Phenix Technologies, Inc.
75 Speicher Drive
Accident, Maryland 21520

PM-20

High Voltage Insulation Tester

User Guide

GU-1505RA

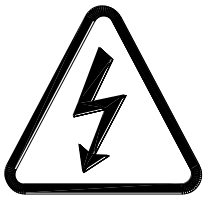
DANGER / WARNINGS

Complete Grounding of this unit is necessary for the safe operation of this equipment. Disconnect inputs before un-grounding this equipment

DANGER / WARNINGS

GENERAL SAFETY PRECAUTIONS

CAUTION



HIGH VOLTAGE

This equipment is capable of providing POTENTIALLY LETHAL VOLTAGES! Improper operation or test practices may result in injury or death to the operator or surrounding personnel.

The operation of High Voltage test equipment should only be performed by personnel familiar with HIGH VOLTAGE testing and safety procedures. The operator of this equipment must be aware of all hazards associated with High Voltage testing. The operator is responsible for himself and others in close proximity of the testing area.

Some General Safety Practices for working with High Voltage Test Equipment have been listed below for your reference.

- **Become familiar with your instrument before performing an actual test**
- **Know your work area, check that all circuits are de-energized and locked out.**
- **Never work alone; always work with another qualified worker.**
- **Mark off entire work area with barriers and warning tape.**
- **Make all personnel aware of your testing activities.**
- **Be aware of dangerous conditions that may arise from energizing a test specimen.**
- **Never modify test equipment; modifications to equipment could introduce an unknown hazard or hinder a designed-in safety feature.**
- **DO NOT operate damaged equipment. Remove power, and do not use the equipment until safe operation can be verified by service-trained personnel.**

Phenix Technologies, Inc. assumes no liability for unsafe or improper use of test equipment.

PM-20 Safety Warnings

- Before using this instrument, this manual and Safety Warnings must be read and understood.
- Observe Safety procedures and rules for working near high voltage energized systems during the use of this equipment. The generated voltages may be dangerous.
- Do not connect or disconnect the test leads during the measurement.
- Do not touch the acrylic cover of the galvanometer with the energized terminals. This could cause a static charge that will affect all the measurements.
- Be careful not to make a short-circuit between the high voltage terminals and the “-R” or “Guard” terminals while a measurement is running. It may be dangerous for the operator and the output fuse may blow-up.
- Be sure that there is not any voltage difference between the points to which the insulation tester will be connected to, or between them and ground.
- The panel, terminals, and connectors of the equipment must stay dry and clean.

This equipment should be used only by a trained and competent person, strictly applying suitable safety rules.

Symbols Used

	Caution, risk of electric shock.
	Caution, refer to User Guide.
	Equipment complies with current EU Directives.
	The rubbish bin with a line through it means that in the European Union, the product must undergo selective disposal for the recycling of electric and electronic material, in compliance with Directive WEEE 2002/96/EC.

TABLE OF CONTENTS

1. Description

The PM-20 high-voltage insulation tester is a truly portable device that allows measurements of insulation resistances using test voltages up to 20kV. It employs state-of-the-art technology for safe measurements of insulation resistances up to 4,000,000 MΩ with 4 test voltages: 5kV - 10 kV - 15 kV - 20 kV.

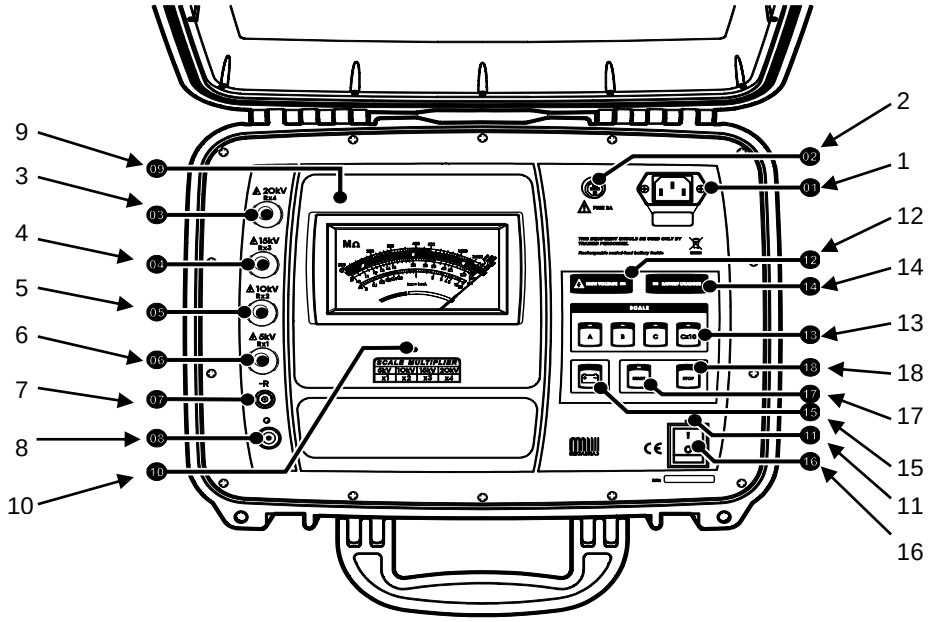
Readings are performed through an easy-to-read analogue indicator, having a broad scale. This equipment is especially well suited to test insulation resistances in transmission lines and medium voltage distribution systems, whether aerial or underground, as it performs testing with voltages near to the operational value. It is an excellent auxiliary when detecting cable failures.

In order to maximize the operator's safety, this equipment was made within a plastic cabinet of high dielectric strength. A light indicator warns about dangerous voltages present, both in the equipment and in the element under testing, and switches off only when the discharge process has finished.

This equipment has a GUARD terminal that allows avoidance of the effects of parasitic resistances and surface currents on the insulation resistances under test. Due to its compact size and reduced weight, mechanical strength, and self-contained battery supply, this apparatus is particularly suitable for field tests under severe environments. It is easily carried, very simple to operate, and stands severe handling conditions. Those harsh conditions include frequent shocks, extreme temperatures, vibrations during transportation on rough roads, long direct exposure to solar radiation, dust, sand and other air-borne impurities, etc. Accuracy is not affected by all these adverse conditions, and it is still comparable with that of the best laboratory instruments.

2. Measurements

2.1 Control Panel



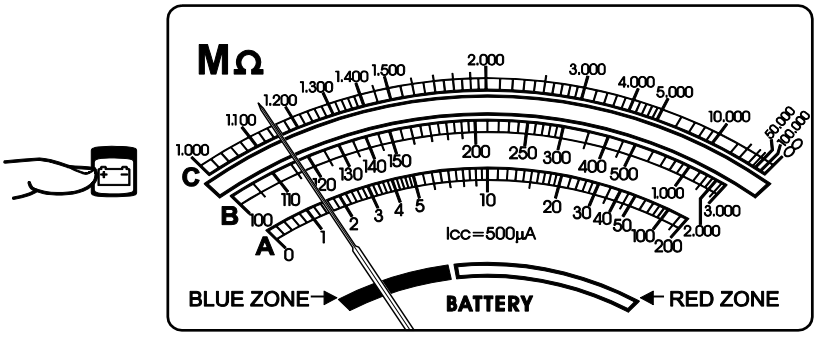
1. **POWER INPUT**.
2. **FUSE**.
3. **20 kV TEST VOLTAGE**.
4. **15 kV TEST VOLTAGE**.
5. **10 kV TEST VOLTAGE**.
6. **5 kV TEST VOLTAGE**.
7. **CURRENT RETURN** terminal (-R).
8. **GUARD** terminal (G).
9. **ANALOG** indicator.
10. **MECHANICAL ADJUST** (INFINITE).
11. **ON** indicator.
12. **HIGH VOLTAGE** indicator.
13. Key board **RANGE** (A, B, C & Cx10).
14. **BATTERY CHARGER** indicator.
15. **BATTERY CHECK** key.
16. **ON/OFF** switch.
17. **START** key.
18. **STOP** key.

3. Power Supply

Internal rechargeable 12V - 7Ah battery.

1.1. Checking battery status

Battery measurement can be performed without interrupting high-voltage generation, which provides a better evaluation of the battery status, by pressing the **BATTERY CHECK** during the measurement. The battery test is performed under actual consumption conditions and, for long lasting measurements, (i.e. *Polarization Index*), the battery status can be checked without affecting the measurement. The meter pointer should stop over the blue zone. If the pointer stops over the red zone, the battery is discharged and must be charged.



1.2. Battery charger

This equipment has an intelligent built-in circuit that controls the battery charge and doesn't allow the equipment to operate during the charging process. To charge the battery, follow this procedure:

- Verify that the **On/Off** switch is in OFF.
  Connect the equipment to 220 – 240 V~ mains supply with power cord at the **power input** of the equipment.
- After a while, the **battery charger** indicator will blink alternatively in green and red during one second, while the charger verifies the initial condition of the battery to select the optimized parameters of the charge.

The following chart summarizes the meaning of battery charger LED:

Green and red flashing alternatively	Test of the initial condition of the battery when plugging the mains, during one second.
Permanent red	Battery under charge.
Flashing red	Charging current is less than normal.
Permanent green	The charging process has been successfully finished. Battery OK.
Flashing green	The charging process has finished, nevertheless the battery hasn't received the complete charge.

At the end of battery useful life, the battery must be recycled or disposed of properly, in order to protect the environment.

The rechargeable battery has no "memory effect" and there are no restrictions to start charging it as many times as is needed. However, the battery could be damaged if it remains in deep discharge for long periods.

To avoid this effect, charge the battery before storing the equipment, and recharge within 30 days, even if the instrument was not used (under storage, the battery loses part of its charge).

4. High Voltage Indicator

The **High Voltage** indicator warns the presence of high voltage at the output terminal during a measurement and remains lit until the discharge process is completed. When you press the **STOP** key, the equipment will start discharging the potentials accumulated in the unit, internal capacitances, and in the element under test as well. When this discharging process is over, the **high voltage** led will turn off automatically. The test leads may then be disconnected.

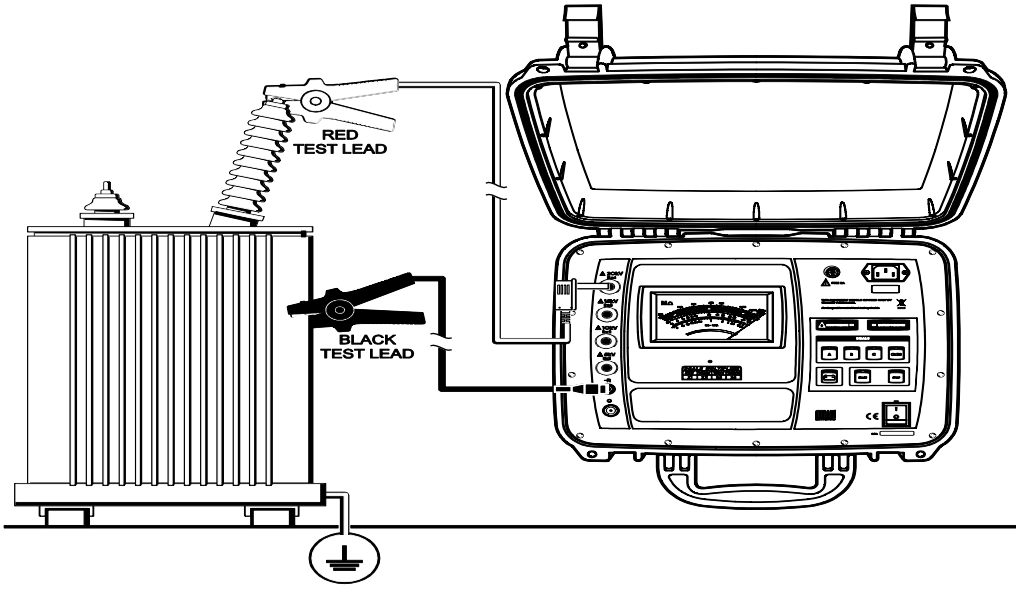
5. Operating Instructions

ATTENTION: For safe operation, the procedures detailed below should be carried out with the device Powered-**Off.**

Check if there is no differences of potential voltage between the points where the equipment will be connected to, nor between them and the ground.

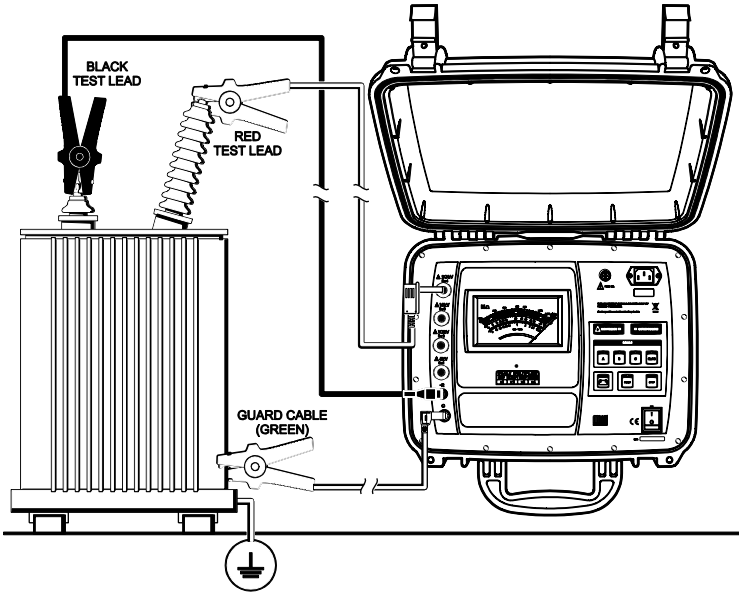
1. Connect the red test lead to the 20 kV, 15 kV, 10 kV or 5 kV terminal in accordance with the desired test voltage.

2. Connect the black test lead to the -R terminal.



(The test leads in the drawings are only for illustration.)

3. The green **GUARD (G)** terminal is not always used.



Operating Instructions (Cont'd)

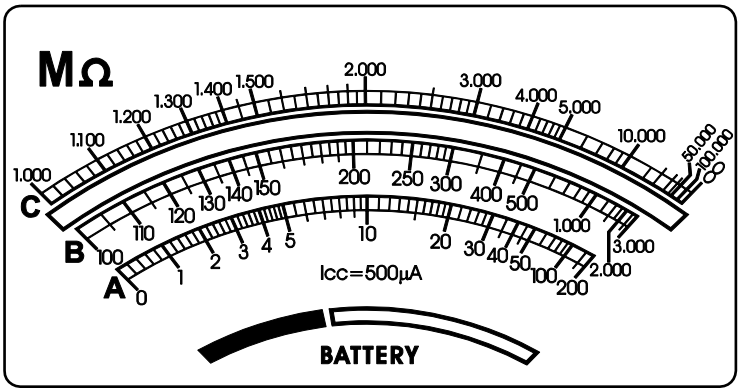
Technical Note 32 explains the use of **GUARD (G)** terminal in order to minimize the effect of stray resistances. When measurement is carried out between parts where none of them is grounded, (like between high-side and low-side windings of a transformer), **GUARD** terminal must be connected to ground in order to fix the apparatus potential. **At any time a measurement is performed, either the -R or GUARD terminals must be connected to ground but never both simultaneously.** If none of these terminals are connected to ground, the insulation tester can reach a high potential that may result in an unstable, non-reliable reading. **If both terminals are simultaneously connected to ground**, there is a short-circuit between them, and consequently the insulation tester **will measure with error**.

NOTE: The insulation tester is unable to generate test voltage while it is connected to mains. The power cable has to be unplugged from mains prior to pressing the **Start** button.

4. Turn On the apparatus by pressing the **ON / OFF** key. The **ON led** begins to brighten.

5. Press the **Start** key. The high-voltage generator starts operating and the corresponding indicator light turns on at the front panel. The meter pointer will indicate the value of the unknown resistance. If the element to be measured is strongly capacitive, it will initially indicate a low resistance value that will be gradually increased while the charging of that capacitance takes place. The instrument will always begin in the scale **A**.

6. When the measured resistance exceeds the maximum value in range **A**, press range **B** key, and if the value is not achieved, press keys of ranges **C** or **C x 10**, as required.



7. Always remember to multiply the reading by the factor stated in the following table, depending on selected test voltage.

SCALE MULTIPLIER			
5kV	10kV	15kV	20kV
x1	x2	x3	x4

8. When key **C x 10** is used, reading will be carried out in range **C** and will be multiplied by 10, in addition to the factor corresponding to the test voltage.

9. When you press the **Stop** key, the insulation tester will start discharging the potentials accumulated in the unit's internal capacitances and in those of the element under test as well. When this discharging process is over (up to 60 seconds after turn off), the **High voltage** will turn off automatically. The test leads may be disconnected. To finish measurement press **On/Off** switch.

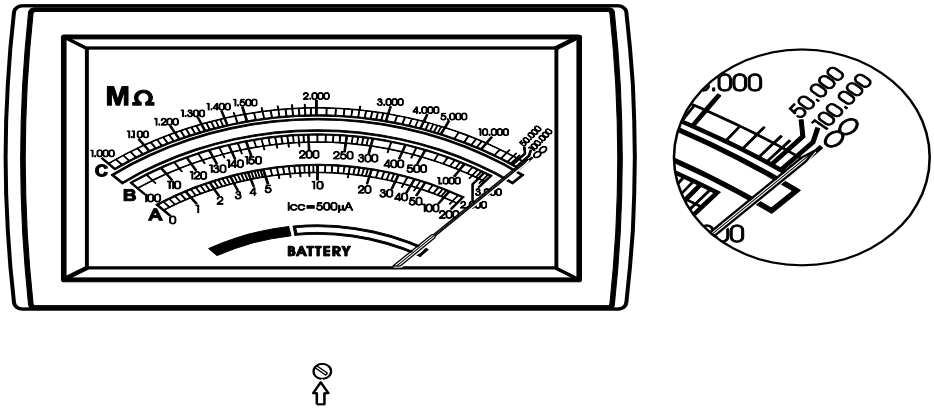
6. Polarization Index (PI)

For this type of test, the instrument must be connected and applying high voltage to the sample for 10 minutes. The polarization index is the ratio between the insulation resistance value measured after 10 minutes and the value measured after 1 minute.

$$PI = \frac{R_{10\ min}}{R_{1\ min}}$$

7. Infinite Setting

The mechanical zero of galvanometer must be periodically checked. To perform this check, be sure that the insulation tester is powered-off. The pointer should stay on the right end of the scale just over the infinite mark on scale **C**. In other cases, the plastic screw at the bottom of the galvanometer acrylic cover shall be adjusted.



8. Replacement Fuse

To check the instrument **Fuse**, remove it with a screw driver. If the fuse is ruptured, replace it by another with the following specifications:

Fuse Schurter, model SPT 5x20 (Time-lag) 2A/250V. High breaking capacity.

9. Cleaning

To clean this instrument, use a soft cleaning anti-static liquid, after verifying that it doesn't affect the plastic parts used in the case and in the Control Panel of this equipment.

10. Technical Specifications

:

Test voltages 5 kV – 10 kV – 15 kV – 20 kV

Insulation test up to : 4,000,000 MΩ

Test volt-age	MEASURING INTERVALS (MΩ)				Scale multi-plier	Output resist.
	A	B	C	C x 10		
5 kV	0 - 200	100 - 3.000	1.000 - 100.000	10.000 - 1.000.000	x1	10 MΩ
10 kV	0 - 400	200 - 6.000	2.000 - 200.000	20.000 - 2.000.000	x2	20 MΩ
15 kV	0 - 600	300 - 9.000	3.000 - 300.000	30.000 - 3.000.000	x3	30 MΩ
20 kV	0 - 800	400 - 12.000	4.000 - 400.000	40.000 - 4.000.000	x4	40 MΩ

Short-circuit current : 500 µA

Test voltages accuracy : ± 2% of nominal test voltages @ R ≥ 10 GΩ

Insulation tester accuracy :
Class 2 (±2% of full scale deflection)

Analog indicator : Up to 98 mm scale length, taut band, with mirror (thus avoiding parallax errors)

Safety specifications : Electrical safety according to IEC 61010.

E.M.C. : In accordance with IEC 61326-1

Electrostatic immunity : In accordance with IEC 61000-4-2

Measurement category : CAT III – 600 V.

Power supply : Internal rechargeable 12 V – 7 Ah battery

Battery charger : 220 – 240 V~ mains supply.

Environmental protection :
IP54 (with closed lid)

Operating temperature range :
-5 C to +50 C

Storage temperature range :
-25 C to +65 C

Humidity range : 95% RH (non condensing)

Weight : Approx. 9.8 kg

Dimensions : 378 x 308 x 175 mm

Supplied accessories : 2 measuring test leads (1.80 m).
GUARD test lead (1.80 m).
Charger power cord.
Carrying case
User's guide.

Application Note 32

Use of "Guard" terminal in insulation testers

When insulation resistance measurements are performed with insulation tester, especially with high sensitivity instruments measuring high resistance values, the use of the *GUARD* terminal avoids the harmful influence of stray resistances.

In order to better explain the function of this terminal, let us review the insulation tester basic circuit diagram of fig. 1.

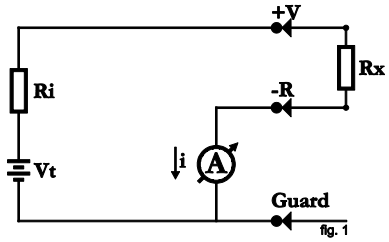


fig. 1

Where:

Vt : DC high-voltage generator
Ri : Generator internal resistance
A : Indicator meter (micro-ammeter)

The unknown resistance (*Rx*) is connected between *+V* and *-R* terminals. Its value determines the current passing through the circuit, which in turn is indicated by the micro-ammeter. The value of *Rx* can be determined as follows:

$$Rx = \frac{V}{i} - Ri$$

In many cases the resistance to be measured is in parallel with other stray resistances which influence on Rx should be minimized.

A typical example of this situation occurs when the insulation resistance between primary and secondary windings of a transformer mounted inside a metal housing is to be measured.

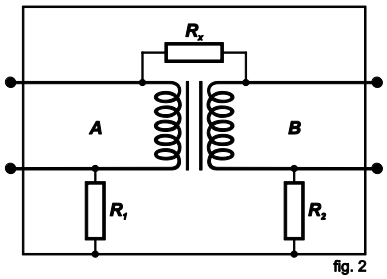


fig. 2

Rx: Insulation resistance between primary and secondary winding.
R1: Insulation resistance between primary winding and housing.
R2: Insulation resistance between secondary winding and housing.

If insulation tester (terminals *V* and *R*) is connected to transformer terminals A and B, and considering that the resistance of the coils on each side of the transformer may be disregarded, Rx appears to be in parallel with (R1 + R2). The situation is changed if we connect the transformer housing to GUARD terminal. Then the circuit will be:

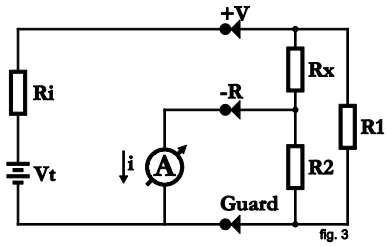


fig. 3

In the circuit of Fig. 3 it may be noted that R1 is in parallel with a low-value resistance (the one from the micro-ammeter), therefore its influence is reduced during reading.

Through resistance R2 circulates a current which is not passing through the meter and consequently does not affect the reading. In fact, current through R2 originates a certain error, because it creates an additional voltage drop in R1 which was not regarded during insulation tester calibration.

As regards the practical use of insulation tester, it will be considered that if R1 and R2 are higher than 100 MΩ, any value of Rx will be measured with an error lower than 10%. For example: Let us consider Rx = 3,000 MΩ and R1 = R2 = 100 MΩ, the reading without using the GUARD terminal would be 187.5 MΩ, which is quite wrong. On the other hand, if the GUARD terminal is properly used, we would have 3,000 MΩ, with an error lower than 10%.