GENERATOR INSPECTION AND TESTING

PROCEDURES TO TEST LOW AND MEDIUM VOLTAGE GENERATORS AT EMWD PLANT SITES

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- The objective of this training session is to establish practices to safely field test low and medium voltage generators by EMWD technicians.
- The primary objective is to assure all procedures are carried out in a safe manner and that all required safety protocols are observed.
- This training is provided to assure that your generating assets perform as expected in the event of a power outage or curtailment event.
- The recommended procedures and documentation are at this point only proposed and not fully adopted by EMWD. Any comments, questions or suggestions you may have during this class would be welcomed and are encouraged.

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- SAFETY FIRST!
- Establish protocols and procedures to safely de-energize, lock out and tag out equipment prior to inspections and testing.
- Assure the engine CAN NOT ROTATE! Determine if adequate lock out means exist to assure engines cannot crank, otherwise you will need to implement procedures such as disconnecting batteries to assure your safety.
- Determine is unit is connected to live bus across a single breaker or disconnect to determine if a flashover event can occur.
- Final risk hazard determinations will be made by your in-house safety personnel and risk management department.

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- After LOTO procedures performed, first step is to remove covers and access panels as needed.
- Fill out your information on the inspection sheet.
- A visual inspection will be performed of the generator connection box, exciter area, front and rear of stator, flexible coupling if installed, current transformers and voltage regulators (if installed locally in generator).
- Document any problems found. If you have documentation from previous testing, refer to it to determine if previous problems still exist or have been addressed/resolved.

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GENERATOR INSPECTION AND TESTING DATA SHEET						
GENERATOR DATA						
JOB#		PLANT SITE		UNIT #		
BLDG		MANUFACTURER		DATE		
MAKE		MODEL		HOURS		
SERIAL#		RATING (kW or kVA)		VOLTS		
Visual Inspection						
Condition of lugs and terminals						
Condition of cables and conductors						
Condition of busbars and supports						
Condition of diodes and surge suppressor						
Condition of excitor rotor and stator						
Condition of PM rotor and stator						
Condition of main rotor and stator						
Condition of AVR and wiring/connections						
General condition, is dirt present?						
General condition, is corrosion present?						
General condition of CT's and PT's						
Resistance Measurements		Field		PM		Ohms
Air Gap Measurement	Top		Bottom		Ratio	

Top portion of inspection data sheet, complete as much as possible to help develop good records and repeatable test and inspection procedures.

Use a strong light, take a close look at the components and areas listed, also note if the bearing have been neglected or over-greased.

If one or more of the listed things don’t apply, mark them N/A.

Resistance and air gap measurements will be demonstrated during hands on portion of training.

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Generator Field Tests					
Insulation Resistance Spot Test	30 Sec		60 sec	DAR	Test Volts
Main Stator					
Main Rotor					
Exciter Stator					
Excitor Rotor					
PM Stator					
Voltage Step Test					
Main Stator					
Main Rotor					
Exciter Stator					
Excitor Rotor					
PM Stator					
Polarization Index Test	1 Min		10 Min	PI	
Main Stator A Phase					
Main Stator B Phase					
Main Stator C Phase					
Main Rotor					

Field tests, hands on portion of training will show how to select appropriate test tooling, and to make tests as needed.

We will also cover assuring that stator, field and PMG circuits are cleared to make sure nothing (like AVR's and controls) don't get damaged.

As we review this data sheet any comments or suggestions to meet your typical work procedures would be helpful.

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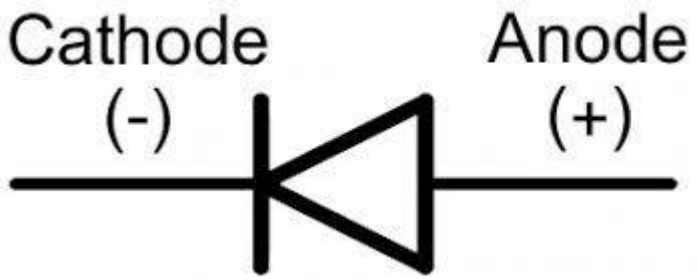
Diode and Surge Suppressor Tests						
		Meter RED on Cathode		Meter RED on Anode		
Positive 1 or Positive Block						
Positive 2						
Positive 3						
Negative 1or Negative Block						
Negative 2						
Negative 3						
Surge Suppressor						
Test Meter	Mfg/Model		Serial		Cal Date	
Ambient Temperature						
Ambient Humidity						
Test Comments						

Diode testing requires a good quality DMM preferably with a diode test function, a digital ohmmeter will work, but sometimes test results are not accurate.

Make sure actual ambient conditions are recorded for temperature and humidity

If you see something that you think needs to be reviewed, further tested or checked, please note it in the Comments section of the form.



GENERATOR INSPECTION AND TESTING

Draft Policies and Procedures for Generator Inspection and Testing

This is a working document to define preferred and acceptable procedures for the inspection and field testing of AC generators, and the policies defining decisions based on the results of those inspections and tests.

Reasons for Defining Policies and Procedures

In recent times, the number of generator problems and failures appears to have increased. There are multiple contributing factors for this. The main reason is that generators are currently built with less excess capacity, cost pressures and the overall drive to reduce product cost has led to better engineered packages that are more closely matched to customer requirements, without providing large reserve margins. Insulation packages have also changed, that while they are better for thermal stability, they are more prone to erosion and the absorption of moisture.

Primarily the purpose of this document is to improve personnel safety, for both our own staff and our customers, and to reduce the occurrence of catastrophic failure in generator components, and possible related equipment damage

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Testing Frequency

Per CAT and other manufacturers guidelines, all generators should be tested at a ***minimum*** of once a year. Units not stored or installed in enclosed climate controlled environments will be tested more often based on actual conditions. Factors influencing these decisions will be,

Ambient humidity and temperature where stored or operated,
Installation and use of generator space heaters when not operating,
Operating hours per year,
Types of load unit is operating on,
Environmental factors in operating area such as salt air, corrosive chemicals, rock or cement dust, etc.,
Unit overall age and/or operating hours,
Special unit configuration or manufacturers recommendation,

Target testing frequencies are,

Once per year, standby and building service units, with space heaters in use.
Once every six months, prime units operating more than 6 months per year, with space heaters in use.
Once every three months, units operating in material plants, units operating or stored without space heaters, units operating or stored in coastal areas or in environments above 70% RH.
Once every month in applications is sea air or corrosive environments.

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Test Procedures

EMWD technicians will perform three types of tests. These are,

Spot type test, also called a DAR (Dielectric Absorption Ratio) consists of a measurement held for 60 seconds, with the 30 and 60 second reading recorded. The DAR value is the 60 second reading divided by the 30 second reading. Example, a 30 second reading of 100 meg-ohms and a 60 second reading of 210 meg-ohms. 210 divided by 100 equals 2.1

PI or Polarization Index test, is done similar to the spot type test, except the test is run for 10 minutes with readings recorded at 1 minute and 10 minutes. The PI index is calculated similar to the DAR test, the 10 minute reading is divided by the 1 minute reading.

Step voltage test, an automated test applying a set of increasing voltages at 1 minute intervals. This test is used when it appears there may be a problem with a generator stator and is applied to further diagnose condition.

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Inspection Procedures

Prior to insulation resistance testing, the generator will be visually inspected. The unit will be locked out and tagged out and will positively be inhibited from cranking. If a generator breaker is installed tying the unit to a utility or plant bus, the breaker will be racked out, locked out, and tagged out. The generator covers will be removed, and a general inspection will be made as to cleanliness, evidence of moisture and/or corrosion, and signs of mechanical damage. A close visual inspection will be made of the insulation on the stator end turns, looking for cracking or erosions of the insulation. The rotating rectifier assembly will be inspected for corrosion and mechanical damage, and integrity of rectifiers and surge suppressors. All wires and cables will be inspected for chaffing, cuts and tears, proper support, and signs of overheat or insulation breakdown.

The PMG (if installed) rotor and stator will be inspected for mechanical damage, damage to end turns, signs of overheating, insulation stress, etc. You should look for signs of corrosion in the form of verdigris (*a bright bluish-green encrustation or patina formed on copper or brass by atmospheric oxidation, consisting of basic copper carbonate*)

The same type inspections will be made for the exciter rotor and stator, and the main rotor.

During the visual inspection process, determine if external sensing of current or voltage is connected to the generator leads, exciter connections and/or the PMG circuits. You will need to disconnect those connections prior to applying test voltage.

Air gaps will be at the 12 o'clock and 6 o'clock positions using either feeler (thickness) gauges, or a taper gauge. Ideally, air gaps should be centered. Take the upper and lower measurements and add them together, the lower measurement should no less than 30% of the total of the two measurements.

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Testing Procedures

We will refer to vendors manuals for this section.

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After Testing,

Recommended pass and fail criteria as follows,
General criteria,
Units operating at normal loads will initially use the spot test method. If the reading is above 100 M Ohms, no other action needs to be taken.
If the reading is less than 100 M Ohms, but greater than 50 M Ohms, or if the units is to be operated with inverter or high harmonic loads, a PI test will be performed.
A unit with a reading of less than 50 M Ohms will also have a step voltage test performed.
A unit with a reading of less than 10 M Ohms, but greater than 1 M Ohm will have its space heater energized overnight and retested, if the test results have not improved to over 50 M Ohms after heating the stator, the unit will require further evaluation.
A unit with a reading of less than 1 M Ohm is considered not usable and further evaluation or repair will be needed.

At every insulation test, the diodes and surge suppressors will be tested and results recorded. All diodes for either polarity should have similar voltage drops, a variation of more than 10% indicates that one or more diodes may have been stressed, in which case ALL diodes and the surge suppressor should be replaced.

A DAR test should have a reading greater than 2, readings of less than 2 indicate that the insulation system is beginning to deteriorate.

A PI test ideally should have a value of 4, new or reworked machines may have a reading of 5.
A PI of less that 2 indicates further investigation is warranted.
In some cases a very high PI number can also indicate a problem and requires previous test history to fully determine if a problems does exist.

A Step Voltage test is usually done when you suspect a problem with the winding you are testing, in general, the insulation resistance reading should not go lower when the next higher voltage step is applied

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We will review the following publications, PDF copies are included in the material provided on the flash drive.

Biddle, A Stitch in Time

AEMC Insulation Resistance Testing Guide

CAT, Generator Test Procedures

And many others as we have time.

Thank you for your participation, on to the hands on stuff!