

CONSULTANTS MANUAL

Principles and Engineering Application

INTRODUCTION

The major causes of motor failures are:

- **insulation degradation**
- **electrical problems**
- **mechanical problems**

Excellent devices are readily available to provide warning of, or protection against, electrical problems such as overload, phase loss, etc.; and mechanical problems such as misalignment, vibration and bearing wear.

For some industries, the **major** cause of motor breakdown is insulation degradation when the motor is idle. For these industries, periodic testing with a Megger™ Tester does not provide a practical and efficient method of protection against production loss caused by motor failures. Only continuous monitoring of idle motors will do that.

Until the MotoSafe Monitor was introduced, **automatic** warning of impending insulation problems was **not available**. MotoSafe devices provide continuous monitoring of insulation resistance with automatic early warning of possible insulation failure.

The relationship between motor age, dielectric strength and insulation resistance, with the ranges covered by MotoSafe and by high voltage Megger Testers, is shown below.

In the MotoSafe monitor range, the motor has already lost its dielectric strength and its insulation resistance is low (1-10 Megohms) so it is not necessary to use a high-test voltage to obtain reliable readings. In fact, for safety a low-test voltage is desirable for continuous monitoring. The MotoSafe test voltage is 24V. D.C., current limited to 30 microamperes, to make it intrinsically safe.

DEGRADATION SPECTRUM OF MOTOR INSULATION				
← Low voltage MotoSafe Range →				
MEGGER TESTING RANGE				
DIELECTRIC STRENGTH				
NEW MOTOR	EXCELENT	GOOD	PREVENTATIVE MAINTENANCE	DANGER
> 1000 MEG.	1000 – 100 MEG.	100 – 10 MEG.	10 – 1 MEG.	1 – 0 MEG.
INSULATION RESISTANCE				
→ MOTOR AGE INCREASING ←				



PRINCIPLE OF OPERATION

When the motor is idle, the windings are connected, through precision series resistors, R_s , and an isolation relay contact, to a regulated voltage source (see Fig. 1).

The precision resistor and the motor winding insulation resistance form a voltage divider, so the voltage across the motor windings is a function of the insulation resistance. This voltage is monitored by a comparator and when it falls below the comparator reference voltage the alarm relay is activated.

ALARM SETTINGS: Many variables in the motor operating conditions affect the choice of alarm setting, so it is difficult to choose a single, universally acceptable, level for early warning. However the minimum operating level of 1 Megohm per 1kV line voltage is recommended.

Fig. 2: Shows the general consensus, based on practical experience, that if the motor is operated for a long time after the insulation level has fallen to 0.5 Megohm, the insulation level will continue to deteriorate and will be practically impossible to recover it, regardless of any preventative maintenance efforts. It also shows that an alarm level of 1 Megohm gives practically a 100% chance of recovery, using simple procedures taught to all electricians.

Fig. 3: Illustrates that, at about the 10 Megohm level, a zone of increasing risk of failure begins and the zone widens rapidly below the 1 Megohm level so that at the 0.5 Megohm level, there is a finite risk of immediate failure. Therefore, the factory set 1 Megohm. alarm level is a reasonable compromise. Higher or lower levels, to meet individual requirements, are available by special request.

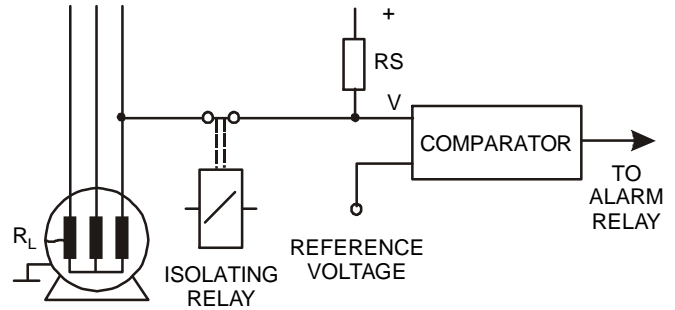


Fig. 1 Principle of Operation

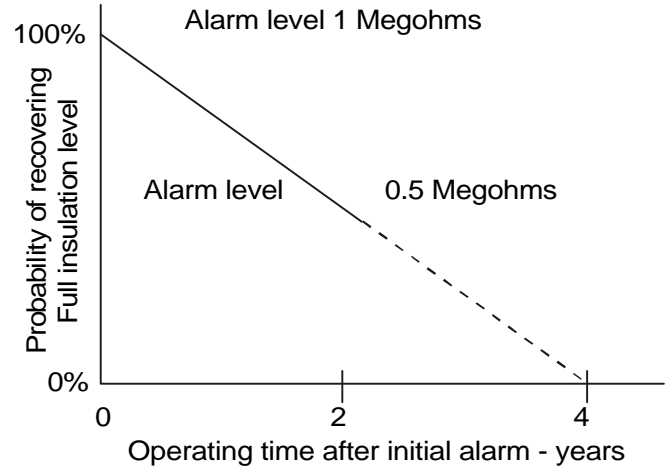


Fig. 2 Alarm Setting v. Probability of Recovery - Low Voltage Motors

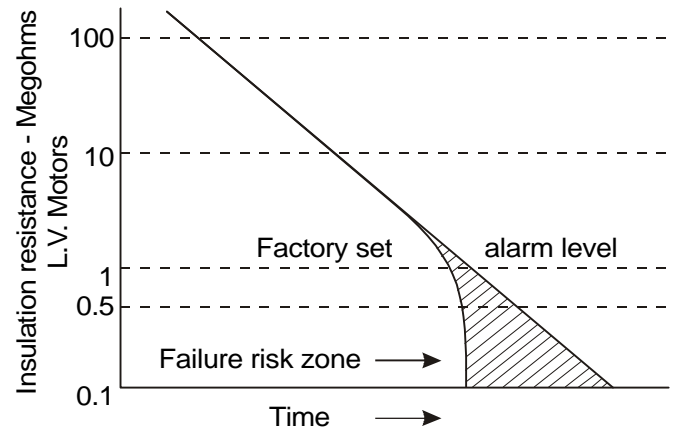


Fig. 3 Alarm Setting v. Probable Time to Failure - Low Voltage Motors

DESCRIPTION

Fig. 4: Shows the block diagram of a basic low voltage MotoSafe Insulation Monitor. Other types are available which differ in detail.

Terminal 1 and 2: Control Power input to the unit is through an internal, step-down, isolating Transformer to a rectifier circuit producing stabilized 24 volts D.C. for the sensing circuitry. The sensing circuit is state-of-the-art-design, constructed on a glass-epoxy printed circuit board meeting the highest requirements of CSA and UL.

Note: Units for DC control power are available; for D.C. voltages higher than 24V, a DC-to-DC converter available. The converter will keep the control power ungrounded.

Terminal 6 and 3: the 24 volt D.C. measuring voltage, current-limited to 30 microamperes, is injected into the motor windings via terminal 6 (Sense) and 3 (Ground) through a measuring resistance. The measuring circuit measures the voltage across the resistor to monitor the insulation resistance when the motor is not energized.

Note: This particular type of monitor does not have separate isolation terminals and has solid state isolation circuitry that senses the line voltage. Some units have a separate input for the isolation circuit. Then the **Isolation Terminals** are connected to sense if the motor is energized. If it is, the isolation circuit triggers the internal isolating relay, isolating the monitor from the motor windings. The isolating circuit is designed to accept any voltage AC or DC, 24 to 600 Volts.

Terminals 4 & 5 and 9 & 10: When the insulation resistance falls to the preset alarm level, the sensing circuit operates the alarm relay. The contacts are rated at 5 amps, 250 volts AC, resistive. Relays are available in change-over configurations.

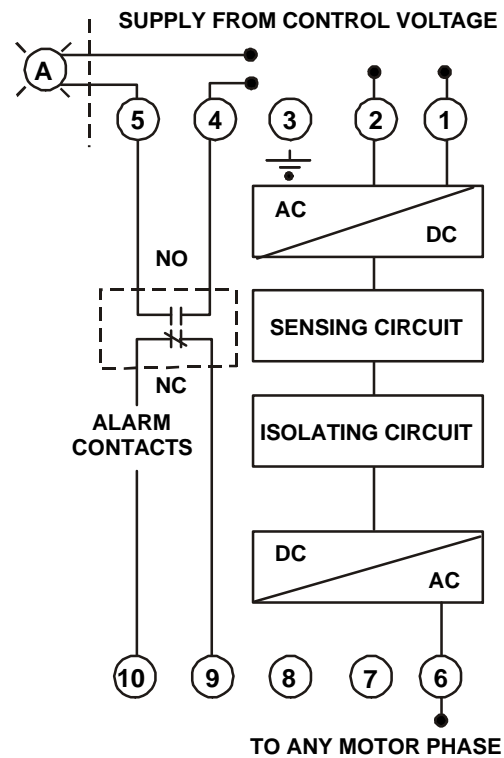


Fig. 4 Typical MotoSafe Block Diagram

Alarm Setting Switch: On the monitor faceplate, a slide switch offers three settings – 5, 3, & 1 Megohm. It should be set at 5 Megohm initially and switched to a lower setting when the unit alarms. A short interval between alarm level changes indicates rapid insulation deterioration. Schedule Preventive maintenance when the unit alarms at 1 Megohm.

If the Alarm Relay is wired for Start Prevention, the motor can be restarted at the 5 Megohm and 3 Megohm alarm setting by switching to the next lower setting. The motor will be locked out when the unit alarms at the 1 Megohm setting.

BASIC APPLICATION PRINCIPLES FOR MOTORS UP TO 600V

The MotoSafe Insulation Monitors are designed to operate on industrial power systems. It senses the insulation level of a motor when the motor is **not** energized.

It can be used with **all types** of motor starters if the following three simple rules are followed.

1. When it is not energized, the motor must be completely isolated from the supply.

Note: all motors controlled by the conventional electromagnetic starters meet this condition.

2. If the motor is controlled by a solid-state starter, there must be an electromagnetic contactor between the solid state starter and the supply.

Note: The solid state starter by itself does **not** isolate the motor from the supply.

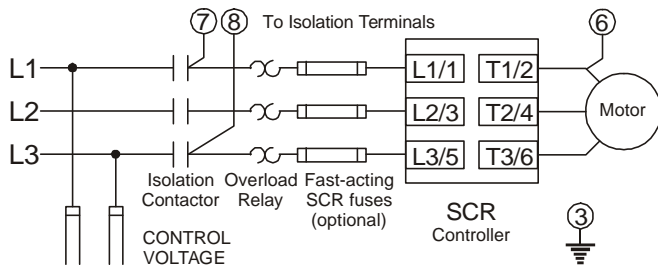


Fig. 5 Solid State Starter with Isolation Contactor – MotoSafe Connection

3. The isolation circuit must sense the voltage applied to the motor windings, while the motor is energized.

Note: If isolation terminals are provided connect them accros the isolation contactor coil or alternatively to the main contactor on the load side. This applies to the motors with variable speed or soft start drive.

Connect MotoSafe Sense terminal to motor starters as follow:

Direct-on-line: to any phase on the load side of the main contactor (see Fig. 6).

Star-Delta: to any phase on the load terminals of the main contactor (see Fig. 7).

Autotransformer: to any phase on the load side of the main contactor (see Fig. 8).

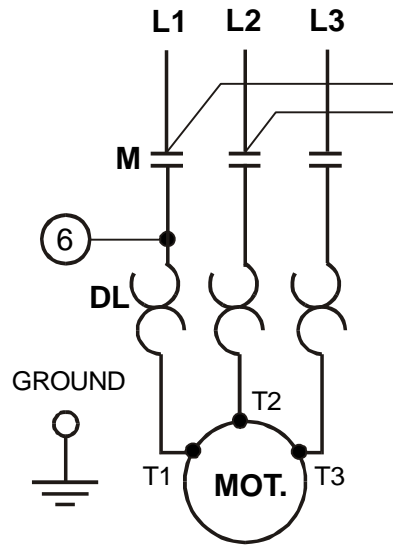


Fig. 6 Direct-on-line Starter – MotoSafe Connection

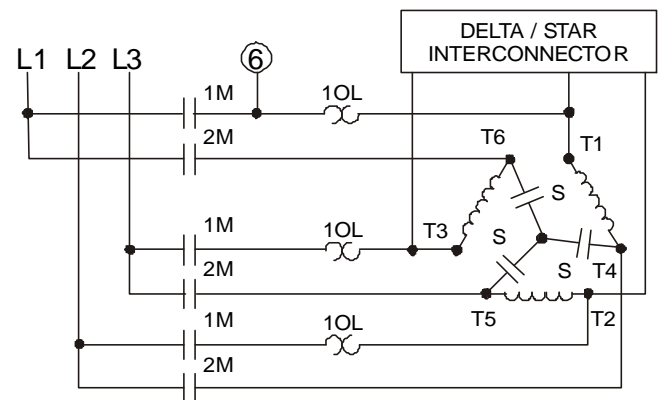


Fig. 7. Star-Delta Starter – MotoSafe Connection

Contactors “2M” & “S” are mechanically interlocked. The Delta/Star interconnector is constructed of high resistance resistors and does not interfere in motor operation. It allows to monitor all three motor phases by one monitor.

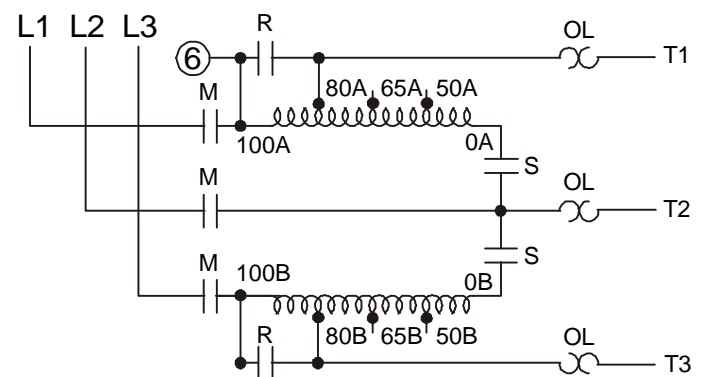


Fig 8. Autotransformer starter – MotoSafe Connection

Contactors “S” & “R” are mechanically interlocked

Multispeed, Same Winding: to any phase on the load side terminals of the Slow Speed contactor (see Fig. 9)

Reversing: to any phase on the load terminals of either contactor (see Fig. 10).

Multispeed, Separate Winding: consider as individual motors, use a MotoSafe Insulation monitor for each speed; connect each as Direct-on-Line.

Slip Rings Motor: for the stator, to any phase on the load side of the contactor. For the rotor, an additional monitor is required; connect to any slip ring phase (see Fig 11).

D.C. Motors: same as A.C. motors with solid state starters (Fig. 5).

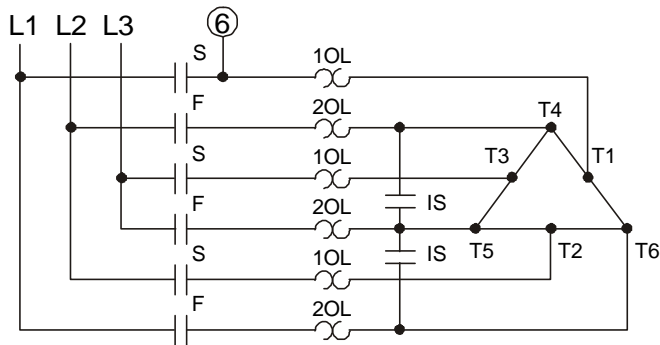


Fig 9. Two-Speed, Same Winding Starter – MotoSafe Connection

Fast “F” & Slow “S” contactors are mechanically interlocked

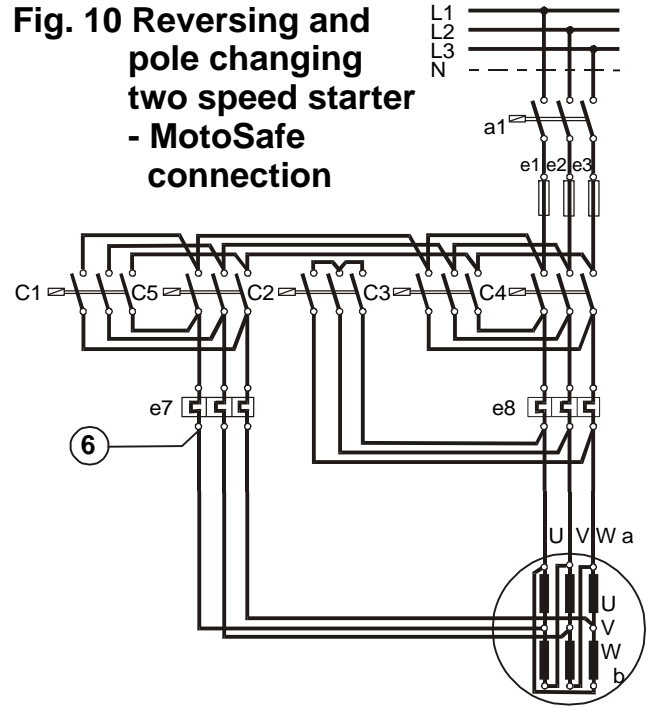


Fig. 10 Reversing and pole changing two speed starter - MotoSafe connection

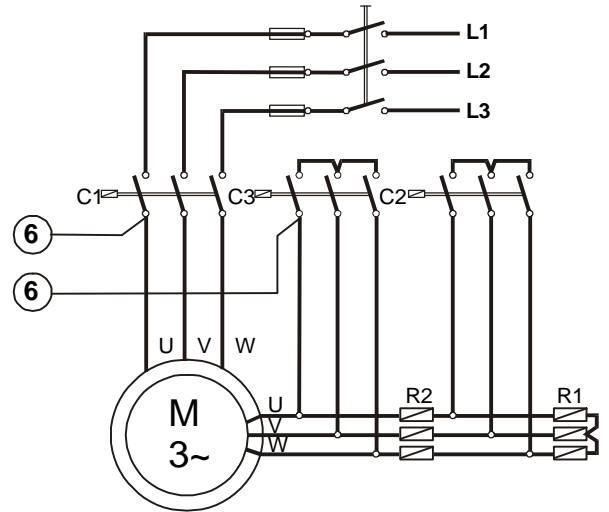


Fig 11. Slip Ring Motor – MotoSafe connection

MULTIPLE MOTOR INSTALLATIONS

In installations with several motors controlled by multiple contactors located in one starter enclosure, it is recommended that the Multichannel MotoSafe Insulation Monitor be installed in the motor starter enclosure.

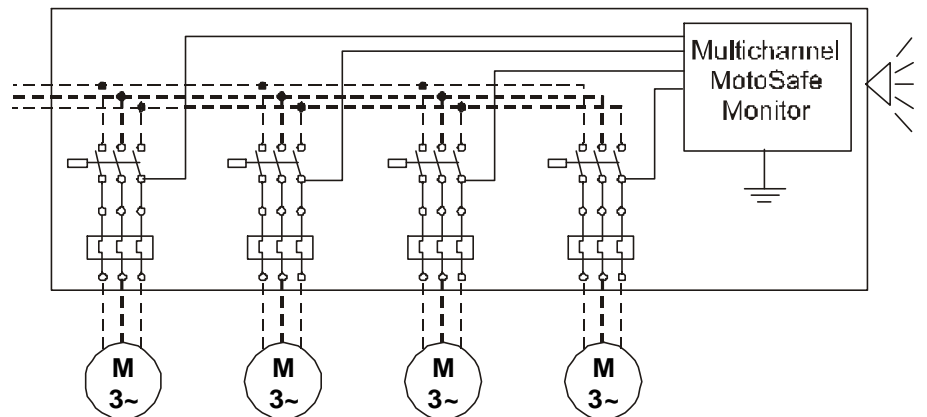


Fig. 12 Multiple Motor Installation – Typical Method

BASIC APPLICATION PRINCIPLES FOR GENERATORS

AC GENERATORS

The MotoSafe Insulation Monitor can be applied to all 3-Phase generators, if the generator neutral is isolated when the generator is idle.

Note: In new installations the generator breaker should be a four-pole unit, with the fourth pole breaking the neutral. In a retrofit application with a three-pole breaker, it should be changed to a four-pole breaker if possible. Alternatively, a correctly rated, single-pole contactor may be used to isolate the neutral.

If the generator feeds a 3-wire system fitted with an artificial neutral, the artificial neutral must be connected to the system main bus, not ahead of main breaker.

When the neutral isolation has been assured, connect Sense terminal to any phase of the generator side of the breaker.

D.C. GENERATORS

The MotoSafe Insulation Monitor can be applied to all D.C. generators, if the output is not grounded. Connect terminal 6 to any terminal on the generator side of the breaker, in any polarity.

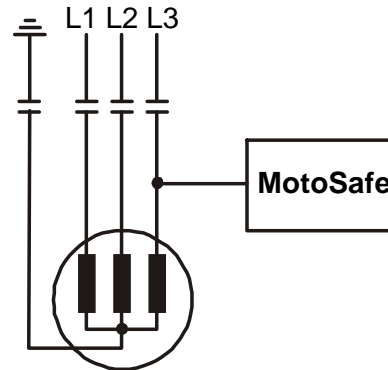


Fig. 13 Standby Generator – Basic Application Principle

BASIC APPLICATION PRINCIPLES FOR HIGH VOLTAGE MOTORS

The MotoSafe Insulation Monitor for High Voltage Motors is the same in principle as the unit for Low Voltage motors, with the following additional features.

- 1) Time Delay: As many H.V. Motors are fitted with line-to-ground capacitors, the sensing circuit has an optional 10 minute delay, to allow time for the capacitor to discharge
- 2) The unit has circuitry for forced discharge of residual voltage.
- 3) Remote Reset: Terminals are provided for a remote “Reset” button.
- 4) Additional Contacts: A second set of changeover contacts is provided on the alarm relay.
- 5) Isolating terminals 5 & 6 will accept any A.C. or D.C. voltage from 24 to 600 volts.

However, as the MotoSafe device is installed in the (L.V.) instrument compartment of the H.V. starter, the way it is installed is different from installations for L.V. motors.

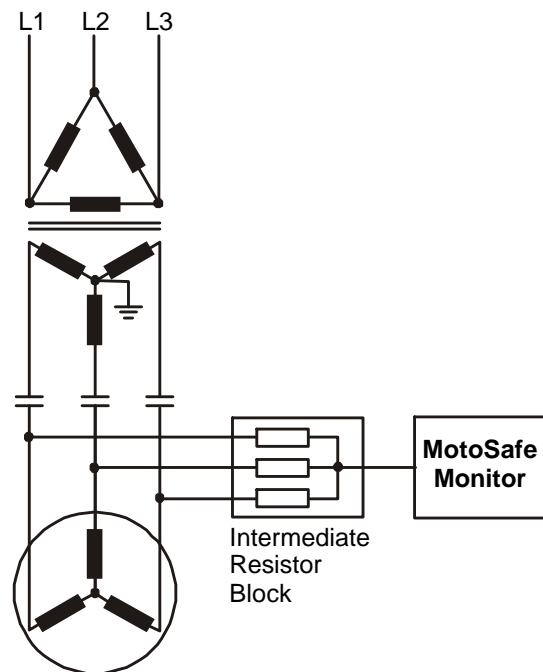


Fig. 14 High Voltage Transformer – Coupled Motors

INTERMEDIATE RESISTOR BLOCK

As the L.V. MotoSafe device monitors winding insulation resistance, it can be connected to any point on the winding. For H.V. motors, the neutral point is preferred for safety. An artificial neutral (the Intermediate Resistor Block) is created by joining three 10 Megohm resistors in star connection. It is mounted in the H.V. compartment and connected to the motor terminals. The star point forms a safe, convenient, low voltage connection point for the MotoSafe device.

To eliminate the hazard to personnel, the connection between the Intermediate Resistor Block in the high voltage compartment and the MHV monitor unit in the low voltage compartment of the motor control gear, is current limited by the high internal impedance of the Intermediate Resistor Block to a maximum of 1.15 milliamperes, i.e. 23% of the mandated GFCI trip level. This maximum current flows through the "Sense" line (the red conductor of the Intermediate Resistor Block) to terminal 4 of the MHV monitor unit only if terminal 4 is shorted to ground when a ground fault exists on one phase of the motor supply.

When the motor is idle, the three resistors are effectively in parallel and in series with the winding insulation resistance, thus adding 3.33 Megohms to the apparent value. The

calibration of the MotoSafe device compensates for this, so the alarm levels correspond to actual insulation resistance values (see Fig. 14).

This method of connection complies with all applicable codes and is approved by CSA and UL. When the Intermediate Resistor Block is installed inside the High Voltage compartment, fuses are not required.

Every unit bears a serial number and is tested at 225% of its rated line voltage for one minute, to meet CSA and UL requirements, by an independent test laboratory.

TRANSFORMER COUPLED HIGH VOLTAGE MOTORS

If the motor is transformer-coupled (Fig. 14) the MotoSafe Insulation Monitor can only be installed if one of the following conditions is met:

- 1) There is a contactor between the motor and the transformer, or
- 2) The transformer secondary is not grounded, or
- 3) A correctly rated one pole contactor is installed to isolate the grounding resistor from the neutral.

OTHER APPLICATIONS

The MotoSafe product was developed to meet the well-defined need to monitor idle motors in adverse conditions to warn of insulation deterioration, but it has many other applications.

Some such applications are:

Airport runway lighting circuits

Standby power systems for firepumps

Air conditioning systems during the off season

Standby pumps for water and sewage systems

Hospital emergency power systems

Buried standby power distribution cables

i.e. whenever insulation sits idle but must be effective when needed, a MotoSafe Insulation Monitor can eliminate untimely failures.

GENERAL NOTES

The design of MotoSafe Insulation Monitor ensures that any component failure in the unit will not affect the normal operation of the motor gear.

The MotoSafe Insulation Monitor will withstand the high voltage applied by a Megger™ Tester (to 1000V D.C.)

The enclosure of the MotoSafe Insulation Monitor is made of self-extinguishing plastic and all terminals are completely shrouded, for safety.

Provision for DIN-rail mounting is included on the back of the unit. When installed as instructed, the unit will withstand shock testing to Spec Mil No. S901C (U.S. Navy).

“TEST” and “RESET” buttons on the face of the unit permit routine testing of the MotoSafe Insulation Monitor.

To ensure that the external wiring has been done correctly, a Test Resistor is provided. It consists of a 100 Kilohm resistor attached to 14 inches of # 18 a.w.g. wire and it should be used to ground the motor winding temporarily when the installation procedure has been completed. This is done to simulate a low phase-to-ground insulation condition.

A flashing visual alarm unit is provided in the installation kit. Using a neon lamp instead of an incandescent lamp ensures long life and the life is further extended as the lamp is flashed instead of being permanently “ON”. Note also that the alarm only operates when the motor insulation falls to the preset level.

The visual alarm unit is drip-proof and may be used where regulations permit. Other types of visual alarm units may be used, if desired. A self-adhesive “WARNING” label is provided.

INSTALLATION KIT

The MotoSafe Insulation Monitor is shipped complete with an installation kit. This kit contains all of the material and hardware required for a typical retrofit application in a motor starter enclosure. If the “Installation Instructions” are followed, the installation will be completed quickly, in a workmanlike, reliable, fashion.

The kit contains the following items:

- Installation instruction**
- DIN-rail mounting bracket**
- Self-tapping mounting screws**
- Flashing visual alarm unit**
- Sufficient hook-up wire for a typical installation**
- Crimp-on wire terminals**
- Plastic cable ties**
- Self-adhesive “Warning” and “Instruction” labels**
- A Test Resistor**

Installation Instruction for all models may be found at www.msegroup.net