WIDE RANGE RESISTANCE METER
Model 871

Operating Instructions

6/08

electro-tech systems, inc.
3101 Mt. Carmel Avenue, Glenside, PA 19038 • Tel: (215) 887-2196 • Fax: (215) 887-0131

1.0 INTRODUCTION

Many applications, especially, in the area of static control require the measurement of the resistance characteristics of packaging, materials, work surfaces, flooring plus any object where the build-up and dissipation of static charge is of concern. Some materials are nonlinear and have a measured resistance that is a function of test voltage. Various specifications including those written by the ESDA (STM 4.1, 11.11, 11.12, 11.13, etc.), ASTM (D257, 4496, F150 etc.), EIA, SAE (J1645, etc.), NFPA (77, 99 etc) military (MIL PRF 81705 etc.) plus many international documents (IEC, CECC etc) specify or use test voltages of 10 and 100 Volts.

Specifications such as ASTM F-150, NFPA 99 and certain DOD Standards require test voltages of 500 volts. Normally, higher test voltages will generally result in lower resistance readings. Hence, an acceptable reading utilizing 10 or 100 volts will typically meet those resistance requirements specified at higher voltages where resistance below a specified value is required. However, when 500 V is required to ensure that resistance does not drop below a specified value for safety purposes, then a 500 V instrument **MUST** be used.

The ETS Model 871, shown in Figure 1.0-1 is an accurate, battery/AC powered, microcomputer-based instrument that meets the requirements for measuring resistance from 10^2 to $>10^{12}$ Ohms using user selectable regulated test voltages of 10 or 100V. The included external universal voltage power module allows continuous operation of the Model 871 without draining the batteries.

Figure 1.0-1: Model 871

2.0 DESCRIPTION

The Model 871 Wide Range Resistance Meter is an accurate, easy to use laboratory grade, microprocessor-based, autoranging instrument. The Meter is activated when the **MEASURE** select paddle switch is placed in either the V_e=10V or 100V position.

Optionally, a foot switch enables remote activation of the instrument. This function is very convenient when measurements are being performed in a test chamber. The included universal power module (90-265VAC, 50/60Hz) permits continuous operation of the Meter without draining the batteries. The 2-line alphanumeric LCD readout displays the measured resistance on the top line and the test voltage (V_e=10 or 100V) on the bottom line. Resistance is displayed in engineering units (ex: 6.35e+8 Ω = $6.35x10^8$ Ω) plus **UNDERSCALE and OVERSCALE** indication. The lowest measurable resistance is 100 Ω at 10V and 10 kΩ at 100V. The highest measurable resistance is approximately 5 $x10^9$ Ω at 10V and $5.5x10^{12}$ Ω at 100V. Measurement accuracy is better than 2% over the entire measurement range.

Electrification time is a function of the test lead, probe and sample capacitance. Generally, probes with 36" (1m) cables will require an electrification time of approximately 60 seconds to achieve maximum reading. External probes are connected to the Model 871 via standard banana jacks located on the rear of the instrument. Refer to available ETS Series 800 Resistance/Resistivity Probes literature sheets for probes to meet virtually any surface, volume (solids, liquids and powders) and point-to-point resistance measurement requirement. Other probes having standard banana plug leads may also be used.

Figure 2.0-1 shows the rear panel of the Model 871.

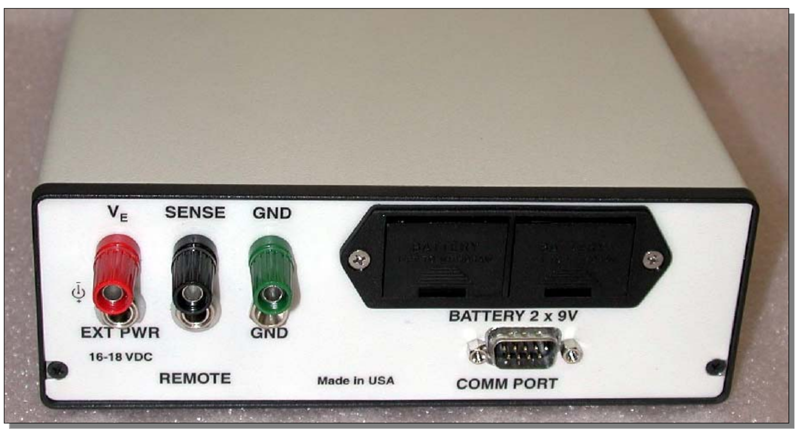


Figure 2.0-1: Model 871 Rear Panel

When battery voltage is low the display automatically displays **Low Battery**.

3.0 OPERATION

3.1 Hook-up

Connect the probe to the input banana jacks located on the rear panel as shown in Figures 3.1-1 to 3.1-5 for measuring surface, point-point and point to ground (RTG) resistance. The Red jack is V_e (test voltage), the Black Jack is SENSE (measuring input) and the Green jack is probe ground. For greater measurement stability at the higher resistance ranges connect the Green cable provided to the GND jack and house electrical ground. If the power module is being used connect it to the EXT PWR jack. **NOTE: When the using the power module the Meter MUST be connected to house electrical ground. Otherwise, incorrect measurements may be obtained.**

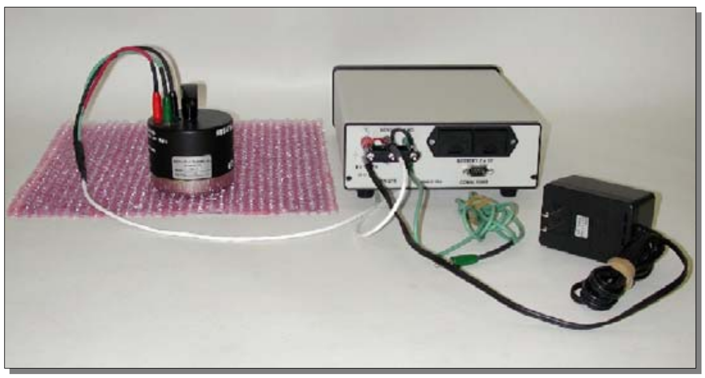


Figure 3.1-1: Connection for measuring surface resistance per ESDA STM 11.11

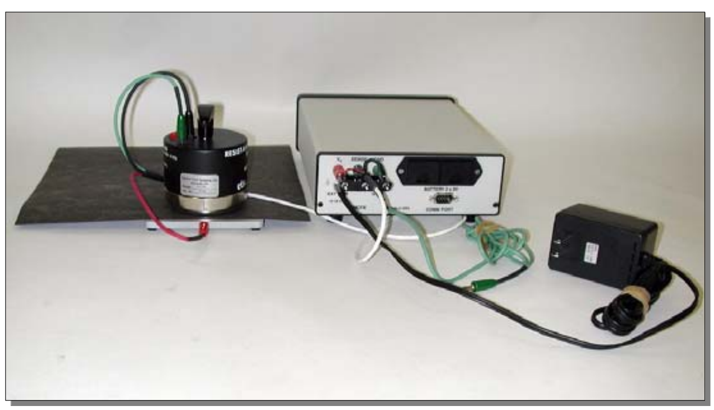


Figure 3.1-2: Connection for measuring volume resistance per ESDA STM 11.12

Figure 3.1-3: Connection for measuring 2-point resistance per ESDA STM 11.13

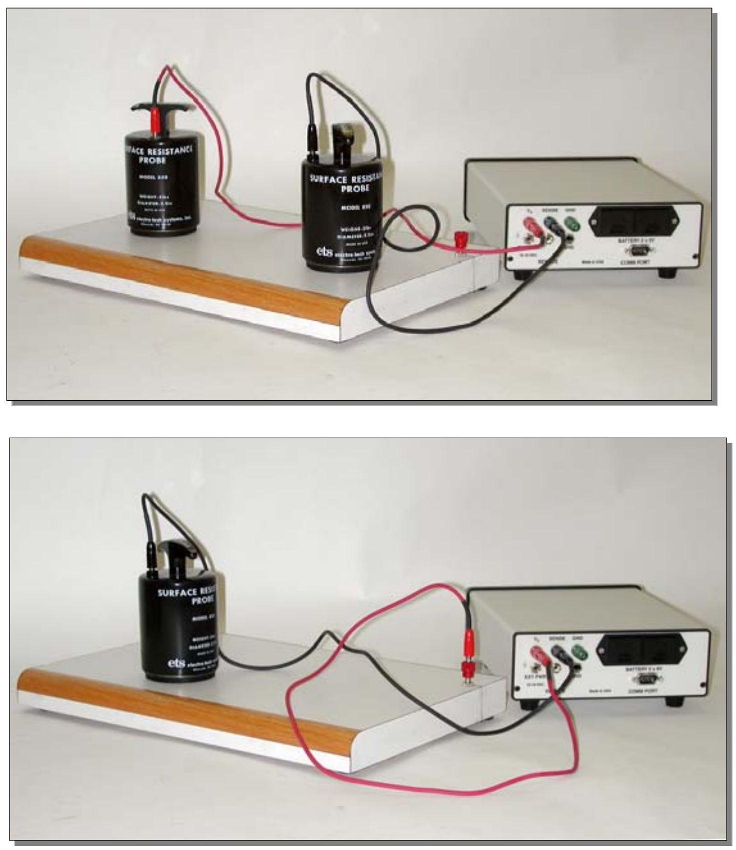


Figure 3.1-4: Connection for measuring point-to-point resistance and RTG per ESDA STM 4.1

Figure 3.1-5: Connection for measuring point-to-point resistance per SAE J1645

When using battery power the display will indicate only the alphanumeric text. When the power module is used the display back light will automatically be activated, enhancing the readout.

3.2 Taking Measurements

Turn on the Meter and place the MEASURE paddle switch in the STANDBY (center) position. The display will read STANDBY. Place or attach the probe(s) as indicated above on or to the object being measured. If the resistance of the sample is unknown, place the MEASURE switch in the V_e=10V position. Wait at least 5 seconds or until a stable reading is obtained. If the measured resistance is greater than $1x10^6$ Ohms switch to V_e=100V and take a reading. Measurements above or below the measurement range of the Meter will be displayed as UNDERSCALE or OVERSCALE. To repeat the measurement it is best to first go back to STANDBY to bleed off any voltage that may remain on the electrodes. If measuring in accordance with an established test method, then follow the procedure specified. When applicable, the resistance measurement can be converted to resistivity by multiplying the measured resistance by the appropriate probe configurations. For the ETS Model 803B Surface/Volume Resistance Probe multiply the measured surface resistance by 10 ($\rho_s=10R_m$ Ohms/sq).

To make a volume resistance measurement, connect the conductive test bed to the V_e output (Red). Place the planar material to be tested on the conductive plate and then place the probe on top of the material. Select the desired test voltage by placing the paddle switch it the upper (V_e = 10V) or lower position (V_e = 100V) until a stable reading is obtained. To convert a volume resistance measurement to volume resistivity, multiply the reading by 31.7 (the area a 2.5" electrode in cm^2) and divide by the thickness of the sample in cm ($\rho_v=31.7/t$ Ohms-cm). If the center electrode of a Model 803B is used (STM 11.12) then use 7.1 instead of 31.7.

To measure pt-to-pt resistance or RTG plug an ETS Model 850, 845 or equivalent probe into the V_e (Red) jack. To measure pt-pt, place the probes onto the surface to be measured. To measure RTG connect the supplied red wire from the V_e jack to the desired ground point using either the banana plug or the alligator clip adapter supplied. Wait at least 5 seconds (or allow enough time for electrification) before reading the Meter. Since the 5 pound probe weight provides the specified contact pressure, no additional pressure should have to be applied.

For all other measurements refer to the test method referenced for the application such as ESDA STM11.13, SAE J1645, ASTM D257 etc.

The effects of electrification time should also be observed when making pt-pt and RTG measurements, particularly if the resistance range is above 10^{10} ohms.

4.0 MEASUREMENT CONSIDERATIONS

4.1 Resistance

For most film and foam materials the standard 5 pound weight of the Model 803B Resistance Probe is sufficient for the electrodes to make total contact with the material surface. However, for rigid materials such as work surfaces, plastics, cardboard, etc, additional force, which will have to be determined by the user, may have to be applied to the Probe to ensure total electrode contact. Microscopically, these surfaces are generally not smooth and are uneven as illustrated in Figure 4.1-1.

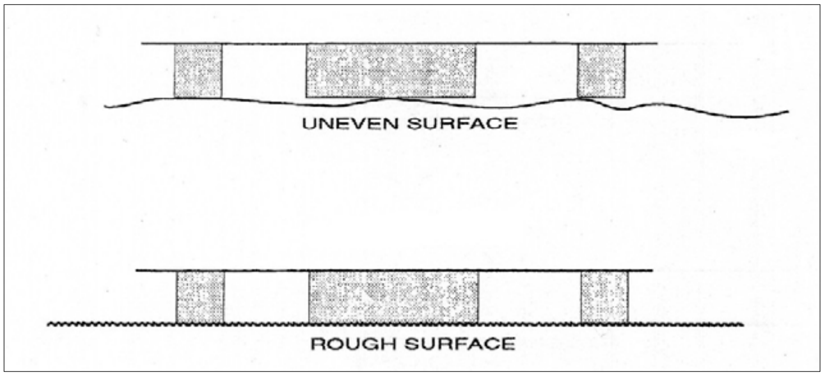


Figure 4.1-1: Microscopic Electrode/Rigid Surface Contact

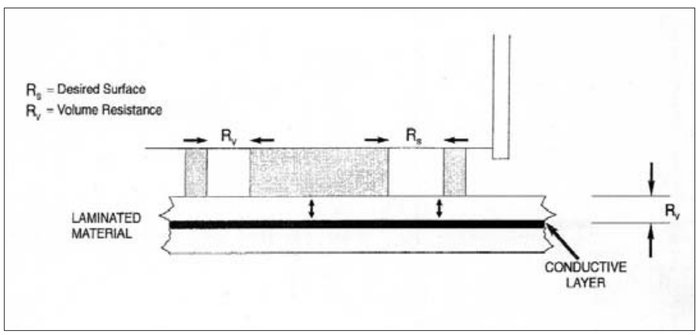
In most cases the application of additional pressure will cause the measured resistance reading to decrease. This is a result of both lower contact resistance and total electrode/surface contact area (greater number of parallel resistance paths). Optimum contact pressure is obtained when the resistance measurement is stable.

Another area that should be considered when attempting to measure surface resistance is the composition of the material being evaluated. ANSI/ASTM D-257, a widely used test standard, is specified for homogeneous, insulating material.

However, many materials are either not homogeneous, relatively conductive and in the case of some composite material, nonlinear. For these materials a surface resistance measurement in accordance with ESD STM11.11 must be used.

For example, the surface resistance of bulk-loaded materials have relatively low volume resistance and cannot easily be measured because the volume and surface resistance become part of the measurement. The current path between the electrodes is not only across the top surface but also through the material.

Similarly, the surface resistance of materials that are coated with, or laminated to, a conductive surface must also be measured using STM11.11. The surface resistance may actually be very high, but the volume resistance may be significantly lower. Therefore, the measured resistance may be that of the surface resistance path between the electrodes in parallel with the series combination of the two volume conductive paths and the conductive layer as shown in Figure 4.1-2.



4.1-2: Multiple resistance paths of laminated material

Composite materials are very difficult to measure. They usually consist of a plastic resin filler with very high resistance properties loaded with a small percentage of a conductive material such as carbon powder, fibers or utilize nanotube technology. When molded these parts exhibit either conductive or static dissipative properties as defined in the ESD ADV1.0: Glossary of Terms. These materials have bulk resistance properties verses the surface only resistance properties found in other ESD materials. When a voltage is applied either across or through the material the dielectric of the filler breaks down and current flows from particle to particle. As the loading of the conductive medium decreases there is greater distance between particles that require a higher voltage to break down the increased dielectric. At some point, once a higher voltage is applied to establish continuity the resistance path created may become altered permanently. It should be noted that loaded thermoplastic materials are only effective in reducing the upper resistance limit to approximately 10^8 Ohms.

Another characteristic of loaded thermoplastic materials that affects the resistance measurement is the microscopic insulative layer that develops on the surface of the molded part. The dielectric of this layer must be broken down before a resistance measurement can be made. Once this occurs the actual resistance of the part may be lower than the measuring range of the instrumentation used.

Essentially, these materials are non-linear and voltage dependent. Different test voltages will give different results. Even the series resistor incorporated in virtually all resistance meters vary from meter to meter and can cause measurement variations. When measuring these materials the initial measurement should be always be made first at V_e = 10V then at 100V.

Another very important consideration in measuring surface resistance is the time of electrification. This is the time for the effective capacitance of the material plus the measuring probe and associated cables to charge up. At this time, the current flow through the material reaches steady state and its flow is then a function of only the resistance of the material.

Effective material capacitance is generally quite low. For low resistance materials, the RC time constant, τ, is very short. On the other hand, for very high resistance materials the time constant can become quite long.

Resistances that are measured before the full time of electrification has occurred will appear to be lower than the actual resistance of the surface. This difference can be several orders of magnitude. ASTM D 257 recommends a time of electrification of 60 seconds, but in many measurements a shorter time may be used or a longer time may be required. Typically for small sample specimens with resistances less than 10^{12} ohms, the of 5 to 30 second electrification time is sufficient. On the other hand, large surfaces such as table tops, floors etc. the capacitance is relatively large and 60 seconds may not be long enough. Here, the user may either wait for complete electrification to obtain a true resistance measurement or specify the measurement at the 60 second electrification time point for a relative resistance measurement. A rule of thumb, “When in doubt, allow more rather than less time!”

4.2 RESISTANCE CHARACTERIZATION

Over the years many different resistivity or resistance values have been assigned to designate the various classifications of ESD material. Surface resistivity per ASTM D257 was the most common specification used to classify materials.

However, this specification is for insulating materials and when the bulk characteristics of the material come into play significant errors are introduced. This became apparent during packaging material specification development approximately 15 years ago. It was found that by specifying all test parameters measurement variations between laboratories testing the same material was reduced from 3 orders of magnitude to better than one-half order of magnitude. Since all measurement parameters were now specified it was no longer necessary to specify the measured resistance readings in Ohms/square since the electrode configuration factor was no longer required. Therefore, all ESD resistance values are now specified in Ohms. This is covered in ESDS STM 11.11, 11.12 and 11.13 for surface, volume resistance and 2-point measurements respectively.

Currently ESD materials are classified as follows:

	Conductive	Dissipative	Insulative
Surface	$<10^4$	10^4 to $<10^{11}$	$\geq 10^{11}$ Ohms
Volume		same	

Materials with bulk resistance characteristics can also be classified by specifying its volume resistivity. This is simply done by multiplying the measured resistance by the area of the measuring electrode or material surface, whichever is smaller, and divided by the thickness. All values are in cm giving a volume resistivity in Ohms-cm. To convert to Ohms-meter, multiply by 100.

Increasing or decreasing the thickness of the material will also change the actual resistance of the part with a specified volume resistivity. This is a common technique used in ESD products to achieve a particular resistance. It is the actual resistance of the part, not its resistivity that determines how a part dissipates a static charge.

While the above resistance classifications were initially developed for ESD packaging materials many specifications used for other applications that specify material resistance/resistivity refer to these resistance limits.

It should be noted that the resistance/resistivity property of material does not predict whether the material will be low charging (antistatic) or not.

4.3 Measurement Documentation

When certifying material it is best to do it under controlled environmental conditions. Since lower humidity can affect the material resistance properties all certification tests should be prepared and performed at 12% RH and 23°C as specified in ESD STM 11.11 & 11.12. ***Since current plastics industry standards specify standard conditions at 50% RH, 23°C certification should also be performed at these conditions also to allow comparison of existing data.***

For testing components and assemblies a controlled environment may not be practical. Under these conditions the humidity and temperature should be recorded at the time of testing.

The following procedure should be followed when measuring and documenting resistance measurements:

1. Sample preparation

2. Test instrumentation including setup and system verification tests.

   For loaded thermoformed material the test instrumentation, electrodes and system verification are critical in obtaining multi-lab correlation and must be specified.

3. A defined electrification period (measuring time).

   When measuring very high resistance the RC time constant of the sample and the instrumentation may require a significant amount of time for the test voltage to completely develop across the sample. The electrification time may be different for different instruments. Hence, measuring a known resistor at the upper limit will enable the user to determine the time it takes to measure the correct value.

   Some materials may exhibit a change in resistance during measurement. Taking measurements at a fixed time minimizes this problem.

4. Test procedure

   The test procedure is extremely important. How the sample is prepared, test electrodes, how the instrumentation is connected, test voltages used and how the measurement is taken all affect the ultimate accuracy of the data.

5. Documentation and reporting of data.

   Complete documentation of the measurements is essential. The level of data processing is a function of the end user requirements.

5.0 COMPUTER INTERFACE

The Model 871 has a 9-Pin sub min-D RS232A COMM PORT (Note 1) that provides real time data through serial communication. A PC will receive data by simply sending character R (for result) to the device. A simple program must be written by the user in order to collect data. The data can then be transferred to a spreadsheet or other program to obtain the desired data logging and/or analysis. To utilize this function connect a standard 9 Pin sub min-D cable to the serial port of the PC. The serial cable is the standard 3-wire null connection (2 to 2, 3 to 3 and 5 to 5).

To collect data without writing a program, standard Hyper Terminal from any windows operating system can be used. In most computers, to bring up the Hyper Terminal program click on “Start” (lower left hand corner), select Accessories then Communications then Hyper Terminal. Double click on exe. Under Name, type in “ETS871” then click OK. Under “Connect using” (on some older Terminals it is the “Phone number”) select the correct **COMM** port, which the supplied cable is connected to. Set the following properties:

Baud rate:	**9600**
Data bit:	**8**
Stop bit:	**1**
Parity:	**None**
Flow Control:	**None**

For the computer to receive the data, depress “**R**” to send the command signal to the ETS871. The ETS 871 sends what is on the liquid crystal display. If the LCD displays **STANDBY**, **OVERSCALE** or **UNDERSCALE** (Note 2), the unit will send the same message. However, the actual result will be sent without any decimal point. For example, if the LCD displays **5.00 e+6 Ω**, the ETS 871 will send **500 e+4** to the host computer instead.

Note 1: Serial communication signals of ETS871 are inverted serial output lines. RS232A is characterized as a ±5V bipolar signal (as opposed to RS232C at ±12V). Most PC recognize serial communication level shift below 5V. However, a level shifting converter such as the MAX232 is required for a PC that can only recognize serial communication with bipolar signal beyond ±5V.

Note 2: If the “**R**” command is sent while LCD displays **foot sw. to read**, the ETS 871 will send the result after the foot switch is pressed.

6.0 MAINTENANCE

The Model 871 has no user serviceable parts except changing the batteries. The instrument must be returned to ETS for service. Contact ETS Repair/Recalibration Department at 215-887-2196 to obtain a Return Material Authorization (RMA) for all warranty, repair and calibration service.

The user can check the calibration of the Meter by measuring the resistance of precision resistors over the measurement range of the instrument.

To change batteries lift and pull out the battery drawers on the rear of the unit as shown in Figure 6.0-1. Replace batteries as a pair. Use only 9-Volt alkaline or other high capacity batteries for best performance.

Figure 6.0-1: Changing batteries

6/08

7.0 WARRANTY

Electro-Tech Systems, Inc. warrants its equipment, accessories and parts of its manufacture to be and remain free from defects in material and workmanship for a period of one (1) year from date of invoice and will, at the discretion of Seller, either replace or repair without charge, F.O.B. Glenside, similar equipment or a similar part to replace any equipment or part of its manufacture which, within the above stated time, is proved to have been defective at the time it was sold. All equipment claimed defective must be returned properly identified to the Seller (or presented to one of its agents for inspection). This warranty only applies to equipment operated in accordance with Seller's operating instructions.

Seller's warranty with respect to those parts of the equipment that are purchased from other manufacturers shall be subject only to that manufacturer's warranty.

The Seller's liability hereunder is expressly limited to repairing or replacing any parts of the equipment manufactured by the manufacturer and found to have been defective. The Seller shall not be liable for damage resulting or claimed to result from any cause whatsoever.

This warranty becomes null and void should the equipment, or any part thereof, be abused or modified by the customer of if used in any application other than that for which it was intended. This warranty to replace or repair is the only warranty, either expressed or implied or provided by law, and is in lieu of all other warranties and the Seller denies any other promise, guarantee, or warranty with respect to the equipment or accessories and, in particular, as to its or their suitability for the purposes of the buyer or its or their performance, either quantitatively or qualitatively or as to the products which it may produce and the buyer is expected to expressly waive rights to any warranty other than that stated herein.

ETS must be notified before any equipment is returned for repair. ETS will issue an RMA (Return Material Authorization) number for return of equipment.

Equipment should be shipped prepaid and insured in the original packaging. If the original packaging is not available, the equipment must be packed in a sufficiently large box (or boxes if applicable) of double wall construction with substantial packing around all sides. The RMA number, description of the problem along with the contact name and telephone number must be included in formal paperwork and enclosed with the instrument. Round trip freight and related charges are the owner’s responsibility.