as electricity tries to find a conductor, it will follow any and all paths to the ground, like metal, wet wood and/or water. The human body is about 70% water, so that makes humans a good conductor, too. For example, touching an energized bare wire or faulty appliance when feet are touching the ground, electricity will automatically pass through the body to the ground, causing a harmful, or even fatal shock.

At many points on its way to the ground, electricity can be potentially dangerous. Such as, the overhead power lines, which are located high off the ground for safety, but have no insulation and can carry more than 500,000 volts; substations and transformers contain "live" parts that are dangerous to contact; and underground power lines are well-insulated, but a shovel can damage them and create a shock hazard.

Due to the many electrical safety hazards, Prowess Utility Group Inc employees will be required to observe the electrical safety orders in this program.

4 GENERAL REQUIREMENTS

4.1 Safe Access

All work locations and equipment will be safely accessible whenever work is to be performed.

4.2 **Protection from Electric Shock**

4.2.1 Before work begins, the following is required:

a. Identify exposed or concealed energized electric power circuits if any person, machine, or tool might come into contact with the circuit.
b. Advise employees of the location of energized circuits, the hazards, and protective measures; and,
c. Provide legible markings or warning signs to indicate the presence of energized electrical circuits.

4.2.2 Protective equipment or devices must be used to protect employees if a recognized hazard exists.

4.2.3 When protective insulating equipment is used, it will comply with the T8, CCR, Electrical Safety Orders.

4.2.4 Barricades will be used in lieu of other protective equipment.

4.3 **Safety Devices and Safeguards**

4.3.1 Safety devices and safeguards will be provided as may be necessary to make the employment or place of employment as free from danger to the safety and health of employees as the nature of the employment reasonably permits.

4.3.2 Each safety device will be examined or tested at such intervals as may be reasonably necessary to ensure that it is in good condition and adequate to perform the function for which it is intended. Any device furnished that is found to be unsafe will be repaired or replaced.

4.3.3 Employees will be required to inspect each safety device, tool or piece of equipment, each time it is used and to use only those in good condition. The use of safety devices and safeguards will be required where applicable.

4.4 **Qualified Electrical Workers**

4.4.1 Only qualified electrical workers will work on energized conductors or equipment connected to energized high-voltage systems.

Exception: When replacing fuses, operating switches, or other operations that do not require the employee to contact energized high-voltage conductors or energized parts of equipment, clearing "trouble" or in emergencies involving hazard to life or property, no such employee will be assigned to work alone.

4.4.2 Employees in training, who are qualified by experience and training, will be permitted to work on energized conductors or equipment connected to high-voltage systems while under the supervision or instruction of a qualified electrical worker.

4.5 Observers

During the time work is being done on any exposed conductors or exposed parts of equipment connected to high-voltage systems, a qualified electrical worker, or an employee in training, will be in close proximity at each work location to:

a. Act primarily as an observer for the purpose of preventing an accident, and
b. Render immediate assistance in the event of an accident. Such observer will not be required in connection with work on overhead trolley distribution circuits not exceeding 1,500 volts D.C. where there is no conductor of opposite polarity less than 4 feet there from, or where such work is performed from suitable tower platforms or other similar structures.

5 WORK PROCEDURES AND OPERATING PROCEDURES

5.1 Voltage Determination

Operating voltage of equipment or conductors will be determined before working on or near energized parts.

5.2 Lock-Out/Tag-Out

Lock-out procedures will be followed during the cleaning, repairing, servicing, or adjusting of machinery. Employees will refer to the Energy Control (LOTO) Program for further information and training. A general overview of lock-out/tag-out procedures are as follows:

a. De-energize the machine. Positively disconnect it from the power source. If there is more than one source of power, disconnect them all.
b. Lock-out the disconnect switches. Each disconnect must have a lock and key before beginning work on the machine.
c. Tag the disconnect switches. Use tags or accident prevention signs.
d. Testing of the machine to verify disconnection and to prevent a re-start of the machine.

5.3 Minimum Approach Distances

5.3.1 Minimum approach distances will be established using one of the following methods:

a. Distances no less than computed by Table 1 for AC Systems or Table 6 for DC Systems using maximum anticipated per-unit transient overvoltage determined by an engineering analysis.
   For voltages over 72.5 kilovolts, the maximum anticipated per-unit transient overvoltage, phase-to-ground, will be determined through an engineering analysis.
   When using portable protective gaps to control the maximum transient overvoltage, the value of the maximum anticipated per-unit transient overvoltage, phase-to-ground, will be provide for five standard deviations between the statistical spark over voltage of the gap and the statistical withstand voltage corresponding to the electrical component of the minimum approach distance. Any engineering analysis conducted to determine maximum anticipated per unit transient overvoltage will be made available upon request to employees and to the Chief of the Division or designee for examination and copying.

b. The minimum approach distances in Table 3, Table 4, and the last row of Table 6.
Note: Approach distances in Table 3 and Table 4 assume a maximum anticipated per-unit transient overvoltage in Table 5.

Minimum approach distances will be adjusted to account for work locations above 3,000 feet using altitude correction factors in Table 7.

5.3.2 No employee will be permitted to approach or take any conductive object without an approved insulating handle closer to exposed energized parts than the established minimum approach distances unless one of the following is met:

a. The employee is insulated or guarded from the energized part (rubber insulating gloves or gloves with sleeves rated for the voltage involved will be considered insulation of the employee from the energized part) upon which the employee is working provided that the employee has control of the part in a manner sufficient to prevent exposure to uninsulated portions of the employee’s body, or
b. The energized part is insulated or guarded from the employee and any other conductive object at a different potential.

5.3.3 When performing work with live line tools, minimum clear distances in Table 1 through Table 3 will be maintained. Conductor support tools, such as link sticks, strain carriers, and insulator cradles, will be permitted to be used provided that the clear insulation is at least as long as the insulator string or the minimum distance specified in Table 1 through Table 3 for the operating voltage.

Table 1: AC Live-Line Work Minimum Approach Distance

The minimum approach distance (MAD; in meters) will conform to the following equations.

For Phase-to-Phase System Voltages of 601V to 5 kV:[1]	
MAD=M+D, where	
D=0.02 m	D is the electrical component of the minimum approach distance
M= 0.31 m for voltages up to 750V and 0.61 m otherwise	M is the inadvertent movement factor
For Phase-to-Phase System Voltages of 5.1 kV to 72.5 kV:[1]	
MAD=M+AD, where	
M=0.61 m	M is the inadvertent movement factor
A= the applicable from Table 7	A is the altitude correction factor
D= the value from Table 2 corresponding to the voltage and exposure or the value of the electrical component of the minimum approach distance calculated using the method provided in Appendix 1.	D is the electrical component of the minimum approach distance
For Phase-to-Phase System Voltages of More Than 72.5 kV, No	
MAD=0.3048(C+a)V_{L-G}TA+M, where	
C=	0.01 for phase-to-ground exposures the consists only of air across the approach distance (gap), 0.01 for phase-to-phase exposures where it can be demonstrated that no insulated tools spans the gap and no large conductive object is in the gap, or 0.0011 otherwise.
V_{L-G}=	Phase-to-ground rms voltage, in kV
T=	Maximum anticipated per-unit transient overvoltage; for phase-to-ground exposures, T equals T^{L-G}, the maximum per-unit transient overvoltage, phase-to-ground, for phase-to-phase exposures, T equals $1.35T^{L-G}+0.45$
A=	Altitude correction factor from Table 7
M=	0.31 m, the inadvertent movement factor
a=	Saturation factor, as follows:

Phase-to-Ground Exposure					
$V_{Peak}=T_{L-G}V_{L-G}\sqrt{2}$	635 kV or less	6.35.1 to 915kV	915.1 to 1,050 kV	More than 1,050 kV	
a	0	$(V_{peak}-635)$ /140,000	$(V_{peak}-645)$ /135,000	$(V_{peak}-675)$ /125,000	
Phase-to-Phase Exposure[3]					
$V_{Peak}=(1.35T_{L-G}+0.45)$					
$V_{L-g}\sqrt{2}$	630 kV or less	630.1 to 848 kV	848.1 to 1,131 kV	1,131.1 to 1,485kV	More than1,485 kV
a	0	$(V_{Peak}-630)$ / 155,000	$(V_{Peak}-633.6)$ / 152,207	$(V_{Peak}-628)$ / 153,846	$(V_{Peak}-350.5)$ / 203,666

NOTE 1: The minimum approach distance in Table 3 may be used if the worksite is at an elevation of more than 900 meters (3,000 feet).

NOTE 2: The minimum approach distance in Table 4 may be used, except for phase-to-phase exposures if an insulated tool spans the gap or if any large conductive object is in the gap. If that worksite is at an elevation of more than 900 meters (3,000 feet), see Note 1 for Table 4.

NOTE 3: Use the equations for phase-to-ground exposure (with VPeak for phase-to-phase exposures) unless it can be demonstrated that no insulated tool spans the gap and that no large conductive objects is in the gap.

Table 2: Electrical Component of the of the Minimum Approach Distance (D; in Meters) At 5.1 to 72.5 kV

Nominal Voltage (kV) phase-to-phase	Phase-to-ground exposure	Phase-to-phase exposure
	D(m)	D(m)
5.1 to 15.0	0.04	0.07
15.1 to 36.0	0.16	0.28
36.1 to 46.0	0.23	0.37
46.1 to 72.5	0.39	0.59

Table 3: Alternative Minimum Approach Distances (In Meters or Feet) For Voltages of 72.5 kV and Less[1]

Nominal voltage (kV) phase-to-phase	Distance			
	Phase-to-ground exposure		Phase-to-phase exposure	
	m	ft	m	ft
0.601 to 0.750[2]	0.33	1.09	0.33	1.09
0.751 to 5.0	0.63	2.07	0.63	2.07
5.1 to 15.0	0.65	2.14	0.68	2.24
15.1 to 36.0	0.77	2.53	0.89	2.92
36.1 to 46.0	0.84	2.76	0.98	3.22
46.1 to 72.5	1.00	3.29	1.20	3.94

NOTE 1: The minimum approach distance distances in this table may be used provided that worksite it an elevation of 900 meters (3,000 feet) or less. If elevations are greater than 900 meters (3,000 feet) above sea level, the minimum approach distance will be determined by

distance will be determined by multiplying the distances in this table by the correction factor in Table 7 corresponding to the altitude of work.

NOTE 2: For single-phase systems, use voltage-to-ground.

Table 4: Alternative Minimum Approach Distances for Voltages for More than 72.5 kV [1,2,3]

Voltage range phase-to-phase (kV)	Phase-to-ground exposure		Phase-to-phase exposure	
	m	ft	m	ft
72.6 to 121.0	1.13	3.71	1.42	4.66
121.1 to 145.0	1.30	4.27	1.64	5.38
145.1 to 169.0	1.46	4.79	1.94	6.36
169.1 to 242.0	2.01	6.59	3.08	10.10
241.1 to 362.0	3.41	11.19	5.52	18.11
362.1 to 420.0	4.25	13.94	6.81	22.34
420.1 to 550.0	5.07	16.63	8.24	27.03
550.1 to 800.0	6.88	22.57	11.38	37.34

NOTE 1: The minimum approach distances in this table may be used provided the worksite is at an elevation of 900 meters (3,000 feet) or less. If the elevation is greater than 900 meters (3,000 feet) above sea level, the minimum approach distance will be determined by multiplying the distances in this table by the correction factor in Table 7 corresponding to the altitude of the work.

NOTE 2: The phase-to-phase minimum approach distances in this table may be used provided that no insulated tool spans the gap and no larger conductive object is in the gap.

Note 3: The clear live line tool distance shall be equal or exceed the values for the indicated voltage ranges.

Table 5: Assumed Maximum Per-Unit Transient Overvoltage

Voltage range (kV)	Type of Current (AC or DC)	Assumed maximum per-unit transient overvoltage
72.6 to 420.0	AC	3.5
420.1 to 550.0	AC	3.0
550.1 to 800.0	AC	2.5
250 to 750	DC	1.8

Table 6: DC Live-line Minimum Approach Distance with Overvoltage Factor[1]

Maximum Anticipated Transient Overvoltage	Maximum Line-To-Ground Voltage (kV)									
	250 (kV)		400 (kV)		500 (kV)		600 (kV)		750(kV)	
	m	ft	m	ft	m	ft	m	ft	m	ft
1.5 or less	1.12	3.67	1.60	5.25	2.06	6.76	2.62	8.59	3.61	11.84
1.6	1.17	3.84	1.69	5.54	2.24	7.35	2.86	9.38	3.98	6.37
1.7	1.23	4.03	1.85	6.07	2.42	7.94	3.12	10.23	4.37	14.33
1.8	1.28	4.20	1.95	6.40	2.62	8.59	3.39	11.12	4.79	15.71

Note:1 The distances specified in this table are for air and live line-line tool conditions. If employees will be working at elevations greater than 900 meters (3,000 feet) above mean sea level, that minimum approach distance will be determined by multiplying the distances in this table by the corrections factor in table 7 corresponding to the altitude of the work.

Table 7: Altitude Correction Factor

Altitude (m)	Altitude (ft)	Correction Factor
0 to 900	Sea level to 3000	1.00
901 to 1,200	3,001 to 4,000	1.02
1,201 to 1,500	4,001- 5,000	1.05
1,501 to 1,800	5,001-6,000	1.08
1,801 to 2,100	6,001-7,000	1.11
2,101 to 2,400	7,001-8,000	1.14
2,401 to 2,700	8,001-9,000	1.17
2,701 to 3,000	9,001-10,000	1.20
3,001 to 3,600	10,001-12,000	1.25
3,601 to 4,200	12,001-14,000	1.30
4,201 to 4,800	14,001-16,00	1.35
4,801 to 5,400	16,001-18,000	1.39
5,401 to 6,000	18,001-20,000	1.44

5.4 Inclement Weather

Work on or from structures will be discontinued when adverse weather, such as high winds, ice on structures, or the progress of an electrical storm in the immediate vicinity, makes the work hazardous, except during emergency restoration procedures.

5.5 Illumination

Illumination will be provided as needed to perform the work safely.

5.6 Work Over or Near Water

5.6.1 When work is performed over or near water and when danger of drowning exists, suitable protection will be provided in accordance with Section 3389 of the General Industry Safety Orders or Section 1602 of the Construction Safety Orders.

5.6.2 An employee may cross streams or other bodies of water only if a safe means of passage, such as a bridge, is available.

5.7 Protection From Backfeed Voltage

Before contacting the high voltage side of deenergized transformer(s), or conductor(s) connected thereto, all possible sources of backfeed will be eliminated by:

a. Disconnecting or grounding the high voltage side, or
b. Disconnecting or short circuiting the low voltage side.

EXCEPTION: System(s) work as energized.

6 TOOLS AND PROTECTIVE EQUIPMENT

6.1 Insulating Equipment

6.1.1 Insulating equipment designed for the voltage levels to be encountered will be provided and management will ensure that they are used by employees as required by this section. This equipment will meet the electrical and physical requirements contained in the standards shown in CCR, Title 8, Article 36, Appendix C.

6.1.2 Whenever rubber gloves are used, they will be protected by outer canvas or leather gloves. This equipment will meet the electrical physical requirements contained in the standards shown in CCR, Title 8, Article 36, Appendix C.

6.1.3 Insulating equipment fabricated of material other than rubber will provide electrical and mechanical protection at least equal to that of rubber equipment.

6.1.4 Management will be responsible for the periodic visual and electrical re-testing of all insulating gloves, sleeves and blankets. The following maximum re-testing intervals for the items covered by the listed ASTM standards will apply (refer to Table 5):

Table 5: Electrical Test Intervals

ASTM STANDARD	MONTHS
Standard Specification for In-Service Care of Insulating Gloves and Sleeves, ASTM F 496-02a	*6 months for gloves *12 months for sleeves
Standard Specification for In-Service Care of Insulating Blankets, ASTM F 479-06	*12 months for blankets

For line hose and covers	
Standard Specification for In-Service Care of Insulating Line Hose and Covers ASTM F 478-92 (Reapproved 1999)	When found to be damaged or defective

*Gloves, sleeves, and blankets that have been electrically tested but not issued for service will not be placed into service unless they have been electrically tested within the previous twelve months.

6.1.5 Gloves, sleeves and blankets will be marked to indicate compliance with the re-test schedule and will be marked with either the date tested, or the date the next test is due.

6.1.6 When not being used, insulating gloves and sleeves will be stored in glove bags or suitable containers. Insulating blankets will be stored in a canister or other means that offers equivalent protection.

6.1.7 Insulating equipment will be stored away from direct sunlight, steam pipes, radiators and other sources of excessive heat and will be protected from physical damage. Gloves, sleeves and blankets will not be folded while in storage; however, blankets will be permitted to be rolled for storage.

6.1.8 Insulating equipment will be visually inspected for defects and damage, and will be cleaned prior to use each day.

6.1.9 Rubber gloves will be air and water tested at the beginning of each work period and at any other time when the glove's condition is in doubt. The gloves will:

a. Be visually examined over their entire inner and outer surface for any defects, i.e., burns, cuts, cracks, punctures and weak spots; and
b. Have the cuff stretched to detect abrasions and weak spots.

6.1.10 Insulating equipment found to be defective or damaged will be immediately removed from service.

6.2 **Fall Protection**

6.2.1 When work is performed at elevated locations more than 4 feet (1.2 meters) above the ground on poles, towers or similar structures, employees will be required to use the following if other fall protection methods have not been provided (e.g., guardrails, safety nets, etc.):

a. Fall arrest equipment;
b. Work positioning equipment; or
c. Travel restricting equipment; if

6.2.2 The use of body belts for fall arrest systems is prohibited.

Exception: Point to point travel may be used by a qualified person, unless conditions such as ice, high winds, design of the structure, or other conditions (e.g., chemical contaminants) prevents the employee from gaining a firm hand or foothold while traveling.

6.3 **Linemen's Body Belts, Safety Straps and Lanyards**

6.3.1 Linemen's body belts and safety straps purchased after January 1, 1993, will be labeled as meeting the requirements contained in ASTM F 887-91, Standard Specifications for Personal Climbing Equipment.

Exception: Linemen's body belts and safety straps purchased before January 1, 1993 which are labeled/tagged as meeting either the ANSI A10.14 or ASTM F 887 Standard in effect at the time of purchase.

6.3.2 Body belts, safety straps, and lanyards will be inspected by a qualified person each day before use to determine that they are safe. Those determined to be unsafe will be immediately removed from service.

6.3.3 Safety straps will not be used when any portion of the red safety marker strip in the strap is exposed.

6.3.4 Leather will not be used for safety straps.

6.4 **Ladders**

6.4.1 Portable conductive ladders will not be used near energized conductors or exposed energized parts of equipment except as may be necessary in specialized work such as in high voltage substations where non-conductive ladders might present a greater hazard than conductive ladders.

6.4.2 Portable conductive ladders will be legibly marked with signs reading "Caution -Do Not Use Near Energized Electrical Equipment" or equivalent wording.

6.4.3 Portable ladders used on structures will be secured to prevent them from being accidentally displaced.

6.5 **Live Line Tools**

6.5.1 Live line tools will meet the requirements specified in CCR, Title 8, Article 36, Appendix B.

6.5.2 Live line tools will be visually inspected for defects before use each day. Tools to be used will be wiped clean and if defects are indicated such tools will not be used.

6.6 **Hand Tools**

6.6.1 Hydraulic tools which are used on or near exposed energized conductors or equipment will use non-conductive hoses having adequate strength for normal operating pressures. The provisions of Section 3556, General Industry Safety Orders, Title 8, California Code of Regulations, will also apply.

6.6.2 Pneumatic tools which are used on or near exposed energized conductors or equipment will:

a. Have non-conductive hoses having adequate strength for the normal operating pressures, and
b. Have an accumulator on the compressor to collect moisture.

6.6.3 Pressure will be released before connections are broken, unless quick acting, self-closing connectors are used. Hoses will not be kinked.

6.7 **Additional Requirements**

6.7.1 Conductive measuring tapes, ropes or similar measuring devices will not be used when working on or near exposed energized conductors or parts of equipment.

6.7.2 Conductive objects of a length capable of contacting energized conductors will not be carried into the level of such conductors unless suitable means are taken to prevent accidental contact.

6.7.3 Lines used for emergency rescue, such as lowering a person to the ground, will have a minimum breaking strength of 2650 pounds and will be readily available on the job site.

6.7.4 Each employee who is exposed to the hazards of flames or electric arcs will be prohibited to wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee. This subsection prohibits clothing made from the following types of fabrics, either alone or in blends, unless the employee can demonstrate that the fabric has been treated with flame retardant: acetate, nylon, polyester, and rayon.

7 HIGH VOLTAGE OVERHEAD LINES

7.1 General

No employee will be required or permitted to perform any function in proximity to energized high-voltage lines; to enter upon any land, building, or other premises and there engage in any excavation, demolition, construction, repair, or other operation; or to erect, install, operate, or store in or upon such premises any tools, machinery, equipment, materials, or structures (including scaffolding, house moving, well drilling, pile driving, or hoisting equipment) unless and until danger from accidental contact with said high-voltage lines has been effectively guarded against.

7.2 Clearances and Safeguards

Clearances or safeguards will be required and the following provisions will be met:

a. The operation, erection, or handling of tools, machinery, apparatus, supplies, or materials, or any part thereof, over energized overhead high-voltage lines will be prohibited.
b. The operation, erection, handling, or transportation of tools, machinery, materials, structures, scaffolds, or the moving of any house or other building, or any other activity where any parts of the above or any part of an employee's body will come closer than the minimum clearances from energized overhead lines as set forth in Table 6 will be prohibited.
c. Operation of boom-type equipment will conform to the minimum clearances set forth in Table 7, except in transit where the boom is lowered and there is no load attached, in which case the distances specified in Table 6 will apply.
d. Boom-type lifting or hoisting equipment. The erection, operation or dismantling of any boom-type lifting or hoisting equipment, or any part thereof, closer than the minimum clearances from energized overhead high-voltage lines set forth in Table 7 will be prohibited.
e. Storage. The storage of tools, machinery, equipment, supplies, materials, or apparatus under, by, or near energized overhead high-voltage lines is hereby expressly prohibited if at any time during such handling or other manipulation it is possible to bring such tools, machinery, equipment, supplies, materials, or apparatus, or any part thereof, closer than the minimum clearances from such lines as set forth in Table 6.

Table 6: General Clearances Required from Energized Overhead High-Voltage Conductors

Nominal Voltage (Phase to Phase)	Minimum Required Clearance (Feet)
600 – 50,000	6
Over 50,000 – 345,000	10
Over 345,000 – 750,000	16
Over 750,000 – 1,000,000	20

Table 7: Boom-Type Lifting or Hoisting Equipment Clearances Required from Energized Overhead High-Voltage Lines

Nominal Voltage (Phase to Phase)	Minimum Required Clearance (Feet)
600 – 50,000	10
Over 50,000 – 75,000	11
Over 75,000 – 125,000	13
Over 125,000 – 175,000	15
Over 175,000 – 250,000	17
Over 250,000 – 370,000	21
Over 370,000 – 550,000	27
Over 550,000 – 1,000,000	42

7.3 Additional Requirements

7.3.1 The specified clearance will not be reduced by movement due to any strains impressed (by attachments or otherwise) upon the structures supporting the overhead high-voltage line or upon any equipment, fixtures, or attachments thereon.

7.3.2 Any overhead conductor will be considered to be energized unless and until the person owning or operating such line verifies that the line is not energized, and the line is visibly grounded at the work site.

7.4 Warning Signs

The owner, agent, or employer responsible for the operations of equipment will post and maintain in plain view of the operator and driver on each crane, derrick, power shovel, drilling rig, hay loader, hay stacker, pile driver, or similar apparatus, a durable warning sign legible at 12 feet reading: "Unlawful To Operate This Equipment Within 10 Feet Of High-Voltage Lines of 50,000 Volts Or Less."

In addition to the above wording, the following statement in small lettering will be provided on the warning sign: "For Minimum Clearances of High-Voltage Lines In Excess of 50,000 Volts, See California Code of Regulations, Title 8, Article 37, High-Voltage Electrical Safety Orders."

7.5 Notification and Responsibility for Safeguards

When any operations are to be performed, tools or materials handled, or equipment is to be moved or operated within the specified clearances of any energized high-voltage lines, the person or persons responsible for the work to be done will promptly notify the operator of the high-voltage line of the work to be performed and will be responsible for the completion of the safety measures as required by Section 7.2 of this program before proceeding with any work which would impair the aforesaid clearance.

APPENDIX 1 – WORKING ON EXPOSED ENERGIZED PARTS

I. Definitions

Exposed – Not isolated or guarded.

Guarded – Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.
Note: to the definition of "guarded" – Wires that are insulated, but not otherwise protected, are not guarded.

Insulated – Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.
Note: to the definition of "insulated" – When any object is said to be insulated, it is understood to be insulated for the conditions to which it normally is subjected. Otherwise, it is, for the purpose of this program, uninsulated.

Isolated (as applied to location) - Not readily accessible to persons unless special means for access are used.

Statistical Sparkover Voltage – A transient overvoltage level that produces a 97.72 percent probability of sparkover (that is, two standard deviations above the voltage at which there is a 50 percent probability of sparkover).

Statistical Withstand Voltage – A transient overvoltage that produces a 0.14 percent probability of sparkover (that is, three standard deviations below the voltage at which there is a 50 percent probability of sparkover).

II. Determination of Minimum Approach Distance for AC Voltages Greater Than 300 Volts

Voltages of 301 to 5,000 Volts – Test data generally forms the basis of minimum air insulation distances. The lowest voltage for which sufficient test data exists is 5,000 volts, and these data indicate that the minimum air insulation distance at that voltage is 20 millimeters (1 inch). Because the minimum air insulation distance increases with increasing voltage, and, conversely, decreases with decreasing voltage, an assumed minimum air insulation of 20 millimeters will protect against sparkover at voltages 301 to 5,000 volts. Thus, 20 millimeters is the electrical component of the minimum approach distance for these voltages.

Voltages of 5.1 to 72.5 Kilovolts – For voltages from 5.1 to 72.5 kilovolts, the Department of Labor, Occupational Safety and Health Administration bases the methodology for calculating the electrical component of the minimum approach distance on the Institute of Electrical and Electronic Engineers (IEEE) Standard 4-1995, Standard Techniques for High-Voltage Testing. Table 1 lists the critical sparkover distances from that standard as listed in IEEE Std 516-2009, IEEE Guide for Maintenance Methods on Energized Power Lines.

Table 1-Sparkover Distance For ROD-To-ROD Gap

60 Hz Rod-to-Rod sparkover (kV peak)	Gap spacing from IEEE Std 4-1995 (cm)
25	2
36	3
46	4
53	5
60	6
70	8
79	10
86	12
95	14
104	16
112	18
120	20
143	25
167	30
192	35
218	40
243	45
270	50
322	60

Source: IEEE Std 516-2009

The electrical component of the minimum approach distance will be determined by using this table. Employees will determine the peak phase-to-ground transient overvoltage and select a gap from the table that corresponds to that voltage as a withstand voltage rather than a critical sparkover voltage. To calculate the electrical component of the minimum approach distance for voltages between 5 and 72.5 kilovolts, use the following procedure:

1. Divide the phase-to-phase voltage by the square root of 3 to convert it to a phase-to-ground voltage.
2. Multiple that phase-to-ground voltage by the square root of 2 to convert the rms value of the voltage to the peak phase-to-ground voltage.
3. Multiply the peak phase-to-ground voltage by the maximum per-unit transient overvoltage, which, for this voltage range, is 3.0, as discussed later in this appendix. This is the maximum phase-to-ground transient overvoltage, which corresponds to the withstand voltage for the relevant exposure.3
4. Divide the maximum phase-to-ground transient overvoltage by 0.85 to determine the corresponding critical sparkover voltage. The critical sparkover voltage is 3 standard deviations (or 15 percent) greater than the withstand voltage.
5. Determine the electrical component of the minimum approach distance from Table 1 through interpolation.

Table 2 illustrates how to derive the electrical component of the minimum approach distance for voltages from 5.1 to 72.5 kilovolts, before the application of any altitude correction factor, as explained later.

Table 2 – Calculating The Electrical Component of MAD 751 V TO 72.5 kV

Step	**Maximum System Phase-to-Phase Voltage (kV)**			
	15	36	46	72.5
1. Divide by √3	8.7	20.8	26.6	41.9
2. Multiply by √2	12.2	29.4	37.6	59.2
3. Multiply by 3.0	36.7	88.2	112.7	177.6
4. Divide by 0.85	43.2	103.7	132.6	208.9
5. Interpolate from Table 1	3+(7.2/10)*1	14+(8.7/9)*2	20+(12.6/23)*5	35+(16.9/26)*5
Electrical component of MAD (cm)	3.72	15.93	22.74	38.25

Voltages of 72.6 to 800 Kilovolts – For voltages of 72.6 kilovolts, this section bases the electrical component of minimum approach distances, before the application of any altitude correction factor, on the following formula:

Equation 1 – For Voltages of 72.6 to 800 kV

D=0.3048(C+a)VL-GT

Where:
D= Electrical component of the minimum approach distance in air in meters;
C= A correction factor associated with the variation of gap sparkover with voltage;
A= A factor relating to the saturation of air at system voltages of 345 kilovotls or higher;4
VL-G= Maximum system line-to-ground rms voltage in kilovolts – it should be the "actual" maximum, or the normal highest voltage for the range (for example, 10 percent above the nominal voltage); and
T= Maximum transient overvoltage factor per unit.

In Equation 1, C is 0.01: (1) For phase-to-ground exposure that can be demonstrated to consist only of air across the approach distance (gap) and (2) for phase-to-phase exposures if it can be demonstrated that no insulated tool spans the gap and that no large conductive object is in the gap. Otherwise, C is 0.011.

In Equation 1, the term varies depending on whether the employee's exposure is phase-to-ground or phase-to-phase and on whether objects are in the gap. Equations in Table 3 will be used to calculate a. Sparkover test data with insulation spanning the gap from the basis for the equations for phase-to-ground exposures, and sparkover test data with only air in the gap from the basis for the equations for phase-to-phase exposures. The phase-to-ground equations result in slightly higher values of a, and, consequently, produce larger minimum approach distances, than the phase-to-phase equations for the same value of VPeak.

Table 3 – Equations For Calculating The Surge Factor, a

Phase-To-Ground Exposures			
$V_{Peak}=T_{L-G}V_{L-G}\sqrt{2}$	635 kV or less 0	635.1 to 915 kV	915.1 to 1,050 kV
A		$(V_{Peak}-635)/140,000$	$(V_{Peak}-645)/135,000$
$V_{Peak}=T_{L-G}V_{L-G}\sqrt{2}$	More than 1,050 kV		
A	$(V_{Peak}-675)/125,000$		
Phase-To-Phase Exposures[1]			
$V_{Peak}=(1.35T_{L-G}+0.45)V_{L-G}\sqrt{2}$	630 kV or less 0	630.1 to 848 kV	848.1 to 1,131 kV
a		$(V_{Peak}-630)/155,000$	$(V_{Peak}-633.6)/152,207$
$V_{Peak}=(1.35T_{L-G}+0.45)V_{L-G}\sqrt{2}$	1,131.1 to 1,485 kV	More than 1,485 kV	
a	$(V_{Peak}-628)/153,846$	$(V_{Peak}-350.5)/203,666$	

In Equation 1, T is the maximum transient overvoltage factor in per unit. As noted earlier in, section 5.3.1(a) requires that the maximum anticipated per-unit transient overvoltage, phase-to-ground, be determined by an engineering analysis or by assuming a maximum anticipated per-unit transient overvoltage, phase-to-ground, in accordance with Table 5. For phase-to-ground exposures, use this value, called TL-G, as T in Equation 1. IEEE Std 516-2009 provides the following formula to calculate the phase-to-phase maximum transient overvoltage, TL-L, from TL-G:

TL-L=1.35TL-G+0.45

For phase-to-phase exposures, use this value as T in Equation 1.

Provisions for inadvertent movement – The minimum approach distance will include an "adder" to compensate for the inadvertent movement of the worker relative to an energized part or the movement of the part relative to the worker. This "adder" will account for this possible inadvertent movement and provide the worker with a comfortable and safe zone in which to work. The distance for inadvertent movement (called the "ergonomic component of the minimum approach distance") will be added to the electrical component to determine the total safe minimum approach distances used in live-line work.

In the case of live-line work, the employee will first perceive that he or she is approaching the danger zone. Then, the worker responds to the danger and will decelerate and stop all motion toward the energized part. During the time it takes to stop, the employee will travel some distance. This distance will be added to the electrical component of the minimum approach distance to obtain the total safe minimum approach distance.

At voltages from 751 volts to 72.5 kilovolts, the electrical component of the minimum approach distance is smaller than the ergonomic component. At 72.5 kilovolts, the electrical component is only a little more than 0.3 meters (1 foot). An ergonomic component of the minimum approach distance will provide for all the worker's anticipated movements. At these voltages, workers generally use rubber insulating gloves; however, these gloves only protect a worker's hands and arms. Therefore, the energized object will be at a safe approach distance to protect the worker's face. In this case, 0.61 meters (2 feet) is sufficient and practical ergonomic component of the minimum approach distance.

For voltages between 72.6 and 800 kilovolts, employees will use different work practices during energized line work. Generally, employees use live-line tools (hot sticks) to perform work on energized equipment. These tools, by design, keep the energized part at a constant distance from the employees and, thus, maintain the appropriate minimum approach distance automatically.

The location of the worker and the type of work methods the worker is using also influence the length of the ergonomic component of the minimum approach distance. In this higher voltage range, the employees use work methods that more tightly control their movements than when the workers perform work using rubber insulating gloves. The worker, therefore, is farther from the energized line or equipment and shall be more precise in his or her movements just to perform the work. For these reasons, this program adopts an ergonomic component of the minimum approach distance of 0.31 m (1 foot) for voltages between 72.6 and 800 kilovolts.

Table 4 – Ergonomic Component of Minimum Approach Distance

Voltage Range (kV)	**Distance**	
	m	**ft**
0.301 to 0.750	0.31	1.0
0.751 to 72.5	0.61	2.0
72.6 to 800	0.31	1.0

Note: Employees shall add this distance to the electrical component of the minimum approach distance to obtain the full minimum approach distance.

The ergonomic component of the minimum approach distance accounts for errors in maintaining the minimum approach distance (which might occur, for example, if an employee misjudges the length of a conductive object he or she is holding), and for errors in judging the minimum approach distance. The ergonomic component also accounts for inadvertent movements by the employee, such as slipping. In contrast, the working position selected to properly maintain the minimum approach distance will account for all of an employee's reasonably likely movements and still permit the employee to adhere to the applicable minimum approach distance. (See Figure 1). Reasonably likely movements include an employee's adjustments to tools, equipment, and working positions and all movements needed to perform the work. For example, the employee should be able to perform all of the following actions without straying into the minimum approach distance:

- Adjust his or her hardhat,
- Maneuver a tool onto an energized part with a reasonable amount of overreaching or underreaching,
- Reach for and handle tools, material, and equipment passed to him or her, and
- Adjust tools, and replace components on them, when necessary during the work procedure.

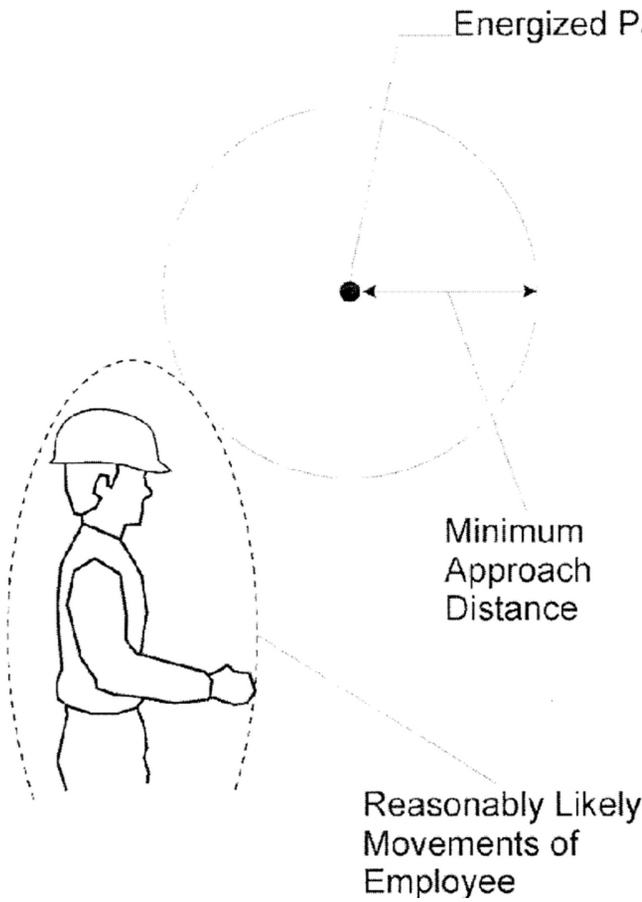

Figure 1 – Maintaining the Minimum Approach Distance

Miscellaneous correction factors – Changes in the air medium that forms the insulation influences the strength of an air gap.

Dielectric strength of air – The dielectric strength of air in a uniform electric field at standard atmospheric conditions is approximately 3 kilovolts per millimeter.

The pressure, temperature, and humidity of the air, the shape, dimensions, and separation of the electrodes, and the characteristics of the applied voltage (wave shape) affect the disruptive gradient.

Atmospheric effect – The empirically determined electrical strength of a given gap is normally applicable at standard atmospheric conditions (20 degrees Celsius, 101.3 kilopascals, 11 grams/cubic centimeter humidity). An increase in the density (humidity) of the air inhibits sparkover for a given air gap. The combination of temperature and air pressure that results in the lowest gap sparkover voltage is high temperature and low pressure. This combination of conditions is not likely to occur. Low air pressure, generally associated with high humidity, causes increased electrical strength. An average air pressure generally correlates with low humidity. Hot and dry working conditions normally result in reduced electrical strength. The equations for minimum approach distances in Table 1 assume standard atmospheric conditions.

Altitude – The reduced air pressure at high altitudes causes a reduction in the electrical strength of an air gap. The minimum approach distance will be increased by about 3 percent per 300 meters (1,000 feet) of increased altitude for altitudes above 900 meters (3,000 feet). Table 7 specifics the altitude correction factor that employees will use in calculating minimum approach distances.

IV. Determining Minimum Approach Distances

Factors Affecting Voltage Stress at the Worksite

System voltage (nominal) – The nominal system voltage range determines the voltage of purposes of calculating minimum approach distances.

Transient overvoltages – Operation of switches or circuit breakers, a fault on a line or circuit or on an adjacent circuit, and similar activities may generate transient overvoltages on an electrical system. Each overvoltage has an associated transient voltage wave shape. The wave shape arriving at the site and its magnitude vary considerably.

Typical magnitude of overvoltages – Table 5 lists the magnitude of typical transient overvoltages.

Table 5 – Magnitude of Typical Transient Overvoltages

Cause	Magnitude (per unit)
Energized 200-mile line without closing resistors	3.5
Energized 200-mile line with one-step closing resistor	2.1
Energized 200-mile line with multistep resistor	2.5
Reclosing with trapped charge one-step	2.2
Opening surge with single restrike	3.0
Fault initiation unfaulted phase	2.1
Fault initiation adjacent circuit	2.5
Fault clearing	1.7 to 1.9

Standard deviation-air-gap withstand – For each air gap length under the same atmospheric conditions, there is a statistical variation in the breakdown voltage. The probability of breakdown against voltage has a normal (Gaussian) distribution. The standard deviation of this distribution varies with the wave shape, gap geometry, and atmospheric conditions. The withstand voltage of the air gap is three standard deviations (3s) below the critical sparkover voltage. (The critical sparkover voltage is the crest value of the impulse wave that, under specified conditions, causes sparkover 50 percent of the time. An impulse wave of three standard deviations below this value, that is, the withstand voltage, has a probability of sparkover of approximately 1 in 1,000.)

Minimum Approach Distances Based on Known, Maximum-Anticipated Per-Unit Transient Overvoltages

Determining the minimum approach distance for AC Systems – The maximum anticipated per-unit transient overvoltage, phase-to-ground, will be determined through an engineering analysis or by assuming a maximum anticipated per-unit transient overvoltage, phase-to-ground, in accordance with Table 5. When an engineering analysis of the system is conducted and determines that the maximum transient overvoltage is lower than specified by Table 5, it will be ensured that any conditions assumed in the analysis, for example, that employees block reclosing on a circuit or install portable protective gaps are present during energized work. To ensure that these conditions are present, new livework procedures reflecting the conditions and limitations set by the engineering analysis may be instituted.

Calculation of reduced approach distance values – The following steps may be taken to reduce minimum approach distances when the maximum transient overvoltage on the system (that is, the maximum transient overvoltage without additional steps to control overvoltages) produces unacceptable minimum approach distances:

1. Determine the maximum voltage (with respect to a given nominal voltage range) for the energized part.
2. Determine the technique to use to control the maximum transient overvoltage. (See "Methods of Controlling Possible Transient Overvoltage Stress Found on a System" and "Minimum Approach Distance Based on Control of Maximum Transient Overvoltage at the Worksite" of this appendix.) Determine the maximum transient overvoltage that can exist at the worksite with that form of control in place and with a confidence level of 3s. This voltage is the withstand voltage for the purpose of calculating the appropriate minimum approach distance.
3. Direct employees to implement procedures to ensure that the control technique is in effect during the course of the work.
4. Using the new value of transient overvoltage in per unit, calculate the required minimum approach distance from Table 1.

Methods of Controlling Possible Transient Overvoltage Stress Found on a System

Operation of circuit breakers – The maximum transient overvoltage that can reach the worksite is often the result of switching on the line on which employees are working. Disabling automatic reclosing during energized line work, so that the line will not be reenergized after being opened for any reason, limits that maximum switching surge overvoltage to the larger of the opening surge or the greatest possible fault-generated surge, provided that the devices (for example, insertion resistors) are operable and will function to limit the transient overvoltage and the circuit breaker restrikes do not occur. The proper functioning of insertion resistors and other overvoltage-limiting devices will be ensured when the engineering analysis assumes their proper operation to limit the overvoltage level. If the reclosing feature cannot be disable (because of system operating conditions), other methods of controlling the switching surge level may be necessary.

Transient surges on an adjacent line, particularly for double circuit construction, may cause a significant overvoltage on the line on which employees are working. The engineering analysis will account for coupling to adjacent lines.

Surge arresters – The use of modern surge arresters allows a reduction in the basic impulse-insulation levels of much transmission system equipment. The primary function of early arresters was to protect the system insulation from the effects of lightning. Modern arresters not only dissipate lightning-caused transients, but may also control many other system transients caused by switching or faults.

Properly designed arresters may be used to control transient overvoltages along a transmission line and thereby reduce the requisite length of the insulator string and possibly the maximum transient overvoltage on the line.

Switching Restrictions – Another form of overvoltage control involves establishing switching restrictions, whereby the operation of circuit breakers until certain system conditions are present will be prohibited.

Minimum Approach Distance Based on Control of Maximum Transient Overvoltage at the Worksite

Where controls of maximum transient overvoltage have been instituted at the worksite by installing portable protective gaps, the minimum approach distance may be calculated by using the following steps:

1. Select the appropriate withstand voltage for the protective gap based on system requirements and an acceptable probability of gap sparkover.
2. Determine a gap distance that provides a withstand voltage greater than or equal to the one selected in the first step.
3. Use 110 percent of the gap's critical sparkover voltage to determine the phase-to-ground peak voltage at gap sparkover (VPPG Peak).
4. Determine the maximum transient overvoltage, phase-to-ground, at the worksite from the following formula:
5. T=VPPGPeak/VL-G√2
6. Use this value of T12 in the equation in Table 1 to obtain the minimum approach distance. If the worksite is no more than 900 meters (3,000 feet) above sea level, this value of T may be used to determine the minimum approach distance from Table 14 through Table 21.
   Note: All rounding will be to the next higher value (that is, always round up).

Sample Protective Gap Calculations

Problem: Employees are to perform work on a 500-kilovolt transmission line at sea level that is subject to transient overvoltages of 2.4 p.u. The maximum operating voltage of the line is 550 kilovolts. Determine the length of the protective gap that will provide the minimum practical safe approach distance. Also, determine what that minimum approach distance is:

1. Calculate the smallest practical maximum transient overvoltage (1.25 times the crest phase-to-ground).
   550kVx√2/√3x1.25=561kV
   This value equals the withstand voltage of the protective gap.
2. Using test data for a particular protective gap, select a gap that has a critical sparkover voltage greater than or equal to:
   561kV ÷ 0.85 = 660kV
   For example, if a protective gap with a 1.22-m (4.0-foot) spacing tested to a critical sparkover voltage of 665 kilovolts (crest), select this gap spacing.
3. The phase-to-ground peak voltage at gap sparkover (VPPG Peak) is 110 percent of the value from the previous step:
   665kV X 1.10 = 732kV

This value corresponds to the withstand voltage of the electrical component of the minimum approach distance.

4. Use this voltage to determine the worksite value of T:
   T=732/564=1.7 p.u.
5. Use this value of T in the equation in Table 1 to obtain the minimum approach distance:
   MAD = 2.29m (7.6 ft)

Location of Protective Gaps

Adjacent structures – Protective gaps may be installed on a structure adjacent to the worksite, as this practice does not significantly reduce the protection afforded by the gap.

Terminal stations - Gaps installed at terminal stations of lines or circuits provide a level of protection; however, that level of protection shall not extend throughout the length of the line to the worksite. The use of substation terminal gaps raises the possibility that separate surges could enter the line at opposite ends, each with low enough magnitude to pass the terminal gaps without sparkover. When voltage surges occur simultaneously at each end of a line and travel toward each other, the total voltage on the line at the point where they meet is the arithmetic sum of the two surges. A gap installed within 0.8 km (0.5 mile) of the worksite will protect against such intersecting waves. Engineering studies of a particular line or system may indicate that employees may be adequately protected by installing gaps at even more distant locations. In any event, unless the default values for T from Table 5 are being used, the determine of T will take place at the worksite.

Worksite – If protective gaps are installed at the worksite, the gap setting establishes the worksite impulse insulation strength. Lightning strikes as far as 6 miles from the worksite can cause a voltage surge greater than the gap withstand voltage, and a gap sparkover can occur. In addition, the gap can sparkover from overvoltages on the line that exceed the withstand voltage of the gap. Consequently, the employer shall protect employees from hazards resulting from any sparkover that could occur.

Disabling Automatic Reclosing

There are two reasons to disable the automatic-reclosing feature of circuit-interrupting devices while employees are performing live-line work:

- To prevent reenergization of a circuit faulted during the work, which could create a hazard or result in more serious injuries or damage than the injuries or damage produced by the original fault;
- To prevent any transient overvoltage caused by the switching surge that would result if the circuit were reenergized. However, due to system stability considerations, it may not always be feasible to disable the automatic-reclosing feature.