Infrastructure Health & Safety Association
Safe Practice Guide
Temporary Grounding and Bonding Techniques

Foreword
This Guide designates the practices that should be followed by the member firms of the Infrastructure Health & Safety Association (IHSA) when involved in de-energizing isolated electrical circuits or apparatus. This Guide is not designed as a training manual, but contains information, best practices and general recommendations deemed appropriate to perform a job in a responsible and safe manner.

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INTRODUCTION

It has been generally accepted that when temporary grounds were applied to isolated equipment, it would become de-energized, thus ensuring electrical hazards would be totally eliminated for anyone who might make contact with the equipment.

Through extensive laboratory testing, this has been proven to be a false perception.

Current will seek any and every available path to ground. The lower the resistance to the travel of electricity, the more current will flow. This is not to say that a person in parallel with a properly installed grounding system will not also be a simultaneous path for current to flow.

A person in contact with even the best grounded equipment may be subjected to a lethal amount of current, should that equipment become energized.

Current will only flow where there is a difference of potential (voltage). Therefore, if we can create a work zone where all equipment is at or close to the same potential, we can eliminate or substantially reduce current flow. This work zone is called an equipotential zone.

PURPOSE

Effective temporary grounding techniques must utilize a combination of grounding and bonding; grounding to clear accidental re-energization and minimize potential; bonding to ensure workers are not subjected to hazardous potential differences during energized situations.
The effective application of temporary grounds will:
1. Provide positive proof of isolation.
2. Eliminate/control induction.
3. Provide a low resistance path for current to ground to ensure rapid isolation, should re-energization occur.
4. Provide a work zone at or near ground potential (zero volts) for the duration of the de-energized work.

**DEFINITIONS**

**Bonding**
Making a mechanically-secure electrical connection between two or more objects to ensure they are at the same potential.

**Grounding**
Metallically connecting a piece of equipment to ground (earth) potential.

**Induction**
Voltage produced on a conductive object that is subjected to a changing magnetic field.

**Multi-Grounded System Neutral**
A system neutral found in areas of mid to high load density, where it is grounded (connected to earth) at frequent intervals. This ensures the neutral has strong reference to ground and is at a potential (voltage) which is at, or very near, ground potential.

**Non Multi-Grounded System Neutral**
A system neutral usually found in rural areas of low load density, where it is infrequently grounded. It may often be at a potential higher than ground potential.
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GENERAL

100 SAFE EXECUTION OF WORK
101 COMPETENT PERSONNEL
102 JOB PLANNING
103 TEAMWORK
104 WORK METHODS
100 SAFE EXECUTION OF WORK
The safe execution of temporary grounding and bonding techniques requires:
- competent personnel
- job planning
- teamwork and communication
- approved work methods and procedures
- approved testing, grounding and bonding equipment

101 COMPETENT PERSONNEL
Workers involved with temporary grounding and bonding applications must have been previously instructed, or be under instruction from a competent person, in the implementation of proper live line techniques.

102 JOB PLANNING
As in all other phases of line work, job planning is of prime importance so that work may be performed safely and efficiently.

103 TEAMWORK
The best teams are made up of people who will work compatibly with one another. Good communication is essential while work is being performed.
104 WORK METHODS

1. Prior to the application of the temporary grounding system, serious consideration must be given to the following:
   - proper identification of equipment using up-to-date operating diagrams,
   - testing for isolation,
   - personal protective equipment (PPE) requirements, and
   - adherence to all work procedure requirements.

2. In addition to good temporary grounding and bonding practices, in situations such as conductor stringing, worker and public safety will be greatly enhanced by completely barricading certain pieces of equipment at ground level through the use of plastic fencing, rope netting, barricades, etc. The proper use of this equipment will help eliminate the possibility of someone entering an area, where they may be subjected to a situation such as a dangerous parallel path to ground.

3. Because of the high number of possible applications with regard to overhead and underground configurations, no attempt is being made to give detailed instructions regarding individual situations. There are, however, many fundamental safe work practices and concepts which can be applied in all temporary grounding applications as reflected in the Purpose section of this Safe Practice Guide.
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ON OVERHEAD LINES

200 HAZARDS OF ISOLATED LINES

Good grounding practices eliminate possible hazards which could exist on isolated overhead circuits or apparatus. Some of these hazards are:

(a) INDUCTION: There is a very real possibility of voltage being induced from energized circuits on the same structure, paralleling structures or circuits crossing over or under the isolated system.

(b) ACCIDENTAL ENERGIZATION: Inadvertent operation of switchgear may energize circuits or apparatus in the work area. Accidents on adjacent circuits at crossovers or underbuilds could result in energized lines coming in contact with isolated lines. Some examples are: customer generation, vehicles hitting poles, trees falling, conductors making contact during stringing operations, other crews working in the area, etc. (See Figure #1)

(c) WIND: Dust particles suspended in the air in conditions of high humidity, fog, etc., could become a conducting medium. Wind blowing over long transmission and distribution lines has an electrostatic generating effect. Water flowing in a river

Figure #1
passing beneath a circuit or alongside it can also be a source of electrostatic charging of the conductors.

(d) LIGHTNING: Although the work area may be free of electrical storms, lightning striking another part of the system could result in transient voltages, which would make the work area very dangerous unless properly grounded. When electrical storms can be seen or heard, all work on overhead lines should be suspended immediately. (See Figure #2)

These situations all call for adequate grounding procedures to help ensure that a safe work area is established and maintained. Proper grounding procedures are effective only if the current carrying capacity of the temporary grounding system is sufficient to carry the available fault current safely ground, thereby activating overcurrent devices (such as line fuses, reclosers, breakers) to isolate the offending circuit.

201 GROUNDING SYSTEMS FOR OVERHEAD LINES—GENERAL

A satisfactory temporary grounding system must be easy to apply; meet the requirements of all field application conditions; require minimum preparation, time, and effort for installation; carry the fault current available; and accept a wide range of conductor sizes and configurations.
1. ADEQUATE CAPACITY CLAMPS

Clamps should be chosen for their fault current carrying capacity as well as their mechanical strength and size to fit the conductor (cable or bus). The clamp must have adequate electrical capacity to withstand the maximum short circuit current available for the full time duration over which that current may flow. One example of such a clamp has manufacturer ratings as follows:

<table>
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<tr>
<th>Continuous Current</th>
<th>Fault Current 15 Cycles</th>
<th>Fault Current 30 Cycles</th>
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<tr>
<td>I/O Extra Flexible Copper Grounding Cable</td>
<td>250 amps</td>
<td>21,000 amps</td>
</tr>
<tr>
<td>4/O Extra Flexible Copper Grounding Cable</td>
<td>400 amps</td>
<td>43,000 amps</td>
</tr>
<tr>
<td>Grounding Cluster Bar (See Figure #3)</td>
<td>400 amps</td>
<td>40,000 amps</td>
</tr>
<tr>
<td>Single (&quot;Duck Bill&quot;) Clamp (See Figure #4)</td>
<td>400 amps</td>
<td>35,000 amps</td>
</tr>
<tr>
<td>Flat Face Copper Clamp (See Figure #5)*</td>
<td>400 amps</td>
<td>25,000 amps</td>
</tr>
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* There is a set screw which is incorporated into the fixed jaw of the flat face copper clamp. Tests have shown that tightening this screw when applying temporary grounds can interfere with the overall surface contact.
NOTE: In any grounding system there may be weak links. Using the aforementioned example, the 1/0 extra flexible copper grounding cable could be considered the weak link as its fault current capacity is less than that of the clamp's. On the other hand, if using the same clamps with 4/0 extra flexible grounding cable, the clamps become the weaker link.

It is imperative to know the fault currents available at all work locations on your electrical system, and to select the appropriate temporary grounding system to cover each application.

Most approved grounding clamps are designed for...
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the attachment of ground clamp support studs. (See Figure #6) Using the support studs as intended helps to maintain control of the grounding leads during installation.

2. ADEQUATE CAPACITY CABLES
There are two major considerations in selecting the cables. The terminal should be such that there is a good mechanical and electrical connection between the clamp and cable. Low resistance is the key. It is provided through the use of machined ferrules which, when crimped properly, provide good electrical contact and mechanically strong connections. This ensures the cable will withstand the severe mechanical forces of short circuit current, and that the current will readily transfer from the clamps to the cables. (See Figure #7)

One manufacturer promotes a different type of compression ferrule for use with its type of clamp. It connects the cable strands with a threaded stud which screws into a tapped boss on the clamp. A
nut increases the contact pressure and further secures the assembly. This device is used in conjunction with a strain relief sleeve which reinforces the cable at this termination. (See Figure #8)

Generally, a temporary grounding system with 1/O grounding cables is adequate for distribution systems, while 4/O grounding cables are selected for transmission and substation applications.
The manufacturers' current rating capacity is based on new equipment used in ideal conditions. This is rarely the case in field applications.

Recognizing the extreme service a temporary grounding system would experience in an inadvertent energization situation, helps us to understand the need for regular maintenance and continuous inspections.

One cracked grounding clamp, corroded connection, frayed cable or loose connection could result in catastrophic failure at a critical instant.

3. TEMPORARY GROUNDING SYSTEMS

The trend in temporary grounding arrangements is to individual jumpers. This is due to varying configurations in construction, different applications, and the weight of a combined system. The jumper sets are comprised of four or five lengths of cable, depending upon the construction styles. An acceptable grounding system may be comprised of the following lengths of extra flexible copper grounding cable:

- two - 1.8 m (6 ft.) lengths
- one length of cable capable of connecting a grounding cluster bar to the nearest phase conductor
- one length of cable capable of connecting the grounding cluster bar to the system neutral

**NOTE:** In rural areas, a ground probe will be a component in the temporary grounding system. In this case, an additional length of cable will be necessary to connect the temporary ground probe and the system neutral (or in the case of a Delta connected system, a grounding cluster bar).
202 PREPARATION FOR TEMPORARY GROUNDING OF OVERHEAD LINES

1. It is fundamental that before considering any conductor or equipment as "dead" or de-energized, it must be properly grounded. Refer to the current Electrical Utility Safety Rules (EUSR) and the Utility Work Protection Code (UWPC) for specific rules pertaining to grounding.

2. PICK A GOOD LOCATION
   If at all possible, temporary grounding devices should be installed at the pole on which work is being performed. However, they should be placed well outside the immediate work area. The violent movement of the grounding cables under high fault current conditions could cause serious injury. To prevent accidental contact with live equipment such as transformers, switches, reclosers, etc., plan the location of temporary grounds carefully.

3. TESTING FOR POTENTIAL
   Perform an approved test for potential on the isolated circuit after receiving confirmation that isolation of the circuit has been completed. Isolation may or may not have been completed, or contact may have been made between the isolated circuit and another energized circuit in the area. Failure to perform an approved test for potential, could result in the worker attempting to install grounds on an energized circuit.

   NOTE: Teasing the isolated conductor with the metallic end of an approved live line tool, or the end of a ground jumper about to be installed is not an approved test for potential.
4. CLEANING THE CONDUCTOR AND EQUIPMENT

It is very important to clean the conductor using approved methods before installing temporary grounding equipment. The surfaces of conductors are normally contaminated or corroded. In some cases, equipment or metal structures are coated with paint. This high resistance surface contamination must be eliminated with an approved conductor cleaning wire brush or a filing process, to ensure positive contact with the surface of the grounding clamps. Consideration might also be given to the use of clamps with serrated jaws to penetrate the residual corrosion or paint following the cleaning attempt. Serrated jaws, however, should not be used on aluminum conductors unless a “split sleeve” or “stirrup” has been installed prior to applying the grounding clamp.

5. MINIMIZE CABLE SLACK

Shorter grounding cables offer lower resistance. During fault currents, tremendous forces result in unpredictable, severe and dangerous cable movement, if there is excessive slack in the grounding cable. Long leads should be lashed at some intermediate point to reduce the possible hazard to personnel, and prevent the dislocation of grounding connections, should a fault current develop.

203 INSTALLING TEMPORARY GROUNDS ON AN OVERHEAD STAR (WYE) CONNECTED CIRCUIT

Historically, the trend for temporary grounding has been to install grounding jumpers between the primary conductors and the system neutral; either on both sides of the worksite or between any source of energy and the worksite. The following installation illustrates this method.
1. In the following procedure, it is assumed that the necessary steps have been taken, as discussed in Section 202, Preparation for Temporary Grounding of Overhead Lines, and the work involves the temporary grounding of a three phase circuit of post-type construction. In this scenario, the worker will be working from an aerial bucket device. This is a live line tool procedure.

(a) If work is taking place in a rural area, a ground probe must be installed as deeply as possible into the ground. A suitable lead is connected to it and the system neutral.

(b) If there is live underbuild on the pole, it first would be protected with cover-up material of the appropriate rating.

(c) At this point, one of the short jumper cables of the set is connected to the system neutral. The clamp with the support stud is used for this purpose. (See Figure #9)

(d) Jumper from the system neutral to the nearest phase. (See Figure #10)

(e) Jumper that phase to the next nearest phase, using the proper clamp first. (See Figure #11)
(f) Follow the same procedure for the last phase. 
(See Figure #12)

By following this procedure, the worker guards against accidental contact with ungrounded conductors.

![Figure #11](image1.png) ![Figure #12](image2.png)

204 INSTALLING TEMPORARY GROUNDS ON AN OVERHEAD DELTA CONNECTED CIRCUIT

Temporary Personal Grounding
Most delta connected primary systems utilize a grounding bank for ground fault indication and relaying purposes. This constantly monitors the circuit and immediately detects any current flowing to ground. In the event of a relatively small amount of current flowing to ground, the circuit breaker should automatically trip. With no neutral in the area, the only option for temporary personal grounding is to utilize a ground probe. The ground probe should be approximately 9 m (30 ft.) from the base of the pole, whereby ground personnel can work in the clear and avoid possible ground gradients, which expose workers to step and touch potentials.
RATIONAL FOR PERSONAL GROUNDING USING THE GROUNDING CLUSTER BAR

For many years the electrical industry has used several methods of applying temporary grounds to protect its work force. The most widely used methods are:

WORKING GROUNDS – temporary grounding jumpers, connecting the three primary conductors and the system neutral, are installed between any source of energy and the work site.

BRACKET GROUNDS – working grounds installed on both sides of the work site are used where the line could be energized from either direction.

PERSONAL PROTECTIVE GROUNDS – in addition to the historical method of grounding; working grounds installed on one side of the work site, with a grounding cluster bar on the pole below the worker's feet and a jumper from the cluster bar to the system neutral.

Investigations by government and private organizations have shown that in most cases, personal protective grounding, using the grounding cluster bar during construction and maintenance of transmission lines, provides the most effective worker protection. The Institute of Electrical and Electronic Engineers (IEEE) Study No. 80-1986 summarized the following data:

- the human limit of electrical perception is one milliampere (ma)
- the so called "let go" current is 9 ma
- exposure to 100 ma for a duration of three seconds, could cause ventricular fibrillation of the heart (Longer duration or higher current flow could cause internal burning and lessen the likelihood of survival.)
Laboratory tests were conducted, using a 911 ohm carbon resistor to simulate a human, to learn the current flow over a worker during the re-energization of a 7.2 kV single phase circuit for 14 to 18 cycles. Available fault current ranged from 4,200 to 5,700 amps.

In the worst case scenario of the testing sequence, the resistance of the pole was jumpered out, simulating a freshly treated pole, wet pole or concrete pole. The voltage through the resistor, in the situation shown in Figure #13, was recorded at 1,745 volts (1.88 amps). In the situation shown in Figure #14, the readings were 19.5 volts (21 ma).

**Summary**
Identical electrical conditions were brought under control by applying a grounding cluster bar to create an equipotential work zone, as seen in Figure #14.

A worker working from a treated, damp or concrete pole without an equipotential work zone, and contacting a phase of a circuit that was grounded with the best grounding equipment available, would have experienced a potentially lethal electrical shock.

A worker performing the same work within an equipotential work zone, as depicted in Figure #14, would have experienced a mild electrical shock.
206 APPLICATIONS IN URBAN AREAS –
MULTI-GROUNDED SYSTEM NEUTRAL

In urban areas with Wye connected systems, only the multi-grounded system neutral should be used for temporary grounding procedures. Ground probes should not be used in urban areas for the following reasons:

(a) In some cases, it is not feasible to utilize ground probes. Most often the work location is on a paved or concrete surface.

(b) Prior to installing objects into the ground in any area, the locations of all underground services should be identified. Consequently, this would be too time consuming when involved with temporary grounding procedures, especially if the job calls for frequent movement of equipment.

(c) A ground probe could create a false sense of security. Low resistance to earth is not guaranteed for many reasons, including whether the soil is wet or dry, loose or hard-packed, sand or clay. With Wye connected systems, currents in excess of the current ratings of system protection devices, (e.g., reclosers, breakers, fuses, etc.), are required to trip the circuit. Should an accidental contact be made, the full available short circuit current may flow through the grounding system without tripping the circuit.

As current flows to the earth through the ground probe, a heating and drying out process swiftly raises ground resistance, thereby lowering any chance of enough current flowing to the earth to trip the circuit. Therefore, it is important that, prior to use, ground rods and temporary ground probes when required, are meggered to a resistance of 25 ohms or less.
(d) The use of a ground probe could result in ground gradients which would be dangerous to both the general public and workers. When applying temporary personal grounds, three phase jumpering provides a short circuiting effect and assists in short circuiting a re-energization from a three phase source. However, should this circuit become energized by induction, or from a single phase source, the most effective method of draining/controlling induction or tripping the offending electrical source is to provide a direct low resistance path to the system neutral.

NOTE: You can't drain off electric or electromagnetic induction, as it's always present – you can only control it by converting it from high voltage to current with the application of temporary grounds.

NOTE: In urban areas with delta connected systems and no system neutral available, the only option for temporary grounding is to utilize a ground probe. The ground probe should be approximately 9 m (30 ft.) from the base of the pole to avoid possible ground gradients. The probe should be meggered and a resistance of 25 ohms or less should be obtained. Prior to installing ground probes, identify the location of all underground services.

In conclusion, in urban areas with Wye connected systems, only the multi-grounded system neutral should be used for temporary grounding procedures. If good grounding practices are followed, the rapid isolation of equipment will be facilitated by providing a low resistance path (multi-ground system neutral) through which enough current can flow to operate the circuit overcurrent protection devices. (See Figure #14)
207 TEMPORARY PERSONAL GROUNDING APPLICATIONS IN RURAL AREAS – NON MULTI-GROUNDED SYSTEM NEUTRAL

Both the non multi-grounded system neutral and the ground probe should be used in the grounding system in rural areas. In rural areas, a ground probe should be properly installed before attempting any type of temporary grounding procedure. A resistance of 25 ohms or less should be obtained with the earth/ground probe contact. A suitable lead would then be connected to the ground probe and to the non multi-grounded system neutral. At this point, follow the same sequence as would be followed when applying temporary personal grounds on a Wye connected system. (See Figure #15)
The logic for utilizing the non multi-grounded system neutral in tandem with a ground probe in rural areas is:

(a) The non multi-grounded system neutral could conceivably carry voltage due to unbalanced loading conditions on the circuit involved, especially when combined with inadequate or deteriorated grounding points often found in rural areas.

(b) The conductor of the non multi-grounded system neutral could be burned off, broken, or sectionalized, preventing a return path to the system protection (e.g., line fuses, oil circuit reclosers).

(c) Induction from the phases can raise potential on the non multi-grounded system neutral above that of ground potential due to a lack of grounding points, and often coupled with deteriorated grounding apparatus or conditions. The ground connection from the ground probe to the system neutral should always be made using rubber gloves and a grip-all stick.

(d) The non multi-grounded system neutral is sometimes installed on a crossarm along with the energized primary phases. A mistake in identification, when installing the grounding lead, would create a hazardous situation. Positive identification should be made with the use of an approved potential indicator.

208 GROUND PROBES

1. An attempt should be made to install temporary ground probes in moist earth and as deep as possible to ensure the lowest resistance.

2. Guy wires should never be used as a means of grounding because of corrosion and non-electrical designed connection to the anchor rod. Available fault currents could completely burn off the guy wire.
allowing the structure to topple over, should an unexpected energization occur.

3. Anchor rods should not be used as a substitute for a driven ground rod, as corrosion could cause these to be in a seriously deteriorated state, even to the point of total isolation from earth.

4. Grounding to street signs, steel fence posts, etc., provides a false sense of security and could create dangerous ground gradients, should an unexpected energization occur, in addition to creating a hazard for workers and the public.

5. Individual transformer grounds or lightning arrester grounds are not heavy enough to carry all of the available fault current, and should, therefore, not be used for temporary grounding. Lack of current carrying capacity, and poor connections, could cause these ground wires to burn off at the point where the grounding clamp of the temporary grounding equipment is applied.

209 PREPARATION FOR TEMPORARY PERSONAL GROUNDING OF OVERHEAD LINES

1. TESTING FOR POTENTIAL
   Perform an approved test for potential on the isolated circuit after receiving confirmation that isolation of the circuit has been completed. Isolation may or may not have been completed, or contact may have been made between the isolated circuit and another energized circuit in the area. Failure to perform an approved test for potential, could result in the worker attempting to install grounds on an energized circuit.

   NOTE: Teasing the isolated conductor with the metallic end of an approved live line tool,
or the end of a grounding jumper about to be installed, is not an approved test for potential.

2. CLEANING THE CONDUCTOR AND EQUIPMENT
   It is very important to clean the conductor by approved methods before installing temporary grounding equipment. The surfaces of conductors are normally contaminated or corroded. In some cases, equipment or metal structures are coated with paint. This high resistance surface contamination must be eliminated with an approved conductor cleaning wire brush or a filing process, to ensure positive contact with the surface of the grounding clamps. Consideration might also be given to the use of clamps with serrated jaws to penetrate the residual corrosion or paint following the cleaning attempt. Serrated jaws, however, should not be used on aluminum conductors unless a “split sleeve” or “stirrup” has been installed prior to applying the grounding clamp.

3. MINIMIZE CABLE SLACK
   Shorter grounding cables offer lower resistance. During fault currents tremendous forces result in unpredictable, severe and dangerous cable movement, if there is excessive slack in the grounding cable. Long leads should be lashed at some intermediate point to reduce the possible hazard to personnel, and prevent the dislocation of grounding connections, should a fault current develop.

210 INSTALLING TEMPORARY PERSONAL GROUNDS ON OVERHEAD CIRCUITS

NOTE: In the following scenarios, potential tests should be taken to prove isolation before
beginning the bonding and grounding procedure.

In each of the scenarios presented, linemen working from a structure have created an equipotential work zone around themselves. The key device in this system is the grounding cluster bar which is always positioned lower on the structure than the worker’s feet. In some instances it may be above the system neutral and in other instances it may have to be positioned beneath the system neutral. The grounding cluster bar should not be placed more than 2.4 m (8 ft.) beneath the worker's feet.

The grounding cluster bar is a device securely fastened to the surface of a pole or structure. This is necessary because an electrical surge over the pole will remain predominantly on the outer surface. Therefore, it is paramount that the grounding cluster bar be as tight as practical against the outer surface of the pole, and completely around the pole's circumference.

1. **On a Multi-Grounded System**, position the cluster bar and secure it tightly to the structure, then install a bonding lead from the cluster bar to the system neutral to equalize potential. (Application Sequence #1 in Figure #16)

   The next step is to connect the grounding cable leading from the cluster bar to the nearest phase wire. (Application Sequence #2 in Figure #16) With these connections completed, the remaining phases can be grounded in the usual fashion. (Application Sequences #3 and #4 in Figure #16)

(b) **On a Non Multi-Grounded System**, a ground probe is driven deep into the earth approximately 9 m (30 ft.) from the structure and meggered. A cluster bar is positioned and secured tightly to the pole.
The next step is to connect the grounding cable leading from the ground probe to the cluster bar. (Application Sequence #1 in Figure #17) A bonding lead is then connected from the cluster bar to the system neutral. (Application Sequence #2 in Figure #17) This is done to ensure that any potential on...
the neutral has been reduced to a level as near to zero as practical. At this point, connect the grounding cable leading from the cluster bar to the nearest phase wire. (Application Sequence #3 in Figure #17)

**Application Sequence**
Install and megger ground probe; connect a long grounding lead to probe; install grounding cluster bar:
1. Install grounding lead from ground probe to cluster bar.
2. Install bonding lead from cluster bar to system neutral.
3. Install grounding lead from cluster bar to nearest phase.
4. Install grounding lead from nearest phase to second phase.
5. Install grounding lead from second phase to third phase.

**Figure #17**
With these connections completed, the remaining phases can be grounded in the usual fashion. (Application Sequences #4 and #5 in Figure #17)

3. **On a Delta Connected System**, a ground probe is driven deep into the earth approximately 9 m (30 ft.)

![Diagram](image)

**Application Sequence**
Install ground probe and connect long grounding lead to probe. Install grounding cluster bar:
1. Install grounding lead from ground probe to cluster bar.
2. Install grounding lead from cluster bar to nearest phase.
3. Install grounding lead from nearest phase to second phase.
4. Install grounding lead from second phase to third phase.

*Figure #18*
from the structure, and meggered.

The next step is to install the grounding cluster bar and connect the grounding cable from the ground probe to the cluster bar.

(Application Sequence #1 in Figure #18) At this point connect the ground-ing cable leading from the cluster bar to the nearest phase. (Application Sequence #2 in Figure #18) With these connections completed the remaining phases can be grounded in the usual fashion. (Application Sequences #3 and #4 in Figure #18)

4. **Pick a Good Location**

If at all possible, temporary grounding devices should be installed at the pole where work is being performed. However, they should be placed well outside the immediate work area. Serious injury could result from violent movement of the grounding cables under high fault current conditions. Likewise, to prevent accidental contact, exercise good judgement with regard to the use of tempo-
rary grounds on poles where there is energized equipment, such as transformers, switches, reclosers, etc.

At these locations the installation of a grounding cluster bar with the usual configuration to the primary phases will create the equipotential work area needed to protect the worker. However, in this case, the grounding system can be situated on an adjacent structure with the same effect, if the neutral and pole are bonded. (See Figure #19.)

211 PERSONAL GROUNDING FOR WORK FROM AN AERIAL DEVICE

A worker working from an insulated aerial device will encounter many tasks to be performed on de-energized overhead circuits. While positioned in an aerial device out of reach of other potentials, the worker is actually in an equipotential zone. However, workers are seldom in a position where other potentials aren’t within reach. Other potentials would be any structure, neutral, other phases, trees, etc.

For this reason (use the same principles as discussed in Section 210 using a grounding cluster bar), personal grounding affords the optimum protection against electrical shock in the event of re-energization. For example, a worker making simultaneous contact with a grounded conductor and the supporting structure would be in a position to receive a severe electrical shock if there were to be a re-energization, unless a grounding cluster bar had been used to create an equipotential work zone. (See Figure #20)
Figure #20
SECTION III
TEMPORARY GROUNDING OF VEHICLES

300 VEHICLE GROUNDS – GENERAL

301 VEHICLE GROUND EQUIPMENT

302 COMPLETE ISOLATION VERSUS TEMPORARY GROUNDING OF VEHICLES
SECTION III
TEMPORARY GROUNDING OF VEHICLES

300 VEHICLE GROUNDS – GENERAL

1. When used in proximity to energized overhead conductors, it is imperative that all radial boom derricks (RBDs), aerial bucket devices (with lower metal booms) and aerial devices that have lower boom inserts which are shunted and/or are being monitored for current leakage, be grounded to the system neutral of Wye connected systems in urban areas, and a combination of system neutral and ground probes in rural areas. Just as important is the fact that all workers and members of the general public must be kept clear of utility vehicles during these operations, with the exception of workers who may be operating the controls of a radial boom derrick.

No harm would come to an operator as long as he/she remains on the operator’s platform, in the operator’s seat, or on a ground gradient control mat bonded to the truck frame. The operator would be unharmed because he/she would be within the equipotential zone similar to that discussed in Section II.

2. Even though the vehicle ground has been connected to the multi-grounded system neutral, a worker or member of the general public standing on the ground, while in contact with the truck body, would create a parallel path to ground should the metallic portion of the boom make contact with overhead energized equipment. That person could be subjected to lethal currents. (See Figure #21)

3. If hold-off protection was in effect and the vehicle
was properly grounded to the multi-grounded system, the non multi-grounded system or a properly installed ground probe (Delta connected system), the vehicle would only become energized momentarily until the system protection activated. Once the offending circuit became isolated it would remain isolated, thereby returning the work area to a relatively safe condition. During the instant of energization, anyone touching the vehicle while in contact with another potential (another vehicle, earth, structure, etc.) could receive a lethal electrical shock.

4. Remember, even though a hold-off is in effect and a truck ground is used, the workers and general public should be kept clear of the vehicle when the boom is in proximity to energized overhead equipment. Work area protection should be used to separate the vehicle from the people on the ground. Barricading the vehicle is an option to keep personnel away.

5. In rural areas where a Wye connected system exists, the non multi-grounded neutral should be used the same as in urban areas where the neutral is classified as a multi-grounded neutral. In addition, a properly installed ground probe should be used to help ensure rapid isolation should an inadvertent energization or contact occur. The ground probe should be positioned approximately
6. Vehicles working in proximity to Delta connected circuits should be grounded using a ground probe driven deep into the earth. The ground probe should be positioned approximately 9 m (30 ft.) from the work area and connected to the grounding cluster bar.

7. If the grounded boom of an RBD or similar hoisting device enters an equipotential work zone, it should be at the same potential as the equipotential work zone. This is done by direct metallic electrical connection of the truck ground to the temporary personal grounding system (using the truck ground to connect directly to the grounding cluster bar). When more than one vehicle is used and a person could touch two vehicles at the same time, the vehicles should be bonded together.

8. The same concept applies whenever the structure is guyed. Guy wires entering an equipotential zone could defeat the safety of the zone by introducing
another potential. Guy wires must also be bonded to the grounding system.

**NOTE:** To not ground in this manner could cause a total breakdown of the equipotential work zone. (See Figure #22)

### 301 VEHICLE GROUND EQUIPMENT

1. All vehicle grounds should be comprised of at least 1/0 extra flexible copper cable, and be capable of being attached to the overhead system neutral using a grip-all stick. One end of the cable should have the appropriate current carrying capacity grounding clamp. The other end of the cable should be solidly and permanently connected to the vehicle frame using an appropriate compression lug fitting, attached via an appropriate current carrying clamp to a vehicle mounted parking stud, or via a reel type vehicle ground.

2. All components of the vehicle, such as the chassis utility box and boom assembly, should be bonded together.

3. Reel type vehicle grounds provide a good means of storing the cable when not in use, and ease of handling when required. This arrangement offers good conductivity when the moving contact (arbour) is inspected and cleaned on a regular basis. Conductivity is further established by welding the metal reel stand to the bin structure of the line vehicle. (See Figure #23) The reel...
stand frame to be bonded to the vehicle chassis. All conductors carrying current, produce an electromagnetic field (EMF). The field size and intensity are directly related to the voltage level and the amount of current flowing.

The configuration of the conductor is extremely important in its capability to carry current. The most efficient configuration is straight and the least efficient is coiled.

A great deal of effort goes into reducing resistance in grounding systems to the lowest levels practicable. This is accomplished by using appropriate ground clamps, heavy copper grounding cables, and maintaining clean, low resistance connections.

These efforts to achieve low resistance can be defeated by leaving grounding cable stored on the reel. When the ground cable is in use, the circular configuration causes inductance which impedes the flow of current. This dramatically impedes the flow of electrons. The more turns, the more impedance. This electrical principle is known as Lenz's Law.

All excess cable must be pulled off any grounding reel during use, in order for the resistance to remain as low as practicable. This will permit the grounding system to function at its greatest fault current capability. In turn, the offending re-energization will be interrupted in fewer cycles as circuit protection devices operate.

**NOTE:** The reel should be completely emptied to prevent any inductive reaction should current flow. Once all the cable is off the reel drum, check the connection for fraying and/or corrosion.
4. Another method for storing the grounding cable when it is not in use is to simply utilize hangers attached to the rear of the bin structure.

Some believe that the vehicle ground should always be at the rear of the vehicle, especially with RBD units, as a constant reminder to the operator to ground the vehicle when the boom is used in proximity to energized apparatus. (See Figure #24)

302 COMPLETE ISOLATION VERSUS TEMPORARY GROUNDING OF VEHICLES

1. This is in reference to line vehicles being used in urban areas, in proximity to energized overhead equipment, by non-electrical utility organizations such as line clearing firms and telecommunications companies.

Throughout this Guide it has been stated that ground probes for use with temporary grounds should not be used in urban areas, and are not as effective as using the system neutral. In addition, personnel from non-electrical utility organizations are not qualified and should not attempt to make connections to the system neutral. Therefore, line clearing aerial devices specifically, should be equipped with lower boom insulated inserts. If not
so equipped, the only approach would be to rope off or barricade the entire vehicle when the boom of the unit is used aloft in proximity to energized equipment. This would protect workers and the general public on the ground from any possible hazard created by a boom contact. Highly visible warning signs would be affixed to the barriers, barricades, etc. (See Figure #25)

2. The operator of an RBD vehicle standing on the operator’s platform, sitting in the operator’s seat, or standing on a ground gradient control mat bonded to the chassis, would not be harmed should a contact occur. This is due to the fact that the worker is within an equipotential zone.
SECTION IV
GROUND GRADIENT CONTROL MATS

400  GENERAL
401  STEP POTENTIAL
402  TOUCH POTENTIAL
403  DESCRIPTION OF A GROUND GRADIENT CONTROL MAT
404  OPERATION OF AIR BREAK SWITCHES
SECTION IV
GROUND GRADIENT CONTROL MATS

400 GENERAL
The ground gradient control mat is used to create an equipotential zone. It brings the surface of the earth, where workers are standing, to the same potential as the equipment on which work is being done. Should an accidental energization occur, or should there be an induced potential, the ground gradient control mat protects against step and touch potentials.

To accomplish its purpose, the ground gradient control mat must be correctly sized and positioned, so work can be performed without workers stepping off the mat. Ground gradient control mats are commonly used for stringing conductor or messenger wire, and for operating air break or load break switches.

401 STEP POTENTIAL
Step potential is defined as the potential difference between two points in a ground gradient area. A ground gradient area is produced where voltage enters the earth.

Due to the variation in the earth's resistance, a person walking or standing in an area where a ground gradient is produced could have a potential difference between their feet. Therefore, current would flow across that potential difference. (See Figure #26)

402 TOUCH POTENTIAL
Touch potential is defined as the potential difference between the point where a person is standing and a
point that person could normally reach. If a person touched a conductor, equipment, or a ground probe at the same time it was energized, that person would be subjected to touch potential due to being a parallel path through which the current can flow. (See Figure #26)

![Figure #26](image_url)

403 DESCRIPTION OF A GROUND GRADIENT CONTROL MAT

A common ground gradient control mat is a grid of metal (galvanized steel; or high flex copper braid strategically positioned on fabric) arranged in such a manner that, workers standing or walking on the mat will always be bridging the grid with their feet. To accomplish this, the steel mat typically consists of a minimum of No. 10 gauge (0.1350) galvanized steel wire, constructed in a 5 cm (2 in.) square mesh, 1.5 m by 6 m (5 ft. by 20 ft.), or as required (i.e. circumstances dictate the length and width of the mat).

The latter would be a typical size for a conductor or messenger stringing set up. In fact, most stringing operations require two or three such mats bonded together. Each mat has a bonding cable threaded
around its perimeter (1/0 copper). Typically, a portable ground gradient control mat for switching operations would be approximately 1.2 m x 1.5 m (4 ft. x 5 ft.), and have an attached bonding lead and clamp. (See Figure #27)

![Figure #27](image)

### 404 OPERATION OF AIR BREAK SWITCHES

A portable ground gradient control mat should be used to stand on while operating air break switches. In the event of mechanical failure or a flashover to the metallic frame of the switch, the operating rod, handle and the earth could become energized. The mat is normally found mounted in a weatherproof container at remote switch locations, or carried on a truck for use when required. The extra flexible copper lead, equipped with an approved type grounding clamp, is connected to either the switch operating rod close to the
handle, or to the flexible ground strap or cable attached to the operating rod.

To be sure that no potential difference can exist between hands and feet during the operation, follow this procedure:

(a) Place the mat in position on the earth
(b) Wear rubber gloves
(c) Stand on the mat and connect the mat lead to the operating rod or flexible ground strap
(d) Keeping both feet on the mat, perform switching operations wearing rubber gloves
(e) Visually check the blades of the air break switch to ensure proper operation, lock the handle, and tag as necessary
(f) Disconnect the extra flexible grounding lead
(g) Step off the mat and remove the rubber gloves
(h) Store the ground gradient control mat
SECTION V
TEMPORARY GROUNDING METHODS FOR
CONDUCTOR STRINGING OPERATIONS

500 GENERAL PRECAUTIONS
501 PROCEDURES FOR SETTING UP
FENCE BARRIERS
SECTION V
TEMPORARY GROUNDING METHODS FOR CONDUCTOR STRINGING OPERATIONS

500 GENERAL PRECAUTIONS
Considerable emphasis is placed on isolation techniques and grounding procedures when using large hydraulically-driven tension machines. However, there is a tendency not to take the same precautions when involved with routine stringing operations using small tension brakes or reel brakes, in conjunction with reel trailers – even though the stringing may be done in the area of energized equipment. The same precautions should apply to routine stringing operations near energized equipment as apply to major stringing jobs using large hydraulically-driven tension machines.

The grounding/bonding of tensioning machines, pulling machines, ground gradient mats, conductors, and travellers is to create an equipotential work zone. This is a very important component in providing a safe work zone for crew members and the general public. Every effort taken during preparation to eliminate a potential difference throughout the project will help prevent injury should something go wrong.

Sometimes, through equipment failure, loss of control, missed communication, oversights or misjudgements, the conductor being strung contacts something that is energized. Equipment may be damaged, power interrupted, and the project delayed. However, if this unplanned event causes no personal injuries the grounding/bonding has worked as designed.

All grounding/bonding connections should be regarded the same as making electrical connections. The lower the resistance and the more direct path to
the system protection (fuses, reclosers, etc.), the more rapid the interruption. Therefore, the preferred connections would always be to the system neutral, when available.

In locations where a system neutral is not available, a series of ground probes with 25 ohms or less resistance is the next best choice. In rural areas, a combination of ground probes and the non multi-grounded system neutral is necessary.

A ground gradient mat should be used for the placement of the tension machine.

**NOTE:** The mat should be large enough to carry out all work without stepping off the mat.

At the tension (pay out) end, work includes operating the machine, changing reels and splicing conductors. A space of 2.4 to 3 m (8 to 10 ft.) is necessary to splice conductors behind a tension machine, without stepping off the mat.

In most instances, two or three separate mats will need to be positioned to adequately encompass the equipment placed upon it. Each mat used should be bonded to a common bus to ensure an equipotential work zone is created.

Bonding cable of 1/0 bare, braided or stranded copper is threaded around the perimeter of the mat, then the mat and lead (bonding cable) are connected together with an appropriate connector, approximately every 0.9 m (3 ft.).

At an appropriate location, an extra flex lead, equipped with an approved type grounding clamp should be connected from the bonding lead to the system neutral. This lead should be a minimum of 1/0 extra flex copper, and should be treated as a possible energized conductor.
NOTE: Ground rods are required when working with delta connected circuits. At each corner of the mat, ground rods would be driven and connected to the bonding cable. Where practical, sufficient ground rods should be driven to obtain a megger reading of 25 ohms or less.

Grounding/Bonding During Stringing Operations
To achieve the goal of establishing a safe work environment, the following setup would be considered as necessary. (See Figure #28)

![Diagram of Conductor Travelling Ground](image)

**Figure #28**

At the Reel
This is the first of a series of grounds to be applied. Even though there are several types of tension machines in use, a standard method is used to ground the conductor on the tension stringing reels. On the large hydraulic tension machines, a bonding
lead is connected from the tail of the conductor (projecting through the reel) to the ground lug provided on the drive arm of the tensioner. Internally, on the drive shaft, a collector ring provides an electrical path, through a set of brushes and extra flex copper, to an external ground lug on the tensioner.

**NOTE:** This is the only opportunity to ground covered conductor during the stringing procedure.

**Ahead of the Reel (Travelling Ground)**
This is the second opportunity to ground the conductor. It maintains a high integrity connection to system protection throughout the entire run. To help ensure this:

a) the full capacity leads and clamps should be thoroughly inspected and adequately tightened;
b) the entire circumference of the wire is involved;
c) the mechanism is spring loaded to accommodate all irregularities in the conductor.

This ground will ensure continuity with the equipotential zone around the tensioner. It will also ensure the conductor is grounded as it passes up through any underbuilt circuits. It is also moveable and remains on the conductor tail as the conductor is cut and lowered down through any underbuilt circuits.

The travelling ground is connected to the tension machine using a 1/0 extra flex copper lead attached to a common grounding point. (See Figure #29)

The ground gradient mat(s) are also connected to the common grounding point. Another 1/0 lead is connected to either the system neutral or to ground probes, as discussed earlier.

**First and Last Traveller**
This is the third and last point in the run to ground the conductor. The conductor’s angle of deflection at these travellers allows for greater surface contact between
the conductor and grounded travellers.
Pressure and increased contact area between these travellers and the conductor is desirable to provide a good path to ground. These may be the only travellers in the run that are able to be grounded.
When the conductor is cut after dead-ending, the grounded traveller continues to provide some contact with ground.

**NOTE:** Travellers with protective coatings on the sheaves are not designed to be grounded.

**General Rule: Fifth Traveller Grounding**
This grounding will provide additional paths to ground throughout the run.

In circumstances where induction could be present, these multiple grounds will help ensure continual draining of induced voltage. Should an inadvertent contact occur, these grounds will help isolate the offending circuit more rapidly. This is also the rationale for grounding both sides of traversing energized circuits.

All workers should understand when grounding any apparatus they are making electrical connections. The same care is to be taken as if the device was being connected to an energized medium to carry current.
The fault current during a short circuit could rise to tens of thousands of amps. Any underrated, loose, or corroded connections will fail, some with catastrophic results.

The more paths to ground the better. The better the connections, the more rapid the protection system will operate; thereby providing a safer work environment. (See Figure #30)

When full puller/tensioner machines are not used, other types of tension devices are used, as shown in Figure #31. Regardless of the type of tensioning or pulling device used, the grounding procedure should be adequate to protect the workers and the general
public. Equipotential work zones are always the objective when grounding systems are being installed.

501 PROCEDURES FOR SETTING UP FENCE BARRIERS

1. Nonconductive barriers should be installed around the perimeter of the ground mat, to prevent personnel from straying on and off the mat except at a controlled location. This controlled location is a 0.9 m (3 ft.) opening for entry/exit. The barrier system will also remind personnel that they should not hand tools into and out of the zone when stringing is in progress.

2. Approximately 0.9 to 1.2 m (3 to 4 ft.) outside this barrier, another barrier (rope, tape, barricades, etc.) should be installed around the enclosure. “Danger Live Apparatus” signs should be hung on this barrier.

3. At the entry/exit point, a piece of plywood 0.9 m by 1.8 m by 1.3 cm (3 ft. by 6 ft. by ½ in.), covered by a nonconductive rubber or plastic mat, should be placed so that one end is on the ground mat and the other is clear of the barrier around the enclosure. This is to protect personnel from step potentials when entering or leaving the enclosure. No personnel may enter or leave the enclosure when stringing is in progress. (See Figure #32)
Setting up ground gradient mat area for stringing

*Figure #32*
SECTION VI
TEMPORARY GROUNDING OF UNDERGROUND EQUIPMENT

600 GENERAL PRECAUTIONS

601 TEMPORARY GROUNDING SYSTEM FOR UNDERGROUND APPLICATIONS

602 CONSIDERATIONS PRIOR TO UNDERTAKING WORK

603 PROCEDURE FOR DE-ENERGIZING AN UNDERGROUND CABLE AT AN ELBOW CONNECTED PADMOUNT TRANSFORMER

604 PROCEDURE FOR DE-ENERGIZING AN UNDERGROUND CABLE AT ARC STRANGLER SWITCHGEAR (NX)
SECTION VI
TEMPORARY GROUNDING OF
UNDERGROUND EQUIPMENT

600 GENERAL PRECAUTIONS
To be considered de-energized and safe to work on (for underground equipment), it must first be positively identified, checked as being isolated, then grounded and tagged. Through good engineering and design of these installations, and utilization of proper procedures, tools and equipment, underground plant can be de-energized in the true sense and work can be performed safely.

601 TEMPORARY GROUNDING SYSTEM
FOR UNDERGROUND APPLICATIONS
There is quite a variety of grounding applications, due to the many types of underground equipment and installations.

Most manufacturers or suppliers of underground equipment can identify the specific type of grounding components required for their particular design.

In some cases, equipment, similar to that used for overhead applications, will work fine on underground installations. In other cases, unique equipment is required for specific designs.

All else considered, the ground sets, by whatever design or application, should meet the ground fault current capacities of your system.

602 CONSIDERATIONS PRIOR TO UNDERTAKING WORK
Just as in temporary grounding of overhead equip-
ment, other good safe work practices must accompany temporary grounding procedures of underground equipment. If applicable to the job at hand, consideration must be given to the following:

- Remove obstacles, snow, etc. and be aware of children and pets prior to opening vaults or doors of enclosures having energized apparatus.
- Do not lay tools and equipment on top of padmount enclosures.
- Always follow the IHSA lock to lock rubber glove rule.
- If a door is part of the underground installation or enclosure, make sure that it will not close accidentally while work is in progress.
- Verify switchgear and cable nomenclature with operating diagrams in accordance with the Application for Work Protection and Switching Operations Forms (UWPC).
- Arrange hold-off protection in accordance with your standard operating procedures.
- Always wear the appropriate personal protective equipment including clothing, head protection, and eye protection.

603 PROCEDURES FOR DE-ENERGIZING AN UNDERGROUND CABLE AT AN ELBOW CONNECTED PADMOUNT TRANSFORMER

In general, the same principles and procedures discussed under this heading, apply to isolating and de-energizing an underground cable at a three-way junction point in an underground vault.

In the following procedures, the necessary steps as outlined in Section 602, will apply and special empha-
sis will be placed on the fact that it is a live line tool operation. The cables involved are terminated with loadbreak elbows, which are quite easy to distinguish by their bell shape. (See Figure #33)

(a) Verify nomenclature of the cable, switchgear, or transformer location with the operating diagram, in conjunction with the Switching Operations Order.

(b) Check the installation for loose wall brackets or parking stands, obvious heating of the elbow semi-conductive exterior or junctions, and for any other components that might fail during operation.

(c) Install a feed-through device on the attached parking stand. It should be cleaned and lubricated prior to installation. (See Figure #34)

NOTE: Use a grip-all live line tool during all operations.

(d) Remove the loadbreak elbow of the cable in question and install it on one of the bushings of the feed-through device.

(e) Install a dead-end receptacle on the vacant ener-
gized bushing of the padmount transformer. (See Figure #35)

(f) Using an approved test point indicator or full potential indicator, verify isolation of the cable in question.

(g) Prepare to install the grounding elbow. (See Figure #36) A proper grounding clamp secured to the other end of this device is installed to the system neutral at the padmount transformer location. The grounding elbow is then installed on the vacant bushing of the feed-through device. (See Figure #37)

(h) Tag the de-energized apparatus as per your Switching Operations Form.
The cable in question at this point is de-energized. If the situation was such that it was a loop system utilizing padmount transformers, the opposite end of the cable would have been previously isolated.

NOTE: Under no circumstances should a non-loadbreak elbow or dead-end receptacle be removed from an energized bushing plug insert at a transformer installation, switching installation, stand-off plug, feed-through device or junction point. Minimal clearances and ionization of air will result in a flashover between the pin contact and conductive shield of the elbow, or between the semi-conductive body of the bushing plug insert and the socket contact. (See Figure #38)

![Figure #38](image)

A cable spiking tool shall be used, as the last step, to guard against the possibility of cutting into mis-identified cable. Approved safe work practices and the recommended manufacturer procedures should be used when using these spiking tools.
604 PROCEDURE FOR DE-ENERGIZING AN UNDERGROUND CABLE AT ARC STRANGLER SWITCHGEAR (NX)

The necessary steps outlined in Section 602, Considerations Prior to Undertaking Work, should be followed prior to beginning the operation. The procedure is as follows:

(a) Verify switchgear and cable nomenclature with operating diagrams.

(b) Using an approved live line tool, open the designated switching apparatus under the direction of the work protection holder, entering times as operations are completed.

Do not use a grip-all stick to operate the switchgear, as damage will result to the pulling eye. Use an approved live line tool like the one shown in Figure #39.

(c) Using the same approved live line tool, remove the arc strangler (NX) assembly. (See Figure #40)

(d) Use an approved full potential indicating device to test for potential at the lower hinge assembly.

(e) When isolation has been established, an approved temporary ground clamp (NX), first attached to a low resistance ground, may then be installed with a grip-all stick to the lower hinge
Figure #40

assembly of the switchgear. The cable at this location is now de-energized. (See Figure #41)

(f) Tag the apparatus as per the Work Protection Code requirements.

Figure #41
SECTION VII
TEMPORARY GROUNDING
WITHIN SUBSTATIONS

700 GENERAL PRECAUTIONS

701 SUITABLE TEMPORARY GROUNDING
SYSTEMS FOR SUBSTATION
APPLICATIONS

702 TEMPORARY GROUNDING
PROCEDURES FOR SUBSTATIONS
SECTION VII
TEMPORARY GROUNDING
WITHIN SUBSTATIONS

700 GENERAL PRECAUTIONS
Improved design of modern substations, along with more advanced technology and equipment, has helped to eliminate many of the inherent hazards which were sometimes found in older substations.

However, the importance of proper grounding procedures cannot be over emphasized, regardless of the type of substation.

Of equal concern is the available fault current at the substation, and the ability of temporary grounding systems to provide necessary protection for workers.

701 SUITABLE TEMPORARY GROUNDING SYSTEMS FOR SUBSTATION APPLICATIONS
In most cases, the selection of adequate temporary grounding systems would be on the advice of a reputable manufacturer. The electromechanical specifications of certain grounding equipment should be researched and verified so that it will meet the requirements of its intended use.

To some extent, the jumper-type grounding systems referred to in Section II would apply. Consideration should be given to the size of the conductor or bus work, and whether it is tubular or flat. (A popular clamp used in substation applications is shown in Figure #42)

It can swivel so that it can be connected readily in difficult areas such as vertical bus work, or on a conductor at the end of a string of dead-end insulators.
Another feature of this clamp is its interchangeable jaws, which can be adapted for either flat or tubular bus work.

During the construction of modern substations, permanent stirrup arrangements are often installed on the large size tubular bus. Grounding clamps large enough to adapt to this bus would not be practical and, as a result, the stirrups allow for the use of regular size grounding clamps. (See Figure #43)
Support studs are sometimes permanently installed on large size tubular bus work. Grounding sets, comprised of two cables per phase, with specialized clamps, are attached to these studs when temporary grounding is required.

As previously mentioned, 1/0 copper extra flex cable should be the minimum size for temporary grounding sets. In many cases, the requirements for substation applications could be, for example, 4/0 cable or equivalent parallel cables.

### 702 TEMPORARY GROUNDING PROCEDURES FOR SUBSTATIONS

Basically, the same temporary grounding techniques apply to substation situations as those discussed in the grounding of overhead lines. However, due to the high fault current available at substations, heavier duty equipment may be required. Depending on the weight of the cable involved, consideration may have to be given to the use of special tools and techniques for hoisting the temporary grounding equipment into place. (See Figure #44)

The same considerations as previously mentioned in this Guide are equally important in substation applications. These include picking the proper location for temporary grounding, proper testing for...
potential prior to applying grounds, cleaning the conductor, and minimizing cable slack.

In substations, where numerous sets of temporary grounds could be applied at any given time, grounding devices should be identified to ensure all grounds have been removed before service is restored.

Refer to the current EUSR for "Work on Isolated Circuits" and "Use of Temporary Grounds."
SECTION VIII
CONCLUSION

800  DANGEROUS MISCONCEPTIONS
801  CONCLUSIONS
SECTION VIII
CONCLUSION

800  DANGEROUS MISCONCEPTIONS
Do not be misled by some of these common beliefs:
1. Electricity only takes the path of least resistance to ground.
2. If vehicles and equipment are grounded, they are safe to touch in any circumstance.
3. Grounds placed between a worker and all tagged open points guaranteeing isolation, act as barricades or insulators, blocking any voltage rise or current flow at the worker's location.
4. Working near a ground rod connected to a set of grounds does not present any particular hazard.
5. Inductive voltages build up over time, therefore, grounds can sometimes be removed by hand.
6. If you are standing on a wood pole, you are safe since wood poles are nonconductive.
7. Induction is eliminated once grounds are applied.

801  CONCLUSIONS
1. Induction is an ever present danger to utility personnel and the public, and can result in serious injury or even a fatality.
2. Any vehicle, piece of equipment, or ground probe, connected to an isolated line, can subject the body to severe step and touch potentials under given conditions.
3. Induction on isolated equipment cannot be eliminated, but it can be controlled.
4. Phase to neutral voltage increases as you move away from a temporary grounding site.

5. Creating an equipotential work zone greatly decreases the potential for hazardous current flow through the body.

6. An equipotential work zone can only be established through the combined efforts of grounding and bonding.
Available Safe Practice Guides

- Bare Hand Live Line Techniques
- Conductor Stringing
- Entry and Work in a Confined Space
- Excavating with Hydrovacs in the Vicinity of Underground Electrical Plant
- High Voltage Rubber Techniques up to 36 kV
- Hydraulics
- Ladder Safety
- Line Clearing Operations
- Live Line Tool Techniques
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