Vacuum Circuit Breakers
5kV and 15kV, Type GMI

Power Transmission and Distribution, Inc.

Instruction
Installation
Operation
Maintenance

SGIM-3268H

SIEMENS

Courtesy of NationalSwitchgear.com
**DANGER**

Hazardous voltages.

Will cause death, serious injury or equipment damage.

Always de-energize and ground the equipment before maintenance. Read and understand this instruction manual before installing, operating, or maintaining the equipment. Maintenance should be performed only by qualified personnel. The use of unauthorized parts in the repair of the equipment or tampering by unqualified personnel will result in dangerous conditions which will cause death, severe personal injury, or equipment damage. Follow all safety instructions contained herein.

**IMPORTANT**

The information contained herein is general in nature and not intended for specific application purposes. It does not relieve the user of responsibility to use sound practices in application, installation, operation, and maintenance of the equipment purchased. Siemens reserves the right to make changes in the specifications shown herein or to make improvements at any time without notice or obligations. Should a conflict arise between the general information contained in this publication and the contents of drawings or supplementary material or both, the latter shall take precedence.

**QUALIFIED PERSONS**

For the purpose of this manual a qualified person is one who is familiar with the installation, construction or operation of the equipment and the hazards involved. In addition, this person has the following qualifications:

(a) is trained and authorized to de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.

(b) is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

(c) is trained in rendering first aid.

**SUMMARY**

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser’s purposes, the matter should be referred to the local sales office.

The contents of this instruction manual shall not become part of or modify any prior or existing agreement, commitment or relationship. The sales contract contains the entire obligation of Siemens Power Transmission & Distribution Inc. The warranty contained in the contract between the parties is the sole warranty of Siemens Power Transmission & Distribution Inc. Any statements contained herein do not create new warranties or modify the existing warranty.
# 5kV and 15kV Vacuum Circuit Breakers

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Introduction

The GMI family of vacuum circuit breakers is designed to meet all the applicable ANSI, NEMA and IEEE standards. Successful application and operation of the equipment depends as much upon proper installation and maintenance by the user as it does upon the careful design and fabrication by Siemens.

The purpose of this Installation Manual is to assist the user in developing safe and efficient procedures for the installation, maintenance and use of the equipment.

Contact the nearest Siemens representative if any additional information is desired.

Qualified Person

For the purpose of this manual and product labels, a “Qualified Person” is one who is familiar with the installation, construction and operation of this equipment, and the hazards involved. In addition, this person has the following qualifications.

• Training and authorization to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
• Training in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses, face shield, flash clothing, etc., in accordance with established safety procedures.
• Training in rendering first aid.

Signal Words

The signal words “Danger”, “Warning” and “Caution” used in this manual indicate the degree of hazard that may be encountered by the user. These words are defined as:

Danger—Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

Warning—Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution—Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Dangerous Procedures

In addition to other procedures described in this manual as dangerous, user personnel must adhere to the following:

1. Always work on a de-energized circuit breaker. Always de-energize a circuit breaker, and remove it from the metal-clad switchgear before performing any tests, maintenance or repair.
2. Always perform maintenance on the circuit breaker after the spring-charged mechanisms are discharged (except for test of the charging mechanisms).
3. Always let an interlock device or safety mechanism perform its function without forcing or defeating the device.

Field Service Operation

Siemens can provide competent, well-trained Field Service Representatives to provide technical guidance and advisory assistance for the installation, overhaul, repair and maintenance of Siemens equipment, processes and systems. Contact regional service centers, sales offices or the factory for details, or telephone Siemens Field Service at 1-800-347-6659 (919-365-2200 outside the U.S.)
Introduction
Type GMI Vacuum Interrupter Circuit Breakers are normally installed in assembled metal-clad switchgear, and the Switchgear Instruction Manual (SGIM-3258) contains the Receiving, Handling and Storage instructions for assembled metal-clad switchgear.

This manual covers the Receiving, Handling and Storage instructions for Type GMI circuit breakers shipped separately from the switchgear. This section of the manual is intended to help the user identify, inspect and protect the circuit breaker prior to its installation.

Receiving Procedure
Make a physical inspection of the shipping container before removing or unpacking the circuit breaker. Check for shipment damage or indications of rough handling by the carrier. Check each item against the manifest to identify any shortages.

Accessories, such as the manual charging lever, the racking crank and the plug jumper, are shipped separately.

Shipping Damage Claims (When Applicable) - Follow normal shipment damage procedures, which should include:

1. Check for visible damage upon arrival.
2. Visible damage must be noted on delivery receipt, and acknowledged with driver’s signature. Notation, “Possible internal damage, subject to inspection” must be on delivery receipt.
3. Notify Siemens Sales office immediately of any shipment damage.
4. Arrange for carrier’s inspection. Do not move the unit from its unloading point.

Handling Procedure
1. Carefully remove the shipping carton from the circuit breaker. Keep the shipping pallet for later use if the circuit breaker is to be stored prior to its installation.
2. Inspect for concealed damage. Notification to carrier must take place within 15 days to assure prompt resolution of claims.
3. Each circuit breaker should be appropriately lifted to avoid crushing the side panels of the circuit breaker, or damaging the primary disconnect subassemblies.

Type GMI circuit breakers weigh between 385 to 575 pounds (175 to 261 kg). See Table A-4, Technical Data in Appendix.

4. The palleted circuit breaker can also be moved using a properly rated fork-lift vehicle. The pallets are designed for movement by a standard fork-lift vehicle.

Storage Procedure
1. Whenever possible, install circuit breakers in their assigned switchgear enclosures for storage. Follow instructions contained in the Switchgear Instruction Manual.
2. When the circuit breaker will be placed on its pallet for storage, be sure the unit is securely bolted to the pallet and covered with polyethylene film at least 10 mils thick.

Indoor Storage - Whenever possible, store the circuit breaker indoors. The storage environment must be clean, dry and free of such items as construction dust, corrosive atmosphere, mechanical abuse and rapid temperature variations.

Outdoor Storage - Outdoor storage is not recommended. When no other option is available, the circuit breaker must be completely covered and protected from rain, snow, dirt and all other contaminants.

Space Heating - Space heating must be used for both indoor and outdoor storage to prevent condensation and corrosion. When stored outdoors, between 150 and 200 watts per circuit breaker of space heating is recommended. If the circuit breakers are stored inside the switchgear enclosures, and the switchgear is equipped with space heaters, energize the space heaters.
Introduction
This section provides a description of the inspections, checks and tests to be performed on the circuit breaker prior to operation in the metal-clad switchgear.

Inspections, Checks and Tests without Control Power
Vacuum circuit breakers are normally shipped with their primary contacts open and their springs discharged. However, it is critical to first verify the discharged condition of the spring-loaded mechanisms after de-energizing control power.

De-Energizing Control Power in Switchgear - When the circuit breaker is mounted in switchgear, open the control power disconnect device in the metal-clad switchgear cubicle. Figure 1 shows the location of the disconnect in a standard GM switchgear assembly.

The control power disconnect device is located on the device panel above the lower circuit breaker and below the upper circuit breaker. Figure 1 shows a pullout type fuse holder. Removal of the fuse holder de-energizes control power to the circuit breaker in the respective switchgear cell. In some switchgear assemblies, a molded case circuit breaker is used in lieu of the pullout type fuse holder. Opening this circuit breaker accomplishes the same result: control power is disconnected.

Spring Discharge Check (Figure 2) - Perform the Spring Discharge Check before removing the circuit breaker from the pallet or removing it from the switchgear.

The spring discharge check consists of simply performing the following tasks in the order given. This check assures that both the tripping and closing springs are fully discharged.

1. Press red Trip pushbutton.
2. Press black Close pushbutton.
3. Again press red Trip pushbutton.
4. Verify Spring Condition Indicator shows DISCHARGED.
5. Verify Main Contact Status Indicator shows OPEN.

DANGER
Hazardous voltages and high-speed mechanical parts.
Will cause death, serious injury, or property damage.
Read instruction manuals, observe safety instructions and use qualified personnel.
Installation Checks and Initial Functional Tests

Removal from Lower Cell in Indoor (if not on raised pad) and Shelter-Clad Outdoor Switchgear -
1. Open the circuit breaker.
2. If the circuit breaker is in the Connect position, insert the racking crank on the racking screw on the front of the breaker cell, and push in. This action operates the racking interlock latch. Figure 3 shows racking of a circuit breaker in the upper cell - the process is similar for a breaker in the lower cell. Rotate the racking crank counterclockwise until the circuit breaker is in the Test position. (If the circuit breaker is in the Disconnect position, turn the racking crank clockwise to rack the circuit breaker from the Disconnect position to the Test position.) If the racking crank is not of the "Captive" type, constant inward pressure is required during racking to maintain engagement with the racking mechanism.
3. With the circuit breaker in the Test position and OPEN, de-energize control power to the circuit breaker. Figure 1 shows the location of control power disconnects in a normal unit.
4. Perform the Spring Discharge Check, and verify that the circuit breaker is OPEN and the closing spring indicator shows DISCHARGED.
5. Insert the racking crank on the racking screw on the front of the circuit breaker cell, and push in, as described in step 2. Rotate the racking crank counterclockwise until the circuit breaker is in the Disconnect position. The circuit breaker can now be removed from the cubicle.
6. The circuit breaker is now free to be rolled out on the floor using the handles as shown in Figure 4. The wheels of the circuit breaker are virtually at floor level (unless the switchgear is installed on a raised pad), and one person should be able to easily handle the unit.

Removal from Upper Cell (Indoor and Shelter-Clad Outdoor Switchgear) - Removal of the upper circuit breaker in a two-high assembly is similar to removal of a circuit breaker from a lower cell, with several additional steps.

Figure 5 shows one of the two circuit breaker extension rails being inserted into the fixed rails within the upper cell of two-high switchgear equipment. The rails engage locking pins in the fixed rails to secure them in position.

The procedure for removal of an upper circuit breaker is:
1. Open the circuit breaker.
2. If the circuit breaker is in the Connect position, insert the racking crank on the racking screw on the front of the circuit breaker cell, and push in. This action operates the racking interlock latch. Figure 3 shows racking of a circuit breaker in the upper cell - the process is similar for a circuit breaker in the lower cell. Rotate the racking crank counterclockwise until the circuit breaker is in the Test position. (If the circuit breaker is in the Disconnect position, turn the racking
Installation Checks and Initial Functional Tests

Crank clockwise to rack the circuit breaker from the disconnect position to the Test position.) If the racking crank is not of the “Captive” type, constant inward pressure is required during racking to maintain engagement with the racking mechanism.

3. With the circuit breaker in the Test position and OPEN, de-energize control power to the circuit breaker. Figure 1 shows the location of control power disconnects in a normal unit.

4. Perform the Spring Discharge Check, and verify that the circuit breaker is OPEN and the closing spring indicator shows DISCHARGED.

5. Insert the two extension rails into the fixed rails. Be sure the extension rails are properly secured in place. (This can be done at step 7 if preferred.)

6. Insert the racking crank on the racking screw on the front of the circuit breaker cell, and push in, as described in step 2. Rotate the racking crank counterclockwise until the circuit breaker is in the Disconnect position.

7. If you have not yet installed the extension rails, do so now. Note that some difficulty may be experienced installing the extension rails if the circuit breaker is in the Disconnect position. If difficulty is encountered, rack the circuit breaker to the Test position, install the extension rails, and then rack the circuit breaker to the Disconnect position.

8. Move the circuit breaker release latch to the left and pull the circuit breaker out from the Disconnect position. The circuit breaker is now free to be rolled out of the two extension rails using the handles on the front of the circuit breaker.

9. Remove the circuit breaker from the two extension rails using the approved Siemens breaker lifting device or lifting sling.

10. Lift the two extension rails and withdraw them from the switchgear.

**WARNING**

Heavy Weight.
Can cause death, serious injury, or property damage.

Always use extension rails to remove or install circuit breaker in the upper cell or in cells not installed at floor level.

Figure 6: Manual Charging of Closing Springs.

Figure 7: Split Plug Jumper Connected to Circuit Breaker.
Installation Checks and Initial Functional Tests

Removal from Upper and Lower Cell in Outdoor Non-Walk In Enclosures or for Indoor Switchgear Installed on a Raised Pad - Because the floor level in non-walk in outdoor enclosures is approximately 6 inches above grade (foundation) level, the lower circuit breaker in either a one-high or two-high section of switchgear must be removed using the preceding procedure for upper circuit breaker removal.

The approved circuit breaker lifting device or lifting sling should be used for removal of both lower and upper circuit breakers from the extension rails of outdoor non-walk in enclosures.

Physical Inspections
1. Verify that rating of the circuit breaker is compatible with both the system and the switchgear.
2. Perform a visual shipping damage check. Clean the circuit breaker of all shipping dust, dirt and foreign material.

Manual Spring Charging Check
1. Insert the manual spring charging lever into the manual charge handle socket as shown in Figure 6. Operate the lever up and down until the spring condition indicator shows the closing spring is Charged.
2. Repeat the Spring Discharge Check.
3. Verify that the springs are discharged and the circuit breaker primary contacts are open by indicator positions.

As-Found and Vacuum Integrity Check Tests
Perform and record the results of both the As-Found insulation test and the vacuum integrity check high-potential test. Procedures for these tests are described in the Maintenance Section of this manual.

Automatic Spring Charging Check
Note: A temporary source of control power and test leads may be required if the control power source has not been connected to the switchgear. (Refer to the specific wiring information and rating label for your circuit breaker to determine the voltage required and where the control voltage signal should be applied. Usually, spring charging power is connected to secondary disconnect fingers SD16 and SD15, closing control power to SD13 and SD15, and tripping power to SD1 and SD2.) When control power is connected to the GMI circuit breaker, the closing springs should automatically charge.
The automatic spring charging features of the circuit breaker must be checked. Control power is required for automatic spring charging to take place.

1. Open control power circuit by removing pullout fuse holder shown in Figure 1.
2. Install circuit breaker end of split plug jumper (if furnished) shown in Figure 7 to the circuit breaker. The plug jumper is secured by means of screws, over the circuit breaker's secondary contacts.
3. Install the switchgear end of the plug jumper shown in Figure 8 to the secondary disconnect block inside the switchgear cubicle. The jumper slides into place. The plug jumper interconnects all control power and signal leads (e.g., remote trip and close contacts) between the switchgear and the circuit breaker.
4. Energize (close) the control power circuit disconnect (Figure 1).
5. Use the Close and Trip controls (Figure 2) to first Close and then Open the circuit breaker contacts. Verify contact positions visually by observing the Open/Closed indicator on the circuit breaker.
6. De-energize control power by repeating Step 1. Disconnect the plug jumper from the switchgear first and next from the circuit breaker.
7. Perform the Spring Discharge Check again. Verify that the closing springs are discharged and the primary contacts of the GMI circuit breaker are open.

Final Mechanical Inspections without Control Power
1. Make a final mechanical inspection of the circuit breaker. Verify that the contacts are in the Open position, and the closing springs are Discharged.
2. Check the upper and lower primary studs and contact fingers shown in Figure 9. Verify mechanical condition of finger springs and the disconnect studs.
3. Coat movable primary contact fingers (Figure 9) and the secondary disconnect contacts (Figure 9 and 22) with a light film of Siemens Contact Lubricant No. 15-172-791-233).
4. The GMI vacuum circuit breaker is ready for installation into its assigned cubicle of the metal-clad switchgear. Refer to removal procedures and re-install the circuit breaker into the switchgear.
5. Refer to the Switchgear Instruction Manual for functional tests of an installed circuit breaker.
Introduction
The Type GMI vacuum circuit breaker is of drawout construction designed for use in medium voltage, metal-clad switchgear. The GMI circuit breaker conforms to the requirements of ANSI standards C37.20.2, C37.04, C37.06, C37.09 and C37.010.

GMI circuit breakers consist of three vacuum interrupters, a stored energy operating mechanism, necessary electrical controls and interlock devices, disconnect devices to connect the circuit breaker to both primary and control power and an operator housing. On some circuit breaker ratings, insulating barriers are located between the vacuum interrupters or along the sides.

This section describes the operation of each major subassembly as an aid in the operation, installation, maintenance and repair of the GMI vacuum circuit breaker.

Vacuum Interrupters and Primary Disconnects
The operating principle of the GMI vacuum interrupter is simple. Figure 11 is a cutaway view of a typical vacuum interrupter. The entire assembly is sealed after a vacuum is established. The interrupter stationary contact is connected to the upper disconnect stud of the circuit breaker. The interrupter movable contact is connected to the lower disconnect stud and driving mechanism of the circuit breaker. The metal bellows assembly provides a secure seal around the movable contact, preventing loss of vacuum while permitting vertical motion of the movable contact.

When the two contacts separate an arc is initiated which continues conduction up to the following current zero. At current zero, the arc extinguishes and any conductive metal vapor which has been created by and supported the arc condenses on the contacts and on the surrounding vapor shield. Contact materials and configuration are optimized to achieve arc control and to minimize switching disturbances.

Figure 10: Front View of GMI Circuit Breaker.

Figure 11: Cutaway View of Typical Vacuum Interrupters.
Primary Disconnects
Figure 12 is a side view of the circuit breaker with side phase barriers removed to show details of the primary disconnects. Each circuit breaker has three upper and three lower primary disconnects. Upper primary disconnects are connected to the stationary contacts of the vacuum interrupters, and the lower primary disconnects to the movable contacts. Each disconnect arm has a set of multiple spring loaded fingers that mate with bus bars in the metal-clad switchgear. The number of fingers in the disconnect assembly varies with the continuous and/or momentary rating of the circuit breaker.

There are three insulating push rods. Each push rod connects the movable contact of one of the vacuum interrupters to the jack shaft driven by the closing and tripping mechanism. Flexible connectors ensure secure electrical connections between the movable contacts of each interrupter and its bottom primary disconnect.

Phase Barriers
Phase barrier configurations vary among GMI circuit breakers depending on voltage and continuous current ratings.

Figure 13a and 13b are rear views of a circuit breaker that shows the two types of phase barrier configurations; molded “chair” around individual pole and individual barriers configurations. The insulated “chair” molded barrier is fixed mounting. Individual barrier configuration includes two outer (phase to ground) insulating barriers and two interphase barriers. The interphase barriers are not provided on all circuit breaker ratings. The sheets of glass polyester insulating material and the insulated molded chair are attached to the circuit breaker and provide electrical insulation between the vacuum interrupter primary circuits and the housing.

Stored Energy Operating Mechanism
The stored energy operating mechanism of the GMI circuit breaker is an integrated arrangement of springs, solenoids and mechanical devices designed to provide a number of critical functions. The energy necessary to close and open the contacts of the vacuum interrupters is stored in powerful tripping and closing springs. The closing springs are normally charged automatically, but there are provisions for manual charging. The operating mechanism that controls charging, closing and tripping functions is fully trip-free, i.e., spring charging does not automatically change the position of the primary contacts, and the closing function may be overridden by the tripping function at any time.

Note: Two different latch systems have been used in GMI circuit breakers, with changeover from one design to the other occurring in mid-1991. This instruction manual describes both designs.

Pages 11-13 describe the operation of the mechanism used beginning in approximately mid-1991.

Pages 13-15 describe the operation of the mechanism used from 1989 until approximately mid-1991.
Modes of Operation - Mid-1991 and After

Pages 11-13 describe the operation of the mechanism used beginning in approximately mid-1991.

This mechanism can be identified by observing the close latch above the spring charging motor on the left side of the circuit breaker. Refer to Figure 18. The close latch is installed on the close shaft assembly 72, and includes a hardened latch face. This face contacts a bearing which is part of the close hatchet assembly 105. If the mechanism has a close hatchet which bears directly on the close shaft, refer to pages 13-15 for the description of your mechanism.

Modes of Operation Discussion

Some maintenance procedures are more easily understood when the operating mechanism modes of operation are described in detail. The next few paragraphs explain the five modes or status conditions (charging, closing, trip-free, opening and rapid auto-reclosing) of the stored energy operating mechanism.

Note: All discussion of modes of operation assumes that the reader is viewing the operator from the front, or from the right hand side.

Spring Charging Mode

Figures 14a and 15a show several key components of the operator mechanism in positions corresponding to the circuit breaker open, with the closing springs discharged (Figure 14a) and charged (Figure 15a). Figure 16a shows portions of the operator mechanism that manually or electrically charge the closing springs. The drive cam (20), the closing spring crank arms (Figure 19) and spring condition indicator cam (18) are directly keyed to the main cam shaft (3). The main cam shaft rotates counterclockwise. The closing springs are attached to the crank arms, and are extended during the charging cycle.

Figure 16a shows the ratchet wheel (15) which is free to rotate about the main cam shaft (3). The ratchet wheel is driven by either the charging motor or the manual charge handle socket (52). When the springs are charged electrically, the motor eccentric (100) introduces a rocking motion into the drive plate (13). As this plate rocks back and forth, the lower pawl (24-1) (which is connected to the drive plate) imparts counterclockwise rotation of the ratchet wheel (15), one tooth at a time. The upper pawl (24-2) acts as a holding pawl during electrical charging.

When the springs are charged manually, up and down pumping action of the spring charging handle in the manual charge handle socket (52) causes the pawl plate (11) to rock back and forth through the movement of the
manual charging link (48). The upper pawl (24-2) drives the ratchet plate counterclockwise during manual charging, and the lower pawl (24-1) becomes the holding device.

At the beginning of the charging cycle, ratchet pin (16) is at the 6 o’clock position. The ratchet pin is connected to the ratchet wheel. Upon being advanced by ratchet action to the 12 o’clock position, this pin engages the drive arms (8) which are keyed to the main cam shaft. Consequently, counterclockwise rotation of the ratchet wheel causes the ratchet pin to drive the main cam shaft counterclockwise. When the ratchet pin reaches the 6 o’clock position, the closing springs are fully charged. Driving pawl (24-1) is disengaged, the spring condition indicator cam (18) has rotated allowing the spring charged flag (132) to drop into the lower (charged) position, which also operates the motor cutoff switch (LS1) an spring charged switch (LS2) (258) (see Figures 17a and 27). The closing springs are restrained fully charged by close ratchet (22) against close shaft (72).

Closing Mode (Figure 17a)
Energizing the close solenoid (265) pulls the solenoid armature against the closing shaft actuator (75) and causes the close shaft (72) to rotate approximately 15°. If the closing springs are charged, the close hatchet (22) will be released by this rotation allowing the main cam shaft (3) to be driven by the closing springs. Depressing the manual close button on the operator panel causes the rotation of the close shaft (72) by the lower end of the close shaft actuator (75). Rotation of the main cam shaft (3) in a manual closing operation is identical to that of an electrical closing operation. As the main cam shaft (3) rotates, the cam follower (115) is driven by drive cam (20), and the main link (120) is forced outwards, and rotation of the jack shaft assembly (217) occurs. There are three drive links attached to Point “A” of each of the three jack shaft drive plates. Each drive link is connected to the movable contact of one vacuum interrupter. Closing rotation (counterclockwise) of the jack shaft assembly closes the contacts of the three vacuum interrupters. During closing operation, rotation of jack shaft assembly (217) forces the opening (i.e., tripping) spring into its charged position.

Trip Free Mode
If at any time during circuit breaker closing, the trip shaft (79) (Figure 14a) operates as a result of either an electrical or mechanical trip, trip hatchet (99) is free to rotate. When the trip hatchet (99) rotates, cam follower (115) is displaced by drive cam (20) without motion of the jack shaft (217). Mechanical trip free operation is provided by manual tripping, electrical tripping and/or the mechanical interlocks.
Interrupter/Operator Description

Opening Mode
Opening or tripping the vacuum interrupter contacts is accomplished by rotation of the trip shaft (79). Rotation may be produced either electrically, by energizing the trip solenoid (266) (Figure 15a), or manually by pressing the trip button. Energizing the trip solenoid causes the upper arm of the trip actuator (152) to rotate counterclockwise. Pressing the trip button causes the trip actuator lower arm to move, again producing rotation of the trip shaft. All of the linkages are trip free, and tripping or opening is unaffected by charging status of the closing springs or position of the drive cam (20).

Rapid Auto-Reclosing Mode
The closing springs are automatically recharged by the motor driven operating mechanism when the circuit breaker has closed. The operating mechanism is capable of the open-close-open duty cycle required for rapid auto-reclosing.

For circuit breakers provided up to mid-2001, an optional reclosing control circuit was provided. This used a trip latch check switch and a relay (delay on dropout) to prevent release of the closing spring energy if the trip hatchet (99) is not in its reset position. This ensures that the mechanism does not operate trip-free on an instantaneous reclosure.

Circuit breakers provided from mid-2001 comply with the minimum reclose time in ANSI C37.06-2000 (table 9) of 0.3 second. It is the user’s responsibility to assure that the required 0.3 second time delay is incorporated in the external control scheme. This time delay is not incorporated as an integral element of the circuit breaker mechanical design or electrical control circuitry.

It is recognized that some users will wish to reclose with a time delay of less than 0.3 second (300 ms). As the time delay is decreased from 300 ms, the chances increase that a reclose operation will fail due to excess ionization of air at the point of the fault. It is recommended that the reclosing relay be set to issue a reclose command no sooner than six cycles (100 ms) after the ‘52/b’ switch makes during an opening operation. If the reclosing relay does not monitor the ‘52/b’ switch to determine that the circuit breaker is open before it issues the close command, then the reclosing relay should be set to issue the reclose command no sooner than ten cycles (167 ms) after the opening signal is issued.

Modes of Operation - Up to Mid-1991
Pages 13-15 describe the operation of the mechanism used from 1989 until approximately mid-1991

This mechanism can be identified by observing the close latch above the spring charging motor on the left side of the circuit breaker. Refer to Figure 18. The close hatchet 22 has a latch face which bears directly on the close shaft 72. If the close hatchet includes a bearing which contacts a hardened latch installed on the close shaft, refer to pages 11-13 for the description of your mechanism.

Modes of Operation Discussion
Some maintenance procedures are more easily understood when the operating mechanism modes of operation are described in detail. The next few paragraphs explain the five modes or status conditions (charging, closing, trip-free, opening and rapid auto-reclosing) of the stored energy operating mechanism.

Note: All discussion of modes of operation assumes that the reader is viewing the operator from the front, or from the right hand side.

Spring Charging Mode
Figures 14b and 15b show several key components of the operator mechanism in positions corresponding to the circuit breaker open, with the closing springs discharged (Figure 14b) and charged (Figure 15b). Figure 16b shows portions of the operator mechanism that manually or electrically charge the closing springs. The drive cam (20), the closing spring crank arms (Figure 19) and spring condition indicator cam (18) are directly keyed to the main cam shaft (3). The main cam shaft rotates counterclockwise. The closing springs are attached to the crank arms, and are extended during the charging cycle.

Figure 16b shows the ratchet wheel (15) which is free to rotate about the main cam shaft (3). The ratchet wheel is driven by either the charging motor or the manual charge handle socket (52). When the springs are charged electrically, the motor eccentric (100) introduces a rocking motion into the drive plate (13). As this plate rocks back and forth, the lower pawl (24-1) (which is connected to the drive plate) imparts counterclockwise rotation of the ratchet wheel (15), one tooth at a time. The upper pawl (24-2) acts as a holding pawl during electrical charging.

When the springs are charged manually, up and down pumping action of the spring charging handle in the manual charge handle socket (52) causes the pawl plate (11) to rock back and forth through the movement of the manual charging link (48). The upper pawl (24-2) drives the ratchet plate counterclockwise during manual charging, and the lower pawl (24-1) becomes the holding device.
Interrupter/Operator Description

At the beginning of the charging cycle, ratchet pin (16) is at the 6 o’clock position. The ratchet pin is connected to the ratchet wheel. Upon being advanced by ratchet action to the 12 o’clock position, this pin engages the drive arms (8) which are keyed to the main cam shaft. Consequently, counterclockwise rotation of the ratchet wheel causes the ratchet pin to drive the main cam shaft counterclockwise. When the ratchet pin reaches the 6 o’clock position, the closing springs are fully charged. Driving pawl (24-1) is disengaged, the spring condition indicator cam (18) has rotated allowing the spring charged flag (132) to drop into the lower (charged) position, which also operates the motor cutoff switch (LS1) and spring charged switch (LS2) (258) (see Figures 17b and 27). The closing springs are restrained fully charged by close hatchet (22) against close shaft (72).

Closing Mode (Figure 17b)
Energizing the close solenoid (265) pulls the solenoid armature against the closing shaft actuator (75) and causes the close shaft (72) to rotate approximately 15°. If the closing springs are charged, the close hatchet (22) will be released by this rotation allowing the main cam shaft (3) to be driven by the closing springs. Depressing the manual close button on the operator panel causes the rotation of the close shaft (72) by the lower end of the close shaft actuator (75). Rotation of the main cam shaft (3) in a manual closing operation is identical to that of an electrical closing operation. As the main cam shaft (3) rotates, the cam follower (115) is driven by drive cam (20), and the main link (120) is forced outwards, and rotation of the jack shaft assembly (217) occurs. There are three drive links attached to Point “A” of each of the three jack shaft drive plates. Each drive link is connected to the movable contact of one vacuum interrupter. Closing rotation (counterclockwise) of the jack shaft assembly closes the contacts of the three vacuum interrupters. During closing operation, rotation of jack shaft assembly (217) forces the opening (i.e., tripping) spring into its charged position.

Trip Free Mode
If at any time during circuit breaker closing, the trip shaft (79) (Figure 14b) operates as a result of either an electrical or mechanical trip, trip hatchet (99) is free to rotate. When the trip hatchet (99) rotates, cam follower (115) is displaced by drive cam (20) without motion of the jack shaft (217). Mechanical trip free operation is provided by manual tripping, electrical tripping and/or the mechanical interlocks.
Interrupter/Operator Description

Opening Mode
Opening or tripping the vacuum interrupter contacts is accomplished by rotation of the trip shaft (79). Rotation may be produced either electrically, by energizing the trip solenoid (266) (Figure 15b), or manually by pressing the trip button. Energizing the trip solenoid causes the upper arm of the trip actuator (152) to rotate counterclockwise. Pressing the trip button causes the trip actuator lower arm to move, again producing rotation of the trip shaft. All of the linkages are trip free, and tripping or opening is unaffected by charging status of the closing springs or position of the drive cam (20).

Rapid Auto-Reclosing Mode (Optional)
The closing springs are automatically recharged by the motor driven operating mechanism when the circuit breaker has closed. The operating mechanism is capable of the open-close-open duty cycle required for rapid auto-reclosing. A trip latch check switch and a relay (delay on dropout) prevent release of the closing spring energy if the trip hatchet (99) is not in its reset position. This ensures the mechanism does not operate trip free on an instantaneous reclosure.

Figure 16b: Pawl and Ratchet Drive.

Figure 17b: Closing Mode.

Figure 18: Identification of Mechanism Vintage.
Interrupter/Operator Description

Closing and Opening Springs
The stored energy assembly consists of two dual closing springs and a single opening spring. Figure 19 shows the three springs and their linkages to the charging devices. The two closing springs are connected to crank arms mounted on the rotating main cam shaft. The closing springs are extended, and charged, by rotation of the crank arms connected to the movable ends of the springs. The fixed ends of these springs are attached to a support arm, which in turn is bolted to the structure of the circuit breaker.

The opening spring is connected to the jack shaft. When the circuit breaker closes, rotation of the jack shaft causes the opening spring push rod to compress and charge the opening spring. Consequently, the opening spring is automatically charged whenever circuit breaker contacts are closed.

Trip Free Operation
The GMI circuit breaker is mechanically and electrically trip free. This important function enables the breaker to be tripped before, after or during a closing operation. Whenever the circuit breaker trip shaft is moved as the result of manual or electrical signals or mechanical interlocks, a) a closed circuit breaker will open, b) a circuit breaker in the process of closing will not complete the close operation and will remain open, or c) an open circuit breaker will not be able to be closed.

Damper
GMI circuit breakers are equipped with a sealed, oil-filled viscous damper, or shock absorber (Figures 19 and 19a). The purpose of this damper is to limit overtravel and rebound of the vacuum interrupters’ movable contacts during the conclusion of an opening operation. The damper action affects only the end of an opening operation.

Two types of dampers are used on GMI circuit breakers, depending on the vacuum interrupter family used. The respective damper systems are as described in the following sections.

Damper (used with all vacuum interrupters except type VS-15050) (refer to Figures 19a and 37a)
The cylindrical body of the damper is secured to the circuit breaker frame with a yoke. The damper’s piston and striker tip protrude from the opposite end of this cylinder (the lower end as installed on the circuit breaker). A striker block is fixed within an outer tube, which is guided by the cylindrical body of the damper. The end of the outer tube is attached to the circuit breaker jack shaft.

The outer tube and (inner) damper remain uncoupled until the end of the opening operation is reached. At this time, the tube’s striker block contacts the damper piston, to begin control of the movable contact dynamics.
Interrupter/Operator Description

Spring Charging Motor

Figure 19a shows the spring charging motor mounted at the bottom of the left side of the circuit breaker housing. A mounting bracket holds the motor firmly in place. A universal motor is used to permit operation on either AC or DC control power.

The motor control circuits call for automatic charging of the springs by the motor whenever control power is available and the springs are discharged. The springs automatically recharge following a closing operation.

Electrical connections to the motor utilize quick disconnect terminations for easy inspection or removal.

Damper (used with type VS-15050 vacuum interrupters) (refer to Figures 19a and 37a)

The cylindrical body of the damper has outer threads, for mating with a threaded adapter which is mounted in the upper portion of the circuit breaker frame. The body of the damper is inserted into a cylinder which extends from the damper down to the connection on the circuit breaker jack shaft in the lower portion of the operating mechanism. The damper’s piston head is installed inside the outer cylinder, which serves to guide the cylinder during opening and closing operations. The end of the outer cylinder is attached to triangular damping arms attached to the circuit breaker jack shaft.

The outer cylinder and (inner) damper remain uncoupled until the end of the opening operation is reached. At this time, the cylinder’s striker pin contacts the damper piston, to begin control of the movable contact dynamics.

Manual Spring Charging

Manual charging of the closing springs is accomplished using a lever in lieu of the spring charging motor. Figure 20 shows the principal components of the manual spring charging mechanism.

The manual spring charging lever is inserted into a rectangular socket in the hand operator. This socket is accessible through the front panel of the circuit breaker. Moving the lever up and down in a cranking or pumping motion causes rotation of the internal spring charging components.

Spring Charging Motor

Figure 19a shows the spring charging motor mounted at the bottom of the left side of the circuit breaker housing. A mounting bracket holds the motor firmly in place. A universal motor is used to permit operation on either AC or DC control power.

The motor control circuits call for automatic charging of the springs by the motor whenever control power is available and the springs are discharged. The springs automatically recharge following a closing operation.

Electrical connections to the motor utilize quick disconnect terminations for easy inspection or removal.

Close Solenoid, Trip Solenoid and Anti-Pump Relay

Figure 21 shows the two solenoids controlling operation of the circuit breaker by external electrical signals.

When the close solenoid is energized it causes the two closing springs to be released from their extended or charged state. This forces the three insulating push rods to move the movable vacuum interrupter contacts vertically upwards, and close the circuit breaker.

The anti-pump relay (Figure 41) electrically isolates signals to the close solenoid such that only one releasing action
Interrupter/Operator Description

by the close solenoid can occur during each application of the close command. The circuit breaker must be tripped, the springs recharged and the closing signal removed (interrupted) before the close solenoid can be energized the second time.

When the trip solenoid is energized, it allows rotation of the jack shaft by the tripping spring. This rotation pulls the insulating push rods attached to the movable contacts of the three vacuum interrupters, and the circuit breaker contacts are opened.

Electrical connections to the close solenoid and trip solenoid are made through quick disconnect terminations.

Secondary Disconnect
Signal and control power is delivered to the internal circuits of the circuit breaker by an arrangement of movable contact fingers mounted on the left side of the circuit breaker. These fingers are shown in Figure 22.

When the circuit breaker is racked into the Test or Connected positions in the metal-clad switchgear, these disconnect fingers engage a mating disconnect block on the inside of the switchgear shown in Figure 23. These electrical connections automatically disengage when the circuit breaker is racked from the Test to the Disconnect position.

All of the control power necessary to operate the circuit breaker is connected to the disconnect block inside the switchgear. The external trip and close circuits and status indicators are also connected to this same disconnect block.

Auxiliary Switch
Figure 24 shows the circuit breaker mounted auxiliary switch. This switch provides auxiliary contacts for control of circuit breaker closing and tripping functions. Contacts are available for use in relaying and external logic circuits. This switch is driven by linkages connected to the jack shaft. The auxiliary switch contains both ‘b’ (Normally Closed) and ‘a’ (Normally Open) contacts. When the circuit breaker is open, the ‘b’ switches are closed and the ‘a’ switches are open.

MOC (Mechanism Operated Cell) Switch
Figures 25 and 26 show the principal components that provide optional control flexibility when operating the circuit breaker in the Test and Connected positions.

Figure 25 shows the MOC switch operating arm that projects from the right side of the circuit breaker, just above the bottom rail structure. The MOC switch operating arm is part of the jack shaft assembly, and directly reflects the open or closed position of the circuit breaker primary contacts.

As the circuit breaker is racked into the appropriate position inside the switchgear, the MOC switch operating arm passes a wiring protective cover plate, and engages the pantograph linkage shown in Figure 26. Operation of the circuit breaker causes the pantograph linkage to transfer motion to the MOC switches located above the pantograph. The ‘a’ and ‘b’ contacts can be used in relaying and control logic schemes.

All circuit breakers contain the MOC switch operating arm. However, MOC switches are provided in the switchgear only when specified.

The circuit breaker engages the MOC auxiliary switch only in the connected (operating) position unless an optional test position pickup is specified in the contract. If a test position pickup is included, the circuit breaker will engage...
the auxiliary switch in both positions (Figure 26). Up to 24 stages may be provided.

**TOC (Truck Operated Cell) Switch**

**Figure 26** shows the optional TOC cell switch. This switch is operated by the circuit breaker as it is racked into the Connect position.

Various combinations of ‘a’ and ‘b’ contacts may beoptionally specified. These switches provide control and logic indication that a circuit breaker in the cell has achieved the Connect (ready to operate) position.

**Limit Switches**

**Figure 27** – The motor cutoff switch (LS1) is used to sense the position of the driven mechanisms. This switch de-energizes the charging motor when the Charged position of the closing springs is reached. When the closing springs are discharged, this switch energizes the control circuit powering the spring charging motor.

Spring charged switch (LS2) operates simultaneously with motor switch (LS1). The spring charged switch allows the close solenoid to be energized only when the springs are charged, and also is part of the anti-pump circuitry.

The trip latch check switch (LS3) operates when the trip latch linkage is in the reset position. It also is driven by operating bars that sense when the breaker is in either the Test or Connected position inside the switchgear. Control circuitry prevents an electrical release of the closing
springs unless the breaker is either in the Test of Connected position, or is out of the compartment.

**Standard Schematic Diagrams**

*Note: Figure 28a and 28b show typical schematic for a circuit breaker not provided with a capacitor trip device. Figure 28c shows a circuit breaker with capacitor tripping. These are typical — refer to the specific drawing for your project.*

Inspection of the schematic diagrams shown in Figures 28a-28c provides a clear picture of the logic states of the various devices for the three basic control functions.

These are: 1) automatic charging of the closing springs; 2) electrical closing of the primary contacts; and 3) electrical tripping of the primary contacts.

Automatic spring charging by charging motor occurs when secondary control power is available, and motor cutoff switch LS1 has not operated. The springs are automatically recharged after each closing operation.

Electrical closing occurs with closing control power applied and when all of the following conditions exist: 1) External control switch CS/C is closed; 2) Anti-pump relay 52Y is not energized; 3) Auxiliary switch 52b indicates the breaker is in open position; 4) Limit switch LS3 shows that the trip latch has been reset and the circuit breaker is in the Test or Connected position, or is out of the compartment; and 5) Limit switch LS2 indicates that the closing springs are charged. Electrical tripping occurs with tripping control power applied and when the auxiliary switch 52a shows the circuit breaker is closed, and a trip signal is provided by the control switch CS/T or the protective relays. While external control power is required for either electrical closing or tripping, the circuit breaker can be manually charged, closed and tripped without external control power.

**Capacitor Trip Device (Optional)**

The capacitor trip device is an auxiliary tripping option providing a short term means of storing adequate electrical energy to ensure circuit breaker tripping.

This device is applied in circuit breaker installations lacking independent auxiliary control power or station battery. In such installations, control power is usually derived from the primary source. In the event of a primary source fault, or disturbance with attendant depression of the primary source voltage, the capacitor trip device will provide short term tripping energy for circuit breaker opening due to relay operation.

Refer to Figure 28c. An electrolytic capacitor resides across the tripping supply voltage connected through a half wave rectifier and resistor. The rectifier allows the capacitor to assume a charge approximating the peak voltage of the AC tripping supply voltage. The series resistor limits the magnitude of charge current flowing into the capacitor.

The charged capacitor is then connected across the circuit breaker trip coil circuit through an external contact which closes upon trip command.

The capacitor size and charge current magnitude are tuned to the inductance and resistance of the tripping solenoid, an RLC series circuit, to produce a discharge current through the solenoid, which emulates the magnitude of current and current duration which the solenoid would experience if operated from a DC tripping supply voltage.

**Undervoltage Release (Optional)**

The undervoltage release is used for continuous monitoring of the tripping supply voltage. If the trip supply voltage falls significantly, the undervoltage release will provide for automatic tripping of the circuit breaker.

**Description of Operation**

The undervoltage release consists of a spring stored energy mechanism, a latching device and an electromagnet. These elements are accommodated in a single assembly as shown in Figure 29.

The stored energy spring (1), spring charging arm (2) and latch face are arranged in a cylindrical assembly concentric with the trip latch shaft (3). The cylindrical assembly is retained by the support bracket (4), yet remains free to rotate. The cylindrical assembly is supported by the trip latch shaft which rotates freely on the trip shaft supported by needle bearings.

The stored energy torsion spring (1) has one tail bearing on a lug fixed to the cylindrical assembly, and an opposite tail fixed on a lug of the support bracket. Thus, the torsional tension of the spring will cause the cylindrical assembly (5) to be forcibly rotated relative to the support bracket.

The cylindrical assembly is notched at the end nearest the mechanism side sheet with the notch engaging a spring pin (6) driven into the trip latch shaft. The notch has sufficient arc width to permit the trip latch shaft to rotate normally in response to the circuit breaker receiving a trip command.

The circuit breaker jackshaft (7) is fitted with an arm and track roller (8) which bears on the charging arm (2) of the cylindrical assembly. Whenever the circuit breaker is opened, the arm and roller cause the charging arm to be rotated charging or winding up the stored energy torsion spring.
**Interrupter/Operator Description**

**Figure 28a:** DC Control Power.

**Figure 28b:** AC and DC Control Power.

**Figure 28c:** AC Control Power (with Capacitor Trip).

**Symbols**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>LS1</td>
<td>Motor Cutoff Switch</td>
</tr>
<tr>
<td>LS2</td>
<td>Spring Charged Switch</td>
</tr>
<tr>
<td>LS3</td>
<td>Checks Trip Latch Reset and Blocks Electric Close while Racking &quot;Test&quot; to &quot;Connect&quot;</td>
</tr>
<tr>
<td>52/a</td>
<td>Aux. Switch, Open when Brk. is Open</td>
</tr>
<tr>
<td>52/b</td>
<td>Aux. Switch, Closed when Brk. is Open</td>
</tr>
<tr>
<td>52T</td>
<td>Opening Solenoid (Trip)</td>
</tr>
<tr>
<td>52SRC</td>
<td>Spring Release Solenoid (Close)</td>
</tr>
<tr>
<td>88</td>
<td>Spring Charging Motor</td>
</tr>
<tr>
<td>52/a</td>
<td>Aux. Switch, Open when Brk. is Open</td>
</tr>
<tr>
<td>52/b</td>
<td>Aux. Switch, Closed when Brk. is Open</td>
</tr>
<tr>
<td>52Y</td>
<td>Anti-Pump Relay</td>
</tr>
<tr>
<td>52SRC</td>
<td>Spring Release Solenoid (Close)</td>
</tr>
<tr>
<td>52T</td>
<td>Opening Solenoid (Trip)</td>
</tr>
<tr>
<td>88</td>
<td>Spring Charging Motor</td>
</tr>
<tr>
<td>CS/C</td>
<td>Control Switch Close</td>
</tr>
<tr>
<td>CS/T</td>
<td>Control Switch Trip</td>
</tr>
<tr>
<td>R</td>
<td>Red Indicating Lamp</td>
</tr>
<tr>
<td>G</td>
<td>Green Indicating Lamp</td>
</tr>
<tr>
<td>W</td>
<td>White Indicating Lamp</td>
</tr>
</tbody>
</table>

**Notes on Schematic Arrangement**

Schematics are shown with:

1. Closing Springs Discharged
2. Circuit Breaker Open
3. Circuit Breaker Located in Test, Connect or Withdrawn Position

Note that, in this condition, the trip latch is free to reset, but is temporarily blocked until the closing springs are partially recharged. Prior to full spring charge, LS3 (NO) closes, and LS3 (NC) opens.
A spring loaded latch arm (9) rises to engage the latch face, which is an integral feature of the cylindrical assembly. The latch arm (9) is held in this position by the vertical lever (10), which is pulled to the supporting position by the electromagnet. The vertical lever is pivoted (11) by the electromagnet (12) against the force developed by an extension spring (13), which constantly attempts to pull the vertical lever (10) into a position which releases the stored energy torsion spring.

The latch arm supported by the vertical lever retained in position by the electromagnet will retain the stored energy state until the electromagnet senses a loss of trip supply voltage. When the supply voltage falls to a level 30 to 60 percent of nominal, the electromagnet releases the vertical lever, the latch arm descends and the cylindrical assembly rotates displacing the trip shaft. Latching is established at 85% nominal voltage.

**Interlocks**

There are two interlocks which prevent certain unsafe operating conditions. They are the rating interlock and the trip-free interlock.

**Trip-Free Interlock**

Figure 30 shows the devices providing the trip-free interlock function. The purpose of the trip-free interlock is to hold the circuit circuit breaker operating mechanism mechanically and electrically trip free whenever the circuit breaker is between the Test and Connected positions within the switchgear enclosure. This interlock ensures that the circuit breaker primary contacts can only be closed when in the Connect position, or the Test position, or out of the switchgear cell.

**Rating Interlock**

Figure 30 shows the rating interlock interference plates mounted on the circuit breaker frame. The circuit breaker interference plates are complemented by matching plates located in the cubicle.

The interference plates (rating interlocks) test the circuit breaker voltage, continuous current, interrupting and momentary ratings and will not allow circuit breaker insertion unless they match or exceed the cell rating.

**Circuit Breaker Frame**

The frame of the GMI circuit breaker contains several important devices and features deserving of special attention. These are the ground disconnect, the four racking wheels and four handling wheels.
Interrupter/Operator Description

Ground Disconnect

Figure 30 shows the ground disconnect contact mounted at the bottom of the circuit breaker. The spring loaded fingers of the disconnect contact engage the ground bar (Figure 31) at the bottom of the switchgear assembly. The ground bar is to the right of the racking mechanism, shown at the bottom center of the switchgear.

Circuit Breaker Handling Wheels

The GMI circuit breaker is designed for easy movement into and out of the metal-clad switchgear assembly. A section of indoor or Shelter-Clad switchgear does not require a transfer truck or lifting truck for handling of the circuit breaker when all circuit breakers are located in the lower cells. Once the circuit breaker is racked out of the switchgear, the unit can be pulled using the handles on the front of the circuit breaker. The circuit breaker will roll on its bottom four wheels.

On indoor and Shelter-Clad switchgear with circuit breakers located in the lower cell, the circuit breaker is easily rolled out of the switchgear by a single person. When circuit breakers are located in the upper cells, handling of the circuit breakers requires the use of a hoist or crane. These lifting devices are also required for removal of the lower circuit breaker of non walk-in type outdoor switchgear.

Racking Mechanism

Figure 31 shows the racking mechanism in the switchgear used to move the circuit breaker between the Disconnect, Test and Connected positions. This mechanism contains a set of interface blocks that mate with the bottom of the circuit breaker housing, and lock the circuit breaker to the racking mechanism during in and out movement. A racking handle (not shown) mates with the threaded shaft of the racking mechanism. Clockwise rotation of the crank moves the breaker into the switchgear, and counterclockwise rotation removes it.

The racking and trip-free interlocks provides several essential functions.

1. They prevent racking a closed circuit breaker into or out of the switchgear assembly.
2. They discharge the closing springs whenever the circuit breaker is inserted into, or withdrawn from, the switchgear.
3. They prevent closing of the circuit breaker unless it is in either the Test of Connect positions.

The rating interlock prevents insertion of a lower rated circuit breaker into a cubicle intended for a circuit breaker of higher ratings.
Introduction and Maintenance Intervals
Periodic inspections and maintenance are essential to obtain safe and reliable operation of the GMI circuit breaker.

When GMI circuit breakers (manufactured beginning January, 1992) are operated under "Usual Service Conditions," maintenance and lubrication is recommended at five year (one year if manufactured before January, 1992) intervals or at the number of operations indicated in Table 2. "Usual" and "Unusual" service conditions for Medium Voltage Metal-Clad Switchgear are defined in ANSI C37.20.2, sections 4 and 8.1. Generally, "usual service conditions" are defined as an environment in which the equipment is not exposed to excessive dust, acid fumes, damaging chemicals, salt air, rapid or frequent changes in temperature, vibration, high humidity, and extremes of temperature.

The definition of “usual service conditions” is subject to a variety of interpretations. Because of this, you are best served by adjusting maintenance and lubrication intervals based on your experience with the equipment in the actual service environment.

Regardless of the length of the maintenance and lubrication interval, Siemens recommends that circuit breakers should be inspected and exercised annually.

For the safety of maintenance personnel as well as others who might be exposed to hazards associated with maintenance activities, the safety related work practices of NFPA 70E, parts II and III, should always be followed when working on electrical equipment. Maintenance personnel should be trained in the safety practices, procedures and requirements that pertain to their respective job assignments. This manual should be reviewed and retained in a location readily accessible for reference during maintenance of this equipment.

The user must establish a periodic maintenance program to ensure trouble-free and safe operation. The frequency of inspection, periodic cleaning, and preventive maintenance schedule will depend upon the operation conditions. NFPA Publication 70B, "Electrical Equipment Maintenance" may be used as a guide to establish such a program. A preventive maintenance program is not intended to cover reconditioning or major repair, but should be designed to reveal, if possible, the need for such actions in time to prevent malfunctions during operation.

Recommended Hand Tools
Type GMI circuit breakers use both standard American and metric fasteners. Metric fasteners are used for the GMI vacuum interrupters. American fasteners are used in all other locations. This list of hand tools describes those normally used in disassembly and re-assembly procedures.

**Metric (Vacuum Interrupter Only)**
- Deep Sockets: 19 and 24 mm
- Torque Wrench: 0-150 Nm (0-100 ft-lbs.)
- Allen Wrenches: 8 and 10 mm

**American (All Other Breaker Locations)**
- Socket and Open-End Wrenches: 5/16, 3/8, 7/16, 1/2, 9/16 and 3/4 in.
- Hex Keys: 3/16 and 1/4 in.
- Screwdrivers: 0.032 x 1/4 in. wide and 0.55 x 7/16 in. wide
- Pliers
- Light Hammer
- Dental Mirror

---

### Table 1 – Maintenance Tasks

<table>
<thead>
<tr>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checks of the Primary Power Path</td>
</tr>
<tr>
<td>Checks of the Interrupter Operator Mechanism</td>
</tr>
<tr>
<td>Electrical Control Checks</td>
</tr>
<tr>
<td>High Potential Test</td>
</tr>
<tr>
<td>Inspection and Cleaning of Breaker Insulation</td>
</tr>
<tr>
<td>Functional Tests</td>
</tr>
</tbody>
</table>

---

**DANGER**

Hazardous voltages and high-speed mechanical parts.
Will cause death, severe personal injury, or property damage.
Read instruction manuals, observe safety instructions and limit use to qualified personnel.

**WARNING**

Failure to maintain the equipment could result in death, serious injury or product failure, and can prevent successful functioning of connected apparatus.

The instructions contained herein should be carefully reviewed, understood, and followed.

The maintenance tasks in Table 1 must be performed regularly.
Recommended Maintenance and Lubrication
Periodic maintenance and lubrication should include all the tasks shown in Table 1. Recommended procedures for each of the listed tasks are provided in this section of the manual.

For a “quick reference” to these tasks see “Periodic Maintenance and Lubrication Tasks” chart on page 44.

The list of tasks in Table 1 does not represent an exhaustive survey of maintenance steps necessary to ensure safe operation of the equipment. Particular applications may require further procedures. Should further information be desired or should particular problems arise which are not covered sufficiently for the Purchaser’s purposes, the matter should be referred to the local Siemens sales office.

Removal from Switchgear
Prior to performing any inspection or maintenance checks or tests, the circuit breaker must be removed from the switchgear. The Installation and initial Functional Tests section describes the removal procedure in detail. Principal steps are repeated here for information and guidance, but without the details of the preceding section.

1. Open the circuit breaker.
2. Rack the circuit breaker to the test position. Review instructions for removal of a circuit breaker from the upper or lower cell, as appropriate, for information on racking.
3. With the circuit breaker in the Test position and OPEN, de-energize control power to the circuit breaker. Review Figure 1
4. Perform the Spring Discharge Check, by first pushing the red Trip pushbutton, then the black Close pushbutton, and finally the red Trip pushbutton again. Verify that the circuit breaker is OPEN and the closing spring indicator shows DISCHARGED. See Figure 32, which shows the circuit breaker condition preceding the second operation of the red Trip pushbutton.
5. Rack the circuit breaker to the Disconnect position, and remove the circuit breaker from the switchgear. Refer to the instructions for removal of a circuit breaker from the upper cell for special instructions and precautions regarding removal of the upper circuit breaker.
6. The circuit breaker can be located either on the floor or on a pallet. Each circuit breaker has handles and four wheels to allow one person to maneuver the unit on a level surface without assistance.

Checks of the Primary Power Path
The primary power path consists of the three vacuum interrupters, the three upper and the three lower primary disconnects. These components are checked for cleanliness and condition. The vacuum interrupters are also checked for vacuum integrity.

Some test engineers prefer to perform the contact erosion check during the manual spring charging check of the operator, since charging of the springs is necessary to place the contacts in the closed position.

Also, the vacuum integrity check is usually performed in conjunction with the High Potential tests.

These instructions follow the recommendation that these tests (contact erosion/manual spring charging check, and vacuum integrity/high potential tests) will be combined as described.

Cleanliness Check

Figure 33 is a side view of the GMI circuit breaker with the outer insulating barriers removed to show the vacuum interrupter, and the upper and lower primary disconnects.

All of these components must be cleaned and free of dirt or any foreign objects. Use a dry lint-free cloth. For stubborn dirt, use a clean cloth saturated with denatured alcohol.

Inspection of Primary Disconnects

Figure 34 shows the primary disconnect contact fingers engaged. When the contacts are mated with the switchgear’s primary stud assembly, there is forceful contact distributed over a wide area. This maintains low current flow per individual contact finger.

Inspect the contact fingers for any evidence of burning or pitting that would indicate weakness of the contact finger springs.

Inspect the primary disconnect arms for physical integrity and absence of mechanical damage.

Inspect the flexible connectors that connect the bottom movable contacts of the vacuum interrupters to the lower primary disconnect arms for tightness and absence of mechanical damage, burning, or pitting.

Using a clean cloth saturated with denatured alcohol, clean old lubricant from primary disconnects, and apply Siemens contact lubricant (reference 15-172-791-233) in a very thin layer.

Checks of the Stored Energy Operator Mechanism
The stored energy operator checks are divided into mechanical and electrical checks for simplicity and better organization. This first series of checks determine if the basic mechanism is clean, lubricated and operates smoothly without control power. The contact erosion check of the vacuum interrupter is also performed during these tasks.

Table 2: Maintenance and Lubrication Intervals
ANSI C37.06 Table 8 - Usual Service Conditions
Maintenance Based Upon Number of Circuit Breaker Closing Operations

<table>
<thead>
<tr>
<th>Circuit Breaker Type</th>
<th>Number of Years/Closing Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-GMI-350</td>
<td>5 years¹ / 1,000 operations</td>
</tr>
<tr>
<td>5-GMI-50</td>
<td></td>
</tr>
<tr>
<td>15-GMI-1000</td>
<td></td>
</tr>
<tr>
<td>15-GMI-50</td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td>5 years¹ / 2,000 operations</td>
</tr>
</tbody>
</table>

¹ Five year interval for GMI circuit breakers manufactured January, 1992, or later.
² One year interval for units manufactured earlier.

Maintenance and Lubrication
The operator mechanism shown in Figure 35 with the front cover and the operator control panel removed to show construction details. Both the tripping spring and the two closing springs are shown. The movable end of each closing spring is connected to a crank arm. The movable end of the opening spring is connected to the jack shaft by a pull rod. The dashpot is connected to the jack shaft operating shaft by a pushrod linkage.

Clean the entire stored energy operator mechanism with a dry, lint-free cloth.

Check all components for evidence of excessive wear. Place special attention upon the closing spring cranks and the various pushrods and linkages.

Lubricate all non-electrical moving or sliding surfaces with a light coat of synthetic grease or oil. Lubricants composed of diester oils and lithium thickeners will be compatible.

Shell (drawn cup) needle bearings: Use either Beacon (Exxon) 325 (reference 18-658-676-422 and part number 15-337-131-001), or Supermil (Amoco) A-72832 (reference 18-758-676-423), or Anderol 732.

Pivots, sliding, and/or rolling surfaces and general lubrication: Use Anderol 732 aerosol synthetic fluid grease (reference part number 15-172-816-058).

In addition to lubricating the stored energy operating mechanism, use Anderol 732 to lubricate both the OD of the bushing and the ID of the wheel for the four floor wheels.
Fastener Check
Inspect all fasteners for tightness. Both lock-nuts and retaining rings are used. Replace any fasteners that appear to have been frequently removed and replaced.

Manual Spring Charging and Contact Erosion Checks
Perform the Manual Spring Charging Check contained in the section describing the Installation Check and Initial Functional Tests. The key steps of this procedure are repeated here.
1. Insert the hand charging lever into the manual charge handle socket at the front of the operator control panel. Figure 20 shows the lever inserted. Up and down motion of the lever charges the closing springs. Continue cranking until the Charged flag appears in the window of the spring indicator.
2. Press the Close (black) pushbutton. The contact position indicator on the operator control panel should indicate that the circuit breaker contacts are closed.
3. Perform the contact erosion check. Contact erosion occurs when high fault currents are interrupted or when the vacuum interrupter is nearing the limit of its contact life. Determination of acceptable contact condition is checked by the visibility of the white erosion mark shown in Figure 36. The white erosion mark is located in the keyway (or slot) on the movable stem of the vacuum interrupter, near the plastic guide bushing.

The contact erosion check procedure is:
• Be sure the breaker primary contacts are Closed.
• Observe the white erosion mark (Figure 36) of each pole. When this mark is visible, contact wear is within acceptable limits. For some circuit breakers (with a vacuum interrupter having an internal arc shield), a flashlight and dental mirror will be needed to observe the white erosion mark.

4. Press the red Trip pushbutton after completing the contact erosion check. Visually verify the Discharge condition of the closing springs and that the circuit breaker contacts are Open.
5. Press the black Close pushbutton. Nothing should happen. The manual spring check should demonstrate smooth operation of the operating mechanism.
Maintenance

**Damper Assembly Check (for circuit breakers equipped with all vacuum interrupters except type VS-15050)**

GMI circuit breakers contain a viscous damper assembly, shown in Figure 37a, and described in some detail on page 16, and in Figure 19a.

While performing the manual spring charging check, a simple check of the damper mounting yoke, pin, retaining rings, and the nut for tightness should be completed.

The cylindrical surface of the damper and telescoping tube should be well greased. The full periphery of the tube and cylinder should be coated with Beacon 325.

**Damper Assembly Check (for circuit breakers equipped with type VS-15050 vacuum interrupters)**

GMI circuit breakers contain a viscous damper assembly, shown in Figure 37b, and described in some detail on page 16 and in Figure 19b.

While performing the manual spring charging check, a simple check of the damper mounting adapter, pin, retaining rings, X-washer, and other hardware for tightness should be completed.

The outer surface of the damper and telescoping cylinder should be well greased. The full inner periphery of the cylinder and outer surface of the damper should be coated with Beacon 325.

**Electrical Control Checks**

The electrical controls of the GMI circuit breaker should be checked during inspections to verify absence of any mechanical damage, and proper operation of the automatic spring charging and Close and Trip circuits.

Unless otherwise noted, all of these tests are performed without any control power applied to checks and the circuit breaker.

**Check of the Wiring and Terminals**

1. Physically check all of the circuit breaker wiring for evidence of abrasion, cuts, burning or mechanical damage.
2. Check all terminals to be certain they are solidly attached to their respective device.

**Check of the Secondary Disconnect**

In addition to checking the terminals of the secondary disconnect, the secondary contact fingers need to be free to move without binding. Depress each finger, confirm presence of spring force (contact pressure), and verify freedom of motion.
Maintenance

**Automatic Spring Charging Check — Control Power Required**
Repeat the automatic spring charging check described in the section entitled Installation Checks and Initial Functional Tests.

Primary tasks of this check are:
1. The circuit breaker is energized with control power for this check.
2. De-energize the source of control power (Figure 1).
3. Install the circuit breaker end of the split plug jumper over the secondary disconnect of the circuit breaker. The split plug jumper has one male and one female connector and cannot be installed incorrectly (Figure 7).
4. Install the switchgear end of the plug jumper over the secondary disconnect block inside the switchgear (Figure 8).
5. Energize the control power source.
6. When control power is connected to the circuit breaker, the closing springs should automatically charge. Visually verify that the closing springs are charged.

Note: A temporary source of control power and test leads may be required if the control power source has not been connected to the switchgear. When control power is connected to the GMI circuit breaker, the closing springs should automatically charge.

**Electrical Close and Trip Check — Control Power Required**
A check of the circuit breaker control circuits is performed while the unit is still connected to the switchgear by the plug jumper. This check is made with the breaker energized by control power from the switchgear.
1. Once the circuit breaker springs are charged, move the switchgear Close/Trip switch to the Close position. There should be both the sound of the circuit breaker closing and indication that the circuit breaker contacts are closed by the main contact status indicator.
2. As soon as the circuit breaker has closed, the automatic spring charging process is repeated.
3. After a satisfactory close operation is verified, move the switchgear Close/Trip switch to the Trip position. Verify by both sound and contact position that the contacts are open. Completion of these checks demonstrates satisfactory operation of auxiliary switches, internal relays and solenoids.

**Checks of the Spring Charging Motor**
No additional checks of the spring charging motor are necessary. Once every 10,000 operations, the motor brushes need replacement (reference kit 18-658-612-886). Use the operation counter as the basis for establishing the operation frequency.

**High-Potential Tests**
The next series of tests (Vacuum Integrity Test and Insulation Tests) involve use of high voltage test equipment. The circuit breaker under test should be inside a suitable test barrier equipped with warning lights.

**Vacuum Integrity Check**
A high potential test is used to verify the vacuum integrity of the circuit breaker. This test is conducted on the circuit breaker with its primary contacts in the Open position.

**WARNING**
Hazardous voltages and high-speed mechanical parts. Can cause death, severe personal injury, or property damage.
Follow safe procedures, exclude unnecessary personnel and use safety barriers. Follow NFPA 70E requirements.

**High Potential Test Voltages**
The voltages for high potential tests are shown in Table 3.

**WARNING**
Vacuum interrupters may emit X-ray radiation. Can cause personal injury. X-rays can be produced when a high voltage is placed across two circuit elements in a vacuum. Keep personnel more than six (6) feet away from a circuit breaker under test.

**DANGER**
High potential tests employ hazardous voltages. Will cause serious injury or death. Follow safe procedures, exclude unnecessary personnel and use safety barriers. Keep away from the circuit breaker during application of test voltages. Follow NFPA 70E requirements. Disconnect the plug jumper from between the circuit breaker and switchgear before conducting high potential tests. After test completion, ground both ends and the middle portion of the vacuum interrupter to dissipate any static charges.

**Note:** Do not use DC high potential testers incorporating half-wave rectification. These devices produce high peak voltages. These high voltages will produce X-ray radiation. These devices also show erroneous readings of leakage current when testing vacuum circuit breakers.
Maintenance

Vacuum Integrity Test Procedure
1. Observe safety precautions listed in the danger and warning advisories. Construct the proper barrier and warning light system.
2. Ground each pole not under test.
3. Apply test voltage across each pole for one minute.
4. If the pole sustains the test voltage for that period, its vacuum integrity has been verified.

Note: This test includes not only the vacuum interrupter, but also the other insulation components in parallel with the interrupter. These include the standoff insulators and the insulated drive links, as well as the insulating (tension) struts between the upper and lower vacuum interrupter supports. If these insulation components are contaminated or defective, the test voltage will not be sustained. If so, clean or replace the affected components, and retest.

As-Found Insulation and Contact Resistance Tests
As-Found tests verify the integrity of the circuit breaker insulation system. Megger or insulation resistance tests conducted on equipment prior to installation provide a basis of future comparison to detect changes in the protection afforded by the insulation system. A permanent record of periodic As-Found tests enables the maintenance organization to determine when corrective actions are required by watching for significant deterioration in insulation resistance, or increases in contact resistance.

Insulation and Contact Resistance Test Equipment
In addition to the High Potential Test Equipment capable of test voltages as listed in Table 3, the following equipment is also required:

- AC High Potential tester with test voltage of 1500 volts, 60 Hz.
- Ductor for contact resistance tests.

Insulation and Contact Resistance Test Procedure
1. Observe safety precautions listed in the danger and warning advisories for the Vacuum Integrity Check tests.
2. Close the circuit breaker. Ground each pole not under test. Use manual charging, closing and tripping procedures.
3. Apply the proper AC (i.e., either 14 or 27kV) or DC (i.e., either 20 or 38kV) high potential test voltage between a primary conductor of the pole and ground for one minute.
4. If no disruptive discharge occurs, and the test voltage is sustained for that period, the insulation system is satisfactory.
5. After test, ground both ends and the middle of each vacuum interrupter to dissipate any static charge.
6. Disconnect the leads to the spring charging motor.
7. Connect all points of the secondary discharge with a shorting wire. Connect the shorting wire to the high potential lead of the high voltage tester, and ground the circuit breaker housing. Starting with zero volts, gradually increase the test voltage to 1500 volts, RMS, 60 Hz.

Table 3 – High Potential Test Voltages

<table>
<thead>
<tr>
<th>Equipment kV Rating</th>
<th>Max AC RMS</th>
<th>Max DC Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.76kV</td>
<td>14kV</td>
<td>20kV</td>
</tr>
<tr>
<td>8.25kV</td>
<td>27kV</td>
<td>38kV</td>
</tr>
<tr>
<td>15.0kV</td>
<td>27kV</td>
<td>38kV</td>
</tr>
</tbody>
</table>

Table 4 – Maximum Contact Resistance

<table>
<thead>
<tr>
<th>Current Rating (Amps)</th>
<th>Contact Resistance (Micro-Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>60</td>
</tr>
<tr>
<td>2000</td>
<td>40</td>
</tr>
<tr>
<td>3000</td>
<td>20</td>
</tr>
</tbody>
</table>

Maintain test voltage for one minute.
8. If no disruptive discharge occurs, the secondary control insulation level is satisfactory.
9. Disconnect the shorting wire and re-attach the leads to the spring charging motor.
10. Perform contact resistance tests of the primary contacts using a ductor. Contact resistance should not exceed the values listed in Table 4.
11. Make a permanent record of all tests performed.

Inspection and Cleaning of Circuit Breaker Insulation
1. Perform the Spring Discharge Check on the circuit breaker, after all control power is removed. The Spring Discharge Check consists of 1) depressing the red Trip pushbutton, 2) then depressing the black Close pushbutton, and 3) again depressing the red Trip pushbutton. All of these controls are on the circuit breaker front panel. Visually verify the Discharge condition of the springs.
2. Remove any interphase and outer phase barriers as shown in Figure 13.
3. Clean barriers and post insulators using clean cloth and one of the following cleaning solvents:
   - No. 1 or No. 2 denatured alcohol
   - Isopropyl or isobutyl alcohol
4. Replace all barriers. Check all visible fasteners again for condition and tightness.

Table 4 – Maximum Contact Resistance

Note: Do not use any cleaning compounds containing chlorinated hydrocarbons such as trichlorethylene, perchlorethylene or carbon tetrachloride.

These compounds will damage the phenylene ether copolymer material used in the barriers and other insulation on the circuit breaker.

Functional Tests
Refer to the Installation Checklist in the Installation Checks and Initial Functional Tests section of this manual. Functional tests consist of performing at least three functional tests as described below:

Manual Spring Charging Checks and three (3) Automatic Spring Charging Checks. After these tests are complete, and the springs fully discharged, all fasteners and connections are checked again for tightness and condition before re-installing the circuit breaker into the metal-clad switchgear.
Introduction
For following procedures along with the troubleshooting charts at the end of this section, provide maintenance personnel with a guide to identifying and correcting possible malfunctions of the GMI vacuum circuit breaker.

Table 5
Table 5 lists the recommended overhaul schedule for GMI circuit breakers operating under ANSI usual conditions. When actual operating conditions are more severe, overhaul periods should occur more frequently. The counter on the front panel of the circuit breaker records the number of operations.

<table>
<thead>
<tr>
<th>Circuit Breaker Type</th>
<th>Number of Closing Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-GMI-350</td>
<td>5,000 operations</td>
</tr>
<tr>
<td>5-GMI-50</td>
<td></td>
</tr>
<tr>
<td>15-GMI-1000</td>
<td>5,000 operations</td>
</tr>
<tr>
<td>15-GMI-50</td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td>10,000 operations</td>
</tr>
</tbody>
</table>

Circuit Breaker Overhaul

Replacement at Overhaul
The following components are replaced during an overhaul of the circuit breaker, when required:
- Vacuum interrupters as determined by vacuum integrity test, contact erosion, or after 30,000 operations (10,000 for VS-15050).
- Spring charging motor brushes should be replaced after 10,000 operations (reference kit 18-658-612-886).

Replacement of Closing Springs
Figure 38 shows the use of a 3/4 inch socket wrench to relieve spring tension on the closing springs. The top cover of the circuit breaker has openings providing access to the tensioning bolts. Turning the left and right hand support bolts counterclockwise relieves spring tension.

Replacement of Closing Springs

For early models of the GMI circuit breaker, once tension has been relieved, retaining ring pliers are needed to remove the top and bottom retaining rings attaching each spring to its cross-arm support shaft and its crank arm.

For later models of the GMI circuit breaker, the lower spring hangers are fastened to the crank arms, using hex socket shoulder bolt and nut. The nut is applied using thread locking adhesive, Loctite 271, with Loctite type T primer.

When one or both springs are reinstalled, be sure the support bolts are inserted inside their support bolt bushing. These bushings maintain the correct tension on the closing springs. Replace all retaining rings during the re-assembly.

WARNING
Hazardous voltage and high speed mechanical parts.
Can cause death, serious injury, or property damage.
All replacement of circuit breaker components must be performed with the circuit breaker completely de-energized and the springs discharged.

Figure 38: Use of Socket Wrench to Release Tension on Closing Springs.

Figure 39: Removal of Opening Spring.
Re-tighten by turning the support bolts clockwise until the support bolt bushings firmly butt up against the support bolt attachment bracket and the cross arm support shaft.

Replacement of Opening Spring
The opening spring may be removed and replaced without the need to use a spring keeper or compression aid.

The opening spring assembly consists of the top and bottom spring caps, threaded coupling rod with nuts, and a supporting shelf. The shelf features location holes and tabs which work in concert with supports in the circuit breaker frame to secure the shelf.

Before disassembling the opening spring, carefully measure and record the dimension between both spring caps (refer to Figure 39). The dimension is adjusted during breaker production cycling test at factory and should be between 6.75” and 6.875” or may slightly vary.

An adjustable crescent wrench allows an easy means of grasping the shelf and lifting it slightly to disengage the tabs in the self locating holes. With the tabs disengaged, and grasping the top of the spring, the whole assembly can be pulled forward.

When re-assembling, apply upward pressure to the shelf over stationary support and to engage the shelf tab guides. The shelf may then be guided into place. Verify that the dimension between both spring caps corresponds to the factory adjustment.

Replacement of Closing and Tripping Solenoids (Devices 52SRC and 52T)
Replacement of either the closing or tripping solenoids is straightforward. Each solenoid has two mounting screws and one quick disconnect terminal. Removing the mounting bolts and quick disconnect terminal of the solenoid permits it to slide out and to be removed. Replacement requires careful insertion of the solenoid and re-attachment of the mounting bolts and quick disconnect. Figure 40 shows the two screws which attach the close coil and the quick disconnect terminal for control leads. The trip coil arrangement is similar.

Replacement of Anti-Pump Relay (Device 52Y)
Figure 41 helps illustrate the anti-pump relay removal procedure. The two nuts holding the relay and its mounting bracket are removed. The wires connected to the relay should be tagged and disconnected, the relay and bracket can then be extracted and replaced.
Replacement of the Auxiliary Switch

*Figure 41* shows the auxiliary switch and its key mounting components. Two mounting screws hold the switch to the mounting bracket. First remove the quick disconnect terminals after marking their position. The screw, washer and nut connecting the switch’s operating lever to the operating shaft is removed, and then the two mounting screws. Re-assemble in reverse order.

Replacement of Motor Cut-Off Switch (Device LS1) and Spring Charged Switch (LS2)

The motor cut-off switch (LS1) and spring charged switch (LS2) form a common assembly of two switches on one mounting bracket. Should either switch require replacement, it is recommended that both be replaced as a single assembly. The motor cut-off switch (LS1) is the “outboard” device with respect to the mounting bracket. Removal of the two mounting screws shown in *Figure 42* allows both switches to be brought out for convenient removal of the interconnecting wiring.

Next, mark all wires to both switches. Remove the wires. Then replace the switches, rewire, and reassemble the switches to their mounting bracket. Be sure to use the same flat washer, lock washer and nut configuration in reassembly as was present in the as-shipped condition.

Replacement of Trip Latch Reset Check Switch (Device LS3)

*Note:* Two different latch systems have been used in GMI circuit breakers, with changeover from one design to the other occurring in mid-1991. This instruction manual describes both designs.

Pages 11-13 describe the operation of the mechanism used beginning in approximately mid-1991.

Pages 13-15 described the operation of the mechanism used from 1989 until approximately mid-1991.

Replacement of LS3 - Mid-1991 and After

The following paragraphs describe replacement of the trip latch reset switch for the mechanism used beginning in approximately mid-1991.

This mechanism can be identified by observing the close latch above the spring charging motor on the left side of the circuit breaker. Refer to *Figure 18*. The close latch is installed on the close shaft assembly 72, and includes a hardened latch face. This face contacts a bearing which is part of the close hatchet assembly 105. If the mechanism has a close hatchet which bears directly on the close shaft, refer to the next section for replacement of the trip latch reset switch for your mechanism.
The trip latch reset check switch (LS3) is mounted on the trip shaft actuator stop plate, as shown in Figure 43a. To replace this switch, the trip shaft actuator must be removed by backing out two #10-32 hex socket screws, and then removing two 3/8” nuts which secure the trip shaft actuator stop plate to the mechanism.

Wires to the switch must be marked and removed. The stop plate and switch may then be removed as a subassembly. The switch is a bushing type, for panel mounting, and threads into the stop bracket. After adjustment, it is secured by a jam nut and locking nut.

Adjustment requires the tip of the switch plunger to be set 0.06-0.09” ahead of the stop bracket tab, as illustrated in Figure 43a. Secure the switch, position the stop bracket assembly, and reattach the wires. Install the 3/8” nuts to secure the trip shaft actuator stop plate to the mechanism. Remount the trip shaft actuator.

Confirm that the switch is vertically aligned to ensure that it will not be struck by the closing hatchet or the trip shaft actuator.

Replacement of LS3 - Up to Mid-1991
The following paragraphs describe replacement of the trip latch reset switch for the mechanism used up to approximately mid-1991.

This mechanism can be identified by observing the close latch above the spring charging motor on the left side of the circuit breaker. Refer to Figure 18. The close hatchet 22 has a latch face which bears directly on the close shaft 72. If the close hatchet includes a bearing which contacts a hardened latch installed on the close shaft, refer to the preceding section for replacement of the trip latch reset switch for your mechanism.

The trip latch reset check switch is mounted to the left (when facing the front of the breaker) vertical mechanism side sheet as shown in Figure 43b. The switch is held in place by two screws. When replacement of the trip latch reset switch is required, both screws need to be removed.

Next, mark both wires to the switch, and remove them. Then replace the switch, rewire and reassemble the switch to the left hand mechanism side sheet. Be sure to use the same washer and nut configuration as was present in the as-shipped condition.

Replacement of Damper Assembly (for circuit breakers with all vacuum interrupters except type VS-15050)
Damper replacement will require the removal of a pin which ties the damper mounting yoke to the circuit breaker frame. Refer to Figure 45a.

The damper is attached to the mounting yoke with a lock washer and 5/8-18 jam nut. For added security, the jam nut is treated with a thread locking adhesive (Loctite 271 with Loctite type T primer), and then torqued to a value of 17-20 ft-lbs.

Check all associated parts, damper body and telescoping tube, for wear. Replace as necessary.

The telescoping tube and internal striker block employ slugs in variable thicknesses and quantity to control moveable contact motion. If the telescoping tube is replaced, the tube must be replaced with the correct tube to assure that the correct type and number of slugs are present.
Replacement of Damper Assembly (for circuit breakers equipped with type VS-15050 vacuum interrupters)

Damper replacement will require the removal of a pin which ties the damper mounting adapter to the circuit breaker frame. While disassembling the pin, carefully note the position of all spacers so that the adapter will be correctly centered between the vertical circuit breaker frame members upon reassembly. Refer to Figure 45b.

Prior to installing the replacement damper, adjust the setting of the damper to “9”, and secure the setting by tightening the set screw to a torque of 6 in-lbs. Install the damper by screwing it into the mounting adapter, and secure with internal tooth lock washer and nut. The nut requires a 11/4 inch open end wrench. The damper should be adjusted so that the head of the piston just touches the striker pin inside the outer cylinder when the circuit breaker is in the open position. A hole in the outer cylinder is provided so that the clearance between the striker pin and the head of the piston can be observed.

Check all associated parts, damper body and telescoping cylinder for wear. Replace as necessary. If bolts securing the triangular damper arms are loose, they should be treated with a thread locking adhesive (Loctite 271 with Loctite type T primer) and then torqued to a value of 6-9 ft-lbs.

Replacement of Spring Charging Motor (Device 88)

Remove the quick-disconnect terminals. Then remove the screws holding the motor mounting bracket to the circuit breaker housing. The motor slips out as a complete assembly. Check and replace as required.

Replacement of Primary Disconnect Fingers

The primary disconnect finger assembly is secured with standard hardware. With the bolt removed, the finger assembly can be slid off the retaining arm as a unit. Replace burnt fingers or broken springs as necessary.
Replacement of Vacuum Interrupters

The following procedures are for the removal and replacement of the vacuum interrupters.

Note: Special care needs to be exercised in removal of hardware around the bottom, or movable contact end, of the vacuum interrupter.

The movable contact uses a metal bellows assembly to maintain the vacuum seal while still permitting up and down motion of the contact. This bellows assembly is rugged and reliable, and is designed to withstand years of vertical movement. However, care should be exercised in subjecting the bellows to excessive torque during removal and replacement. Twisting the bellows through careless bolt removal or tightening may damage the vacuum interrupter.

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Preparation

Identify vacuum interrupter family and breaker continuous current rating. The interrupter will have an identifying nameplate showing the family designation and the continuous current requirement can be taken from the circuit breaker's rating label.

Check the “Index of Figures” to find the appropriate side elevation picture of the circuit breaker pole unit assembly. Confirm that the figure applies by comparing the figure carefully to the circuit breaker.

Read through the replacement procedures, noting recommended tools, gaging requirements and torquing limits, etc.

Vacuum Interrupter Removal

1. Make provision to save and retain hardware. Rejoin fastener parts (bolts, nuts, washer, lockwashers, etc.) as they are removed. Save in an appropriate container.

2. Remove interphase and outer barriers as required. Carefully note the exact sequence and arrangement of barriers and supports, so that these parts can be correctly positioned during reassembly. Barrier and support arrangements vary by circuit breaker rated voltage, continuous current, interrupting current, vacuum interrupter type, and other factors. It is suggested that photos be taken of the circuit breaker prior to the start of disassembly to aid in correctly reassembling the circuit breaker.

3. Loosen, but do not remove, bolt fastening trunnion to the movable contact stem of the vacuum interrupter. An 8mm or a 10mm Allen wrench is required.

4. Disconnect insulating pushrod at bell cranks. Remove and discard two 0.25” X-washer. Spread the bell crank elements and allow the pushrod to drop down.

5. Refer to Figure 51, and using the procedure shown to secure head and nut, proceed to loosen the bolts which fasten the flexible shunt clamp to the movable contact of the tube. For 2000A ratings using VS-15050 interrupters, and all 3000A ratings not using the chair support design, it will first be necessary to remove the heat sinks attached to each side of the flexible shunt clamp. Keep hardware and heat sinks for reuse.

6. Remove the two X-washer (discard) fastening the bell cranks to the trunnion.

7. Loosen, but do not remove insulating centering devices near the movable contact end of the vacuum interrupter.

8. Remove the bolt fastening the trunnion to the end of the interrupter. Be certain to save the washer, spacer, trunnion and hardware for later use.

Note: List the order and location of each flat and lock washer.

It is critical that these spacing washer be replaced in their exact order upon reassembly to assure proper operation of the circuit breaker.

9. Vacuum Interrupter Stationary Contact Disassembly and Interrupter Removal.

9.1. Circuit breakers rated 1200 and 2000A using the VS12015, VS 25002 or VS17006 Interrupters (Figure 48). Using an 19mm socket and extension, remove bolt fastening vacuum interrupter stationary contact to the upper primary connectors and upper stab support. Save bolt washer and lockwasher. Carefully remove and set aside the heavy copper spacer connecting the interrupter to the upper primary bars. Handle with care to maintain flat ends on the cylindrical spacer.

9.2. Circuit breakers rated 1200A using the VS10006 or VS10028 interrupters (Figure 47). Using 9/16 (and 11/16) socket and backup wrench, remove two 3/8 fasteners joining upper primary extensions to the stab support. Rejoin hardware and save with primary extensions for reuse. Using a 24mm socket and extension,
loosen and remove hex bolt joining the interrupter stationary contact to the bus extensions and stab support. Remove primary extensions and save.

9.3. Circuit breakers rated 2000A using the VS10006 interrupter (Figure 50). Using a 24mm socket and extension, loosen and remove hex bolt joining the interrupter stationary contact to the primary extensions and stab support. After removing the bolt carefully, remove a 3/8 copper spacer, handle carefully and save protecting the flat contact surfaces.

9.4. Circuit breakers rated 2000 and 3000A using the VS15050 interrupter. Using a 9/16 socket and extension, remove four 3/8 hex bolts fastening the upper primary stab support to the red post insulator. Lift and remove, set aside with care. This item is bulky and awkward, and an extra person may be required to hold the primary extension and the attached insulating support plates when the bolts are being removed.

9.5. Circuit breakers rated 1200A using the VS10028 interrupter (Figure 49). Remove four hex socket flat head screws joining the insulating support plate to the upper primary stab support. A 5/32 (0.156) hex key and 7/16 back up wrench will be required (hex key socket preferred). These screws have been secured with a thread locking adhesive. Preheating the fasteners to 350°F using a hot air gun prior to breaking them free is recommended. Remove, rejoin and save fasteners for future use. Using a 24mm socket and extension, loosen and remove the hex bolt joining the interrupter stationary contact to the primary extensions. Using 9/16 socket and extension, remove four 3/8 hex bolts fastening the upper primary stab support to the red post insulator. Lift and remove, set aside with care. This item is heavy, and two people may be required to safely remove.

9.6. Circuit breakers rated 2000 or 3000A using VS15050 interrupter (Figure 54). Remove four (two on each side) hex socket flat head screws joining the insulating support plates to the lower primary stab support. A 5/32 (0.156) hex key (hex key socket preferred) and 7/16 backup wrench will be required. These screws have been secured with a thread locking adhesive. Preheating the fasteners to 350°F using a hot air gun prior to breaking them free is recommended. Remove, rejoin, and save fasteners for future reuse.

Using a 24mm socket and extension, loosen and remove the hex bolt joining the interrupter stationary contact to the primary extensions. Using a 5/16 hex key (hex key socket preferred), remove two 3/8 socket head screws which secure the primary extension to the primary stab support.

Using a 9/16 socket and extension, remove four 3/8 hex bolts fastening the upper primary stab support to the red post insulator. Lift and remove, set aside with care. This item is bulky and awkward, and an extra person may be required to hold the primary extension and the attached insulating support plates when the bolts are being removed.

9.7. Circuit breakers rated 3000A with chair support design interrupter (Figure 55). Remove the X washer from each end of pin X in the pole bottom, spread the levers and disengage from the pin. Let the push rod drop down. Using a 24mm socket and extension, loosen and remove the hex bolt joining the interrupter stationary contact to the primary extensions. Remove pole top from chair by removing four (4) hex socket head cpa screw (M6 Allen wrench). Remove four (4) hex socket head cap screw from pole bottom (M6 Allen wrench). Remove vacuum interrupter with pole bottom from chair. Remove the socket head cap screw from movable stem of the vacuum interrupter. Remove the four (4) hex head cap screws, which hold the flexible shunts to the pole bottom.

10. (For all ratings except 3000A with VS015050 interrupter and chair support design) Check the clamp on the movable contact to ensure that it will slide freely from the interrupter movable stem. The clamp may have to be wedged or worked open in order to slide freely from the interrupter. With the clamp free, the vacuum interrupter may be lifted clear of the clamp and pole unit structure.

Vacuum Interrupter Replacement

11. Inspect all silver plated surfaces for cleanliness. Wipe clean with solvent and clean rag. Do not abrade.

12. Insert replacement vacuum interrupter into the lower stab support oriented according to the following table. For interrupters having an evacuation nipple or tubulation, the vacuum interrupter should be oriented with the evacuation nipple or tubulation oriented as shown in the table. If the interrupter does not have an evacuation nipple or tubulation, the interrupter should be oriented with the label towards the rear of the circuit breaker (away from the operating mechanism).

| VS-12015 | Tubulation toward primary fingers |
| VS-25002 | Tubulation toward primary fingers |
| VS-17006 | Tubulation toward primary fingers |
| VS-10006 | Tubulation toward mechanism housing |
| VS-10028 | Tubulation toward mechanism housing |
| VS-15050 | Label toward primary fingers |
13. Slip the flexible shunt clamp over the movable contact stem of the interrupter. Replace clamp hardware, bolt(s), washer(s), and nut(s). Raise clamp until it bears on step or retaining ring 33 to 48mm up from the end of the stem.

**Note:** Finger tighten only! Excessive clamping force at this time may deform movable contact stem.
Later in this procedure a trunnion bolt will be inserted and secured. After this bolt’s insertion and adjustment, the clamp may then be tightened.

14. Stationary Contact Assembly
14.1. VS12015, VS25002, and VS17006 Interrupters. Align copper spacer bar with large hole in stab support. Insert long M12 bolt through lockwasher, washer, stab support and copper spacer. Align interrupter stationary contact and (by hand) engage the M12 bolt (Figure 48).

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

14.2. VS10006 and VS10028 Interrupters in Circuit Breakers rated 1200A (Figure 47).
With the interrupter in alignment under stab support, place the primary extension into the gap between stab support and interrupter stationary contact.
Make sure contact surfaces are wiped clean.
Replace, finger tight, two 3/8 fasteners joining the primary extension to the stab support.
Insert an M16 hex bolt through lockwasher, washer, stab support and primary extension. Align interrupter stationary contact, and (by hand) engage the M16 bolt.

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

14.3. VS10006 Interrupter in 2000A Circuit Breakers (Figure 50).
With interrupter aligned under the primary stab, place the 3/8” copper spacer between primary extensions and stationary contact of the vacuum interrupter.
Insert the M16 hex bolt through a lock washer, washer, stab support, primary extension and 3/8” copper spacer. Align vacuum interrupter stationary contact, and (by hand) engage the M16 bolt.

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

14.4. VS10028 Vacuum Interrupter Applied in Circuit Breakers Rated 2000 and 3000A (Figure 49).
Allow interrupter to rest on the lower stab support.
Replace upper primary stab support with primary bus extensions. Fasten with four 3/8” hex bolts to the primary insulator. Use 3/8 bolt, lock washer and washer torqued 20-25 ft-lbs.
Align vacuum interrupter stationary contact. Insert M16 hex bolt through lock washer, washer, upper stab support and primary bus extensions. Manually engage bolt into interrupter by applying hand torque only.

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

Fasten the insulating support plate to the upper primary stab support. Use four hex socket flat head screws. Clean external and internal threads. Apply “Loctite” Primer T to the external and internal threads. Apply “Loctite” threadlocker 262 to the external threads. Engage and torque 8-10 ft-lbs.

14.5. VS15050 Vacuum Interrupter Applied in Circuit Breakers Rated 1200A (Figure 53).
With interrupter in alignment under stab support, place the primary extension into the gap between stab support and interrupter stationary contact. Make sure contact surfaces are wiped clean.
Replace, finger tight, two 3/8 fasteners joining the primary extension to the stab support.
Insert an M16 hex bolt through lock washer, washer, stab support, and primary extension. Align interrupter stationary contact, and (by hand) engage the M16 bolt.

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

Fasten two 3/8 fasteners securing the primary extensions (26-36 ft-lbs).

14.6. VS15050 Vacuum Interrupter Applied in Circuit Breakers Rated 2000 and 3000A (Figure 54) Having separate phase barriers.
Allow interrupter to rest on lower stab support.
Replace upper primary bus extension with attached insulating plates. This component is awkward, so it is helpful to have an extra person to hold the parts while the bolts are inserted. Install six (three on each side) hex socket flat screws to secure the insulating plates to the lower primary support. Screws should be loose.
Install the upper primary stab support. Fasten with four 3/8 hex bolts to the primary insulator. Use 3/8 bolt, lock washer and washer torqued to 20-25 ft-lbs.
Connect the upper primary extension to the upper primary stab support, using two 3/8 socket head screws, torqued to 12-17 ft-lbs.

14.7. VS15050 Vacuum Interrupter Applied in Circuit Breakers Rated 3000A (Figure 55) Having separate phase barriers.
Allow interrupter to rest on lower stab support.
Replace upper primary stab support with primary bus extensions. Fasten with four 3/8” hex bolts to the primary insulator. Use 3/8 bolt, lock washer and washer torqued 20-25 ft-lbs.
Align vacuum interrupter stationary contact. Insert M16 hex bolt through lock washer, washer, upper stab support and primary bus extensions. Manually engage bolt into interrupter by applying hand torque only.

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

Fasten two 3/8 fasteners securing the primary extensions (26-36 ft-lbs).

14.8. VS15050 Vacuum Interrupter Applied in Circuit Breakers Rated 4000A (Figure 56) Having separate phase barriers.
Allow interrupter to rest on lower stab support.
Replace upper primary stab support with primary bus extensions. Fasten with four 3/8” hex bolts to the primary insulator. Use 3/8 bolt, lock washer and washer torqued 20-25 ft-lbs.
Align vacuum interrupter stationary contact. Insert M16 hex bolt through lock washer, washer, upper stab support and primary bus extensions. Manually engage bolt into interrupter by applying hand torque only.

**Note:** Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.

Fasten two 3/8 fasteners securing the primary extensions (26-36 ft-lbs).
Align vacuum interrupter stationary contact. Insert M16 hex bolt through lock washer, washer, upper stab support and primary bus extensions. Manually engage bolt into the tube by applying hand torque only.

Now it is time to secure the hardware connecting the insulating plates on each side of the pole to the lower pole support. Use four (two on each side) hex socket flat head screws. Clean external and internal threads. Apply "Loctite" Primer T to the external and internal threads. Apply "Loctite" thread locker 262 to the external threads. Engage and torque to 8-10 ft-lbs.

15. Trunnion and Movable Contact Adjustment
15.1. The trunnion is fitted to the interrupter movable stem in concert with spacer and shim washer. A special tool consisting of a threaded shaft and gage block is to be used to determine the correct number of shimming washer. Gaging tool consists of:

Note: VS10028 Interrupter will not require a spacer.
Threaded Shaft M12 18-658-137-105
Threaded Shaft M12 18-658-137-102
Gage Block 6mm: 18-750-171-001
Gage Block 8mm: 18-750-171-002
Gage Block 11mm: 18-750-171-003
Gage Block 9mm: 18-750-171-004
VS12015 requires 6mm gage and stroke
VS25002 requires 8mm gage and stroke
VS17006 requires 8mm gage and stroke
VS10028 requires 8mm gage and stroke
VS10006 requires 11 mm gage and stroke
VS15050 requires 9mm gage and stroke

The gage will set the trunnion center at one half the stroke magnitude above the center of the bell crank's major pivot. The gage block includes allowances for trunnion thickness, 1/2 the stroke and radius of the major bell crank pivot (Figure 52).

15.2. Torque fastener at the interrupter stationary contact to fix the tube stationary contact against the primary extensions, using torque shown in Table 7. The companion lock washer is to be fully collapsed. Hold interrupter in the alignment required under Article 12 of the vacuum interrupter replacement procedure while tightening this fastener.

15.3. Thread gaging shaft, by hand, into movable stem of the vacuum interrupter.
M10 thread for VS12015, VS25002 and VS17006.
M12 thread for VS15050.
M12 thread for VS15050.
Thread by hand until fully and firmly seated.

15.4. Apply shim washer, approximately 7, spacer and correct gage block over the shaft. Raise the gage block until the gage foot just bears or comes within one washer thickness of bearing upon the lower surface of the bell crank shaft. washer may have to be removed or added to achieve these conditions. The spacer and washer above the gage block must be packed against the vacuum interrupter movable stem when observation of the gage foot to bell crank clearance is made. The gage foot must just touch the shaft or be within one shim washer thickness of doing so.

Note: The VS10028 interrupter will not require a spacer.

15.5. Having determined the required number of washer, insert hex bolt through lockwasher, trunnion, spacer and shim washer. Engage bolt into the vacuum interrupter stem and tighten by hand to snugness. Engage trunnion to bell crank (both sides) and tighten hex bolt further until lockwasher is just collapsed.

15.6. Manually exercise bell cranks, moving interrupter contact approximately 1/4 to 3/8 of an inch. Release bell cranks, interrupter contact should snap freely to the closed position. The main contacts should be clearly heard as they meet upon closing.
Check to make certain the insulating centering blocks or rings at the base of the interrupter are loose to permit interrupter alignment. It may be necessary to repeatedly free the interrupter stationary fastener, shift the interrupter slightly, retighten and recheck bell crank snap action closing until full movable contact freedom is assured.

15.7. Once free movement of the movable contact is achieved, the interrupter centering blocks or ring may be fastened. Select two X-washer from parts kit and crimp into grooves at each end of the trunnion.

16. Open Stroke Adjustment
The open position is established by the insulating coupler which when adjusted to the proper length, and attached to the bell cranks, will hold the interrupter open at the proper contact gap or separation.
In Article 15, the trunnion shaft center was set at one half the required vacuum interrupter stroke above the bell crank shaft horizontal center line. The open position will be established with the trunnion shaft center one half the required vacuum interrupter stroke below the bell crank shaft horizontal centerline.

Note: Stationary contact is annealed copper.
Thread damage will occur if threads are crossed. Be sure the bolt can be fully engaged with light manual torque.
The adjustment requires the insulating pushrod length be varied by turning the threaded pushrod end into or out of the pin coupling the pushrod to the breaker jack shaft.

Required trunnion center below bell crank shaft center:

- VS12015 3mm (0.118 in)
- VS25002 4mm (0.157 in)
- VS17006 4mm (0.157 in)
- VS10006 5.5mm (0.217 in)
- VS10028 4mm (0.157 in)
- VS15050 4.5mm (0.177 in)

Engage pushrod to bell cranks and gage trunnion shaft center distance below bell crank shaft center. If less than required, the pushrod must be shortened, screwed into the jackshaft pin. If greater than required, the pushrod must be lengthened by screwing it out of the jackshaft pin.

By interactively engaging the trunnion shaft center, disconnecting the coupler, adjusting the coupler, reattaching the coupler to the bell cranks, and again gaging the trunnion center, the required trunnion center position relative to the bell crank shaft center will be achieved.

The gage block (18-750-171-001, -002, -003, or -004 as appropriate), when held firmly on the trunnion, will just contact the lower surface of the bell crank shaft at the correct open position (Figure 52).

17. Concluding Operations

17.1. Torque vacuum interrupter stationary and movable contact fasteners to values indicated in Table 7.

17.2. Using procedure shown in Figure 51 and torque limits established in Table 7 secure interrupter clamp hardware.

Note: Check to be certain the interrupter clamp has been raised into firm bearing against the movable stem step or retaining ring before securing the clamp.

17.3. For 2000A ratings using VS15050 interrupter, and all 3000A ratings not using the chair support design. After the hardware for the flexible shunt (interrupter) clamp have been secured in section 17.2, the heat sinks that were removed in section 5 must be replaced. The heat sinks must be installed with a coating of copper-loaded grease (T&B "Kopr-Shield"), approximately 1/10 inch thick, between the heat sink and the flexible shunt clamp.

17.4. Replace all barriers. Special attention should be given to assure that all barriers and supports are mounted in exactly the same configuration as they were prior to disassembly. Refer to the notes and photos taken during disassembly, section 2.

17.5. Perform High Potential Test across open vacuum interrupter and from each primary extension to ground (see Table 3 on page 30).

Figure 46: GMI Circuit Breaker Side Elevation (Typical)

Figure 47: VS10006 and VS10028 1200A.
Table 6 – Recommended Tools

Open End or Box End Wrenches:
7/16, 1/2, 9/16, 5/8, 11/16

Socket Wrenches: (1/2" drive preferred)
7/16, 1/2, 9/16, 5/8, 11/16
19mm, 24mm
Ratchet
2 Extensions (6" maximum)
Torque Wrench (0-150 ft-lbs.)

Hex Socket Keys (Allen wrenches):
5/16 (0.156) socket type preferred,
M6, M8, M10 socket type preferred

Miscellaneous:
Pliers
Hot Air Gun
“Loctite” Threadlocker 262
“Loctite” Primer T
Copper-loaded grease
(2000A or 3000A circuit breakers only with separate phase barriers)
(T&B “Kopr-Shield”)

Table 7 – Critical Fasteners and Torque Limits

<table>
<thead>
<tr>
<th>Tube Family</th>
<th>Stationary Contact</th>
<th>Movable Contact</th>
<th>Interrupter Clamp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Torque</td>
<td>Size</td>
</tr>
<tr>
<td>All Current Ratings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS25002</td>
<td>M12 x 1.75</td>
<td>60-65 ft-lbs.</td>
<td>M20 x 1.5</td>
</tr>
</tbody>
</table>
Overhaul

Figure 48: VS12015, VS25002 and VS17006, 1200 and 2000A.

Figure 49: VS10028 2000 and 3000A.

Figure 50: VS10006 2000A.

Figure 51: Interrupter Clamp Fastening Procedure.
Figure 52: Gaging Procedure and Stroke Adjustment.

Figure 53: VS-15050 1200A.

Figure 54: VS-15050 2000A and 3000A with separate phase barriers.

Figure 55: VS-15050 3000A with chair Support Design.
## Periodic Maintenance and Lubrication Tasks

<table>
<thead>
<tr>
<th>Sub-Assembly</th>
<th>Item</th>
<th>Inspect For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Power Path</td>
<td>Vacuum Interrupter</td>
<td>1. Cleanliness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Contact erosion Note: Perform with Manual Spring Checks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Vacuum integrity Note: Perform with High Potential Tests</td>
</tr>
<tr>
<td></td>
<td>Primary Disconnects</td>
<td>1. Burnt or damaged fingers</td>
</tr>
<tr>
<td></td>
<td>Vacuum Interrupter Contact Resistance</td>
<td>1. Record contact resistance with contacts closed and re-check each year to monitor condition.</td>
</tr>
<tr>
<td></td>
<td>Cleanliness</td>
<td>1. Dirt or foreign material</td>
</tr>
<tr>
<td></td>
<td>Fasteners</td>
<td>1. Tightness of nuts and other locking devices</td>
</tr>
<tr>
<td></td>
<td>Lubrication</td>
<td>1. Evidence of excessive wear.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Lubrication of wear points</td>
</tr>
<tr>
<td></td>
<td>Wire</td>
<td>1. Mechanical damage or abrasion</td>
</tr>
<tr>
<td></td>
<td>Terminals and Connectors</td>
<td>1. Tightness and absence of mechanical damage</td>
</tr>
<tr>
<td></td>
<td>Close and Trip Solenoids, Anti-Pump Relay, Auxiliary Switches, Secondary Disconnect</td>
<td>1. Automatic charging</td>
</tr>
<tr>
<td></td>
<td>Spring Charging Motor (88)</td>
<td>1. Replace brushes after 10,000 operations</td>
</tr>
<tr>
<td>High Potential Test</td>
<td>Primary Circuit to Ground and between Primary Disconnects</td>
<td>1. 60 second withstand, 14 or 27kV, 60 Hz (20 or 38kV DC) (depending upon voltage rating of breaker)</td>
</tr>
<tr>
<td>Insulation</td>
<td>Control Circuit to Ground</td>
<td>1. 60 second withstand, 1500V, 60 Hz</td>
</tr>
<tr>
<td></td>
<td>Barriers and all Insulating Components</td>
<td>1. Cleanliness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Cracking</td>
</tr>
</tbody>
</table>
### Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Symptoms</th>
<th>Possible Causes and Remedies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaker fails to close</td>
<td>Closing springs will not automatically charge</td>
<td>1. Secondary control circuit is de-energized or control circuit fuses are blown. Check and energize or replace if necessary.</td>
</tr>
<tr>
<td></td>
<td>Closing springs charge, but breaker does not close</td>
<td>2. Secondary disconnect contacts 15 or 16 are not engaging. Check and replace if required.</td>
</tr>
<tr>
<td></td>
<td>• Closing coil, or solenoid (52SRC) fails to energize. No sound of breaker closing</td>
<td>3. Damage to wiring, terminals or connectors. Check and repair as necessary.</td>
</tr>
<tr>
<td></td>
<td>• Closing coil energizes. Sound of breaker closing is heard, but breaker contacts do not close.</td>
<td>4. Failure of charging motor (88). Check brushes and replace if required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Motor cut-off switch (LS1) failed to operate. Replace if necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Mechanical failure of operating mechanism. Refer to factory or authorized service shop.</td>
</tr>
</tbody>
</table>

- **Closing coil, or solenoid (52SRC) fails to energize.**
  - Check and energize or replace if necessary.

- **Secondary disconnect contacts 15 or 16 are not engaging.**
  - Check and replace if required.

- **Damage to wiring, terminals or connectors.**
  - Check and repair as necessary.

- **Failure of charging motor (88).**
  - Check brushes and replace if required.

- **Motor cut-off switch (LS1) failed to operate.**
  - Replace if necessary.

- **Mechanical failure of operating mechanism.**
  - Refer to factory or authorized service shop.
### Troubleshooting (continued)

<table>
<thead>
<tr>
<th>Problem</th>
<th>Symptoms</th>
<th>Possible Causes and Remedies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuisance or false close</td>
<td>Electrical problem</td>
<td>1. Nuisance or false closing signal to secondary disconnect contact 13. Check relay logic. Correct as required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Closing coil (52SRC) terminal 2 is shorted to ground. Check to determine if problem is in wiring or coil. Correct as required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mechanical problem</td>
</tr>
<tr>
<td></td>
<td>Tripping coil, or solenoid (52T) does not energize. There is no tripping sound.</td>
<td>1. Mechanical failure of operating mechanism. Check and contact factory or authorized service shop.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Damage to wiring, terminals or connectors. Check and repair as necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. No tripping signal to secondary disconnect contact 1. Check for continuity and correct relay logic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Secondary disconnect contacts 1 or 2 are not engaging. Check and replace if required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Failure to trip coil (52T). Check and replace if necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Auxiliary switch NO contacts 1-2 or 5-6 are open when breaker is closed. Check linkage and switch. Replace or adjust as necessary.</td>
</tr>
<tr>
<td>Circuit breaker will not trip</td>
<td>Tripping coil (52T) energizes. No tripping sound is heard, and breaker contacts do not open (i.e., they remain closed).</td>
<td>1. Failure of tripping spring or its mechanical linkage. Check and replace if required.</td>
</tr>
<tr>
<td></td>
<td>Tripping coil (52T) energizes. Tripping sound is heard, but breaker contacts do not open.</td>
<td>1. Mechanical failure of operating mechanism. Check and contact factory or authorized service shop.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. One or more of the vacuum interrupters are held closed. Check and replace as necessary.</td>
</tr>
<tr>
<td>Nuisance or false trip</td>
<td>Electrical problem</td>
<td>1. Tripping signal remains energized on secondary disconnect contact 1. Check for improper relay logic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Mechanical failure of operating mechanism. Check and contact factory or authorized service shop.</td>
</tr>
</tbody>
</table>
### Table A-1A – Type GMI Circuit Breaker Ratings (Historic “Constant MVA” Rating Basis)

These ratings are in accordance with the following standards:

| ANSI C37.04-1979 | Standard Rating Structure for AC High-Voltage Circuit Breaker Rated on a Symmetrical Current Basis |
| ANSI C37.06-1987 | AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities |
| ANSI C37.09-1979 | Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis |
| ANSI C37.010-1979 | Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis |

<table>
<thead>
<tr>
<th>Measured Parameter</th>
<th>Units</th>
<th>5-GMI-250</th>
<th>5-GMI-350</th>
<th>7-GMI-500</th>
<th>15-GMI-500</th>
<th>15-GMI-750</th>
<th>15-GMI-1000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal Voltage Class</td>
<td>kV</td>
<td>4.16</td>
<td>4.16</td>
<td>7.2</td>
<td>13.8</td>
<td>13.8</td>
<td>13.8</td>
</tr>
<tr>
<td>Nominal 3-Phase MVA Class</td>
<td>MVA</td>
<td>250</td>
<td>350</td>
<td>500</td>
<td>500</td>
<td>750</td>
<td>1000</td>
</tr>
<tr>
<td><strong>Rated Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>Maximum Design Voltage (V)²</td>
<td>kV rms</td>
<td>4.76</td>
<td>4.76</td>
<td>8.25</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>Voltage Range Factor (K)³</td>
<td>—</td>
<td>1.24</td>
<td>1.19</td>
<td>1.25</td>
<td>1.30</td>
<td>1.30</td>
</tr>
<tr>
<td>Insulation Levels</td>
<td>Withstand Voltage Levels</td>
<td>kV rms</td>
<td>19</td>
<td>19</td>
<td>36</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Power Frequency</td>
<td>kV rms</td>
<td>60</td>
<td>60</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Lightning Impulse (8IL)</td>
<td>kV crest</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Rated Current</td>
<td>Continuous⁴</td>
<td>A rms</td>
<td>4.0</td>
<td>6.6</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>Short-Circuit (at rated maximum design voltage) (I)⁵,⁶,⁷</td>
<td>kA rms</td>
<td>29</td>
<td>41</td>
<td>33</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Interrupting Time</td>
<td>Cycles</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Permissible Tripping Delay (Y)</td>
<td>Sec.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Related Required Capabilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated Maximum Design Voltage (V) divided by K (= V/K)</td>
<td>kV rms</td>
<td>3.85</td>
<td>4.0</td>
<td>6.6</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Max. Sym Interrupting (K x 1)⁸</td>
<td>kA rms sym</td>
<td>49</td>
<td>49</td>
<td>41</td>
<td>23</td>
<td>36</td>
<td>48</td>
</tr>
<tr>
<td>Short Time Current (K x 1) (3 seconds)</td>
<td>kA rms</td>
<td>36</td>
<td>36</td>
<td>49</td>
<td>41</td>
<td>23</td>
<td>36</td>
</tr>
<tr>
<td>Closing and Latching (Momentary)</td>
<td>Asymmetrical (1.6 x K x 1)⁹</td>
<td>kA rms</td>
<td>58</td>
<td>78 opt¹</td>
<td>78</td>
<td>66</td>
<td>77 opt¹</td>
</tr>
<tr>
<td>Peak (2.7 x K x 1)¹⁰</td>
<td>kA peak</td>
<td>97</td>
<td>132 opt¹</td>
<td>132</td>
<td>111</td>
<td>130 opt¹</td>
<td>62</td>
</tr>
</tbody>
</table>

### Footnotes:

1. High close and latch (momentary) rating available for special application.
2. Maximum voltage for which the circuit breaker is designed, and the upper limit for operation.
3. K is the ratio of the rated maximum design voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical interrupting capabilities vary in inverse proportion to the operating voltage.
4. Continuous current and short-circuit faults, the specific conditions stated in clause 5.10.2.3 of ANSI C37.04-1979 apply.
5. For operating voltages below 1/K times rated maximum design voltage, the required asymmetrical interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.
6. Standard duty cycle is CO – 15s – CO
7. Within the limitations stated in ANSI C37.04-1979, all values apply to polyphase and line-to-line faults. For single-phase-to-ground faults, the specific conditions stated in clause 5.10.2.3 of ANSI C37.04-1979 apply.
8. To obtain the required symmetrical interrupting capability of a circuit breaker at an operating voltage between 1/K times rated maximum design voltage and 1/K times rated design voltage, the following formula shall be used: Required Symmetrical Interrupting Capability = Rated Short-Circuit Current (I) x (Rated Maximum Design Voltage) / (Operating Voltage). For operating voltages below 1/K times rated maximum design voltage, the required symmetrical interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.
9. Rated values in this row are not to be exceeded even for operating voltage below 1/K times rated maximum design voltage. For operating voltages between rated maximum design voltage and 1/K times rated maximum design voltage, follow footnote 5 above.
10. Rated values in this row are independent of operating voltage up to and including rated maximum design voltage.

"Nominal 3-Phase MVA Class" is included for reference only — this information is not listed in ANSI C37.06-1987.

### Table A-1B – Type GMI Circuit Breaker Ratings (New “Constant kA” Rating Basis)

These ratings are in accordance with the following standards:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI C37.04-1999</td>
<td>Standard Rating Structure for AC High-Voltage Circuit Breakers</td>
</tr>
<tr>
<td>ANSI C37.06-2000</td>
<td>AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities</td>
</tr>
<tr>
<td>ANSI C37.09-1999</td>
<td>Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis</td>
</tr>
<tr>
<td>ANSI C37.010-1999</td>
<td>Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rated Values</th>
<th>Units</th>
<th>Circuit Breaker Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Design Voltage (V)(^1)</td>
<td>kV rms</td>
<td>4.76</td>
</tr>
<tr>
<td>Voltage Range Factor (K)(^2)</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Power Frequency</td>
<td>Kv rms</td>
<td>19</td>
</tr>
<tr>
<td>Lightning Impulse (BIL)</td>
<td>kV crest</td>
<td>60</td>
</tr>
<tr>
<td>Continuous(^3)</td>
<td>A rms</td>
<td>1200</td>
</tr>
<tr>
<td>Short-Circuit (I)(^4,(^5))</td>
<td>kA rms sym</td>
<td>31.5</td>
</tr>
<tr>
<td>Interrupting Time</td>
<td>ms Cycles</td>
<td>83(^5)</td>
</tr>
<tr>
<td>Permissible Tripping Delay (Y)</td>
<td>Sec</td>
<td>2</td>
</tr>
<tr>
<td>Max Sym Interrupting (I)</td>
<td>kA rms sym</td>
<td>31.5</td>
</tr>
<tr>
<td>% dc Component</td>
<td>%</td>
<td>47</td>
</tr>
<tr>
<td>Short-Time Current (I), 3 seconds</td>
<td>kA rms</td>
<td>31.5</td>
</tr>
<tr>
<td>Closing &amp; Latching (Momentary)</td>
<td>kA rms</td>
<td>49</td>
</tr>
<tr>
<td>Peak (2.6 x I)</td>
<td>kA peak</td>
<td>82</td>
</tr>
</tbody>
</table>

**Footnotes**

\(^1\) Maximum voltage for which the circuit breaker is designed, and the upper limit for operation.

\(^2\) K is listed for informational purposes only. For circuit breakers rated on a “kA basis”, the Voltage Range Factor is 1.0.

\(^3\) 3000A ratings with VS-10028 vacuum interrupter are self cooled for indoor installations. 3000A ratings using VA-15050 vacuum interrupter and separate phase barriers require supplemental fan-cooling in the switchgear circuit breaker structure. 3000A ratings using VS-15050 vacuum interrupter and chair design support are self-cooled for indoor installations. Consult drawings for the switchgear for arrangement provided.

\(^4\) All values apply to polyphase and line-to-line faults.

\(^5\) Standard duty cycle is O – 0.3s – CO – 15s = CO.
Table A-2 – 5kV, 7.2kV and 15kV Type GMI Circuit Breaker Control Data

Typical Spring Release (Close Coil), Trip Coil and Spring Charging Motor Characteristics

<table>
<thead>
<tr>
<th>Control Voltages, ANSI C37.06 Table 10</th>
<th>Close Coil</th>
<th>Trip Coil</th>
<th>Spring Charging Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Close Amperes</td>
<td>Trip Amperes</td>
<td>Amperes</td>
</tr>
<tr>
<td>48 VDC 38-56</td>
<td>10(^1)</td>
<td>10(^2)</td>
<td>8.5</td>
</tr>
<tr>
<td>125 VDC 100-140</td>
<td>4</td>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>250 VDC 200-280</td>
<td>3</td>
<td>3</td>
<td>1.3</td>
</tr>
<tr>
<td>120 VAC 104-127</td>
<td>4</td>
<td>–</td>
<td>3.3</td>
</tr>
<tr>
<td>240 VAC 208-254</td>
<td>3</td>
<td>–</td>
<td>1.7</td>
</tr>
</tbody>
</table>

1. Current at nominal voltage.
2. 23A for coils supplied up to mid-1993.

Table A-3 – Interrupting Capacity Auxiliary Switch Contacts

<table>
<thead>
<tr>
<th>Type Auxiliary Switch</th>
<th>Continuous Current Amperes</th>
<th>Control Circuit Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>120 VAC 240 VAC 48 VDC 125 VDC 250 VDC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Inductive Circuit Interrupting Capacity in Amperes</td>
</tr>
<tr>
<td>Breaker Auxiliary Switch</td>
<td>20</td>
<td>20 20 20 10 2</td>
</tr>
<tr>
<td>TOC Auxiliary Switch</td>
<td>15</td>
<td>15 10 0.5 0.5 0.2</td>
</tr>
<tr>
<td>MOC Auxiliary Switch</td>
<td>20</td>
<td>15 10 10 10 5</td>
</tr>
</tbody>
</table>

|                                        |                            | Inductive Circuit Interrupting Capacity in Amperes |
| Breaker Auxiliary Switch                | 20                         | 20 20 20 10 2            |
| TOC Auxiliary Switch                    | 15                         | 15 10 0.5 0.5 0.2        |
| MOC Auxiliary Switch                    | 20                         | 15 10 10 10 5            |

Table A-4 – Circuit Breaker Weights [lbs (kg)]

<table>
<thead>
<tr>
<th>Breaker Type</th>
<th>Continuous Current Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1200 A 2000 A 3000 A</td>
</tr>
<tr>
<td>5-GMI-250</td>
<td>385 (175) 425 (193) —</td>
</tr>
<tr>
<td>5-GMI-31</td>
<td>385 (175) 425 (193) —</td>
</tr>
<tr>
<td>5-GMI-350</td>
<td>440 (200) 550 (250) 575 (261)</td>
</tr>
<tr>
<td>5-GMI-40</td>
<td>440 (200) 550 (250) 575 (261)</td>
</tr>
<tr>
<td>5-GMI-50</td>
<td>450 (205) 560 (255) 585 (266)</td>
</tr>
<tr>
<td>7-GMI-500</td>
<td>440 (200) 550 (200) 585 (266)</td>
</tr>
<tr>
<td>7-GMI-40</td>
<td>440 (200) 550 (200) 585 (266)</td>
</tr>
<tr>
<td>15-GMI-500</td>
<td>415 (188) 455 (206) —</td>
</tr>
<tr>
<td>15-GMI-25</td>
<td>415 (188) 455 (206) —</td>
</tr>
<tr>
<td>15-GMI-750</td>
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<td>15-GMI-50</td>
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