

Electrical Equipment - Course 230.2

SWITCHGEAR: PART 5

DISCONNECT SWITCHES, GROUND SWITCHES AND GTD's

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1. OBJECTIVE

The student must be able to:

1. State:

- (a) the two purposes of disconnect switches.
- (b) why a disconnect switch cannot be used to make or break load or fault currents.
- (c) the operating sequences between breakers and disconnect switches.
- (d) the consequences of using the incorrect sequences.

2. State:

- (a) the purpose of ground switches and grounding test devices (GTD's).
- (b) when ground switches and GTD's are used.

3. State:

- (a) the correct operating sequences for breakers, disconnect, ground switches and GTD's associated with the following:
  - (i) motors,
  - (ii) generators,
  - (iii) transformers,
  - (iv) transmission lines.
- (b) the consequence of using the incorrect sequences.

## 2. LESS CONTENT

This lesson is split into three sections:

- (a) Disconnect Switches.
- (b) Ground Switches and Ground Test Devices.
- (c) Operating Sequences.

## 3. DISCONNECT SWITCHES

### 3.1 Introduction

When isolating circuits controlled by air breakers or vacuum contactors, the complete chassis (truck) must be racked out from its IN-SERVICE position to the isolated (disengaged) position. The shutters are then locked in their closed position.

Because of their size, oil and air blast circuit breakers cannot be racked. To provide isolation, disconnect switches are connected either side of each breaker. In most instances one of the disconnect switches is motorized, the other being manually operated. Figure 1 shows the electrical symbol for a high voltage (above 15 kV) breaker and its two associated disconnect switches.

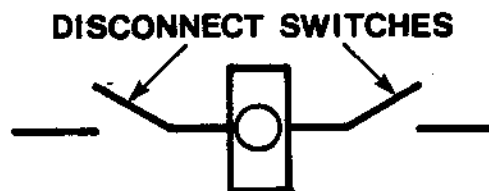


Figure 1: Main Power Circuit Breaker (Above 15 kV).

### 3.2 Principle of Operation and Construction Details

Because of their design, disconnect switches are not capable of making or breaking load or fault currents. A circuit breaker must be used for this purpose. The essential difference between a disconnect switch and a circuit breaker is that a circuit breaker has means for interrupting an arc but a disconnect switch does not have this feature.

Figure 2 shows an example of an HV disconnect switch. When the opening (or closing) mechanism is operated, a connecting link turns the torque insulator on each of the three phases. Rotation of the torque insulators moves the operating rods, arms and the moving contacts.

- To close the disconnect switch, the moving contacts are lowered and engaged with the fixed contacts.
- To open the disconnect switch, the moving contacts are raised disengaged from the fixed contacts.
- There is no device for extinguishing any arc which would develop if load (or fault) current was broken.

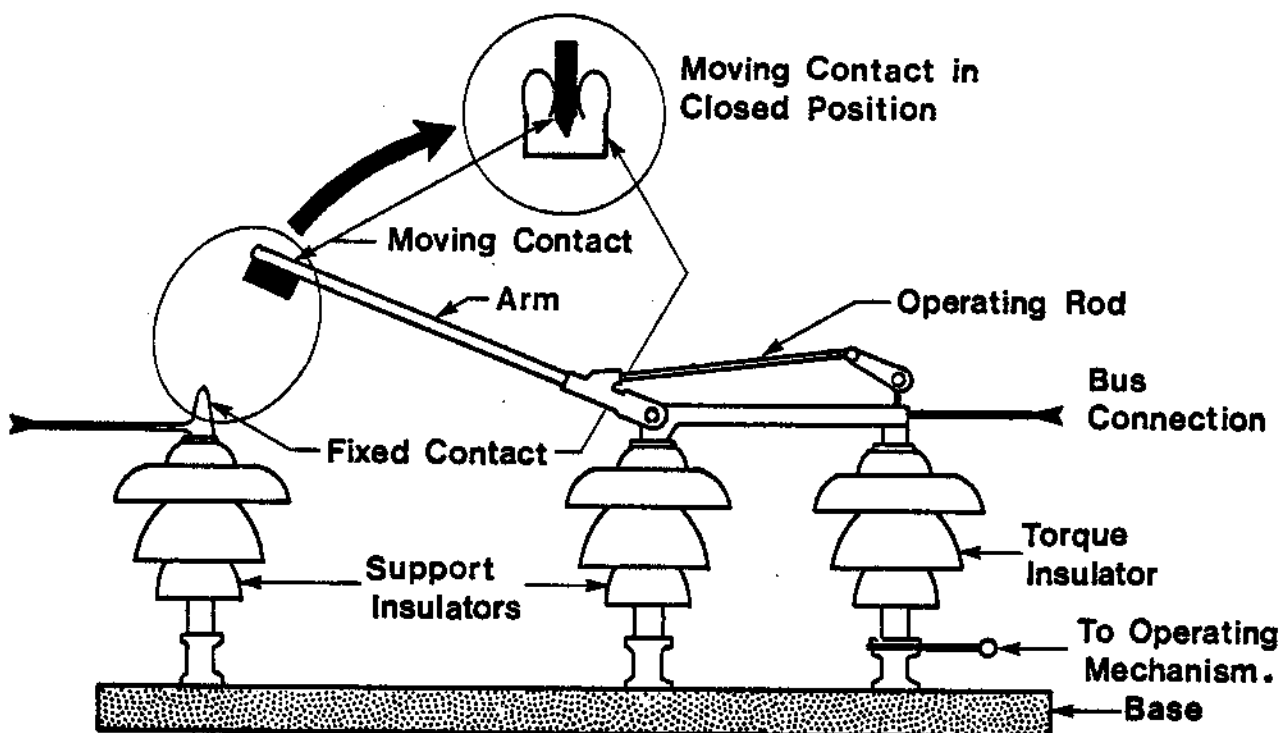


Figure 2: High Voltage Disconnect Switch.

After a disconnect switch has been opened and all three phases have been visibly checked to be open, the disconnect switch is locked in the open position. In addition, the power supply to the drive motor is isolated. This disconnect switch is now a guaranteed point of isolation and when required, is quoted on work permits.

### 3.3 Isolation

Before proceeding further the student must clearly understand:

#### Circuit Breakers

- (a) are used for control purposes, ie for making load currents and for interrupting load and fault currents.
- (b) must not be used for circuit isolation purposes. This is because:
  - (i) a breaker can be opened or closed at any time manually or by its control system.
  - (ii) the open contacts are not visible and cannot be used as a guaranteed point of isolation.

#### Disconnect Switches

- (a)
  - (i) are not capable of making load currents,
  - (ii) are not capable of interrupting load and fault currents.
- (b)
  - (i) are used for isolation purposes.
  - (ii) are quoted on work permits as a guaranteed point of isolation.

### 3.4 Disconnect Switches: Problems

Because disconnect switches are simple devices they are often taken for granted. It is important that the alignment between all three contacts is kept exact. If the alignment is not exact, one or more contacts may not close (or open) fully. Therefore, after each closing (or opening) operation, a visible check must be done to ensure that all three arms and their associated contacts are in their correct position. Failure to do this visible check can result in severe arcing (if the contacts are not closed fully) or a flashover (if they have not opened fully). There have been instances where, due to linkage failure, the contact on one phase has not closed or opened. Clearly, if not spotted in time, this can lead to a very dangerous situation.

#### 4. GROUNDING SWITCHES AND GROUNDING TEST DEVICES

##### 4.1 Grounding Switches

4.1.1 Introduction. Grounding switches are provided to ensure high voltage conductors are at ground potential. Figure 3 shows the symbol for a three phase ground switch.

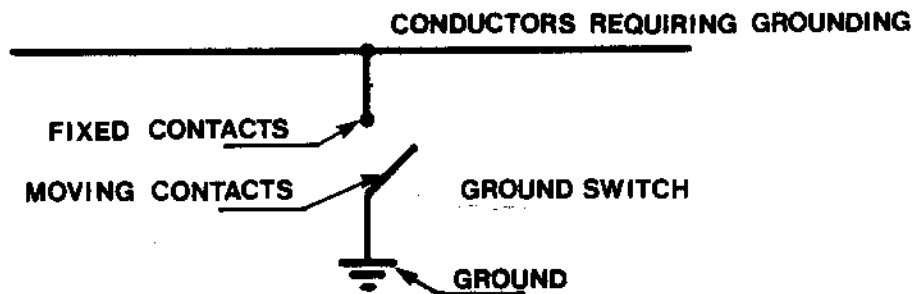


Figure 3: Ground Switch: Symbol.

The fixed contacts of a three phase ground switch are connected directly to the conductors requiring grounding. The moving contacts are connected directly to the grounding system.

The contact arrangement is similar to that used with disconnect switches, ie, there is no provision for interrupting an arc.

4.1.2 Procedure for Use. Because grounding switches have no current making or interrupting capability, they can only be operated after the circuit:

- (a) has been de-energized by opening relevant breakers and eliminating all infeeds.
- (b) has been isolated by opening disconnect switches and racking out breakers.

The grounding switch can now be safely closed.

## 4.2 Ground Test Devices

4.2.1 Introduction. Ground Test Devices (GTD's) are provided to ensure grounding of 13.8 kV, 4160 V and 2400 V metalclad busbars and the feeders associated with metalclad switchgear. GTD's are also used to provide access points for testing of busbars and feeders.

### 4.2.2 Procedure For Use

The procedure for use of the GTD is:

- (a) first, the circuit is de-energized by opening relevant breakers and eliminating all other infeeds.
- (b) then the circuit is isolated by racking out the breaker.
- (c) the GTD is then racked in.
- (d) the ground lead of the grounding cluster is attached to the ground bus.
- (e) the circuit is tested for potential.
- (f) the phase leads of the grounding cluster are applied using a live-line stick.

The grounding cluster must be rated to carry the full available short circuit current.

- NOTE:
1. If a grounding cluster of too low a rating is used, the cluster could fail due to thermal (overheating) or magnetic (attractive and repulsive forces).
  2. It is important to note that these are two types of GTD, ie,
    - those that are solely for the use of grounding feeders with the tulips in the lower position.

- those that are for the use of grounding busbars where the tulips can be in the upper or lower position. When busbars are grounded at the tie breaker cubicle, a connection may have to be made to the upper or lower stabs. (On one side the busbars are connected to the upper stabs and on the other side the busbars are connected to the lower stabs.)

## 5. OPERATING SEQUENCES

### 5.1 Introduction

Before a work permit can be issued for an electrical circuit, the circuit has to be:

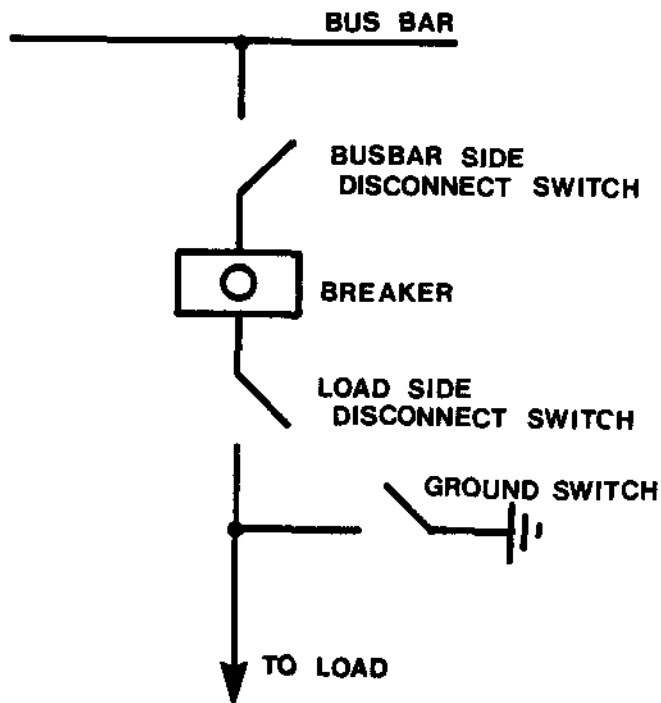
- (a) de-energized, (breaker(s) opened).
- (b) isolated, (disconnect switch(es) opened and breaker(s) racked out).
- (c) grounded, (ground switch(es) closed, portable ground(s) applied or GTD's used.

The work permit can then be issued. When isolating or de-isolating a circuit. It is vital that the correct operating sequence is observed between breakers, disconnect switches and grounding switches (or GTD's). The next two sections, 3.2 and 3.2 detail correct operating sequences.

### 5.2 Isolating a Circuit

Figure 4, shows a circuit controlled by a breaker, disconnect and grounding switches. When isolating a circuit of this type, each device must be operated in this order:

- (a) First the breaker(s) must be opened, see Figure 4.
- (b) Both disconnect switches must then be opened. All three phases must be visibly checked to ensure they are open.
- (c) Both disconnect switches must be locked in the open position.
- (d) The ground switch(es) must be closed and locked in the closed position. All three phases must be visibly checked to ensure they are fully closed.



**Figure 4:** Circuit-Controlled by a Breaker, Disconnect and Grounding Switches.

The work permit can then be issued. (This assumes all other necessary isolations have been done.)

**NOTE:** Opening a disconnect switch before the breaker is opened will cause damage to plant and may cause injury to personnel. An electrical interlock in the drive motor of the disconnect switch prevents this, but manual operation of the disconnect switch can cause the injury and the damage mentioned above.

### 5.3 De-Isolating a Circuit

When de-isolating the circuit (returning to service) shown in Figure 4, the following procedure must be followed in this order:



- (a) first the work permit must be surrendered.
- (b) the ground switch(es) must be unlocked and opened. All three phases must be checked to ensure they are open.
- (c) the disconnect switches must be unlocked and closed. All three phases must be checked to ensure they are closed.
- (d) the breaker can then be closed putting the circuit back in service.

NOTE: Closing the disconnect switch after the breaker is closed will cause damage to the plant and may cause injury to personnel.

#### 5.4 Disconnect and Grounding Switch in Other Locations

Up to this point, this lesson has considered disconnect switches, which are located either side of a circuit breaker. However, other points of isolation are required in a power system. For example, transformers, transmission lines and generators have to be isolated. Disconnect switches are provided for this purpose and they have to be operated in correct sequence in conjunction with the associated breakers and grounding switches.

5.4.1 Transformer Disconnect Switches. On the high voltage side of the system services transformer there is a disconnect switch. This disconnect switch provides isolation between the transformer, the switchyard and the line, see Figure 5. This particular disconnect switch is constructed to be able to break the transformer no load (magnetizing) current. It is not constructed to be able to break load or fault current and therefore, both the secondary winding breakers must be open before the transformer disconnect switch can be opened by motorized control.

When open, this disconnect switch provides isolation between the switchyard and the system services transformer.

Assuming work is to be done on the transformer, then:

- (a) both low voltage breakers are opened, after the unit electrical load has been transferred to the generator service transformer.
- (b) the transformer disconnect switch is opened.
- (c) the transformer high voltage ground switch is closed. The low voltage side of the transformer is grounded using GTD's. These grounds ensure the transformer and its associated circuits are at ground potential.

A transformer work permit can now be issued. When work is complete and the work permit has been surrendered the GTD's are removed, and the transformer high voltage ground switch is opened. Finally, the transformer can be returned to service by reclosing its disconnect switch and reclosing the low voltage breakers. This will transfer part of the unit electrical load from the generator service transformer to this transformer.

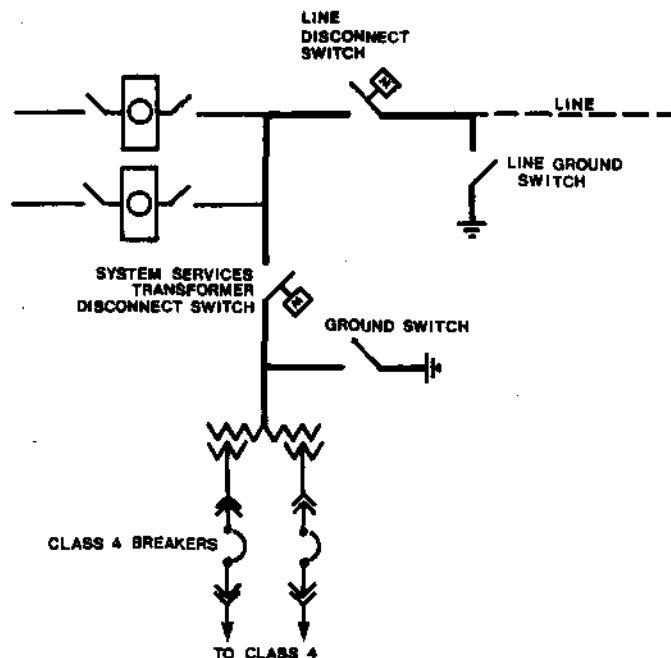


Figure 5: Transformer Disconnect Switch, Ground Switch and Class 4 Breakers.

5.4.2 Line Disconnect Switches. Line disconnect switches provide isolation between a transmission line and the associated switchyards, see Figure 6.

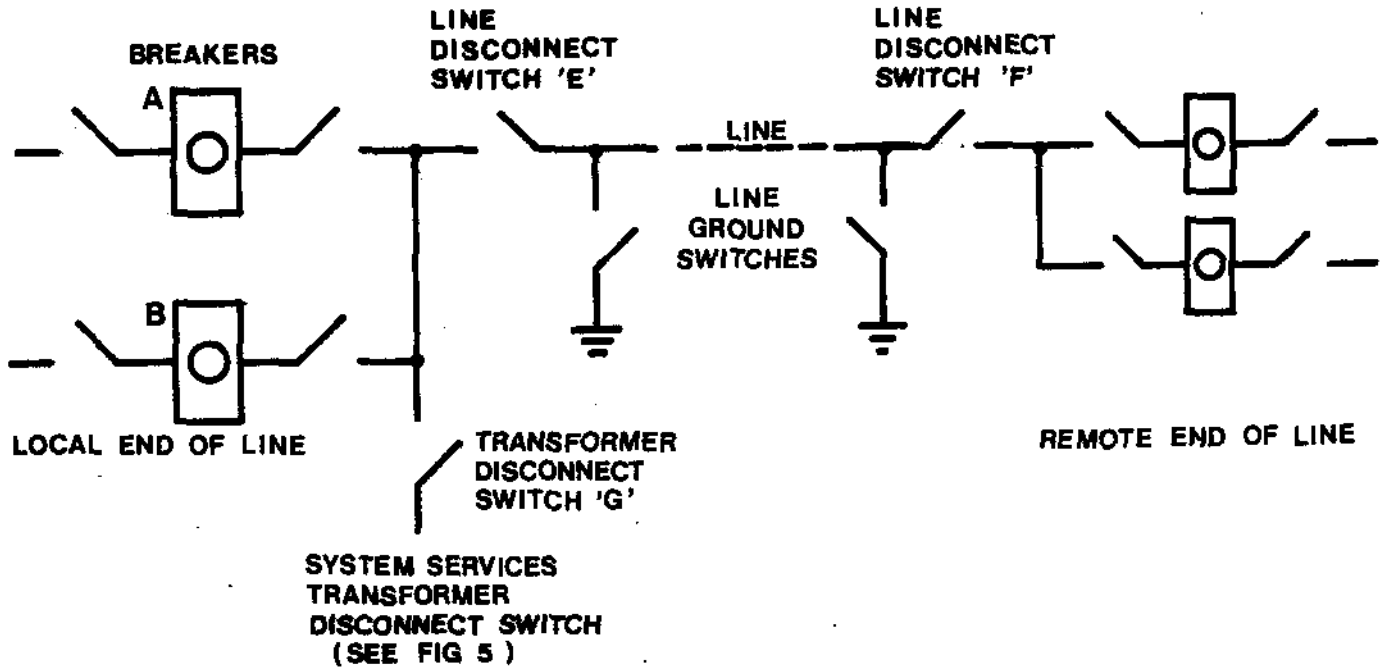


Figure 6: Line Disconnect Switches and Line Grounding Switches.

In this case, the line disconnect switch 'E' can only be opened after breakers 'A' and 'B' have been opened and the transformer disconnect switch 'G' has also been opened (see Section 5.4.1). This will ensure there is no current flow through disconnect switch 'E' and it can now be safely opened.

Assuming work is to be done on the line, then in this order:

- (a) the breakers 'A' and 'B' are opened. The transformer LV breakers are opened and racked out. The transformer HV disconnect switch is opened. The breakers are opened at the far end of the line. The line is now carrying no current and is de-energized (except for any voltages that may be induced from adjacent circuits).

- (b) The line disconnect switches 'E' and 'F' are opened (and locked open at both ends of the line. (At this stage, if required, the breakers 'A' and 'B' can be re-closed.
- (c) The line ground switches are closed at both ends of the line. These ground switches ensure the line is at ground potential.

After the work permits have been issued, line work can commence.

When the line work is complete, the permits are surrendered and the ground switches at both ends of the line are opened. Provided breakers 'A' and 'B' and the breakers at the far end of the line are open, the line and transformer disconnect switches 'E', 'F' and 'G' can be re-closed. The breakers 'A' and 'B' and the breakers at the far end of the line can now be re-closed (after synchronizing checks). Closing the breakers puts the line back into service and re-energizes the transformer. Finally, the transformer LV breakers are racked in and re-closed (after synchronizing checks). This puts the transformer back into service.

5.4.3 Generator Disconnect Switches. Generator disconnect switches provide isolation between the generator (including the main transformer) and the switchyard, see Figure 7.

Assuming work is to be done on the generator and its associated transformers, the electrical output (MW and Mvar) from the generator is reduced to zero. The unit electrical service load is transferred to the system services transformer and then:

- (a) first, the switchyard breakers 'C' and 'D' are opened.
- (b) next, the generator disconnect switch is opened. The field breaker is opened and the turbine-generator is shut down. Breakers 'C' and 'D', if required, can be re-closed.

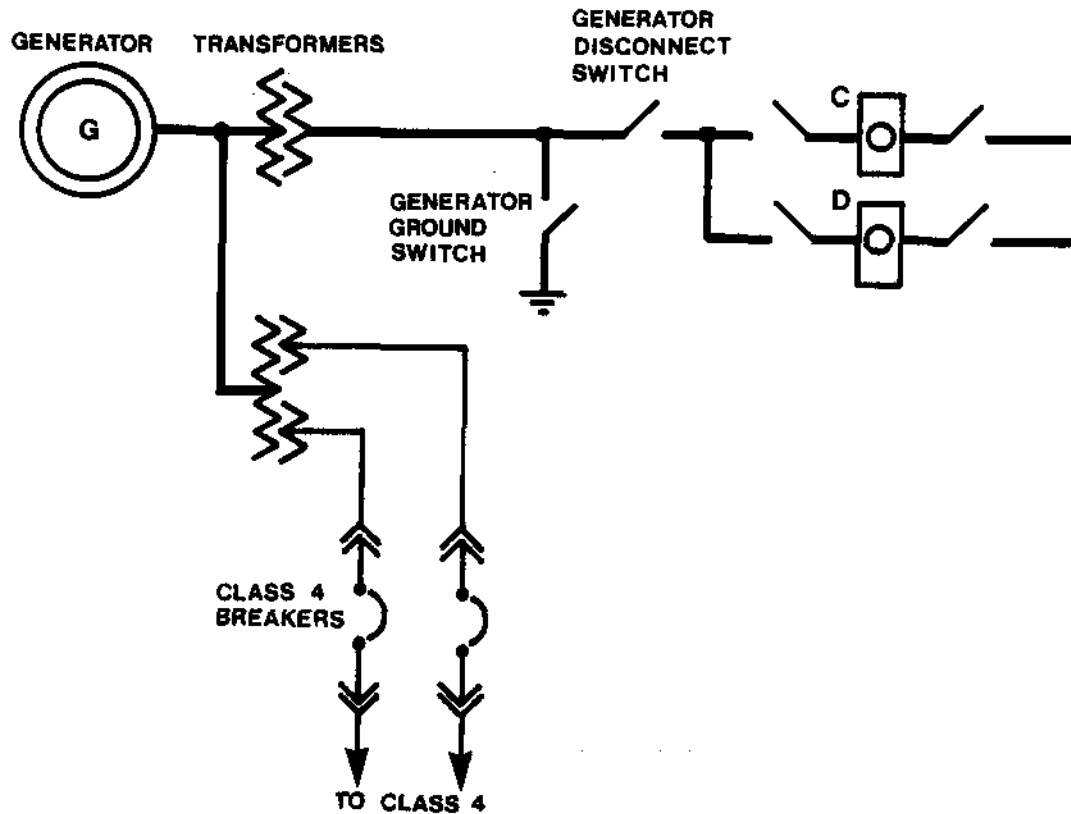


Figure 7: Generator Disconnection Switch and Generator Ground Switch.

(c) finally, the generator ground switch is closed and (if required) portable grounds are applied. These grounds ensure that the generator and its associated circuits are at ground potential.

Work on the generator (and its associated circuits) can now commence.

When work is complete, the work permit is surrendered, the portable grounds are removed (if used) and the ground switch is opened. The breakers 'C' and 'D' are opened allowing the disconnect switch to be re-closed. After synchronizing checks, breakers 'C' and/or 'D' can be re-closed which will re-connect the generator to the switchyard.

ASSIGNMENT

1. State:

- (a) two reasons why a breaker cannot be used for isolation purposes. (Section 3.3)
- (b) the two purposes of a disconnect switch. (Section 3.3)
- (c) the two limitations of disconnect switches. (Section 3.3)
- (d) the operating sequence between a breaker and its associated disconnect switches when:
  - (i) a circuit is being isolated,
  - (ii) returning the circuit to service.(Section 5.2 and 5.3)
- (e) the consequences of using the incorrect breaker and disconnect operating sequence when:
  - (i) the circuit is being isolated,
  - (ii) returning the circuit to service.(Sections 5.2 and 5.3)
- (f) the purpose of the following disconnect switches:
  - (i) line,
  - (ii) generator,
  - (iii) transformers.(Sections 5.4.1, 5.4.2, and 5.4.3)
- (g) the operating sequence for the breakers, disconnect and ground switches associated with:
  - (i) a line,
  - (ii) a generator,
  - (iii) a transformer.(Sections 5.4.1, 5.4.2, and 5.4.3)

- (h) the check that must be made after:
  - (i) opening, and
  - (ii) closing a disconnect or ground switch.

(Sections 3.4 and 5.2)
  
- (j) (i) the purpose of a GTD.  
(ii) the procedure for grounding a circuit using a GTD.  

(Section 4.2)

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