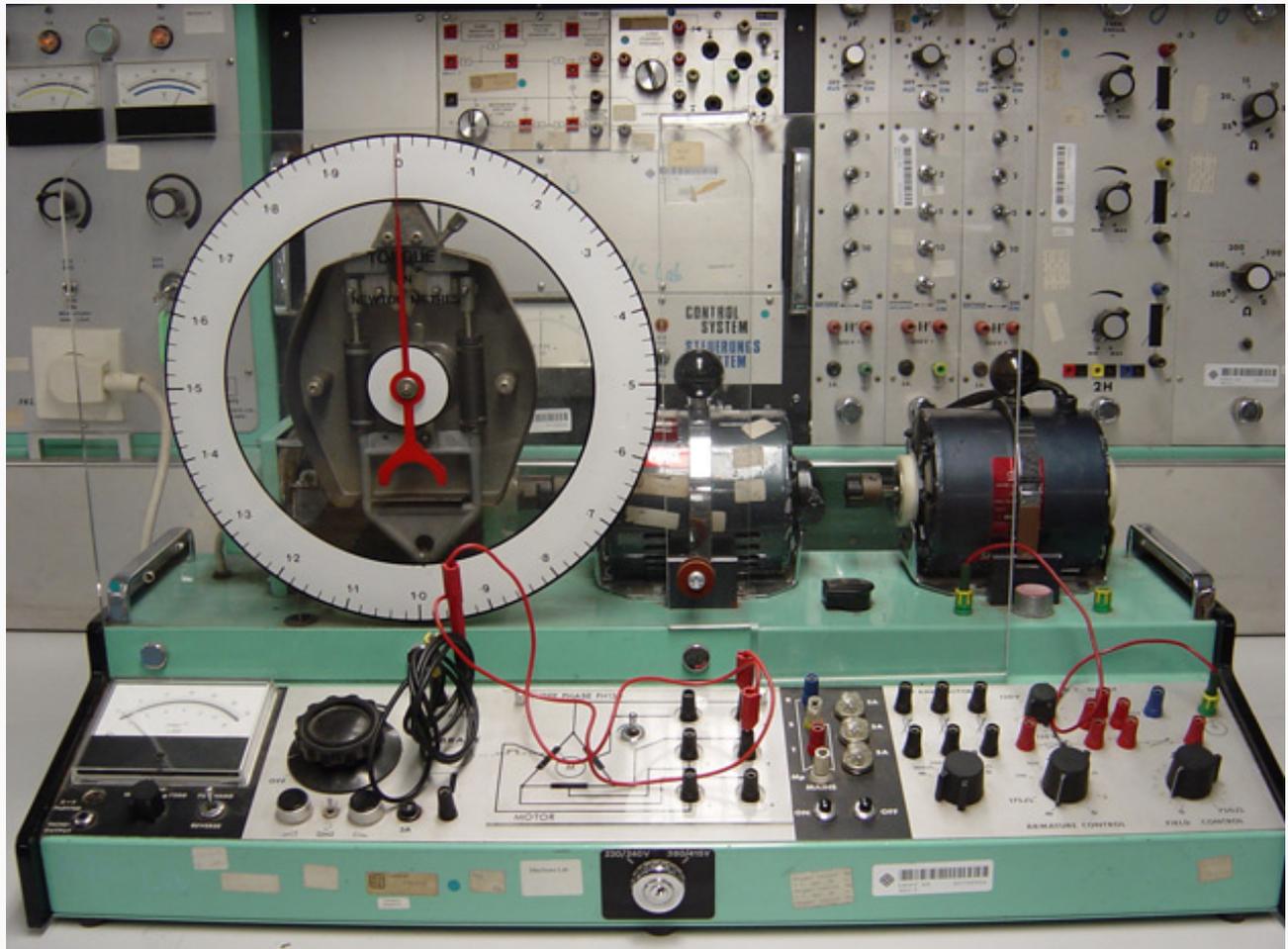


Inspection and test procedures for Rotating Machinery, Synchronous Motors and Generators

Edvard



Inspection and test procedures of Rotating Machinery, Synchronous Motors and Generators (On photo: Small machine test set – ee.polyu.edu.hk)

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1. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
5. [Inspect bolted electrical connections for high resistance](#) using one or more of the following methods:
 1. Use of low-resistance ohmmeter in accordance with procedure for LR ohmmeter usage.
 2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or **Table 100.12** (see below).
 3. Perform thermographic survey.
6. Perform special tests such as air-gap spacing and machine alignment.
7. Verify the application of appropriate lubrication and lubrication systems.
8. Verify that **resistance temperature detector (RTD)** circuits conform to drawings.

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2. Electrical Tests

1. Perform [resistance measurements](#) through bolted connections with a low-resistance ohmmeter, if applicable.
2. Perform insulation-resistance tests in accordance with **ANSI/IEEE Standard 43**.
 1. Machines larger than 200 horsepower (**150 kilowatts**):
Test duration shall be for ten minutes. Calculate polarization index.
 2. Machines 200 horsepower (**150 kilowatts**) and less:
Test duration shall be for one minute. Calculate dielectric-absorption ratio.
3. Perform dc dielectric withstand voltage tests on machines rated at 2300 volts and greater in accordance with **ANSI/IEEE Standard 95**.
4. Perform **phase-to-phase stator resistance test** on machines 2300 volts and greater.
5. ** Perform insulation power-factor or dissipation-factor tests.
6. ** Perform power-factor tip-up tests.
7. ** Perform surge comparison tests.
8. Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data, if applicable.
9. Test surge protection devices.
10. Test motor starter.
11. Perform resistance tests on resistance temperature detector (RTD) circuits.
12. Verify operation of machine space heater, if applicable.
13. ** Perform vibration test.

14. Perform insulation-resistance tests on the main rotating field winding, the exciter-field winding, and the exciter-armature winding in accordance with **ANSI/IEEE Standard 43**.
15. ** Perform an ac voltage-drop test on all rotating field poles.
16. ** Perform a high-potential test on the excitation system in accordance with **ANSI/IEEE Standard 421.3**.
17. Measure resistance of machine-field winding, exciter-stator winding, exciter-rotor windings, and field discharge resistors.
18. ** Perform front-to-back resistance tests on diodes and gating tests of silicon-controlled rectifiers for field application semiconductors.
19. Prior to re-energizing, apply voltage to the exciter supply and adjust exciter-field current to nameplate value.
20. Verify that the field application timer and the enable timer for the power-factor relay have been tested and set to the motor drive manufacturer's recommended values.
21. ** Record stator current, stator voltage, and field current for the complete acceleration period including stabilization time for a normally loaded starting condition. **From the recording determine the following information:**
 1. Bus voltage prior to start.
 2. Voltage drop at start.
 3. Bus voltage at machine full-load.
 4. Locked-rotor current.
 5. Current after synchronization but before loading.
 6. Current at maximum loading.
 7. Acceleration time to near synchronous speed.
 8. **Revolutions per minute (RPM)** just prior to synchronization.
 9. Field application time.
 10. Time to reach stable synchronous operation.
22. ** Plot a V-curve of stator current versus excitation current at approximately 50 percent load to check correct exciter operation.
23. ** If the range of exciter adjustment and machine loading permit, reduce excitation to cause power factor to fall below the trip value of the power-factor relay. Verify relay operation.

** **OPTIONAL**

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3. Test Values

3.1 Visual and Mechanical Test Values

1. **Inspection:**

1. Air baffles shall be clean and installed in accordance with manufacturer's published data.
 2. Filter media shall be clean and installed in accordance with manufacturer's published data.
 3. Cooling fans shall operate.
 4. Slip ring alignment shall be within manufacturer's published tolerances.
 5. Brush alignment shall be within manufacturer's published tolerances.
 6. Brush rigging shall be in accordance with manufacturer's published data.
2. **Compare bolted connection resistance values** to values of similar connections. Investigate any values that deviate from similar bolted connections by more than 50 percent of the lowest value.
 3. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use **Table 100.12** (see below)
 4. Results of thermographic survey to be analysed.
 5. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.

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3.2 Electrical Test Values

1. Compare bolted connection resistance values to values of similar connections. Investigate any values that deviate from similar bolted connections by more than 50 percent of the lowest value.
2. The dielectric absorption ratio or polarization index shall not be less than 1.0. The recommended **minimum insulation resistance (IR 1 min)** test results in megohms shall be corrected to **40°C** and read as follows:
 1. **IR 1 min = kV + 1** for most windings made before 1970 (*kV is the rated machine terminal-to-terminal voltage in rms kV*)
 2. **IR 1 min = 100 megohms** for most dc armature and ac windings built after 1970 (*form-wound coils*).
 3. **IR 1 min = 5 megohms** for most machines and random-wound stator coils and form-wound coils rated below 1 kV.

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NOTE: Dielectric withstand voltage and surge comparison tests shall not be performed on machines having values lower than those indicated above.
3. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, **the test specimen is considered to have passed the test.**
4. Investigate phase-to-phase stator resistance values that deviate by more than five percent.
5. Power-factor or dissipation-factor values shall be compared to manufacturer's published data. In the absence of manufacturer's published data these values will be compared with previous values of similar machines.
6. Tip-up values shall indicate no significant increase in power factor.
7. If no evidence of distress, insulation failure, or lack of waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, **the test specimen is considered to have passed the test.**
8. Insulation resistance of bearings shall be within manufacturer's published tolerances. In the absence of manufacturer's published tolerances, the comparison shall be made to similar machines.

9. Test results of surge protection devices shall be in accordance with procedures for testing of LV surge arresters.
10. Test results of motor starter equipment shall be in accordance with procedures for testing of motor starter equipment.
11. RTD circuits shall be in accordance with system design intent and machine protection device manufacturer's published data.
12. Heaters shall be operational.
13. Vibration amplitudes of the uncoupled and unloaded machine shall not exceed values shown in **Table 100.10** (see below). If values exceed, perform complete vibration analysis.
14. The recommended **minimum insulation resistance (IR1 min)** test results in megohms shall be corrected to 40°C and read as follows:
 1. **IR 1 min = kV + 1** for most windings made before 1970, all field windings (*kV is the rated machine terminal-to-terminal voltage in rms kV*)
 2. **IR 1 min = 100 megohms** for most dc armature and ac windings built after 1970 (*form-wound coils*).
 3. **IR 1 min = 5 megohms** for most machines and random-wound stator coils and form-wound coils rated below 1 kV.

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NOTE: Dielectric withstand voltage, high-potential, and surge comparison tests shall not be performed on machines having values lower than those indicated above.
15. The pole-pole AC voltage drop shall not exceed 10 percent variance between poles.
16. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the winding is considered to have passed the test.
17. The measured resistance values of motor-field windings, exciter-stator windings, exciter-rotor windings, and field-discharge resistors shall be compared to manufacturer's published data. **In the absence of manufacturer's published data, the comparison shall be made to similar machines.**
18. Resistance test results of diodes and gating tests of silicon-controlled rectifiers shall be in accordance with industry standards and system design requirements.
19. Exciter power supply shall allow exciter-field current to be adjusted to nameplate value.
20. Application timer and enable timer for power-factor relay test results shall comply with manufacturer's recommended values.
21. Recorded values shall be in accordance with system design requirements.
22. Plotted V-curve shall indicate correct exciter operation.
23. When reduced excitation falls below trip value for the power-factor relay, the relay shall operate.

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Electrical machine wired for electrical testing

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TABLE 100.10

Maximum Allowable Vibration Amplitude

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Electrical machine wired for electrical testing (photo credit: komel.katowice.pl)

TABLE 100.12

US Standard Fasteners – Bolt-Torque Values for Electrical Connections

- a. Consult manufacturer for equipment supplied with metric fasteners.
- b. This table is based on bronze alloy bolts having a minimum tensile strength of 70,000 pounds per square inch.
- c. This table is based on aluminum alloy bolts having a minimum tensile strength of 55,000 pounds per square inch.
- d. This table is to be used for the following hardware types:
 - Bolts, cap screws, nuts, flat washers, locknuts (18?8 alloy)
 - Belleville washers (302 alloy).

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Reference: ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and



The Electrical Machines Laboratory (photo credit: ee.polyu.edu.hk)

RPM @ 60 Hz	Velocity in/s peak	Velocity mm/s	RPM @ 50 Hz	Velocity in/s peak	Velocity mm/s
3600	0.15	3.8	3000	0.15	3.8
1800	0.15	3.8	1500	0.15	3.8
1200	0.15	3.8	1000	0.13	3.3
900	0.12	3.0	750	0.10	2.5
720	0.09	2.3	600	0.08	2.0
600	0.08	2.0	500	0.07	1.7

Table 100.10 – Maximum Allowable Vibration Amplitude

Table 100.12.1 Heat-Treated Steel - Cadmium or Zinc Plated				
Grade	SAE 1&2	SAE 5	SAE 7	SAE 8
Head Marking				
Minimum Tensile (Strength) (lb/in ²)	64K	105K	133K	150K
Bolt Diameter in Inches	Torque (Pound-Feet)			
1/4	4	6	8	8
5/16	7	11	15	18
3/8	12	20	27	30
7/16	19	32	44	48
1/2	30	48	68	74
9/16	42	70	96	105
5/8	59	96	135	145
3/4	96	160	225	235
7/8	150	240	350	380
1.0	225	370	530	570

Table 100.12.1 – Heat-Treated Steel – Cadmium or Zinc Plated

Table 100.12.2 Silicon Bronze Fasteners ^b Torque (Pound-Feet)		
Bolt Diameter in Inches	Nonlubricated	Lubricated
5/16	15	10
3/8	20	14
1/2	40	25
5/8	55	40
3/4	70	60

Table 100.12.2 – Silicon Bronze Fasteners

Table 100.12.3 Aluminum Alloy Fasteners ^c Torque (Pound-Feet)	
Bolt Diameter in Inches	Lubricated
5/16	8.0
3/8	11.2
1/2	20.0
5/8	32.0
3/4	48.0

Table 100.12.3 – Aluminum Alloy Fasteners

Table 100.12.4 Stainless Steel Fasteners ^d Torque (Pound-Feet)	
Bolt Diameter in Inches	Uncoated
5/16	14
3/8	25
1/2	45
5/8	60
3/4	90

Table 100.12.4 – Stainless Steel Fasteners

Source :

<http://electrical-engineering-portal.com/inspection-and-test-procedures-for-rotating-machinery-synchronous-motors-and-generators>