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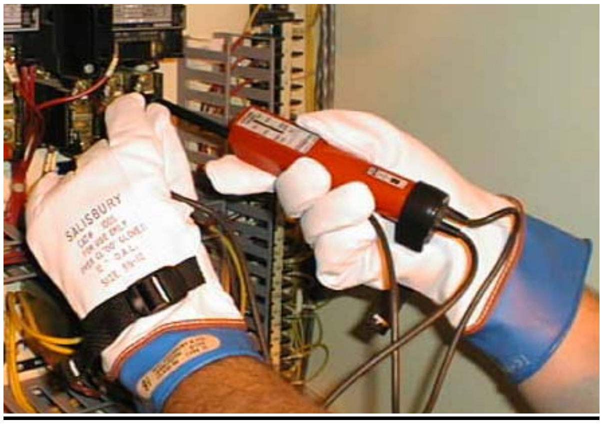
Facilities Technical Services

Standard For
Electrical Safe Work Practices
ESWP



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Document revisions:

By	Date	Revision Description
A. Fyffe	9/27/02	• Replaced "Delphi Automotive Systems" with "Delphi Corporation" throughout document.
A. Fyffe	5/21/02	• Removed "No Jewelry" form minimum PPE listing in **Section 7.3** • Added Flame Resistant (FR) Category I Clothing to minimum PPE listing in **Section 7.3**. • Added " Insulating Sleeves" to listing of additional PPE listing in **Section 7.3** • Added " Metal Fish Tape" to listing of Conductive Materials, Tools and Equipment being Handled in **Section 7.4** • Changed "Flash Flame" to Flash Resistant in **Section 7.4.4**. • Changed Testing Interval for insulating blankets to "Before First Issuance and every 12 months thereafter in **Section 7.5** • Deleted "And Leg" from "Foot and Leg Protection" in **Section 7.6** • Modified Flow Chart (Figure 6) for Installing and Removing Personal safety Grounds in **Section 8.2.3** • Modified (b) Restricted Approach Boundary in **Annex A2.**
A. Fyffe	4/11/02	• Updated Title Page and Header to reflect name change from Delphi Corporation to Delphi Corporation.
A. Fyffe	12/17/01	• Modified the text regarding "Plan Every Job" to match to initial intent described in the training handbook. • Added clarification to Flash Protection Boundary Distance in Annex A-3
ESWP Team	11-01-01	First Issuance

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1. General

1.1 Scope

The following document pertains to all electrical work performed at Delphi Corporation North American Operations.

1.2 Purpose

The purpose of this document is to provide consistent standards for the safe performance of electrical work.

2. Definitions

In order to maintain continuity with established regulatory agencies and industry consensus standards-making organizations, the following definitions were obtained from the following sources:

1. National Fire Protection Association (NFPA) 70-E Standard for Electrical Safety Requirements for Employee Workplaces, 1995 Edition.
2. OSHA Regulations, Standard 29 CFR 1910.
3. Delphi Corporation – Electrical Safe Work Practices Committee.

Approve - Review job requirements and planning documents, and if appropriate, authorize that actual task(s) can be performed. Requires signature of approver**.**

Barehanded Work - A technique of performing work on exposed energized conductors or circuit parts, after the worker has been raised to the potential of the energized conductor or circuit part. Barehanded work is not acceptable at Delphi Corporation.

Barricade - A physical obstruction such as tapes, cones, or A-frame type wood or metal structures intended to provide warning about and to limit access to a hazardous area. Barricades are generally only installed temporarily.

Barrier - A physical obstruction that is intended to prevent contact with exposed energized electrical conductors or circuit parts. Barriers may be installed temporarily or permanently.

Bonding - The permanent joining of metallic parts to form an electrically conductive path that will ensure continuity and the capacity to conduct safely any current likely to be imposed. A bond need not be a weld to be considered a permanent connection.

Buddy - Person assigned to accompany another person on a particular job and is instructed on how to give aid in case of an accident. For electrical work, this person must be qualified in accordance with section 5 of this document.

Clamp-On Ammeter – A metering device that can be utilized for measuring AC or DC current flowing in a circuit, without having to interrupt or be in series with the circuit. This is accomplished via magnetic coupling between the circuit conductor and a split/clamp-on current transformer integral to the meter.

Close out Inspection – Inspection to be performed on equipment prior to release for operation that ensures that all tools, foreign objects, or other improper materials have been removed.

Conductive – Any material capable of carrying electric current.

De-energized - Having been disconnected from all sources of voltage and/or stored electrical charge (i.e. – capacitors, induced voltages), resulting in zero volts to ground on the conductors.

Electrical Circuit Conductors - Components (including wire, bus and terminals) which are intended to be in the normal current carrying path of the electrical system.

Electrical Energy State -

> De-energized - Having been disconnected from all sources of voltage and/or stored electrical charge (i.e. – capacitors, induced voltages), resulting in zero volts to ground on the conductors.
>
> Energized - Electrically connected to a source of voltage or stored electrical charge (i.e. – capacitors, induced voltages) to have conductors elevated above ground potential.

Potentially Energized Equipment - Any equipment or component that is physically connected to a power source.

Electrical Hazard - A condition where exposed energized conductors or live parts exist above 50V AC or DC, and where inadvertent or unintentional contact or equipment failure may result in shock, arc flash burn, thermal burn, or blast.

Electrical Incident - An event resulting in equipment damage or potential of injury to employees brought about by either personnel action or electrical equipment failure. An electrical incident has the potential to result in injury from:

- electrical flash and/or burn,
- electrical shock (if >50 volts), or
- reflex action to an electric shock.

Electrical Safety - Recognizing hazards associated with the use of electrical energy and taking precautions so those hazards do not cause injury or death.

Electrically Nonhazardous Task - A task that involves equipment energized at a voltage less than 50 volts AC or DC.

Electrically Safe Working Condition - A conductor or circuit part is considered electrically safe after it has been:

1) disconnected from energized parts;
2) locked out/tagged in accordance with Delphi Lockout/Hazardous Energy Control standards;
3) tested to ensure zero volts to ground;
4) where necessary, temporary safety grounds applied.

Enclosure - The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.

Energized - Electrically connected to a source of voltage or stored electrical charge(i.e. – capacitors, induced voltages) to have conductors elevated above ground potential.

Equipment – Individual electrical enclosure or multiple electrical enclosures that are adjacent to each other to make a larger unit, such as several sections of Motor Control Centers (MCC's) or switchgear.

Exposed (as applied to live parts) – Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts that are not suitably grounded, isolated, or insulated.

Exposed (as applied to wiring methods) – On or attached to the surface or behind panels designed to allow access.

Flash Hazard - A dangerous condition associated with the release of energy caused by an arc that suddenly and violently changes material(s) into a vapor.

Gloves – All gloves are only to be used with leather protectors and shall conform to ASTM D120 requirements. Listed below are the voltage level and glove class relationship:

Voltage Level	Class Rating
50 – 500 Volts	Class 00
501 – 1000 Volts	Class 0
1001 – 7500 Volts	Class 1
7501- 17,000 Volts	Class 2

Ground - A conducting connection, whether intentional or accidental, between an electrical circuit and the earth or some conducting body that serves in place of the earth.

Grounded - Connected to earth or some external conducting body that serves in place of the earth, whether the connection may be intentional or accidental

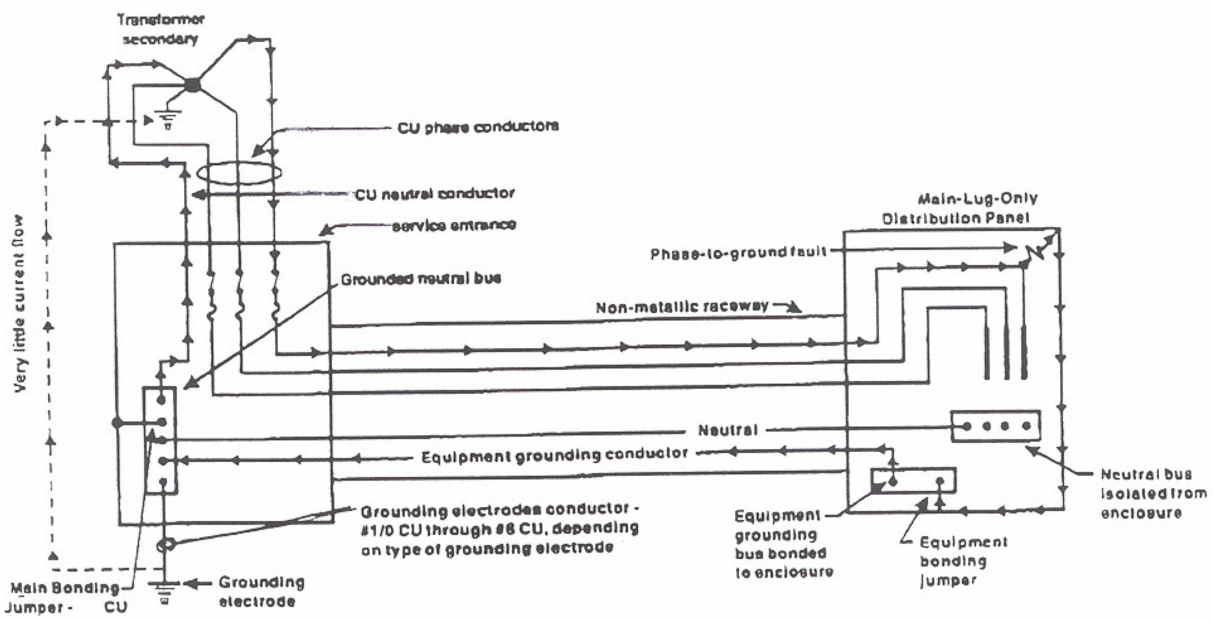
Grounded conductor - A system or circuit conductor that is intentionally grounded. This is usually a current carrying conductor and it is called the neutral or power return.

Grounding conductor, equipment or ***Equipment grounding conductor*** - That conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system. This conductor is also called the "green" wire and must not be used to carry load current. The color green may not be used on any other conductor.

Grounding electrode - That conductor that specifically makes contact with the earth for grounding a power system.

Grounding electrode conductor - A conductor used to connect the grounding electrode to the equipment-grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of the separately derived system.

Grounding jumper or ***Grounding strap*** - A strap of wire used to connect equipment housings to the equipment-grounding conductor.



Function of System Ground and Equipment Ground
Under Ground-Fault Conditions in Example Power Supply

Hot Work (Working On) - Working on means coming in contact with exposed energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing. This is the same as being inside the Prohibited Approach Boundary.

Incoming Supply - All conductors, cables, or rigid buswork that introduce power to a piece of equipment. This includes the primary or alternate supplies, temporary supply, or interlock control wiring.

Induced Voltage Detectors (e.g. Tic Tracer) - A device designed to indicate voltage by sensing the magnetic and/or electric field emitted by energized conductors. **Warning -**This device must be treated very cautiously as it can be easily "fooled" and let the user believe that a circuit is de-energized when in fact it is not.

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

Isolated -. It can mean lifted from ground or earth, separated by a transformer, use of a shielded transformer, separation by distance, separated by special circuits, and so forth. An isolated circuit may or may not have a conductive path to another circuit.

Isolated Ground – A system of grounding conductors, insulated from portions of the conventional grounding of the power system, which interconnects the grounds of electric devices for the purpose of improving immunity to electromagnetic noise.

Job Plan - A description of the nature, timing, location, and procedures of an electrical job that addresses all safety considerations. A job plan also includes the sequence of events needed to complete the scope of work safely and efficiently.

Live-Line Tool Work - A technique of performing work on exposed energized conductors or circuit parts where the worker utilizes insulated live-line tools, rated for the voltage involved to provide insulation of the person from the energized part on which hot work is to be performed. (Note: The use of insulated tools does not eliminate the need for proper PPE.)

Live Parts -Electric conductors, busses, terminals, or components that are uninsulated or exposed and where an electrical hazard exists.

Main bonding jumper or ***bonding jumper, main*** - The connection between the grounded conductor and the equipment grounding conductor at the service. This connection is the key to electrical safety and thus this conductor is given a special name.

Neutral conductor - The grounded conductor used to bring power to a facility or to a load. This phrase is usually used to describe the grounded conductor in three-phase power.

Non-Resident Expert - A person qualified to make engineering and safety judgments regarding issues in question, and who is not in the chain of command of the organization needing assistance; provides expertise and educated opinions.

Non-Routine Job – Any job that would be classified as falling outside the normal day-to-day tasks of the person doing the job (example: assigning a normal troubleshooting electrician a job to perform work in an electrical substation).

Philosophy – A study of fundamental beliefs and the grounds for them.

Plan - A written document that details the steps required to complete a given task. Plans in regards to electrical work shall be completed on Delphi Corporation Electrical Work Planning Sheet(s) and requires the approval (signature) of the planner(s).

Policy – A method of actions selected to guide and determine present and future decisions.

Potential Energized Equipment - Any equipment or component that is physically connected to a power source.

Procedure – A series of steps followed in a regular order.

Proximity Work (Working Near) - Working near is any activity inside the Limited Approach Boundary of exposed energized electrical conductors or circuit parts that are not put into an *electrically safe work condition*.

Qualified (Delphi Corporation) - Meets the "OSHA Expanded" definition, is thoroughly familiar with the Delphi Corporation Safe Electrical Work Practices and intends to implement them in the work place.

Qualified (OSHA, Expanded) - A qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method, and shall be trained to recognize and avoid the electrical hazards that may be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools and test equipment. A person may be considered qualified with respect to certain equipment and methods but still are unqualified for others. Such persons permitted to work within the limited approach boundary of exposed energized conductors and circuit parts shall at a minimum be additionally trained in the following:

(a) The skills and techniques necessary to distinguish exposed energized parts from other parts of electric equipment,
(b) The skills and techniques necessary to determine the nominal voltage of exposed energized parts, and
(c) The approach distances specified in Annex B and the corresponding voltages to which the qualified person will be exposed,
(d) The decision making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to safely perform the task, as defined in section 6.0 of this document.

Rated Voltage - A rating that indicates the highest voltage that an electrical device and/or PPE may contact without risking insulation failure and electrical device failure/destruction (and potentially personal injury).

Review - Review job requirements and planning sheet, looking for errors in logic and procedures, and working with the planner to modify. Requires the signature of the reviewer.

Routine Job – Any job that would be classified as a part of the normal day-to-day tasks of the person doing the job(Examples: "debugging" equipment for a normal troubleshooting electrician or making an electrical service drop for a normal construction electrician).

Rubber Glove Work - A technique of performing work on exposed energized conductors or circuit parts where the worker utilizes rubber insulating gloves, rated for the voltage involved, to provide insulation of the person from the energized part on which work is to be performed. The gloves utilized shall be protected by outer leather gloves.

Scope of Work - A description of the work to be accomplished, including the physical boundaries of the work.

Separately derived system - A premises wiring system whose power is derived from a battery, a solar photovoltaic system, or from a generator, transformer, or converter windings, and that has no direct electrical connection, including a solidly connected ground circuit conductor, to supply conductors originating in another system.

Shock Hazard - A dangerous condition associated with the flow of current through a person's body caused by contact or approach to exposed electrical conductors or live parts nearer than the minimum air insulation distance.

Step Potential - A potential differences over the surface of the earth which can cause current flow from foot-to-foot through the body. This condition is most commonly caused by a nearby lightning strike or a large local ground fault.

Touch Potential - A potential difference that can cause current flow from hand-to-hand or hand-to-foot through the body.

Troubleshooting - the logical analysis of symptoms to determine the cause of a failure and return the equipment or system to service.

Unqualified - A person not meeting the qualifications established in section 5.0 which includes the OSHA expanded and the Delphi Corporation additional qualifications.

Voltage (of a circuit) – The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.

> *NOTE: Some systems, such as 3-phase 4-wire, single-phase 3-wire, and 3-wire direct-current may have various circuits of various voltages.*

Voltage, Low – A class of nominal system voltage less than 600 V.

Voltage, Medium – A class of nominal system voltages equal to or greater than 600 V and less than 100,000 V.

Voltage, Nominal – A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240 volts, 480Y/277 volts, 600 volts). The actual voltage at which a circuit operates can vary from nominal within a range that permits satisfactory operation of equipment.

Voltage to Ground – For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Voltage Testing - A task intended solely to measure or sense voltage.

Voltage Sensing - A task intended solely to sense for the presence or absence of voltage.

Voltmeter - An instrument utilized to determine the voltage difference between two points by contacting each of two probe leads on the points in question. An analog or digital display is utilized to indicate the value of the voltage. This type of meter will also include a limited ability to measure current, as well as the ability to measure resistance (ohms). Also known by the term VOM, or volt-ohm meter. DVOM represents a digital volt-ohm meter.

Wiggy - A voltage tester commonly carried on electrician's tool belts and utilized as an indicator of the approximate voltage between two points of concern. There is typically a very approximate analog scale indicator, along with an indicator in the end of the device that serves as an "energized"--"non-energized" gage. This device is useful during troubleshooting where exact voltage values aren't necessary.

Work Area – the area required to safely perform the assigned task that is equal to or greater than the maximum distance required in either the Limited Approach Boundaries or the Flash Protection Boundaries as defined in Annex A. For example, less than 750 Volts 3'-6", between 750 Volts and 2000 Volts 4'-0" and greater than 2000 Volts and less than 15,000 Volts 16'-0".

3. Normative references

The following normative references contain provisions that, through reference in this text, constitute provisions of this standard. The editions indicated were valid at the time of publication. All normative documents are subject to revision and the most recent editions of the normative standards indicated below shall apply

NFPA 70E,*Standard for Electrical Safety Requirements for Employee Workplaces 2000 Edition.*
IEEE 902-1998,*IEEE Maintenance, Operation, and Safety of Industrial and Commercial Power Systems.*
OSHA 29CFR 1910.269,*SubPart "R" - Special Industries.*
OSHA 29 CFR 1910.301, SubPart "S" - Electrical, General
OSHA 29 CFR 1910.147: Control of Hazardous Energy Sources
OSHA 29 CFR 1910.302 – 308: Design Safety Standards for Electrical Systems
OSHA 29 CFR 1910.331 – 335: Safety Related Work Practices
Delphi Corporation Health & Safety Manual – Section Common Core H&S Element: Machine/Equipment Energy Control
Delphi Corporation Health & Safety Manual – Section Minimal Program Requirements: Machine/Equipment Energy Control

4. Principles and Policies

4.1 Objective

This Electrical Safe Work Practices document describes the philosophy, policies, required procedures and applicable work instructions. in support of electrical safety for Delphi Corporation. It is recognized that local ordinances and conditions may require additions or supplements to this document.

4.2 Responsibilities

4.2.1 Management Responsibility

It is management's responsibility to support an environment in which safety is the overriding priority in everything that we do. Management must provide the time and funds necessary to insure that each employee exposed to electrical hazards is provided with the proper instruction and tools in order to perform their job safely. Each supervisor must set an example by demonstrating the proper attitude and behavior toward safety. The supervisor's conduct is reflected in the conduct of those that he or she supervises. Each supervisor should empower the people under his or her direction to be proactive in continuously improving their own safety and the safety of others. Engineering personnel are responsible to give technical direction when necessary to guide the activities of the supervisor and the employees performing the work

Although it is clearly understood that every employee is responsible for himself/herself, it does not negate the responsibilities of management to properly educate every member of the crew/team on the task to be performed. Each member shall be kept up to date on the appropriate level of technical skills that are required to perform the functions of the job to be completed.

Every employee (Delphi personnel and/or outside contractors) performing work that exposes them to electrical hazards shall be provided with the appropriate safety instructions. Management must insure that there is no misunderstanding on what to do if there is an injury because of electric shock, blast, or flash. This may include:

- Location of the Nearest Telephone
- Plant Emergency telephone numbers.
- Plant Security telephone numbers.
- Medical Department telephone numbers.
- Location of Nearest Fire Alarm.

4.2.2 Personal Responsibility

Each person is responsible for his or her own safety. Each person's actions can impact the safety of others. Each person is expected to understand, and use applicable safety procedures as tools to guide all tasks. If a person feels that they are uncomfortable with the procedures, methods, or the training presented to them, they should contact their supervisor and safety representative for further clarification or advice.

4.3 Electrical Safety Principles

The following principles provide a process that, when followed, can help ensure the safe accomplishment of any electrical work and should be utilized as a means to communicate essential information.

4.3.1 Plan Every Job

Plan all jobs, regardless of their size.[1]Planning is a fundamental principle that makes good sense and is the cornerstone to safely and efficiently complete any job. For simple jobs the planning, process may be rather simple. This does not mean that planning is any less essential, even for simple jobs. When the job is complicated, critical, or hazardous, the process must be detailed.

When a task requires a person to cross one of the electrical hazard approach boundaries and expose the worker to the electrical hazards, it is unacceptable to perform that task without written documentation that properly addresses the protection of the worker while performing that task. (Discussed Annex A: Safe Approach Distances).

In consultation with the safety department and floor supervisor, it is an acceptable method to develop a standard operating procedure (SOP), sanctioned by management, for use as a guide or work instruction that addresses those potential hazards related to a task. These documents can be added to a database and distributed for people to reference when performing a routine task. If this SOP is developed and communicated to the workers, it fulfills the requirement for written documentation discussed in the previous paragraph.

Identify all potential hazards associated with a task, and consider each of them separately. Hazards are not always easily identified. If you are not sure you have identified all of the hazards, ask for help. Discussion with co-workers or technical support personnel in the planning process and prior to a job can help direct attention to potential hazards. Remember that potential hazards are not always electrical.

4.3.2 Anticipate Unexpected Events

Before undertaking any task, ask “What if...?” and decide upon contingency plans in the event that something goes wrong. Don’t confine your thinking to electrical energy. Instead, consider the overall environment such as what will happen if someone walking by happens to trip while you are performing the task

4.3.3 Use the Right Tool for the Job

Identify the proper tool for the job, and don’t perform the task until you have the right tool at hand. Using the proper fuse pullers or the right voltage tester can help guarantee your safety. Find out if the tasks you have planned require special tools.

4.3.4 Use Procedures and Work Instructions as Tools

Procedures and/or Work Instructions provide a roadmap for accomplishing a job safely. Procedures and/or Work Instructions prompt you to ask the right questions. They are tools that help you plan your work; and, like tools; they should be properly maintained. Each step identified in a procedure and/or work instruction should be followed unless there is reason to believe that performing the task another way will result in less exposure to hazards.

4.3.5 Isolate the Equipment

Isolate electrical equipment, both physically and electrically, to reduce the possibilities for damage or injury. Isolation can mean performing hazardous energy control/lockout, providing insulating barriers, and/or barricades.

4.3.6 Identify the Hazards

Identify potential hazards associated with a task, and consider each of them separately. Hazards are not always easily identified. If you are not sure you have identified all of the hazards, ask for help. Remember that potential hazards are not always electrical.

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[1] A mental review of the steps involved in the task along with an approved SOP or work instruction constitutes a plan in this context.

4.3.7 Minimize or Eliminate Hazards

As stated in the Delphi Corporation Health and Safety Manual, hierarchy of controls process, elimination or substitution is the most preferred method for risk management. When this is not possible, minimize the hazards by up-grading your **plan**, **isolating** the equipment, limiting the time of exposure, installing safety grounds, choosing scaffolds instead of ladders, or by using insulating barriers or barricades.
The basic rule at Delphi Corporation is that it is undesirable to perform "**HOT WORK**," and it is unacceptable to perform **"BAREHANDED WORK"** on energized conductors. The preferred approach to working on or near equipment is to put the equipment in an electrically safe condition before the work begins.

4.3.8 Protect the Person

Use appropriate personal protective equipment (PPE) for each potential hazard. Even if you apply all of the previous principles and appropriate engineering considerations, PPE is necessary as the final protection against injury. For more information see Section 7, "Electrical PPE."

4.3.9 Audit These Principles

Review these principles frequently to verify that they reflect current values and result in less exposure to hazards. Do they reflect the new values professed by you and the organization? Learning continues outside of the classroom. Keep your eyes and ears open to evaluate work as it progresses. Make use of additional written references.

4.3.10 Evaluate Each Completed Job

The work is not to be considered complete until it's scope has been reviewed to include, but not limited to, the following points:

1. Lessons learned.
2. Proper submittal of redlined drawings, if necessary. Identify on existing prints the difference found and/or changes made.
3. Identification and recommendation of necessary enhancements to systems or equipment.

4.3.11 Continuous Improvement

Each person must recognize that the practices of the past do not insure future safety. A particular manner in which we go about performing a task is not safe merely because "we've always done it that way." As technological advances give us a better understanding of the work that we do, we must improve our standards, practices, procedures and work instructions.

4.4 Policies

4.4.1 Documentation Policy

Drawings used in planning electrical work must reflect the current condition of equipment and installations. Single-line diagrams, schematics, underground drawings, and all other necessary system documentation must be up-to-date so that proper planning can take place. In addition, up-to-date drawings can help identify potential hazards. Inaccurate drawings can compromise the safe execution of an electrical task, no matter how well planned the task might be. Engineering shall maintain all drawings in an up-to-date condition. Changes shall be recorded and file copies appropriately updated.

4.4.2 Electrically Safe Work Condition

It is the company's position that live parts to which an employee may be exposed shall be put into an electrically safe work condition before an employee works on or near them, unless it has been demonstrated that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations (such as troubleshooting and voltage testing).[2] Furthermore, all exposed conductors shall be considered energized or potentially energizable until placed in an electrically safe work condition per approved procedures.

Employees shall not be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition unless they are qualified and trained to understand the hazards and to select and use safe work practices as well as personal and other protective equipment.[3]

.3 Safe Approach Distance

Safe work practices shall be used to protect employees from injury while they are working within specific distances from circuit parts that are, or may become energized. The specific safe work practices shall be determined by the level of hazards to which the employee may be exposed, as well as the approach distance that is required to perform a task. Refer to Annex A for determination of these distances.

4.4.4 Test (and ground where required) Before Touch

All terminals, conductors, or other exposed components of electrical circuitry which could be contacted (purposely or accidentally) are to be treated as energized until they have been isolated, tested for the absence of voltage using approved test equipment, and locked out per approved procedures. Consult Section 9 (Voltage Testing) and Annex B (Specifications for Voltage Test Equipment) for reference information. If the conductor at issue is of a nominal system voltage of greater than 600V or where the possibility of induced voltages or stored electrical energy exists, use temporary personal safety grounds in accordance with Section 8.

4.4.5 Work On or Near Energized Equipment

The basic rule at Delphi Corporation is that **it is undesirable to PERFORM "HOT WORK", and IT IS UNACCEPTABLE TO PERFORM BAREHANDED WORK ON ENERGIZED CIRCUITS.** The preferred approach to working near electrical equipment is to de-energize the equipment before the work begins. If situations arise that require work to be performed on or near energized equipment requiring planning, the planning and authorization are to be performed in accordance with Section 6, Planning Electrical Work.

4.4.6 Abandoned Lines, Wires, or Cables

Electrical lines, wires, and cables that are removed from service or not connected should be removed. If they cannot be removed, individual conductors must be taped and then tagged to indicate the location of the other end. Underground wiring that has been abandoned in place must be maintained on drawings for reference. Wiring installed to provide power during construction must be removed when it is no longer required.

4.4.7 Electrical Incidents

All electrical incidents shall be reported to your local Health and Safety Representatives. Workers can learn from electrical incidents. Insights gained during the incident investigation will help revise current policies and procedures in order to reduce the likelihood of future injuries.

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[2] NFPA 70E, 2000, p. 49, paragraph 2-1.1.1

[3] NFPA 70E, 2000, p. 49, paragraph 2-1.1.2

5. Qualification of Personnel Procedure

5.1 Objective

This procedure describes the requirements and procedures necessary to qualify personnel with regard to electrical safety.

5.2 Qualifications

5.2.1 Qualified

The Qualified person as defined in Section 2 meets the "OSHA " definition as well as the additional Delphi requirements regarding the knowledge and the intention to use the procedures listed in this document. Additional consideration was given to accommodate enhancements from the National Fire Protection Association (NFPA) 70E Standard for Electrical Safety Requirements for Employee Workplaces. Furthermore, qualification is a task-based term. In other words, an employee might be qualified to perform a particular type of task and not be qualified to perform some other task. Consult the General Motors' Electrical Power Equipment Maintenance Manual (EMM-1) for details on levels of qualifications

5.2.2 Unqualified

When an Unqualified person(s) is (are) working at or close to the Limited Approach Boundary as specified in Annex A, the designated Person-In-Charge of the work space where the electrical hazard exists shall cooperate with the designated Person-In-Charge of the unqualified person(s) to ensure that all work can be done safely. This should include advising the unqualified person(s) of the electrical hazard and warning them to stay outside of the Limited Approach Boundary*.*

When there is a need for an unqualified person(s) to cross the Limited Approach Boundary to perform a minor task, or look at equipment, a qualified person shall advise them of the possible hazards and ensure that the unqualified person(s) is (are) safeguarded. Under no circumstances shall such unqualified person(s) be permitted to cross the Restricted Approach Boundary.

Unqualified person(s) shall be trained in and be familiar with any of the electrical safety related practices which may not be specifically addressed in this document, but are necessary for their safety.

5.2.3 Exceptions

An employee may be considered to be a qualified person for the performance of specific duties given that all of the following criteria are met:

1. The specific duties are encountered in the course of on-the-job training.
2. The employee has demonstrated an ability to perform duties safely at his or her level of training.
3. The employee is under the direct supervision of a qualified person who is directly observing the duties being executed.

5.3 General

5.3.1 Personnel to be Trained

The following personnel shall be trained in safety related work practices and procedural requirements as necessary to provide protection from electrical hazards associated with their respective job or task assignments:

- all electricians
- all electrical technicians
- all supervisors of electricians and/or electrical technicians
- all electrical engineers involved in the electrical area
- all personnel contracted to Delphi Corporation who meet the preceding descriptions

5.3.2 On-The-Job Training

On-the-job training shall be held for the above groups:

- shortly after major changes to equipment or procedures
- periodically through regular safety contacts by supervisors with employees

5.3.3 Qualification Documentation

The following qualification items are the minimum documentation required:

- completion of qualification training on record in employees training file, including proof of on-the-job training for unqualified personnel.
- certificate of training completion awarded to trainee
- applicable materials delivered to trainee
- safety contact (talks) records

6. Planning Electrical Work

6.1 Objective

This procedure establishes the guidelines to be utilized when planning is required by Section 4.3.1 for the safe execution of electrical work. Policies and practices shall be used for all non-routine electrical work to be performed at Delphi Corporation (includes any contracted services).

6.2 Procedure Sequence

1. Define the scope of the work, including the physical boundaries and safe approach distances (Annex A) of the work. Also, define all of the hazards. List potential energy hazards such as gravity as well as electrical hazards.
2. Classify the electrical work by completing the Electrically Hazardous Written Job Plan when dealing with voltage levels greater than 50 V. Figure 2 is an example of the type of plan that must be completed.
3. Where necessary, determine when and/or whether the equipment may be secured by completing a Request for Machine Maintenance Access/Shutdown for the affected equipment. Figure 1 gives an example of such a form.
4. If the job plan is to be performed on a weekend or in a remote area of the facilities, an emergency response plan should be developed.
5. Hold a utility interruption or project pre-meeting to discuss personal and equipment safety and job purpose. During this meeting, identify the qualified person(s) involved and develop contingency plans.
6. The supervisor in charge shall be responsible for ensuring that a job briefing with the workers involved has been held before the start of the work. This briefing shall be on the job site if possible and include technically knowledgeable personnel. The formality and structure of the meeting shall match the level of complexity and risk that the job poses.
7. Employees shall be instructed to be alert at all times during the job and reminded of any job-specific hazards that might exist.
8. After the work is completed, hold an exit evaluation meeting to document lessons learned and opportunities for plan improvement.

Figure 1: Request for Machine Maintenance Access / Shutdown Sample Form

SAMPLE

Request for Machine Maintenance Access/Shutdown

1. Site:____________________________ Area:_______________ Project:____________________
2. Planned start date:_______________ Start Time:_______________ Expected Duration:___________________
3. Weather Forecast for the Date(s) Above: _______________________________
____
4. Description of work to be done:____
____
____
5. The following is requested to be shut down:_______________________________
____

☐ Until work is complete_______________________

☐ Temporarily while barriers are being placed__________________________

6. Will Production be able to run during the job (circle one)? Yes No
7. The following contingency plans have been made in case the equipment being shut down can't be restored to service as planned:
____
____

Persons to notify if contingency plans must be utilized:
Person:_________________ Position:____________ Phone:_______________
Person:_________________ Position:____________ Phone:_______________

8. Shutdown Requested by:____
Dept/Title:____________________________________Date:______________

(Items 9-12 be completed by Authorized Manager of the Affected Area)

9. Shutdown Is: ☐ Granted ☐ Denied

10. If denied, the next available date for shutdown is?___________________________________
11. Reason(s) for shutdown denial____
____
____

12.Signature:______________________ Dept:____________ Date:____________

Figure 2: Sample Electrically Hazardous Job Written Plan

Electrically Hazardous (>50V) Job Given To:______________________________
Written Job Plan Date:____________________

(To be completed by supervisor or person doing work, attached to Request for Shutdown, and submitted for approval.)

1. General description of work to be done: ______________________________

   Place Splice Box 2-09-04 on roof of building 04 for the south.

   primary distribution system in an electrically safe work condition

   Why is it necessary to perform this task with the equipment energized?: ____

.The task is to de-energize the equipment .

____

2. Using the information contained in Annex A, identify the voltage of the exposed energized circuit parts to be encountered. Circle the approach boundaries to be crossed when performing the task:

   Limited Approach Restricted Approach

   Prohibited Approach Flash Protection - Fuse Protected Equipment

   [✓ Flash Protection - Circuit Breaker Protected Equipment]

4. Based on the attached information in Annex B and the approach boundaries circled above, circle the protective items below which are required to perform the task:

   a. Safety Glasses

   b. Rubber Gloves with Protectors -- Voltage Rating:___________________

   c. Insulated Tools -- List: ____
      -- Voltage Rating: ____

   [✓ d. Flash Protective Hood, Face Shield, and Coveralls]

   [✓ e. Voltage Tester/Meter -- Rate Voltage: *15 kV* AC] __________DC

5. Is a Qualified Electrical Backup (Buddy) required? [✓ Yes] No

6. Are communications equipment required (circle one)? Yes [✓ No]
What kind?____

SAMPLE

Figure 3: Sample Electrically Hazardous Job Written Plan (Page 2)

Figure 4: Sample Electrically Hazardous Job Written Plan (Page 3)

Electrically Hazardous (>50V)
Written Job Plan

12. List additional hazards, concerns, or precautions to be taken, and how the exposed persons will be protected:

Hazard of arc-flash is possible when switching 15kv gear.... .

Employees will wear flash-flame PPE during these operations.

13. Does the current weather forecast support being able to perform the task at the time requested? (Circle one): [✓ Yes] No

14. Will a non-resident expert as outlined in Annex A be required for the task? (Circle one)
Yes [✓ No]
Has one been identified and scheduled? Yes No

15. Number to call in an emergency on the site: *6-1644*

16. Signatures required per Annex A:

Planner	Date
Planner	Date
Planner	Date
Planner	Date
Skilled Trades Supervisor	Date
Non-Resident Expert	Date

*Answer just prior to performing the work:
Has all personal protective equipment been inspected and/or tested to insure its integrity (circle one)? [✓ Yes] No

SAMPLE

7. Personal Protective Equipment (PPE) Requirements

7.1 Objective

This procedure defines the personal and other protective equipment (PPE) necessary to protect personnel from electrical hazards. Further, this chapter discusses the maintenance and the care of that PPE.

7.2 General

Safety related work practices should be used to safeguard employees from injury while they are working within specific distances from electrical circuit parts that are or may become energized. The specific safety related work practice and PPE required for each task shall be determined by the nominal system voltage, the distance from the employee to exposed energized conductors, and the current overprotection device type as specified in Annex A. Even if all safe work practices and the appropriate engineering considerations are applied, PPE is necessary as the final protection against serious injury.

When determined by an evaluation of the degree of hazard and exposure, employees shall wear protective equipment for the head, face, neck, chin, eyes, ears, body, and extremities. This equipment may be worn alone or combined with normal apparel. When deemed necessary by a flash hazard assessment, flame resistant apparel shall be worn. Even with flame resistant protective apparel, the energy that can potentially be released by arc flash is sufficient to melt some synthetic materials such as polyester. Therefore, it is recommended that all personnel whose primary job function is electrical work wear only natural fiber clothing to work.

7.3 Equipment List

When exposed to live circuits greater than 50 volts, the following is the minimum PPE required:

- Safety Glasses (with sideshields where required by plant safety policies).
- Proper Voltage Rated Gloves with leather protectors
- Insulated Tools rated at the appropriate voltage level
-
- Flame Resistant (FR) Category I Clothing

Additional personal safety and protective equipment includes, but is not limited to, the following items:

- Voltage Testers and Hot Sticks
- Insulating Sleeves
- Insulating Blankets and Mats
- Protective Barriers
- External Circuit Breaker Rack-Out Devices
- Disconnects / Isolation Devices
- Portable Lighting Units
- Safety Grounding Equipment
- Dielectric and Insulating Footwear

When determined by flash hazard assessment, the following additional protective equipment shall be utilized:

- Flash Suit (Nomex™ or other comparable fire resistant fabric.)
- Flash Protection Face Shield
- Insulating Voltage Class Rated Gloves with Leather Protectors (Note: The leather provides low-level flash protection)

7.4 General Equipment

Safety glasses are required at all times when doing any work around energized equipment. Earplugs shall be worn if required by the individual location. If hearing protection is deemed necessary and verbal communication is vital between workers on a particular job, an alternate communication method shall be established to ensure safe completion of the job task.

Items NOT to be worn

Conductive articles of jewelry and clothing, such as watch bands, bracelets, rings, necklaces, metallic aprons, cloth with conductive thread, metal headgear, or **unrestrained** metal frame glasses [illegible]all not be worn where they present an electrical contact hazard with exposed energized conductors or [illegible]cuit parts. These items may be allowed if they are properly insulated by covering, wrapping, or some other method which make them non-conductive.

Conductive Materials, Tools, and Equipment Being Handled

Conductive materials, tools, and other equipment that are in contact with any part of an employee's body shall be handled in a manner that will prevent accidental contact with exposed energized electrical conductors or circuit parts. Examples of these types of materials are as follows:

- Ducts
- Pipes
- Tubes
- Conductive Hoses/Ropes
- Metal-Lined Rules, Scales, Tape Measures
- Pulling Lines and Metal Fish Tape
- Metal Scaffold Parts
- Structural Members
- Bull Floats
- Chains

7.4.1 Personal Protective Equipment Required for Various Tasks

Listed in Table 3-3.9.1 is a number of common work tasks with the respective Hazard/Risk Category associated with each task. Once the Hazard/Risk Category has been identified, refer to Table 3-3.9.2. The assumed "normal" short circuit current capacities and fault clearing times for various tasks conducted on low voltage (600 Volts and below) equipment are listed in the notes to Table 3-3.9.1. For task not listed, or for power systems greater than the normal short circuit current capacity or for longer than assumed fault clearing times (for the assumed current and time values, see the Notes to Table 3-3.9.1), a flash hazard analysis is required in accordance with section 2-1.3.3 of Part II of the NFPA 70E 2000 edition.

> *Note: Energized parts that operate at less than 50 volts are not required to be de-energized to satisfy an "electrically safe work condition." Consideration should be given to the capacity of the source, any overcurrent protection between the energy source and the worker, and whether the work task related to the source of operating at less than 50 volts increases exposure to electrical burns or to explosion from an electric arc.*

7.4.2 Protective Clothing and Personal Protective Equipment Matrix

Once the Hazard/Risk Category has been identified, refer to Table 3-3.9.2. Table 3-3.9.2 lists the requirements for protective clothing and other protective equipment based on Hazard/Risk Category numbers 0 through 4. This clothing and equipment shall be used when working on or near energized equipment within the Flash Protection Boundary.

> *Note 1: See Table F-1 for a suggested simplified approach to assure adequate PPE for electrical workers within facilities with large and diverse electrical systems.*
> *Note 2: The PPE requirements of this section are intended to protect a person from arc-flash and shock hazards. While some situations may results in burns to the skin, even with the protection described in Table 3-3.9.2, any burn injury should be relatively minor and survivable. Due to the explosive effect of some arc events, physical trauma injuries may*

occur. The PPE requirements of this section do not provide protection against physical trauma". (NFPA 70E Section 3-3.9-2)

NFPA 70E Table 3-3.9.1 Hazard Risk Category Classification with Delphi Additions (See Notes at end of table)

Task (Assumes Equipment Is Energized, and Work Is Done Within Flash Protection Boundary)	Hazard/Risk Category	V-Rated Gloves	V-rated Tools
Panelboards rated 240 V and below – Notes 1 , 3 and 7	--	--	--
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N
Panelboards or Switchboards rated > 240 V and up to 600 V (with molded case or insulated case circuit breakers) – Notes 1, 3 and 7	--	--	--
CB or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
600 V Class Motor Control Centers (MCCs) – Notes 2 (except as indicated) and 3	--	--	--
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch or starter operation with enclosure doors open	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts > 120 V exposed	2*	Y	Y
Insertion or removal of individual starter "buckets" from MCC – Note 4	3	Y	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized parts)	2*	N	N
Opening hinged covers (to expose bare, energized parts)	1	N	N
600 V Class Switchgear (with power circuit breakers or fused switches) – Notes 5 and 6	--	--	--
CB or fused switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	1	N	N
600 V Class Switchgear (with power circuit breakers or fused switches) – Notes 5 and 6	--	--	--
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below; exposed	0	Y	Y
Work on control circuits with energized parts > 120 V exposed	2*	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open	3	N	N
Application of safety grounds, after voltage test	2	N	N
Removal of bolted covers (to expose bare, energized parts)	2*	Y	N
Opening hinged covers (to expose bare, energized parts)	2	N	N
Other 600 V Class (277 V through 600 V, nominal) Equipment – Note 3	**--**	**--**	**--**
Lighting or small power transformers (600 V, maximum)	--	--	--
Removal of bolted covers (to expose bare, energized parts)	2*	N	N
Opening hinged covers (to expose bare, energized parts)	1	N	N
Work on energized parts, including voltage testing	2*	N	N

Task (Assumes Equipment Is Energized, and Work Is Done Within Flash Protection Boundary)	Hazard/Risk Category	V-Rated Gloves	V-rated Tools
Lighting or small power transformers (600 V, maximum)	--	--	--
Application of safety grounds, after voltage test	2*	N	N
Revenue meters (KW-hour, at primary voltage and current)	--	--	--
Insertion or removal	2*	Y	N
Cable trough or tray cover removal or installation	1	N	N
Miscellaneous equipment cover removal or installation	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
NEMA E2 (fused contactor) Motor Starters, 2.3 kV through 7.2 kV	--	--	--
Contactor operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Contactor operation with enclosure doors open	2*	N	N
Work on energized parts, including voltage testing	3	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts > 120 V, exposed	3	Y	Y
Insertion or removal (racking) of starters from cubicles, doors open	3	N	N
Insertion or removal (racking) of starters from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	3	Y	N
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Metal Clad Switchgear, 1kV and above	--	--	--
CB or fused switch operation with enclosure doors closed	2	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	4	N	N
Work on energized parts, including voltage testing	4	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	2	Y	Y
Work on control circuits with energized parts > 120 V , exposed	4	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open	4	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	4	Y	N
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Opening voltage transformer or control power transformer compartment	4	N	N
Other Equipment 1kV and above	--	--	--
Metal clad load operation switches, fused or unfused	--	--	--
Switch operation, doors closed	2	N	N
Work on energized parts, including voltage testing	4	Y	Y
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Metal clad load operation switches, fused or unfused	--	--	--
Outdoor disconnect switch operation (gang-operated, from grade)	2	N	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examination, in open area	2	Y	N

Legend:

V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which will be done.
V-rated Tools are tools rated and tested for the maximum line-to-line voltage upon which will be done.
2* means that a double-layer switching hood and hearing protection are required for this task in addition to the other Hazard/Risk Category 2 requirements of Table 3-3.9.2 of Part II.
Y = yes (required)
N= no (not required)

Notes:

1. 25-kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
2. 65-kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
3. For < 10 kA short circuit current available, the Hazard/Risk Category required may be reduced by one Number.
4. 65-kA short circuit current available, 0.33 second (20 cycle) fault clearing time.
5. 65-kA short circuit current available, up to 1.0 second (60 cycle) fault clearing time.
6. For < 25kA short circuit current available, the Hazard/Risk Category required may be reduced by one number.
7. **Delphi Note** – For Delphi facilities panelbaords include control enclosures.

NFPA 70E Table 3-3.9.2 Protective Clothing and Personnel Protective Equipment (PPE) Matrix

Protective Clothing & Equipment **Protective Systems for Hazard/Risk Category**

Hazard/Risk Category Number	**-1 (Note 3)**	**0**	**1**	**2**	**3**	**4**
Untreated Natural Fiber						
a. T-shirt (short sleeve)	X			X	X	X
b. Shirt (long sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing (Note 1)						
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
d. Jacket, parka, or rainwear			AN	AN	AN	AN
FR Protective Equipment						
a. Flash suit jacket (2 layer)						X
b. Flash suit pants (2 layer)						X
Head Protection						
a. Hard Hat			X	X	X	X
b. FR Hard Hat liner					X	X
Eye Protection						
a. Safety glasses	X	X	X	AL	AL	AL
b. Safety goggles				AL	AL	Al
Face protection double-layer switching hood				AR (Note 8)	X	X
Hearing protection (ear canal inserts)				AR (Note 8)	X	X
Leather Gloves (Note 2)		AN	X	X	X	X
Leather Work Shoes		AN	X	X	X	X

Legend:
AN = As needed
AL = Select one in group
AR = As Required
X = Minimum required

Notes:
1. See Table 3-3.9.3 (APTV is the Arc Thermal Performance Exposure Value for a garment in cal/cm^2.)
2. If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfies this requirement.
3. Class 1 is only defined if determined by Notes 3 or 6 of Table 3-3.9.1 Part II.
4. Regular weight (minimum 12 oz/yd^2 fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants. FR pants used for Hazard/Risk Category 1 shall have a minimum ATPV of 5.
5. Alternate is to use FR coveralls (minimum ATPV of 5) instead of FR shirt and FR pants.
6. If the FR pants have a minimum ATPV of 8, long pants of untreated natural fiber are not required beneath the FR pants.
7. Alternate is to use FR coveralls (minimum ATPV of 5) over untreated natural fiber pants and T-shirt.
8. A double-layer switching hood and hearing protection are required for the tasks designated 2* in Table 3-3.9.1 Part II.
9. Alternate is to use two sets of FR coveralls (each with a minimum APTV of 5) over untreated natural fiber clothing, instead of FR coveralls over FR shirt and FR pants over untreated natural fiber clothing.

Table 3-3.9.3 Protective Clothing Characteristics

Typical Protective Clothing Systems

Hazard Risk Category	**Clothing Description (Number of clothing layers is given in parentheses)**	**Total Weights oz / yds**	**Minimum Arc Thermal Performance Exposure Value (ATPV)* or Breakopen Threshold Energy EBT)* Rating of PPE cal/cm^2**
0	Untreated cotton (1)	4.5 – 7	N/A
1	FR shirt and FR pants (1)	4.5 – 8	5
2	Cotton underwear plus FR shirt and FR pants (2)	9 – 12	8
3	Cotton underwear plus FR shirt and FR pants plus FR coverall (3)	16 – 20	25
4	Cotton underwear plus FR shirt and FR pants plus double layer switching coat and pants (4)	24 – 30	40

*APTV is defined in the ASTM P S58 standard arc method for flame resistant (FR) fabrics as the incident energy that would just cause the onset of a second degree burn (1.2 cal/cm^2). EBT is reported according to ASTM P S58 and is defined as the highest incident energy, which did not cause FR fabric breakopen and did not exceed the second-degree burn criteria. EBT is reported when ATPV cannot be measured due to fabric breakopen.

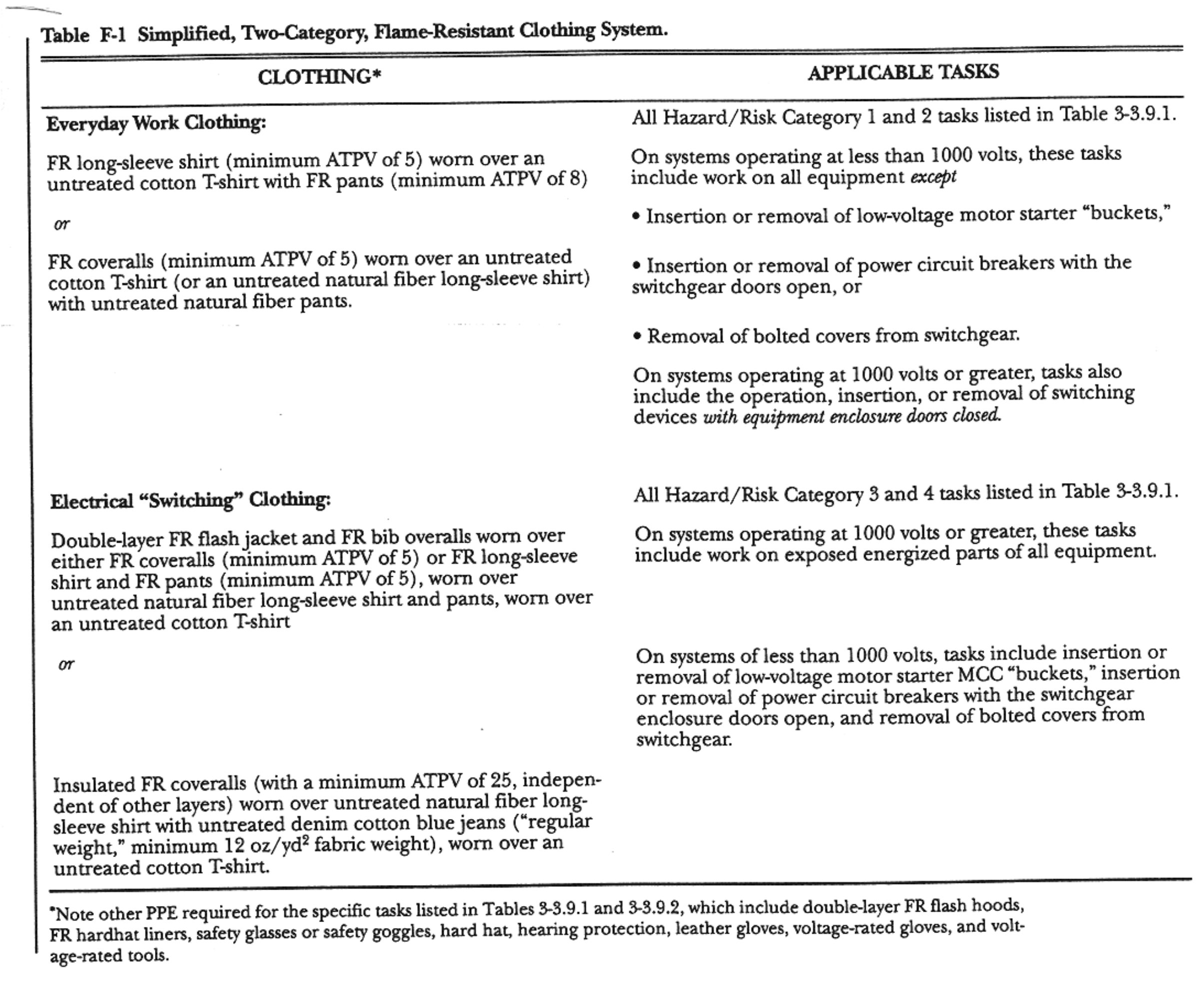


Table F-1 Simplified, Two-Category, Flame-Resistant Clothing System.

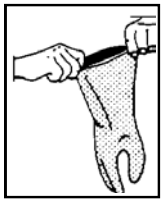
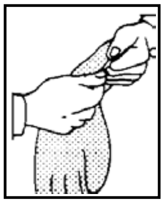
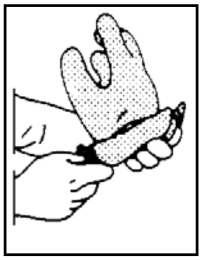
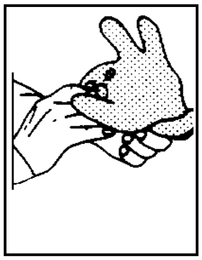
CLOTHING*	APPLICABLE TASKS
Everyday Work Clothing: FR long-sleeve shirt (minimum ATPV of 5) worn over an untreated cotton T-shirt with FR pants (minimum ATPV of 8) *or* FR coveralls (minimum ATPV of 5) worn over an untreated cotton T-shirt (or an untreated natural fiber long-sleeve shirt) with untreated natural fiber pants.	All Hazard/Risk Category 1 and 2 tasks listed in Table 3-3.9.1. On systems operating at less than 1000 volts, these tasks include work on all equipment *except* • Insertion or removal of low-voltage motor starter "buckets," • Insertion or removal of power circuit breakers with the switchgear doors open, or • Removal of bolted covers from switchgear. On systems operating at 1000 volts or greater, tasks also include the operation, insertion, or removal of switching devices *with equipment enclosure doors closed.*
Electrical "Switching" Clothing: Double-layer FR flash jacket and FR bib overalls worn over either FR coveralls (minimum ATPV of 5) or FR long-sleeve shirt and FR pants (minimum ATPV of 5), worn over untreated natural fiber long-sleeve shirt and pants, worn over an untreated cotton T-shirt *or* Insulated FR coveralls (with a minimum ATPV of 25, independent of other layers) worn over untreated natural fiber long-sleeve shirt with untreated denim cotton blue jeans ("regular weight," minimum 12 oz/yd^2 fabric weight), worn over an untreated cotton T-shirt.	All Hazard/Risk Category 3 and 4 tasks listed in Table 3-3.9.1. On systems operating at 1000 volts or greater, these tasks include work on exposed energized parts of all equipment. On systems of less than 1000 volts, tasks include insertion or removal of low-voltage motor starter MCC "buckets," insertion or removal of power circuit breakers with the switchgear enclosure doors open, and removal of bolted covers from switchgear.

*Note other PPE required for the specific tasks listed in Tables 3-3.9.1 and 3-3.9.2, which include double-layer FR flash hoods, FR hardhat liners, safety glasses or safety goggles, hard hat, hearing protection, leather gloves, voltage-rated gloves, and voltage-rated tools.

7.4.3 Insulating Equipment

Insulating equipment shall be inspected for damage before each day’s use and immediately following any incident that can reasonably be suspected of having caused damage to it. Insulating gloves shall be given an air test, along with the inspection. Figure 5 outlines the process to complete the air test:

Figure 5: Insulating Glove "Air Test"

1. HOLD THE GLOVE WITH THUMBS AND FOREFINGERS AS ILLUSTRATED. 	2. TWIRL THE GLOVE AROUND QUICKLY TO FILL WITH AIR 	3. TRAP THE AIR BY SQUEEZING THE GAUNTLET WITH ONE HAND. USE THE OTHER HAND TO SQUEEZE THE PALM, FINGERS, AND THUMB IN LOOKING FOR WEAKNESSES AND DEFECTS. 	4. FOLD THE GLOVE TO THE FACE TO DETECT AIR LEAKAGE OR HOLD IT TO THE EAR AND LISTEN FOR ESCAPING AIR. 

Insulating equipment found to have defects that might affect its insulating properties should be immediately removed from service and returned for testing.

Insulating equipment with any of the following defects shall not be used:

- Holes, Tears, Cut, or Puncture
- Ozone Deterioration
- Mechanical stress into a series of interlocking cracks
- Embedded Foreign Objects
- Texture Deterioration (i.e. swelling, softening, hardening,)

7.4.4 Flame Resistant Equipment

Flame Resistant equipment shall be inspected for damage before each day’s use and immediately following any incident that can reasonably be suspected of having caused damage to it. Flame Resistant equipment found to have defects that might affect its barrier properties should be immediately removed from service and replaced. The equipment shall be kept clean and dry. Follow all recommended maintenance and inspection recommendations from the manufacturer. **Employees shall care for the equipment as though their life depends on it**. The following are examples of defects that are unacceptable in flash-flame protective equipment:

- Holes, Tears, Punctures, Cuts
- Embedded Foreign Objects
- Texture Deterioration (i.e. swelling, softening, hardening)

7.4.5 Test Instruments and Equipment

All test equipment and components shall be visually inspected prior to use for obvious defects. If any defect is found that could endanger employees, the instrument shall be immediately removed from service until it is repaired. Furthermore, if voltage test equipment is being used for the purpose of determining whether a circuit is de-energized, the equipment should be checked on a "known live" circuit before and after checking the circuit in question in order to verify the reading on the circuit in question.

7.5 Electrical Testing

Electrical (insulating) protective equipment shall be subjected to periodic electrical tests. The test voltage to be used in the tests, as well as the interval between the tests, is dictated by OSHA. Table 1 that follows shows the testing intervals for different insulating materials and other electrical equipment:

Table 1: Electrical Equipment Testing Intervals

EQUIPMENT	*TESTING INTERVAL*
Insulating gloves / sleeves	Before first issue and every 6 months thereafter
Hot Sticks	Annually
Voltage test indicators	Regular intervals to validate data obtained
Safety Grounds	As dictated by conditions of use(70E section 11-3.2)
Insulating Blankets	Before first issue and every 12 months thereafter

IN NO CASE SHALL THE INTERVAL EXCEED THREE YEARS

7.6 Specific Equipment Information

7.6.1 Hand and Arm Protection

As stated in the NFPA 70-E standard, "Insulating rubber gloves with leather protectors and insulating rubber sleeves shall be used as required where there is a danger of hand and arm injury from electric shock or burns due to contact with exposed, energized electrical conductors or circuit parts. Appropriate hand and arm protection shall be worn where there is possible exposure to arc flash burns."[4] Protective gloves shall be worn over insulating gloves. For tasks requiring high dexterity, the equipment should be de-energized and validated prior to beginning task.

7.6.2 Foot tection

Industrial safety footwear protection such as steel toe cap and steel shanks are allowed for employees who work on or near exposed, energized electrical conductors or circuit parts. te : Insulated soles are not being considered as primary personal protection against step and touch potential. Where step and touch potential protection is required insulated mats and/or blankets shall be used.)

7.6.3 Insulated Tools and Equipment

Employees shall use suitably insulated tools and/or handling equipment when working inside the Limited Approach Boundary of exposed energized electrical conductors or circuit parts where it could be reasonably anticipated that the tools or handling equipment may make accidental contact with the energized conductor or circuit part. Insulated tools shall be protected from damage to the insulating material. Fuse and fuse holder handling equipment, suitably insulated for the circuit voltage, shall be used to remove or install fuses. Only nonconductive ropes and hand lines shall be used near exposed energized parts.

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[4] NFPA 70-E, 2000, paragraph 3-3.6 p. 54

7.6.4 Voltage Testing and Other Test Equipment

"Test instruments and their accessories shall be voltage rated for the circuits and equipment to which they will be connected and shall be suitable for the environment in which they will be used."[5] Further, they must meet the minimum criteria set forth in Annex B (Test Equipment Specifications).

7.6.5 Flash/Flame PPE

Employees shall wear clothing resistant to flash flame whenever working on or around exposed energized electrical conductors inside of the flash protection boundary as determined by a flash hazard assessment. Refer to Annex A for table of Flash Protection Boundary[6] if a site specific flash hazard assessment has not been performed. This assessment might allow the use of denim jeans and a cotton shirt. Alternatively, it may require the employee to wear a full body flash protection suit.

7.6.6 Protective Shields and Barricades

Insulated protective barriers can be installed to separate live conductors and parts from personnel performing maintenance or inspection. Employees shall use protective shields, protective barriers, or suitably insulated materials to protect themselves from exposure to electrical hazards when they are working within the Limited Approach Boundary. Work-site barricades shall also be used when necessary in order to insure the safety of the workers and those that might be wandering into the job site.

7.6.7 Insulating Blankets and Mats

Insulating blankets and mats are to be used only as a supplemental protection for employees. They are not to be used as the sole means of protection. Insulating blankets and mats must be stored in suitable containers or in compartments of trucks that are used solely for the storage of such protective equipment.

7.6.8 Personal Safety Grounding Equipment

Temporary protective grounding equipment shall be required to meet the specific fault duty of the electrical system for which it will be utilized. The fault duty may be obtained from the site Short Circuit Study, if necessary. After de-energization, grounding cables are to be connected from the station (earth) ground to each of the three phases (also to the neutral or grounded phase if used). This method of grounding will minimize the voltage drop across the work plane and help facilitate the operation of the circuit overcurrent protection device upon accidental re-energization. The cable sets shall be inspected for cuts in the protective sheath and damage to the conductors. Clamps and connectors strain relief devices shall be checked for tightness. See Section 8 for specific information regarding personal safety grounding equipment.

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[5] NFPA 70-E, 2000, paragraph 3-4.10, p. 63

[6] NFPA 70E – Part II section 2-1.3.3

8. Personal Safety Grounding

8.1 Objective

This procedure describes the requirements for utilization of Personal Safety Grounds.

8.2 General

Based upon a Hazard Risk Assessment, employees of Delphi are required to install temporary Personal Safety Grounds in accordance with Figure 6 prior to working on electrical conductors that could potentially be inadvertently or accidentally re-energized.

8.2.1 Why are Personal Safety Grounds needed?

Employees working on or around exposed, de-energized electrical conductors that could potentially be inadvertently or accidentally re-energized shall be protected from the associated hazards of electric shock and arc flash burns. Some examples of accidental or inadvertent re-energization are:

- Induced Voltages.
- Lightning Strikes.
- Failures that allow another energized circuit to be exposed to the de-energized one.
- Switching Errors.

The installation of Personal Safety Grounds will create an equipotential zone in which all exposed conductors that the employee(s) could possibly contact are at the same voltage level. This procedure thus eliminates the possibility of current flow through a person because there is no potential difference between the parts of his or her body that are in contact with the conductors. The safety grounds will also facilitate the efficient operation of the system protective devices.

8.2.2 Selection of Grounding Sets

The criteria set forth in this section establishes the technical requirements for personal safety ground sets. Each facility shall contact a supplier of personal safety ground sets in order to have an evaluation completed by a representative of the supply unit. This evaluation will result in a recommendation of the appropriately rated ground sets for the various applications at each facility.

8.2.2.1 Clamps

The clamps that are used to connect to the phase conductors and the grounding conductor shall have adequate mechanical ability to fit and electrical capacity to carry the maximum available fault current.

8.2.2.2 Cables

The cables used in Personal Safety Ground sets shall meet the following criteria:

- The interface between the cable ends and the clamps must have the capacity to carry the maximum available fault current.
- The cable must be of sufficient ampacity to withstand the maximum available fault current. See Table 2 for the ASTM Standard Specifications for Temporary Grounding Systems.
- The cable must have clear insulation so to mechanically protect the conductors and facilitate inspection.

Table 2: Grounding Cable and Jumper Ratings

	Withstand Rating (Symmetrical) kA RMS @ 60 Hz		Ultimate Capacity** (Symmetrical) kA RMS @ 60 Hz				Continuous Current Rating A RMS @ 60 Hz
Cable Size, AWG (Copper)	15 cycles	30 cycles	6 cycles	15 cycles	30 cycles	60 cycles	
#2	14.5	10	29	18	13	9	200
1/0	21	15	47	30	21	14	250
2/0	27	20	59	37	26	18	300
3/0	36	25	74	47	33	23	350
4/0	43	30	94	60	42	29	400
250 kcmil	54	39	120	70	49	35	450
350 kcmil	74	54	150	98	69	49	550

* Withstand and ultimate short circuit properties are based on performance with surges not exceeding 20% asymmetry factor.

** Ultimate capacity represents a calculated symmetrical current which the cable or jumper is capable of conducting for the specified time.
These currents are based upon the fusing (melting) current-time values for copper at 40°C.
Reference: ASTM Standard F855-1990, pg. 14

8.2.3 Temporary Personal Safety Grounds Procedure

Before attempting to install temporary grounds on any piece of equipment, the conductors that you will be grounding must be de-energized and verified de-energized with the appropriate test equipment. Verify the equipment is de-energized in accordance with Electrical Safe Work Procedure #9.

The following precautions should be observed when installing temporary grounds:
1. Establish a written procedure to follow when installing temporary grounds. The procedure shall include the type of safety ground set to be used and where they are to be applied.
2. Never use chains or other devices that are not designed for this purpose.
3. Visually verify the equipment to be grounded is locked out / tagged out.
4. Wear the PPE appropriate for the voltage class.
5. Verify zero voltage on the conductor where the temporary grounds are to be placed following the recommended procedure in Section 9. (Volt meter and amp meter use)
6. Ensure the connection points for the grounding cluster are cleaned before installing them.
7. The ground cluster should be attached first to a good station or switchgear-grounding conductor.
8. Attach the ground cluster as close as possible to the actual work location.
9. Equipment that has temporary grounds installed should always be marked as such to ensure that it is not re-energized until the temporary grounds are removed.
10. No equipment can provide complete protection from a lightning strike. Temporary grounds cannot offer adequate protection for personnel to ensure complete protection. Strong consideration should be given to delaying the work if lightning storms are in the area.
11. Use the procedure developed for installation of the temporary grounds as a reference when removing the temporary grounds after the work is complete. This will reduce the possibility of accidentally energizing the circuit with a temporary ground still in place.

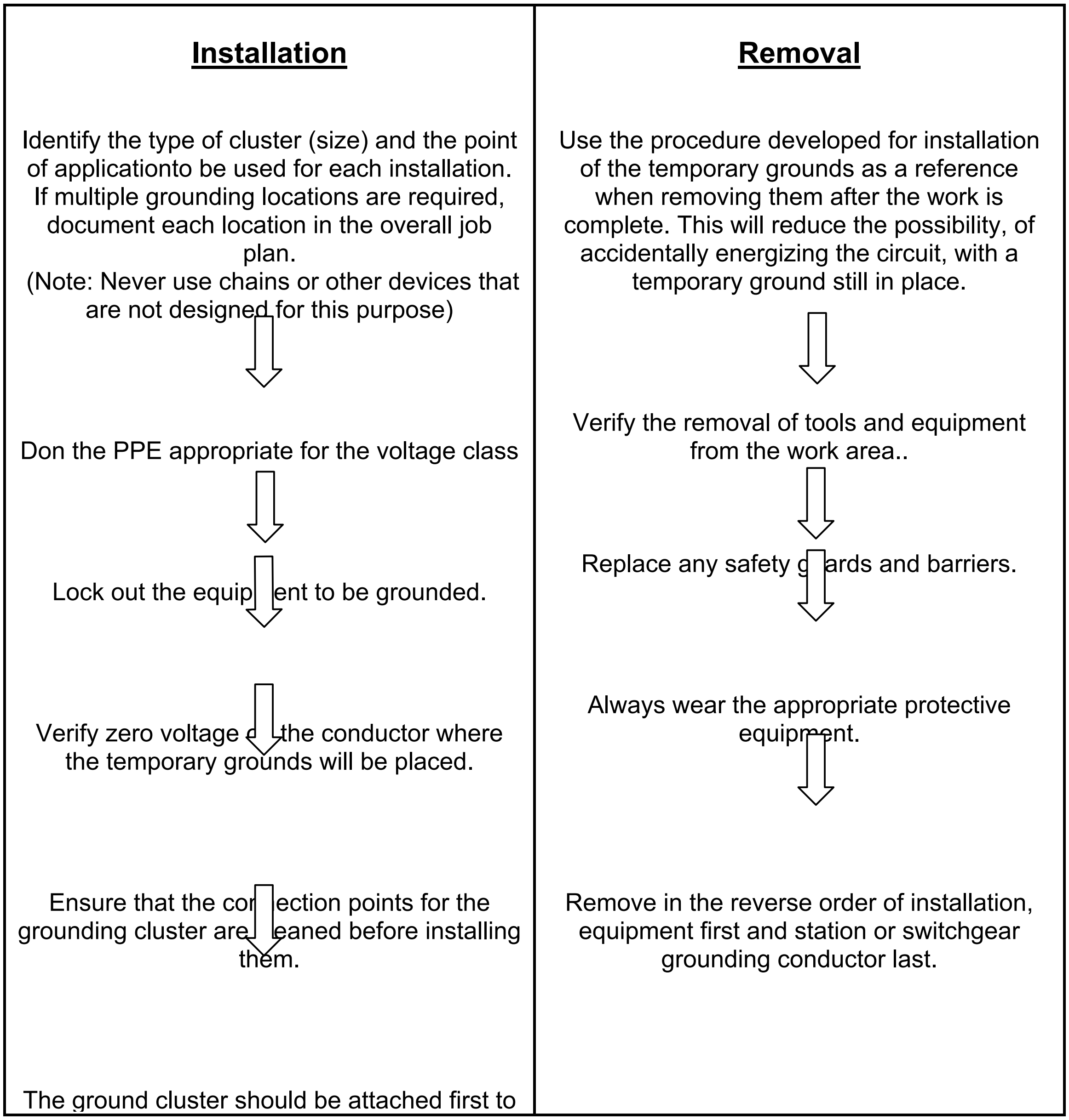
While performing the work, it is recommended that anytime an employee working on the circuit leaves the work location, the employee verifies that the equipment is still locked out and grounds still in place before continuing with the work.

When the work is complete, remove tools and equipment from the work area, replace any safety guards and barriers, and inspect all areas where the work was performed to verify that no tools or equipment has been left in the work area. ***Many electrical incidents have occurred where tools or other equipment was left on exposed conductors upon re-energization of the circuit.***

When removing temporary grounds, remove in the reverse order of installation, equipment first and ground last. Always wear the appropriate protective equipment when removing the grounds. (The same PPE should be worn as if the equipment was energized) It is extremely important that a tracking system be used as a control to ensure that temporary ground is removed prior to clearing lockouts and re-energizing equipment.

Before re-energizing the circuit, use a megger to verify that the circuit is clear of phase to phase and phase to ground conditions. Figure 6 shows the flow-chart for installing and removing personal safety grounds.

Figure 6: Flow-chart for Installing and Removing Personal Safety Grounds



Installation

Identify the type of cluster (size) and the point of applicationto be used for each installation. If multiple grounding locations are required, document each location in the overall job plan.
(Note: Never use chains or other devices that are not designed for this purpose)

Don the PPE appropriate for the voltage class

Lock out the equipment to be grounded.

Verify zero voltage on the conductor where the temporary grounds will be placed.

Ensure that the connection points for the grounding cluster are cleaned before installing them.

The ground cluster should be attached first to

Removal

Use the procedure developed for installation of the temporary grounds as a reference when removing them after the work is complete. This will reduce the possibility, of accidentally energizing the circuit, with a temporary ground still in place.

Verify the removal of tools and equipment from the work area..

Replace any safety guards and barriers.

Always wear the appropriate protective equipment.

Remove in the reverse order of installation, equipment first and station or switchgear grounding conductor last.

the actual work location. ⇩ Attach the ground cluster as close as possible to the actual work location ⇩ Mark Equipment that is temporarily grounded to ensure it is not re-energized until the temporary grounds are removed. .	

8.3 Medium Voltage De-energizing and Grounding of Equipment to Provide Protection for Electrical Maintenance Personnel[7]

8.3.1 Personal Protective Equipment (PPE) Selection:

1) Personnel working on, or in close proximity to, de-energized lines or conductors in electrical equipment should be protected against shock hazards and flash burns that could occur if the circuit was to be inadvertently re-energized.
2) The extent of protection that should be provided will be dictated by specific circumstances. Refer to Section 7 for the PPE requirements. The following possible conditions and occurrences should be considered in determining the type and extent of protection to be provided:
   a) Induced voltage from adjacent energized conductors; these can be appreciably increased when high fault currents flow in adjacent circuits.
   b) Switching errors causing inadvertent re-energizing of the circuit.
   c) Any unusual condition that might bring energized conductor into electrical contact with the de-energized circuit.
   d) Extremely high voltages caused by direct or nearby lightning strikes.
   e) Stored charges from capacitors or other equipment.

8.3.2 Planning and De-Energization:

As soon as practical before the power outage, all areas of the facility to experience the outage should be notified by memo as to the extent and duration of the outage. This memo should remind personnel in the affected area to make plans for perishable items in coolers or machines, sump pumps, battery back-up for programmers, etc.

1) Providing proper protection should include, but not necessarily be limited to, the following steps:
   a) De-energize the proper circuit. Check applicable up-to-date drawing, diagrams, and identification tags to determine all possible sources of supply to the specific equipment. Open the proper disconnecting devices for each source. In cases where visible blade disconnecting devices are used, visually verify that all blades are fully open. Drawout-type circuit breakers should be withdrawn to the fully disconnected position. Do not consider automatic switches or control devices to be disconnecting means for personnel safety.
   b) Take precautions to guard against accidental re-energization. Attach to the operating handles of the open disconnecting device, locks and hold tags with sufficient information thereon. If fuses have been removed to de-energize the equipment, special precautions should be taken to prevent their unauthorized reinsertion. An established lock and tag policy is an essential part of any electrical maintenance safety program.
   c) Test the circuit to confirm that all conductors are de-energized. This test is especially important on circuits that involve switches and fixed-type circuit breakers in which the blades cannot be visually checked. Use an adequately rated voltage detector to test each de-energized circuit for **NO VOLTAGE BEFORE AND AFTER** testing the affected conductors, determine that the voltage detector is operating satisfactorily by proving it on a source that is know to be energized. Some high and medium voltage detectors are equipped with a device that will provide necessary proof voltage.
   d) Until they are grounded, conductors should be considered energized, and personnel should not touch them. If the test indicates that there is **No Voltage** on the affected conductors, they should be adequately grounded in accordance with established procedures. Ground the conductors to protect personnel in event that, in spite of all precautions, the equipment does become re-energized. When capacitors are involved, they should be grounded and shorted to drain off any stored charge.
   e) Involve all personnel connected with the work. Each individual should personally satisfy him or herself that all necessary steps have been executed in the proper manner.

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[7] The majority of this information was obtained from the NFPA 70B – Recommended Practices for Electrical Equipment Maintenance 1994 Edition.

   f) Take precautions against back-feeds from UPS and generators on the low voltage side of the circuit.

8.3.3 Selection of Grounding Equipment:

1) In spite of all precautions, de-energized circuits can be inadvertently re-energized. When this occurs, adequate grounding is the only protection for personnel working on them. For this reason, it is especially important that adequate grounding procedures be established and rigidly enforced.
2) Grounding equipment consists mainly of special heavy-duty clamps that are connected to cables of adequate capacity for the system fault current. Fault currents may be well in excess of 100,000 amperes that will flow until the circuit overcurrent protection devices operate to de-energize the conductors. The grounding equipment should not be larger than necessary, because bulkiness and weight hinder personnel while connecting them to conductors, especially when working with hot-line sticks. Five major considerations in selecting grounding equipment:
   a) Grounding clamps should be of proper size to fit the conductors and have adequate capacity for the fault current. An inadequate clamp can melt or be blown off under fault conditions. Hot-line clamps should not be used for grounding de-energized conductors because they are not designed to carry the high current that would flow if the circuit were to be inadvertently re-energized.
   b) Grounding cables should be of adequate capacity, which, in some instances, might require two or more to be paralleled. Three factors that contribute to adequate capacity are (1) terminal strength, which is largely depends on the ferrules installed on the cable ends, (2) size to carry maximum current without melting, and (3) low resistance to keep the voltage drop across the areas in which the personnel are working at a safe level during any period of inadvertent re-energization.
   c) Solid metal-to-metal connections are essential between grounding clamps and the de-energized conductors. Conductors are often corroded and are sometimes covered with paint. Ground clamps should have serrated jaws because it is often impractical to clean the conductors. Ground clamps that are attach to the steel tower, switchgear, or station ground bus are equipped with pointed or cupped set screws that should be tightened to ensure penetration through corrosion and paint, to provide adequate connections.
   d) Grounding cables should be no longer than is necessary to keep resistance as low as possible and to minimize slack in cables prevents their violent movement under fault conditions. If the circuit should be inadvertently re-energized, the fault current and resultant magnetic forces could cause severe and dangerous movement of slack grounding cables in the area where personnel are working. Proper routing of grounding cables to avoid excessive slack is essential for personnel safety.
   e) Grounding cables should be connected between phases to the grounded structure and to the systems neutral (when available) to minimize the voltage drop across the work area if inadvertent re-energization should occur.

8.3.4 Installation of Grounding Equipment:

1) Prior to installing grounding equipment, it should be inspected for broken strands in the conductors, loose connections to the clamp terminals, and defective clamp mechanisms. Defective equipment should not be used.
2) Grounding equipment should be installed at each point where work is being performed on de-energized equipment. Often it is advisable to install grounding equipment on each side of a work point or at each end of a de-energized circuit.
3) One end of the grounding down lead should be connected to the metal structure or ground bus of the switchgear before connecting the other end to a phase conductor of the de-energized equipment. Then, and only then, should the grounding cables be connected between phase conductors.

8.3.5 Removal of Grounding Equipment:

1) When removing grounding equipment, the above installation procedure should be reversed by first disconnecting the cables between the phases, then disconnecting the down lead from the phase conductor and, finally, disconnecting the down lead from the metal structure or ground bus.
2) Removal of grounding equipment before the circuit is intentionally re-energized is equally as important as was its initial installation but for other reasons. If grounding equipment is forgotten or overlooked after the work is completed and the circuit is intentionally re-energized, the supply circuit overcurrent protective devices will immediately open because the conductors are jumpered and grounded. The short-circuit current can damage the contacts of a breaker having adequate interrupting capacity and can cause an inadequate breaker or fuses to explode. If the grounding cables are inadequate, they can melt and initiate damaging power arcs. A procedure should be established to ensure removal of all grounding equipment before the circuit is intentionally re-energized.
3) A recommendations for a Ground Removal Procedures is as follows:
    a) Assign an identification number to each grounding equipment set and rigidly control all sets that are available for use by all parties, including contractor personnel. Record the number and location of each set that is installed. Cross-that number off the record when each set is removed.
    b) Before re-energizing the circuit, account for all sets of grounding equipment by number to ensure that all have been removed.
    c) Do not install a set of grounding equipment inside switchgear and then close the door or replace the covers so it will be hidden from view. If it is necessary to do so to conceal grounding equipment, place a highly visible sign on the door or cover to remind personnel that a ground is inside.
    d) Before re-energizing, have personnel inspect interiors of equipment to verify that all grounding sets, including small ones used in testing potential transformers, relays, etc., have been removed.
    e) Before re-energizing, test all conductors with a megohmmeter to ascertain if any are grounded. If so, determine the cause and take corrective action.

9. Voltmeter and Ammeter Use

9.1 Objective

This work instruction explains the proper selection and use of voltmeters and clamp-on ammeters on energized circuits.

9.2 Work Instruction Sequence

9.2.1 Meter Selection

The first issue in selecting the instrument to use is deciding whether exact voltages are required, or whether approximate indications are sufficient. As noted in the definitions, approximate values could point to the use of a Wiggy™ instead of a meter. Next, the circuit must be evaluated to determine the *maximum voltage that could be anticipated* at the test points to be utilized in the circuit. It is important to note whether this value represents possible failure conditions as well as every day situations, as some equipment failure modes cause much higher voltages to be present than otherwise would be. Having determined this value, obtain a meter with an AC and DC rating higher that the highest expected voltage in the circuit. Additionally, all of the test instruments used to perform voltage testing, voltage measurement, and current measurement must meet the minimum specifications set forth in Annex B. As always, refer to any of the manufacturer's recommendations for use to determine suitability.

9.2.2 Using a Wiggy™ or other Voltage Test Equipment

Utilize the following work instructions when performing the process of voltage testing (testing for the presence or absence of voltage):

Voltage/Amperage Testing Work Instruction

1. Review schematics and wiring diagrams.
2. Remove or properly safeguard all personal metallic or conductive objects which might make contact with energized conductors (i.e.- watches, rings, etc.)
3. Insure adequate lighting.
4. Establish a work area equal to or greater than the Limited Approach Distance as defined in Annex A. **Wear appropriate PPE as required.**
5. Remove or properly secure all metallic or conductive objects which might make contact with energized conductors.
6. Don appropriates Personal Protective Equipment (PPE). Refer to Section 7.
7. Inspect physical integrity of test equipment and test leads to be used.
8. Secure Door/Cover in the open position.
9. Insulate exposed energized parts, where possible.
10. Verify the tester setting (i.e. – proper voltage setting or amperage setting) prior to use.
11. Secure the tester in an appropriate location and manner so that it can easily read. If provisions do not exist for securing the meter, contact your supervisor for assistance.
12. Check the tester on a known live circuit and then obtain the voltage measurement or amperage measurement of concern in accordance with section 9.2.3 – 9.2.8.
13. Check the continued operation of the tester by checking it again on a known live circuit.
14. After identifying the problem, lock the equipment out prior to making the repair.
15. Perform closeout inspection to insure that all parts and equipment have been removed and that the circuit is returned to normal operation.
16. Close and secure door/cover.

Note: DO NOT leave a Wiggy™ or other solenoid-type voltage testing equipment on the energized circuit any longer than absolutely required, or 2 seconds, whichever is shorter. Voltage testing equipment of this type is not designed for continuous use and will fail if used otherwise -- typically failing open circuited/non-indicating.

9.2.3 Obtaining a Voltage Measurement

The preceding work instruction can be used as a guide to performing the process of voltage measurement (obtaining an actual measured value of voltage). The following additional guidelines are to be followed when taking a voltage measurement:

- If the meter is auto ranging, set the meter buttons or dial to indicate voltage AC or DC, depending on which is being measured.
- If the meter is not auto ranging, set the buttons or dial to the highest voltage of the meter and to AC or DC as appropriate.
- Using voltage rated gloves, protectors, and other PPE equipment as is required under the circuit conditions and voltage exposure. Be careful to keep as much of your body as possible from electrical exposure.
- Secure the meter where it can easily be seen while performing the testing. If provisions do not exist for securing the meter, contact your supervisor for assistance. The black lead should be connected to the "Com." terminal on the meter, and the red probe to the "Volts" terminal.
- Hold onto the insulated portion of the red and black probes. If one of the circuit conductors in the test circuit is grounded put the black lead on this conductor first. If the circuit is a DC circuit, put the black lead on the conductor anticipated to be at the lower voltage of the two. Next, put the red probe on the other conductor. NOTE: if the meter deflects hard to the left (DC circuit, analog meter), immediately remove the leads, and repeat the procedure reversing the black and red leads.
- Attempt to read the meter. On an auto-ranging meter, the display should indicate the voltage of the circuit and may be read directly. On other meters, reduce the meter scale from the highest scale down to a scale that causes the meter to indicate in the upper third of its scale (best accuracy) and then note the reading. Carefully remove the leads from the circuit when finished.
- If the meter is being used to test for the presence or absence of voltage, the meter must now be tested on a known energized circuit to insure that it is still functioning properly (Live, Dead, Live Test).

9.2.4 Using a Volt-Ohm Meter (VOM) to Measure Resistance

The resistance measurement is accomplished in the meter by supplying an internally generated low voltage to the meter leads and the circuit connected to them, and by measuring the current that flows in the circuit. Utilizing Ohm's Law, V = I x R, the resistance can be calculated by the meter. The steps to be followed are:

- The circuit to be tested must be de-energized and have all residual voltage and electric charge removed.
- Untangle the leads, as this can affect the readings if the value of resistance is low.
- On an analog meter or manual digital meter:
    - Put the meter on the highest resistance scale. Touch the ends of the leads together. The meter should indicate zero ohms. If not, there should be a zero adjustment knob, this can be turned in order to zero the meter (analog meter).
    - Once the meter is zeroed, put the leads across the circuit to be measured. If the meter deflects into the upper third of the scale, read the value. If the meter indicates full scale, the reading is considered to be infinity, or greater than the full-scale value.
    - If the meter is not in the upper third of scale, lower the meter scale one range, re-zero the meter, and repeat the reading. Continue this process until a scale is found where a proper reading can be taken. If the meter reads zero, even on the lowest meter range, then within the precision constraints of the meter, the reading is continuity.
    - **NOTE:** Most analog meters will be damaged if voltage is applied to the leads if the meter is in the resistance measurement mode. To protect the meter, most

manufacturers' fuse the meter against this possibility, with the fuse being inside the meter case. _If this fuse is blown, the meter could indicate zero voltage on a live circuit -- emphasizing the need to check the meter against a known live circuit when testing for voltage presence._

- On an auto-ranging digital meter:
  - Put the meter in the resistance measuring position. Untangle the leads and touch the ends of the leads together. The meter should indicate very close to zero ohms (a few milliohms may be indicated, as the leads do not have zero resistance). If not, try a different set of leads and/or check the connections of the leads to the meter. If this still does not fix the problem, replace the battery in the meter and check again. The meter needs repaired or calibrated if the problem persists. Use another instrument.
  - Put the leads across the circuit to be measured. The meter should automatically scale the reading and directly display the value of resistance.
  - Note that most of the digital meters in use today are internally protected from contacting a voltage source when in the resistance measurement mode, as long as the applied voltage is within the meter's rated voltage. Even so, the meter should still be checked against a known live source when being used to test for the presence or absence of voltage.

9.2.5 Using a VOM to Measure Current

Most VOM's have a limited ability to measure current (usually in milliamps) -- make sure not to exceed the meter's rating. In order to do so, the meter leads must be in series with the path of the current -- thereby requiring that the circuit be de-energized and locked out before proceeding with insertion of the meter leads in the circuit. When the circuit is locked out, the meter should be secured in an accessible location, the black lead plugged into COM on the meter, the red lead plugged into AMPS/current on the meter, and the meter leads installed in a secure manner in series with the circuit. It is important that the leads not be removed while under current carrying conditions.

- Put the meter into the ammeter mode. Re-energize the circuit. Follow the same steps for ranging the meter as used in voltage or resistance testing, depending on the type of meter used.
- De-energize and lock out the circuit, and remove the meter from the circuit.

9.2.6 Effects of Meter Leads on Measurements

Meter leads do not have zero resistance. However, for most resistance measurements, the leads are a very tiny percentage of the resistance of the device being measured, and therefore can be ignored. It is possible though, to impact the reading when attempting to measure a very small value -- especially with a digital meter. In this situation, the best alternative is to use a meter that is especially designed to measure low range resistances. If one is not available, however, the meter leads can be shorted and the reading noted, with this value being subtracted from the total reading seen when measuring the item of interest.

9.2.7 Clamp-On Ammeter Selection

The first issue in selecting a clamp-on ammeter is deciding whether exact currents are required or whether approximate indications are sufficient. Need of only approximate values could point to the use of an analog device, while greater accuracy points to digital equipment. Next, the circuit must be evaluated to determine the maximum current flow that could be anticipated, the maximum voltage the clamp-on portion of the meter could be subjected to (especially of concern in bare conductor measurements), as well as the maximum conductor diameter to be clamped around. Having determined these values, obtain a meter with physical characteristics and electrical ratings sufficient for the circuit in question.

9.2.8 Obtaining a Current Reading with a Clamp-On Ammeter

After obtaining a proper meter, it is turned on (if digital) and then:

- If the meter is auto ranging, set the meter buttons or dial to indicate AC or DC, depending on which is being measured.
- If the meter is not auto ranging, set the buttons or dial to the highest current range of the meter and to AC or DC as appropriate.

Using voltage rated gloves and protectors, and other personal protective equipment as is required under the circuit conditions and voltage exposure, clamp the meter over the circuit conductor of interest, being careful to keep as much of your body as possible away from electrical exposure

- Allow the clamp to spring shut securely, and center the conductor in the opening. **Note** that as current flow increases, electromagnetic forces increase causing vibration that will be felt in the hands, and noise which will be heard. Additionally, these conditions may cause the clamp to be more difficult to open for removal. It is important to be prepared for these conditions.
- Once clamped on, read the value of current directly on the display. If your meter is not auto ranging, lower the range until the meter is indicating in the upper third of the selected range. This gives greatest accuracy.
- Once the reading is finished, open the clamp, remove the meter, and move away from the energized conductors.

9.2.9 Proper Use and Care of Metering Devices

Meters should be properly stored when not in use. They should be kept in a cool dry location, and kept from undue physical shock. If they are expected to be stored for a long period, remove any batteries before storage. If the meter needs to be cleaned, wipe clean with a dry cloth, or one very slightly dampened with water. Do not use solvents or harsh chemicals.

Meter leads should be loosely coiled (to prevent premature cracking and breaking) and stored with the meter. If meter leads need to be cleaned, try wiping with a clean dry cloth. If this is insufficient to clean the leads, try using a small amount of solvent, such as electrical contact cleaner. If this is still unsuccessful, replace the leads.

10. Troubleshooting Electrical Equipment

10.1 Objective

This section describes how to safely apply the steps of effective troubleshooting to electrical equipment.

10.2 General

As indicated in the definitions section, troubleshooting is the means by which non-operating equipment is safely restored to service in the least possible time. The troubleshooting process is a systematic and logical approach in searching out and eliminating the problem(s). Often times, problems observed are just symptoms of the root cause and can lead the troubleshooter down the wrong path. Knowing equipment and its operation strengthens troubleshooting abilities.

10.3 Safety Considerations

The following are safety items to consider prior to beginning to troubleshoot hot equipment:

- Perform Hazardous Risk Assessment to identify level of PPE required . (See Table 3-3.9.1 in Section 7.4.2)
- Ensure proper workspace is available to perform the assigned task
- Apply Appropriate PPE (Safety Glasses, Rubber Gloves with Leather Covers, etc.)
- Utilize properly rated tools (insulated tools, fuse pullers, VOM, Wiggy, glow sticks, etc.)
- Once problem is identified lock out equipment prior to starting repair activity
- Verify all tools are removed from the panel(s) prior to re-energization.

The failure mode of equipment warrants different troubleshooting methodologies, if equipment fails to operate due to tripping of an overcurrent device (i.e. – short circuit, overload, etc.) refer to section 10.5 for re-energization instructions.

If unfamiliar with the Delphi safety practices refer to the appropriate Sections of this document.

10.4 Troubleshooting Methodology

There are six basic steps to troubleshooting as discussed below:

10.4.1 Know the System/Equipment

Without knowledge of how equipment is supposed to operate, one can not efficiently and safely troubleshoot a problem. It is the system knowledge that allows us to know what the normal operating condition is and the symptoms for the most common failures. By understanding a system's operation, proper safety precautions and utilizing the proper personal protective equipment, downtime will be minimized. If unfamiliar with the sequence of operation, seek the assistance of other knowledgeable personnel (jobsetter, equipment operator, other skilled trades, engineers, etc.)

10.4.2 Investigate the Symptoms

The next step in a logical approach is to determine that there is, in fact, a problem.

- Ask an operator, if possible, what happened.
- Try to arrive at the machine or equipment in its "failed" state (e.g. before operators attempt to set it back up).
- Check to ensure equipment is lined up for normal operation. Have circuit breakers tripped? Is power lost? Is equipment in the "home" position?
- Analyze the performance of the equipment to ensure it actually has a failure and is not just reacting to an external condition. Ask if anything different is being done than normal. (i.e., new part run, recent overhaul, etc.)
- Try to determine if performance appears degraded or total equipment failure has occurred.

- Know the equipment; recognize the symptoms of an impending failure.
- Try to be as specific as possible in defining the problem.
- Check and take note of engineered failure mode indicators (i.e. overloads and trip flags)
- Note variations from specified readings, even if they are still within the tolerance band.
- Attempt to determine if the variations have developed slowly (i.e. drift) or occurred suddenly at a specific time or date.

10.4.3 List the Probable Causes

Utilizing the information gathered, list (either on paper or mentally) the probable causes of the problem. Most often, the problem can be categorized into one or more of the following:

- Power Supply – no movement, no lights on panels, etc.
- Load Controllers – motor starters, contactors, PLC output cards, etc. Symptoms include power being present, but that the load won't operate unless the controller is bypassed.
- Load Itself – valves, motor, solenoids, etc. Manually move or operate the load, or bypassing the controlling devices results in no movement.
- Input Device – position sensing switches, pushbuttons, Human Machine Interface, PLC input card, etc. Symptoms would be no power present at input card with switch activated.
- System Logic – motion sequencing program. Symptoms would include an abnormal sequence of operation.

10.4.4 Eliminate the Possibilities

Using the list of probable causes determined in the previous step, isolate and/or eliminate causes from the list. This may include performing various equipment tests.

- Use drawings/diagrams to plan test points and sequences.
- Know approximately what value to expect before taking a reading, both for test equipment safety and to limit confusion about results obtained.
- If an incorrect reading is obtained, verify both the reading and the test equipment setup.
- If possible, compare test readings with the equipment normal values (i.e. baseline data) rather than general data values found in service manuals. This requires record keeping over time.
- Only take measurements that will prove a condition or aid in drawing a logical conclusion. Be systematic.
- Repeat sequence until the problem is found.

10.4.5 Execute the Repair

- Repair the problem, and validate that the equipment has been returned to proper operation.

10.4.6 Discover the Root Cause(s)

Many times the cause of a problem goes deeper than just what appeared to happen to the user. In order to drive out unexpected down time and failures, it is essential to find the ultimate cause for the failure and eliminate it. For example, the equipment quits operating, and by troubleshooting the problem, we find that a wire lead on a large motor in the system has burnt open. We fix it and it runs fine. However, why did the lead burn? In addition, how long will it be until it happens again? Could it hurt someone if it happened in a particular way? What will it cost if it happens again in the middle of a production run? These are all questions worth asking and worth finding the answers to. It could be that the motor lead splice box is not sealed well and that water from the roof drips on it when it rains, eventually causing the lead to fail. Most importantly, we must keep asking why, why, why, why ... why, why, until we can't answer it any more. At that point we will have discovered our root cause(s) and can attempt to deal with the problem in such a way that effectively eliminates it forever. This is the step most commonly left out of the process, allowing operating costs to be driven up and disruptions to be common place.

10.5 Re-energization after protective device operation

Re-energization of a circuit or system with an uncorrected problem can lead to equipment damage and serious injury. If the system's protective devices operated due to a fault condition (short circuit), some investigation is necessary to determine the probable cause. Testing of the circuit should be completed, if possible. According to OSHA Regulation 1910.334(b)(2), manual re-energization must not be attempted until it has been determined that it is safe to do so. Immediate re-energization is only permitted when the cause of the operation of the protective device was initiated by an overload condition.

11. Bus plug-in units and busway

11.1 Objective

This procedure establishes the installation and removal practices for bus plug-in units and similar equipment utilized on 600V class electrical distribution busway.

11.2 General

It is preferred that all bus plug-in unit insertions and removals be completed with the busway de-energized.. However, it is understood that in some circumstances, de-energizing a busway can be difficult to schedule and could present some additional hazards (i.e. when lighting is fed from the busway at issue).

Therefore, if an insertion or removal is to be completed with the busway energized, the proper planning as described in Section 6 must be completed and **<u>all</u>** of the following additional criteria <u>must</u> be met:

- **The person(s) doing the installation/removal or in the immediate vicinity (i.e. – in the vertalift) are wearing full arc-flash protective equipment for the head, hands, arms, torso, and legs. (Refer to Annex A for a table of Flash Protection Boundary)**
- Plug-in unit rating is 200 A or less.
- Plug-in unit fingers <u>only</u> enter <u>one</u> plug-in opening in the busway. *
- The disconnect switch or circuit breaker on the plug-in unit is in the “open” or “off” position. *
- The bus plug is designed for insertion/removal while the bus is energized.
- Follow the Delphi Fall Hazard Control Program when working on overhead busway.
- The following safe work practices from this section are adhered to.

11.3 Procedural Sequence

11.3.1 Disconnect Switch and Stab Assembly Inspection (Figure 9)

Units shall be inspected prior to installation. The inspection shall include the following:

- Check to ensure that the plug-in unit is compatible with the busway.
- Check to ensure that line shields are in place.
- Check for loose or broken hardware and terminals.
- Check the line stabs and ground stab for alignment and damage.
- Check for broken, cracked, or missing insulators and phase barriers.
- Check the mechanisms of all-electrical and mechanical interlocks and padlocking means for proper operation. Assure that the door interlock is functioning properly.
- Operate the switch several times to make sure that all mechanisms operate freely and are in working order.
- Check the fuseholder and fuse clips for signs of damage, overheating, or any other abnormal condition.
- Clean switch frames insulators and line contacts where necessary according to manufacturers recommendations.
- Megger test the plug-in device phase to phase, and phase to ground. Plug in unit shall megger at least 10 megohms with 1000 VDC applied. This test should be performed with the switch in the closed position. The switch should then be Megger from Line to Load with the switch in the open position.
- If the bus plug fails any of these inspections, obtain another bus plug.

Units shall be inspected prior to removal. The inspection shall include the following:

- Verify that line shields are in place.

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* NEMA Standard “BU1-1994 for Busways”

- Check for loose or broken hardware and terminals.
- Check the mechanisms of all-electrical and mechanical interlocks and padlocking means for proper operation. Assure that the door interlock is functioning properly.

11.3.2 Power Distribution Busway Inspection (Figure 9)

Note: If busway is energized, the appropriate PPE is required.

Verify the busway to be used and its identification markings. Verify the source(s) that feed the busway. All busways are to be considered energized until it is verified that it is locked out and should be approached with the proper precautions.
If the bus is to be de-energized, the feeder circuit breaker shall be locked out. *NOTE: Loop fed busway must be similarly isolated from both ends.*
Before any bus plug-in unit installation or removal, the power distribution busway shall be visually checked for any loose components, hardware, foreign objects, or any other abnormal conditions. In addition, before installation, the busway must be inspected to including the following:

- With the plug-in opening cover closed, clean off busway enclosure in the area where the plug-in device is to be installed. Use dry, clean rags and avoid the use of cleaning agents.
- Open plug-in opening cover and visually inspect for any abnormal condition, foreign objects, or other improper materials.
- If no abnormal conditions of the plug-in device or the busway are found the installation may proceed.

11.3.3 Installation (Figure 8)

Note: If busway is energized, the appropriate PPE is required.

After completing the inspection of the plug-in device and power distribution busway, the plug-in unit shall be installed as follows:

- Review manufacturer's installation instructions before proceeding to ensure compliance.
- Persons installing plug-in units shall place themselves in a secure position to avoid falling, stumbling, slipping, or inadvertently moving into an unsafe condition. Never stand in front of the busplug. Busway shall not be used as a tie-off point or as a walkway.
- Assure that the plug-in unit disconnect is open with fuses removed and the door closed and latched.
- Align device flanges and stabs and push the unit firmly onto the busway. Secure the unit to the busway. The unit shall be installed to the busway by normal manual force only. **On larger plugs, the plug assist shall not be used to force the plug-in unit onto the busway. *CAUTION:* If there is any difficulty in installing the plug-in unit, it shall be removed and inspected to determine the problem. Necessary repairs shall be made or the plug-in unit replaced.**
- Install device mounting bolts or clamps as applicable.
- Once the unit is installed and secured in place, open the door and verify that the load side of the switch (line side of fuse clips, all three poles) is de-energized.
- At this time, the busway may be re-energized.
- Close and latch the plug-in unit door, throw the switch to the “on” position. Personnel shall not stand directly in front of unit while operating the switch. Re-open the door and verify that nominal voltage is present on all three phases at the line side of the fuse clips. Close the door and throw the switch to the “off” position.
- Verify that nominal voltage is not present on the load side of the fuse clips.
- Proceed to connect the load side equipment to be served.
- After equipment connection is completed, the fuses shall be inserted and the door closed and latched. At this time, the switch may be closed. Stand off to one side or use a switch pole to operate the switch.

If there is a question or concern about the safety of the installation at any point, employee shall consult technical assistance from his/her supervisor and/or engineering. In some cases, safety may dictate that a particular installation or removal be completed with the bus de-energized.

11.3.4 Unit Removal (Figure 8)

Note: If busway is energized, the appropriate PPE is required.

If the unit is damaged, or a condition exists that is not normal, do not attempt to remove the unit until the busway has been verified that it is de-energized.

- Review manufacturer's removal instructions if available before proceeding to ensure compliance.
- Persons removing devices shall place themselves in a secure position to avoid falling, stumbling, slipping, or inadvertently moving into an unsafe condition. Busway shall not be used as a tie-off point or as a walkway.
- Open the device disconnect and remove fuses utilizing the appropriate fuse pullers.
- Verify load side of switch (line side of fuse clips, all three poles) is de-energized.
- Proceed to disconnect the load side equipment being served.
- Do not remove any load without also removing the associated conduit and wiring. The plug-in unit switch shall be open and locked out until such conduit and wiring is completely removed.
- Remove device mounting bolts or clamps as applicable.
- Remove unit from bus. The plug-in unit shall be removed from the busway by normal manual force only. No power assist devices shall be used to force the plug-in unit away from the busway.
- Install the busway plug-in opening access cover.
- The busway may now be re-energized.

11.3.5 Busplug Abandonment --

Note: If busway is energized, the appropriate PPE is required.

- Persons removing equipment feeds shall place themselves in a secure position to avoid falling, stumbling, slipping, or inadvertently moving into an unsafe condition. Busway shall not be used as a tie-off point or as a walkway.
- Open the device disconnect, verify that voltage is not present and remove fuses utilizing the appropriate fuse pullers.
- Verify that voltage is not present on the load side of switch (line side of fuse clips, all three poles).
- Proceed to disconnect the load side equipment being served.
- Do not remove any load without also removing the associated conduit and wiring. The plug-in unit switch shall be open and locked out until such conduit and wiring is completely removed.

After removing associated conduit, fill conduit holes with the appropriate device(s).

Figure 7: Busplug Insertion / Removal Sequence

UNIT INSTALLATION

Inspect Switch/Stab Assembly and Busway (Figure 9)

Review manufacturers installation instructions. (if available)

Remove all personal conductive items and utilize proper PPE.

Assure disconnect device open with fuses removed.

Align device flanges/stabs and push unit firmly into busway.

Install device mounting bolts or clamps as applicable.

Verify load side of switch de-energized.

Connect load side equipment to be served.

Operate switch as required.

UNIT REMOVAL

Review manufactures removal instructions.(if available)

Remove all personal conductive items and utilize the proper PPE.

Open plug-in unit disconnecting device.

Verify load side of switch de-energized.

Remove plug-in unit fuses.

Disconnect load side equipment being served.

Remove device mounting bolts or clamps as applicable.

Remove plug-in unit from busway.

install busplug opening cover.

Figure 8: Plug-In Unit and Busway Inspections

SWITCH/STAB ASSEMBLY INSPECTION

Ensure that the plug-in unit is compatible with the busway.

Ensure that line shields are in place.

Check for loose or broken hardware and terminals.

Check the line stabs and ground stab for alignment and damage.

Check for broken, cracked, or missing insulators and phase barriers.

Check mechanisms of electrical and mechanical interlocks and padlocking means for proper operation.

Assure that the door interlock is operational.

Operate switch several times to ensure that all mechanisms operate freely and properly.

Check fuseholder and fuse clips for signs of damage, overheating, or any other abnormal condition.

Clean switch frame, insulators, and line contacts, where necessary.

Megger phase to phase and phase to ground (must be minimum 10 MΩ with 1000VDC applied). Refer to Section 11.3.1

BUSWAY INSPECTION

Visually check busway for any loose components, hardware, or foreign objects.

With plug-in opening cover closed, clean off busway enclosure in the area where the plug-in device is to be installed.

If the bus is to be de-energized, feeder circuit breaker shall be racked out and locked out.
Loop fed busway must be isolated at both ends.

Remove plug-in opening cover and inspect for any foreign objects, improper materials, or any other abnormal conditions

.

12. Conduit and Wireway Installation - Wire Pulling

12.1 Objective

This procedure establishes the guidelines to be utilized when pulling wire in conduit and wireway installations. Policies and practices shall be utilized for electrical work performed at Delphi Corporation (including contracted work).

12.2 Procedural Sequence

12.2.1 General Requirements

- All jobs, including emergencies, that require planning shall comply with Section 6.0, Planning Electrical Work. Authorization must be obtained before beginning work.
- Follow all applicable Local Health & Safety Work Rules. If there is doubt about what rules exist or their interpretation, or if more information is needed, stop work and contact a qualified supervisor, engineer or manager before proceeding with jobs.
- All electrical conductors, including those that are insulated, shall be treated as energized until proven otherwise. All terminals, conductors and other exposed components of the electrical circuitry which could be contacted (purposely or accidentally) by body parts, tools or equipment must be tested for presence of voltage using an approved voltage tester before the job begins. Refer to Section 9.2.3 – 9.2.8
- Always utilize the proper PPE for the job.

- **CAUTION: HAZARDS OTHER THAN ELECTRICAL SHOCK MAY EXIST.** Protective measures may be necessitated by other potential hazards. There may be the possibility of electrical burns, severe electrical arcing, or explosions resulting from arcing in a work area. Refer to Annex A for definitions of approach boundaries. **All work on energized systems at any voltage shall be evaluated for such possibilities.**

12.2.2 50 to 150 Volts

If necessary, it is permitted to install or remove conductors in a raceway containing energized conductors as long as **all** of the following conditions are met:

- Appropriate PPE per section 7.3 is worn by all workers involved
- The system nominal voltage to ground of all the conductors in the raceway or enclosure is 150 volts or less.
- The overcurrent protective devices at the source of all energized conductors are not greater than 20 amps.
- A person is observing at each end of the pull or feed.

12.2.3 151 to 750 Volts

Pulling or feeding of wire in raceways containing energized conductors with a system nominal voltage to ground over 150 volts is **not** permitted.

Installing or removing wire or cable in **cable trays** containing energized conductors is permitted as long as **all** of the following conditions are met;

- Appropriate PPE per section 7.3 is worn by all workers involved
- Cable tray contains only insulated conductors with a system nominal voltage to ground of 750 volts or less.
- Handling of wire or cable must be done in such a way that there is a minimum disturbance of existing conductors.

A-1 Annex A (Normative): Safe Approach Distances

Annex A.1 General

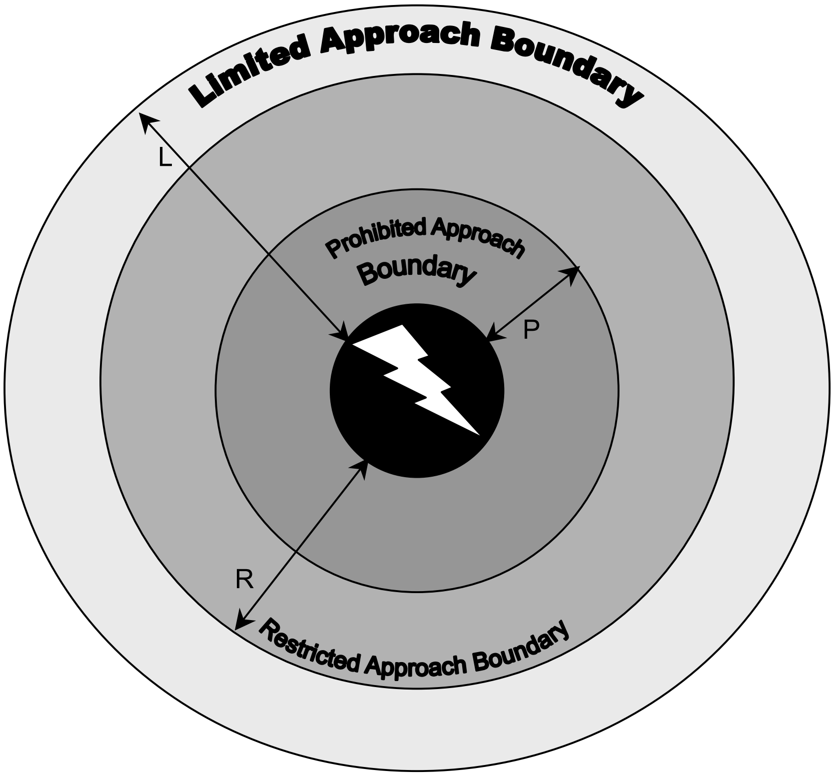
The Safe Approach Distance criteria is a tool to use when determining the specific safety-related tools, equipment, and procedures to use when completing a specific task. There are two subsets of this distance. The first deals with shock hazard protection and the other is concerned with arc flash protection.

Annex A.2 Shock Hazard

Shock Hazard - A dangerous condition associated with the flow of current through a person's body caused by contact or approach to exposed electrical conductors or live parts nearer than the minimum air insulation distance

An exposed, energized electrical conductor has an air gap that provides sufficiently high resistance to effectively insulate the voltage from other phase conductors and ground. The voltage level is the main determinant of how large that air-gap must be. The Limited Approach Boundary, Prohibited Approach Boundary, and Restricted Approach Boundary are identified as levels of approach towards the exposed energized conductor where different levels of precaution must be taken in order to protect against the hazard of electric shock by an exposed, energized conductor. Each of these boundaries is determined by the voltage level of the exposed energized conductor. In addition, the Limited Approach Boundary is depended upon whether the conductor is fixed or movable. Figure 10 illustrates the shock hazard boundaries.

Figure 9: Shock Hazard Safe Approach Boundaries



(a) Limited Approach Boundary

The following are the Limited Approach Boundary values to an exposed, energized electrical conductor. Reference Table 3 for the Limited Approach Boundary relative to a fixed or movable exposed energized conductor.

Table 3: Limited Approach Boundary Dimensions (L)

Nominal System Voltage (Phase to Phase)		<300	300-750	750-2k	2k-15k
Limited Approach Boundary Distance (L)	From a **Fixed** Conductor	3'6"	3'6"	4'0"	5'0"
	From a **Movable** Conductor	10'0"	10'0"	10'0"	10'0"

Inside of the Limited Approach Boundary (L), the qualified employee is responsible for the requirements inside of this boundary and performing the work or inspection necessary. The employee shall use insulated tools and/or handling equipment when working inside the limited approach boundary of live parts where tools or handling equipment might make accidental contact.

The requirements typically include the proper PPE, establish the proper workspace and associated barricades and communication of job scope and potential hazards to unqualified personnel.

If the conductor at issue is more than 750V, the employee must be accompanied by a partner or "buddy."

Unqualified person(s) shall stay outside of the Limited Approach Boundary unless working under the direction of a qualified person(s).

(b) Restricted Approach Boundary

Inside of the Restricted Approach Boundary, the qualified employee formulates boundary requirements after approval by his/her supervisor. If the voltage exceeds 750 V, both the supervisor and a non-resident expert, must approve the work plan, and an assistant or another qualified employee, must be present. The employee(s) must use insulated tools and voltage-rated gloves and instruments. The Restricted Approach boundary dimensions are listed in Table 4:

Table 4: Restricted Approach Boundary Dimensions (R)

Nominal System Voltage (Phase to Phase)	<300	300-750	750-2k	2k-15k
Restricted Approach Boundary Dimension (R)	Avoid Contact	1'0"	2'0"	2'2"

(c) Prohibited Approach Boundary

Crossing the Prohibited Approach Boundary is considered the same as making contact with energized conductors. Inside of this boundary, the qualified employee formulates boundary requirements after approval by supervision. If the conductor at issue is more than 750V, a non-resident expert must approve the review of the supervisor. Further, the qualified person shall:

1. Has specialized training in this type of work.
2. Have a plan conforming to the requirements of procedure 6.0.

3. Perform a risk analysis as outlined in the NFPA 70E Standard or in Table 3-3.9.1 included in Section 7.4.2.
4. Work with a partner.
5. Use PPE and insulating equipment rated for the voltage and energy level involved.

The Prohibited Approach boundary dimensions are as follows in Table 5:

Table 5: Prohibited Approach Boundary Dimensions (P)

Nominal System Voltage (Phase to Phase)	<300	300-750	750-2k	2k-15k
Prohibited Approach Boundary Dimension (P)	Avoid Contact	0’1”	0’3”	0’7”

Annex A.3 Arc Flash Hazard

(a) Background / Description

Flash Hazard - A dangerous condition associated with the release of energy caused by an arc that suddenly and violently changes material(s) into a vapor.

When a power system fault occurs (i.e. phase to phase, or phase to ground), an arc flash occurs that releases a tremendous amount of energy in the form of light, heat, sound, and UV radiation. As this energy is radiating out from the source of the fault, it can cause serious injury to employees not wearing proper PPE and are close to the source of the fault. The Flash Protection Boundary establishes minimum criteria for protection from the hazards of an arc flash. Most of the energy from an arc flash is in the form of heat. Therefore, the considerations for PPE requirements center on fire protection. Since many factors enter into the equations relative to the amount of energy released from a particular fault, the flash protection boundary conditions established in this section are categorized by the voltage levels encountered and the type of upstream protective device that is utilized. This process yields a “worst-case” scenario for energy level exposure from fault conditions. Any part of the body that is inside of this boundary must be protected by NOMEX™ brand flash protective equipment, or a material that has equivalently performing Fire Retarding properties.

(b) Hazard/Risk Assessment

To establish a site specific set of criteria, a formal flash hazard assessment must be completed, utilizing current short circuit data, for specific job tasks, to make a proper evaluation of the energy level exposure possibilities from an arc flash. This hazard assessment should include:

- What environment is the system operating in? (wet/dry, clean/dirty, etc...)
- When was the protective devices last calibrated?
- Is there any reason to believe that the system will not operate the way it was designed?

Part II Appendix D of the [illegible]0 NFPA 70-E Standard elaborates on this procedure and should be referenced as a guide in the [illegible]luation process.

(c) Current Limiting Protective Devices

Flash Protection Boundary (Circuit Protected by Current Limiting Device):
The Flash Protection Boundary dimension (F) for a circuit with a nominal system voltage of 750V or less that is protected by current limiting fuses is 9 inches[8]. Any other application of this type must have the calculation for the flash boundary completed using the method listed in Part II, Chapter 2 of the 2000 version of the NFPA 70-E standard. Inside of this boundary, the qualified employee plans and performs

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[8] The distance given as 9 inches is for circuits fed from 2000 kVA transformers or less. The Flash Protection Boundary distance for circuits fed from transformers greater than 2000 kVA should be calculated under Engineering Supervision utilizing the equations in NFPA 70E 2000 Edition Appendix B.

the work. Most frequently, an employee's hands cross this boundary when performing voltage testing/measurement. In the case where the hands are the only part of the body to cross the boundary, only the hands are required to be protected. Appropriately, rated rubber gloves with leather protectors provide an adequate level of Fire Retarding protection.

(d) Conventional Circuit Breakers

Inside of the Flash Protection Boundary of a circuit protected by conventional circuit breakers, the qualified employee formulates boundary requirements after approval by supervisor. If the conductor at issue is more than 750 V, a non-resident expert must approve the review of the supervisor. Further, the employee must wear PPE for full flash protection for the face and body. Unqualified employees must not cross the Flash Protection Boundary unless they are wearing appropriate personal protective clothing and are under the close supervision of a qualified person.

Table 6: Flash Protection Boundary Dimensions (F)

(Circuit Protected by Conventional Circuit Breaker)				
Nominal System Voltage (Phase to Phase)	<300	300-750	750-2k	2k-15k
Flash Protection Boundary Dimension (F)	3’0”	3’0”	4’0”	16’0”

B-1 Annex B (Normative): Specifications for Voltage Testing Equipment

Annex B.1 General

Testing for voltage is a common task performed by personnel very frequently within the corporation. There have been instances where the equipment is not designed to perform the task for which it was utilized. This practice can lead to the device being mis-read, malfunctioning, or failing. In some instances, there have been accidents resulting in injury from test equipment failure. In order to safeguard employees against using inadequate test instruments, this Annex sets forth a minimum set of requirements to be used as criteria in the selection of test equipment to be used within Delphi Corporation. Each operating unit is free to further specify, based upon its needs, additional criteria to be used in the selection process.

Annex B.2 Multimeters

The following is the set of features that are required:

- Rated for the voltage-level of the application.
- Retractable insulated tip test probes.
- A self-contained fault protection or limitation device, such as internal current limiting fuses or probes current limiting resistors.
- Voltage/Current path from the probes is not routed through the mode selector switch.
- Conforms to National Consensus Standards (i.e. UL 1244, MIL-T-28800C). This requirement insures that the device has third party certification.

Annex B.3 Direct-Contact Voltage Sensing Devices

In addition to the set of criteria for multimeters, the following additional requirements shall apply towards devices used solely for sensing for the presence (or absence) of voltage:

- Single function, voltage only test device, or
- Device must have automatic mode sensing feature that check for voltage before switching to other modes (i.e. resistance, continuity).
- Fail-safe system to guard against accidental mis-connection of the test leads. (permanently attached leads or only two connection points)

Annex B.4 Non-Contact Voltage Sensing Devices

There are some applications in which direct contact voltage testers (i.e - when exact voltage measurements are required) cannot be used to sense voltage. In these circumstances, an inductive type, non-contact voltage sensor can be utilized. When deciding whether to use this type of test device, it is imperative to consider its limitations:

- Sensitivity to frequency (cannot detect D.C. or low frequency voltages).
- Sensitivity to the voltage level of the conductor.
- Sensitivity to the orientation to and distance from the conductor.
- Phase cancellation can occur if sensing a 3 phase multi-conductor cable.
- Sensitivity to surrounding or nearby metal components (i.e. enclosures, armoring).
- Sensitivity to temperature.
- Sensitivity to the distance of the conductor being sensed to ground.
- This type of voltage sensor may be used only to sense voltage, not measure it.

Annex B.5 Approved Test Equipment

Table 7 lists test instruments that have been found to meet the criteria established within this section. All Delphi. locations may use the equipment designated here. Each location must, if they wish to use equipment other than those specified in Table 7, develop the supporting documentation in order to certify it for use as referenced in Section B.2 – B.4 above

Table 7: Approved Test Equipment

Task	Test Instrument	Approved Manufacturer
Voltage Testing (≤ 600 Volts)	Voltmeter	Tegam Model 110A
	Solenoid	Ideal Model 61-080 and 61-067 with resistor probe option or "Wiggy" equivalent
Voltage Sensing (≤ 600 Volts)	Non-Contact	Pasar "Tic Tracer" Model TIF 100HV or Santronics AC Sensor
Voltage Sensing (> 600 Volts) Grounded System Only	Non-Contact	Salisbury Model 4244
Grounded or Ungrounded	Voltmeter	A.B. Chance Phasing Testor Catalog #1876
Measuring and Troubleshooting	Multi-meter	Fluke Model 10, 20, and 80 Series, Triplett 3450, or Simpson Series 260 - Model 7
Current Measurement	Clamp-On meter	Amprobe Model Series RS-3 or Fluke Series 33
Phase Sequence Detection		J.G. Biddle Catalog #560060
Setting up Phasing (≤ 1000 Volts)		Tegam (Model 110A)
(> 1000 Volts)		A.B. Chance Phasing Testor Catalog #3 H1876
Insulation Testing (> 750 Volts)		J.G. Biddle #210170CL

Reference: "Electrical Test Equipment and Special Tools, Standard B-1.12, Item 3-1, " SAFETY HEALTH ENVIRONMENT, DuPont Corporation.

C-1 **Annex C : Blank Forms**

Request for Machine Maintenance Access/Shutdown

1. Site:____________________________ Area:_______________ Project:____________________
2. Planned start date:_______________ Start Time:_______________ Expected Duration:__________________
3. Weather Forecast for the Date(s) Above: ______________________________

   ____
4. Description of work to be done:____

   ____

   ____
5. The following is requested to be shut down:____

   ____

   ☐ Until work is complete______________________

   ☐ Temporarily while barriers are being placed_________________________
6. Will Production be able to run during the job (circle one)? Yes No
7. The following contingency plans have been made in case the equipment being shut down can’t be restored to service as planned:

   ____

   ____

   Persons to notify if contingency plans must be utilized:
   Person:_________________ Position:____________ Phone:_______________
   Person:_________________ Position:____________ Phone:_______________
8. Shutdown Requested by:____
   Dept/Title:___________________Date:______________

(Items 9-12 be completed by Authorized Manager of the Affected Area)

9. Shutdown Is: ☐ Granted ☐ Denied
10. If denied, the next available date for shutdown is?_____________________________________
11. Reason(s) for shutdown denial____

    ____

    ____
12. Signature:_____________________ Dept:____________ Date:____________

Electrically Hazardous (>50V) Job Given To:______________________________
Written Job Plan Date:____________________

(To be completed by supervisor or person doing work, attached to Request for Shutdown, and submitted for approval.)

1. General description of work to be done: ______________________________
____.

2. Why is it necessary to perform this task with the equipment energized?: ____
____. ____________.
____

3. Using the information contained in Annex A of Delphi Electrical Safe Work Practices document, identify the voltage of the exposed energized circuit parts to be encountered. Circle all of the appropriate approach boundaries to be crossed when performing the task:

Limited Approach

Limited Approach Boundary Dimensions (L)

Nominal System Voltage (Phase to Phase)		<300	300-750	750-2k	2k-15k
Limited Approach Boundary Distance (L)	From a **Fixed** Conductor	3'6"	3'6"	4'0"	5'0"
	From a **Movable** Conductor	10'0"	10'0"	10'0"	10'0"

Restricted Approach

Restricted Approach Boundary Dimensions (R)

Nominal System Voltage (Phase to Phase)	<300	300-750	750-2k	2k-15k
Restricted Approach Boundary Dimension (R)	Avoid Contact	1'0"	2'0"	2'2"

Prohibited Approach

Prohibited Approach Boundary Dimensions (P)

Nominal System Voltage (Phase to Phase)	<300	300-750	750-2k	2k-15k
Prohibited Approach Boundary Dimension (P)	Avoid Contact	0'1"	0'3"	0'7"

Flash Protection - Fuse Protected Equipment

The Flash Protection Boundary dimension (F) for a circuit with a nominal system voltage of 750V or less that is protected by current limiting fuses is 9 inches. Any other application of this type must have the calculation for the flash boundary completed using the method listed in Part II, Chapter 2 of the 2000 version of the NFPA 70-E standard or reference Table "XX" in Annex A.

Flash Protection - Circuit Breaker Protected Equipment

Table 8: Flash Protection Boundary Dimensions (F)

(Circuit Protected by Conventional Circuit Breaker)				
Nominal System Voltage (Phase to Phase)	<300	300-750	750-2k	2k-15k
Flash Protection Boundary Dimension (F)	3'0"	3'0"	4'0"	16'0"

4. Based on the attached information in Annex A of Delphi Electrical Safe Work Practices document and the approach boundaries circled above, circle the protective items below which are required to perform the task:

a. Safety Glasses

b. Rubber Gloves with Protectors -- Voltage Rating:___________________

c. Insulated Tools -- List: ____
-- Voltage Rating: ____

d. Flash Protective Hood, Face Shield, and Coveralls

e. e. Voltage Tester/Meter -- Rate Voltage: _________AC __________DC

f. Other :_______________________________

5. Is a Buddy required? (Only required if voltage is 750 volts or above) Yes No

6. Are communications equipment required (circle one)? Yes No
What kind?____

7. How will non-qualified or affected personnel be kept beyond the Limited Approach Boundary?

a. Barricades -- describe: ____

b. Barriers -- describe: ____

c. Other –describe:______________________________

8. Have all the parts necessary for performing the task been identified and gathered for use? (Circle one): Yes No
List items still needed and plan to procure: ____
____

9. Are additional tradespersons required to help perform the work? (circle one):
Yes No
List trade required and/or work to be performed: ____________________
____

10. Have prints and/or manuals for the equipment been located, verified for correctness, and reviewed? (Circle one) : Yes No
List items still required to be reviewed and timing associated with review:______________________

11. List the step-by-step outline of the work:

____________________.
____________________.
____________________.
____________________.
____________________.
____________________.
____________________.
____________________.
____________________.
____________________.

12. List additional hazards, concerns, or precautions to be taken, and how the exposed persons will be protected:

____________________.

____________________.

13. Does the current weather forecast support being able to perform the task at the time requested? (Circle one): Yes No

14. Will a non-resident expert as outlined in Annex A be required for the task? (Circle one): Yes No
Has one been identified and scheduled? Yes No

15. Number to call in an emergency on the site:

16. Signatures required per Annex A:

Planner	Date
Planner	Date
Planner	Date
Planner	Date
Skilled Trades Supervisor	Date
Non-Resident Expert	Date

*Answer just prior to performing the work:
Has all personal protective equipment been inspected and/or tested to insure its integrity (circle one)? Yes No