

# Instructions for Field Testing of Systems Pow-R Breakers



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## Scope

The purpose of this instruction leaflet is to describe the types of field tests that can be conducted on a completely assembled Systems Pow-R Breaker. These tests include *Simulated, Primary Injection*, and *Full Power* test currents under “in cell” and/or “out-of-cell” test conditions. No attempt will be made to cover the detailed field testing of the individual breaker internal components or remote mounted accessories. Tests for these items - where applicable - will be covered in one or more of the following instruction leaflets:

Description	Instruction Leaflet
General Instructions	I.B. 15082
Pow-R Trip 7 Trip Device	I.L. 15044
Pow-R Trip Trip Device	I.L. 15132
Shunt Trip Device	I.L. 15158
Spring Release Device	I.L. 15161
Undervoltage Release Device	I.L. 15162
Electrical Operator	I.L. 15160
Auxiliary Switch	I.L. 15159
Time Delay Undervoltage Device	I.L. 15141
Ground Fault Test Panel	I.L. 15072

**Caution:** Due to the introduction of improvements from time to time, the right is reserved to supply products which differ slightly from those illustrated and described in this publication. Should there be variations in your received product and where questions arise, consult the factory by giving specific shop order references appearing on the breaker nameplate and, if required, specific variations in test procedures will be provided.

In addition, changes may have been incorporated into the assembled switchboard that could affect the operation of the breakers being tested. Therefore, the applicable switchboard job shop drawing should be reviewed before initiating any test procedures.

## Section 1— Purpose of Field Testing

### 1.0 GENERAL

The main purpose of field testing any circuit breaker is to permit the user to determine that it is capable of providing the protection for which it is intended. Field testing should not be used to determine that a circuit breaker *exactly* meets the manufacturer's time-current curves. However, for circuit breakers equipped with solid state trip devices, test results can be more exacting than with conventional thermal magnetic type trip devices.

When circuit breaker trip performance characteristics are to be tested in the field, there are many test variables that must be recognized and taken into consideration. Some testing simplifications will be necessary. Testing variations can and do exist between one test set-up and another that will cause differences in test results. It must be recognized that a circuit breaker can furnish adequate protection, yet appear defective because of the test procedure used.

Systems Pow-R Breakers are designed, built, tested and listed in accordance with the requirements outlined in the Underwriters' Laboratories, Inc. "Standard For Safety For Molded Case Circuit Breakers and Circuit Breaker Enclosures," UL 489. Systems Pow-R Breakers exceed many of these performance requirements, particularly in the areas of short time capability and endurance. Electrical and mechanical production tests are conducted on every Systems Pow-R Breaker prior to its shipment to review the individual components installed, the internal connections and the operation of all components. Mechanical adjustments are made at the factory and should require no further attention during the life of the breaker except those that may be affected during the field installation of additional accessories. Any adjustments required by these installations will be given in the applicable instruction leaflet. General information regarding the "Inspection and Maintenance" of Pow-R Breakers is given under Section 6 of I.B. 15082.

Systems Pow-R Breakers are equipped with solid state trip devices having “discreet step” type adjustments and consequently, no factory calibration type tests with the marking of individual “set points” are required. However, production type “calibration” checks are conducted to ensure the accuracy and correctness of the installed components. With solid state components, these adjustment points should remain very stable over the life of the breaker so that field tests can be limited to “verification” type testing to confirm the accuracy of the illustrated time/current curve settings.

Any properly conducted field testing of a circuit breaker removed from its cell will determine the accuracy and operating integrity of the circuit breaker. Proper “in-cell” testing can also serve to confirm the correctness of the following types of details:

- 1) Stationary Mounting Frame - If Drawout Construction is Used
- 2) All Related Primary Bus Connections

- 3) All Related Secondary Control Wiring Connections
- 4) All Related Mechanical Linkages, Interlocks, Etc.
- 5) Current Sensor (Transformer) Polarity Connections
- 6) All Related, Externally Mounted Auxiliary Devices
- 7) Special Interlocking and/or Sequencing Arrangements Between Related Breakers

The accuracy and correctness of most of the above details should have been verified by the switchboard assembler prior to the shipment of the assembled apparatus. Field testing of these same details should ensure that no changes have occurred during transit. Since complete field testing of all of the components within any specific assembled switchboard will require access to a complete set of switchboard drawings, this publication will be limited to generalized testing instructions.

## Section 2 — When to do Field Testing

### 2.0 GENERAL

The successful and safe operation of switchboards and their internal components is dependent upon proper handling, installation, operation, maintenance, testing, as well as upon proper design and manufacture. Neglecting certain fundamental installation and maintenance requirements may lead to personal injury and the failure and loss of the switchboard as well as damage to other property.

**Warning: There is a hazard of electrical shock or burn whenever working in or around electrical equipment. Always turn off power supplying this equipment before working inside switchboards.**

There is adequate experience to indicate that where electrical testing is not practical, or cannot be justified, the manual mechanical exercising of a circuit breaker is usually effective in assuring its proper electrical operation. This will keep mechanical linkages free and the wiping action by the contacts will tend to avoid resistance build-up and thereby minimize heating. Circuit breakers used for frequent switching need no further exercising.

Circuit breakers and the associated assembled switchboard are normally operated and/or tested during the initial switchboard installation. The amount and type of testing will be dictated by the individual job requirements which should take into consideration the economics of the situation, the complexity of the final installation and the local code requirements.

In the absence of established standards, it is recommended that a routine inspection be conducted at the end of the first six months of service for breakers used under normal operating conditions. (Refer to I.B. 15082, Section 6.) After the first inspection, inspect at least once a year unless the maintenance condition and schedule dictate otherwise.

When a breaker opens a known heavy fault, at or near its rating, give it a visual inspection withdrawn from the compartment and with the front cover and arc chutes removed. For breakers equipped with trip mode indicators, the need for this type of inspection can be quickly seen.

## Section 3—Things to do Prior to Field Testing any Systems Pow-R Breaker

### 3.1

Collect and review all instruction literature and drawings applicable to the tests to be conducted. *Do the following:*

#### 3.1.1

Determine if the planned test procedure is appropriate. Different considerations must be given for “in-cell” versus “out-of-cell” test procedures as well as the source of test current to be used.

#### 3.1.2

Determine if the test equipment for the proposed test procedure is adequate.

#### 3.1.3

Ensure that qualified test personnel for the type of tests planned are used.

#### 3.1.4

Contact the user, the specifying engineer and/or the equipment manufacturer where questions arise that could affect the outcome of the planned tests.

### 3.2

Check the breaker nameplates, the trip unit and determine the features and options included with the breaker to be tested. *Do the following:*

#### 3.2.1

Determine if the breaker is fixed or drawout mounted. If drawout, review the method of racking the breaker in and out of the cell as described in Section 3 of I.B. 15082.

#### 3.2.2

Determine if the breaker is electrically or manually charged. Review the methods of charging and closing the breaker as described in Section 3 of I.B. 15082.

#### 3.2.3

Determine what type of trip unit is provided, i.e., Pow-R Trip or Pow-R Trip 7. This instruction leaflet may be used

to test breakers equipped with either type; however, the number of options and features differ between the two types and considerations must be made for these differences in planning the tests to be conducted.

#### 3.2.4

Determine if the trip unit has ground fault protection included as an option. If ground fault protection is included, then *the following points should be considered:*

##### 3.2.4.1

Determine what method of ground fault sensing is used, i.e., *Residual, Zero Sequence, Ground Return*, other.

##### 3.2.4.2

Determine if the distribution system is grounded in a manner that the ground fault sensing method used can operate properly when the breaker is installed in the cell.

##### 3.2.4.3

Determine if the external current sensors have been properly connected with respect to polarity markings.

##### 3.2.4.4

Determine that the side mounted GFP terminal block shown in Fig. 6 is properly connected for the intended application whether it be a testing or operational mode. An instruction nameplate is provided adjacent to the terminal block.

##### 3.2.4.5

Determine if zone interlocking is used between related breakers. If not, then confirm that appropriate jumpers have been added to terminals C4 and C5 to activate the ground fault timing circuitry.

### 3.3

Determine if any external accessories are used with the breaker that could affect the proper operation of the breaker including the following:

1. Ground Fault Test Panel
2. Automatic Trip Relays

3. Time Delay Undervoltage Device
4. Capacitor Trip Device
5. Other Auxiliary and/or Control Devices

#### 3.4

Determine if any electrical or mechanical interlocking scheme is employed that could affect the breaker being tested. This is particularly important for any "in-cell" testing procedures.

#### 3.5

Learn the location of all secondary control terminations and/or test points that could be used during the planned test procedure.

#### 3.6

*Before beginning any test*, record all trip unit settings so that they can be returned to their original settings following the test - unless other settings are specified.

#### 3.7

Make sure that the correct rating plug is installed and properly seated in the trip unit.

#### 3.8

Determine and observe all safety precautions consistent with established safe testing practices.

## Section 4—Methods of Field Testing

### 4.0 GENERAL

Field testing of the Systems Pow-R Breaker can be generally divided into categories depending upon the location of the breaker during the test and the source of test current employed. Breakers may be tested either "in-the-cell" or "out-of-the-cell." One of the advantages of "draw-out" breaker construction is that the breaker can be easily withdrawn from its cell for remote testing.

Test current for field testing may be derived from one of the following methods:

1. *Simulated*, i.e., Low-level test current from a separate source.
2. *Primary Injection*, i.e., Fault level, low-voltage test current from a separate source.
3. *Full Power*, i.e., Controlled fault level test current from energized switchboard bus at rated voltage.

Each method has its advantages and/or disadvantages and will be covered separately. The *Simulated* method involves the use of an SPB portable test kit as illustrated in Fig. 1. This is the easiest and most inexpensive method which should satisfy most testing requirements. This type of testing can be conducted by qualified maintenance personnel during routine maintenance schedules.

*Primary Injection* testing requires the use of portable, high current test equipment along with experienced testing personnel.

*Full Power* tests are conducted by qualified testing personnel with the assembled switchboard energized at rated voltage levels. Power resistors are employed to control the amount of test current through the breaker. Tests using this method will be required to satisfy field performance test requirements for ground fault protective devices outlined in Article 230-95-(C) of the National Electrical Code.

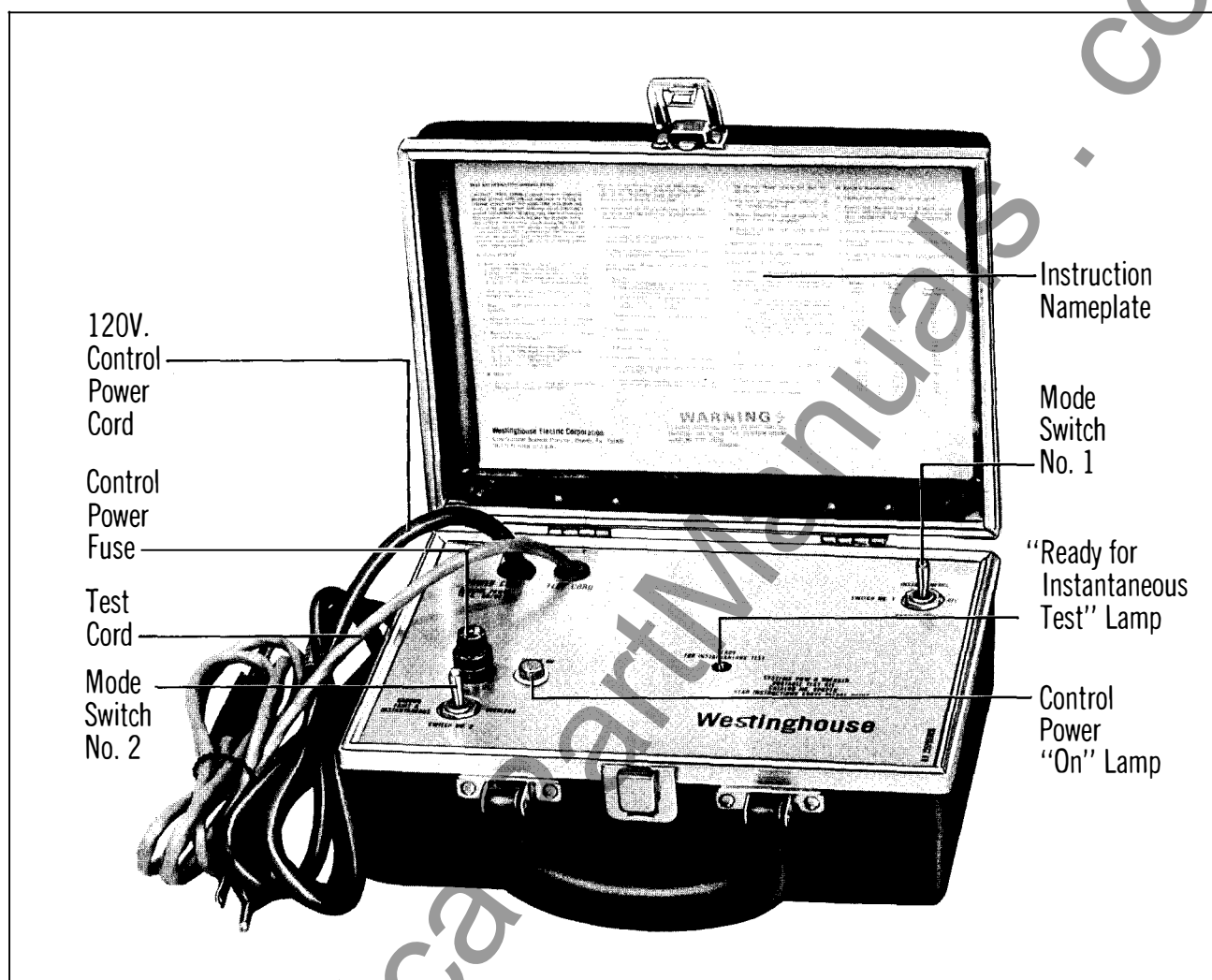


Fig. 1 Catalog No. SPBPTK Systems Pow-R Breaker Portable Test Kit

## Section 5— Simulated Test Method

### 5.0 GENERAL

Every Systems Pow-R Breaker is equipped with a trip unit that has test points that can be used with a portable hand-held test kit for "functional" testing of the internal protection circuits and the "Flux Transfer" shunt trip device. The portable test kit may be used - *when proper precautions are taken* - for "In Service" testing as well as the more conventional "Out-of-Service" testing.

**Caution:** While simulated tests may be conducted on the Systems Pow-R Breaker while it is "in service" and carrying normal load current, it is recommended that test routines be limited to normal maintenance schedules con-

ducted during "off-load" hours. In situations where a switchboard is energized, drawout mounted breakers may be safely tested while in the "Test," "Disconnected," or "Withdrawn" cell positions.

In certain applications, "In service" testing should be avoided to prevent unnecessary power transfer operations for breakers applied in automatic power transfer schemes. Should breakers be applied with generators where synchronizing may be required prior to reclosing, proper synchronizing procedures should be followed before reclosing the breaker.

All tests performed by the test kit are "*functional*" tests only, designed to electrically test the operating integrity

of the trip unit, the flux transfer shunt trip device, the mechanical opening of the breaker, as well as the operation of remote mounted, related accessories. Tests are not designed as a check of the calibration accuracy of the trip unit since these types of tests can best be done at the factory with precise calibration equipment under controlled conditions. While it should not be considered as a "calibration" check, the performance repeatability of any given breaker-test kit combination should be excellent under similar test conditions.

### 5.1 FUNCTIONAL TESTS THAT CAN BE PERFORMED WITH TEST KIT

#### 5.1.1

Functional operation of the instantaneous or short time tripping mode including:

1. Tripping of the breaker.
2. Operation of the self-contained "short circuit" pop-up indicator - when provided.
3. Operation of the remote mounted automatic trip relay "LED" indicator - when provided.
4. Operation of the alarm and lock-out contacts of the remote mounted automatic trip relay - when provided.

**Note:** The operations indicated under 5.1.1.3 and 5.1.1.4 above will occur only during "In Service" testing or during tests conducted on drawout mounted breakers in the "Test" position where secondary control wiring is engaged.

#### 5.1.2

Functional operation of the overload tripping mode including:

1. Tripping of the breaker.
2. Operation of the self-contained "overload" pop-up indicator - when provided.
3. Operations same as above under 5.1.1.3 and 5.1.1.4.

#### 5.1.3

Functional operation of the ground fault tripping mode including:

1. Tripping of the breaker.
2. Operation of the self-contained "ground fault" pop-up indicator - when provided.
3. Operation of the "ground fault" trip indicator in the remote mounted ground fault test panel - when provided.
4. Operations same as above under 5.1.1.3 and 5.1.1.4.

### 5.2 TESTS THAT CANNOT BE PERFORMED WITH PORTABLE TEST KIT

1. Functional testing of any tripping mode *without* tripping the breaker.
2. True calibration check of any specific trip setting.

**Note:** Since one test kit can be used with any and all Systems Pow-R Breakers regardless of the frame rating and/or rating plug installed, pick-up and time delay results must vary. The test kit output test current is constant for a specific control voltage level and therefore the apparent input to the breaker trip units seems to vary.

3. Continuity checking of the internal current sensors and/or bridge circuits.
4. Confirmation of the accuracy of the polarity connections for externally mounted sensors employed in ground fault sensing schemes. Overall correctness of these connections can best be accomplished via a complete wire check followed by a full power test suggested in Section 9 of this leaflet.

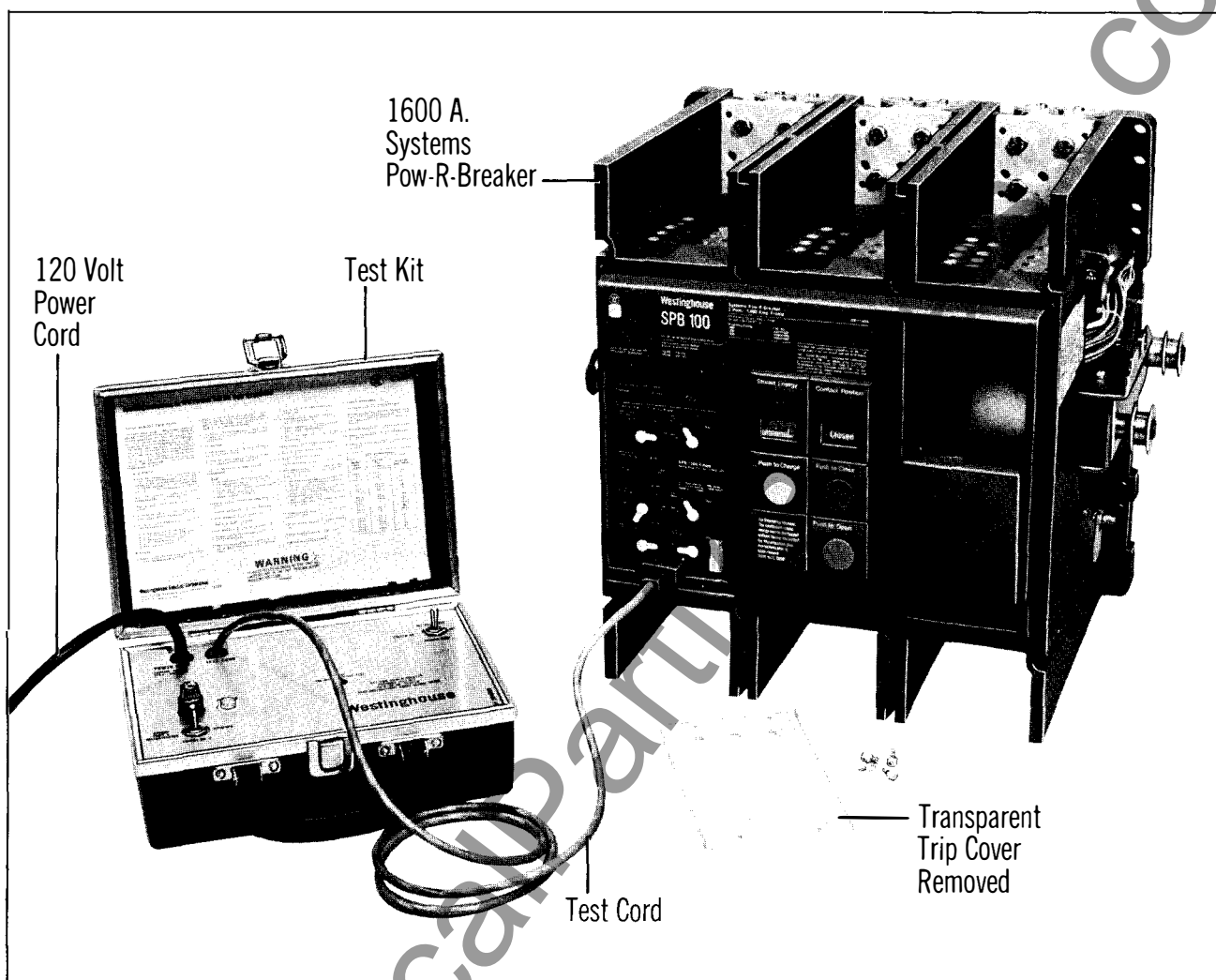
### 5.3 SIMULATED TEST PROCEDURES USING SPB PORTABLE TEST KIT, CAT. NO. SPBPTK

General test procedures given below are duplicated on the instruction sheet attached to the inside cover of the test kit as shown in Fig. 1. These instructions should be followed in detail to ensure proper operation.

#### 5.3.1 Things To Do Before Hookup

1. Refer to the *Caution* note under Section 5.0 in this leaflet regarding "In Service" testing. Tests may be best done with drawout mounted circuit breakers in the "Test" or more removed cell positions.





**Fig. 2** Typical Systems Pow-R Breaker Ready for Functional Testing with Portable Test Kit, Cat. No. SPBPTK

2. With the comments in Section 5.0 taken into consideration, place the circuit breaker in the "Closed" position. (Refer to I.B. 15082, Section 3).

3. Place the two mode selector switches (Fig. 1) in the "Off" position.

4. Record all trip unit position settings so that they can be returned to their original settings after tests are conducted (Fig. 3).

5. Remove the trip unit transparent cover from the face of the breaker (Figs. 2 and 4) and make the following adjustments (method of changing settings illustrated in Fig. 5):

1. Set short time band to "Minimum."

2. Set long time band per Table 1.

3. Set instantaneous pick-up to maximum position.

4. Set short time pick-up to maximum position.

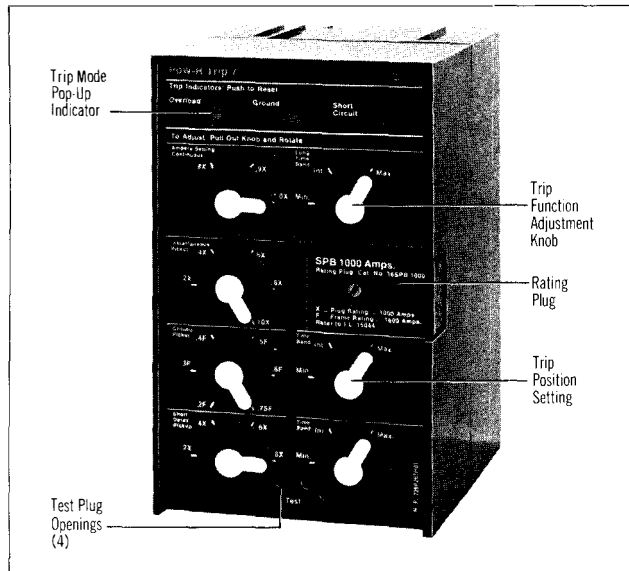
5. Leave other settings "as is."

### 5.3.2 Hook-Up

1. Remove test cord (Fig. 1) from the test kit and insert it as shown in Fig. 2 into the trip unit openings marked "Test" (Fig. 3).

2. Remove the test kit power cord (Fig. 1) and insert into a 120 Volt, 60 Hz. power source. The "Power On" lamp should turn on. If it does not, check the power source and then the control power fuse in the test kit.

The “Ready For Instantaneous Test” lamp should turn “On” within one minute after the power cord is plugged into the power source.



**Fig. 3** Pow-R Trip 7 Trip Unit with all Available Adjustments and Optional Trip Mode Indicators

### 5.3.3 Functional Tests

#### 5.3.3.1 To Functionally Test the Instantaneous or Short Time Pick-up Mode (Short Circuit)

1. Using both hands, move test Switches No. 1 and No. 2 shown in Fig. 1 simultaneously to the instantaneous position.

**Note:** A test will not be made with only one switch actuated.

#### Results

- 1) The breaker should open instantaneously, and
- 2) Trip unit “short circuit” pop-up indicator - when supplied - should operate, and
- 3) LED indicator in remote mounted automatic trip relays - when supplied - should operate.
- 4) “Ready For Instantaneous Test” light should go out.
2. Release both switches (they will spring return to “OFF”)

Table 1 – Test Setting		
Breaker Frame, Amps.	Trip Unit Plug, Amps.	Long Time Band Setting
4000	4000	Intermediate
4000	3000	Intermediate
4000	2500	Maximum
4000	2000	Maximum
3000	3000	Intermediate
3000	2500 <sup>②</sup>	Intermediate
3000	2000 <sup>②</sup>	Intermediate
2500	2500	Intermediate
2000	2000	Intermediate
2000	1600 <sup>②</sup>	Maximum
2000 <sup>①</sup>	2000	Intermediate
2000 <sup>①</sup>	1600	Intermediate
1600	1600	Intermediate
1600	1200	Intermediate
1600	1000	Intermediate
1600	800 <sup>②</sup>	Maximum
1200	1200	Intermediate
1200	1000	Intermediate
800	800	Intermediate
800	700	Intermediate
800	600	Intermediate
800	500	Maximum
800	400	Maximum
800	300	Maximum
250	250	Intermediate
250	225	Intermediate
250	200	Intermediate
250	175 <sup>②</sup>	Intermediate
250	150 <sup>②</sup>	Maximum
250	125 <sup>②</sup>	Maximum
250	100 <sup>②</sup>	Maximum

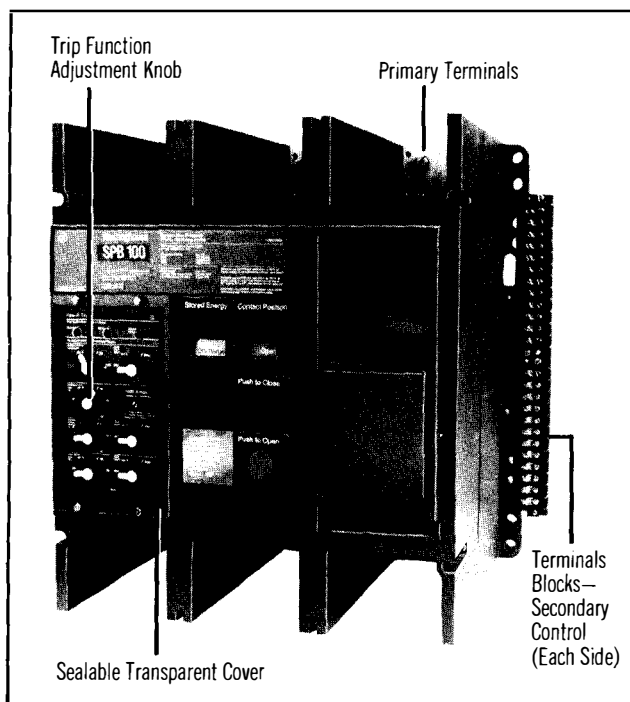
① Compact frame, 16 inches high.

② Non-Standard rating.

3. “Ready for Instantaneous Test” light will turn on in a few seconds.

4. Reset all indicator circuits supplied and

5. Reclose the breaker as required.



**Fig. 4** Fixed-Mounted SPB Breaker with Control Terminal Blocks Installed

#### 5.3.3.2 To Functionally Test the Long Time (Overload) Mode:

**Caution:** When testing a circuit breaker equipped with internal ground fault pop-out indication or with an external ground fault test panel, false indication may occur in the ground fault indicator circuit following a normal test operation involving a long time test function. This situation could occur because the portable test kit uses external control power which, during the course of the test, could be reset too slowly. Should this occur, reset Switch No. 2 in test kit to “Off” position as well as the ground fault indicator that may have operated. This situation will not occur during normal breaker tripping operation.

1. Confirm that the long time delay band has been pre-set per Table 1.
2. Move selector switch No. 2 shown in Fig. 1 to “Overload” (it will stay in this position after the hand is removed.)

Results:

- 1) The breaker should open in less than two minutes, and

- 2) Trip unit “Overload” pop-up indicator - when supplied - should operate, and
- 3) LED indicator in remote mounted automatic trip relays - when supplied - should operate.
- 4) “Ready For Instantaneous Test” light will remain “On” after breaker trips.
3. Return selector switch No. 2 to “Off” position, and
4. Reset all indicator circuits supplied and
5. Reclose the breaker as required.

#### 5.3.3.3 To Functionally Test the Ground Fault Trip Mode:

1. Move selector switch No. 1 to “ground fault” and move selector switch No. 2 to “ground fault” and hold for 1 second.

Results:

- 1) The breaker should open instantaneously, and



**Fig. 5** Changing Trip Position Setting on Pow-R Trip 7 Trip Device

- 2) Trip unit "Ground Fault" pop-up indicator - when supplied - should operate, and
- 3) LED indicator in remote mounted automatic trip relays - when supplied - should operate, and
- 4) Ground fault lamp in remote test panel - when supplied - should turn "On."
- 5) "Ready for Instantaneous Test" lamp will remain "On" after breaker trips.

2. Release selector switch No. 2 (it will spring return to "Off").
3. Return selector switch No. 1 to "Off" position, and
4. Reset all indicator circuits - if any - and
5. Reclose the breaker as required.

#### 5.3.4 Test Results

##### 5.3.4.1 When Tests Comply With Instructions

1. Disconnect power cord from 120 volt, 60 Hz source.
2. Remove test cord from trip unit.

**Caution:** Avoid contact with test plug prongs until power cord has been disconnected and internal capacitors are discharged. Shielded prongs prevent accidental contact.

3. Return all trip unit settings to their original settings using data tabulated prior to beginning tests.

4. Replace the transparent trip unit cover.
5. Reinstall the breaker in its cell - if drawout.
6. Return to service following established procedures.

##### 5.3.4.2 When Tests Do Not Comply With Instructions:

###### 5.3.4.2.1 With Control Power Lamp Not "On"

1. Confirm that control power is available.
2. Confirm that a good control power fuse is in place.
3. Confirm that a good control power lamp bulb is in place.
4. Take corrective action on above items where required, then re-start test sequence.

###### 5.3.4.2.2 With Control Power Lamp "On"

1. Confirm the rating plug is properly installed.
2. Confirm the test cord is properly installed.
3. Confirm that preliminary settings agree with required settings shown in 5.3.1.5.
4. With trip unit settings in correct position, repeat prescribed test procedures under 5.3.3.

**Note:** Should tests again fail to comply with expected test results, do not return the breaker to service, but contact the factory for further instructions.

## Section 6—Primary Injection Test Method

### 6.1 GENERAL INFORMATION

Primary Injection testing is the method of testing a circuit breaker with a portable, single phase, high-current, low-voltage test device. This type of equipment is normally used by qualified testing service organizations. Because of the many variables that can occur in field testing as compared to the manufacturer's factory testing, variations in test results can occur. All Systems Pow-R Breakers are 100% tested using Primary Injection methods prior to shipment. Since solid state trip devices are not subject to as many test variations as are the more conventional thermal magnetic type devices, field testing should closely duplicate factory test results.

Primary injection test methods are generally employed where it is required to test a circuit breaker completely. This type of testing includes the internally mounted current transformers as well as all elements of the sensing and tripping circuitry. Tests on circuit breakers using this method of testing may be conducted on circuit breakers while they are in the "Connected" position within their cell or on a test bench removed from the cell. Since these tests employ separate power test sources, all testing will be "out-of-service" type testing only.

Before beginning any test series, determine the proper test current levels. In general, test current values should be held to minimum values to avoid unnecessary contact deterioration. Values should be approximately 110-125% of the pick-up setting of the circuit being tested.

**Caution:** *Ground Fault Protection* Systems Pow-R Breakers may be equipped with internal provisions for sensing and tripping under ground fault conditions. When so equipped, breakers are provided with an external, side mounted, four point terminal block. Refer to Fig. 6. Connections are made to this terminal block to enable a user to apply the breaker in various ground fault sensing schemes including: *Residual*, *Zero Sequence*, and *Ground Return*. Different jumper connections are required depending on the sensing method employed. Also, and more importantly, temporary connections at this terminal block are required prior to doing any Primary Injection testing to disable ground fault tripping during single pole, phase current testing. Complete instructions are given on a nameplate mounted adjacent to the four point terminal block as shown in Fig. 6. A copy of these nameplates is given in Figs. 7 and 8 of this leaflet. Complete connection details are given in Sheet 2 of drawings 1273C40, 1273C41 and in I.S. 15262. On multi-source systems, al-

ternate connections may be required for main and tie breakers employing a residual sensing scheme. These variations will be shown on Sheet 3 of 1273C40 or 1273C41 and a different nameplate may be applied to the side of the breaker.

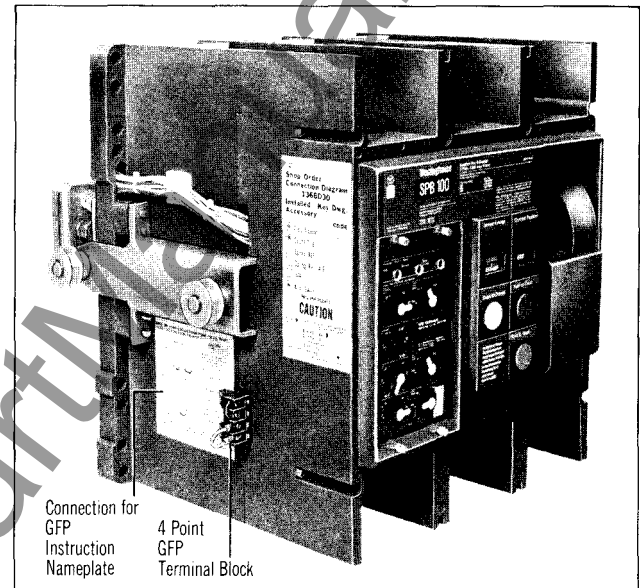


Fig. 6 View of 1600 Amp SPB Drawout Breaker Equipped with Ground Fault Protection

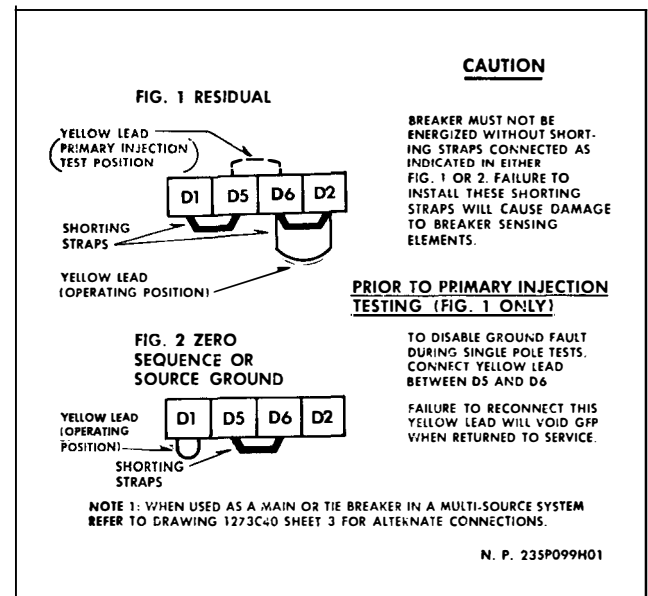


Fig. 7 Basic GFP Terminal Block Connections for SPB Frames Rated 2000 Amp Maximum (2000 Amp in Compact 16 In. High Frame)

## 6.2 TYPES OF TESTS CONDUCTED

### 6.2.1 With Breaker “Out of Cell”

Both individual phase and ground fault tests may be conducted on a breaker removed from its cell using A.C., single phase, low-voltage, Primary Injection methods. However, this type of testing will not confirm the correctness of the polarity connections of any externally mounted ground fault current sensors. Confirmation of the accuracy of this circuitry will require further “Primary Injection” or “Full Power” testing with the breaker in the “Connected” position in the cell. Details on these tests are covered in subsequent sections.

### 6.2.2 With Breaker in Connected Position “In Cell”

Both individual phase and ground fault tests may be conducted on a breaker while it is mounted in its cell in the “connected” position using A.C., single phase, low-voltage, Primary Injection test methods. Since these type tests employ separate power test sources, all testing must be “out of service” type testing with the normal power source de-energized.

In most applications, this type of testing will confirm the correctness of the polarity connections of any externally mounted ground fault sensors. However, “Full

Power” testing will still be required to confirm the accuracy of all connections in certain multi-source systems. Full Power ground fault operational tests will still be required for compliance with section 230-95-c of the National Electrical Code.

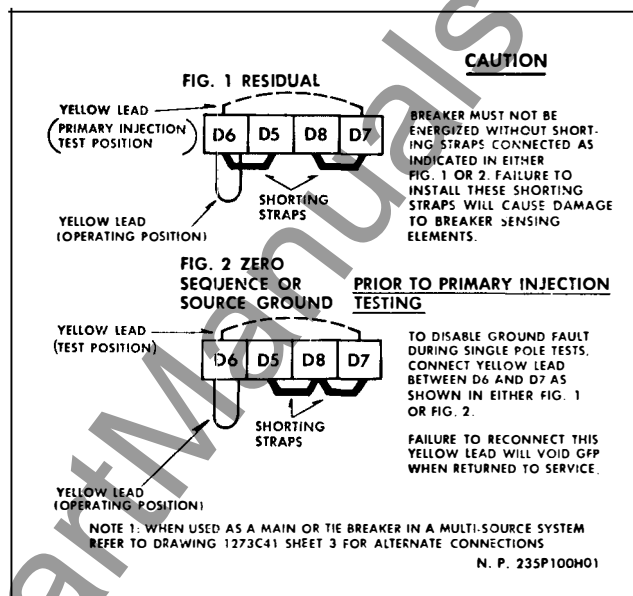


Fig. 8 Basic GFP Terminal Block Connections for SPB Frames Rated 2000 Amp Minimum (2000 Amp in 22 In. High Frame)

## Section 7—Primary Injection Testing with Breaker “Out-of-Cell”

### 7.1 THINGS TO DO BEFORE DOING ANY SINGLE PHASE TESTING

#### 7.1.1 250/800/1200/1600/2000 Amp Breaker Frames (2000 Amp in Compact 16 In. High Frame)

When ground fault protection is included as an option in the trip unit, refer to Fig. 7 and make the following connections on the side mounted, four point terminal block:

##### 7.1.1.1 When Applied in a Residual Sensing Scheme:

1. Connect shorting straps D1 to D5 and D2 to D6.
2. Connect “yellow” test lead from D5 to D6.

**Note:** This connection disables ground fault circuitry during single phase tests.

**Caution:** Failure to return the “yellow” test lead to its operating position on terminals D6 and D2 will void GFP when the breaker is returned to service.

##### 7.1.1.2 When Applied in Either Zero Sequence or Source Ground Sensing Schemes

1. Connect shorting straps D5 to D6.

**Note:** These are permanent locations for the indicated type of ground fault sensing and no changes need be made following testing prior to returning the breaker to service.

#### 7.1.2 2000/2500/3000/4000 Amp Breaker Frames (2000 Amp in 22 In. High Frame)

When ground fault protection is included as an option in the trip unit, refer to Fig. 8 and make the following connections on the side mounted, four point terminal block:

### 7.1.2.1 When Applied in a Residual Sensing Scheme

1. Connect shorting straps D5 to D6 and D7 to D8.
2. Connect "yellow" lead from D6 to D7.

**Note:** This connection disables ground fault circuitry during phase tests.

**Caution:** Failure to return the "yellow" test lead to its operating position on Terminal D6 will void GFP when the breaker is returned to service.

### 7.1.2.2 When Applied in Either Zero Sequence or Source Ground Sensing Schemes

1. Connect shorting straps D5 to D8 to D7.
2. Connect "yellow" lead from D6 to D7.

**Note:** This connection disables ground fault circuitry during single phase tests.

**Caution:** Failure to return the "yellow" test lead to its operating position on Terminal D6 will void GFP when the breaker is returned to service.

## 7.2 PROCEDURE FOR DOING PHASE TESTS

### 7.2.1 Overload

1. Pre-set ampere setting to 1.0X.
2. Pre-set instantaneous and short time pick-up settings to maximum positions.
3. Leave all time delay band settings as pre-set or change to minimum as desired.
4. Ignore ground fault settings.
5. Conduct single phase test with connections as illustrated in Fig. 9. Start with Phase "A," then move to Phases "B" and "C."
6. Record trip times and compare with values shown on time-current curves.
7. Reset "Overload" pop-up indicator - when supplied - between tests.

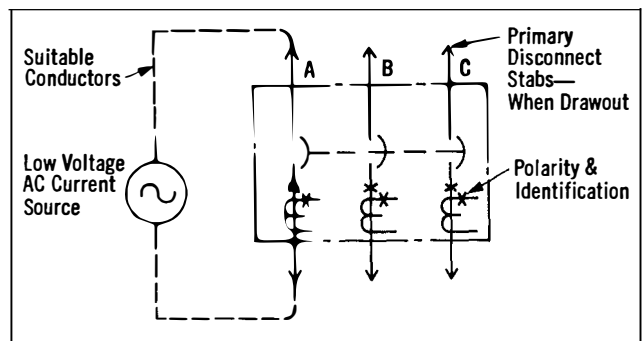
### 7.2.2 Instantaneous Pick-Up

1. Pre-set ampere setting to 1.0X.

2. Pre-set instantaneous pick-up to minimum value.
3. Pre-set short time pick-up to maximum value.
4. Leave all time delay band settings as pre-set or change to minimum as desired.
5. Ignore ground fault settings.
6. Conduct single phase test with connections as illustrated in Fig. 9. Start with Phase "A," then move to Phases "B" and "C."
7. If desired, and with proper timing equipment available, record trip times and compare with values shown on time-current curves.
8. Reset "short circuit" pop-up indicator - when supplied - between tests.

### 7.2.3 Short Time Pick-Up

1. Pre-set ampere setting to 1.0X.
2. Pre-set instantaneous pick-up to maximum value.
3. Pre-set short time pick-up to minimum value (2X).
4. Leave all time delay band settings as pre-set or change to minimum as desired.
5. Ignore ground fault settings.
6. Conduct single phase test with connections as illustrated in Fig. 9. Start with Phase "A," then move to Phases "B" and "C."
7. If desired, and with proper timing equipment available, record trip times and compare with values shown on time-current curves.



**Fig. 9** Connection Details for Conducting Single Pole, Single Phase Current Tests with Breaker Removed from Cell

8. Reset “short circuit” pop-up indicator - when supplied - between tests.

### 7.3 THINGS TO DO BEFORE DOING GROUND FAULT TESTING

#### 7.3.1 General Information

Regardless of the type of ground fault sensing scheme the breaker being tested is applied in, i.e., *Residual*, *Zero Sequence*, or *Source Ground*, for Primary Injection testing of the breaker *out of the cell*, connect the breaker using “*Residual*” type connections during the tests.

**Caution:** Systems Pow-R Breakers are equipped with zone interlocking circuitry on ground fault protection. As such, while being tested out of the cell, breakers will trip near instantaneously (0.08 Sec.) - regardless of the time delay band setting - unless a jumper is added between control terminals C4 and C5. With this done, the breaker will respond to the pre-set time delay settings. (This jumper and note are shown on connection diagram 1366D30 and I.S. 15262 Sh. 31).

#### 7.3.2 250/800/1200/1600/2000 Amp Breaker Frames (2000 Amp in Compact 16 In. High Frame)

1. Refer to Fig. 7 and make the following connections:

- 1) Connect for residual scheme by connecting shorting straps D1 to D5 and D6 to D2.
- 2) Connect yellow test lead between D6 and D2.

**Note:** This is normal operating position of the “yellow” lead when ground fault protection is “armed.”

2. Pre-set the ground fault pick-up setting to 0.2F.
3. Leave the ground fault time delay band as pre-set unless changes are desired.
4. Using Table 2 (page 27) as a guide, establish approximate test current levels as follows:

250 Amp Frame: 66 Amps  
800 Amp Frame: 200 Amps  
1200 Amp Frame: 318 Amps  
1600 Amp Frame: 400 Amps  
2000 Amp Frame: 504 Amps

#### 7.3.3 2000/2500/3000/4000 Amp Breaker Frames (2000 Amp Frame in 22 In. High Frame)

1. Refer to Fig. 8 and make the following connections:

- 1) Connect for residual scheme by connecting shorting straps D6 to D5 and D8 to D7.
- 2) Connect both ends of the “yellow” test lead to D6.

**Note:** This is normal operating position of the “yellow” lead when ground fault protection is “armed.”

2. Pre-set the ground fault pick-up setting to minimum position.
3. Leave the ground fault time delay band as pre-set unless changes are desired.
4. Using Table No. 2 (page 29) as a guide, establish approximate test current levels as follows:

2000/2500/3000A Frames - 798 Amps  
4000A Frame - 1154 Amps

### 7.4 PROCEDURE FOR TESTING GROUND FAULT PICK-UP

#### 7.4.1

Pre-set trip units as follows:

Ampere Setting	- 1.0X
Inst. Pick-Up	- Maximum Position
Short Time Pick-Up	- Maximum Position
Long Time Band	- Leave as Pre-set
Short Time Band	- Leave as Pre-set
Ground Fault Pick-Up	- Minimum Position
Ground Fault Time	- Minimum or as Pre-set

#### 7.4.2

Establish test current as suggested in 7.3.2.4 or 7.3.3.4 in line with the frame rating of the breaker being tested.

#### 7.4.3

Conduct single phase test with connections as shown in Fig. 9. Start with Phase “A,” then, move to Phases “B” and “C.”

#### Results

The breaker should open during each test and the “Ground Fault” pop-up indicator - when supplied - should pop-up.



#### 7.4.4

Reset the "Ground Fault" pop-up indicator - when supplied - between each of the above tests. Failure to reset it will not affect subsequent breaker operations but will prohibit proper trip indication of that function.

#### 7.4.5

Record trip times - if suitable equipment is available - and compare with values shown on time-current curves.

**Note:** If suitable timing equipment is not available, it should be adequate to run two tests on one pole to confirm that the time delay circuitry is operating. Run the first test with the time delay set at 0.1 sec. and the second test at 0.5 sec. There should be an audible time delay between the two tests.

#### 7.4.6

Conduct single phase test with connections as shown in Fig. 10. Start with Phases "A and B" then, move to "A and C" and to "B and C."

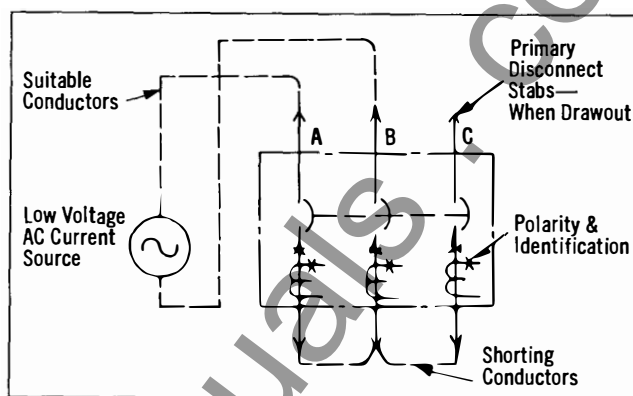
#### Results

The breaker *should not open* and the "Ground Fault" pop-up indicator *should not operate* on either test.

**Note:** This test confirms the correctness of the polarity connections of the internal current sensors.

### 7.5 TEST RESULTS

Should the breaker fail initially to comply with published time-current trip characteristics or for any other reason, review the complete instructions and retest to confirm the initial results. Should the tests again fail to comply, do not return the breaker to service and do contact the factory for further instructions.



**Fig. 10** Connection Details for Conducting Single Phase Current Tests with Breaker Removed from Cell

### 7.6 THINGS TO DO BEFORE RETURNING BREAKER TO SERVICE

#### 7.6.1

Return all trip unit settings to original position using data recorded prior to beginning the tests. *Revise position settings where required.*

#### 7.6.2

Return all shorting straps and/or "yellow" test leads to operating position as indicated in either Fig. 7 or 8 unless other data is given on the side of the actual breaker tested. Make sure that proper connections are made on each breaker for the type of sensing means employed, i.e., *Residual, Zero Sequence or Source Ground.*

#### 7.6.3

Remove any zone interlocking defeater jumper that may have been installed temporarily between control terminals C4 and C5.

## Section 8 — Primary Injection Testing with Breaker "In-Cell"

### 8.1 THINGS TO DO BEFORE DOING ANY TESTING

#### 8.1.1

Review "Things to do Prior to Field Testing Any Systems Pow-R Breaker" under Section 3.

#### 8.1.2

Open all breakers in the switchboard and remove any tie connections to ensure that the breaker being tested is totally isolated and that all power sources to the breaker are de-energized.

**Warning:** There is a hazard of electrical shock or burn whenever working in or around electrical equipment. Always turn off power supplying this equipment before working inside switchboards.

### 8.1.3

Examine the switchboard "job shop" drawings and determine whether or not any interlocking exists between the breaker being tested and any other related breaker that could affect the operation of the breaker during tests. If so, temporary control connections may be required to allow proper breaker operation.

**Caution:** Any temporary connections made for the purpose of conducting breaker tests should be restored to proper operating condition before returning the breaker to service.

### 8.1.4

Establish test plan of action. This can best be done by creating a simple three line switchboard diagram as illustrated in Fig. 11 or by using a marked copy of the applicable "job shop" drawings where simplicity permits. For the more complex switchboards with multiple power sources and/or grounds, a combination of these efforts may be required.

Figure 11 is a three line diagram illustrating the main bus connections and ground fault sensing transformer locations for a typical, single source, radial distribution switchboard. An infinite number of variations could be created; however, this simple version should serve to illustrate several key points and test planning considerations including the following:

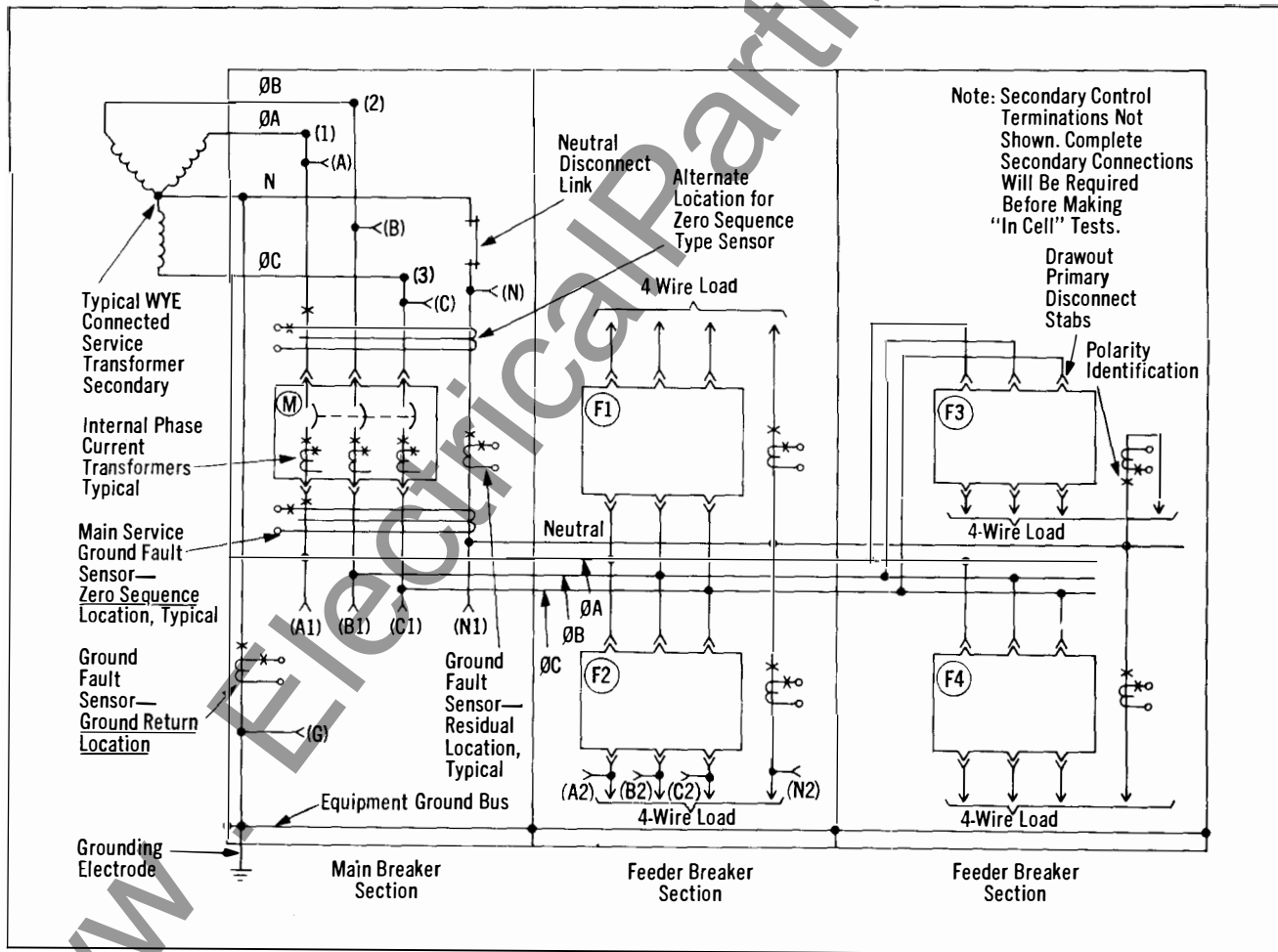


Fig. 11 Three Line Diagram of Typical Radial Distribution Switchboard

#### 8.1.4.1 Power Source Isolation

Paragraph 8.1.2 requires that all power sources to the switchboard be de-energized or disconnected prior to doing any Primary Injection type testing with the breaker mounted in its cell.

In this example switchboard, isolation can be accomplished by mechanically separating the supply conductors illustrated at points (1), (2) and (3). *Additional isolation points may be required for the actual switchboard being tested.*

**Caution:** Any conductors isolated for test purposes should be properly re-connected before placing the switchboard in service.

#### 8.1.4.2 Temporary Test Power Connections

To perform Primary Injection testing using a separate A.C., low-voltage test source, temporary power connection points will be required. Temporary connections are illustrated in Fig. 11 as follows:

Main incoming connections - (A), (B), (C), (N), (G)  
Main through bus connections - (A1), (B1), (C1), (N1)  
Typical load side feeder connections - (A2), (B2), (C2), (N2)

*Other temporary connection points may be required for the actual switchboard being tested.*

#### 8.1.4.3 Proper System Grounding Locations

Proper system grounding is necessary to satisfy the requirements of the National Electrical Code and for correct ground fault protection sensing.

**Note:** Additional system grounding points are not permitted on the load side of either neutral mounted ground fault sensors applied in a *residual* sensing mode or on the load side of *zero sequence* ground fault sensors.

**Caution:** There are many special ground fault protection application schemes that have been designed for multiple-source, multiple-grounded distribution systems. Only the more simple arrangements have been illustrated in Fig. 11. Consult the "job shop" drawings for possible special applications in the switchboard being tested.

#### 8.1.4.4 Appropriate Ground Fault Sensing Method

Check and ensure that the method of ground fault sensing is appropriate for the type of distribution system and the

grounding method employed. For illustration purposes, three different ground fault sensing methods are shown in Fig. 11, i.e., *Residual*, *Ground Return* and *Zero Sequence*. Depending upon the complexity of the distribution system and the ground fault system selective co-ordination desired, variations and/or combinations of these different methods may be required. *Consult the "job shop" drawings for special applications in the switchboard being tested.*

#### 8.1.4.5 Correct Sensor Polarity Connections

For proper ground fault sensing and breaker operation, the polarity connections of the ground fault sensors *must be correct*. Complete polarity relationships and secondary terminal designations for the individual Systems Pow-R Breakers are shown on drawings 1273C40, 1273C41 and in I.S. 15262.

Bus bar configurations vary between switchboards for different reasons. Fig. 11 illustrates a couple of significant variations. For example, breaker "F1" is *reverse fed*, i.e., power is supplied from the bottom side, as compared to the other breakers. In a residual sensing scheme, the polarity on the internally mounted phase current transformers - see typical breaker "M" in Fig. 11 - must be located in the same direction with respect to the supply source as the polarity on the neutral mounted sensor. All polarity markings may be either towards the source or away from the source as long as all four are the same. Since the position of the three internal phase current transformers is fixed, the variations must occur in the neutral mounted sensor. Note the variations of the polarity connections with respect to the "source" - between breakers "M", "F1", "F2" and "F3."

#### 8.1.5

Provide suitable control power source - when required - for electrical operation of all accessories involved in the testing of the selected breakers.

**Caution:** All supplementary control power utilized during Primary Injection testing *must* be kept electrically isolated from the Primary Injection test voltage. This will require a detailed review of the "job shop" drawings and could possibly require some changes as tests progress.

Any temporary control power connection modifications made to facilitate testing *must* be properly reconnected prior to placing the switchboard in service.

### 8.1.6

Rack any drawout mounted breakers being tested into the "connected" cell position.

## 8.2 THINGS TO DO BEFORE DOING ANY PHASE TESTING

### 8.2.1

*Follow all steps* - for the rating of the breaker being tested - outlined under Paragraph 7.1 entitled: "Before doing any single phase testing." *Initial* preparations for doing single phase testing on the breaker are the same whether the breaker is "in" or "out" of the drawout cell or fixed mounted cell position.

### 8.2.2

Select the breaker to be tested while following the established test plan suggested in Paragraph 8.1.4.

**Note:** For the next series of tests, the following assumptions relative to Fig. 11 will be made:

1. Breaker "M" shall be the breaker tested.
2. Power source isolation as described in Paragraph 8.1.4.1 has been accomplished by separating the supply conductors at points (1), (2) and (3).
3. Temporary test power connection points as described in Paragraph 8.1.4.2 have been established.

## 8.3 PROCEDURES FOR DOING PHASE TESTS

### 8.3.1 Overload

1. Pre-set ampere setting to 1.0X.
2. Pre-set instantaneous and short time pick-up settings to maximum position.
3. Leave all time delay band settings as pre-set or change to minimum as desired.
4. Ignore ground fault settings.
5. Conduct single phase test with connections as illustrated in Fig. 12. Start with phase "A" (points A-A1) then move to "B" (points B-B1) and "C" (points C-C1).

6. Record trip times and compare with values shown on time-current curves.

7. Reset "overload" pop-up indicator - when supplied - between tests.

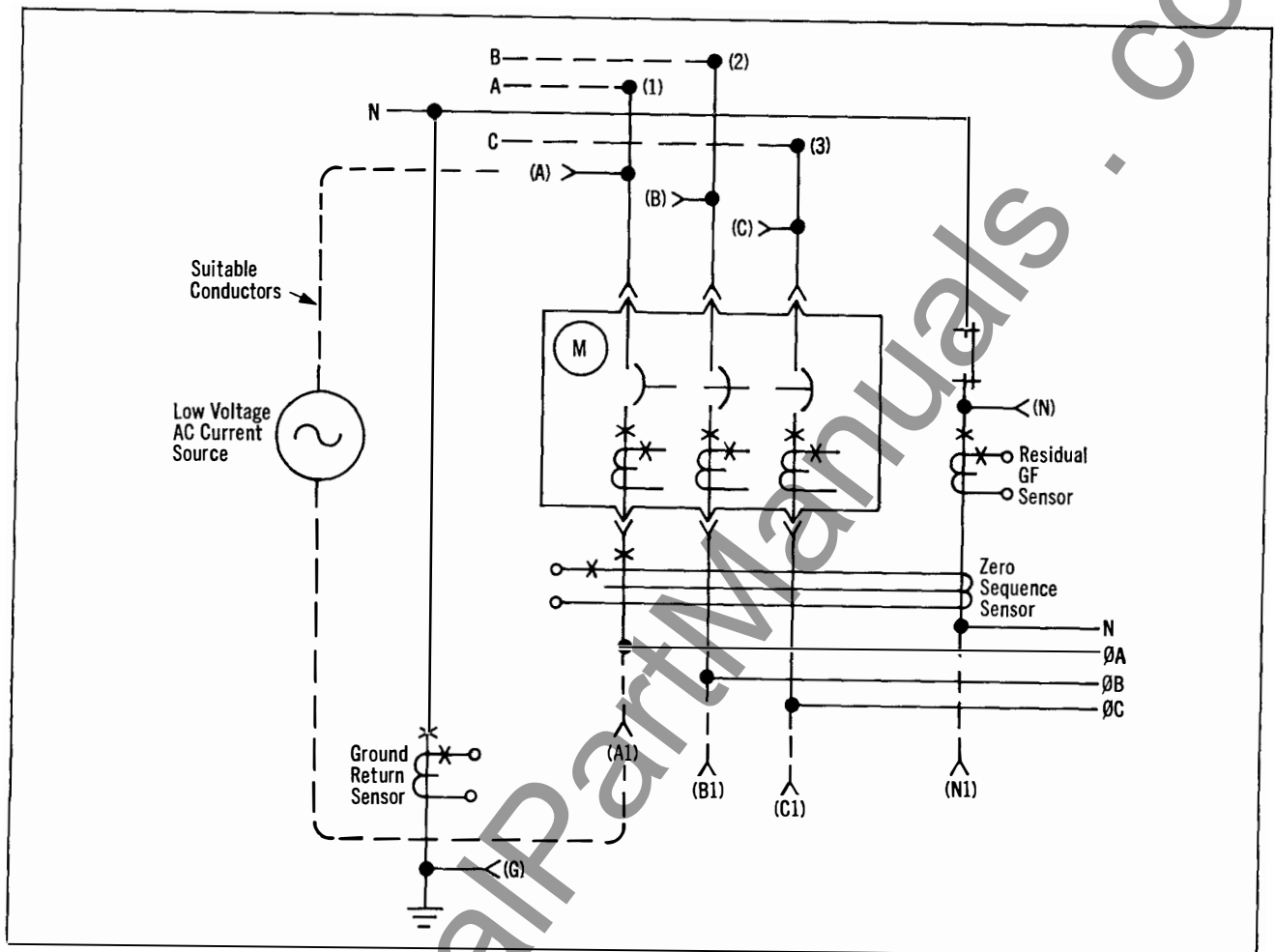
8. Reset "automatic trip relay" - when supplied as external accessory - between tests.

### 8.3.2 Instantaneous Pick-Up

1. Pre-set ampere setting to 1.0X.
2. Pre-set instantaneous pick-up to minimum position.
3. Pre-set short time pick-up to maximum position.
4. Leave all time delay band settings as pre-set or change to minimum as desired.
5. Ignore ground fault settings.
6. Conduct single phase test with connections as illustrated in Fig. 12. Start with phase "A" (points A-A1) then move to "B" (points B-B1) and "C" (points C-C1).
7. If desired, and with proper timing equipment available, record trip times and compare with values shown on time-current curves.
8. Reset "short circuit" pop-up indicator - when supplied - between tests.
9. Reset "automatic trip relay" - when supplied as accessory - between tests.

### 8.3.3 Short Time Pick-Up

1. Pre-set ampere setting to 1.0X.
2. Pre-set instantaneous pick-up to maximum position.
3. Pre-set short time pick-up to minimum position.
4. Leave all time delay band settings as pre-set or change to minimum as desired.
5. Ignore ground fault settings.
6. Conduct single phase test with connections as illustrated in Fig. 12. Start with phase "A" (points A-A1) then move to "B" (points B-B1) and "C" (points C-C1).



**Fig. 12** *Connection Details for Conducting Single Pole, Single Phase Current Tests with Breaker Connected in Cell (View taken from Fig. 14)*

7. If desired, and with proper timing equipment available, record trip times and compare with values shown on time-current curves.
8. Reset “short circuit” pop-up indicator - when supplied - between tests.
9. Reset “automatic trip relay” - when supplied as external accessory - between tests.

## 8.4 PRIOR TO TESTING TWO BREAKERS IN SERIES

Various types of single phase tests can be conducted with two breakers in series to prove different co-ordinating capabilities. For illustration purposes, only one type of test will be shown. In this example, the following assumptions will be made:

1. The two selected breakers from Fig. 11 shall be “M” and “F2”. It is further assumed that the current rating of “M” is higher than “F2.”
2. The two breakers in series tests are a follow-up to the single *phase* tests described for breaker “M” under 8.2 and 8.3
3. Ground fault protection for breaker “F2” has also been defeated in line with the applicable instructions from Paragraph 7.1 entitled: “Things to do Before Doing Any Single *Phase* Testing.”

#### 8.4.1 Procedures for Testing Co-ordination of Two Breakers in Series on Short Time Delay, i.e., Breakers “M” and “F2” of Fig. 11

1. Pre-set ampere settings of breakers “M” and “F2” to 1.0X.

2. Pre-set instantaneous pick-up of breakers "M" and "F2" to maximum position.
3. Pre-set short time pick-up of breakers "M" and "F2" to minimum position.
4. Leave long time delay band settings of breakers "M" and "F2" as pre-set.
5. Ignore ground fault settings.
6. Set short time delay band settings of breaker "F2" to minimum (0.1 sec.) and breaker "M" to intermediate (0.2 sec.).
7. Pre-set the single phase test current to be 25% above the pick-up setting of breaker "M."
8. Conduct single phase test with connections to temporary terminals at points "A" and "A2" of Fig. 11. If desired, move next to points "B" and "B2" and then to points "C" and "C2." (Since this is a timing test, *a single test should suffice.*)

Results: Only breaker "F2" should trip.

9. Reset "short circuit" pop-up indicator and "automatic trip relay" for breaker "F2" when supplied as options.

## 8.5 THINGS TO DO BEFORE DOING GROUND FAULT TESTING

**Caution:** Before attempting any ground fault testing with the breaker in the "connected" cell position, the jumper connections on the side mounted, four point GFP terminal will have to be in the correct position. Should the ground fault tests follow the single phase tests outlined beginning with Paragraph 8.4, then changes will be required from those used during the single phase tests.

When conducting ground fault tests using Primary Injection test methods with the breaker in the "connected" cell position, the jumpered connections on the GFP terminal block should be connected to agree with the ground fault application mode of the breaker being tested, i.e., *residual, source ground or zero sequence. Reference to the appropriate "job shop" drawings will be required to determine the correct application mode for each breaker tested.*

There are many special ground fault protection schemes - particularly for main and tie breakers - that have been designed for multiple source/multiple grounded dis-

tribution systems. Where any questions exist, contact the Specifying Engineer, the switchboard assembly plant or the breaker manufacturer direct for proper testing instructions.

**Note:** If the breaker is drawout mounted, these GFP terminal block connections can best be made and the instructions better seen with the breaker in the "with-drawn" cell position. Therefore, rack the breaker into this position using instructions given in I.B. 15082 under Section 3.2. Return the breaker to the "connected" position when the jumpered connections are properly installed.

### 8.5.1

Connect the side mounted GFP terminal block to agree with required application mode.

#### 8.5.1.1 Residual Application Mode

8.5.1.1.1 250/800/1200/1600/2000 Amp Breaker Frames (2000 Amp in Compact 16 In. High Frame)

Refer to the side mounted instruction label which should be the same as Fig. 7 of this leaflet and make the following connections:

1. Connect shorting straps D1 to D5 and D6 to D2.
2. "Store" the "yellow" test lead in the operating position between terminals D6 and D2.

8.5.1.1.2 2000/2500/3000/4000 Amp Breaker Frames (2000 Amp in 22 In. High Frame)

Refer to the side mounted instruction label which should be the same as Fig. 8 of this leaflet and make the following connections:

1. Connect shorting straps D6 to D5 and D8 to D7.
2. "Store" the "yellow" test lead in the operating position on terminal D6.

#### 8.5.1.2 Zero Sequence or Source Ground Application Mode

8.5.1.2.1 250/800/1200/1600/2000 Amp Breaker Frames (2000 Amp in Compact 16 In. High Frame)

Refer to the side mounted instruction label which should be the same as Fig. 7 of this leaflet and make the following connections:

1. Connect both shorting straps from D5 to D6.
2. "Store" the "yellow" test lead in the operating position on terminal D1.

#### 8.5.1.2.2 2000/2500/3000/4000 Amp Breaker Frames (2000 Amp in 22 In. High Frame)

Refer to the side mounted instruction label which should be the same as Fig. 8 of this leaflet and make the following connections:

1. Connect shorting straps D5 to D8 and D8 to D7.
2. "Store" the "yellow" test lead in the operating position on terminal D6.

#### 8.5.2

Using Table 2 (page 29) as a guide, establish approximate test current levels as follows:

Frame Rating Being Tested	Test Current Amperes
250	66
800	200
1200	318
1600	400
2000①	504
2000/2500/3000②	798
4000	1154

① 2000 amp in compact 16 in. high frame.

② 2000 amp in 22 in. high frame.

#### 8.5.3

Determine the desired operating mode of the zone interlocking for the breaker being tested.

Systems Pow-R Breakers are equipped with zone interlocking circuitry on ground fault protection. As such, while being tested in the "connected" cell position, breakers tested individually will trip near instantaneously (0.08 sec.) regardless of the time delay band setting, unless a jumper is added between control terminals C4 and C5. With this done, the breaker will respond to the pre-set time delay setting. (This jumper and note are also shown on connection diagram 1366D30 and I.S. 15262.)

### 8.6 PROCEDURE FOR TESTING GROUND FAULT PICK-UP OF A SINGLE BREAKER

**Note:** For this test, the following assumptions relative to Fig. 11 will be made:

1. Breaker "M" in Figs. 11 and 12 shall be the breaker tested.
2. Power source isolation as described in Paragraph 8.1.4.1 has been accomplished by separating the supply conductors at points (1), (2) and (3).
3. Temporary test power connection points as described in Paragraph 8.1.4.2 have been established.

#### 8.6.1

Pre-set trip unit as follows:

Ampere Setting	- 1.0X
Instantaneous Pick-Up	- Maximum Position
Short Time Pick-Up	- Maximum Position
Long Time Band	- Leave as Pre-set
Short Time Band	- Leave as Pre-set
Ground Fault Pick-Up	- Minimum Position
Ground Fault Time	- Minimum Position

#### 8.6.2

Pre-set the test current for the rating of the breaker frame being tested as suggested in Paragraph 8.5.2.

#### 8.6.3

Add temporary jumper connections between points (A1), (B1), (C1), and (N1).

**Caution:** Jumpers should be removed following completion of testing breaker "M" alone.

#### 8.6.4

Conduct appropriate tests depending upon mode of GFP sensing employed.

##### 8.6.4.1 Residual Sensing Mode - Only

##### 8.6.4.1.1

Conduct single phase test using Fig. 12 as a reference. Start with connections at points (A) and (N1).

## Results

1. The breaker should open.
2. The “ground fault” indicator - when supplied - should pop-up.
3. The LED indicator on the remote mounted automatic trip relay - when supplied - should turn “on.”
4. The ground fault indicating lamp on the remote mounted ground fault test panel - when supplied - should turn “on.”

### 8.6.4.1.2

Record trip time - if suitable equipment is available - and compare with values shown on time-current curves.

**Note:** If suitable timing equipment is not available, it should be adequate to run two tests on one pole to confirm that the time delay circuitry is operating. Run the first test with the time delay set at minimum (0.1 sec.) and the second test at maximum (0.5 sec.). There should be a distinguishable, audible time delay between the two tests.

### 8.6.4.1.3

Reset the “ground fault” pop-up indicator, the automatic trip relay indicator and the ground fault test panel “ground fault” indicator lamp when these options are supplied. Failure to reset either of these accessories will not affect subsequent breaker operations, but will prohibit proper “ground fault” trip indication on subsequent tests.

### 8.6.4.1.4

Conduct additional tests - *if desired* - with connections at points (B) and (N1) and at points (C) and (N1). The results should be the same as under 8.6.4.1.1.

### 8.6.4.1.5

Conduct single phase test using Fig. 12 as a reference. Start with connections at points (A) and (N). *Maintain the test current for approximately 2-3 seconds only.*

## Results

1. The breaker should not open.
2. No indicator accessories - if supplied - should operate.

**Note:** This test confirms the correctness of the polarity relationship between the internal phase current transformer and the neutral mounted residual sensor.

### 8.6.4.1.6

Conduct additional tests - *if desired* - with connections at points (B) and (N) and at points (C) and (N).

## Results

1. The breaker should not operate at either test location.

### 8.6.4.2 Zero Sequence Sensing Mode - Only

#### 8.6.4.2.1

Using Fig. 12 as a reference, conduct single phase test with connections at points (A) and (N1).

## Results

1. Breaker should open with other results and follow-up actions the same as under “Residual sensing” Paragraph 8.6.4.1.1 through 8.6.4.1.3.

#### 8.6.4.2.2

Using Fig. 12 as a reference, conduct single phase test with connections at points (A) and (N). *Maintain the test current for approximately 2-3 seconds only.*

## Results

1. The breaker should not open.
2. No indicator options - if supplied - should operate.

### 8.6.4.3 Source Ground (or Ground Return) Sensing - Only

Using Fig. 12 as a reference, conduct single phase test with connections at points (A) and (G).

## Results

1. Breaker should open with other results and follow-up actions the same as under “Residual sensing” Paragraph 8.6.4.1.1 through 8.6.4.1.3.

#### 8.6.4.3.2

Using Fig. 12 as a reference, conduct single phase test



with connections at points (A) and (N). *Maintain the test current for approximately 2-3 seconds only.*

#### Results

1. The breaker should not open.
2. No indicator options - if supplied - should operate.

### 8.7 PROCEDURE FOR TESTING GROUND FAULT PICK-UP OF TWO BREAKERS IN SERIES

**Note:** Various types of ground fault tests can be conducted with two breakers in series to prove different co-ordinating capabilities. For this example illustration, only one type of test will be covered and the following assumptions will be made:

1. The two selected breakers from Fig. 11 shall be "M" and "F2" and the current rating of "M" shall be higher than "F2".
2. Both breakers "M" and "F2" shall have their side mounted GFP terminal blocks properly connected for "Residual" sensing application. (Refer to Paragraph 8.5.1.)
3. Ground fault interlock wiring between breakers (M) and (F2) may or may not be connected as required by the "job shop" drawings. When used, the connections shall be in accordance with drawing 1366D30 or I.S. 15262 - see Paragraph 8.5.3.

**Caution:** Due to the mode of operation of the ground fault timing circuitry plus the added influence of component tolerance variations, timing variations can exist between breakers being tested in series with single phase ground fault tests initiated from a no-load start-up condition versus an actual ground fault tripping operation initiated during a normal three phase loaded condition. This testing condition can lead to what appears to be a lack of co-ordination during the single phase testing stage if trip units are set too close between protective zone levels.

For the above reason, it is recommended that each trip unit - including those utilizing zone selective interlocking circuitry - between protective zone levels be set with at least one time level difference between ground fault protective zones.

4. Any trip times recorded shall have been made with suitable timing equipment.

#### 8.7.1

Pre-set trip units as follows:

##### Breakers "M" and "F2"

Ampere Setting	- 1.0X
Instantaneous Pick-Up	- Maximum Position
Short Time Pick-Up	- Maximum Position
Long Time Band	- Leave as Pre-set
Short Time Band	- Leave as Pre-set
*Ground Fault Pick-Up	- Minimum Position

\*If minimum position of both breakers "M" and "F2" should be 600 amps, then set breaker "M" to 750 amps and uprate test current accordingly.

##### Breaker "M"

Ground Fault Time	- Maximum Position (0.5 sec)
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##### Breaker "F2"

Ground Fault Time	- Intermediate Position (0.3 sec)
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#### 8.7.2

Pre-set test current as suggested in Paragraph 8.5.2 for breaker "M." Should the recommended test current for breakers "M" and "F2" be the same, i.e., 800 amps, then increase the test current to 1000 amps.

#### 8.7.3

Conduct co-ordination tests as a function of mode of zone interlocking employed, i.e.:

##### 8.7.3.1

*Zone interlocking defeated*, i.e., terminals C4 to C5 jumpered per drawing 1366D30 or I.S. 15262 on breakers "M" and "F2."

##### 8.7.3.1.1

Conduct single phase test using Fig. 11 as a reference with connections at points (A) and (A2).

#### Results

1. Only breaker "F2" should open.
2. The "ground fault" indicator on breaker "F2" - when supplied - should pop-up.

3. The LED indicator on the remote mounted automatic trip relay for breaker "F2" - when supplied - should turn "on."

4. The ground fault indicating lamp on the remote ground fault test panel for breaker "F2" - when supplied - should turn "on."

5. The total opening time should be 0.3 seconds.

**Note:** This test time confirms that the interlocking circuitry on breaker "F2" is operating.

#### 8.7.3.1.2

Remove jumper C4 to C5 on breaker "F2."

#### 8.7.3.1.3

Reclose breaker "F2," reset all related accessories.

#### 8.7.3.1.4

Re-conduct the same single phase test as described in Paragraph 8.7.3.1.1.

#### Results

1. Same as in Paragraph 8.7.3.1.1 except the total opening time should be 0.08 seconds.

### 8.7.3.2 Zone Interlock Wiring Between Breakers "M" and "F2" Used

#### 8.7.3.2.1

Change ground fault time settings as used in the previous test as follows:

*Breaker "M"* - Intermediate position (0.3 sec.)

*Breaker "F2"* - Maximum position (0.5 sec.)

#### 8.7.3.2.2

Add jumper between terminals C4 and C5 on breaker "F2" only.

#### 8.7.3.2.3

Conduct single phase test using Fig. 11 as a reference with connections at points (A) and (A2).

#### Results

1. Only breaker "M" should open.

2. The "ground fault" indicator on breaker "M" - when supplied - should pop-up.

3. The LED indicator on the remote mounted automatic trip relay for breaker "M" - when supplied - should turn "on."

4. The ground fault indicating lamp on the remote mounted ground fault test panel for breaker "M" - when supplied - should turn "on."

5. The total opening time should be 0.3 seconds.

**Note:** This test confirms the accuracy of the timing circuitry of breaker "M" as well as sets the stage for the following test.

#### 8.7.3.2.4

Reclose breaker "M," reset all related accessories and re-conduct the same test as described above under Paragraph 8.7.3.2.3 except remove jumper C4 to C5 on breaker "F2."

#### Results

1. Only breaker "F2" should open and the related indicators should operate.

2. The total opening time should be 0.08 seconds.

**Note:** This test confirms that the interlocking circuitry between breakers "F2" and "M" is operating.

### 8.7.4 Confirm Correctness of Polarity Relationship of Neutral Sensors on Breakers "M" and "F2"

#### 8.7.4.1

Pre-set ground fault time settings as follows:

*Breaker "M"* - Maximum position (0.5 sec.)

*Breaker "F2"* - Intermediate position (0.3 sec.)

#### 8.7.4.2

Return zone interlocking wiring to "job shop" drawing position, i.e., either used or defeated.

#### 8.7.4.3

Referring to Fig. 11, add suitable connection between points (A2) and (N2).

#### 8.7.4.4

Conduct single phase test using Fig. 11 as a reference with connections at points (A) and (N). *Maintain test current approximately 2-3 seconds.*

#### Results

Neither breaker “M” nor “F2” should open.

**Note:** This test confirms the correct polarity relationship of the neutral mounted sensors used with breakers “M” and “F2.”

### 8.8 RESULTS OF TESTS CONDUCTED WITH BREAKER IN CELL

Should any breaker fail initially to comply with published time-current trip characteristics or other expected test results, review the complete instructions, test plan and re-test to confirm the initial results. Should the tests again fail to comply, do not return the breaker to service until corrective actions have been taken.

Since the tests were conducted with the breaker in the “connected” cell position, the operating difficulty - depending on the type of problem - could be in the testing procedure used, in the switchboard assembly or in the breaker proper. Should the problem be determined to be in the breaker, then contact the factory for further instructions.

### 8.9 THINGS TO DO BEFORE RETURNING THE BREAKER AND/OR SWITCHBOARD TO SERVICE

#### 8.9.1

Return all trip unit settings to original position using data recorded prior to beginning the tests. *Revise position settings where required.*

#### 8.9.2

Remove all temporary connections and place the switchboard in original “job shop” drawing condition. *Make “job shop” drawing modifications where required and advise the switchboard supplier accordingly.*

#### 8.9.3

Restore all power service connections temporarily removed for the purpose of power source isolation during “in cell” testing.

#### 8.9.4

Connect the side mounted GFP terminal block on all breakers equipped with ground fault protection for the type of sensing application specified in the “job shop” drawings. Place all “yellow” ground fault defeater test leads in the operating position per the instructions provided.

#### 8.9.5

Return all breakers to their proper cell position as required per the “job shop” drawings following instructions provided in I.B. 15082.

#### 8.9.6

Prepare suitable test records for future reference and deliver to the switchboard user.

## Section 9—Full Power Tests with Breaker in Cell—for Ground Fault Performance Verification

### 9.1 GENERAL INFORMATION

The performance of a single Systems Pow-R Breaker can be adequately tested as a component of a switchboard by using either *Simulated* test methods described in Section 5 or *Primary Injection* test methods as described in Section 7. Since proper ground fault protection includes not only the breaker but also externally mounted ground current sensors that may be applied in a variety of sensing schemes, properly installed grounding connections and

correct electrical interconnections, complete verification testing requires alternate test methods. Proper ground fault performance can best be verified by testing all components as a “system” under *Full Power* conditions.

*Full Power* testing as described in this leaflet involves the creation of a controlled, low level, phase to ground test current in a completely connected and energized switchboard for the purpose of testing under realistic conditions the ground fault protection system. This test cur-

rent will be established via the use of a suitably selected power resistor temporarily connected phase to ground at the desired test locations. Using this approach, all components involved in the ground fault protection system will be tested *simultaneously* under “as built” and installed conditions.

The 1978 edition of the National Electrical Code under Article 230-95-c requires that a ground fault protection system be “performance tested” when *first installed*.

Local codes have begun to supplement this requirement by requiring not only the initial test but repeat tests on an annual basis with complete records maintained - which shall be available to the inspection authority - including the following types of information:

- 1 - Current and time delay settings
- 2 - Results of the initial and annual tests
- 3 - All operations of the ground fault protection relay - or system
- 4 - Such corrective measures as may be required to assure proper functioning of the ground fault interrupter

## 9.2 WHEN TO TEST – USING FULL POWER TEST METHODS

**Caution:** Full power testing should be conducted *only* by qualified testing personnel using appropriate test equipment and procedures.

Initial full power testing should be done when the switchboard is first installed and the accuracy of the installation is confirmed to be in accordance with the Specifying Engineer’s drawings, the switchboard manufacturer’s “job shop” drawings and applicable code requirements. *Tests should be conducted prior to the time any loads are connected.*

Any subsequent Full Power testing - if and when required - should be scheduled during a normal maintenance shut down to avoid any unnecessary load interruptions.

## 9.3 THINGS TO DO BEFORE DOING ANY FULL POWER TESTING

### 9.3.1

Confirm that the switchboard is accurately installed in accordance with the Specifying Engineer’s drawings, the

Switchboard Manufacturer’s “job shop” drawings and applicable code requirements. *Clear any modifications required with the responsible authority.*

### 9.3.2

Review all applicable steps outlined under Section 3, i.e., “Things to do Prior to Field Testing Any Systems Pow-R Breaker.”

### 9.3.3

Complete all planned preliminary testing of the Systems Pow-R Breakers whether it be of the *Simulated* (Section 5) or *Primary Injection* (Section 6) type testing.

### 9.3.4

Establish a *Full Power* test plan. Contact the user, Specifying Engineer or equipment manufacturer where questions arise that could affect the outcome of the planned tests.

### 9.3.5

Establish approximate test current levels in line with the breaker ratings being tested. These levels will establish the required test resistor ratings.

### 9.3.6

Conduct all tests with the ground fault pick-up settings pre-set for the test at minimum values. Actual test currents should be approximately 125-150% of these setting values to ensure breaker operation. Field tests should be “go/no-go” type tests rather than calibration tests. Suggested test current levels are shown in Table 2.

**Caution:** Should only one value of test current be used for all breaker frame ratings that is in excess of the largest values shown in Table 2, the lower rated breakers could open via either short time or instantaneous circuitry - depending upon their specific settings - rather than on ground fault which is the purpose of the test. To determine possible conflicts, review the value of the rating plug installed, the trip unit settings and the applicable time-current curve.

### 9.3.7

Determine appropriate power resistor in line with suggested test current levels. The exact values selected for any given breaker will be a factor of the system voltage

and available resistors. Table 2 suggests a series of test current levels that are based on series/parallel combinations of a standard style resistor that is available. An infinite number of alternate combinations could be developed depending upon the combinations and ratings of resistors available.

A typical resistor calculation on a 480Y/277 volt distribution system using a 1600 amp rated breaker with a minimum ground fault pick-up setting of 320 amps (0.2 x 1600) and a suggested test current of 400 amps (125% x 320) would be as follows:

$$R = \frac{277 (V_L - N)}{400 \text{ amps}} = .695 \text{ ohms}$$

**Caution:** The resistors shown in Table 2 have been selected on the basis of their 10 second current rating. The tests conducted should be programmed and the equipment provided - if necessary - to ensure that this time period is not exceeded.

#### 9.3.8

Place all breakers involved in the ground fault tests in the "connected" position - if drawout type construction - us-

ing instructions provided in I.B. 15082 under Section 3.2. All breakers not involved in the ground fault tests should be either "open" or in the "disconnected" cell position.

### 9.4 PROCEDURE FOR GROUND FAULT TESTING A MAIN BREAKER IN A TYPICAL SWITCHBOARD

**Note:** For this example illustration, Fig. 11 will be used and the breaker tested will be "M." The mode of ground fault sensing used will be assumed to be *Residual*. Similar test concepts can be developed using the "job shop" drawings of the actual switchboard to be tested.

#### 9.4.1

Pre-set the ground fault pick-up setting of breaker "M" to the *minimum* position. All other settings may remain as pre-set for operational conditions as determined by the Specifying Authority.

#### 9.4.2

Select the proper test resistor for the applicable phase to ground voltage from Table 2 for the rating of the breaker frame being tested.

**Table 2. Suggested Test Current and Resistor Ratings for Full Power Ground Fault Tests**

Breaker Frame Rating Being Tested	Minimum Ground Fault Pick-Up Amperes	Phase to Ground Voltage									
		120 Volts					277 Volts				
		Suggested Test Current in Amps	Resistor Test Resistance Ohms	Tap Position in Ohms	No. Resistors in Series	No. Resistors in Parallel	Suggested Test Current in Amps	Resistor Test Resistance Ohms	Tap Position in Ohms	No. Resistors in Series	No. Resistors in Parallel
250	50	86	A 1.39	1.39	1	—	66	A 4.17	1.39	3	—
800	160	218	A 0.275	0.55	1	—	200	A 1.39	1.39	1	—
1200	240	325	A 1.39	0.739	—	2	318	D 2.18	1.74	—	2
1600	320	436	A 0.55	0.55	—	2	400	A 0.695	1.39	—	2
2000 <sup>①</sup>	400	536	C 0.28	0.224	1	—	504	A 1.39	1.10	—	2
2000/2500/3000 <sup>②</sup>	600	779	B 0.154	0.154	1	—	798	A 0.347	1.39	—	4
4000	900	1125	C 0.28	0.224	—	2	1154	A 0.24	1.2	—	5

<sup>①</sup> Compact 16 In. High Frame. <sup>②</sup> Twenty-two In. (22 In.) High Frame.

All resistors shown below are Westinghouse Type LG that have been selected on the basis of their ohmic value and 10 second current rating.

Resistor

A - S# 1777568, 1.39 ohms, 255 amps; B - S# 1777564, 0.187 ohms, 870 amps; C - S# 1777565, 0.28 ohms, 630 amps;  
D - S# 1776157 ohms, 158 amps.

#### 9.4.3

With the switchboard de-energized and all safety conditions observed, place the test resistor between temporary test points (A1) and (G) as shown in Fig. 11.

#### 9.4.4

Energize the switchboard from the normal power source.

#### 9.4.5

Close breaker "M."

##### Results

1. Breaker "M" will open near instantaneously (0.08 sec.) regardless of the time delay setting if the zone interlocking *has not* been defeated or,
2. Breaker "M" will open with the time delay as pre-set (0.1, 0.3, or 0.5 sec.) if the zone interlocking *has been* defeated, i.e., jumper added to terminals C4 and C5 as shown on drawing 1366D30 and I.S. 15262.
3. The "ground fault" indicator on breaker "M" - when supplied should pop-up.
4. The LED indicator on the remote mounted automatic trip relay for breaker "M" - when supplied - should turn "on."
5. The ground fault indicating lamp on the remote mounted ground fault test panel for breaker "M" - when supplied - should turn "on."

#### 9.4.6

Reset the "ground fault" pop-up indicator, the automatic trip relay indicator and the ground fault test panel "ground fault" indicator lamp when these accessories are provided. Failure to reset any of these items will not affect subsequent breaker operations but will prohibit proper "ground fault" trip indication on subsequent tests.

#### 9.4.7

Conduct additional tests - if desired - with the test resistor connections between points (B1) and (G) and then (C1) and (G). The results should be the same as above.

**Caution:** De-energize the switchboard and observe all safety conditions before changing the test resistor each time.

#### 9.4.8

When the *Residual* method of ground fault sensing is employed, confirm the accuracy of the neutral sensor polarity connections by doing the following:

##### 9.4.8.1

With the switchboard de-energized and all safety conditions observed, place the test resistor between temporary test points (A1) and (N1) as shown in Fig. 11.

##### 9.4.8.2

Energize the switchboard from the normal power source.

##### 9.4.8.3

Close breaker "M."

##### Results

1. Breaker "M" should not open.
2. No optional indicators - when supplied - should operate.

##### 9.4.8.4

Open breaker "M" manually *after 2-3 seconds* to protect the test resistor.

##### 9.4.8.5

De-energize the switchboard, observe all safety conditions and remove the test resistor.

### 9.5 PROCEDURE FOR GROUND FAULT CO-ORDINATION TESTING TWO BREAKERS IN SERIES IN A TYPICAL SWITCHBOARD

**Note:** For this example illustration, Fig. 11 will be used and the breakers tested will be "M" and "F2." The mode of ground fault sensing used will be assumed to be Residual. Similar test concepts can be developed using the "job shop" drawings of the actual switchboard to be tested.

#### 9.5.1

Pre-set the ground fault pick-up setting of both breakers to the *minimum* position. All other settings may remain as pre-set for operational conditions as determined by the Specifying Authority.

### 9.5.2

Select the proper test resistor for the applicable phase to ground voltage from Table 2 for the rating of breaker frame "M" being tested.

**Caution:** Should the resistor size selected for breaker "M" be such that the test current will exceed the instantaneous pick-up and/or short time delay settings of breaker "F2" - which may have a low value rating plug installed - the following steps may be necessary to avoid incorrect tripping mode of breaker "F2":

1. Either temporarily adjust the instantaneous and/or short time pick-up settings of breaker "F2" to the maximum position or
2. Temporarily change the rating plug installed in breaker "F2" to the maximum rating available or
3. Do both.

### 9.5.3

With the switchboard de-energized and all safety conditions observed, place the test resistor between temporary test points (A2) and (G) as shown in Fig. 11.

### 9.5.4

Energize the switchboard from the normal power source.

### 9.5.5

Close breaker "M" and then breaker "F2."

#### Results

1. Breaker "F2" will open near instantaneously (0.08 sec.) regardless of the time delay setting if the zone interlocking *has not* been defeated or
2. Breaker "F2" will open with the time delay as preset (0.1, 0.3, or 0.5 sec.) if the zone interlocking *has been* defeated, i.e., jumper added to terminals C4 and C5 on breaker "F2" as shown on drawing 1366D30 and I.S. 15262.
3. Any ground fault indicator accessory provided with breaker "F2" will operate.

### 9.5.6

Reset all optional ground fault indicators associated with breaker "F2."

### 9.5.7

Conduct additional tests - if desired - with the test resistor connections between points (B2) and (G) and then (C2) and (G). The results should be the same as above.

**Caution:** De-energize the switchboard and observe all safety conditions before changing the test resistor each time.

### 9.5.8

When the *Residual* method of ground fault sensing is employed on breaker "F2," confirm the accuracy of the "F2" neutral sensor polarity connections by doing the following:

**Note:** The method of sensing employed on breaker "M" will not affect this test nor will "M" operate.

#### 9.5.8.1

With the switchboard de-energized and all safety conditions observed, place the test resistor between temporary test points (A2) and (N2) as shown in Fig. 11.

#### 9.5.8.2

Energize the switchboard from the normal power source.

#### 9.5.8.3

Close breaker "M" then breaker "F2."

#### Results

1. Neither breaker "M" nor "F2" should open.
2. No indicators associated with either breaker should operate.

#### 9.5.8.4

Open breaker "F2" manually *after 2-3 seconds* to protect the test resistor.

#### 9.5.8.5

De-energize the switchboard, *observe all safety conditions* and remove the test resistor.

## 9.6 SPECIAL PURPOSE GROUND FAULT PROTECTION SYSTEMS, i.e., MULTIPLE SOURCE/MULTIPLE GROUND SYSTEMS

There are many special ground fault protection schemes that have been designed for multiple source, single and multiple ground distribution systems. Only the more simple arrangements for a single source, radial distribution system have been covered in this leaflet. If the basic principle is understood from these examples, then an adequate test program can be established for the more complex systems using similar logic. *Consult the Manufacturer's "job shop" drawings and establish appropriate test procedures for the actual switchboard being tested.*

Regardless of the type of sensing scheme provided for the main service breakers and tie breakers in a multiple source system, similar *Full Power* tests as described in this leaflet can be conducted to verify the performance of the ground fault protection system of these breakers. Once the incoming service protection system has been performance verified, then co-ordination can be verified with the downstream feeders.

## 9.7 RESULTS OF TESTS CONDUCTED USING "FULL POWER" PROCEDURES

Should any breaker fail initially to comply with expected test results, review the complete instructions and test plan and if all details are correct, retest to confirm the initial results. Should the tests again fail to comply, do not place the switchboard in service until corrective actions have been taken.

Since the tests were conducted with the breakers in the "connected" cell position, the operating difficulty - depending on the type of problem - could be in the testing procedure used, the switchboard assembly or in the breaker proper. Should the problem be determined to be in the breaker, then contact the factory for further instructions.

## 9.8 THINGS TO DO BEFORE PLACING THE SWITCHBOARD IN SERVICE

### 9.8.1

Return all trip unit settings to original position using data recorded prior to beginning the tests. *Revise position settings where required.*

### 9.8.2

Remove all temporary connections and place the switchboard in original "job shop" drawing condition. *Make modifications where required and advise the switchboard supplier accordingly.*

### 9.8.3

Return all breakers to their proper cell position as required per the "job shop" drawings following instructions provided in I.B. 15082.

### 9.8.4

Prepare suitable test records for future reference and deliver to the switchboard user for his information and records.