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of the
IEEE Power Engineering Society**

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Foreword

(This Foreword is not a part of IEEE Std 11-1980, IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles.)

This standard provides for usual conditions. In addition it provides for special conditions that have been found convenient or necessary at times in the industry, which may be invoked by agreement between manufacturer and purchaser. The conditions chosen may affect the economics or performance, or both, of machines in a given situation.

Provisions where special agreement between manufacturer and purchaser may be invoked are as follows:

3.1.2	High ambient temperature
3.1.3	Special conditions of environment
3.2.1	Type test quantities
3.2.2.3	Routine commutation and characteristic test quantities
3.3.5	Special conditions of electric input or output
5.2	Waiver of temperature-rise limits
7.1	Dielectric test
8.2.1	Commutation routine tests
8.2.3	Level of visible sparking
8.3.1	Interruption type tests
9.3.1	Maximum design speed
10.7.4	Tolerance from contract curve
10.8.1, 10.8.2 , 10.8.3	Tolerances from declared curve
11.2	Variation of performance with voltage
11.3	Load reduction under condition of low supply voltage
13.1	Commutator trueness measurement
13.2	Vibration measurement
13.3	Sound measurement

This standard parallels the major technical contents of International Electrotechnical Commission Recommendation Publication 349 (1971), Rules for Rotating Electrical Machines for Rail and Road Vehicles. It differs from IEC recommendation 349 in certain important respects, as given in the Appendix.

These differences have been called to the attention of the U.S. Committee of Experts for IEC Technical Committee 9, the International Mixed Committee on Electric Traction Equipment, and resolution of these differences will be sought in future meeting of TC 9.

This standard was prepared by a Working Group under the sponsorship of the Direct-Current Machinery Subcommittee of the Rotating Machinery Committee of the IEEE Power Society. The members of the working group were:

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An American National Standard

IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles

1. General

1.1 Scope

This standard applies to rotating electric machinery which forms part of the propulsion and major auxiliary equipment on internally and externally powered electrically propelled rail and road vehicles and similar large transport and haulage vehicles and their trailers where specified in the contract.

Major auxiliary equipment includes equipment such as blower and compressor motors, motor-generator and motor-alternator sets, auxiliary generators, and exciters, usually larger than 3 kilowatts.

1.2 Intent

The intent of this standard is to define ratings, tests, and calculation procedures to permit comparison among machines for similar use, and to enable evaluation of the suitability of machines for a given use.

1.3 Standards References

Reference is made in this standard to the documents listed below. In case of conflict between this standard and a referenced document, this standard shall govern. Those provisions of the referenced document not in conflict with this standard shall remain effective.

ANSI/IEEE Std 100-1977, Dictionary for Electrical and Electronics Terms

IEEE Std 1-1969, General Principles for Temperature Limits in the Rating of Electric Equipment

IEEE Std 85-1973, Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery

ANSI/NEMA CB 1-1977, Brushes for Electrical Machines

IEEE Std 113-1973, Test Code for Direct Current Machines

2. Definitions

alternator: An alternating-current generator.

as built curve: A curve that is found on an individual machine during testing. *Syn.:* manufactured curve.

average voltage: The value declared by the user to be the average of the system described, where externally powered.

continuous rating: The output that the machine can sustain for an unlimited period under the conditions of Section 4. without exceeding the limits of temperature rise of Section 5.

contract curve: A specified machine characteristic curve that becomes part of the contract.

current ripple: Current ripple, for the purposes of this standard, is defined as $[(I_{\max} - I_{\min}) / (I_{\max} + I_{\min})] \times 100$, expressed in percent, where $I_{\max}$ and $I_{\min}$ are the maximum and minimum values of the current waveform, provided that the current is continuous.

declared curve: A characteristic curve of the machine type, as obtained by averaging the results of testing four to ten machines, of which at least two shall have had a type test.

electric thermometer: An instrument that utilizes electric means to measure temperature (ANSI/IEEE Std 100-1977, Dictionary of Electrical and Electronics Terms). Electric thermometers include thermocouples and resistance temperature detectors.

heating-up run: A period of operation with current and ventilation designed to bring the machine to approximately its temperature-rise limit.

manufacturer: The organization supplying the electric machinery to the purchaser. For the purpose of this standard it may include a repair contractor.

nominal system voltage: A number used to denote the general level of voltage of the system described and, in the case of an externally powered system, selected from the list of preferred values in Section 11.

one hour rating: The output that the machine can sustain for 1 hour starting cold under the conditions of Section 4. without exceeding the limits of temperature rise of Section 5.

purchaser: The organization placing the contract for the machinery or its repair; often called the "user."

pulse control: Means by which the voltage applied to a machine circuit departs from being essentially constant if unidirectional, or from being essentially sinusoidal if alternating. Pulse-control devices include, but are not limited to, choppers, inverters, and rectifiers.

rated voltage: The voltage specified at the terminals of a machine.

rating: The output at the shaft if a motor, or at the terminals if a generator, assigned to a machine under specified conditions of speed, voltage, temperature rise, etc.

routine test: A test showing that each machine has been run and found to be sound electrically and mechanically, and is essentially identical with those that have been type tested.

short-time overload rating: The output that the machine can sustain for a specified time starting hot under the conditions of Section 4., without exceeding the limits of temperature rise of Section 5.

smooth current: Current that remains unidirectional and the ripple of which does not exceed 3 percent.

type test: A test made by the manufacturer on a machine that is identical in all essential respects with those supplied on an order, to demonstrate that it complies with this standard.

undulating current: Current that remains unidirectional, but the ripple of which exceeds that defined for smooth current.

3. Service Conditions, Test Categories, and Electric Inputs or Outputs

3.1 Service Conditions

This standard applies under the following conditions:

3.1.1 Altitude

All temperature tests at the manufacturer's plant shall be made at the sea-level rating. No correction in rating is necessary when normal service altitude does not exceed 1200 meters (4000 feet). A reduction in current rating of 1 percent shall be made for each 300 meters (1000 feet) additional elevation or fraction thereof.

3.1.2 Temperature

Whenever the temperature in the shade exceeds 40° C, special stipulations may be agreed upon by the manufacturer and the purchaser.

3.1.3 Special Conditions

The manufacturer shall be informed by the purchaser of any particularly arduous condition such as dust, humidity, temperature, snow, dynamic effects, etc, under which the machines are intended to work.

3.2 Test Categories

3.2.1 Type Tests

Type tests to establish ratings and characteristics shall be carried out on all new products. The number of type tests shall be one for every order for a new type, up to 100 machines on the order, and one for every additional 300 machines (or part thereof) for larger orders, unless otherwise agreed to between manufacturer and purchaser. Machines given type tests shall also be given routine tests.

3.2.2 Routine Tests

Routine tests shall be carried out on all machines. They include the dielectric test (Section 7.) and the overspeed test (Section 9.) in every case. Requirements for commutation tests (Section 8.) and characteristic tests (Section 10.) shall be met by one of the methods given below. Routine tests shall be preceded by a heating-up run. In no case do routine tests require precise temperature measurements.

3.2.2.1

Load test may be used to demonstrate commutation and characteristics directly.

3.2.2.2

Simulated load test may be used to demonstrate that the factors that affect commutation and characteristics agree with identical tests on machines that have had type test.

3.2.2.3

On machines produced in large quantity and assembled by precision methods, statistical methods may be used to determine the number of machines subject to commutation and characteristic tests. The quality control and sampling plan may be subject to agreement between manufacturer and purchaser.

3.3 Electric Inputs or Outputs

3.3.1

Direct-current motors supplied from rectified polyphase alternating current with not less than 6-pulse rectification without phase control are considered to be operating on smooth current. No correction is needed from tests run on smooth current.

3.3.2

Direct-current motors supplied from rectified single-phase alternating current or from pulse-control devices are considered to be operating on undulating current. Type tests for temperature rise, commutation, characteristics, and efficiency shall be made with undulating current with pulsation frequency and ripple as in service. Tests with smooth current may also be run.

3.3.3

Alternating-current machines that operate with essentially sinusoidal waveform should be tested under those conditions.

3.3.4

Alternating-current machines producing or fed with nonsinusoidal waveform should have type tests with waveforms as in service. Tests with sinusoidal waveform may also be run.

3.3.5

The effects of load characteristics and supply characteristics (11.3 and 11.4) shall be taken into account in specifying electric inputs or outputs of machines, particularly alternating-current auxiliaries.

3.3.6

Special conditions of electric input or output are subject to agreement between manufacturer and purchaser.

4. Ratings and Temperature-Rise Tests

4.1 Classes of Ratings

This standard recognizes three classes of ratings: continuous rating, 1 hour rating, and short-time overload rating.

4.2 Conditions of Excitation during Temperature-Rise Test of Traction Motors with Variable Excitation.

The parameters used to state the ratings of motors operated with variable excitation shall determine excitation. In general a test with the greatest rated excitation, providing the greatest rated tractive effort, is preferred. In the case of a self-ventilated motor a test with lower excitation may be added. Waveforms for the test shall be as in service.

4.3 Ventilation during Temperature-Rise Test.

The test shall, be carried out with the machine arranged as in service, with all those parts that would affect the temperature rise of the machine in place, but without any ventilation corresponding to that produced by the motion of the vehicle itself.

4.4 Duration of Temperature-Rise Test of a Machine to Determine the Continuous Rating

The temperature test shall be continued until the temperature rises which can be observed during test have attained a steady final value. See Table 1. In order to abridge the long time required to attain steady temperature, reasonable overload or reduction in ventilation during the preliminary heating period is permissible.

4.5 Initial Temperature of Machine for Temperature-Rise Test to Determine 1-Hour Rating

The temperature-rise test to determine the 1 hour rating shall commence only when the windings and other parts of the machine are within 4 °C of the cooling-air temperature at the time of starting the test.

4.6 Making of Short-Time Overload Test

The short-time overload capacity of the machine shall be determined by one or more temperature-rise tests following the continuous rating test at the highest continuous current. The cooling curve of the earlier rating test shall be plotted as taken, and the overload shall be applied when the extrapolation of this curve indicates that the proper initial armature temperature rise has been reached. The overload shall then be applied under normal ventilation conditions and at the voltage that corresponds to the test current on the machine characteristic and shall be maintained constant for a period estimated to reach the final temperature rise given in Table 2. The short-time overload rating of the machine may be calculated from a test that does not differ in final temperature rise from that in Table 2 by more than plus or minus 10 °C.

4.7 Voltage during Temperature-Rise Test

The voltage applied to a machine during the temperature-rise test shall be the rated voltage as defined in 4.8.

4.8 Rated Voltage

4.8.1 Motors on Externally Powered Vehicles

The rated voltage of a motor is the same as the nominal supply voltage of the traction network (see Table 3, Section 11.) in all cases where the motor is fed directly from the line. In the case of alternating-current motors fed through a transformer placed on a car or locomotive, it is equal to 90 percent of the maximum no-load secondary voltage of the transformer including the transition coils (if used) when the primary of the transformer is fed at the nominal supply voltage of the traction network.

4.8.2 Motors in Series

For motors connected permanently in series the rated voltage of the motor is designated by the ratio E/n , E being the nominal supply voltage and n the number of motors in series.

4.8.3 Motors on Internally Powered Vehicles

The rated voltage of a traction motor fed from a generator carried on the vehicle shall be at least equal to its share of the generator output voltage at the continuous rating of the motor.

4.8.4 Traction Generator or Alternator

A traction generator or alternator which is part of a motor-generator set carried on the vehicle or is driven from a prime mover on the vehicle usually will have a variable-voltage, variable-current characteristic. High voltage is of interest since it will stress the commutator, or rectifiers in the case of an alternator where the rectifiers form an integral part of the generator, and since the exciting field windings are operated at high current. High current is of interest from the standpoint of heating of the armature and other windings and rectifiers which carry main current. Such a generator or alternator has two continuous ratings on its characteristic curve which are as follows:

4.8.4.1

The continuous current rating of a generator or alternator is the continuous rating that corresponds to the higher output current. The continuous current rating for an alternator with rectifiers is the value of the rectified direct current at the output of the rectifiers.

4.8.4.2

The continuous voltage rating is the continuous rating that corresponds to the higher output voltage.

4.8.5 Exciting Supply

The rated voltage of the exciting supply shall be sufficient to provide this continuous voltage rating of the main generator.