

# **ENERGIZED FACILITY MAINTENANCE**

**MAY 1990**

**BUREAU OF RECLAMATION**

**FACILITIES INSTRUCTIONS, STANDARDS, AND TECHNIQUES  
VOLUME 3 - 29**

Internet Version of this Manual Created  
July 2000

*The Appearance of the Internet Version of This Manual  
May Differ From the Original, but the contents Do Not*

## **PURPOSE AND SCOPE**

The purpose of this FIST is to provide rules governing energized facility maintenance for Bureau of Reclamation employees or through contract. Some offices may use it as a guide while serving on boards with other Federal agencies.

Prepared by

Howard E. Watson  
Senior Electrical Engineer for Power O&M  
FACILITIES ENGINEERING BRANCH  
ENGINEERING DIVISION  
DENVER OFFICE  
DENVER, COLORADO

# CONTENTS

Section	Page
1	Energized Facility Maintenance - General . . . . . 1
1.1	Definitions . . . . . 1
1.2	Scope . . . . . 1
2	Operating Equipment near Energized Equipment . . . . . 3
2.1	Operation of Equipment near High-voltage Facilities . . . . . 3
2.2	Minimum Distance Requirements for Equipment being Operated near Energized Facilities for Power O&M Employees . . . . . 4
3	Hotstick Work . . . . . 6
3.1	Minimum Distances . . . . . 6
3.2	Hot Work . . . . . 6
3.3	Hot-Line Tools . . . . . 7
3.4	Conductive Objects . . . . . 8
3.5	Untying Insulators . . . . . 8
3.6	Transporting Tools . . . . . 8
3.7	Tailgate Briefing . . . . . 8
3.8	Transmission Line Construction . . . . . 8
4	Live-Line Barehand Maintenance . . . . . 9
4.1	General . . . . . 9
4.2	Insulated Aerial-Lift Equipment (Vehicle-Mounted) . . . . . 12
4.3	Insulating Ladders . . . . . 15
4.4	Insulated Tower Booms . . . . . 17
4.5	Conductor Carts . . . . . 19
5	Insulated Hand Tools . . . . . 21
5.1	Scope . . . . . 21
5.2	Tools . . . . . 21
5.3	Applicable Standards . . . . . 21
5.4	In-service Inspection . . . . . 21
<b>Appendices</b>	
A	Acceptance Testing and In-service Testing of Live-line Tools . . . . . A-1
B	Acceptance Testing and In-service Inspection and Testing of Insulated Aerial Lift Equipment (Vehicle Mounted) . . . . . B-1

## Bibliography

# ENERGIZED FACILITY MAINTENANCE

## FIST Volume 3 - 29

### Section 1. Energized Facility Maintenance - General

#### 1.1 Definitions

Insulating - Used to describe a material made up solely of insulation (dielectric substance offering a high resistance to the flow of current) or that part of a device that provides the insulation.

Insulated - Separated from other conducting surfaces by a insulating material.

#### 1.2 Scope

This volume is written to provide procedures for operating equipment near energized equipment, hotstick work, live-line barehand work, and insulated tools for low voltage work. Previously where hot work was authorized on energized circuits or apparatus between 600 and 5,000 volts, rubber gloves, linemen's protector shields, hose, rubber blankets, etc. were used. Because of the problems of personnel training, maintaining, and testing these rubber goods, Reclamation no longer uses rubber goods for energized facility maintenance. Personnel using techniques covered in this FIST on equipment rated 600-volts and above shall be trained in Power System Clearance Procedures, FIST Volume 1 - 1; and depending on the type and use, as detailed in subsequent sections, specialized training, testing, and certification may be required.

Much of the material contained herein was in sections 8 and 9 of the superceded Power Systems Safety Standards. Some material from section 14 is also included. This material was intentionally left out of Reclamation O & M Safety Standards because it was felt that it contained too much specialized information that was in general not applicable to most O&M employees.

1.2.1. Operating equipment near energized equipment occurs often when equipment is being added or replaced in existing switchyards and substations.

1.2.2. Hotstick work is generally limited to measuring distances between an energized conductor and ground or another energized conductor, using a hotstick-held clamp-on ammeter, testing a conductor (buzzing) to determine if it is

energized, installing and removing personal protective grounds, operating hook disconnects, and removing and replacing fuses.

1.2.3. Live-line barehand work will normally be performed by other agencies. Reclamation owned insulated aerial devices (at rated voltage or less than rated voltage) will normally be for use on deenergized and grounded equipment.

1.2.4. Insulated tools for low voltage work may be used on energized circuits rated below 600-volts, using Danger Tags. These tools may be used on deenergized and grounded equipment.

## Section 2. Operating Equipment Near Energized Equipment.

### 2.1. Operation of Equipment Near High-voltage Facilities.

Except for power O&M employees operating equipment in strict accordance with this FIST, no employee shall set up or operate any piece of mechanized equipment where it is possible to bring such equipment or any part thereof within the minimum clearance distance specified in the following table of any high-voltage (600 volts and above) line or installation unless at least one of the following safety precautions has been taken:

- a. The utility company or owner of the line has been notified, the line deenergized and grounded, and positive control measures taken to prevent energization of the line during the progress of the work.
- b. Adequate guards have been installed, or barriers erected, to prevent the equipment or any part thereof from coming within the specified minimum clearance distance of an energized conductor or part.
- c. A full-time signalman, aided by an automatic warning device installed on the equipment and/or an insulated measuring device, is utilized to warn the operator when the equipment approaches the specified minimum distance.

Nominal phase-to-phase voltage Kilovolts	Minimum Distance	
	Feet	M
50 and below	10	3.0
	(minimum for any energized conductor)	
69	11	3.2
115	12	3.7
138	13	3.9
161	14	4.2
230	16	4.9
345	20	6.0
500	25	7.6

Use 10 feet (3 meters) plus 0.4 inch (0.01) meter for each 1 kV over 50kV for other voltages.

NOTE: A NOTICE OF THE MINIMUM CLEARANCE (sic, should have been DISTANCE) REQUIREMENTS SHALL BE POSTED IN THE OPERATOR'S CAB OF

CRANES, SHOVELS, BACKHOES, AND RELATED EQUIPMENT. A decal, Form 7-1941, for this purpose is available on request from the Denver Office (Attention D-7923A).

2.1.1. Grounding Mobile Equipment. Mobile rubber-tired equipment with booms or extensions above the cab level shall be equipped with a minimum 1/0 AWG extra flexible copper or equivalent ground lead for use whenever the equipment is operated where it is possible to bring any part of the equipment within 10 feet (3 meters) [15 feet (4.5 meters) for 500 kV and above] of energized high-voltage lines and equipment. See [Paragraph 4.2.3](#) for grounding method.

## **2.2 Minimum Distance Requirements for Equipment Being Operated Near Energized Facilities by Power O&M Employees.**

Distance requirements for equipment operated by nonpower employees are covered in paragraph 2.1. Power employees trained and certified in equipment operation for energized facility maintenance may use mechanized equipment in conjunction with work on or near energized facilities if no part of the mechanized equipment is operated within 10 feet (3 meters) of an energized part, except that:

2.2.1. For vehicles and booms, in transit with no load and boom lowered, the equipment distance shall be a minimum of 4 feet (1.2 meters) for voltages less than 50 kV, 10 feet (3 meters) for voltages over 50 kV and up to and including 345 kV, and 16 feet (4.9 meters) for voltages over 345 kV and up to and including 750 kV.

2.2.2.. Equipment may be driven or moved within 10 feet (3 meters) of energized parts, but not less than the distances specified in [Section 3](#), if the distance is monitored by an observer.

2.2.3. Equipment may be operated between 10 feet (3 meters) and the distances specified in [Section 3](#) if all of the following conditions are met:

- a. Specific written procedures, including a job hazard analysis, as defined in ROMSS, for the proposed operation have been developed, signed by the foreman, and reviewed by the foreman's supervisor.
- b. The foreman has the written procedures in his or her possession and has reviewed them with all crew members prior to the start of the operation and each day that the work continues thereafter (tailgate meetings).
- c. A Hot Line Order has been issued.

d. The activity is being performed under the direct supervision of a crew foreman trained and competent in this type of work. The foreman is the Job Supervisor (person to whom Hot Line Order has been issued).

e. The critical distance between energized parts and the equipment or load is monitored with an insulating measuring device while the equipment or load is being moved within the 10-foot (3-meter) distance.

f. Each piece of mechanized equipment is properly grounded with a minimum 1/0 AWG extra-flexible copper or equivalent ground lead (refer to paragraph 3. for grounding method. No one, other than necessary operating or work personnel, are permitted in contact with equipment, during its operation. The operation or work personnel are on the equipment, i.e. not operating from a position on the ground.

2.2.4. Noninsulated aerial-lift equipment may be used for tree trimming, pole spraying, and similar activities in accordance with [paragraph 2.2.2](#) above, provided the operating capabilities of the equipment meet all the mechanical conditions outlined in [Section 4](#) for aerial-lift equipment.

### Section 3. HOTSTICK WORK

#### 3.1 MINIMUM DISTANCES.

Employees shall keep themselves and objects (except hot-line tools) carried by them beyond the minimum distances specified in the table on the this page from unprotected energized conductors and parts. For live-line barehand work using insulated aerial lifts, see [Section 4](#) for applicable minimum working distances and safety rules.

#### 3.2 HOT WORK.

Hot work is not authorized for Reclamation employees on energized circuits or apparatus between 600 and 5,000 volts. Routine work, such as fuse replacement, switching, checking for current or voltage is not considered hot work for this limitation. Rubber gloves, linemen's protector shields, hose, and rubber blankets are not used. Approved hot-line tools may be used for work above 5000 volts. Before work begins, a Hot Line Order shall be obtained and all automatic reclosing features capable of reenergizing the circuit shall be removed from service and tagged. Such work shall be performed under the personal supervision of the designated crew foreman or supervisor at the jobsite.

#### ALTERNATING CURRENT-MINIMUM DISTANCES

Voltage range (phase-to-phase kilovolt)	Minimum working and clear hot-stick distance	
	(ft-in)	Meters
2.1 to 15.0	2 - 0	0.6
15.1 to 35.0	2 - 4	0.7
35.1 to 46.0	2 - 6	0.8
46.1 to 72.5	3 - 0	0.9
72.6 to 121.0	3 - 4	1.0
138.0 to 145.0	3 - 6	1.1
161.0 to 169.0	3 - 8	1.2
230.0 to 242.0	5 - 0	1.5
345.0 to 362.0*	7 - 0	2.1
500.0 to 552.0*	11 - 0	3.4
700.0 to 765.0*	15 - 0	4.6

\*Note: For 345 to 362, 500 to 552, and 700 to 765 kilovolts, the minimum working distance and the minimum clear hot-stick distance may be reduced provided that



such distances are not less than the shortest distance between the energized part and a grounded surface. (The above data are from table V-1 of 29 CFR 1926.950-OSHA; metric added.)

A telescoping fiberglass measuring stick, alternately yellow (or white) and red striped at 0.1-meter intervals, with every tenth (1 meter) stripe black, is recommended for monitoring minimum distances.

### **3.3 HOT-LINE TOOLS**

3.3.1 Minimum Working Distances. Hot-line tools shall be of sufficient length to provide a minimum free insulated working distance between any part of the workmen and the energized conductor or part being worked on as specified in [paragraph 3.2](#).

3.3.2 Care of Hot-line Tools. All hot-line tools when not in use shall be kept clean and dry in an approved protective container. To prevent scratching while inserting and removing hot-line tools stored in pipes, it is recommended that PVC pipes be used rather than steel pipes.

3.3.3 Maintenance of Hot Sticks. Any splitting or deep cracks in the insulating material, or cracks or other signs of weakness in metal parts shall be considered sufficient reason for discarding the particular tool. FRP (fiberglass reinforced plastic) portions of hot-stick tools shall be maintained in accordance with the manufacturer's recommendations. The use of emery or carborundum papers, steel wool, or paint brushes that have been used for other purposes shall NOT be used for refinishing hot-stick equipment.

3.3.4. Inspection of Hot-line Tools. Hot-line tools shall be visually inspected prior to use.

3.3.5 Testing Hot-line Tools. Insulated portions of hot-line tools shall be properly tested for insulation value at least once a year and the results logged. Inservice care, inspection, testing, and use shall be in accordance with the latest ASTM (American Society for Testing and Materials) specifications or IEEE (Institute of Electrical and Electronic Engineers) guidelines. In the absence of such specifications and guidelines, inservice care, inspection, testing, and use shall be in accordance with the recommendations by reputable tool manufacturers and accepted practices among comparable electric utility organizations.

### **3.4 CONDUCTIVE OBJECTS.**

Metal tapes, fabric measuring tapes having metal threads, level surveying rods, etc., shall be kept away from all high-voltage lines and apparatus.

### **3.5 UNTYING INSULATORS.**

When untying insulators, linemen shall keep the tie wire cut short enough so that it cannot reach any part of the supporting structure.

### **3.6 TRANSPORTING TOOLS.**

Tools shall not be thrown into boxes or truck beds, but shall be carefully placed and secured in place.

### **3.7 TAILGATE BRIEFING.**

Before starting transmission line work, a tailgate briefing shall be held so that all members of the crew understand the job and know how the foreman wants it done. Points to be discussed are covered in ROMSS Section 8.

### **3.8 TRANSMISSION LINE CONSTRUCTION.**

Transmission lines, shall be constructed or dismantled in accordance with the safety requirements of CSS, section 27, "Transmission and Distribution Line Construction".

## **SECTION 4. LIVE-LINE BAREHAND MAINTENANCE**

### **4.1 GENERAL**

4.1.1 Clearances and Supervision. Before using the barehand technique of performing work directly on energized high-voltage conductors or parts, a check shall be made of: (1) the voltage rating of the circuit on which the work is proposed, (2) the distances from energized parts to ground and to other energized phases, and (3) the voltage limitations of the personnel-support equipment intended to be used.

Only equipment designed, tested, and approved for live-line barehand work shall be used. All work shall be personally supervised by a regular crew foreman or a supervisor trained and certified to perform this work.

4.1.2 Hot Line Order. A Hot line Order shall be obtained before working on any energized line or equipment.

4.1.3 Instruction and Certification. Workmen using the barehand technique shall be certified in writing, by a qualified certifying official designated by the project manager or regional director, that they have:

- a. Satisfactorily completed an 80-hour basic training course of instruction and practice with one or more accepted types of personnel-support equipment.
- b. Been examined at least annually to test their knowledge of barehand rules and procedures and their ability to safely perform barehand work, including the control and positioning of personnel-support equipment being used.
- c. Successfully passed an annual physical examination and demonstrated their physical fitness to perform barehand work.

4.1.4 Supervisory Responsibility. The foreman or supervisor must know the operating capabilities of each member of his or her crew and maintain continuous surveillance over the physical and mental condition of each member of the crew. No person shall be allowed to work as a crew member if that person is suspected of being in such a physical or mental state as to jeopardize the safe operation of the crew or equipment. The designated crew foreman or supervisor shall be responsible to ensure that detailed plans are worked out in advance, using "as-built" drawings or actual measurements, to determine the location of all grounded and energized parts in the vicinity of the proposed work. Safe distances

to the personnel-support equipment, including movements during the work, shall be determined in advance and strictly observed.

4.1.5 Procedures. Whenever possible, a written procedure shall be provided to the crew for each different type of work prior to initiation of the work. Specific written procedures shall be provided for major programs, particularly substation maintenance and complex transmission line functions, Procedures shall not be arbitrarily disregarded or changed during the actual work. Procedural changes during the work program shall be carefully developed through discussion among well-trained craft and supervisory personnel, with the original procedure-writer participating, if available. Procedures shall be continuously examined and updated to take advantage of new equipment and work methods.

4.1.6 Electric Storms. Work shall not be performed while there is any indication of lightning in the area.

4.1.7 Inspection Measures. The equipment shall be regularly and thoroughly inspected in accordance with manufacturers' and/or operating office's instructions. A rigid preventive maintenance program, including appropriate maintenance checklists, shall be initiated and carried out. These maintenance checklists shall be maintained in the responsible operating office.

4.1.8 Conductive Clothing. Personnel using this technique shall wear conductive footwear. Approved conductive clothing may be used at any time, but it shall be used for all barehand work at 200 kilovolts phase-to-phase and above, or when specified.

4.1.9 Minimum Distances. When approaching, leaving, or bonded to an energized part, workmen shall maintain themselves and their support platforms at a distance from grounded parts no less than specified in column (a) shown in the table on the following page. Also, the minimum phase distance as specified in column (b) below shall be maintained from the workmen and their support platforms to other phase conductors. The minimum phase-to-ground and phase-to-phase distances may be cumulative during nonbonded operations.

4.1.10 Handlines and Conductive Materials. The use of handlines between personnel-support equipment and the ground is prohibited. Approved nonconductive-type handlines may be used from line to ground when not supported by the support platform(s). The nonconductive-type handlines shall be stored and protected from foreign matter by use of nonconductive canisters. No conductive materials over 3 feet (1 meter) long shall be placed on support platforms except appropriate length jumpers, armor rods, and approved tools.

## BAREHAND MINIMUM DISTANCES

Voltage range (phase-to-phase kilovolts)	(a)		(b)	
	Phase-to-ground (ft-in) Meters		Phase-to-phase (ft-in) Meters	
30.0- 35.0	2-4	0.7	2-4	0.7
35.1 - 46.0	2-6	0.8	2-6	0.8
46.1 - 72.5	3- 0	0.9	3-0	0.9
72.6- 121.0	3 -4	1.0	4-6	1.4
138.0 - 145.0	3 - 6	1.1	5 - 0	1.5
161.0 - 169.0	3 - 8	1.2	5 - 6	1.7
230.0 - 242.0	5 - 0	1.5	8 - 4	2.5
345.0 - 362.0	7 - 0	2.1	13 - 4	4.1
500.0 - 552.0	11 - 0	3.4	20 - 0	6.1

Note: These data are from table V-2 of 29 CFR 1926.955-OSHA; metric added.

4.1.11 Measuring Sticks. When the nature of the work requires that minimum distances be approached, calibrated insulating measuring sticks shall be used to verify the distances. Crews using the live-line barehand technique shall be equipped with at least one short insulating telescoping measuring stick for use from support platforms and at least one long insulating telescoping measuring stick for use from the ground. A telescoping fiberglass measuring stick, alternately yellow (or white) and red striped at 0.1-meter intervals, with every tenth (1 meter) stripe black, is recommended for monitoring minimum distances.

4.1.12 Wooden Structure Members. For circuits mounted on poles or attached to wooden structures, all wood members shall be considered at ground potential.

4.1.13 Testing Insulators. Prior to replacement of broken or defective suspension-type insulators by barehand methods, each insulator in the string shall be tested by means of a meter-type insulator tester mounted on a hot stick, started at the "hot end" of the insulator string, with individual insulator meter readings recorded on a graph. If the recorded meter reading indicates more than 20 percent of the insulators have no insulation value, surge limiting devices must be properly installed prior to barehand replacements or the insulators must be replaced by other than barehand procedures. For work at the energized terminal end of an acceptable insulator string, the aerial platform must be positioned so that no more than one insulator or 10 percent of the insulator string (whichever is greater) is shunted by the aerial platform, including the workman's body and tools, with distances from grounded parts and other phases not less than specified in [subsection 4.1.9](#). Shunting of insulator(s) in an insulator string containing insulators

with no insulation value is permissible only if the insulator(s) being shunted is the insulator(s) with no insulation value, or if work is being performed between properly installed surge limiting devices.

## **4.2 INSULATED AERIAL-LIFT EQUIPMENT (VEHICLE-MOUNTED)**

NOTE: As used in this section, the term "aerial-lift platforms" includes "aerial-lift buckets."

4.2.1 Voltage Limitation. The live-line barehand technique using aerial-lift platforms is limited to use on energized circuits with a line-to-line voltage rating exceeding 30 kilovolts.

4.2.2 Operating Practices. Normally two certified persons should be on the aerial platform at the worksite whenever this technique of live-line barehand work is being used, except (1) that during training periods the occupant(s) may be uncertified while undergoing instructions; (2) when it is deemed necessary that a specific individual, such as an engineer or other specialist, participate during a test or inspection program, such occupant need not necessarily be a trained individual; and (3) with the specific prior approval of the foreman's supervisor, special work on transmission lines or in substations may be performed with a single workman aloft. The number of certified personnel required on the aerial platform shall be dictated by the type of aerial-lift equipment being used, the physical and technical difficulty of the work to be performed, and the distance restrictions surrounding the work area. When two or more workmen are on the aerial platform, they shall work together as a team.

4.2.3 Grounding and Outriggers. Before the aerial platform is elevated, the outriggers on the vehicle shall be extended and adjusted to stabilize the vehicle, and the body of the vehicle shall be properly grounded with a minimum 1/0 AWG extra-flexible copper or equivalent ground lead. The ground should be attached to a ground rod by the side of and near the vehicle center. In no case shall the ground lead be attached to a nearby structure or pole ground, except in a substation or switchyard equipped with a groundmat, a ground of 10 feet or less may be connected to the nearest structure ground or in an area on concrete or on solid rock, where it is impossible to drive a ground rod, the closest available ground may be used. When two or more aerial lift devices are being used and it is possible for a workman to bridge the gap between the devices, they shall be bonded together or ground leads connected to the same ground rod located between the two aerial lift devices.

4.2.4 Preoperative Tests. Before moving the aerial-lift equipment into the work position, all controls (ground level and bucket or platform) shall be checked. In

addition, for aerial-lift equipment with hydraulic lines to controls at platform level, the aerial platform shall be raised to its maximum height and left in the raised position for 5 minutes. Initial contact of an energized feature shall be made with one on the platform so that the dielectric arm-current may be measured. No one standing on the ground shall be in contact with the vehicle while tests are being made. This arm-current reading shall be taken from a position on the equipment before starting work each day, each time during the day when a higher voltage is going to be worked, and when changed conditions indicate a need for additional tests. If the dielectric arm-current is less than 1 microampere for each kilovolt of nominal line-to-line voltage, the aerial platform may be lowered and work started. A written record of these tests shall be maintained both with the equipment and in the responsible operating office. Work operations shall be suspended immediately upon indication of a malfunction in the equipment.

4.2.5 Cleaning Surfaces. Workmen shall thoroughly clean the bottom of conductive footwear before entering the aerial platform. The floor of the aerial platform shall be inspected for dirt or other material which might prevent good contact between the floor and conductive footwear. Foreign material discovered by this inspection shall be removed immediately.

4.2.6 Warning and Control Procedures. One person, capable of operating all the controls, shall be stationed on the ground near the vehicle when workmen are on the aerial platform. He or she shall keep other persons from walking under the work area, and shall keep them clear of the vehicle when the aerial platform is elevated. When workmen are on the aerial platform, all movements of the lift assembly shall be controlled by the workmen aloft, except under emergencies. Under such emergency conditions, the ground operator shall mount the vehicle by means of an insulated or insulating device or by other means such that the operator does not simultaneously contact the vehicle and ground. No one on the ground shall be in contact with the vehicle or protective grounds while the aerial platform is in a raised position.

4.2.7 Bonding Straps. Initial contact with the energized circuit should be made by a wand bonded to the aerial platform. The braided bonding straps from the aerial platform shall be attached to the energized conductor before a workman otherwise makes bodily contact with the energized circuit. Bonding straps and connections shall be thoroughly inspected before use. At least one bonding strap shall remain attached to the energized conductor at all times while work is being performed on the circuit. Before an energized conductor is opened, a temporary jumper with positive connections and adequate current carrying capacity shall be used as a bridge to prevent the bonding straps from becoming the source of circuit conductance, Bonding straps, including anchorage and clips,

shall be maintained in first-class condition and their length confined to that necessary to permit free working conditions. Wand and bonding straps shall be so restrained as to prevent them from falling below the bottom of the platform.

4.2.8 Special Minimum Distance Precautions. When observing distances specified in [subsection 4.1.9](#), be sure that:

No portion of the insulating section of the aerial-lift equipment is permitted to be less than the phase-to-ground distance, as shown in column (a), from an external grounded part, or from any grounded parts such as the lower arm sections or portions of the vehicle. This requirement is particularly important when work is being performed with an articulating-boom-type assembly in either a low or a jackknifed position.

No portion of the grounded section of the aerial-lift equipment is permitted to less than phase-to-ground distance to an energized conductor, as shown in column (a)

No portion of a workman, tools, aerial platform, or insulating section of the aerial-lift equipment is permitted to be less than phase-to-phase distance to another energized conductor, as shown in column (b).

For work at the energized terminal end of a bushing on a circuit with a phase-to-phase voltage of less than 200 kilovolts, the aerial platform must be positioned so that none of the bushing insulation is shunted by the aerial platform, with distances from grounded parts and other phases not less than specified in [subsection 4.1.9](#). For work at the energized terminal end of a bushing on a circuit with a phase-to-phase voltage of 200 kilovolts or more, the aerial platform must be positioned so that no more than 10 percent of the bushing insulation is shunted by the aerial platform, with distances from grounded parts and other phases not less than specified in [subsection 4.1.9](#).

4.2.9 Distance Tables. The minimum distance tables as shown in [subsection 4.1.9](#) shall be printed on a plate of nonconductive material and shall be mounted in or near the aerial platform(s) so as to be visible to the operator of the aerial-lift equipment.

4.2.10 Safety Belts. When working aloft, both legs shall be inside the aerial platform at all times, with at least one foot on the bottom of the aerial platform. Workmen shall be belted in with approved-type safety belts.



4.2.11 Overstressing Equipment. The aerial platform and insulating section of the aerial-lift equipment shall not be overstressed by attempting to lift or support weights (test loads may be in excess) in excess of the manufacturer's rating. To protect the fiberglass parts, none of the aerial platform, or insulating section of the aerial-lift equipment, shall be used as a fulcrum for prying or lifting. Where a short auxiliary insulated boom is provided, it may be used for lifting or supporting procedures if permitted by the operating office.

4.2.12 Testing of Aerial-lift Equipment. In addition to the preoperative tests required in [subsection 4.2.4](#), all insulated aerial-lift equipment shall be periodically inspected and tested in accordance with subsection 4.8.2.

### **4.3 INSULATING LADDERS**

4.3.1 Voltage Limitation. Insulating ladders may be used as personnel support for work performed by the barehand technique on circuits or equipment with a phase-to-phase voltage rating exceeding 30 kilovolts, provided minimum distances specified in subsection 4.1.9 are maintained.

4.3.2 Operating Practices. Only certified personnel shall perform live-line work from energized insulating ladders, except (1) that during training

periods, a workman undergoing training may practice mounting and dismounting and dismounting the insulating ladder and may perform specific work from an energized insulating ladder; and (2) when it is necessary that an engineer or other specialist participate in a specific test or inspection program involving the use of an energized insulating ladder, such specialist need not be a certified workman as specified in [subsection 4.1.3](#).

4.3.3 Additional Requirements. The following requirements shall be observed in addition to [subsection 4.1](#).

a. Preoperative Tests.- Tests shall be made before starting work each day, each time during the day when a higher voltage is going to be worked, and when changed conditions indicate a need for additional tests. A microammeter designed for use with insulating ladders shall be used for testing the dielectric current through the ladder legs with all legs bonded together at the metering point. If the measured dielectric current after 1 minute is less than 0.333 microampere for each kilovolt of nominal phase-to-phase voltage, the insulating ladder may be placed and the work started. A written record of these tests shall be maintained both with the equipment and in the responsible operating office. Work operations shall be suspended immediately upon indication of a malfunction in the equipment.

b. Clothing.- Workmen on the insulating ladder shall be completely clothed in conductive clothing designed for barehand work. Workmen on steel towers shall also wear conductive footwear.

c. Bonding.- Before beginning work, workmen shall bond their conductive clothing to the energized circuit. Additionally, if two workmen are involved at the same work location on an insulating ladder, they shall bond their clothing to each other.

d. Rigging.- Before a workman is allowed on the insulating ladder, the crew foreman must first make sure that all rigging is complete and secure.

e. Passing Objects.- Objects that are to be passed by hot stick to the workman on the insulating ladder shall be passed only after he or she is bonded to the energized circuit. These items shall not be passed directly to the workman, but shall first be touched to the energized circuit.

f. Safety Straps.- Except when mounting or dismounting the insulating ladder, workmen shall maintain their safety straps around the insulating ladder at all times. Insulating ladders shall be equipped with nonconductive safety ropes along the rails. The use of ladder snaps on the safety straps is required. Workmen shall be snapped to the insulating ladder when they are in a working position and when the insulating ladder is being moved.

4.3.4 Structure-mounted Ladders. The following additional requirements shall be observed for structure-mounted insulating ladder operations:

a. Securing Ladder.- One end of the insulating ladder shall be positively secured to the structure, either by clamps or safety chains. Neither the energized end of the insulating ladder nor the workmen shall be solidly clamped or tied to the conductor, insulator string, or other suspended component when a known defect exists or when the suspension devices or connectors are being worked on.

b. Control of Ladder.- Positive movement control of the insulating ladder shall normally be provided from the structure or ground, using hot sticks and/or nonconductive rope. The control equipment shall provide a positive means of moving workmen on insulating ladders a safe distance away from any energized feature. Sufficient personnel shall be provided on the structure or on the ground to adequately handle and control the insulating ladder. The insulating ladder shall be moved to a safe deenergized position prior to permitting workmen to mount or dismount it. Under certain conditions, where work is on other than the conductor or suspension devices, workmen on the insulating ladder may use a hot stick attached to the energized conductor or other energized part to help guide them to

and from the bonding position. The hot-stick guide shall be removed when workmen are bonded to the conductor.

4.3.5 Base-supported Ladders. An insulating ladder may be supported on a fixed base and used for live-line barehand work in accordance with the following basic minimum requirements:

a. Grounding.- The equipment being used as a fixed base support for the insulating ladder shall be grounded, (refer to [paragraph 4.2.3](#) ) and shall provide a sturdy, safe support for the length of insulating ladder and weight to be supported.

b. Minimum Distances.- When the workmen mount the insulating ladder to the work position with the insulating ladder energized, the length of insulating ladder from ground to the energized circuit shall be sufficient to provide the minimum phase-to-ground distances specified in column (a) of the table in [subsection 4.1.9](#), plus 8 feet (2.4 meters) to allow for the length of insulating ladder occupied by the workmen. When a workman is on an insulating ladder and the insulating ladder is in an energized condition, all other personnel shall stay clear of the insulating ladder and base.

#### **4.4 INSULATED TOWER BOOMS**

4.4.1 Voltage Limitation. Insulated tower booms may be used as personnel support for work performed by the barehand technique on circuits or equipment with a phase-to-phase voltage rating exceeding 100 kilovolts.

4.4.2 Operating Practices. Only certified workmen shall perform live-line work from insulated tower booms, except that during training periods, a workman undergoing training may practice mounting and dismounting the personnel-support platform of the insulated tower boom and may perform specific work while supported by an energized insulated tower boom. Various types of personnel-support platforms may be used satisfactorily with the insulated tower boom, including, but not limited to, bosun's chair, basket or bucket, tree-trimmer's saddle, and conductor cart. The specific support platform to be used shall be properly attached to the insulated tower boom and all component parts shall have an adequate safety factor for the load to be carried. All components of the insulated tower boom and associated support platforms shall have a minimum load rating of 500 pounds (2,244 newtons).

4.4.3 Minimum Requirements. The following minimum basic requirements shall be observed in addition to [subsection 4.1](#):

a. Preoperative Tests.- Tests shall be made before starting work each day, each time the insulated tower boom mounting is relocated, and when changed conditions indicate a need for additional tests. A microammeter designed for use with insulated ladders shall be used for testing the dielectric current through the horizontal insulated boom pole, If the measured dielectric current after 1 minute is less than 0.333 microampere for each kilovolt of nominal line-to-line voltage, the insulated tower boom may be placed and the work started. A written record of these tests shall be maintained both with the equipment and in the responsible operating office. Work operations shall be suspended immediately upon indication of a malfunction in the equipment.

b. Clothing.- Workmen on insulated tower booms shall be completely clothed in conductive clothing designed for barehand work. Workmen on steel towers shall also wear conductive footwear.

c. Securing Boom.- The insulated tower boom shall be positively secured to the structure by means of a tower mount and adequately sized insulating sticks, all tightly clamped to prevent slippage or creepage. Neither the energized end of the insulated tower boom nor the workman shall be solidly clamped or tied to the conductor, insulator string, or other suspended component when connectors are being worked on.

d. Rigging.- Before a workman is allowed on the insulated tower boom, the crew foreman must first make sure that all rigging is complete and secure.

e. Control of Boom.- Positive movement control of the insulated tower boom shall normally be provided from the structure or ground, using hot sticks and/or nonconductive rope. The control equipment shall provide a positive means of moving the workman on the insulated tower boom a safe distance away from any energized feature. Sufficient personnel shall be provided on the structure or on the ground to adequately handle and control the insulated tower boom.

The insulated tower boom shall be moved to a safe, deenergized position prior to permitting the workman to mount or dismount it.

f. Bonding.- Before beginning work, the workman shall bond his or her conductive clothing to the energized circuit.

g. Passing Objects.- Objects that are to be passed by hot stick to the workman on the insulated tower boom shall be passed only after he or she is bonded to the energized circuit. These items shall not be passed directly to the workman, but shall first be touched to the energized circuit.

h. Safety Straps.- Except when mounting or dismounting the personnel-support platform, the workman shall keep his or her safety strap or safety rope attached to the insulated tower boom or personnel-support platform at all times. A safety harness may be used instead of the conventional lineman's body belt, particularly when a bosun's chair, basket or bucket, or conductor cart is used as the personnel-support platform.

## **4.5 CONDUCTOR CARTS**

4.5.1 Voltage Limitation. Conductor carts may be used as personnel-support platforms for work performed by the barehand technique on circuits or equipment with a phase-to-phase voltage rating exceeding 60 kilovolts, and with a phase spacing of at least 10 feet.

4.5.2 Operating Practices. Only certified workmen shall perform live-line work from conductor carts, except (1) that during training periods, a workman undergoing training may practice mounting and dismounting the conductor cart and may perform specific work from an energized conductor cart, and (2) when it is necessary that an engineer or other specialist participate in a specific test or inspection program involving the use of an energized conductor cart, such specialist need not be certified workman as specified in subsection

4.1.3. Conductor carts may be used on single or bundled conductors. The conductor(s) should be of adequate size and strength to support the combined weight of the conductor cart, workman, and tools. A close visual inspection shall be made of the insulator assemblies on each end of the span. All components of the conductor cart shall have a minimum working load rating of 500 pounds (2,244 newtons) with a factor of safety of 3. The conductor cart shall be metal or metal lined, and shall be equipped with a spring-mounted grounding wheel attached to the frame of the conductor cart. The conductor cart shall be equipped with safety chains or other suitable means to prevent the conductor cart from accidentally falling free from the conductor(s).

4.5.3 Minimum Requirements. The following minimum basic requirements shall be observed in addition to [subsection 4.1](#):

a. Clothing.- Workmen riding conductor carts shall be completely clothed in conductive clothing designed for barehand work.

b. Rigging.- The conductor cart normally shall be raised to its position on the conductor(s) by means of nonconductive rope handlines attached to the conductor(s) or overhead ground wires on dead-end structures, or at midspan, or to the tower arm on suspension structures. Running sheaves attaching the

nonconductive handlines to the overhead ground wires aid in the positioning of the conductor cart on the conductor(s). The conductor cart and workman can be positioned directly on the conductor(s) at a dead-end structure by means of an insulated tower boom.

c. Bonding.- The energized workman preparing to position the conductor cart on the conductor(s) shall not make physical contact with the conductor cart until it is at the same voltage potential as the workman. This can be accomplished by either allowing the conductor cart to be pulled up against the conductor(s) to which the workman is bonded, or by having the workman reach out and energize the conductor cart with a bond. A workman need not be bonded while in the conductor cart.

d. Mounting the Conductor Cart.- Workmen can mount conductor carts from most types of insulated and insulating personnel-support equipment, including aerial-lift equipment and insulating ladders. Both the workman and the conductor cart are normally mounted on the conductor(s) by means of the insulated tower boom. A workman mounting a conductor cart from insulated personnel-support equipment shall remain safety-strapped to the insulated personnel-support equipment until safely inside the conductor cart. A workman mounting insulated personnel-support equipment from a conductor cart shall safety-strap to the insulated personnel-support equipment before stepping up and out of the conductor cart. A safety harness and safety rope may be used instead of the conventional lineman's body belt and safety strap while working in a conductor cart.

e. Passing Objects.- Objects that are to be passed by hot stick to the workman in the conductor cart shall not be passed directly to the workman, but shall first be touched to the energized circuit.

f. Safety Lines.- When using a conductor cart on a single conductor, the workman in the conductor cart shall wear a safety harness. A nonconductive rope lifeline shall be attached to the safety harness, pass up through a set of running sheaves on an overhead ground wire, then down to a secure lifeline anchorage at ground level. The safety harness shall be in accordance with subsection 3.9.5. The nonconductive rope lifeline shall be in accordance with subsection 3.11, and the lifeline anchor shall be in accordance with subsection 3.9.2.

## **Section 5. INSULATED HAND TOOLS**

### **5.1 Scope.**

Insulated or insulating hand tools are intended for working on, or in close proximity to, energized electrical apparatus or conductors operating at a maximum voltages of 1000 volts ac. They may be used on deenergized and grounded high-voltage circuits where it is impractical to work close to the personal protective grounds or where the earth rise or expected voltage across the worker may exceed the 75 or 100-volt limit. Live work is not recommended on uninsulated (field applied electrical tape is not considered adequate insulation) station-service 460-volt buses, where the fault currents are very high.

### **5.2 Tools.**

Tools include pliers, screwdrivers, knives, wrenches, etc. Construction is such that only a minimum of uninsulated material is exposed and guards are in place to prevent the hand from slipping onto the exposed areas.

### **5.3 Applicable Standards.**

ASTM standards have been approved, but have not been published and no number has been assigned. These standards will be applicable to Reclamation purchases of insulated or insulating hand tools.

### **5.4 In-service inspection.**

Insulated hand tools shall be inspected prior to use. Insulation showing nicks, wear, or the under color showing through shall be discarded.

# **ACCEPTANCE TESTING AND IN-SERVICE INSPECTION, REPAIR, AND TESTING OF LIVE-LINE TOOLS**

## **A1. General**

All insulating (and insulated) live-line tools purchased and used by Reclamation shall be assembled from fiberglass reinforced plastic (FRP) rod and tube which has been manufactured in accordance with ASTM Standard Specification No. F 711, and various metal or fiberglass end fittings or components which allow the tool to be used for specific types of work on energized electrical conductors and equipment. These live-line tools must withstand high 60-Hz voltages for sustained periods of time, as well as occasional switching surges. Therefore, Reclamation requires acceptance testing on all new insulating live-line tools, as well as annual inspections and tests for in-service live-line tools.

## **A2. Acceptance Testing**

Acceptance testing of new insulating live-line tools, performed by the manufacturer and/or the responsible Reclamation office, shall include, but not be limited to, the 60-Hz withstand and switching surge tests outlined in [Table A1](#). Gradient control devices (corona rings) should be used at both the high-voltage and grounded terminals to shield against damage to the FRP caused by corona discharge streamers on the pole surface during the 60-Hz tests.



**TABLE A1****Acceptance Test Criteria for Live-line Tools**

Minimum Operating Voltage Lengths	Minimum Live-line Tool Insulating Gradient/Foot			Application Voltage to Ground	Test Potential 60-Hz 1 Minute	Switching Surge
	ft	in	m			
15-kV	2	0	0.6	4.5kV	120kV	--
35-kY	2	4	0.7	8.7kV	140kV	--
46-kV	2	6	0.8	10.6kV	150kV	--
69-kV	3	0	0.7	13.3kV	180kV	--
115-kY	3	4	1.0	20.0kV	200kV	--
138-kV	3	6	1.1	22.8kV	210kV	--
161-kV	3	8	1.2	25.3 kV	220 kV	--
230-kY	5	0	1.5	26.6 kV	300 kV	565 kV
345-kV	7	0	2.1	28.4 kV	420 kV	850 kV
500-kY	11	0	4.6	26.3 kV	660 kV	1020 kV
765-kV	15	0	4.6	29.5 kV	900 kV	1560 kV

**A3. Inservice Inspection**

Hotsticks shall be shall be electrically tested in a shop or laboratory at least annually. Acceptable tests include the 60-Hz withstand test, high-potential dielectric leakage test, AC dielectric loss test, and moisture tests. These tests shall be conducted in accordance with manufacturers instructions.

# ACCEPTANCE TESTING AND IN-SERVICE INSPECTION AND TESTING OF INSULATED AERIAL LIFT EQUIPMENT

## (VEHICLE MOUNTED)

B1. General. Periodic electrical and mechanical testing programs are essential in order to evaluate the integrity and stability of the insulating and support components of vehicle mounted insulated aerial lift equipment over its expected working life. Therefore, vehicle mounted insulated aerial lift equipment test programs shall be as follows:

B2. Acceptance Tests. Electrical acceptance testing for vehicle mounted insulated aerial lift equipment is well defined in ANSI A92.2-1979. All new units are subjected to these acceptance tests and certified before they are placed in service. Procurement specifications for new vehicle mounted insulated aerial lift equipment should require the Manufacturer's Certification Test described herein. Additionally, procurement specifications should also require inspection and nondestructive testing by an independent testing organization.

B2.1. Electrical Acceptance Test. Following is an outline of the acceptance test procedure to be performed by the unit manufacturer:

B2.1.1. The assembled insulated aerial lift equipment in operable condition shall be tested on a grounded vehicle or a grounded test stand. The voltage shall be applied to the upper electrode of the insulated boom, and the lower end of the insulated boom shall be connected to ground potential. The test voltage shall be applied at a low voltage and steadily raised until the test voltage is reached and maintained for the recommended test period.

B2.1.2. Tests shall consist of rated, double rated, and at the option of the manufacturer, either momentary withstand or switching surge voltage (see the footnote to [Table B1](#)). The voltage is raised to rated voltage and the dielectric arm current recorded. The voltage is then raised to double rated voltage and held for three minutes, recording the dielectric arm current at the start and end of the three minute test period, during which the dielectric arm current shall not increase more than ten percent or exceed the values in [Table B2](#).

B2.1.3. For 230-kV and above rated units, the corona ring shall not exhibit positive streamers during the 60-Hz tests. In addition, any corona discharges during high voltage tests must not impinge on the insulating portion of the boom.

B2.2. Inspection and Nondestructive Tests. Following is an outline of the inspection and nondestructive tests procedure to be performed after the insulated aerial lift equipment is completely assembled, mounted, all other tests completed, and immediately prior to delivery of equipment:

B2.2.1. The inspections and tests shall be performed by a recognized and reputable nondestructive testing organization specified or agreed by the contracting officer.

B2.2.2. Acoustic emission tests (ASTM F 914 for Acoustic Emission for Insulated Aerial Personnel Devices and ASTM F (number not assigned as of this writing) for Acoustic Emission for Insulated Material Handling Aerial Devices) shall be performed on the insulated aerial lift device, with transducers placed from the end of the boom in at least eight locations down to the bottom of the main frame assembly. Test loading for insulated material handling aerial lift devices should be limited to one and one-half times rated load.

B2.2.3. High stress areas of the fiberglass boom sections shall be radiographically (x-ray) tested to detect internal cracks or deficiencies not revealed through visual inspections.

B2.2.4. Welded areas in steel booms subject to high stress and critical steel castings in booms, turrets, and outriggers shall be radiographically tested to cracks, slag, and inadequate penetration of welds.

B2.2.5 Critical boom pins and bolts shall be tested by radiographic and/or ultrasonic methods to detect any deficiencies.

B2.2.6. Deficiencies detected in critical components by inspection and nondestructive testing shall be corrected by the manufacturer and the previous deficient component(s) retested by the inspection and testing organization.

B2.3. Reports. The contractor shall provide the contracting officer with formal inspection and results for all acceptance testing.

B2.4 Witness of Tests. The contractor shall advise the contracting officer at least 3 working days prior to all acceptance testing so that a representative may witness all or part of the tests.

B3. Periodic Inservice Inspection and Testing Programs. Each operating office using this equipment shall establish programs for periodic inservice inspection on a regular basis. These programs shall include, but not be limited to, the following inspections and tests of all vehicle mounted insulated aerial lift equipment.

B3.1. Inspection and Nondestructive Testing. At approximate 12-month intervals the following inspection and nondestructive tests for vehicle mounted insulated aerial lift equipment shall be developed and conducted in cooperation with the equipment manufacturer and/or a recognized and reputable nondestructive testing organization.

B3.1.1. A complete visual inspection shall be made in accordance with a written format, complying with ANSI B30.5, B30.15, and A92.2, as applicable, on the entire unit and subframe area under the unit. Fiberglass and steel boom members, and all pin and wear points, shall be carefully inspected for deformation, cracks, or excessive wear. Hydraulic lines and fittings shall be checked for cracks and leaks.

B3.1.2. Ultrasonic inspections shall be made on all accessible structural pins, including the outrigger pins.

B3.1.3. Magnetic particle and/or fluorescent dye penetrant inspections shall be made on critical welds and castings, and other suspected areas.

B3.1.4 Acoustic emission tests (refer to A2.2.2 for ASTM reference test standards) shall be performed on each unit.

B3.1.5. A dielectric test shall be performed on the oil in each hydraulic system in compliance with ASTM D 1816 test method with a minimum acceptable dielectric breakdown voltage of 15 kV. ASTM D 877 may be substituted but, a breakdown value has not been established. We assume the value to be between 15 and 20 kV.

B3.1.6. Deficiencies detected in critical components by any of the following inspections and tests shall be corrected and the equipment appropriately retested before it is returned to service. All other deficiencies shall be scheduled for correction as soon as practicable.

B3.2. Electrical Testing Program. The daily test of measuring the dielectric current serves as a go no-go indication of the actual condition and safety of the boom under the conditions at which the test was made, but it does not evaluate the boom for abnormal conditions such as switching surges of up to 3 per unit voltage. At about 12-month intervals each vehicle mounted insulated aerial lift unit

used in live-maintenance by the barehand method shall be electrically evaluated by means of dc high potential tests.

B3.2.1. Electrical Test Electrodes. Generally insulated aerial devices are delivered or retrofitted with test electrodes permanently installed on the inside and outside surfaces of the insulating portion of the upper boom for the purpose of monitoring dielectric leakage current as required by paragraph 3.3.5 of ANSI A92.2. Prior to conducting the following tests, it will be necessary to ascertain that all hydraulic and pneumatic lines and leveling mechanisms, which bridge the insulating portion of the boom, are still connected to the test electrodes.

B3.2.2. High-Voltage DC. A dc test set with a capability of 400-kV and 2.5-milliamperes is recommended for testing FRP booms certified by the manufacturer for use on line to line rms voltages up to 345-kV. However; a dc test set of 100-kV and 5-milliamperes may be used if both dry and wet tests as discussed later are performed.

B3.2.3. Boom Orientation. Raise the lower boom so as to clear the nesting cradle by at least 2 feet (0.6 meters) for each kV of test voltage. Bring the upper boom to a horizontal position and hold for 15 minutes to allow any contaminants to settle horizontally in the hydraulic tubing before testing. Prior to and during electrical testing the truck chassis the truck chassis must be grounded. Refer to Paragraph 4.2.3. The case of the test set must also be connected to the chassis ground.

B3.2.4. Dry Test Procedure. Test the major upper boom insulation system which includes the FRP boom, hydraulic lines, and leveling mechanism. The high voltage terminal of the test set is connected to the upper (platform end) test electrodes. The lower test electrode is connected to the chassis ground or to the test set ground. Raise the voltage smoothly to the appropriate test level shown in Table B2 and hold for three minutes. Read and record the dielectric leakage current. Some of the incipient breakdowns that can be detected with this test include deterioration of the insulation resulting from ionization along the surface or internal voids, moisture, absorption, and structural aging. Any significant change in dielectric current values from previous test values warrants an investigation into the cause. If the dielectric current exceeds 0.5 microampere per kV of applied test voltage, the boom should be cleaned, rewaxed and retested.

B3.2.5. Wet Test Procedure. Any new insulated boom as delivered has a waxed or silicone surface to repel water. This surface must be carefully maintained and replaced as necessary. A dry boom with a chalky or nonwater repelling surface may pass the dry dielectric test and still be a virtual short circuit on a moist morning or after a brief shower. Therefore, a wet test is recommended for all test voltage, and is required if the test set is limited to 100-kV rating. To conduct the

wet test, wet the insulating portion of the boom thoroughly, using drug store grade distilled water applied with a spray applicator. Retest the upper insulating system as in B3.2.4. above within 3 minutes of wetting. The dielectric leakage current should not exceed 100 times the dry leakage current, and should not exceed 1 milliampere at rated test voltage.

B3.3. Records of all inspections, tests, and corrective maintenance on vehicle mounted insulated aerial lift equipment shall be maintained in the responsible operating office.

**Table B1**

**MANUFACTURER'S CERTIFICATION TEST**

Rated Line Voltage rms kV	60-Hz Rated Voltage Test		60-Hz Double-Rated Voltage Test		60-Hz Momentary Withstand Voltage rms kV	Switching Surge Withstand Voltage crest kV	Permanent Electrodes Required
	Test Voltage rms kV	Boom Current rms FA	Test Voltage rms kV	Boom Current rms FA			
69	40	40	80	80	120	170	YES
115-138	80	80	160	160	240	340	YES
230	133	133	265	265	400	340	YES
345	200	200	400	400	600	850	YES
500	288	288	575	575	720	1020	YES
765	442	442	885	885	1105	1560	YES

Test voltages specified for the momentary or switching surge test are based upon a 3 per unit switching surge factor through 345-kV ratings, 2.5 per unit switching surge factor for 500-kV rating, and 2.2 per unit switching surge factor for 765-kV rating. When run, the switching surge factor will consist of 10 applications at both positive and negative polarity switching surge test waves, with the test waves having a front between 150 and 350/Fs.

**Table B2**

**DC MAINTENANCE 3-MINUTE TEST**

Rated Line Voltage rms kV	DC Test Voltage kV	Maximum Allowable Dielectric Current FA
69	100	100
115-138	160	160
230	265	265
345	400	400
500	575	575

## **Bibliography**

Liveline Maintenance, Power System Maintenance Manual, Chapter 3, August 3, 1984, Western Area Power Administration

Power System Safety Standards, U.S. Bureau of Reclamation, July, 1981 (superceded)

Reclamation O&M Safety Standards, U.S. Bureau of Reclamation, April 1989