Mutual Assistance Crew’s Guidebook

Damage Restoration For LADWP
Safety Message

“No job is so important, or service so urgent, that we cannot take time to perform our work safely”

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Introduction

This book’s intent is to provide mutual assistance crews with the information necessary to safely and efficiently transition to support this mutual assistance effort.

If at any time you believe an unsafe condition exists or you are uncertain about how to proceed – STOP – and ask.

Safety

Crew Guides
Crew Guides are experienced LADWP line crew supervisors and tree crew supervisors who will be assigned to assist the mutual assistance crews. Your Crew Guide will direct you to your job assignments and assist in obtaining information, supplies and equipment. The Crew Guide will also act as the liaison between your crew and other LADWP personnel.

Safety Equipment
Due to your unfamiliarity with our electric system, along with the age of our facilities, as always, care must be taken when working around energized equipment and when performing switching. Proper precautions and care shall be taken while performing restoration on the electric system. As an outside utility worker assisting in restoring LADWP’s electric system, you must follow both the safety practices of your own company along with some of LADWP’s referenced in this guidebook.

Personal Protective Equipment
Personal Protective Equipment (PPE) helps safeguard workers...
against potential exposures. PPE is mandatory for all employees and must comply with Federal, State, local and/or applicable safety standards.

**Protective Clothing** – Fire retardant clothing and 100% pure cotton undergarments are to be worn when there is a potential for electric flash. Synthetic fabrics are not acceptable.

**Head Protection** – All workers must wear ANSI approved dielectric protective hard hats to prevent head injuries.

**Eye Protection** – At all times, workers must wear ANSI approved eye protection suitable for the hazard.

**Footwear** – Proper footwear shall be worn at all times; ANSI approved work boots are recommended.

**Hand Protection** – When performing work, work gloves shall be worn at all times unless Rubber Gloves are required.

**Full Body Harness** – A full body harness with lanyard is mandatory whenever working in an aerial lift device.

**Rubber Gloves**

Rubber Gloves of the appropriate electrical protection are required whenever exposure to live electric circuits is possible.

**Class I** – The use of Class I Rubber Gloves is required for, but not limited to, the following operations or conditions:

- Working on or near energized or de-energized 300 volt to 7,500 volt circuits and equipment **UNLESS** they are known to be shorted and grounded.
- Working on lower voltage circuits if Class 00 gloves are not used.
- Working on series street light circuits including the installation or removal of lamps.
- Raising or lowering poles or other supporting structures between or near energized 600 volt to 34,500 volt circuits
- Connecting or disconnecting equipment grounds
- Climbing a pole or rack, where energized equipment is known or suspected of being defective.
- When within reaching or falling distance of exposed 600 volt to 7,500 volt circuits.
- When using test instruments in contact with conductors energized or suspected of being energized at 300 volts to 7,500 volts.
- Whenever an employee or supervisor deems it necessary for safety.

**Class 00** – The use of Class 00 Rubber Gloves is required for, but not limited to working on or near energized 50 volt to 300 volt circuits.

**Backfeed**
Customers may have auxiliary generators or equipment that can backfeed power. Use extreme caution and make sure that all backfeed situations are identified.

**Job Briefing – Tailgate**
The crew leader shall hold a job briefing with the crew at every jobsite, identifying the hazards associated with the job, work procedures involved, special precautions, energy sources and control, along with PPE. Additional job briefings shall be held if significant changes occur that may affect the safety of the worker(s) during the course of the work.

**Work Area Protection**
When you are setting up a jobsite alongside or in traffic lanes, proper work area protection must be setup prior to beginning the associated work. Be sure to setup an adequate number of cones and other warning devices at sufficient distances to warn oncoming traffic. When work is being performed on State Highways requires an illuminated flashing arrow board.
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Reporting Accidents
- If an accident occurs, you must report it immediately to your Crew Guide so that the appropriate LADWP personnel can be notified.

Is an accident or medical emergency occurs that requires local emergency services to respond, dial 911.

General Information

Work Hours
LADWP work schedule during restoration events is typically 16 hours on, eight hours off. At LADWP discretion, work hours and schedules may be changed or be reduced. You will be notified through your Crew Guide in advance of any changes.

Lodging
LADWP will make every attempt to provide the best possible lodging facilities for outside crews.

Family Phone Line
LADWP activates a dedicated telephone number during restoration in case your family needs to reach you. The line is active 24/7.

(213) 367-XXXX

Worker Conduct
The following policies must be adhered to during restoration. Any violation of these policies shall result in dismissal from LADWP’s restoration effort.
- No consumption of alcoholic beverages during regular work hours, overtime, or at meals.

www.ladwp.org
- The unlawful use, possession, sale or purchase of “controlled substances” is prohibited.
- No person shall enter LADWP property while in possession of a firearm/weapon of any description, loaded or unloaded.
- Room accommodations will be treated respectfully.
- Personnel who are sick, injured, or otherwise unable to report to work shall inform their immediate supervisor, who shall inform their Crew Guide.
- Communication with the media is prohibited.

**News Media Policy**

If news media representatives approach field workers and start asking questions during restoration activities, the reporter should be referred to your Crew Guide. Only authorized LADWP personnel shall provide information or speak with the media.

**Department of Transportation**

The Federal DOT exempts utility workers from the DOT driving restrictions during system emergencies to restore electric power.

**Security**

- All LADWP buildings are staffed with security personnel who adhere to strict security procedures. You must have identification to gain access to any LADWP facility or temporary staging area.
- Vehicles and equipment being used by other utilities will be provided with security when staged off LADWP property or outside of a temporary staging area.
Fueling
All vehicles and equipment, including those from other utilities, will be fueled and maintained at their assigned staging areas.

Tree Crews
Tree trim crew will consider all lines energized unless a particular line have been confirmed de-energized and temporary protective “personnel” shorts and grounds have been installed.

Expenses
- LADWP will only pay for one long distance telephone call per day.
- LADWP will not pay for in-room movies.
- LADWP will not pay for alcoholic beverages.
- All mutual assistance field personnel will be lodged two to a room; supervision will be lodged one per room when applicable.
- All personnel lodged at LADWP’s expense are liable for hotel damages.
Service Territory and Distribution Districts

LADWP’s service territory encompasses 465 square miles, and serves over 3.9 million city residents. The city has two major geographic areas (Metro and Valley) which are divided by Mulholland Drive. Crews are dispatched from seven Distribution Districts.
LADWPs distribution system encompasses 6,800 miles of 34.5-kV and 4.8-kV overhead lines attached to over 320,000 poles. Typical conductor sizes for the different voltages are:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>34.5-kV</th>
<th>4.8-kV</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>795 A.A.C.</td>
<td>477 A.C.S.R.</td>
<td>1/0 Al. Triplex (Reverse Twist)</td>
</tr>
<tr>
<td></td>
<td>336 A.C.S.R.</td>
<td>3/0 A.C.S.R.</td>
<td>1/0 Al.</td>
</tr>
<tr>
<td></td>
<td>3/0 A.C.S.R.</td>
<td>#2 A.C.S.R.</td>
<td>#2 Al.</td>
</tr>
<tr>
<td></td>
<td>350 Cu.</td>
<td>4/0 Cu.</td>
<td>1/0 Cu.</td>
</tr>
<tr>
<td></td>
<td>1/0 Cu.</td>
<td>#6 Cu.</td>
<td>#4 Cu.</td>
</tr>
</tbody>
</table>

![Diagram of Electric System Overview](https://www.ladwp.org/11)
Receiving Stations
Receiving Stations (RS) receives bulk power at a relatively high voltage and transforms it to 34.5kV, which is LADWP sub-transmission system voltage for use in the Distribution Stations (DS) and Industrial Stations (IS) on its system. All of the RSs are tied together on the high-side as shown below.

![Diagram of Belt Lines With One Radial-Fed Station]
Distribution Stations

DSs receive power at 34.5kV and transform it to 4.8kV delta-connected circuits for local distribution. The diagram below illustrates a typical 34.5kV sub-transmission circuit that runs between two DSs and feeds multiple ISs and includes multiple switching points.
Basic Circuit Overview

Most primary circuits consist of both overhead and underground conductors which emanate from distributing stations mainly by way of underground cables. The underground cables are encased in conduits, a short distance from the distributing station they transition from the underground and rise up on power poles to the overhead portion of the circuit.

The portion of underground cable or overhead conductors from the DS to the first switch points is called the feeder; there is not any load tapped to the feeder. The typical sizes of underground feeder cables are 500 m.c.m. copper, or 750 m.c.m. aluminum. The typical size overhead feeder conductor is 4/0 copper or 477 a.c.s.r. There are usually at least two switching points tapped to the feeder; these switches are known as feed-center switches.

The conductors after the feed-center switches are known as primary. The primary is that part of the circuit to which the load is tapped. The main branch of primary is usually 1/0 copper or 3/0 a.c.s.r. The conductor sizes of the sub-branches tapped to the main branch of the primary are usually #2 a.c.s.r. and #6 copper. There are various types of equipment tapped to the primary such as; distribution transformers, streetlight transformers, capacitors, and switches for underground cables that feed pad-mounted transformers.

Each primary branch fed by the feed-center switch usually has an open-switch tie to another circuit that is used to pick-up load on the primary for maintenance, or in the event of problems on the feeder portion of the circuit.
4.8-kV Delta-connected Distribution System
LADWP uses an isolated, three-phase, delta connected, ungrounded, 4.8-kV distribution system. A delta-connected system is preferred over a wye-connected system because a single ground does not relay the feeder, and therefore service continuity is maintained to customers. For this reason, in a delta-connected system a grounded phase could go undetected until another phase becomes grounded and causes a short circuit, potentially burning wire down or destroying equipment. This is why a “ground detector” is used in the distributing stations.

Characteristics of an Ungrounded System
The word “ground” is commonly used in electric power systems to cover both system grounding and equipment grounding.

The terms “system ground” and “ungrounded” are defined by the National Electric Code as follows:
System Ground: A system ground is a connection to ground from one of the current-carrying conductors of a distribution system or of an interior wiring system.

Ungrounded: Ungrounded means without an intentional connection to ground except through potential indicating or measuring devices.

The term “ungrounded system” is used to identify a system in which there is no intentional connection between the system conductors and ground. This term defines the LADWP’s 4.8-kV distribution system.

The term “4.8-kV ground” refers to an accidental ground on the 4.8-kV distribution system, such as would be caused by an overhead conductor contacting the ground, or by a failed transformer.

Ground Detectors
Ground detectors are installed in distribution stations for the purpose of helping the operator to recognize and locate accidentally grounded 4.8-kV circuits or equipment. These accidental grounds will usually be found on the 4.8-kV feeder circuits, but may occur on any of the 4.8-kV equipment in the station such as feeder voltage regulators, power transformers, busses, cables, potheads, etc.

The ground detector meters are connected to the secondary windings of potential transformers having primary windings wye-connected across the three phases of a 4.8-kV bus (Figure 1). The neutral point of the ground detector potential transformers normally operate at 58 percent of normal line voltage, but may be subjected to full line voltage or higher if one phase of the delta circuit becomes grounded. A fuse is
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placed in each leg of the ground detectors potential transformer.

Effects of a Ground on an Ungrounded Delta System
When a conductor of an ungrounded delta system contacts ground (or a grounded object), the normal static balance of the system is displaced, raising the potential between the other phases and ground to full line voltage. The current which flows through such a contact is proportional to the leakage and capacitance of the other two phases and the system. As the system becomes larger, this current becomes greater and when arcing grounds occur, the insulation of the entire system is subjected to abnormally high voltage stresses.

An accidental ground can cause a rise in the voltage of the ungrounded phase conductors to 1.73 times the normal phase to ground circuit voltage. This means that normally, the insulation of the system must be able to withstand such voltage stresses if they should occur.

Usually, the insulation between each line and ground is adequate to withstand full line-to-line voltage. However, if this voltage is applied for long periods, it may result in failure of
insulation, which may have deteriorated because of age or severe service conditions.

**Ground Detector Bank Operation**
If any phase of the 4.8-kV isolated system emanating from a station becomes accidentally grounded, a path is created from this point to the neutral connection of the ground detector potential transformer circuit. The ground detector potential transformer on the grounded phase will be shorted out. The lower the resistance of the accidental ground, the less will be the impedance of the ground return path, and hence the greater the shorting effect on the involved ground detector potential transformer. The ground detector meter across the shorted potential transformer will register somewhere between zero and 100 percent ground, depending on how completely the potential transformer has been shorted out. The ground detector meters on the ungrounded phases will indicate somewhere between zero and the upper end of the meter scale, which is usually colored red to indicate when the voltage on the ungrounded phases is reaching a dangerous level, probably due to an arcing ground.

**Additional Grounds**
In an ungrounded system, a second ground fault on another phase may occur before the first fault is removed. The second fault may be on the same feeder circuit as the original fault, or on another that is fed from the same source. In any event, the resulting phase-to-phase fault will actuate relays or circuit breakers and trip one or both circuits. Thus, a single ground fault of relative unimportance may eventually result in considerable damage because of the relatively high phase-to-phase fault current and the interruption on one or both circuits.
Ground detectors will indicate the existence of a ground. The detector will also indicate an abnormally high phase-to-ground voltage which may be associated with the ground in certain instances.

**Automatic Reclosers**
Most of the feeders in unattended stations are equipped with devices known as automatic reclosers, and the operation it performs is known as an automatic reclosure. These reclosers are set so they will reclose the circuit breaker on a feeder that has relayed 30 seconds after the initial relay operation. If the feeder is all underground construction, a second relay operation -- within a period of two minutes -- will cause the recloser to “lock out” the feeder. This means that an operator must reset the recloser manually in order to reclose the feeder circuit breaker. If the feeder remains energized on the first reclosure, the outage is 30 seconds.

In the case of a feeder that is all overhead, or part overhead and part underground, the recloser is set to close after 30 seconds on the first relay operation, and after 40 seconds on the second. It will lock out on the third relay operation, assuming that the action all takes place within the two-minute time bracket. The outage time for two relay operations followed by a successful reclosure within the two-minute time bracket, is one minute, 10 seconds. If the time between relay operations extends beyond the two-minute time limit, the recloser resets and looks at a subsequent relay operation as a “first one” again.

**High Voltage Conditions**
In any practical system, there always exists a capacitive coupling between system conductors and ground. Consequently, our so-called ungrounded system is in reality a
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capacitive grounded system by virtue of the distributed capacitance from system conductors to ground.

Because of this effect, under certain conditions it is possible for destructive, transient over-voltages, several times normal, to appear from phase-to-ground. In one instance, this condition will result from the repeated re-strike of the arc in an arcing fault from phase-to-ground. In a second instance, this condition has resulted from resonance effects in series inductive-capacitive circuits. Experience has shown that there is nearly always a fault-to-ground associated with this type of high-voltage problem. During normal operations, the voltage across both the series capacitance and inductance of the circuit may be several times the rated phase-to-phase voltage. Should a fault-to-ground occur at the junction between certain values of series capacitance and inductance, the location of ground potential will tend to become the voltage of this junction point instead of the center of the AC system’s voltage triangle. The total system capacitive impedance to ground is generally high and thus offers practically no opposition to this shift in the location of ground potential. The phase-to-ground voltage, as a result, may be elevated to a point where it exceeds the line-to-ground insulation, at which point an insulator flashover occurs. As in all other cases, this over-voltage is communicated to all equipment metallically connected with this circuit.
Primary Circuit Maps

Description
Primary Circuit Maps are drawings of the 4.8-kV circuitry from the distributing station to the end of the circuit. The maps are usually drawn at a 1” = 400’ scale and are printed out on 11” X 17” sheets of paper. There are usually a few sheets for each map. Typically, the first one or two pages show the circuit itself and the later pages show detailed information on switch diagrams, pad-mounted and underground transformers. The maps are drawn and maintained by the Distribution Drafting Section; the maps provide a great deal of information which is useful for field personnel.

Lay-out
The bottom portion of the map is reserved for the title block which denotes the following:
- Distribution district the circuit is located in
- Reference Maps numbers both Overhead Record Map and Spacing Maps
- Circuit voltage and regulator amperage rating
- Scale
- Underground cable sizes
- Revision dates
- Number of sheets
- Primary circuit number
On the periphery of the main portion of the map you will find the following:

- North arrow
- The receiving station the distributing station (DS) is fed from
- Load estimates on different sections of the circuit are the total load on the circuit at the time multiplied by the percentage of kVA transformation tapped to that section of line.
- Symbol for co-generation if there is some connected to the circuit

The next several pages contain map symbols that are used on primary circuit maps.
4.8-kV Overhead Switches
The Department has several types of overhead switches; both load break and non-load break types. The most common are Positect’s, Open-air Chute Break’s, and some Open-air Non-load Break’s. Before operating overhead switches they shall be visually inspected to check the condition of the switch itself and the 5-kV leads. Correct phasing must be checked before closing switches. Generally, when closing switches; the switch closest to the operator should be closed first, then working towards the outermost switch. When opening switches; the farthest switch should be opened first and the closest switch last.

300 amp Positect
Before operating Positect switches; check to see if they have snuffers attached. The snuffer aids in extinguishing the arc when load is dropped when opening the switch. Before attempting to open the switch rotate the handle clockwise to ensure that it is fully engaged to the bayonet. Positect’s are identified by the symbol (LB) after the switch number on primary circuit and overhead maps.
300 amp Open-air Chute Break
Open-air Chute Break switches are identified by the symbol (CB) after the switch number on primary circuit and overhead maps.

300 amp Open-air Non-load Break
Open-air switches without load break attachments are known as solid blade switches. They are identified by the symbol (SB) after the switch number on primary circuit and overhead maps. Opening this type of switch under load requires the use of the load-buster. The load buster is rated to drop 600 amps.
Sectionalizing Switches
In order that service may be restored as quickly as possible to a major portion of the area served by the feeder in which a fault exists, sectionalizing switches are installed on the primaries to separate them into smaller units. This allows the faulted feeder or a faulted portion of it to be removed from service until the fault is located and at the same time provides for almost immediate restoration of service to the un-faulted portions of the primary circuit. The sectionalizing switches also provide a method for clearing the feeder back into the station in order that work may be accomplished on the feeder terminal components in the station.

Tie Switches
Tie switch connections are installed between different primary circuits fed either from the same station or, when practical, from different distributing station or feeders. These may be closed as required during switching or during fault conditions to feed a primary from another source. This economically gives added flexibility and reliability to the radial system.
Definitions and Work Authorities

ACCIDENT PREVENTION TAGS (APT)
Temporary signs that have preprinted instructions and markings and are used to:
- Restrict operation or other action so that personnel and or systems and components are protected.
- Warn that the tagged system or component is in a condition for test or maintenance activities.
- Indicated that the system or component is under the operating jurisdiction of an organizational unit other that the operating agent.

CLEARANCE
A Work Authority issued by a LADWP Representative that states the specific circuit, circuit component, or equipment is DISCONNECTED from specified sources of energy. It is assurance to the authorized person receiving the CLEARANCE that the specified circuit, circuit component, or equipment will remain so DISCONNECTED until the holder of the CLEARANCE releases it. A CLEARANCE permits the performance of work specified when the CLEARANCE was issued.
CUSTOMER STATION
An Electric Station that normally consists of one or more transformers, associated Switchgear, and metering equipment installed on the customer’s property that is dedicated to serve a single customer or group of customers. The primary electrical supply to such stations is at 34.5-kV or less.

DISCONNECTED
The term DISCONNECTED, as used in the preparation of electrical circuits and equipment for a Work Authority, means that a required open, usually visible, exists between specified sources of electric energy and the circuit or circuit component that is cleared.

ELECTRIC TROUBLE DISPATCHER
A Field Representative of the Load Dispatcher who has been delegated the authority to originate Field Clearances and Oks TO _____.

FIELD CLEARANCE
A CLEARANCE issued by an Electric Trouble Dispatcher on a portion of a Primary Circuit that can be DISCONNECTED without any switching in a Distributing Station or on a Customer Station (IS) Feeder.

FIELD REPRESENTATIVE
A FIELD REPRESENTATIVE is employed by LADWP and receives WORK AUTHORITY from the Load Dispatcher and reissues them to the Mutual Assistance Crew Supervisor (MACS).

LOAD DISPATCHER
A NERC certified power system employee who is responsible for the daily operation of the Los Angeles power system.
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Mutual Assistance Crew (MAC)
A MAC is a non-LADWP crew that is working on LADWPs electric system.

Mutual Assistance Crew Supervisor (MACS)
A MACS is supervisor of a non-LADWP crew that is working on LADWPs electric system.

OK TO ____
A Work Authority issued by a Los Department of Water and Power Representative:
- Permitting and describing specified work to be done,
- On or near specified circuits or equipment,
- Under specified conditions.

An OK TO ____ may be granted:
- Without the circuit or equipment necessarily being DISCONNECTED from specified sources of energy.
- With the equipment energized or de-energized.
- With or without any connected Co-generation sources necessarily being DISCONNECTED.

In each case, there must be a clear and thorough understanding as to the exact status of the circuit or equipment. No changes in conditions shall be made by any person involved in an OK TO ____ without a review of the entire circumstances of the transaction by all parties.

OK TO WORK HOT WITH A HOLD IN CASE OF RELAY
A Work Authority allowing work on or near energized circuits or equipment that includes a statement from the Load Dispatcher or their Field Representative that the circuit will not be re-closed from a source under control of the Department after a relay until the holder of the OK TO WORK HOT WITH A HOLD IN CASE OF RELAY is contacted.
WORK AUTHORITIES
Any CLEARANCE or OK TO _____ issued by the Load Dispatcher or their Field Representative to an Authorized Person for the performance of specified work.

Work Practices for Electric Crews

All lines shall be considered energized until they have been proven de-energized, and protective “personal” shorts and grounds have been applied to each side of the work area.

Pole Climbing
Climbers shall ascend and descend the pole with their positioning strap around the pole with the snap ends secured to each “D” ring of their body belt from ground-to-ground. The use of a second positioning strap or similar is required to be used when maneuvering obstacles to ensure the climber is always tethered to the pole.

Metallic or Concrete Pole Procedures
Working with metallic or concrete poles present hazards not associated with wood poles, such as:
- Conductive poles coming into contact with energized lines while setting or removing.
- Ground potential in the area of normal body movement and exposed energized conductor being worked.

The procedures below shall be implemented when working on or near conductive poles.
- Exposed grounded lines, conductors, or parts in the work area, shall be guarded or insulated. The protective cover shall extend beyond the reach of the employees normal body movement.
- 50 – 600 volts: All work can be performed working
from the pole, or from insulated aerial equipment.
- 600 – 7,500 volts: Work shall be performed from the pole either with live line tools, or with rubber insulating gloves from an insulated platform, or from insulated aerial equipment.
- 7,500 – 34,500 volts: Work shall be performed from an insulated platform with live line tools, or from insulated aerial equipment.

34.5-kV Clearances and Grounds
When working on a 34.5-kV circuit under a CLEARANCE, the following actions shall take place before commencing work on the lines:
- The MACS will receive a CLEARANCE from the Patrolman.
- The MAC will test de-energized lines to be sure they are absent of normal voltage before installing shorts and grounds.
- Before working on de-energized lines, install temporary protective “personal” shorts and grounds at each side of the work location.
- Shorts and grounds shall be at least 4/0 copper.
- Attach the ground end first, and then attach the other end to the de-energized conductor using live line tools.
- Attach a completed “Do Not Operate” tag at the ground connection point to the grounding rod.
- If a ground is required at a station remote from the work location, a request is made by the LADWP Field Representative to the Load Dispatcher, who then orders the ground on.
- All grounds must be removed before the MACS turns in the CLEARANCE to the Patrolman, who then releases the clearance back to the load dispatcher.
In each case, there must be a clear and thorough understanding as to the exact status of the circuit or equipment. No changes in conditions shall be made by any person involved in an OK To ___ without a review of the entire circumstances of the transaction by all parties.

4.8-kV Switching and Tagging
During restoration, switching, opening, or closing any segment of the 4.8-kV distribution system performed by MAC must be at the direction of LADWPs Electric Trouble Dispatchers. The Electric Trouble Dispatchers will provide the appropriate APT number to the MACS so that the APT may be installed. All APT data must be completed legibly in ink.

Environmental Compliance – Spills
Immediately report all oil spills to your Crew Guide so they may initiate notifications, and coordinate the clean-up. The following information is required when reporting a spill:
- The field location where the spill occurred.
- Date and time of spill, if known.
- The source of the spill (type of equipment).
- The approximate volume of the spill.
- The approximate area the spill covers.
- The type of fluid involved in the spill, if known.
- The potential for further spill to occur.
- The stats of the spill, including whether or not the spill:
  - Involved or may eventually involve Navigable Waters.
  - Left the site.
  - Was cordoned off.
  - Was contained.
  - Was cleaned up or is being cleaned up.
- Equipment labeling non-PCB transformers are tagged with a sticker.

Connectors
The following guidelines apply when working service restoration on LADWP facilities.
- Use only an aluminum or bi-metal connector whenever an aluminum conductor is involved in the connection (aluminum-to-aluminum or aluminum-to-copper). These connectors may be bolted parallel groove, fire-on-wedge, or compression. **Note:** Aluminum always goes above copper.
- Use only copper or bronze connectors for copper-to-copper. These connections may be compression or split bolt.

No other types of connectors may be used during this mutual assistance effort.
Use of Primary Phasing Meter

Normal Circuit Status
To properly check the status of a given 4.8-kV circuit; voltage reads must be taken to ensure the normal status of the circuit. The reads shall include both phase-to-ground and phase-to-phase voltages. Phase-to-ground reads should be taken from a known ground such as; grounded secondary neutral, grounded phone messenger, or temporary ground rod. Phase-to-ground reads should be consistent and at or near 2770 volts. A 4.8-kV circuit operating normally will have the following voltage reads:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A-to-ground</td>
<td>2770 volts</td>
<td></td>
</tr>
<tr>
<td>B-to-ground</td>
<td>2770 volts</td>
<td></td>
</tr>
<tr>
<td>C-to-ground</td>
<td>2770 volts</td>
<td></td>
</tr>
<tr>
<td>A-to-B</td>
<td>4800 volts</td>
<td></td>
</tr>
<tr>
<td>A-to-C</td>
<td>4800 volts</td>
<td></td>
</tr>
<tr>
<td>B-to-C</td>
<td>4800 volts</td>
<td></td>
</tr>
</tbody>
</table>

Abnormal Circuit Status
As mentioned above phase-to-ground readings should be consistent with each other and at or near 2770 volts. The 4.8-kV delta system will operate with one phase grounded. The following reads would occur if A phase had a 100% ground on it:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A-to-ground</td>
<td>0 volts</td>
<td></td>
</tr>
<tr>
<td>B-to-ground</td>
<td>4800 volts</td>
<td></td>
</tr>
<tr>
<td>C-to-ground</td>
<td>4800 volts</td>
<td></td>
</tr>
<tr>
<td>A-to-B</td>
<td>4800 volts</td>
<td></td>
</tr>
<tr>
<td>A-to-C</td>
<td>4800 volts</td>
<td></td>
</tr>
<tr>
<td>B-to-C</td>
<td>4800 volts</td>
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Paralleling Two 4.8-kV Circuits
Before paralleling two 4.8-kV circuits arrangements must be made with the Electric Trouble Board to set-up an OK To
Parallel and Separate. All parallel and separations should be completed in the shortest time possible.

Proper phasing methods shall be used before paralleling two 4.8-kV circuits. The first step is to verify that each circuit is operating normally; the second step is to check phasing between the two circuits.

Check each circuit for normal voltage reads (12 reads total):

- A-to-ground: 2770 volts
- B-to-ground: 2770 volts
- C-to-ground: 2770 volts
- A-to-B: 4800 volts
- A-to-C: 4800 volts
- B-to-C: 4800 volts

Cross-check one circuit against the other for proper phasing (9 reads total):

- A-to-A: 0 volts
- A-to-B: 4800 volts
- A-to-C: 4800 volts
- B-to-A: 4800 volts
- B-to-B: 0 volts
- B-to-C: 4800 volts
- C-to-A: 4800 volts
- C-to-B: 4800 volts
- C-to-C: 0 volts

A minimum of 21 voltage reads are required to properly phase two 4.8-kV circuits; if the last read is zero, an additional known voltage read must be taken to ensure that the meter is functioning properly.
A voltage reading of 0 volts across the two circuits indicates LIKE PHASES. Voltages between LIKE PHASES should read zero volts. Voltages may vary due to source location, circuit loading, impedance, and system operating limitations. LIKE PHASES may be safely paralleled up to a maximum of a 1000 volts difference. During the phasing operation LIKE PHASES should be identified across the same open switch or if jumpers are going to be installed LIKE PHASES should be marked with phasing pins with colored tape on them. After correct phasing has been established across the open switches they should be closed in the recommended manner; starting with the switch closest to the operator working towards the switch farthest away.

When installing jumpers to parallel two circuits and there is a large voltage difference; mechanical jumpers may be used to make the connection temporarily between the two circuits to eliminate arcing between the conductors when making the permanent taps.

Immediately after the parallel has taken place between the two circuits; the separation shall be made. The times of the parallel and the separation shall be reported to the electric trouble dispatcher.

**Energizing Underground Cable and Equipment**

Before energizing new underground cable and/or equipment; the circuit that will feed it must be checked to ensure that circuit status is normal. The reads shall include both phase-to-ground and phase-to-phase voltages. Phase-to-ground reads should be taken from a known ground such as; grounded secondary neutral, grounded phone messenger, or temporary ground rod. Phase-to-ground reads should be consistent and
at or near 2770 volts. A 4.8-kV circuit operating normally will have the following voltage reads:

- A-to-ground: 2770 volts
- B-to-ground: 2770 volts
- C-to-ground: 2770 volts
- A-to-B: 4800 volts
- A-to-C: 4800 volts
- B-to-C: 4800 volts

Check for the absence of voltage on the cable and equipment that will be energized. The meter should read zero volts when checking each phase-to-ground and each phase-to-phase.

Energizing the new cable and equipment involves performing a ground search. The procedure for ground searching is:

1. Meter on A phase; verify 2770 read then close A phase switch or tap temporary jumper – check the reading on the primary phasing meter; if the phase is clear of grounds the meter read will not change appreciably. Open switch or remove temporary jumper.

2. Move the meter to B phase; verify 2770 read then close B phase switch or tap temporary jumper – check the reading on the primary phasing meter; if the phase is clear of grounds the meter read will not change appreciably. Open switch or remove temporary jumper.

3. Move the meter to C phase; verify 2770 read then close C phase switch or tap temporary jumper – check the reading on the primary phasing meter; if the phase is clear of grounds the meter read will not change appreciably.
If all phases were clear of grounds phases A and B may be closed at this time.

When one phase is closed; beware of back feed that will occur if equipment is tapped to the conductors.

**Picking-up Load**

Before picking-up load; the line side conductors shall be checked for correct voltage reads. The reads shall include both phase-to-ground and phase-to-phase voltages. Phase-to-ground reads should be taken from a known ground such as; grounded secondary neutral, grounded phone messenger, or temporary ground rod. Phase-to-ground reads should be consistent and at or near 2770 volts. A 4.8-kV circuit operating normally will have the following voltage reads:

- A-to-ground 2770 volts
- B-to-ground 2770 volts
- C-to-ground 2770 volts
- A-to-B 4800 volts
- A-to-C 4800 volts
- B-to-C 4800 volts

Check for the absence of voltage on the load side equipment that will be energized. The meter should read zero volts when checking each phase-to-ground and each phase-to-phase.

When energizing the load side conductors follow the ground search procedure listed below:

- Meter on A phase; verify 2770 read then close A phase switch or tap temporary jumper – check the reading on the primary phasing meter; if the phase is clear of grounds the meter read will not change appreciably. Open switch or remove temporary jumper.

- Move the meter to B phase; verify 2770 read then
close B phase switch or tap temporary jumper – check the reading on the primary phasing meter; if the phase is clear of grounds the meter read will not change appreciably. Open switch or remove temporary jumper.

Move the meter to C phase; verify 2770 read then close C phase switch or tap temporary jumper – check the reading on the primary phasing meter; if the phase is clear of grounds the meter read will not change appreciably.

If all phases were clear of grounds phases A and B may be closed at this time. If the load is being picked-up with jumpers; the use of load pick-up mechanical jumpers is required for the closing of A and B phases.

When one phase is closed; beware of back feed that will occur if equipment is tapped to the conductors.

**Transformers**

There are established procedures for working with transformers; which must be followed to prevent accidents and protect against possible damage to equipment. Understanding the correct procedures is paramount for success. The following pages document the procedures for:

- Checking voltages on transformers; both single-phase and three-phase banks.
- Phasing procedures for paralleling and separating transformers; single-phase lighter, power, and three-phase banks.
- Installing hogwagons.
- Checking and marking phase rotation.
Before transformers are taken to the field for installation it is important to:
  - Check the nameplate and stenciling to verify the correct class and capacity.
  - Use a transformer tester to check for shorts or opens in the primary and secondary coils.

**Energizing**
Energized transformers can build up a capacitive charge on the case, exercise caution when working on or near them; consider the case energized! Do not tap any load to the transformer until the correct output voltages have been verified.

**Class 200 Single-phase Transformers**

**Transformer Class**
Nearly all of the single-phase transformers used on the LADWP’s system are Class 200; which provides an output of 120/240 volts. Single-phase transformers are mainly used to supply homes, and some smaller commercial applications. Sizes range from 25 to 167kVA; normally 50-kVA transformers are the largest capacity that feed single-family homes.

**Voltage Checks**
Procedures shall be followed when energizing single-phase transformers which include:
  - Grounding the neutral, keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
  - Close the cut-outs.
  - Checking for proper voltage **three reads required**.
    - Two 120-volt reads phase-to-neutral.
    - One 240-volt read phase-to-phase.
It takes three reads to check for correct voltages, after verification load may be tapped to the secondaries.

**Permanent Single-phase Paralleled Transformers**

In the 1950’s and 1960’s some transformers were permanently paralleled; primarily in the San Fernando Valley to provide shared capacity. Parallels are broken when the pole lines are rebuilt. When transformers were permanently paralleled transformer impedance was an issue; it had to be closely matched to prevent the transformer with the lowest impedance carrying a greater portion of the load. Paralleled transformers are identified in the field by “Parallel” tags on the pole and crossarms.
Temporary Paralleling Single-phase Class 200 Transformers

Before paralleling two single-phase transformers the following items shall be checked, and procedures followed:

- Transformers are of the same class (i.e. CL200).
- They are tapped to the same primary circuit on identical phases.
- The transformer that the load is being transferred to; has the capacity to carry the additional load.
- The neutrals are tied together.
- Check the secondary voltage on each transformer six reads.

  Transformer One
  o Two 120-volt reads phase-to-neutral.
  o One 240-volt read phase-to-phase.

  Transformer Two
  o Two 120-volt reads phase-to-neutral.
  o One 240-volt read phase-to-phase.

- Cross-check each transformer phases against the other transformer phases four reads. This is a sample order that the reads may be taken, the order in which you take the reads may be different.
  o “A”-phase to “A”-phase 0 volts
  o “A”-phase to “B”-phase 240 volts
  o “B”-phase to “A”-phase 240 volts
  o “B”-phase to “B”-phase 0 volts

- If necessary mark like (zero reads) phases with phasing tape.
- If the last read taken was a zero another voltage read needs to be taken to ensure the meter is working.

It takes a minimum of 10, possibly 11 (to verify meter is working) voltage reads to check phasing before paralleling two single-phase transformers.
After all of the required reads are taken:
- Tap **like** phases together to establish a parallel between the two transformers.

**Breaking Parallels**

After transformers have been paralleled; the transformer/s that are being taken off the line need to be deenergized. The following steps need to be taken:
- Break the parallel on the secondary side *only* (to prevent back feed); by removing the jumpers between the phases, leave the neutral tie tapped.
- Open the cut-outs.
- Remove the neutral tap from the deenergized transformer.
- Self-protected transformers (CPs) do not utilize cut-outs; the primary bushings are directly tapped to the primary through 5-kV copper insulated wire; when one bushing is tapped the other bushing becomes energized.

**Three-phase Transformer Banks**

**Transformer Class**

Single-phase transformers are often banked together to provide three-phase service primarily for commercial and industrial customers. The most common three-phase service voltages include:
- Class 200 – Open delta / closed delta.
  - 120/240-volt – four wire.
- Class 400 – Open delta / closed delta.
  - 480-volt – three wire.
- Class 200/Par 120 – Delta / Wye.
  - 120/208-volt – four wire.
- Class 277 – Delta / Wye.
  - 277/480-volt – four wire.
General Steps to Temporary Parallel Three-phase Transformer Banks
Before paralleling two three-phase transformer banks the following items shall be checked:
- The transformers are of the same class (i.e. CL200).
- Transformers must be tapped to the same primary circuit (delta connected secondary banks must have the lighter transformer tapped to the same primary phases).
- The banks must have the same angular displacement.
- The transformers that the load is being transferred to; have the capacity to carry the additional load.
- A common tie needs to be established between the two banks.

It takes a minimum of 21, possibly 22 (to verify meter is working) voltage reads to check the phasing before paralleling two three-phase transformer banks.

After all of the required reads are taken:
- Tap like phases together to establish a parallel between the two transformers.
Voltage Checks

Class 200 – Open Delta
The following procedures shall be followed when energizing the three-phase transformer bank:
- Ground the neutral, keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
- Close the cut-outs.
- Check for proper voltage six reads required.
  o Two 120-volt reads phase-to-neutral.
  o One 208-volt read phase-to-neutral.
  o Three 240-volt reads phase-to-phase.
Class 200 – Closed Delta
The following procedures shall be followed when energizing the three-phase transformer bank:

- Ground the neutral, keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
- **Do not close the delta on the secondary side until 0-volt read on delta leg is verified.**
- Close the cut-outs.
- Check voltage on transformer that is not tied on the secondary side for 240-volt output; once verified check for a 0-volt read from open secondary bushing to delta leg; once 0-volt read is verified, re-check 240-volt read to ensure meter is working; close the delta on the secondary side.
- Check for proper voltage **six reads required.**
  - Two 120-volt reads phase-to-neutral.
  - One 208-volt read phase-to-neutral.
  - Three 240-volt reads phase-to-phase.
Steps to Parallel Two Class 200 Delta / Delta Connected Banks with Grounded Neutrals

- Check the secondary voltage on each transformer bank twelve reads.
  - Transformer Bank One
    - Two 120-volt reads phase-to-neutral.
    - One 208-volt read phase-to-neutral.
    - Three 240-volt reads phase-to-phase.
  - Transformer Bank Two
    - Two 120-volt reads phase-to-neutral.
    - One 208-volt read phase-to-neutral.
    - Three 240-volt reads phase-to-phase.

- Establish a common tie between the two transformer banks (neutrals tied together).

- Cross-check Transformer Bank One’s phases against Transformer Bank Two’s phases nine or ten reads. This is a sample order that the reads may be taken, the order in which you take the reads may be different.
  - “A”-phase to “A”-phase 0 volts
  - “A”-phase to “B”-phase 240 volts
  - “A”-phase to “C”-phase 240 volts
  - “B”-phase to “A”-phase 240 volts
  - “B”-phase to “B”-phase 0 volts
  - “B”-phase to “C”-phase 240 volts
  - “C”-phase to “A”-phase 240 volts
  - “C”-phase to “B”-phase 240 volts
  - “C”-phase to “C”-phase 0 volts

- If necessary mark like (zero reads) phases with phasing tape.

- If the last read taken was a zero another voltage read needs to be taken to ensure the meter is working.

It takes a minimum of 21, possibly 22 (to verify meter is working) voltage reads to check the phasing before paralleling...
two three-phase transformer banks.

After all of the required reads are taken:
   - Tap like phases together to establish a parallel between the two transformers.

**Breaking Parallels**
After transformers have been paralleled; the transformer/s that are being taken off the line need to be deenergized. The following steps need to be taken:
   - Break the parallel on the secondary side only (to prevent back feed); by disconnecting the bank that is going to be deenergized from the load; leave the neutral tapped.
   - Open the cut-outs.
   - Remove the neutral tie.

**Corner-grounded Transformer Banks**
There are some corner-grounded three-phase transformer banks (phase is grounded instead of the neutral) connected to the 4.8-kV system; these cannot be paralleled with neutral grounded banks. The ground location needs to be the same on each bank.
Class 400 – Open Delta

The following procedures shall be followed when energizing the three-phase transformer bank:

- Keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
- Close the cut-outs.
- Check for proper voltage three reads required.
  o Three 480-volt reads phase-to-phase.
Mutual Assistance Guidebook

Class 400 – Closed Delta

The following procedures shall be followed when energizing the three-phase transformer bank:

- Keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
- **Do not close the delta on the secondary side until 0-volt read on delta leg is verified.**
- Close the cut-outs.
- Check voltage on transformer that is not tied on the secondary side for 480-volt output; once verified check for a 0-volt read from open secondary bushing to delta leg; once 0-volt read is verified, re-check 480-volt read to ensure meter is working; close the delta on the secondary side.
- Check for proper voltage **three reads required.**
  - Three 480-volt reads phase-to-phase.
Steps to Parallel Two Class 400 Delta / Delta Connected Banks

- Check the secondary voltage on each transformer bank twelve reads; verify banks are clear of grounds.
  - Transformer Bank One
    - Three 0-volt reads phase-to-ground.
    - Three 480-volt reads phase-to-phase.
  - Transformer Bank Two
    - Three 0-volt reads phase-to-ground.
    - Three 480-volt reads phase-to-phase.
- Establish a common tie between the two transformer banks.
- Cross-check Transformer Bank One’s phases against Transformer Bank Two’s phases nine or ten reads; caution: use a 10-kV meter to perform the cross-checks, if the incorrect tie is made a 960-volt read will occur. This is a sample order that the reads may be taken, the order in which you take the reads may be different.
  - “A”-phase to “A”-phase 0 volts
  - “A”-phase to “B”-phase 480 volts
  - “A”-phase to “C”-phase 480 volts
  - “B”-phase to “A”-phase 480 volts
  - “B”-phase to “B”-phase 0 volts
  - “B”-phase to “C”-phase 480 volts
  - “C”-phase to “A”-phase 480 volts
  - “C”-phase to “B”-phase 480 volts
  - “C”-phase to “C”-phase 0 volts
- If necessary mark like (zero reads) phases with phasing tape.
- If the last read taken was a zero another voltage read needs to be taken to ensure the meter is working.

It takes at least (depending on the common tie) a minimum of
21, possibly 22 (to verify meter is working) voltage reads to check the phasing before paralleling two three-phase transformer banks.

After all of the required reads are taken:
- Tap like phases together to establish a parallel between the two transformers.

**Breaking Parallels**
After transformers have been paralleled; the transformer/s that are being taken off the line need to be deenergized. The following steps need to be taken:
- Break the parallel on the secondary side only (to prevent back feed); by disconnecting the bank that is going to be deenergized from the load.
- Open the cut-outs.
Mutual Assistance Guidebook

Class 200 / Par 120 – Delta / Wye
The following procedures shall be followed when energizing the three-phase transformer bank:
- Ground the neutral, keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
- Close the cut-outs.
- Check for proper voltage six reads required.
  - Three 120-volt reads phase-to-neutral.
  - Three 208-volt read phase-to-phase.

Steps to Parallel Two Class 200 / Par 120 Delta / Wye Connected Banks with Grounded Neutrals
- Check the secondary voltage on each transformer bank twelve reads.
  - Transformer Bank One
    - Three 120-volt reads phase-to-neutral.
    - Three 208-volt reads phase-to-phase.
  - Transformer Bank Two
    - Three 120-volt reads phase-to-neutral.
    - Three 208-volt reads phase-to-phase.
- Establish a common tie between the two transformer banks (neutrals tied together).
- Cross-check Transformer Bank One’s phases against Transformer Bank Two’s phases nine or ten reads. This is a sample order that the reads may be taken, the order in which you take the reads may be different.
  - “A”-phase to “A”-phase 0 volts
  - “A”-phase to “B”-phase 208 volts
  - “A”-phase to “C”-phase 208 volts
  - “B”-phase to “A”-phase 208 volts
  - “B”-phase to “B”-phase 0 volts
  - “B”-phase to “C”-phase 208 volts
  - “C”-phase to “A”-phase 208 volts
  - “C”-phase to “B”-phase 208 volts
  - “C”-phase to “C”-phase 0 volts
- If necessary mark like (zero reads) phases with phasing tape.
- If the last read taken was a zero another voltage read needs to be taken to ensure the meter is working.

It takes a minimum of 21, possibly 22 (to verify meter is working) voltage reads to check the phasing before paralleling two three-phase transformer banks.

After all of the required reads are taken:
- Tap like phases together to establish a parallel between the two transformers.

Note: If the two banks will not phase together the angular displacement between the banks doesn’t match; rotate the taps on two primary phases on one bank, this will change the angular displacement so the banks can be paralleled.
Breaking Parallels
After transformers have been paralleled; the transformer/s that are being taken off the line need to be deenergized. The following steps need to be taken:

- Break the parallel on the secondary side only (to prevent back feed); by disconnecting the bank that is going to be deenergized from the load; leave the neutral tapped.
- Open the cut-outs.
- Remove the neutral tie.

Class 277 – Delta / Wye
The following procedures shall be followed when energizing the three-phase transformer bank:

- Ground the neutral, keep the secondary leads in the clear (i.e. taped-up or isolated from other energized conductors).
- Close the cut-outs.
- Check for proper voltage six reads required.
  - Three 277-volt reads phase-to-neutral.
  - Three 480-volt read phase-to-phase.
Steps to Parallel Two Class 277 Delta / Wye Connected Banks with Grounded Neutrals

- Check the secondary voltage on each transformer bank twelve reads.
  
  Transformer Bank One
  o Three 277-volt reads phase-to-neutral.
  o Three 480-volt reads phase-to-phase.
  
  Transformer Bank Two
  o Three 277-volt reads phase-to-neutral.
  o Three 480-volt reads phase-to-phase.

- Establish a common tie between the two transformer banks (neutrals tied together).

- Cross-check Transformer Bank One’s phases against Transformer Bank Two’s phases nine or ten reads. This is a sample order that the reads may be taken, the order in which you take the reads may be different.
  o “A”-phase to “A”-phase 0 volts
  o “A”-phase to “B”-phase 480 volts
  o “A”-phase to “C”-phase 480 volts
  o “B”-phase to “A”-phase 480 volts
  o “B”-phase to “B”-phase 0 volts
  o “B”-phase to “C”-phase 480 volts
  o “C”-phase to “A”-phase 480 volts
  o “C”-phase to “B”-phase 480 volts
  o “C”-phase to “C”-phase 0 volts

- If necessary mark like (zero reads) phases with phasing tape.

- If the last read taken was a zero another voltage read needs to be taken to ensure the meter is working.

It takes a minimum of 21, possibly 22 (to verify meter is working) voltage reads to check the phasing before paralleling two three-phase transformer banks.
After all of the required reads are taken:
- Tap like phases together to establish a parallel between the two transformers.

Note: If the two banks will not phase together the angular displacement between the banks doesn’t match; rotate the taps on two primary phases on one bank, this will change the angular displacement so the banks can be paralleled.

**Breaking Parallels**
After transformers have been paralleled; the transformer/s that are being taken off the line need to be de-energized. The following steps need to be taken:
- Break the parallel on the secondary side only (to prevent back feed); by disconnecting the bank that is going to be de-energized from the load; leave the neutral tapped.
- Open the cut-outs.
- Remove the neutral tie.