

TechTopics No. 87

Ground and test devices

This issue of TechTopics is one of several on the subject of protective grounding in switchgear assemblies. This particular issue focuses on the ground and test device, which is a device that is typically used to apply temporary personal protective grounds to medium-voltage conductors in the switchgear assemblies.

The ground and test device is a very important element of the process of creating an electrically safe work condition as defined by NFPA 70E®, the Standard for Electrical Safety in the Workplace, and as required by OSHA regulations. Under the concept of NFPA 70E, achieving an electrically safe work condition requires:

1. Identify all possible energy sources for the equipment
2. Open and isolate each of the identified sources
3. Where possible, visually verify that the sources are isolated
4. Apply lockout/tagout devices to all identified sources
5. Use appropriate voltage test device to verify absence of voltage
6. Apply temporary personal protective grounds to the phase conductors before contacting them.

As described, there are many steps that must occur before the grounds are applied. In essence, grounding is the last step in a coherent process. If the entire process is not followed, including all of the first five steps, there is a risk of shutting down a live system and disrupting the production process, and most importantly, a significant risk of injury to personnel. The risk to personnel arises from the false sense of security when the personnel believe the conductors to be grounded when they are not grounded.

The applicable standard for ground and test devices is IEEE C37.20.6, "IEEE Standard for 4.76 kV to 38 kV Rated Ground and Test Devices Used in Enclosures". For decades, there was no standard for ground and test devices. This was remedied with the first edition of C37.20.6 in 1997, and the revised edition in 2007.

The C37.20.6 standard defines four broad categories of devices, including:

- Simple manual – a device with upper and/or lower terminals with provisions for connecting the phase conductors to ground.
- Complex manual – a device with upper and/or lower terminals, and with a manually operated switch that allows for connection of the upper or the lower terminals to a set of test terminals. The test terminals, in turn, have provisions for connecting the phase conductors of the selected side (upper or lower) to ground.
- Simple electrical – a device with one set of terminals (either upper or lower) and an electrically operated switch to allow connecting this set of terminals (either upper or lower, as applicable) to ground even if the system is energized. The device may be provided with test ports that allow voltage testing of both the upper and the lower terminals of the device. The device has the capability to apply the ground even to a system that is energized.
- Complex electrical – a device with upper and/or lower terminals, and with a manually operated switch to allow for connection of the upper or the lower terminals to the power-operated grounding switch. The device has the capability to apply the ground even to a system that is energized. The device may be provided with test ports for voltage testing.

IEEE C37.20.6 specifies performance requirements for ground and test devices, but leaves construction aspects to the manufacturer. The major need in construction of a ground and test device is to provide interphase, outerphase, and inter-terminal barriers to reduce the chance of inadvertently bridging from live conductor to ground or between terminals of the device. This is particularly important with manual devices, where the user applies cables or other conductors to make the ground connection.

Manual devices are often available with NEMA 4-hole pads for connection of grounding cable lugs, and may be available with ground stirrups or ground bails. A ground stirrup (or ground bail) is a device that provides a round rod for connection of grounding clamps.

Manual devices are often used with maintenance ground clamps, available from several suppliers. These devices need to be applied with insulated tools (typically called "hot sticks"). A ground clamp, with attached cable, secured to the end of a hot stick perhaps six to eight feet long, is not an easy device to manipulate. This is another reason why it is necessary to provide barriers to prevent inadvertent bridging between phase and ground or from one terminal to another.

It is very important to verify that the primary system is de-energized before the grounding is established, since a manual device does not have the ability to establish ground on an energized system.

The capabilities of the ground and test device must be coordinated with the switchgear structure with which it is to be used and meet the current withstand ratings of the switchgear.

The capabilities of the ground and test device are validated by subjecting the device to short-circuit design (or type) tests to validate the momentary and short-time current withstand ratings. The device must pass a test in the power laboratory in which the device successfully withstands a single-phase momentary test at the rated short-circuit current with the first peak current during the test equivalent to the peak withstand current of the device (260% of the rated short-circuit current). The test duration is at least ten power-frequency cycles, with current flowing to the ground conductor from the nearest phase conductor. The test must be repeated as a three-phase test, including ground, with peak current at 260% occurring in the nearest phase to the ground conductor.

The ground and test device must withstand a short-time current test at the rated short-circuit current for two seconds, with current flow to the ground bar from the furthest phase conductor.

Lastly, the ground and test device must withstand the same dielectric withstand tests (one minute power-frequency withstand voltage and full-wave lightning impulse withstand voltage) as are required for the switchgear.

Siemens has tested our ground and test devices under these conditions, with qualification regarding the connection from the terminals to the ground system. These tests were witnessed by UL. The testing was performed with multiple ground cables per phase, on those devices which are used with cables. The number of cables is selected so that the cables can withstand the current. This typically requires three or four 4/0 cables per phase, and thus demands that the device tested be equipped with NEMA four-hole pads suitable for connection of multiple cables per phase. Devices suitable for use with grounding clamps are, of course, limited to the fault current and duration that corresponds to the capabilities of the grounding clamps and cables. For more discussion of grounding cables, refer to TechTopics No. 88.

With any ground and test device, it is imperative that the user develop comprehensive operating instructions to implement the requirements of NFPA 70E. These are needed to avoid unintended shutdown of the electric system, and to ensure that the operating personnel and others near the equipment are protected during use of the devices.

Siemens ground and test devices

Of the devices listed in the standards, Siemens offers simple manual and simple electrical devices. Complex devices, as the term implies, are very complicated, and as a result require great care in use and proper maintenance. Due to space constraints, complex electrical devices often cannot be constructed with the same basic operating mechanism of the corresponding circuit breaker. Since such devices are highly specialized, and produced in very low volumes, reliability becomes questionable. For these reasons, Siemens does not offer complex devices, either manual or electrical.

Siemens offers the following types of devices:

For use in type GM-SG switchgear up to 15kV - type GMSG-MO simple manual device:

A simple manual device is offered, which has two sets of terminals (upper and lower) and has manually operated hookstick-operable single-pole double-throw switches to allow connection of either the upper terminals or the lower terminals to ground. The hookstick-operable switches should be actuated with the device inside the switchgear compartment. The preferred operating sequence is:

- Install all horizontal barriers between the hookstick-operable switches and the upper and lower terminals
- Close and lock the hinged door on the device that covers the terminals that are not intended to be tested and grounded
- Close but do not lock the hinged door on the device that covers the terminals that are to be tested and grounded
- Insert the ground and test device in the cell and rack to the connected position

- Use the hookstick to open the hinged door that covers the terminals that are to be tested and grounded
- Use a voltage measuring device rated for the system voltage to test the terminals for the presence of voltage. Follow the NFPA 70E procedure to validate the test instrument: First test that the voltage measuring device properly indicates voltage on a known live conductor; second, test the terminals that are to be grounded for the presence of voltage; finally, check the voltage measuring device on a known live conductor to verify that the test instrument is still working correctly
- After it has been verified that there is no voltage present on the terminals that are to be grounded, use the hookstick to remove the horizontal barriers between the switches and the terminals that are to be grounded
- Use the hookstick to move the switch blades to the terminals to be grounded, and latch the switch blades in the fully connected position.

Figure 1 shows a section view of the type GMSG-MO manual ground and test device, illustrating the upper and lower terminals and the switch blades. The switch can be in the neutral position, or can be moved to ground the upper or lower terminals. A detent maintains the switch in the neutral position, and the hookstick operable switch blade latches when connected to either power terminal. Removable horizontal barriers are included between the switch blades and the upper terminals, and between the switch blades and the lower terminals. Non-removable vertical barriers are provided between poles. The horizontal barriers are removable with a hookstick to allow for operation of the switches.

Figure 2 shows use of a hookstick to close the switch to ground the lower terminals of the left phase on the device (normally, system phase A). The horizontal barriers are shown in place between the switches and the lower terminals for the center and right phases (normally system phases B and C). The vertical barriers between phases are also shown.

This device is available for use with type GM-SG family of metal-clad switchgear with rated short-circuit current up to 50 kA. The device is suitable for use in 1,200 A, 2,000 A or 3,000 A circuit breaker cells (and 4,000 A for fan-cooled arrangements) without adapters.

The switches eliminate the need for multiple cables per phase to achieve grounding currents equal to the rated short-circuit current of the equipment. Since the device has built-in grounding conductors (the switches in combination with the ground bus system), this eliminates the need for the user to provide or maintain grounding cables for use with the device. Therefore, the type GMSG-MO manual ground and test device is not offered with provisions for connection of cables, either using conventional cable lugs or grounding clamps.

Figure 1: Section view of type GMSG-MO manually operated ground and test device

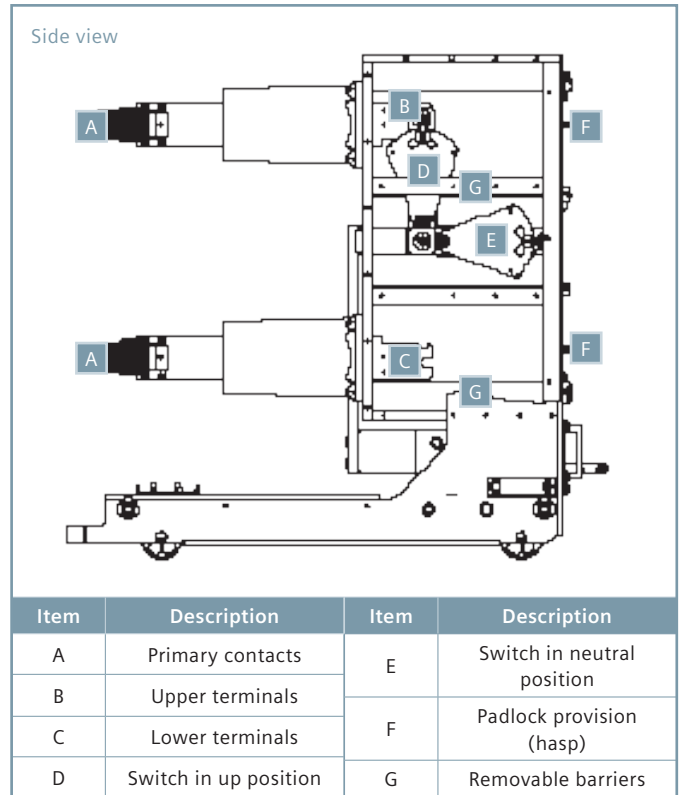
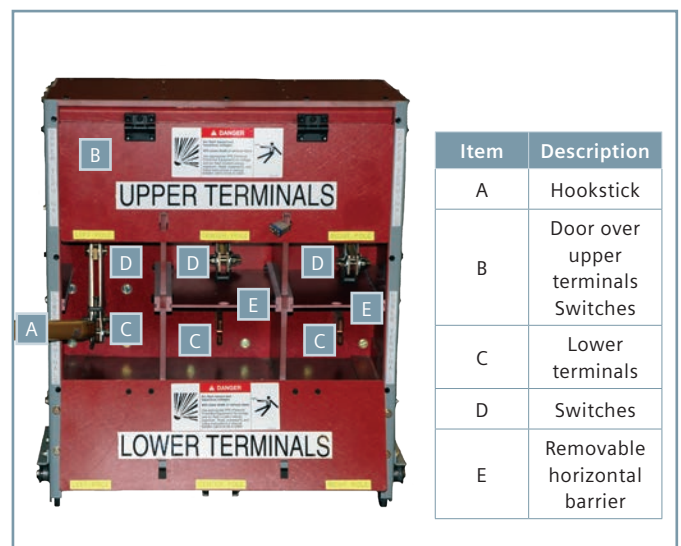


Figure 2: Type GMSG-MO manually operated ground and test device: use of a hookstick to close and latch the switch on the lower terminal of the phase on the left



The device is suitable for voltage (dielectric) testing of the upper terminals or the lower terminals, and also for checking phasing between the upper and the lower terminals. In either case, probes and detection devices rated for at least the voltages involved must be used.

For use in type GM-SG switchgear up to 15kV – type MSGG-EO simple electrical device:

Several electrically operated devices are available. These devices have three power carrying terminals (upper or lower, depending on the specific application), plus three non-power carrying terminals for voltage testing only. The device also includes an electrical operator capable of closing the vacuum interrupter contacts against fault currents equal to the short-circuit capacity of the switchgear. As with the manual devices, the electrical devices are suitable for use in 1,200 A, 2,000 A or 3,000 A (as well as fan-cooled 4,000 A units) without adapters. The devices are suitable for up to 50 kA ratings, and devices suitable for use on equipment rated 63 kA are also available.

Figure 3 illustrates a section view of a typical electrically operated ground and test device. This example shows a device which is intended to ground the upper terminals of a type GM-SG switchgear circuit breaker compartment. A comparable device is available for grounding the lower terminals. In either case, the opposite set of terminals is arranged with “dummy” primaries, adequate for carrying the current involved in voltage testing of the equipment, but not intended to carry higher currents.

Figure 4 shows a front view of the device above. Test ports for testing for the presence of voltage on the upper terminals or the lower terminals are shown. These test ports also allow for conducting phasing tests between the upper and lower terminals. In either case, probes and detection devices rated for at least the voltages involved must be used. The photo also shows interlocks necessary for the correct sequence of operation. All operations of the power-operated closing mechanism to establish the ground on the system are performed using a remote plugin control cord so that grounding operations are conducted by personnel standing remote from the switchgear section in which the device is being used. The photo shows the receptacle on the device to which the remote plugin control cord is attached when in use.

Figure 3: Section view of type MSGG-EO electrically operated ground and test device

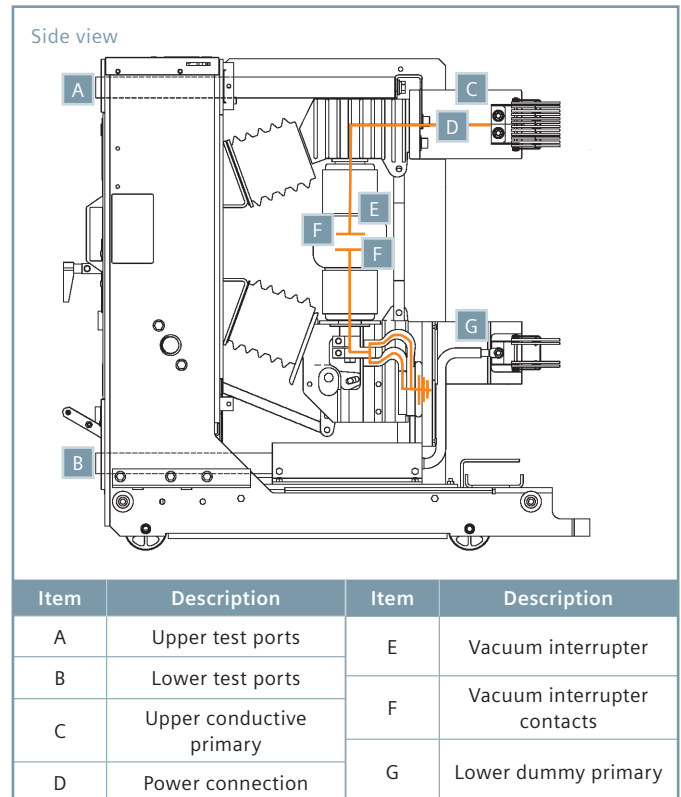
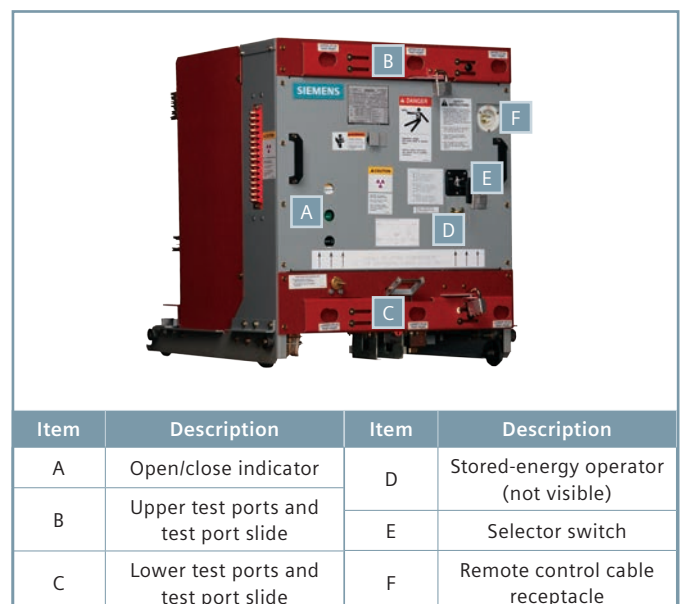


Figure 4: Type MSGG-EO electrically operated ground and test device: use of a hookstick to close and latch the switch on the lower terminal of the phase on the left



For use in type GM38 switchgear up to 38kV – type GM38T simple manual device:

A simple manual device is offered, which has two sets of terminals (upper and lower) and provisions for use of grounding cables. The preferred device has NEMA four-hole pads for bolting cable lugs to the pads, but an alternate arrangement with ground stirrups is also available. With the four-hole pads, the device passes the current withstand tests of C37.20.6. When equipped with ground stirrups, the current and duration limits of the cables and ground clamps (if applicable) used apply.

Figure 5 shows a section view of the manual device. For illustration purposes, the upper terminals are shown with NEMA four-hole pads while the lower terminals are shown with ground stirrups for use with ground clamps. The front of the device has padlockable doors over each set of terminals. The device includes a ground bar on the lower front (not shown), that connects to the ground bar in the switchgear when the device is inserted into the switchgear. Vertical barriers are provided between phases, as well as a horizontal barrier between upper and lower terminals. These barriers are not removable.

Figure 6 shows a view of the front of the devices, with both doors open to show the upper and lower terminals.

This device is available for use with type GM38 metal-clad switchgear up to 38 kV, with rated short-circuit current up to 40 kA. The device is suitable for use in 1,200 A, 2,000 A or 3,000 A (fan-cooled) circuit breaker cells without adapters.

The device is suitable for voltage (dielectric) testing of the upper terminals or the lower terminals, and also for checking phasing between the upper and the lower terminals. In either case, probes and detection devices rated for at least the voltages involved must be used. The user must provide cables to connect from the device terminals to ground.

Figure 5: Section view of type GM38T manually operated ground and test device

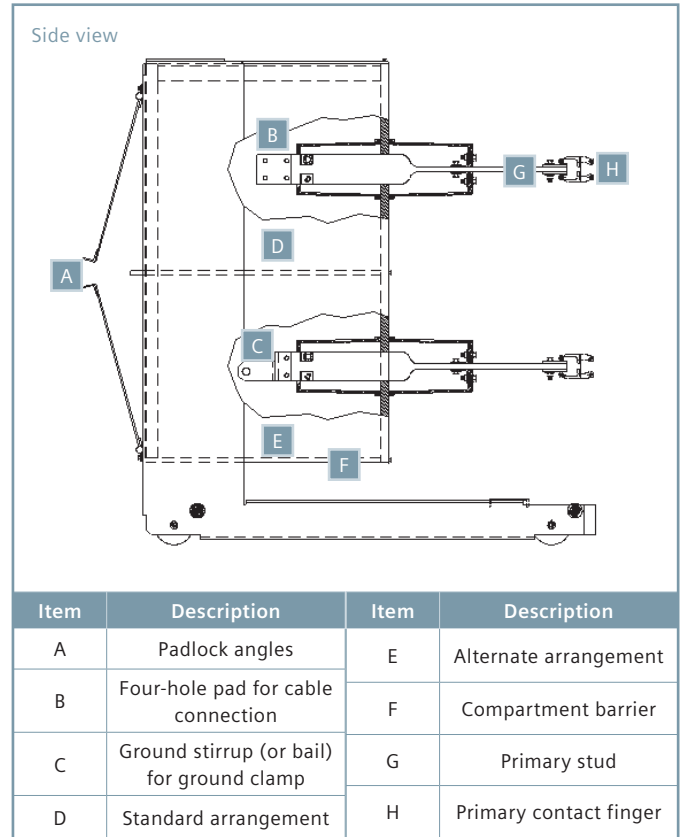
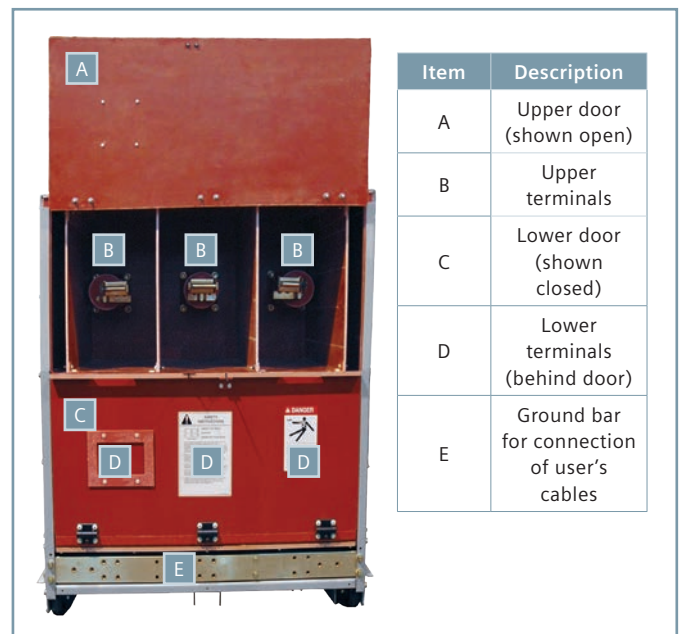


Figure 6: Type GM38T manually operated ground and test device with upper door open



For use in type GM38 switchgear up to 38 kV – type 38-3AH3-GTD simple electrical device:

Two electrically operated devices are available. These devices have three power carrying terminals (upper terminals or lower terminals, depending on the specific application), plus three dummy (non-power carrying) terminals for voltage testing only. The device also includes an electrical operator capable of closing the vacuum interrupter contacts against fault currents equal to the short-circuit capacity of the switchgear. As with the manual devices, the electrical devices are suitable for use in 1,200 A, 2,000 A or 3,000 A (fan-cooled) circuit breaker compartments without adapters. The devices are suitable for use with type GM38 switchgear rated up to 40 kA.

Figure 7 illustrates a side view of a typical electrically operated device. This example shows a device which is intended to ground the lower terminals of a switchgear circuit breaker compartment. A comparable device is available for grounding the upper terminals. In either case, the opposite set of terminals is arranged with “dummy” primaries, adequate for carrying the current involved in voltage testing of the equipment, but not intended to carry higher currents.

Figure 8 shows a front view of the device above. Test ports for testing for the presence of voltage on the upper terminals or the lower terminals are shown. These test ports also allow for conducting phasing tests between the upper and lower terminals. The photo also shows interlocks necessary for the correct sequence of operation. All operations of the power-operated closing mechanism to establish the ground on the system are performed using a remote plugin control cord so that grounding operations are conducted by personnel standing remote from the switchgear section in which the device is being used. The photo shows the receptacle on the device to which the remote plugin control cord is attached when in use.

Figure 7: Type 38-3AH3-GTD electrical ground and test device (for grounding lower terminals)

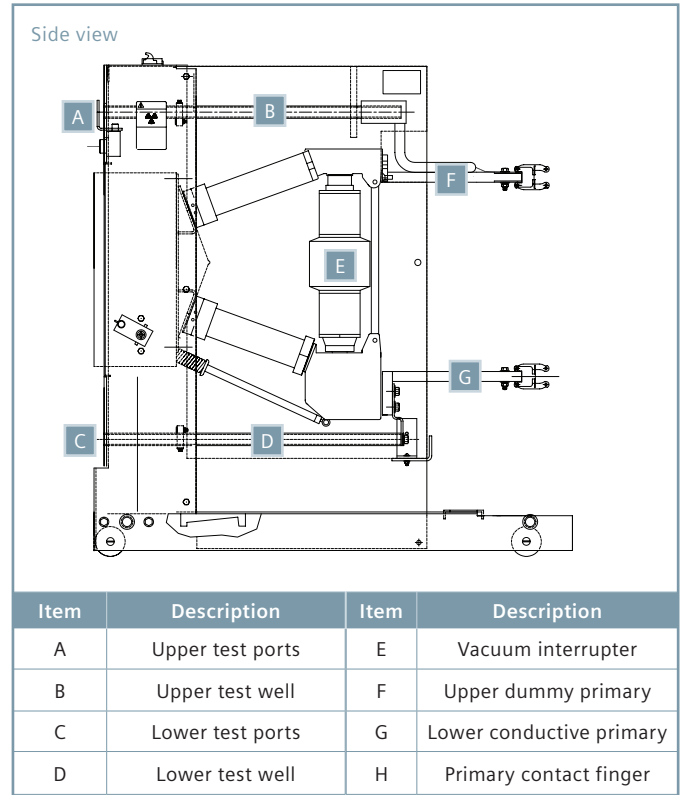
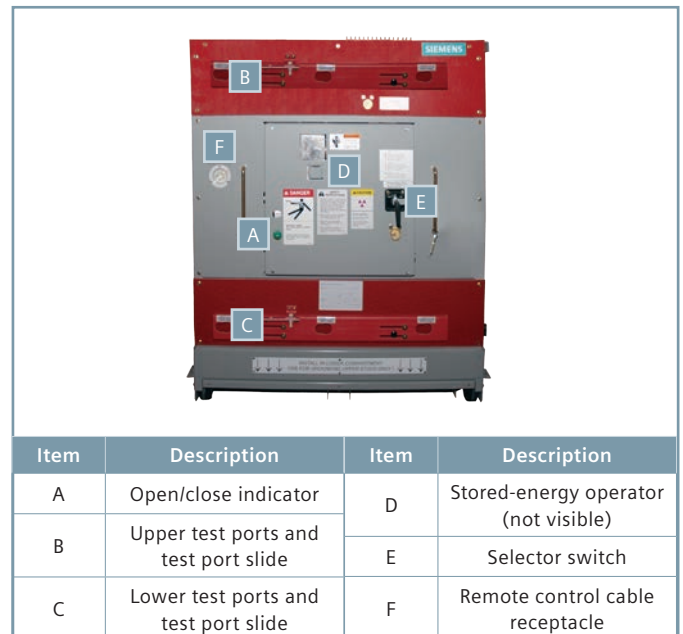
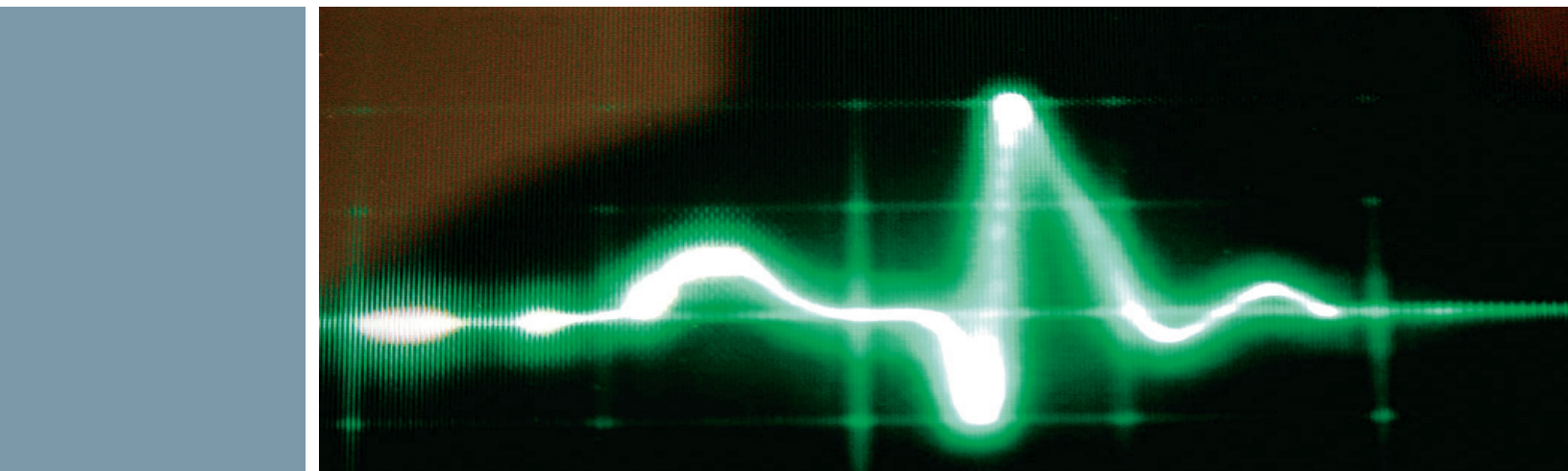


Figure 8: Type 38-3AH3-GTD electrical ground and test device





Ground and test devices have a long history of use, dating back to at least the 1950s. Over the decades of use, the designs have evolved to include greater functionality, improved interlocking functions, and increased ratings. The Siemens devices have also changed to eliminate special primary disconnect arrangements and adapters for use in circuit breaker compartments of different ratings.

In addition, the design test requirements for ground and test devices have evolved, particularly since the introduction of IEEE C37.20.6. While use of ground and test devices was rare in the early days, today, ground and test devices are increasingly specified by users as the best way to apply temporary grounds to the phase conductors in switchgear in compliance with OSHA and NFPA 70E requirements, so as to achieve an electrically safe work condition.

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