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••••• HIGH VOLTAGE HAZARD •••••

WARNING TO USERS:

THE SST-400 CAN PRODUCE VOLTAGES IN EXCESS OF 2000V. ALTHOUGH THE CURRENT SUPPLIED BY THE TESTER ITSELF IS LIMITED TO A NON-LETHAL LEVEL, IT IS POSSIBLE THAT THE CAPACITANCE OF A DEVICE UNDER TEST CAN BE LARGE ENOUGH TO STORE A DANGEROUS AMOUNT OF ELECTRICAL ENERGY THAT CAN DELIVER A DAMAGING OR EVEN FATAL SHOCK TO THE USER.

ACCIDENTAL CONTACT WITH THE TEST LEADS WHILE THE TESTER IS OPERATING CAN DELIVER A PAINFUL SHOCK, AND EVEN THOUGH THIS IS UNLIKELY TO BE DIRECTLY INJURIOUS OR FATAL TO A HEALTHY PERSON, THE DRAWBACK REACTION TO THE DC SHOCK MAY CAUSE THE USER TO BE INJURED BY STRIKING NEARBY OBJECTS WITH GREAT FORCE. THERE MAY ALSO BE LIVE ELECTRICAL PARTS NEARBY THAT COULD BE CONTACTED BY THIS NATURAL DRAWBACK REACTION, CREATING AN ADDITIONAL HAZARD. FOR THIS REASON, THE SST-400 SHOULD NEVER BE USED IN CONFINED SPACES.

A GOOD PAIR OF LINEMAN'S GLOVES SHOULD PROVIDE REASONABLE PROTECTION AGAINST CASUAL BUMPING INTO LIVE TEST PROBES, BUT HASTILY, ILL-CONSIDERED MOVEMENTS CAN NULLIFY THE VALUE OF ANY SUCH PRECAUTIONS. THE TESTER WILL SERVE YOU WELL IF YOU OBSERVE SENSIBLE PRECAUTIONS, BUT MUST NEVER BE USED CARELESSLY OR UNDER DISTRACTING CIRCUMSTANCES. ATSI CANNOT AND DOES NOT ASSUME RESPONSIBILITY FOR INJURY OR DEATH ARISING OUT OF THE USE OF THIS TESTER. ELDERLY PERSONS AND THOSE WITH ANY INDICATION OF HEART PROBLEMS ARE STRONGLY DISCOURAGED FROM USE OF THIS TOOL.

BEFORE OPENING THE CASE FOR BATTERY REPLACEMENT (SEE APPENDIX A), THE TEST PROBES SHOULD BE SHORTED TOGETHER WITH A CLIP LEAD.

IT IS RECOMMENDED THAT THE SST-400 BE USED ONLY BY EXPERIENCED PERSONNEL TRAINED IN ELECTRICAL SAFETY PRACTICES. THE PROCEDURES OUTLINED IN THIS MANUAL SHOULD BE CAREFULLY FOLLOWED TO ASSURE SAFE OPERATION OF THE TESTER.

I. OVERVIEW OF THE SST

The SST-400 is a simple instrument designed to test the wide array of surge suppressor devices available today. The SST-400 tester consists of a 1mA DC current source with up to 2000 volts of compliance. This means the tester has up to 2000 volts available to use in establishing the 1mA DC current through the test leads. By using a number of defined test procedures with the tester unit alone or in combination with device-specific test modules, the basic capabilities of most surge suppressors can be determined.

Shown in *Figure 1* below, the tester unit itself consists of a small hand-held enclosure with a 3-1/2 digit LCD display screen and several switches that control tester operation. Two standard banana jacks on the top of the unit accept either test leads or one of the device-specific test modules. Switches on the tester unit are low-profile to minimize the risk of an accidental power-on, and the TEST push-button has a guard to help prevent accidental activation.

The basic test has been designed to read the DC voltage at which a shunt-type surge suppression device begins to conduct. This is commonly represented by that voltage across the device when it conducts 1 mA DC, so the SST-400 is designed to produce this 1mA current and read the corresponding voltage. The only extension of this simple function is to provide two voltage readings:

- a peak reading that will indicate the voltage at which a device begins to conduct the 1mA test current
- an average reading that will indicate whether the device under test (DUT) "folds back" its voltage after turning on.

Figure 1 SST-400 with test leads

It is recommended that the user thoroughly reads the Technical Supplement, "Transient Voltage Surge Suppressors and Testing Possibilities," before proceeding with this manual or performing any tests with the SST-400. The technical supplement gives an introduction to the various types of surge suppression devices available and the means by which they can be tested. The user will be required in most instances to have knowledge of the type of suppressor being tested before the data presented by the SST-400 can be interpreted as an indication of device capability.

II. PREPARING THE SST-400 FOR TESTING

In its most basic configuration, the SST-400 uses two high-voltage test leads that are inserted into the banana jacks on the top of the tester. These leads have shrouded clips that attach to the leads of the DUT as shown in *Figure 2*. This is the method used to test any two-terminal discrete suppressors like MOVs. **IT IS VERY IMPORTANT THAT THE SURGE SUPPRESSOR BE REMOVED FROM THE CIRCUIT IT PROTECTS BEFORE TESTING**. This point is emphasized both for safety reasons, to protect the user, tester unit and the protected circuit, and also to assure a meaningful test measurement.

Many shunt surge suppressors are connected in parallel with others on the same circuit, especially when there is a common power bus, as in a traffic cabinet or similar installation, so the DUT must be isolated from the others before testing. In most cases, only one lead of a typical two-terminal device needs to be lifted to provide isolation. Often, two sets of tests should be performed, reversing the leads between each test. This depends on the type of suppressor being tested; once again, we note that knowledge of the suppressor type and characteristics is needed for testing (see Technical Supplement).

Figure 2 ***Test setup for a two terminal surge arrestor***

The SST-400 is intended to be a bench-top tester, but it is possible to use it as a field-portable unit if the isolation requirement described above is followed. This requires disconnecting components from the field circuit for testing, but otherwise follows similar test procedures.

III. NORMAL TESTING

A. An Example

"Normal Testing" means testing a simple two-terminal surge suppressor with the basic test lead configuration described in Chapter II. As an example, we will describe how to test the V130LA1, a commonly-encountered MOV often used to protect the 120V AC line input to equipment. It is a small (7mm) disk-type MOV. Since it is designed to protect normal AC line voltage circuits, we can expect the V130LA1 to clamp at a voltage somewhat higher than the peak of a 120V AC rms sine wave, which is about 170 volts, nominally. The manufacturer's MOV data sheet tells us that for the V130LA1, the 1mA DC voltage, called VNOM, is between 184 and 255 volts (see *Figure 3* on the next page). This is an "out of the box" (i.e., manufactured) tolerance. Thus, when we test the 1mA DC clamp voltage of the device with the SST-400, we should check to see that it falls within this range. Otherwise, it should probably be discarded.

RATINGS AND CHARACTERISTICS TABLE

MODEL NUMBER	MAXIMUM RATINGS (25°C) CONTINUOUS RMS VOLTAGE V_{RMS} VOLTS	CONTINUOUS DC VOLTAGE V_{DCM} VOLTS	TRANSIENT ENERGY (10 x 1000 µs) W_{TM} JOULES	TRANSIENT PEAK CURRENT (8 x 20 µs) I_{TM} AMPERES	CHARACTERISTICS V_{NOM} VARISTOR PEAK VOLTAGE MIN. VOLTS	MAX. @ 1 mA DC VOLTS	MAX. @ 1mA AC VOLTS	MAX. CLAMPING VOLTAGE V_C @ TEST CURRENT (8 x 20 µs) V_C VOLTS	I_P AMPS	TYPICAL CAPACITANCE f = 0.1-1 MHz PICOFARADS	MODEL SIZE (mm)
V95LA7A	95	130	20	4000	134	181	207	280	50	1250	14
V95LA7B						165	170	250	50	1250	14
→ V130LA1	130	175	4	500	184	255	273	390	10	180	7
V130LA2			8	1000		232	254	340	10	180	7
V130LA10A			30	4000		232	254	340	50	1000	14
V130LA20A			50	6000		232	254	340	100	1900	20
V130LA20B			50	6000		220	238	325	100	1900	20

Figure 3   MOV Data Sheet. Source: General Electric, Transient Voltage Suppression Manual ©1978.

The test procedure is as follows:

1. Remove the MOV from its circuit if it is not already isolated.
2. Clip one test lead to each lead of the device as shown in *Figure 4*. Make sure the leads are not close to any other conductors, like wires that may be laying on the bench or a metal cabinet, etc. If one of the high voltage test lead contacts another conductor, a painful shock could be delivered.
3. Remove your hands from the test leads and DUT.
4. Turn on the SST-400 with the POWER switch.
5. Set the readout mode to PEAK (actually, for a clamp-type device like the MOV, it doesn't matter which mode is selected because they will give nearly identical readings).
6. Push the TEST button and hold for 1-3 seconds and record the display value. The value may change (usually dropping) as the button is held because of device heating by the test current, so it is important to record the value soon after the current is first applied. This also helps conserve battery power.

Figure 4   A MOV test setup.

7. Set the readout mode to AVERAGE and repeat the test (again, for an MOV the readings should be almost identical). Record the display value.
8. Turn the tester off.
9. In general, the test procedure above should be repeated a second time, reversing the red and black test leads. Although MOVs like the V130LA1 are symmetric and should give the same readings in both directions, some suppressors use back-to-back diodes that can fail only in one direction (see Technical Supplement), so it is important, in general, to perform both sets of tests.

B. What does the Peak/Average Switch do

The PEAK/AVERAGE switch is a feature unique to the SST-400. It simply selects the type of readout given by the display. In PEAK mode we read the highest voltage across the suppressor before it begins to "turn on." For crowbar devices like GDTs and TSPDs whose voltage drops when they "turn on," this is the breakover voltage. In AVERAGE mode the SST-400 displays the average voltage seen across the suppressor. For clamp devices like MOVs and SADs, this reading will be nearly identical to that obtained in PEAK mode, because the voltage of a clamp device does not drop when it "turns on." However, for an operational crowbar device the voltage across the device drops after the breakover voltage is reached, so the PEAK and AVERAGE readings will be different. Because the SST-400 repetitively ramps up to the breakover voltage, a sawtooth-like voltage waveform results while testing of an operating crowbar device is underway, and the average voltage of such a waveform is lower than the peak voltage. The PEAK/AVERAGE switch allows the user to quickly see if a crowbar device is operating after the breakover voltage is reached. Note that some crowbar devices (usually TSPDs) have a turn-on current (I_T) of more than 1mA, the current supplied by the SST-400; in this case the PEAK and AVERAGE readings will be the same because there is insufficient current available from the tester to cause the device to "turn on."

C. What Data Should be Recorded

In most cases the peak and average clamp voltages in each direction of a two-terminal device should be recorded. More complicated suppressors have multiple suppressor elements within them, and these must be tested individually to the extent permitted by the suppressor circuit's topology and external connections. It is for this reason that ATSI develops and maintains device-specific test procedures that guide SST-400 users through the testing of the more popular surge suppressors available from several manufacturers. The more complicated the suppressor circuit, the more data that must be recorded. This situation is described in section IV.A on page 8. Still, the test basically comes down to looking at the 1mA DC clamp voltage of the various individual protective elements within the suppressor circuit. Occasionally, we will use the current-source capability of the tester to check the condition of series elements like resistors and fuses, but this is more effectively done with an ohm-meter. The user may construct his/her own test routines for specific devices, and users may consult ATSI for assistance or to request a custom test procedure design.

D. How to Interpret Readings

Since no clear standards exist for installed suppressor testing (see Technical Supplement), the results of any SST-400 test are subject to the interpretation of the user, but certain guidelines and suggestions apply. These can be grouped according to the type of suppressor being tested, and are summarized on the next page.

A failed device is indicated by any of the following:

Metal-Oxide Varistors (MOVs):

- a change of more than 10% from the installed device's original 1mA DC clamp voltage
- a clamp voltage reading outside of the normal device tolerance,
- a significantly different reading between PEAK and AVERAGE clamp voltage displays on the SST-400

Gas-Discharge Tubes (GDTs):

- a significant change in breakdown voltage, such as 25% or more

Silicon Avalanche Diodes (SADs):

- a change of more than 5% from the installed device's original 1mA DC clamp voltage
- a clamp voltage reading outside of the normal device tolerance
- a significantly different reading between PEAK and AVERAGE clamp voltage displays
- for back-to-back diodes, any significant imbalance of clamp characteristics in each direction

Thyristor Surge Protective Devices (TSPDs):

- a change of more than 5% from the installed device's original turn-on voltage
- a turn-on voltage outside the normal device tolerance
- lack of a difference between PEAK and AVERAGE clamp voltage displays
- any significant imbalance of turn-on characteristics in each direction

It should be clear from the statements above that the basic use of the SST-400 for evaluation of surge suppressor capabilities involves comparing the characteristics of installed devices to those of new devices (i.e., out-of-the-box), the idea being to catch any suppressors that may have been stressed due to their installation environment. It can also be used to screen new devices before they are installed. Although cumbersome, the best method for checking suppressors is to label each suppressor and maintain a written test record for each individual device, tracking it over time from installation to replacement. This can be useful in a number of ways:

- to evaluate various competing surge suppressor models for performance in the field,
- to indicate which areas of an installation are most prone to degradation from either surge events such as lightning or other environmental stresses such as temperature and humidity,
- to provide a written record as evidence of an ongoing maintenance program.

IV. TESTING COMPLEX SURGE SUPPRESSORS

Many surge suppressors contain multiple surge suppressor devices in a somewhat complex circuit. Different circuit topologies are used by designers to match their suppressor to its intended use. High-speed communications circuits require a different type of suppressor than do power circuits or modems or antennas, and so forth. The possibilities are nearly limitless, but a few common suppressor circuit topologies are discussed here to help the user understand how device-specific test routines are generated and stress the need for a thorough understanding of a particular organization's inventory of surge suppressors.

A. Examples of Multi-Element Suppressor Topologies

Line-Voltage Suppressor With Two MOVs:

Figure 5 shows the circuit for this simple type of line-voltage surge suppressor. It uses two MOVs to shunt surges into the safety ground wire from both the AC Hot and AC Neutral lines. This is the type often found in Type-170 cabinets, where the Caltrans specification requires a separate AC Neutral and Earth Ground. NEMA TS-1 cabinets can get by with just a single two-terminal MOV from Line to Neutral (or Ground).

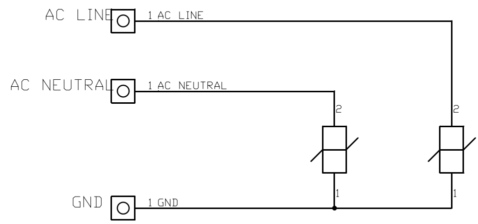

Figure 5 Line-Voltage Suppressor with 2 MOVs

Line-Voltage "Hybrid" Suppressor:

A hybrid suppressor usually combines several different types of surge suppressor elements. In the relatively simple example circuit of *Figure 6* below, we see MOVs both upstream and downstream from a large inductor (typically over 200mH) that is intended to reflect the fast-rising surge energy at the input side of the suppressor.

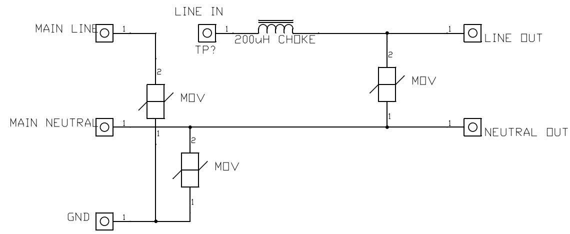

Figure 6 Line-Voltage "Hybrid" Suppressor

Line-Voltage Suppressor With MOVs, SADs, and RFI filter:

Figure 7 below shows how a "simple" AC line protector topology can become somewhat complex. Here, two stages of surge protection are implemented using MOVs and back-to-back SADs separated by a typical RFI filter using inductors and RF suppressor capacitors. The inductors, if large enough, can behave like the choke in *Figure 6*. Like the previous example, this type would probably be called a "hybrid." This circuit also has a third MOV from Line to Neutral on the input side.

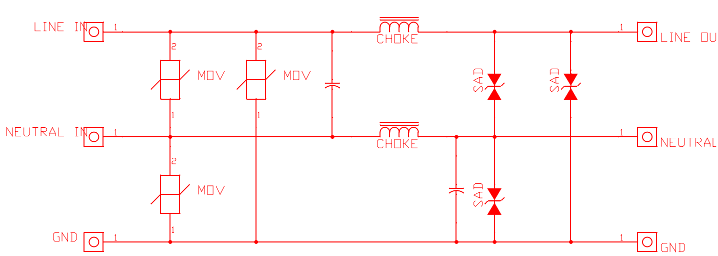

Figure 7 Line-Voltage Suppressor with MOVs, SADs, and RFI Filter

Telecom Surge Suppressor:

Figure 8 shows the topology for a modern telephone network surge suppressor. This is much different from the carbon-block suppressors of old. This one shows three levels of shunt surge protection, beginning with a three-terminal Gas Discharge Tube followed by MOVs and, finally, by SADs. These shunt stages are separated by series resistance elements that limit the current between each stage.

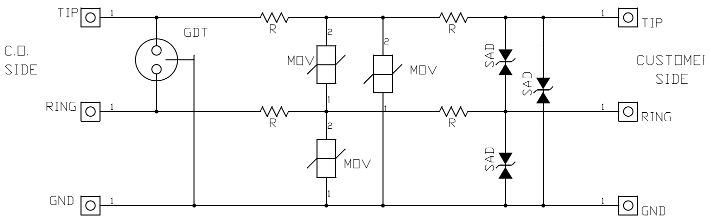

Figure 8 Telecom Surge Suppressor

Data Line Suppressor:

The circuit of *Figure 9* belongs to a very popular device in the traffic signal industry for protecting interconnect data lines. Each line pair is protected by a three-terminal GDT and back-to-back SADs, separated by a small series resistance.

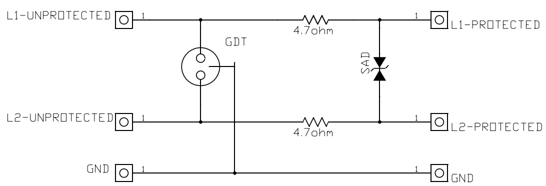

Figure 9 Data Line Suppressor

B. General Test Routine Suggestions

When faced with using the SST-400 to test a device whose internal topology is unknown, we recommend that the user call ATSI. ATSI will research the device and attempt to get specific information from the manufacturer that will allow creation of a test routine specific to that device. Otherwise, the user will be forced to do the same, but manufacturers of surge suppressors are often reluctant to give details of device construction. ATSI has a constantly-expanding inventory of surge suppressors that is used to develop test routines for the SST-400. One bit of advice to the user: if you wish to maximize testability, stick to surge suppressors from recognized and reputable manufacturers who will be there to provide both information and products in the future.

At the most basic level, the SST-400 is a tester of shunt type transient voltage surge suppressors. These are suppressors which connect across the lines of the protected circuit (i.e., in shunt) and limit the voltage that may be applied across those lines. In this sense, we can test any device by simply placing the SST-400 test clips on the protected lines and reading back the clamp or turn-on voltage. However, there are situations, like several of the example circuits above, where several stages are connected across the same two lines. In this case, the SST-400 will only test the suppressor (usually the downstream one, if it is operational) with the lowest clamp or turn-on voltage. Almost all of the multi-element surge suppressors are encapsulated with epoxy, so the remaining devices are simply untestable because they cannot be isolated from the circuit. This is analogous to the situation described above where the AC line protectors of equipment on an AC bus must be removed from the circuit.

It seems logical, however, that the upstream suppressors in a multi-element circuit are required to handle the most surge energy, while the downstream suppressors have progressively smaller surge dissipating capability. This is not always the case, but a properly-designed surge suppressor will usually operate in this way. Thus, a failure of an upstream device from a very large surge is likely to cause a total failure of the downstream devices, and it is reasonably safe to assume that, if the downstream devices test "good", then the upstream devices are also "good." This means that even for multi-element suppressor topologies, the two-terminal test of the SST-400 gives an adequate indication of device capability. If in doubt, replace the suppressor anyway. For example, after a known lightning strike with immediate damage, it would be wise to replace at least the main upstream suppressor that protects the equipment, even if it tests "good."

C. SST-400 Test Modules

Because of the great variety of surge suppressor devices available, many with multiple circuits on a single package, ATSI designed the SST-400 to support easily-interchangeable test modules that simplify some of the user operations that would otherwise be difficult, such as holding the test leads on different connectors (e.g., card edge), selecting the right pins to test a specific circuit in the package, and reversing the leads. The simplest SST-400 test module is the Lead-Reverser, which allows the user to switch the direction of the applied test current with the flip of a switch. ATSI continually produces new test modules for the more common surge suppressors as well as custom test modules for user-specified devices and applications. Be sure to check ATSI's web page for any new modules and updates.

The test modules are designed to connect to the banana jacks on the top of the SST-400 tester unit as shown in *Figures 10a* and *10b*. Only one test module may be used at a time, but they are easily interchangeable.

Figure 10a Type 642 Test Module

Figure 10b Type 642 Test Module attached to the SST-400

V. SERVICE AND REPAIR INFORMATION

The SST-400 is sold with a one-year limited warranty to the original purchaser, as defined by the limited warranty on the inside back cover of this manual. No other warranties, expressed or implied, apply to the SST-400 or associated components. If it is necessary to return your tester to the factory, please refer to **Appendix B**, "Packing the SST-400 For Shipment," before giving it to your delivery service.

After the first year, ATSI will continue to provide repairs to the tester on a parts-plus-labor basis. A phone call describing the problem may allow ATSI to make a non-binding estimate of repair costs, but the surest approach is to send back the tester for a comprehensive evaluation and a binding repair estimate. Please refer to **Appendix B** for packing instructions.

In order to be assured of optimum safety and performance of your tester, ATSI encourages the owner to return the SST-400 every two years to the factory for recalibration and recertification. If your tester is used often (e.g., almost daily), we recommend a 1-year recalibration interval. Factory recalibration restores your SST-400 to performance identical to that of new testers. In addition to recalibration of the test parameters, this service includes replacement of batteries and high-voltage test leads. In the interest of safety, we request that the original high voltage test leads be returned to the factory (with the warning labels intact), so they can be replaced with new high-voltage test leads, as they may have become nicked, scarred, etc. with use. This assures that degraded high-voltage cables do not remain at the user's location, risking their accidental use in the future. Please contact the factory for price and scheduling information on this service. Refer to **Appendix B** for packing instructions.

VI. USER MAINTENANCE OF THE SST-400

Because of the high voltages generated by the SST-400, most repairs require an intimate knowledge of its workings to be safe and successful. On the other hand, battery replacement is one maintenance task which can be easily performed by most technicians. If you use your SST-400 often for high-voltage tests, you may go through several sets of batteries per year.

When the batteries in the SST-400 require replacement, you will notice the BAT LED on the front panel is continuously lit during testing. An occasional flicker may be noted when testing high-voltage crowbar-type devices, but a more steady indication denotes low batteries.

There are three 9V alkaline batteries in the SST-400. Batteries **B1** and **B2** supply the higher power requirements of the high-voltage tester circuit and will require more frequent replacement than **B3**, which only powers the LCD display (see *Figure 11*). To replace the batteries, it is necessary to open the SST-400 enclosure. **FIRST TURN THE TESTER OFF. NEVER OPEN THE BACK PANEL WHILE THE SST-400 POWER IS ON**. Lay the tester face-down on a flat table, making sure that there is nothing underneath the tester that can accidentally flip the power switch to the ON position. Remove the four Phillips head screws located in each corner only. The back panel can then be removed and the access to the batteries obtained as shown in *Figure 11* belows. All the batteries are held in plastic clips and can be removed by lifting the bottom of the battery and pulling it out of the clip. Installation is the reverse of this procedure.

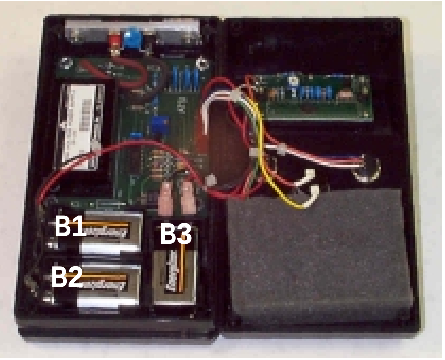

Figure 11 User replaceable batteries.

APPENDIX A. USER MAINTENANCE OF THE SST-400

Opening the SST-400 by the owner is approved for the purpose of replacement of the three 9V alkaline batteries. No other activities or operations on the SST-400 are authorized to the owner or any other parties without voiding any factory warrant in effect. The person performing these functions should be a qualified and experienced electronics technician.

Before opening the SST-400, be sure the tester power switch is OFF and no objects on the table or workbench could contact the power switch during the battery replacement which could turn the power ON. Short the two test probes together with a clip lead. This power switch precaution is simply to avoid any possible shock hazard, since high voltage nodes will be exposed on the inside of the tester.

Lay a clean, soft material (such as a clean shop cloth or a towel) on the workbench under the tester so the finish on the enclosure will not be soiled or scratched. To open the SST-400 enclosure, unscrew the four small phillips-head screws at the extreme corners on the back side of the tester. These screws must be removed and set aside in a safe place. Carefully turn the tester over and set it on the workbench right-side-up. Grip the top section of the three piece enclosure from both sides and lift it straight up, then turn it over onto the workbench face down (opening the enclosure like a book). The top section is attached to the lower section by a wiring, so use care when opening.

APPENDIX B. PACKING THE SST-400 FOR SHIPMENT

Sooner or later, your SST-400 will make the trip back to ATSI. It may be for a recalibration or a possible repair. Proper packing will help assure that your tester arrives safely and in the same condition as when you sent it. Successful shipping is mostly a matter of good sense. It starts with deciding what needs to be shipped. You do not want to expose any more than neccessary to the hazards of the trip. For example, if the shipment is for repair of the SST and a questionable test module, then the other test modules and carrying case (if purchased) need not be shipped. The test leads should always be shipped so they can be inspected for any small cuts or possible damage. ATSI will replace at no cost the test leads if it is determined that they are a possible safety hazard.

Once determined what is being shipped, each item should be wrapped seperately in bubble wrap or some other form of packing and then placed in a box. For damage claim purposes, UPS recommends AT LEAST 2 INCHES OF CUSHIONING ON ALL SIDES OF THE CONTENTS of the box. Appropriate cushioning materials are foam-wrap, bubble-wrap or a good firm filling of foam "peanuts". The package must protect your SST against shock damage (the six-foot drop test) and puncture damage. Do not use a really flimsy box as the outside container, as it may rupture under impact.

In most damage cases, the carrier is not to blame. Failure to properly pack the tester may deprive the use of the tester for weeks while the carrier investigates the damage claim. A half hour spent in careful packing can save many hours of loss of use of the tester.

APPENDIX C. DEVICE-SPECIFIC TEST ROUTINES

This appendix contains the detailed test routines authored by ATSI for specific surge suppression devices. These are created in response to requests by users and to ATSI's own perceptions of which devices are most common in the traffic control and other industries that make use of the SST-400. Most test routines do not make use of specific test modules, but the more general-purpose test modules like the lead-reverser and DVM breakout/protector test modules are included in some of the discrete-device test routines because they can simplify testing operations for those devices. Occasionally, the use of a DVM or other tester is recommended for checking serial components or obtaining higher resolution measurements at low voltages (recall that the SST-400 has a display resolution of 1 volt).

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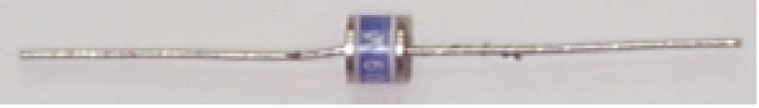
Two-Terminal Gas Discharge Tube, up to 2kV C1.1A

REVISION DATE: 10/30/97 Initial test design

REFERENCES: MIL-STD 188-125A Appendix B, Section 50.4l



TEST PROCEDURE:

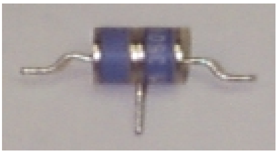
This test should be sufficient for measuring the DC breakdown voltage of a spark gap, as defined in the reference above.

1. Remove or otherwise isolate the GDT from the circuit.
2. Attatch a test clip to each terminal of the GDT.
3. Set the readout mode to PEAK.
4. Turn on the tester unit.
5. Push the TEST button for 1-3 seconds. Record the value, which is the DC breakdown voltage of the GDT. Sometimes there is a visible arc within the tube during testing. This is normal, and an indication that the tube is operating by discharge, as designed. This is also indicated by repeating the test in AVERAGE readout mode, where the display will be considerably less than in PEAK mode if the GDT is striking an arc on breakdown (for most devices, expect an AVERAGE reading of 20-40% less than PEAK).

Three-Terminal Gas Discharge Tube, up to 2kV C1.2A

REVISION DATE: 10/30/97 Initial test design

REFERENCES: MIL-STD 188-125A Appendix B, Section 50.4l

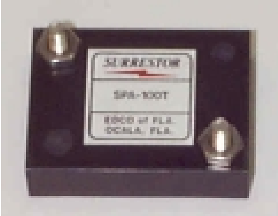


This test should be sufficient for measuring the DC breakdown voltage of a spark gap, as defined in the reference above.

TEST PROCEDURE:

1. Remove or otherwise isolate the GDT from the circuit.
2. Attach a test clip to the common terminal of the GDT (usually the one in the middle). Attach the other test clip to one of the two remaining terminals.
3. Set the readout mode to PEAK.
4. Turn on the tester unit.
5. Push the TEST button for 1-3 seconds. Record the value, which is the DC breakdown voltage of the GDT. Sometimes there is a visible arc within the tube during testing. This is normal, and an indication that the tube is operating by discharge, as designed. This is also indicated by repeating the test in AVERAGE readout mode, where the display will be considerably less than in PEAK mode if the GDT is striking an arc on breakdown (for most devices, expect an AVERAGE reading of 20-40% less than PEAK).
6. Repeat test for the other terminal. Any significant imbalance between the two sides should be noted, and may warrant replacement.

EDCO SPA-100T / HESCO HE-100 SERIES C2.2A



REVISION DATES: 02/13/98 Initial test design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the SPA-100T from the circuit.
2. Attatch a test clip to each terminal of the device.
3. Set the readout mode to AVERAGE.
4. Turn on the tester unit.
5. Push the TEST pushbutton for 1-3 seconds. Record the value. The measured value for the 1mA DC breakdown of this device should be in the range of:

- **EDCO SPA-100T** 216 and 264 volts
- **HESCO HE-100 SERIES** 216 and 264 volts

EDCO SRA-6LC / HESCO HE6LC C4.1A

REVISION DATES: 3/16/98 Initial test design

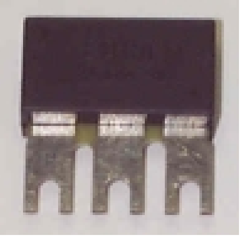
REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the device from circuit. Permanently mark one of the wires to distinguish it from the other. We will call this marked wire #1. The un marked wire is called wire #2.
2. Place the black test lead on the threaded stud.
3. Place the red test lead on lead #1.
4. Set the readout mode to PEAK.
5. Turn on the tester unit.
6. Press the TEST pushbutton for 1-3 seconds and record the display value. This is the breakover voltage and it should be between:
   - **EDCO SRA-6LC** 140 and 170 volts
   - **HESCO HE6LC** 26 and 30 volts
7. Set the readout mode to AVERAGE.
8. Press the TEST pushbutton for 1-3 seconds and record the value. It should be some what lower (about 10-30V lower) than the PEAK reading just obtained. This verifies that the crowbar device is operating.
9. Reverse the test leads and repeat steps 4-8.
10. Now place the red test lead on wire #2 and place the black test lead on the threaded stud.
11. Repeat steps 4-8 with the new lead configuration.
12. Reverse the leads and repeat steps 4-8.
13. Now place the black test lead on wire #2 and place the red test lead on wire #1.
14. Repeat steps 4-8.
15. Reverse the leads and repeat steps 4-8.

You have now thoroughly tested the SRA-6LC/HE6LC by examining each of its three suppressor components independently and in both directions.

EDCO SRA-6LCA-916 & 716 / HESCO HE6LC-TS C4.2A



REVISION DATES: 2/16/98 Initial test design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate suppressor from circuit.
2. Mark one of the outside spade terminations with a permanent mark. We will call this Terminal 1. The middle terminal is GROUND, and the terminal opposite Terminal 1 is Terminal 2.
3. Place the black test lead on the GROUND terminal. Make sure the alligator clip teeth contact the metallized surface of the terminal.
4. Place the red test lead on Terminal 1.
5. Set the readout mode to PEAK.
6. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record value. The breakover voltage should be:
   - **EDCO SRA-6LCA-916 & 716** 140 and 160 volts
   - **HESCO HE6LC-TS** 27 and 29 volts
7. Set the readout mode to AVERAGE. Repeat test and record value, which should be significantly lower than the PEAK reading. This average reading verifies the crowbar operation of the device and should be between 70 and 100 volts.
8. Turn off the tester.
9. Move the red test lead to terminal 2.
10. Repeat steps 5-8.
11. Move the black test lead to Terminal 1.
12. Repeat steps 5-8.

EDCO SHP300-10 / HESCO HE300-15 C5.1A

REVISION DATES: 3/16/98 Initial test design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from circuit. Make sure all 5 non-ground terminals are open.
2. There are 3 clamp-type suppressors in this package, and each will be tested indi vidually in the steps below.
3. Connect the black test lead to the GND terminal of the SHP300-10.
4. Connect the red test lead to the MAIN LINE terminal.
5. Set the readout mode to AVERAGE.
6. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record the clamp voltage and turn off the tester. The clamp voltage should be:
   - **EDCO SHP300-10** 216 and 264 volts
   - **HESCO HE300-15** 216 and 264 volts
7. Move the red test lead to the MAIN NEUTRAL terminal. Repeat step 6.
8. Move the black test lead to the NEUTRAL EQUIP. terminal.
9. Move the red test lead to the LINE IN EQUIP. terminal. Repeat step 6.

HESCO HE6LCB C3.1A

REVISION DATES: 3/9/98 Initial test design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from the circuit.
2. Permanently mark the spade lugs as Lug #1 and Lug #2.
3. Place the two HV test leads on the spade lugs, with the black lead on Lug #1.
4. Turn on the tester unit.
5. Push the TEST pushbutton for 1-3 seconds. Record the breakdown voltage. It should be 18-22V.
6. Turn off the tester unit.
7. Reverse the two HV test leads. Lug #2 now has the black test lead.
8. Repeat steps 4-6.
9. Move the black test lead to the ground wire.
10. Repeat steps 4-6.
11. Reverse the test leads. Now Lug #1 is black, ground is red.
12. Repeat steps 4-6.
13. Move the black HV test lead to Lug #2.
14. Repeat steps 4-6.
15. Reverse the test leads. Now Lug #2 is red, ground is black.
16. Repeat steps 4-6.

HESCO HE1800 C5.2A

REVISION DATES: 3/9/98 Initial test design

REFERENCES:

TEST PROCEDURE:

* NOTE: THESE DEVICES CONTAIN FILTER CAPACITORS WHICH CAN HOLD A DANGEROUS AMOUNT OF ELECTRICAL CHARGE. THIS TEST PROCEDURE SHOULD BE STRICTLY FOLLOWED TO AVOID LEAVING ANY STORED ENERGY IN THE DEVICE.

1. Remove or otherwise isolate the suppressor from the circuit.
2. Place the red test lead on the LINE IN terminal.
3. Place the black test lead on the NEUT IN terminal.
4. Set the readout mode to AVG.
5. Turn on the tester unit.
6. Push the TEST pushbutton for 1-3 seconds. Record the clamp voltage value. It should be 216-264V.
7. Turn off the tester unit and wait 15-30 seconds before removing either of the leads. If you leave the tester on, you will notice that the charge bleeds off rather slowly. This will occur more quickly if the tester is turned off. IT IS VERY IMPORTANT TO BLEED OFF THIS EXCESS CHARGE OR IT WILL BE A SHOCK HAZARD TO PERSONNEL THAT HANDLE THE SUPPRESSOR.
8. Move the black test lead to the GROUND terminal.
9. Repeat steps 5-7.
10. Move the red test lead to the NEUT IN terminal.
11. Repeat steps 5-7.
12. Move the red test lead to the LINE IN terminal. Leave it there for 15-30 seconds with the tester turned OFF. This will bleed off any remaining residual charge.

EDCO SPA-300 / HESCO HE300 C2.3A

REVISION DATES: 3/16/98 Initial test design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from the circuit. For a simple suppressor like the SPA-300 and HE300, it is really only necessary to remove wires from one of the terminals (for example, the hot side wires). So this suppressor is easily checked in the cabinet, but one must still switch off the AC power to the cabinet (creating a dark intersection) during the test.
2. Place the black test lead on the GND terminal.
3. Place the red test lead on the LINE terminal.
4. Set the readout mode to AVG and turn on the tester.
5. Press the test push-button for 1-3 seconds. Record the clamp voltage. It should be between 216-264 volts.*

* *NOTE*: Some older cabinets occasionally contain an EDCO SPA-300 utilizing a gas discharge tube with a breakdown voltage range of 400-500V. If you think your SPA-300 is old, you should check to see if it contains a GDT rather than an MOV. The easiest way to do this is to perform the above test first in AVG and then in PEAK readout mode. If the average voltage is considerably lower than the peak (75V or more), then the SPA-300 is an older one that contains a GDT. If the peak and average readings are nearly identical and in the range 216-264V, the SPA-300 is newer and contains an MOV.

EDCO PC642, no suffix C5.4A

REVISION DATES: 3/31/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

This test procedure requires the **Type 642 Plug-in Adapter** (shown above). Note: these devices contain two independent suppressor circuits that are tested individually by the procedure below. Make sure to distinguish the recorded voltages as "circuit #1 line-to-line, forward," "circuit #2 line-to-ground, reverse," etc.

1. Plug the test adapter into the SST-400. Set the SST-400 to PEAK mode.
2. Place the suppressor in the adapter socket.
3. Set the select knob to position 1. This checks circuit #1 line-to-line.
4. Turn on the tester unit. Be sure to perform the following test in both the FORWARD and REVERSE directions. Push the TEST pushbutton for 1-3 seconds, recording both values (FWD and REV). The voltage should be:

PC642C-008	**14-18V**	**PC642C-043**	**60-100V**
PC642C-015	**26-34V**	**PC642C-050**	**60-100V**
PC642C-020	**36-44V**	**PC642C-060**	**60-100V**
PC642C-030	**56-64V**	**PC642C-200**	**300-350V**
PC642C-036	**60-100V**		

5. Set the select knob to position 2. This checks circuit #1 line 1-to-ground.
6. Perform the following test in both the FORWARD and REVERSE directions. Push the TEST pushbutton for 1-3 seconds, recording both values.

PC642C-008	**7-9V**	**PC642C-043**	**40-46V**
PC642C-015	**13-17V**	**PC642C-050**	**47-53V**
PC642C-020	**18-22V**	**PC642C-060**	**57-63V**
PC642C-030	**28-32V**	**PC642C-200**	**297-303V**
PC642C-036	**34-38V**		

7. Set select knob to position 3. This checks circuit #1 line 2-to-ground.
8. Repeat step 6.
9. Set the select knob to position 4. This checks circuit #2 line-to-line.
10. Repeat step 4.
11. Set the select knob to position 5. This checks circuit #2 line 1-to-ground.
12. Repeat step 6.
13. Set the select knob to position 6. This checks circuit #2 line 2-to-ground.
14. Repeat step 6.
15. Turn off the tester unit.

EDCO PC642, D suffix C5.5A

REVISION DATES: 3/31/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

This test procedure requires the **Type 642 Plug-in Adapter** (shown above). *Note*: these devices contain two independent suppressor circuits that are tested individually by the procedure below. Make sure to distinguish the recorded voltages as "circuit #1 line-to-line, forward," "circuit #2 line-to-ground, reverse," etc.

1. Plug the test adapter into the SST-400. Set the SST-400 to PEAK mode.
2. Place the suppressor in the adapter socket.
3. Set the select knob to position 1. This checks circuit #1 line-to-line.
4. Turn on the tester unit. Be sure to perform the following test in both the FORWARD and REVERSE directions. Push the TEST pushbutton for 1-3 seconds, recording both values (FWD and REV). The voltage should be:

PC642C-008D	**7-9V**	**PC642C-043D**	**40-46V**
PC642C-015D	**13-17V**	**PC642C-050D**	**47-53V**
PC642C-020D	**18-22V**	**PC642C-060D**	**57-63V**
PC642C-030D	**28-32V**	**PC642C-200D**	**297-303V**
PC642C-036D	**34-38V**		

5. Set the select knob to position 2. This checks circuit #1 line 1-to-ground.
6. Perform the following test in both the FORWARD and REVERSE directions. Push the TEST pushbutton for 1-3 seconds, recording both values.

PC642C-008D	**60-100V**	**PC642C-043D**	**60-100V**
PC642C-015D	**60-100V**	**PC642C-050D**	**60-100V**
PC642C-020D	**60-100V**	**PC642C-060D**	**60-100V**
PC642C-030D	**60-100V**	**PC642C-200D**	**300-350V**
PC642C-036D	**60-100V**		

7. Set select knob to position 3. This checks circuit #1 line 2-to-ground.
8. Repeat step 6.
9. Set the select knob to position 4. This checks circuit #2 line-to-line.
10. Repeat step 4.
11. Set the select knob to position 5. This checks circuit #2 line 1-to-ground.
12. Repeat step 6.
13. Set the select knob to position 6. This checks circuit #2 line 2-to-ground.
14. Repeat step 6.
15. Turn off the tester unit.

EDCO PC642, X or LC suffix C5.6A

REVISION DATES: 3/31/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

This test procedure requires the **Type 642 Plug-in Adapter** (shown above). *Note*: these devices contain two independent suppressor circuits that are tested individually by the procedure below. Make sure to distinguish the recorded voltages as "circuit #1 line-to-line, forward," "circuit #2 line-to-ground, reverse," etc.

1. Plug the test adapter into the SST-400. Set the SST-400 to PEAK mode.
2. Place the suppressor in the adapter socket.
3. Set the select knob to position 1. This checks circuit #1 line-to-line.
4. Turn on the tester unit. Be sure to perform the following test in both the FORWARD and REVERSE directions. Push the TEST pushbutton for 1-3 seconds, recording both values. (FWD and REV). The voltage should be:

PC642C-008X/LC 7-9V
PC642C-015X/LC 13-17V
PC642C-020X/LC 18-22V
PC642C-030X/LC 28-32V
PC642C-036X/LC 34-38V
PC642C-043X/LC 40-46V
PC642C-050X/LC 47-53V
PC642C-060X/LC 57-63V
PC642C-200X/LC 297-303V

5. Set the select knob to position 2. This checks circuit #1 line 1-to-ground.
6. Repeat step 4.
7. Set select knob to position 3. This checks circuit #1 line 2-to-ground.
8. Repeat step 4.
9. Set the select knob to position 4. This checks circuit #2 line-to-line.
10. Repeat step 4.
11. Set the select knob to position 5. This checks circuit #2 line 1-to-ground.
12. Repeat step 4.
13. Set the select knob to position 6. This checks circuit #2 line 2-to-ground.
14. Repeat step 4.
15. Turn off the tester unit.

EDCO ACP-340 C5.7A

REVISION DATES: 4/6/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from the circuit.
2. Place the red test lead on the Line In terminal.
3. Place the black test lead on the GND terminal.
4. Set the readout mode to AVG.
5. Turn on the tester. Push the TEST pushbutton for 1-3 seconds and record the clamp value. Turn off the tester. The recorded value should be 216-264 volts.
6. Place the red test lead on the Neut In terminal.
7. Repeat step 5.

NOTE: The presence of shunt filter capacitors on the ACP-340 restricts the ability of the standard SST-400 to test the Line-to-Neutral MOVs in the ACP-340 circuit. If your agency tests many (or exclusively) EDCO ACP-340s, you should consider a custom modification to your SST-400 that would allow more thorough testing of these suppressors. Contact ATSI for details.

EDCO SHA-1210 C5.8A

REVISION DATES: 4/7/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from the circuit.
2. Place the black test lead on the MAIN GND terminal.
3. Place the red test lead on the MAIN AC IN terminal.
4. Set the readout mode to AVG.
5. Turn on the tester. Push the TEST button for 1-3 seconds. Record the clamp value. It should be 216-264V.
6. Turn off the tester.
7. Move the red test lead to the MAIN NEUT IN terminal.
8. Repeat steps 5-6.
9. Move the black test lead to the MAIN AC IN terminal.
10. Repeat steps 5-6.
11. Move the black test lead to the MAIN GND terminal.
12. Move the red test lead to the EQUIPMENT SIDE NEUT OUT terminal.
13. Repeat steps 5-6.

EDCO SRA64C, no suffix C5.9A

REVISION DATES: 5/19/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

Note: Wire Colors: **W= White** **K=Black** **R=Red**

1. Remove the suppressor from the circuit. Tape the ends of W and W/R to prevent accidental contact.
2. Set the tester to PEAK readout mode.
3. Place the red test lead on the **K** wire.
4. Place the black test lead on the **K/R** wire.
5. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record value. The voltage should be:

SRA64C-008	**14-18V**	**SRA64C-043**	**60-100V**
SRA64C-015	**26-34V**	**SRA64C-050**	**60-100V**
SRA64C-020	**36-44V**	**SRA64C-060**	**60-100V**
SRA64C-030	**56-64V**	**SRA64C-200**	**300-350V**
SRA64C-036	**60-100V**		

6. Turn off the tester.
7. Reverse the test leads: red test lead on **K/R** wire, black test lead on the **K** wire.
8. Repeat steps 5 and 6.
9. Place the red test lead on the **K** wire.
10. Place the black test lead on the GND stud.
11. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record value. Voltage should be:

SRA64C-008	**7-9V**	**SRA64C-043**	**40-46V**
SRA64C-015	**13-17V**	**SRA64C-050**	**47-53V**
SRA64C-020	**18-22V**	**SRA64C-060**	**57-63V**
SRA64C-030	**28-32V**	**SRA64C-200**	**297-303V**
SRA64C-036	**34-38V**		

12. Turn off the tester.
13. Reverse the test leads: red test lead on GND stud, black test lead on **K** wire.
14. Repeat steps 11 and 12.
15. Place the red test lead on the **K/R** wire.
16. Place the black test lead on the GND stud.
17. Repeat steps 11 and 12.
18. Reverse the test leads: red test lead on GND stud, black test lead on **K/R** wire.
19. Repeat steps 11 and 12.

EDCO SRA64C, D suffix C5.10A

REVISION DATES: 5/19/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

Note: Wire Colors: **W= White** **K=Black** **R=Red**

1. Remove the suppressor from the circuit. Tape the ends of W and W/R to prevent accidental contact.
2. Set the tester to PEAK readout mode.
3. Place the red test lead on the **K** wire.
4. Place the black test lead on the **K/R** wire.
5. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record value. The voltage should be:

SRA64C-008D	**7-9V**	**SRA64C-043D**	**40-46V**
SRA64C-015D	**13-17V**	**SRA64C-050D**	**47-53V**
SRA64C-020D	**18-22V**	**SRA64C-060D**	**57-63V**
SRA64C-030D	**28-32V**	**SRA64C-200D**	**297-303V**
SRA64C-036D	**34-38V**		

6. Turn off the tester.
7. Reverse the test leads: red test lead on the **K/R** wire, black test lead on the **K** wire.
8. Repeat steps 5 and 6.
9. Place the red test lead on the **K** wire.
10. Place the black test lead on the GND stud.
11. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record value. Voltage should be:

SRA64C-008D	**60-100V**	**SRA64C-043D**	**60-100V**
SRA64C-015D	**60-100V**	**SRA64C-050D**	**60-100V**
SRA64C-020D	**60-100V**	**SRA64C-060D**	**60-100V**
SRA64C-030D	**60-100V**	**SRA64C-200D**	**300-350V**
SRA64C-036D	**60-100V**		

12. Turn off the tester.
13. Move the test leads: red test lead on **K/R** wire, black test lead on GND stud.
14. Repeat steps 11 and 12.

EDCO SRA64, X suffix C5.11A

REVISION DATES: 5/21/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

Note: Wire Colors: **W= White** **K=Black** **R=Red**

1. Remove the suppressor from the circuit. Tape the ends of W and W/R to prevent accidental contact.
2. Set the tester to PEAK readout mode.
3. Place the red test lead on the **K** wire.
4. Place the black test lead on the **K/R** wire.
5. Turn on the tester. Push the TEST pushbutton for 1-3 seconds. Record value. The voltage should be:

SRA64C-008X	**7-9V**	**SRA64C-043X**	**40-46V**
SRA64C-015X	**13-17V**	**SRA64C-050X**	**47-53V**
SRA64C-020X	**18-22V**	**SRA64C-060X**	**57-63V**
SRA64C-030X	**28-32V**	**SRA64C-200X**	**297-303V**
SRA64C-036X	**34-38V**		

6. Turn off the tester.
7. Reverse the test leads: red test lead on the **K/R** wire, black test lead on the **K** wire.
8. Repeat steps 5 and 6.
9. Place the red test lead on the **K** wire.
10. Place the black test lead on the GND stud.
11. Repeat steps 5 and 6.
12. Reverse the test leads: red test lead on the GND stud, black test lead on the **K** wire.
13. Repeat steps 5 and 6.
14. Place the red test lead on the **K/R** wire.
15. Place the black test lead on the GND stud.
16. Repeat steps 5 and 6.
17. Reverse the test leads: red test lead on the GND stud, black test lead on the **K/R** wire.

ISLATROL IC+107 C5.12A

REVISION DATES: 11/30/98 Initial Test Design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from the circuit.
2. Place the black test lead on the **LINE G** terminal.
3. Place the red test lead on the **LINE L** terminal.
4. Set the readout mode to AVG.
5. Turn on the tester.
6. Press the TEST pushbutton for 1-3 seconds and record the clamp voltage. It should be **210-270V**.
7. Turn off the tester.
8. Move the red test lead to the **LINE N** terminal.
9. Turn on the tester.
10. Press the TEST pushbutton for 1-3 seconds and record the clamp voltage. It should be **210-270V**.
11. Turn off the tester.

Note: the IC+107 has a pulse capacitor connected L-N. The leakage associated with this capacitor prevents measurement of the L-N clamp voltage at 1mA. If the SST-400 is connected L-N on the IC+107, it will read 25-50V because the leakage resistance is typically 25K-50K.

EDCO SRA16C-1 C5.13A

REVISION DATES: 5/20/99 Initial Test Design

REFERENCES:

TEST PROCEDURE:

1. Remove or otherwise isolate the suppressor from the circuit.
2. Label the grey wires **L1** and **L2**.
3. Place the red test lead on **L1**.
4. Place the black test lead on **L2**.
5. Set the readout mode to PEAK.
6. Turn the tester on.
7. Make sure hands are clear. Press the TEST pushbutton for 1-3 seconds and record the value. It should be **15-17V**.
8. Turn the tester off.
9. Reverse the test leads. Repeat steps 6-8.
10. Place the red test lead on **L1**.
11. Place the black test lead on the green wire.
12. Turn the tester on.
13. Make sure hands are clear. Press the TEST pushbutton for 1-3 seconds and record the value. It should be **60-100V**.
14. Turn off the tester.
15. Place the red test lead on **L2** (leave the black test lead on the green wire).
16. Repeat steps 12-14.