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## ***Major MEGGER®* Insulation Testers**

**MJ159 (212159), MJ160 (212160), MJ359 (212359), MJ459 (212459), MJ559 (212559)**

### **User Guide**



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## Safety Warnings

- **Safety Warnings** and **Testing Precautions** must be read and understood before the instrument is used. They must be observed during use.
- The circuit under test **must** be switched off, de-energised and isolated before any test connections are made.
- Test leads, probes and crocodile clips **must** be in good order, clean and with no broken or cracked insulation.
- Circuit connections **must not** be touched during a test.
- Circuits must be discharged **before** disconnecting the test leads.
- Replacement fuses **must** be of the correct type and rating.
- When making a voltage measurement, the '**Test**' button **must not** be pressed.
- The instrument should **not** be used if any part of it is damaged.
- U.K. Safety Authorities recommend the use of fused test leads when measuring voltage on high energy systems.
- Refer to '**Testing Precautions**' for further explanations and precautions.

### NOTE

THE INSTRUMENTS MUST ONLY BE USED BY SUITABLY TRAINED AND COMPETENT PERSONS.

## General Description

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Major Megger **MJ159**, **MJ160**, **MJ359**, **MJ459**, and **MJ559** testers are compact instruments designed to give rapid, accurate and direct measurement of continuity and insulation resistance of domestic and industrial wiring, cables, transformers, motors, generators electrical machinery and appliances.

Being self-powered, the instruments are suitable for use during installation and commissioning work as well as for service and maintenance applications.

Insulation measuring range is 0,1  $\Omega$  to 2000 M $\Omega$  (**MJ160** 0,1  $\Omega$  to 1000 M $\Omega$ ). Automatic discharge for capacitive circuits under test is provided.

A guard terminal can be used to minimise the effects of surface leakage when carrying out insulation resistance tests.

In addition each instrument has a 5000 $\Omega$  Resistance range making them ideal for testing electrical installations.

Nominal test voltages are 100 V, 250 V, 500 V and 1000 volts selectable. (**MJ160**: 50 V, 100 V, 250 V and 500 volts).

All instruments have a mains (line) voltage measuring range of 0 to 600 V. Although calibrated for a.c voltage, this feature will give decaying voltage indication following the testing of equipment possessing capacitance.

The instruments use a moving coil meter with taut band suspension; white scales on a black scale plate and an orange 'dayglow' needle indicates the resistance value being measured.

**MJ159** and **MJ160** are powered by a low voltage, hand cranked, brushless a.c generator which is connected, after

rectification, to a d.c. to d.c. converter. The generator is designed to be easy to turn even under full load.

Dual powered units are mains (line) powered with either an internal hand cranked generator, or battery cells that are rechargeable by the instrument's internal charger.

The **MJ359** is dual mains (line) or hand cranked generator powered.

The **MJ559** is dual mains (line) or rechargeable battery powered.

Power for the **MJ459** is derived from six 1,5 V (IEC LR6) cells. The cells are connected to a d.c. to d.c. converter to provide the test voltages.

**MJ459** and **MJ559** are fitted with a button switch to enable the battery charge to be checked.

The case is robust, yet light-weight, made from a strong polycarbonate plastic. Mounted on top of the case is a 5 position, rotary, range selection switch and a 'Test' push button.

Three shrouded 4 mm terminal sockets marked '-', 'G' and '+' are provided on the side of the case for test lead connection. Test lead resistance is included in the instrument calibration. For this reason, only the test leads supplied or replacement ones should be used.

After the test leads have been connected to the instrument terminals, the carrying handle folds down neatly over them. Should the carrying handle accidentally become detached from the case it may easily be 'sprung' back into position.

# Operation

## TESTING PRECAUTIONS



The circuit under test **must** be completely de-energized and isolated **before** test connections are made.

1. The instruments must only be used by suitably trained and competent persons.
2. The instruments can give an electric shock. Highly capacitive circuits (e.g. long lengths of cable) charged to several kV can create a potentially lethal charge. Circuit connections must **not** be touched when testing.
3. Care must be taken to prevent capacitive circuits becoming disconnected during a test, leaving the circuit in a charged state.
4. The voltmeter and automatic discharge feature of the instruments should be regarded as additional safety features and not a substitute for normal safe working practice.
5. Fuse replacements **must** be of the correct type and rating. See '**Specification**'.
6. If any part of the instrument is damaged, it should not be used, but returned to the manufacturer or an approved organization for repair.
7. Should the plug on the power cord (**MJ359** and **MJ559**) not be the type for your receptacles (socket outlets) do not use an adaptor. Use a suitable alternative power cord, or if necessary change the plug by cutting the cord and fitting a suitable plug.


The colour code of the cord is :

	<u><b>U.S.A.</b></u>	<u><b>U.K./ International</b></u>
Ground)	Green	Yellow/Green
Neutral	White	Blue
Line	Black	Brown

If using a fused plug, a 13 Amp fuse to BS1362 should be fitted.

## PRELIMINARY CHECKS

### Battery Condition Check (**MJ459** & **MJ559**)

Before initial use of **MJ559**, charge the battery. To carry out a battery condition check, press the black battery condition button (marked ) and confirm that the needle settles within the portion of the scale marked with the battery symbol. If the needle settles at less than half scale, the cells must be replaced (**MJ459**), or re-charged (**MJ559**) before proceeding with any checks or testing.

### Battery Replacement (**MJ459 only**)

The cells are housed in a battery compartment in the base of the instrument. To change the cells, use a screwdriver to remove the battery cover securing screw and lift off the battery compartment cover. Install 6 IEC LR6 cells ensuring that the polarity is as marked on the base of the battery compartment. Replace and secure the battery compartment cover.

### Battery Charging (**MJ559**)

Using the power cord supplied, connect the tester to a standard a.c. power supply (120 V 50/60 Hz). The red **CHARGE** indicator will light to indicate that charging is in progress. A full charge takes approximately 16 hours. The **MJ559** may be used for testing at the same time as the battery is being charged.

# Operation

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## Performance Checks

The instrument will operate in any position, but the specified accuracies assume that the instrument is face up, on a firm level surface. This is particularly true for hand cranked units to obtain a smooth constant crank speed.

1) Without the test leads being connected to the instrument, but with the rotary selector switch set to the 1 kV range (**MJ160** to 500 V range) press and hold down the '**Test**' button, whilst turning the generator handle, (**MJ159**, **MJ160** and **MJ359**) at >180 rev/min. The meter pointer should remain over the ' $\infty$ ' (infinity) position on the scale. This establishes that there is no leakage through the instrument itself.

2) Check that the test leads, probes and crocodile clips are in good order, clean and with no broken or cracked insulation. Connect two of the test leads to the '+' and '-' terminals on the side of the instrument case and ensure that their clips are not touching anything.

3) Press the '**Test**' button again and keep it pressed whilst turning the generator handle (Hand cranked models) at >180 rev/min and observe the meter needle. The needle should rest over the ' $\infty$ ' (infinity) position on the scale. If it does not, the test leads may be faulty and should be inspected more closely for damage. Replace them if necessary with **calibrated leads** available as optional accessories

4) Connect the test lead clips together, press the '**Test**' button and turn the generator handle (hand cranked models) again. The meter should read zero. If it indicates infinity or a high resistance value the leads may be open circuit and should be inspected further. Replace them if necessary. (Shorting the leads together and obtaining a zero reading also

shows that the instrument is working).

**Note:**—To avoid creating leakage paths when insulation testing, it is advisable not to allow the leads to twist together nor trail across metalwork etc. more than is really necessary.

## Voltage measurement

When not testing (i.e. in standby mode) the instruments act as a voltmeter (0 to 600 Volts a.c.) Therefore, as soon as the test leads are connected to the item under test, any a.c. voltage present will be immediately shown. Thus indication is given that the item has not been completely de-energized. The instrument also monitors circuit discharge when the '**Test**' button is released following an insulation test on a capacitive item, e.g. a long cable. In this case it is important to realize that the actual voltage (d.c. in nature) is not given, but the meter does indicate when the voltage has decayed to zero and therefore when it is safe to remove the test leads. Note, however, that the instrument does not indicate the presence of negative d.c. voltage.

## Resistance Measurement

With the leads connected to the instrument, and having completed the Preliminary Checks:

- 1) Set the selector switch to the ' $\Omega$ ' position.
- 2) Connect the leads across the isolated circuit.
- 3) Press and hold the '**Test**' button and turn the generator handle (hand cranked models) at >180 rev/min.
- 4) The resistance will be indicated on the ' $\Omega$ ' scale.

**Note:-** If necessary repeat the continuity test with the leads reversed. The effects of any stray e.m.f.s. in the sample under test may then be negated by taking the average of the two readings.

### Insulation Testing

After connecting the test leads to the instrument and carrying out the Preliminary Checks:

- 1) Set the selector switch to the required test voltage. Connect the test leads to the isolated circuit to be tested, as follows:-
  - (a) For insulation tests to earth (ground):- Connect the '+' test lead to earth (ground) or the frame of the equipment, and the '-' lead to that part of the circuit to be tested.
  - b) For insulation tests between wires:- Connect a lead to the core of each of the wires.
- 2) Press the **'Test'** button and whilst keeping it pressed turn the generator handle (hand cranked models) at >180 rev/min.
- 3) The meter needle will indicate the value of insulation resistance on the '**MΩ**' scale.

If a capacitive circuit is tested the needle will initially deflect towards zero and then gradually rise to its final steady value as the capacitance is charged up to the output voltage of the tester.

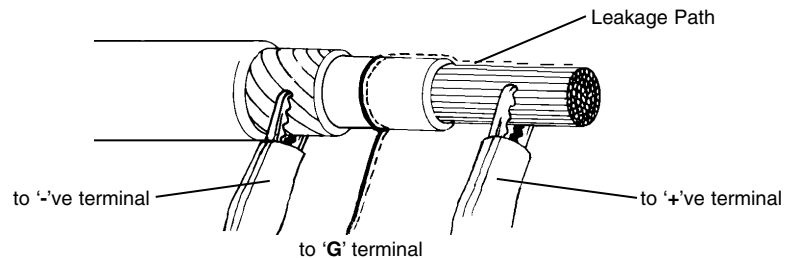
If several successive readings of ' $\infty$ ' are obtained, connect the two farthest ends of the test leads together and carry out a check on the leads. A **zero** reading should result which double checks that the leads are not disconnected or broken and therefore, the insulation resistance readings are correct.

**Note:**—With non-hand cranked models, the readings are taken after pressing the **'Test'** button, there is no other control to operate.

Capacitive circuits automatically discharge through the tester when the **'Test'** button is released. The approximate discharge voltage will be indicated on the voltage scale. Wait a few moments for the voltage to decay to zero before disconnecting the test leads.

### Using the Guard terminal (G)

For basic insulation tests and where there is little possibility of surface leakage affecting the measurement, it is unnecessary to use the guard terminal. i.e. if the insulator is clean and there are unlikely to be any adverse current paths. However in cable testing, there may be surface leakage paths across the insulation between the bare cable and the external sheathing due to the presence of moisture or dirt. Where it is required to remove the effect of this leakage, particularly at high testing voltages, a bare wire may be bound tightly around the insulation and connected via the third test lead to the guard terminal '**G**'.



The guard terminal is at the same potential as the negative terminal. Since the leakage resistance is effectively in parallel with the resistance to be measured, the use of the guard causes the current flowing through surface leakage to be diverted from the measuring circuit. The instrument therefore reads the leakage of the insulator, ignoring leakage across its surface.

# Operation

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## Fuse checking and Replacement

### Resistance Circuit Fuse Check

- 1) Disconnect the test leads and set the rotary selector switch to the ' $\Omega$ ' position.
- 2) Press the '**Test**' button and keep it pressed whilst turning the generator handle (hand cranked models).
- 3) The reading obtained should be beyond full scale.

If the reading is approximately **zero** on the Resistance scale, the 500 mA fuse has ruptured and should be replaced.

### Insulation Circuit Fuse Check

- 1) Connect the test leads together and set the rotary selector switch to a '**M $\Omega$** ' position.
- 2) Press the '**Test**' button and keep it pressed whilst turning the generator handle (hand cranked models).
- 3) The reading obtained should be **zero** on the insulation scale.

If the reading is ' $\infty$ ' the 7 Amp fuse has ruptured and should be replaced.

### Fuse replacement

The fuses are held in a screw type holders situated in the base of the instrument. **Replace with fuses of the correct size and rating** (see Specification on page 10). To change a fuse, use a screwdriver to release the centre part of the holder containing the fuse

## Specification

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### INSULATION RANGE

Insulation Resistance: 0,1 $\Omega$  - 2000 M $\Omega$  (0,1 $\Omega$  -1000M $\Omega$  for **MJ160**)

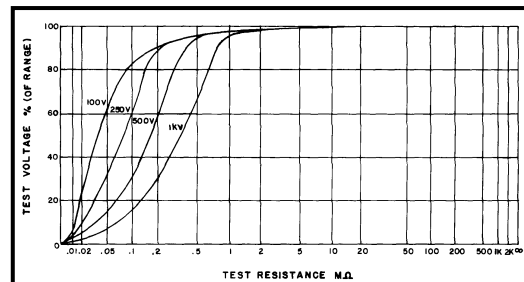
Nominal Test Voltages d.c: 100 V, 250 V, 500 V, 1000 V.  
( **MJ160** only is 50 V, 100 V, 250 V, 500 V)

Accuracy: 250 V, 500 V, 1000 V +30%, -0% maximum  
50 V, 100 V, +40%, -0% maximum

Midscale: 4 M $\Omega$  (2 M $\Omega$  for **MJ160**)

Short Circuit Current: 1,9 mA (0,65 mA for **MJ160**)

Test Voltage characteristics:



Accuracy:  $\pm 1,25\%$  of fsd on a 2,8 in. (71,1mm) arc length: [0,035 in. (0,9mm)]

### RESISTANCE RANGE

0,1 $\Omega$  - 5000 $\Omega$

Open circuit Test voltage: 3 V  $\pm 0,2$  V

Short Circuit Current: 2 mA  $\pm 10\%$

Accuracy:  $\pm 1,25\%$  of fsd on a 2,8 in. (71,1mm) arc length: [0,035 in. (0,09mm)]

## Specification

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<b>Maximum Load Capacitance:</b>	1 $\mu$ F with less than $\pm 0,1$ " pointer movement
<b>Discharge:</b>	Up to 1 $\mu$ F capacitance is discharged from 1000V to less than 42,4 V in less than 4 secs
<b>Safety Voltage Check</b>	
<b>Voltage measurement:</b>	0,1 V - 600 V a.c; the meter is RMS calibrated and average responding
<b>Safety voltage indicator:</b>	Indicates the presence of d.c. voltages. Scaling is not the same as the a.c. meter. True d.c. voltage equals scale reading divided by 2,22
<b>Accuracy:</b>	2,5% of full scale
<b>Power Supplies</b>	
<b><i>MJ159</i> and <i>MJ160</i>:</b>	Low voltage brushless a.c. generator. Cranking speed between 130 rpm and 170 rpm
<b><i>MJ359</i>:</b>	Dual operation low voltage brushless a.c. generator or 120 V 50/60 Hz mains (line) supply
<b><i>MJ459</i>:</b>	Six IEC LR6 cells (AA) <b>Battery life:</b> not less than 1300 insulation or Resistance range tests
<b><i>MJ559</i>:</b>	Dual operation 120 V 50/60 Hz mains (line) supply and rechargeable battery Six Ni Cad cells (e.g. AA, NEDA 15 NC)
<b>Safety:</b>	The instruments meet the requirements for double insulation to IEC 1010-1(1995), EN 61010 (1995) to installation Category II, 300 V phase to earth (ground), 600 V installation Category I
<b>Flash Test:</b>	6 kV a.c. r.m.s.

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<b>Fuses:</b>	500 mA (FF) 660 V Ceramic 50 kA HBC 1¼ ins x ¼ ins (32 mm x 6 mm) 7A (F) 440 V Ceramic 10kA HBC 1¼ ins x ¼ ins (32 mm x 6 mm) 100 mA (F) HBC 20 mm x 5 mm (for line protection only)
<b><i>MJ359</i> and <i>MJ559</i> only:</b>	Power connection plug fuse - 100 mA 240 V HBC <sup>25</sup> / <sub>32</sub> ins x ¼ ins (20 mm x 6 mm) Mains power cord fused plug (when applicable) 3 A 250 V ceramic H.B.C. fuse to BS1362 1¼ ins x ¼ ins (32 mm x 6 mm)
<b>E.M.C.</b>	The instruments meet EN 50081-1 and EN 50082-1 (1992)
<b>Operating Temp. Range:</b>	32° to 113°F (0° to 45°C) for battery operated models 14° to 122°F (-10° to 50°C)
<b>Humidity Range</b>	
<b>Operating:</b>	70% RH max. at 68°F, (20°C) 60% RH max. at 95°F, (35°C) 50% RH max. at 105°F (40°C)
<b>Storage:</b>	95% R.H. max. at 95°F (35°C)
<b>Dimensions</b>	
<b>Length:</b>	180 mm (7 ins) (210 mm [8,3 ins] including generator handle)
<b>Width:</b>	125 mm (4,9 ins)
<b>Height:</b>	130 mm (5,1 ins)
<b>Weight:</b>	Approximately 1 kg (2,3lb)
<b>Cleaning:</b>	Wipe disconnected instrument with a clean cloth dampened with soapy water or Isopropyl Alcohol (IPA).

## Accessories

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### SUPPLIED WITH THE INSTRUMENT

User Guide

6172-113

Test lead set (3 leads, 3 prods, 3 clips)

6220-436

Power cord (Where applicable)

25970-002

(U.S.17032)

Test Record Card (5 supplied)

6172-111

(U.S. 210949)

### AVAILABLE AS AN OPTIONAL EXTRA

Carrying case

6420-043

(U.S.217740)

Test Record Card (Pack of 20)

6111-216

Black test lead with large alligator clip

6220-295

Red test lead with large alligator clip

6220-586

Green test lead with large alligator clip

6220-587

Set of test leads with fused prods (**FPK5**) - 1000 V a.c. 500 mA fuse

6111-288

Test lead set, 3,6m [12 ft] (1 pair)

210972

Electrodes (for floor testing), 2,25 kg [5lb] each (1 pair)

260565

### PUBLICATIONS

'A Stitch In Time'

AVTM21-P8B

## Preventive Maintenance

Regular insulation testing of electrical equipment can help to detect deteriorating insulation. The effects which cause insulation to deteriorate include mechanical damage, vibration, excessive heat or cold, dirt, oil, moisture and localized voltage stresses - all of which can arise on most industrial or utility equipment.

It is therefore important that records of insulation readings are kept, relating to each piece of equipment or 'Asset' in your testing regime. **AVO INTERNATIONAL** supplies test record cards to assist with such record keeping. There are also a number of influences on the insulation readings - temperature, humidity and surface leakage for example and a range of test techniques have been developed to help with the interpretation of your insulation tests.

### Test Record Example

## Application Notes

### Insulation Testing Concepts

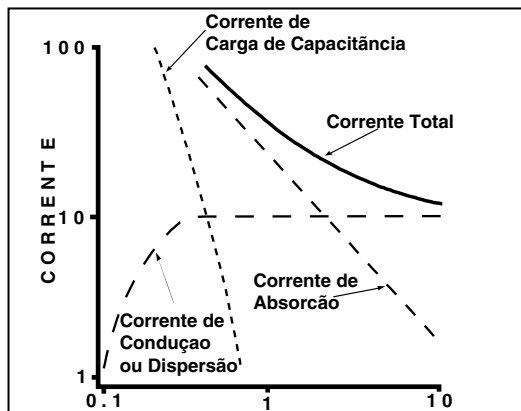
Insulation resistance can be considered by applying Ohm's Law. The measured resistance is determined from the applied voltage divided by the resultant current,

$$R = \frac{V}{I}$$

There are two further important factors to be considered. These are:

- (i) the nature of the current through and/or over the insulation
- (ii) the length of time for which the test voltage is applied. These two factors are linked.

The total current that flows is made up of three separate currents:-



1. Capacitance charging current. This current is initially high and drops as the insulation becomes charged up to the applied voltage.

2. Absorption current. This current is also initially high but drops at a much slower rate than the charging current.
3. Conduction or Leakage current. This is a small steady current that can be sub-divided into two:-

- (a) A current flowing along conduction paths through the insulation material.
- (b) A current flowing along conduction paths over the surface of the insulation material

As the total current depends upon the time for which the voltage is applied, Ohm's Law theoretically applies at infinite time.

The charging current falls relatively rapidly as the equipment under test becomes charged up. The actual length of time depends upon the size and capacitance of the item under test.

Larger items with more capacitance will take longer e.g. long supply cables. The absorption current decreases relatively slowly compared with the charging current. In essence it depends upon the nature of the insulation material.

The conduction or Leakage current builds up quickly to a steady value and then remains constant for a particular applied voltage under stable conditions. It is this current that is affected by moisture, dirt etc. and the degree to which it flows bears a direct relation to the quality of the insulation, and consequently to the value of the insulation resistance measured. An increase in the leakage current is a pointer to possible future problems.