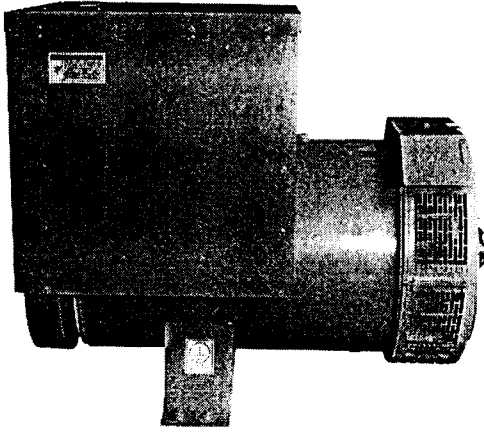




Testing Alternator Insulation (Meggering)

Insulation Testing?

Testing the electrical insulation on wires and other electrical components is a procedure that tells us the condition of that electrical insulation.

Why Test?

Testing the electrical insulation on electrical components, like alternators, is part of the recommended preventive maintenance schedule of the equipment. At planned intervals or when returning an alternator into service after storage, after maintenance, or if the condition of the insulation is in doubt, it must be tested to ensure it is still capable of doing its job.

What Is The Job Of Electrical Insulation?

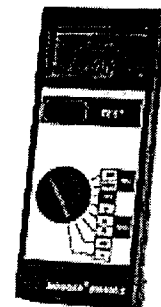
Electrical insulation is the protective coating on electrical components that is designed to keep the electricity inside the device and not let it leak out. If the electricity inside electrical devices leaked out it could injure personnel, damage equipment, cause fires or cause the component failure.

How Do We Test The Insulation?

Testing electrical insulation, commonly known as meggering, is very similar to checking a bicycle tire for leaks. We electrically pressurize the device with a known pressure, or voltage, and then check for current flow through the insulation, or electrical leaks. This pressure test is accomplished by using a special device commonly called a megger meter.

How Does A Megger Meter Work?

A megger meter is a device capable of supplying a controlled DC voltage to the component being tested and then measuring the current that leaks through the insulation being tested. Megger meters usually apply 500VDC, or if selected, 1000VDC to the device being tested. The meter will then measure the leakage current through the insulation and internally calculate the resistance value of the insulation. This Insulation value is then indicated to the operator on the screen, usually in Mega, Giga or Tera Ohms. The megger meter may also have an analog readout as well.



How Much Resistance Should My Insulation Have?

The amount of resistance the insulation should have actually depends on several factors, including the type of device, the operating temperature of the device, the level of protection required and the voltage within the device. For testing purposes, the higher the voltage, temperature and protection required, the greater the level of resistance required. A general industry standard for alternators is that insulation should be at least, 1 Mega-Ohm, plus, for 1 Mega-Ohm for every 1000volts of operating voltage.

$$R = 1M\Omega + \frac{\text{Volts}}{1,000}$$

Does Insulation Degrade?

Electrical insulation, when new, is “almost” perfect. As it gets older, like most things, it gets weaker and shows signs on wear. Time, humidity, thermal cycling, mechanical damage, operating temperatures and the voltages applied to it, does weaken electrical insulation. Sooner or later the insulation in an alternator will degrade to the point where it will fail if not repaired. By periodically testing and recording the alternators insulation resistance readings, we not only know the current condition of the insulation, but also can accurately predict when it needs to be cleaned and/or re-insulated, before it fails. The planned re-insulating of alternators windings is far easier, cheaper and faster than repairing alternator windings after the unit has had an insulation failure.

How Long Will Electrical Insulation Last?

Asking how long electrical insulation will last is like asking how long your car will last. Alternators used in prime power applications, operated in a clean environment, supplied with lots of cool dry air, heated when shut down, never overloaded and properly maintained, can last for 50 years or more. Other units that are cycled on an off continuously, in a dusty environment, overheated by overloads or lack of proper cooling, stored in damp locations, operated in abrasive and wet conditions without proper cleaning and maintenance, may last less than a year.

Does Temperature Really Matter?

Temperature is an important consideration in insulation resistance because electrical insulation has a “Negative Temperature Coefficient”. This negative temperature coefficient means that as the temperature of the insulation rises, its actual electrical resistance lowers. Knowing that electrical insulation is better when it is cool and weaker when it is hot, it is easy to understand why electrically insulated devices must be kept cool. If electrical insulation is allowed to overheat, due to an overload or lack of proper cooling, it may not be able to keep the voltage in. As the temperature of the electrical insulation rises, its resistance falls and if it falls low enough, voltage will punch through. This is why electrical insulation is rated by class, for a maximum operating temperature.

Insulation Class	Maximum Temp at The Hottest Spot
“B”	130°C
“F”	155°C
“H”	180°C
“N”	200°C

How Often Should I Megger?

Caterpillar recommends that all alternators are meggered on installation, to establish a baseline and every 3 months, in wet locations, for prime or continuously operated unit, and annually for all other units. Gensets must also be meggered when removed from storage, after an overhaul or if suspected of damage or failure.

What Windings Do I Megger?

Our generating units, depending on the model, have four or five windings. Although you could megger one or two windings to get an indication of the overall condition of the insulation, you must megger them all to verify their actual operating condition.

Will Temperature Affect The Readings?

Because we know electrical insulation has a negative temperature coefficient, if the windings are warm when tested the resistance will be lower than normal and read higher than normal when cold. If we could always test the insulation at the exact same temperature, we would have no problems. Due to the fact that some units are tested warm and some are tested cold; we need a way to allow for this variance in temperature. That is why we have a temperature correction chart to bring all readings back to, as if we did all testing at a temperature near 40°C. Multiplying your actual megger reading by the temperature coefficient for your winding temperature will give you the corrected insulation resistance value.

Winding Temperature When Meggering	Multiply Megger Reading by a Temperature Coefficient of:
10°C	0.10
15°C	0.15
20°C	0.20
25°C	0.30
30°C	0.40
35°C	0.57
40°C	0.83
45°C	1.03
50°C	1.80
55°C	2.50
60°C	3.25
65°C	4.60
70°C	7.00
75°C	10.0
80°C	15.0

How Do I Megger?

To ensure an accurate reading and protect other electrical components from damage, each winding must be isolated from ground and all other electrical components before meggering. Place the black megger lead on the winding to be tested and the red megger lead on the alternator casing to complete the megger connections. Multiphase windings may have all the phases shorted together and meggered all at once. Megger each winding for 60 seconds, recording the insulation resistance at both 30 and 60 second. Also record the winding temperature and the relative humidity if known.

**Why Megger
For 60
Seconds?**

You have to megger every winding for a minimum of 60 seconds in order to get accurate readings. Because the megger meter must pressurize the winding with 500VDC or more, it takes time to build up the voltage pressure. During the time that you are building up the voltage in the windings, the megger meter is reading the winding charging current. This winding charging process takes several seconds to complete, then the charging current drops to a low level. From that point on, the megger will only read leakage current. Our readings do not start before 30 seconds to ensure the charging process is completed. Then we take another reading at 60 seconds to allow us to have two readings to compare 30 seconds apart.

**What Is
Dielectric
Absorption
Ratio?**

The dielectric absorption ratio is the comparison of the 30 and 60 second reading. The 60 second reading should be better than the 30 second reading. If the 60 second reading is less than the 30 second reading it is indicating that the leakage current is growing as the test continues.

Insulation Condition	60/30 Second Readings
Clean and/or Dry and Retest	<1
Questionable, monitor more often	1.0 to 1.4
Good Condition	1.4 to 1.6
Excellent Condition	>1.6

**What
Megger
Voltage Do I
Use?**

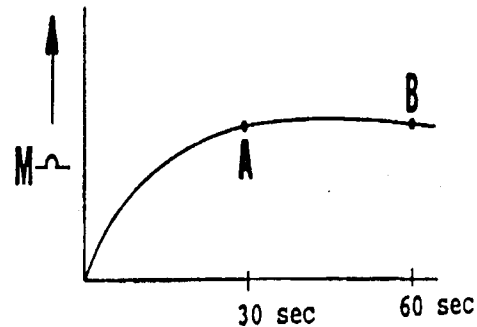
Unless your unit manual specifies something different, the general rule of thumb is:
Use 500VDC for all units 600 Volts or less, and
Use 1000VDC for all units operating above 600Volts.

**What Is A
Good
Reading?**

A good electrical insulation will have all of the following:

Greater than the required insulation value for both the 30 and the 60 second readings.

The 60 second reading is greater than the 30 second reading, giving a ratio of 1.4 or greater



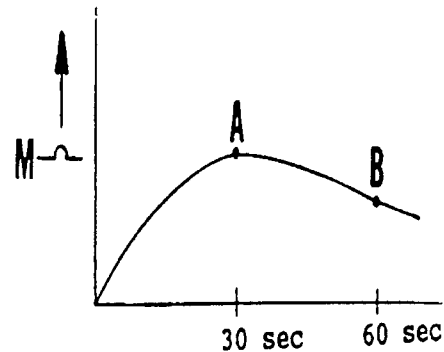
What Is A Bad Reading?

Bad insulation is indicated by any one of the following:

Less than the required insulation value for either of the 30 and the 60 second readings.

A 60 second reading less than the 30 second reading, giving a ratio of <1.4

Erratic needle movement during the test process, indicating internal arcing.



What If The Reading Is Bad?

A bad reading usually indicates that the windings are dirty, wet or both. In the event of a bad reading, clean and/or dry the windings, as required, and retest. If the windings fail the test again on the 2nd attempt, the insulation is bad.

Read the Manual

The specific instructions for your alternator are contained in the maintenance section of the manual. In the event that you do not have the manual, you can use the following “generic” guidelines to assist you.

Preparing to Megger

Lockout and tag the unit ensuring that there is no possible means of accidental start-up.

Lockout and tag all electrical feeds into the alternator, such as the alternator anti-condensation heaters.

Remove the alternator covers and gain access to the windings.

Remove the bond connection between the neutral “T0” and ground.

Meggering the Alternator Armature Winding (Stator)

Either remove all the winding leads from the connection points, or remove all sensing leads from the connection points back to the control panel, and any other connections to other devices.

Place the red megger lead on the alternator casing and the black megger lead on the alternators neutral leads, or the individual phase leads, or all the phase leads shorted together as required. Ensure the other leads do not short to the shaft or other components.

Megger and record the readings, winding temperature and relative humidity.

***Meggering
the
Alternator
Field
Winding
(Rotor)***

Remove both the field winding leads from the rotating diode assembly and the surge suppressor.

Place the red megger lead on the alternator casing and the black megger lead on either one of the alternator field leads. Ensure the other lead does not short to the shaft or other components.

Megger and record the readings, winding temperature and relative humidity.

***Meggering
the Exciter
Armature
Winding
(Rotor)***

Remove all the exciter armature winding leads from the rotating diode assembly and the surge suppressor.

Place the red megger lead on the alternator casing and the black megger lead on all the armature leads shorted together, or individual armature leads, as required. Ensure the leads do not short to the shaft or other components.

Megger and record the readings, winding temperature and relative humidity.

***Meggering
the Exciter
Field
Winding
(Stator)***

Disconnect the wires from the exciter field winding going back to the automatic voltage regulator.

Place the red megger lead on the alternator casing and the black megger lead on either of the exciter field leads. Ensure the other lead does not short to the casing or other components.

Megger and record the readings, winding temperature and relative humidity.

***Meggering
the PMG's
Armature
Winding
(Stator)***

Remove all the leads from the PMG armature to the voltage regulator.

Place the red megger lead on the alternator casing and the black megger lead on all the armature leads shorted together, or individual armature leads, as required. Ensure the leads do not short to the casing or other components.

Megger and record the readings, winding temperature and relative humidity.

*Record the
Actual
Megger
Readings
and the
Winding
Temperature*

Unit Information					
Customer			Location		
Alt Ser #			Arr#		
kW's			Voltage		
Winding Temperature °C			Relative Humidity %		
	Alternator Armature	Alternator Field	Exciter Armature	Exciter Field	PMG Armature
60 Second Reading	Ω	Ω	Ω	Ω	Ω
30 Second Reading	Ω	Ω	Ω	Ω	Ω

*Record the
Temperature
"Corrected"
Readings*

Temperature Corrected Readings					
	Alternator Armature	Alternator Field	Exciter Armature	Exciter Field	PMG Armature
60 Second Reading	Ω	Ω	Ω	Ω	Ω
30 Second Reading	Ω	Ω	Ω	Ω	Ω
Dielectric Absorption Ratio					