Explain Reasons for Temporary Bonding and Grounding
Notes:

**PREREQUISITES**

- Basic knowledge and understanding of basic electricity
- Explain Bonding and Grounding module

**Objectives:** The participant will be able to explain when and why temporary bonding and grounding is required in an electrical system.

**Rationale:** The workers must understand the dangers of an electrical system and when temporary bonding and grounding can be used to protect themselves from these dangers.

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**STUDENT RESOURCES**

- Training Manual

**INTRODUCTION**

This module identifies when and why temporary bonding and grounding are used. The following items are discussed:

- Dangers of "accidentally" energizing apparatus
- Dangers of lightning and static charge build-up
- The concept of placing grounds for confirmation of isolation is discussed
- Finally, the concepts of induced voltages and currents, and methods to protect the worker from these electrical phenomena are introduced
Lesson 1: Reasons for Temporary Bonding and Grounding

Learning Objective: Identify reasons to use temporary bonding and grounding

Learning Method: Self-learning or Instructor Led

Evaluation Method: Final Test

INTRODUCTION

When working on electrical apparatus operating in excess of 250V (AC) phase-to-ground, 300V (AC) phase-to-phase, or 300V (DC), that apparatus must be treated as alive until it is de-energized.

For energized apparatus, the worker must use personal protective equipment. To de-energize apparatus, temporary bonding and grounding are required.

Temporary bonding and grounding applied correctly to isolated apparatus will provide a low resistance path that:

• Acts as a tripping ground
• Is parallel to the worker's body, therefore, limiting the current flow through the worker

It provides protection from many types of electrical hazards.

Accidental Energizing

There are three ways in which apparatus may become "accidentally" energized:

• Switching error
• Conductor contact
• Backfeed

Switching Error

Workers will make certain that the system is isolated or de-energized before beginning their work. Through misunderstanding, switches may be closed and an isolated or de-energized system may be energized.
Conductor Contact

Accidents on adjacent systems, at crossover points, or on rebuilds involving over-stringing, could result in energized lines coming in contact with the isolated or de-energized system.
Backfeed

Many customers depend on a power supply to the point that they have employed backup systems or standby generators to ensure that electrical interruptions are kept to a minimum.

If a customer connects an external power source without the proper switch gear to their system during an outage, this voltage source could possibly "backfeed" through SaskPower's transformation and enter our isolated system at the "stepped-up" voltage (14.4kV).
A storm on some other portion of the system could result in lightning striking the isolated system. This would render the work location extremely unsafe in the instance that it is not properly "bonded and grounded."

**Lightning**

*Figure 3. Dangerous Backfeed*
7 Explain Reasons for Temporary Bonding and Grounding

Notes:

![Diagram of Lightning Hazard]

**Figure 4. Lightning Hazard**

**DANGER**

The dangers of lightning are obvious and no contact will be made with conductors if lightning is in the area.

If there is any concern or indication that lightning may develop, then equipotential bonding and grounding must be used for all pole work involving conductor contact.

**Static Charge Build-Up**

Static charge build-up can occur on isolated metallic objects due to wind driven dust or snow. Dangerously high voltages can occur on isolated power lines.
Static charge build-up can also occur from the movement of fluids through insulated hoses. For example, circulating and pumping of transformer oil, by the de-gasifier (filter and pumping system), from the transformer to a storage tank. An electrical charge can build up on the de-gasifier and storage tank. This charge can be very dangerous. Proper grounding and bonding of all equipment used for this activity prevents any build up of unwanted voltages.

### Induced Voltages and Currents

The problem of induction is a concern of personnel for construction, operating, and maintenance. This is due to the effect of high levels of induced voltage and current on isolated and de-energized electrical circuits running in parallel with, and/or at close spacing to, other energized high-voltage power lines.

The two phenomena that cause induced voltages are:

- Electric field induction (capacitive coupling)
- Electromagnetic induction (magnetic coupling)

#### Electric Field Induction

When an isolated line is near an energized line, the isolated line will assume a potential. This effect is caused due to the fact that any insulated object in the proximity of live equipment has two capacities associated with it:

- Object to line
Notes:

- Object to ground

*Figure 6. Electric Field Induced Voltage*
Notes: It does not matter where the object is in the electric field. It will always assume a voltage which is proportional to its location in the field as long as it is insulated from the ground.

The value of this induced voltage depends upon two factors:

- Voltage of the energized line
- Distance between the insulated object and the energized line

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**NOTE**

Remember that a capacitor is simply two plates or conductors separated by insulation; therefore, increasing the size of the object or increasing the conductor's length, in effect, increases the size of the plates. Increasing the size of the plates allows more charge to build up.

When an isolated line is grounded at one location, two events occur:

- The magnitude of the electric field induced voltage drops
- The discharge current that flows is not usually regarded as being great. However, it can still be lethal near long parallel lines or even extremely large objects
A common example of electric field induced voltage is the build-up of charge on a worker's body near an energized line. This "charge" is often felt as a "bite" when the worker comes in contact with a grounded object. This effect is not dangerous as the resulting current flow is minimal due to the capacitance being so small.
Electromagnetic Induction

When an isolated line is near an energized current carrying line, the isolated line will assume a potential. The live conductor and the nearby isolated conductor are viewed as the primary and secondary windings of a transformer.

Figure 8. Biting Effect

CAUTION

Remember, the "bite" increases as one gets closer to the energized apparatus due to the increase in capacitance.
If the isolated conductor becomes grounded at one point only, an open circuit secondary voltage to earth will appear on the line. The voltage will be near zero at the location of the temporary ground. Voltage at other locations on the line will depend on the total length of the parallel configuration and distance from the temporary ground location.

If the isolated conductor becomes grounded at two points, the secondary winding will be short-circuited through the earth and current will flow. This is commonly referred to as circulating currents or circulating ground currents.
The three requirements to induce an AC current are:

- A closed circuit
- A magnetic field
- Relative motion (expanding and collapsing of the alternating magnetic field) between the magnetic field and a closed circuit

The two factors that affect the magnitude of the induced current on a de-energized line which is in parallel with an energized line are:

- Proximity of the two lines

Figure 10. Circulating Currents
Explain Reasons for Temporary Bonding and Grounding

Notes:

- Magnitude of the current on the energized line

**DANGER**

Induced voltages and current from parallel power lines must be a constant consideration!

Even though a system may have been de-energized (isolated and grounded), there is an electromagnetic induction from any parallel systems that are in the energized state. It makes no difference whether these energized systems are on the same structure or on separate, adjacent structures, which are running parallel to the isolated system.

**NOTE**

The current will be proportional to current flow in the live line. For closely spaced circuits, the induced current may be up to 11 percent of current in the live line, regardless of whether it is load current or fault current on the live line.

If the Powerline Technician were to touch the line, two smaller circuits would be created with the circulating currents flowing through the Powerline Technician and the pole in opposite directions. Although these currents have a canceling effect, they can still be fatal. The following diagram illustrates this.

*Figure 11. Powerline Technician Creating Multiple Circuits for Circulating Current Flow*
Notes:

If a worker was to open the circuit and then put themselves between the open ends, he would be "in series" with the circuit. **The circulating current would then use the worker's body as a current carrying device. This type of situation could result in a fatality,** as illustrated below.

![Diagram of Lineman in Series with Circuit](image)

**Figure 12. Powerline Technician in Series With Circuit**

To avoid becoming in series with an open circuit, a bond must be placed across all parts of a circuit that will be required to be opened. However, if the Powerline Technician was to touch the line, he will still create two smaller circuits with the circulating current flowing through the lineman and the pole in opposite directions. **Although these currents have a canceling effect, they can still be fatal.**
The following diagram will illustrate how Powerline Technicians commonly ground to provide what was thought to be reasonable safe work practices during tasks that involve rapid movement from structure to structure. This is still not a safe or acceptable practice.
Electromagnetic induced voltages can reach values of 0.1 volts per amp per mile of primary line. For example, a 100 mile single-phase line carrying 300 amps could produce 3000V (measured end to end) on an isolated single-phase line running parallel to it.

It would appear that the solution to rectifying the potentially hazardous situation is to simply break the circuit into smaller loops. When extra grounds are added to the de-energized line, the current divides into a series of smaller loops and smaller currents. These currents and voltages can still be fatal; therefore additional bonding and grounding is required.
SUMMARY

What Have I Learned?

To summarize this module, you have learned:

- The dangers of accidentally energized conductors (switching errors, conductor contacts and backfeed)
- The dangers of lightning
- The dangers of static charge build-up
- The dangers of electric field and electromagnetic induction
- And that the practice of temporary bonding and grounding can be used to protect the worker against these hazards and for the confirmation of isolation

DIRECTIONS

Now
- Complete the self-test
- Clarify any questions or concerns you may have
- Complete the final test

PRACTICE FEEDBACK

How Do I Practice?

1. Review the lessons, ask any questions, and complete the self-test.

EVALUATION

How Am I Evaluated?

When you are ready, complete the final test. You are expected to achieve 100%.
Notes:

**REVIEW QUESTIONS**

T / F  1. Temporary bonding and grounding is used to protect from accidental energizing, lightning, and to confirm isolation.

T / F  2. Wind or blowing snow has no effect on an isolated conductor.

3. A line or apparatus can be accidentally energized by:
   (a) A switching error
   (b) Conductor contact
   (c) Backfeed
   (d) All of these

T / F  4. Electric field induction will cause a Powerline Technician to feel a bite when touching grounded hardware on a pole.

T / F  5. Induced current will flow in an isolated conductor when the conductor is grounded at two points.

T / F  6. A worker standing on an insulated ladder close to energized conductors in a station will have a different charge than a grounded steel structure.

7. The requirements for electromagnetic induction are:
   (a) A magnetic field
   (b) A conductor in a closed circuit
   (c) Relative motion between the two
   (d) All of these

8. Electrical apparatus must be treated as alive or apply bonding and grounding when working with voltage in excess of:
   (a) 250V phase-to-ground
   (b) 300V phase-to-phase
   (c) 300V (DC)
   (d) All of these

T / F  9. No contact will be made with conductors if lightning is in the area.

10. The factor(s) that effect the magnitude of the induced current on a de-energized line which is in parallel with an energized line are:
    (a) Proximity of the two lines
    (b) Magnitude of the current on the energized line
    (c) All of these
T / F 11. If an isolated line is paralleling an existing energized line and it is grounded at two points, no current will flow in the grounding system.
REVIEW QUESTION SOLUTIONS

1. T
2. F
3. All of these
4. T
5. T
6. T
7. All of these
8. All of these
9. T
10. All of these
11. F
Figure 5. Static Charge Build-Up
Figure 11. Powerline Technician Creating Multiple Circuits for Circulating Current Flow