Specification No SPEC/E-10/6/02

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

SPECIFICATION AND TEST PROGRAMME
FOR

MOTOR OF MOTOR ALTERNATOR SET, FREQUENCY REGULATOR AND AUXILIARY SMOOTHING REACTOR

FOR

DUAL VOLTAGE AC/DC.
WCAM-1 CLASS LOCOMOTIVES

SPECIFICATION NO. SPEC/E-10/6/02.

FEBRUARY 1975

Issued by:-

RESEARCH DESIGNS & STANDARDS ORGANISATION
LUCKNOW - 11

Feb-1975

11 TESTS

11.1 General

11.1.1 The tests specified below shall normally be carried out at the manufacturer's works. Tests are classified as type and routine tests.

11.1.2 The tests on the motor shall be generally carried out in accordance with the recommendations of IEC 349-1971 - "Rules for rotating electrical machines for rail and road vehicles." The temperature rise limits stated in Table 2 of the said publications shall be reduced by 25°C to account for higher ambient temperature in India. Any deviations from the test programme given here shall be mutually agreed to between the purchaser and the manufacturer.

11.1.3 All the type tests shall be conducted on one of the proto-type motors. Test corresponding to clause 42 of IEC-349 shall be conducted on first ten motors of bulk production. Tests corresponding to clause 35 of IEC-349 shall be done on the first two proto-type motors, first four motors from bulk production and two motors selected at random from bulk production.

11.1.4 For these machines certain type tests (temperature rise, commutation and characteristic curve tests) shall be made with pulsating current at actual pulsation frequency and ripple factor. The equipment used for these tests shall have characteristics which will produce a ripple factor as close as possible to that which will occur in service over the operating range.

11.1.5 The routine tests on these motors shall be done with direct current, provided that the relationships between temperature rises, commutation, and speed characteristics on both direct current and with pulsating current are determined in the type tests.

11.1.6 The type tests shall be performed in chronological order as arranged in this programme.

11.1.7 Instruments used for tests - The indicating instruments used in electrical measurements shall conform to IS:1248-1968 (Specification for electrical indicating instruments). Instruments with the following accuracies shall be used:

(a) For type tests - Instruments of class 0.5 accuracy.

(b) For routine tests - Instruments of class 1.5 accuracy.

the tender, indicating the cost.

10. DRAWINGS

Outline dimensioned drawings of the motor, frequency regulator, smoothing reactor and its accessories, complete and detailed dimensioned drawings for mounting arrangements, shall be furnished along with the tender.

5. LIMITS OF TEMPERATURE RISE

5.1 Limits of temperature rise: The temperature rise of the motor after continuous and starting duties shall not exceed the following values. These are based on IEC-349, reduced by 25°C for higher ambient temperature.

Insulating Meterial	Part	Method of measurement	Temperature rise in °C
Class H	Armature windings	Resistance	135
	Field windings	Resistance	155
	Commutator	Thermometer	85

5.2 The maximum bearing temperature rise shall not exceed 30°C.

5.3 The temperature rise of the cooling air of the machine while delivering full load output at the lowest or the highest operating voltage shall not exceed 25°C.

5.4 The temperature rise of the auxiliary smoothing reactor shall not exceed the values specified by IEC-310 reduced by 25°

6. SCHEDULE OF PARTICULARS

The schedule of particulars of the motor, frequency regulator and smoothing reactor shall be furnished along with the tender as per Annexure and .

7. TECHNICAL DOCUMENTS

Technical literature on the motor, frequency regulator/ speed control system, smoothing reactor and its accessories, such as, type test reports, descriptive write-ups, maintenance manuals, spare parts catalogues, etc., shall be supplied as desired by the purchaser.

8. TOOLS

The supplier shall supply a complete set of tools/ testing kit for the maintenance of the equipments with each equipment set. The list of the recommended tools and their cost shall be furnished along with the tender.

9. SPARES

The tenderer shall furnish his recommendation regarding requirements of spares for each equipment supplied along with

4.4 Auxiliary Smoothing Reactor

4.4.1 The reactor is a choke coil wound on an iron core of approved quality. It shall be designed for natural air cooling.

4.4.2 Entire current of pulsating nature required by motor of the motor-alternator set under various conditions of operation will flow through the smoothing reactor. The primary winding of the main transformer is connected to the 25 kV ac, 50 Hz single phase overhead catenary system and the tertiary winding through a bridge rectifier with silicon cells and smoothing reactor to the motor of the motor-alternator set.

4.4.3 The equipment shall be designed to limit the ripple content of the motor supply voltage over the entire voltage range.

4.4.4 The auxiliary smoothing reactor shall be designed to have relatively uniform inductance with varying loads.

4.4.5 The approximate size of the reactor and associate equipment shall be 670x550 mm and 430 height and shall be suitable to mount on the floor of the locomotive.

4.4.6 The smoothing reactor shall be supplied in fully assembled condition, together with the accessories required for mounting and connecting them with the reactor coil

4.4.7 Marking:

a) Manufacturer's name, type and model

b) Continuous rating

c) Class of insulation

d) Ripple frequency in cycles/second

e) Ripple factor

f) Nature of cooling

g) Type of connection.

4.3.9 The equipment shall be supplied in fully assembled condition. Hardware items required for marking the external connections shall be provided on the terminals and the details of the terminals shall be shown in the drawing furnished along with the tender.

4.3.10 If the frequency regulator/speed control system has already been type tested, then the type test results shall also be furnished along with the tender. The tenderer shall also furnish the details of service experience on the frequency regulator, if any.

4.3.11 The tenderer shall furnish full particulars of the frequency regulator and its components along with the tender.

4.3.12 Marking:

a) Manufacturer's name and model

b) Variation of speed in percentage

c) Voltage range in volts

d) Rated frequency and variation in percentage

e) Type of connection.

4.3 Frequency Regulator

4.3.1 The frequency regulator or alternator speed control system shall be matched with the motor of the motor-alternator set and shall be suitable for maintaining the speed of the dc motor within 1500 ± 3% rpm over the entire voltage range.

4.3.2 Adequate surge protector devices shall be provided at the input and output of the frequency regulator to avoid failure of semi-conductor components due to surges generated on the alternator and the motor control winding.

4.3.3 The frequency regulator/speed control system shall have a protective device to trip the motor-alternator set in the event of overspeed due to failure of the regulator. The device shall be in addition to the mechanical overspeed trip.

4.3.4 The components of frequency regulator shall be liberally rated with adequate safety margins to meet the service conditions and dusty environment and to provide reliability in service.

4.3.5 The termination of regulator components shall be of adequate strength to withstand vibration in service. Flexible multistrand wires shall be used for connection.

4.3.6 The components of the frequency regulator/speed control system shall be tropicalised for working under the service condition stipulated in clause 3.

4.3.7 The terminal connections on the frequency regulator/speed control system shall be suitably provided for connecting 10 mm^2 cable with crimped lugs. Proper locking arrangement of the cable lugs shall be provided preferably with spring washers and nuts.

4.3.8 The frequency regulator/speed control system shall be suitable for mounting vertically on the side-wall of the locomotive near the motor-alternator set.

provided on the motor shaft for coupling it to the alternator. The coupling shall be designed for the starting duty of the set and the continuous transmission of the rated horse-power at speeds of 1500 ± 3% rpm. The coupling shall, however, be capable to withstand frequent overspeed of the set without any deterioration. The design of the coupling shall be subject to the approval of the purchaser. The particulars of a coupling used on similar application are furnished at Annexure 6 for guidance.

4.2.20 The motor shall be screen protected, drip proof and self-ventilated.

4.2.21 The mounting arrangement of the motor, along with its alternator, shall be robust for traction duty and subject to prior approval of the purchaser. Suitable lifting arrangement shall be provided on the motor to lift it individually and on the bed plate to lift the complete set.

4.2.22 The machine and the common bed plate shall be suitably treated to remove dust and should be coated with an anti-rust primer and finished with two coats of battle-ship grey paint.

4.2.23 Marking:

.1 An anodised aluminium rating plate shall be provided on the terminal side on each equipment to show the rating, insulation, method of connection, with necessary circuit diagrams etc. The following particulars shall be clearly and indelibly marked on the rating plate:-

a) Manufacturer's name, type and model
on pulsating current
b) Direct Current (dc) and weather shunt, series or compound

c) Rated output in kW (hp) at the rated voltage

d) Rated voltage and range of voltage

e) Current in amperes, dc and pulsating both, and its range at rated output

f) Rated speed in rpm

g) Excitation voltage and current of the control or shunt winding at rated output
h) Class of insulation

j) Type of duty

.2 An arrow indicating the correct direction of rotation with the supply connected to the corresponding terminals marked on the terminal box shall be permanently fixed on the motor body.

schedule, including a list of recommended lubricants which are indigenously available, quantity of the grease to be packed initially and to be re-charged periodically.

4.2.15 Balancing: The motor armature and the fan shall be dynamically balanced both individually and together and shall have identification marks. The balancing weights shall be suitably secured and welded. The fan shall be keyed to the rotor shaft.

4.2.16 Armature construction

The armature winding shall be suitably secured and impregnated with insulating varnish to resist the action of lubricating oil and dust present in the cooling air. The winding shall be specially strengthened mechanically to resist vibration.

Normally, non-magnetic steel banding shall be used but resiglass banding may be permitted provided it is confirmed that the glass band will withstand 100% humidity and saline atmosphere at elevated temperature. The banding shall be of adequate strength and shall be able to withstand the stresses during overspeed tests and in service without any distress to armature.

4.2.17 Terminal Box: The armature and field connection of the motor shall be brought out to industrial type terminals of adequate size in a terminal box suitable for connecting the supply leads with crimped lugs. The motor leads shall be properly protected against damage to insulation in service. The terminal box of the motor shall be on the side facing the set with the motor on the left-hand side. The terminal arrangements shall, however, be subject to approval of the purchaser. All components including bolts and nuts and washers, screws, etc, shall be suitably protected against corrosion and rust.

4.2.18 Overspeed Trip Devices: A mechanical overspeed trip device of robust design for traction duty shall be incorporated on the motor to trip the motor supply in case the speed exceeds 1800 rpm. The provision shall, however, be made in the design to vary its setting between 1500 to 2000 rpm and its operation shall be stable over the entire range of speed. The tripping device, when operated, shall latch itself mechanically and shall be capable of manual re-setting. The tripping device shall be mounted at the end of the motor shaft and suitable drive arrangement shall be provided for the purpose. It shall, however, be capable of being uncoupled easily for attention without affecting the motor.

4.2.19 Coupling: A flexible coupling designed to take mis-alignment between motor and the alternator shall be

.2 The commutator shall be well seasoned so that the maximum ovality shall not exceed 0.02 mm at overspeed test. The mica shall be undercut and the segments properly chamfered.

.3 The commutator diameter, when new and fully worn-out, and its expected life shall be indicated.

.4 The commutator cone 'V' ring shall have a layer of 'Teflon' or similar material to give a fine and smooth finish and arc resistance surface.

4.2.13 Brushes and Brush Gear

.1 Brush gear and brushes shall be of suitable design for traction duty and shall give satisfactory commutation over the entire supply voltage range. Split brushes with well secured pig-tails shall be used. The brush gear shall be selected to give an adequate life.

.2 The brush grade maximum and minimum permissible height of brush and expected rate of wear of brush in mm per 1000 hours of run shall be indicated.

.3 Brush pressure shall be maintained constant over the full operating height of the brush. It shall be possible to adjust the brush pressure as and when required in service.

4.2.14 Bearings:

.1 The motor bearings shall be of suitable design for traction duty and shall be selected from the standard range of manufacturers. Deep groove ball bearings shall be used preferably in view of the vibrations experienced on the locomotives. Particulars of the bearings and calculations of estimated life shall be furnished. The guaranteed life of the bearing shall, however, be not less than 40,000 working hours.

.2 Grease nipples provided for lubricating the bearings shall be suitably extended to facilitate easy lubrication without dismantling any part of the machine. Unnecessary bends in the grease pipe shall be avoided to have free flow of grease. A vent for the flow of grease shall also be provided in the bearing housing.

.3 The quality of grease to be used on the motor shall be determined in relation to the ambient temperature and service conditions specified. The manufacturer shall supply, along with the maintenance instructions, a lubricating

4.2.4 The mechanical design of the motor shall correspond to its maximum speed reached under most unfavourable conditions of voltage and field currents. The motor shall pass the IEC tests corresponding to this speed. The general design and manufacture of the motor shall be of the highest standard in accordance with modern traction practice and robust in construction.

4.2.5 The motor shall be designed such that it shall be possible to re-start the motor any time after its contactor has tripped by the control relays in the locomotive circuit.

4.2.6 The motor shall be protected against short circuit by HRC fuse. The capacity and the specification of the fuse shall be advised. The tenderer may include this in his offer. In addition to the fuse, an over-load relay, as shown in SK.EL. 2296, has been provided in the existing scheme. The same relay may be retained in the new scheme, if desired by the tenderer. The relay settings are 200, 270 and 340 amps.

4.2.7 The motor shall have class H insulation for the armature and the field coil. The temperature rise shall be limited to the value laid down in clause 5.

4.2.8 The motor shall be self-ventilated type with a fan provided in the rotor shaft.

4.2.9 The motor and the alternator shall be mounted on a common bed plate and the complete bed plate shall form the part of the supply.

4.2.10 Commutator

.1 The commutator shall be manufactured from either high conductivity hard drawn copper or extruded tapered section silvered copper bars.

The insulating material used in this construction shall be suitably cured so that the working stresses in the copper and steel are within the acceptable limits for good mechanical stability in service.

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variations in voltage due to tripping of the traction motors on the locomotive or tripping of other locomotives on the line. Since the speed of the motor and power is practically constant, the current taken by the motor at low voltages will increase.

4.1.3 When working on ac overhead line, the supply from the tertiary winding of the locomotive transformer shall be rectified by a bridge connected silicon rectifier and smoothened by auxiliary smoothing reactor. The details of tertiary winding output are given at Annexure 2.

4.1.4 The details of the starting and operating scheme of the motor have been furnished for guidance. The manufacturer, however, may evolve his own working scheme for the motor, to suit its design and to meet the operating requirements. The full details of any alternative scheme shall be furnished along with the tender. The tenderer shall be responsible for the satisfactory working of the scheme as a whole and of all the equipments included in it.

4.2 General Design and Constructional aspects of motor

4.2.1 The motor shall be either a series or compound wound with suitable separately excited control field winding or windings fed from the frequency regulator for speed control to keep the speed of the motor-alternator set within 1500 ± 3% rpm in order to limit the frequency of ac output of the alternator within 50 Hz ± 3%.

4.2.2 A suitable starting-cum-protective resistor shall be connected in series with the motor to limit the starting current to give a satisfactory starting of the motor at the highest voltage. This resistance shall form a part of the supply and shall be continuously rated to match the operating currents of the motor over the entire working range. The resistance shall be naturally cooled.

4.2.3 The starting torque of the motor shall be sufficient to accelerate the motor-alternator set to full speed within 5 seconds over the entire supply voltage range.

3.2 The equipment and its mounting arrangement shall be of robust design for traction duty and shall withstand satisfactorily the vibrations and shocks normally encountered in service, as indicated below:-

a) Maximum vertical acceleration	1.0 g
b) Maximum longitudinal acceleration	3.0 g
c) Maximum transverse acceleration	0.5 g
d) Maximum frequency 10 Hz with amplitude of 2.5 mm	

(g being acceleration due to gravity)

3.2.1 The vibrations are of sine wave form and the frequency of vibration is between 1 Hz and 50 Hz. The amplitude a, expressed in millimetres is given as a function of f, by the equations :-

$a = \frac{25}{f}$ for values of f from 1 Hz to 10 Hz

$a = \frac{250}{f^2}$ for values of f exceeding 10 Hz and upto 50 Hz.

3.2.2 In the direction corresponding to the longitudinal movement of the vehicle, the equipment is subjected for 2 min to 50 Hz vibrations of such a value that the maximum acceleration is equal to 3 g (amplitude a = 0.3 mm).

4. GENERAL DESIGN AND CONSTRUCTIONAL ASPECTS

4.1 Power Supply to the Motor

4.1.1 The present arrangement of supply to the motor and its starting scheme are given in drawings No. SK.EL.2296 and SK.EL. 2300 enclosed. The dimensions of the alternator and common bed-plate are given in drawing No. (to be supplied by Chittaranjan Locomotive Works). The ratings of the alternator (Kirloskar make) are furnished at Annexure 1. The motor overall dimensions shall not exceed those given in drawing (Chittaranjan Locomotive Works to furnish).

4.1.2 When operating on dc overhead line, the supply to the motor is taken directly from the overhead line and the line voltage varies from 1000 V to 1800 V and is subject to line surges and sudden

2. CAPACITY AND RATING

2.1 Motor

HP rating	:	210 hp at 55°C ambient continuous
Voltage	:	1400 V dc/pulsating current nominal varying between 1000 V to 1800 V (working range) and occasionally dropping to 800 V for short periods of few seconds.
Speed	:	1500 ± 3% rpm maintained by frequency/speed regulator
Ripple factor	:	The motor shall be capable of operating satisfactorily with the ripple factor obtained from the auxiliary smoothing reactor over the entire working range of voltage and currents.
Capacity	:	The motor shall be capable of delivering its full rated output continuously within the prescribed limits of speed and over the entire working range.

2.2 Frequency Regulator

2.2.1 The frequency regulator shall be suitable for maintaining the speed of the dc motor within ± 3% of its rated speed over the entire working range.

2.3 Auxiliary Smoothing Reactor

2.3.1 The smoothing reactor shall be suitable for the currents drawn by motor under various conditions of operation and for reducing the ripple content of rectifier output to match the operating requirements of the motor over the entire working range.

3. SERVICE CONDITIONS

3.1 The motor covered in this specification shall be suitable for service in ambient temperature varying from 0°C to 55°C, relative humidity ranging upto 100%, at an altitude of 1000 metres above mean sea level and in dusty atmospheric conditions.

SPECIFICATION FOR MOTOR - FREQUENCY REGULATOR - AUXILIARY SMOOTHING REACTOR FOR WCAM1 CLASS LOCOMOTIVES

0. FOREWORD

0.1 This specification covers the supply of three items, i.e., the motor of motor-alternator set, frequency regulator and the auxiliary smoothing reactor for dual voltage system 25 kV ac, 50 Hz/1500 V dc electric locomotives.

0.2 The motor is directly coupled to the alternator which supplies 400 V, three phase, 50 Hz, ac power to the induction motors driving various auxiliaries of the locomotive. Under dc system of supply, the motor is directly fed from the line while under ac supply system, the motor is fed at pulsating current through a transformer, auxiliary rectifier and auxiliary smoothing reactor.

0.3 In the preparation of this specification, assistance has been derived from the following specification:-

IEC Publication No. 349 - Rules for auxiliary machines on motor vehicles.

0.4 This specification contains certain clauses requiring agreement between the purchaser and the supplier based on technical information furnished by the manufacturer at the time of submitting the tender.

0.5 Any deviations from this specification, calculated to improve the performance, utility and efficiency of equipment, proposed by the manufacturer, will be given due consideration, provided full particulars with justification thereof are furnished in the tender.

1. SCOPE

1.1 This specification covers the manufacture, supply and tests on the motor of the motor-alternator set, frequency regulator and ripple current auxiliary smoothing reactor. The scope of supply shall also include the supply of associated starting contactor, starting resistor, if used, protective fuse and any other equipment required for the satisfactory working of the motor. The tenderer shall check the suitability of the existing alternators for the system design. If found unsuitable, he shall quote for the alternator also, giving reasons for his alternative choice, and furnish complete technical details and proposed test programme for alternator along with the tender. The tenderer shall furnish cost of individual items in the quotation.

S. No. SPECIFICATION No.SPEC/E-10/6/02

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(RAILWAY BOARD)

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MOTOR OF MOTOR ALTERNATOR SET
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Issued by
RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW-226 011

11.1.8 The type tests will be conducted in the presence of railway representative. Any modification in test conditions required by the supplier shall be subject to the prior approval of the Railway representative.

11.2 TESTS ON MOTOR

Type Tests	Routine Tests
11.2.1 Preliminary checking	
Check and verify the proper terminal connection, brush holder setting and free movement of the rotor without any noise at the bearings. The ovality of the commutator of the motor shall also be measured and recorded.	Same as type test
11.2.2 Direction of rotation	
Check and verify that the direction of rotation of the motor is as per marking on the motor.	Same as type test
11.2.3 Measurement of resistance	
The resistance of the various windings shall be measured by Kelvin Bridge method or by voltage drop method. The measured values shall be corrected by calculation for temperatures of 25°C and 110°C. For this purpose, the machine shall be left in stand-still condition for 12 hours before the measurement. The value of measuring current, in case of voltmeter ammeter method, shall not exceed 5% of rated current.	The measured resistance of the various windings (cold) corrected to 25°C shall not differ by more than ± 5% average of the values derived from the tests on first ten motors.
11.2.4 Measurement of Impedance	
The measuremont of impedance at 50 Hz shall be made on the various windings of the motor separately and next connected together in series. Voltage, frequency and current shall be recorded.	

11.2.5 Measurement and separation of no-load losses

This test shall be conducted with direct current and pulsating current on the motor to plot the saturation curve upto the maximum excitation current anticipated. No-load losses upto 1800 v line voltage and maximum excitation current shall be computed.

11.2.6 No-load characteristics

The characteristics shall be deduced from the above no-load test.

11.2.7 Temperature Rise Test

(a) Continuous heat run test on pulsating current.

The motor shall be arranged for normal operation at rated voltage and continuous rated current with designed ripple factor as obtained with the auxiliary smoothing reactor. The temperature rise test shall be conducted in the following sequences:-

a) Test for 1 hour at 1400 V line voltage
b) Continue test (a) for ascertaining the maximum temperature rise
c) Test for 1 hour at 1000 V line voltage
d) Test for 1 hour at 1800 V line voltage

At the end of each of the above tests, the temperature rise of each of the windings commutator, bearings, maximum temperature of the body core, cooling air inlet and outlet shall be measured and recorded. The time interval between the successive tests shall be limited to 5 minutes. The temperature rise shall not exceed the limits specified.

(b) One hour rating test on pulsating current

The test shall be carried out at the rated/system voltage and one hour rated current of the motor in the same manner as in (a).

(c) Continuous heat run test on dc

The test shall be carried out as in (a) but on dc supply only.

(d) One hour rating test on dc

The test shall be carried out as in (b) at dc supply only.

Same as in type test (d). The temperature rise shall not exceed the limits and also shall not vary more than ± 8% from the declared value during type test.

11.2.8 Load Test

Immediately after the temperature rise test, load test at input system voltages of 1800 V, 1400 V and 1000 V shall be conducted to determine the characteristics of the motor under various load conditions at constant speed of 1500/rpm. The load current shall be varied from no-load to 1.5 times the full load current in steps of 25% and corresponding field excitation recorded. Current in the control field winding shall also be recorded in each case. The curves of torque, shaft horse power and efficiency as a function of load current and for different conditions of excitation and supply voltages specified above shall be plotted.

/± 3%

Immediately after the 1 hour rating temperature rise test, load test shall be carried out as in the type test at rated/voltage. This will/system enable the characteristic values (efficiency expected) of each machine to be compared, at rated current, with the corresponding values of the type tests. For this current, the individual values shall not depart by more than ± 5% of the type test values.

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11.2.9 Over-speed Test

This test shall be done on the machine for 2 minutes when the machine is hot. The motor shall be capable of withstanding a rotational speed of 1.35 times its maximum speed. After this test the machine shall not show permanent deformation. The ovality shall be checked and recorded. It shall not exceed more than 0.03 mm.	Same as type test.

NOTE*

11.2.10 Commutation Test

With direct current

These commutation tests shall be conducted after the over-speed tests in addition to the record of commutation during the determination of characteristics test No.3	The motor shall withstand for 1 min, at system voltage of 1800 V, a current equal to 1.5 times the current corresponding to its rating.

The test shall be carried out with machine when hot for a period of 30 seconds at 1000, 1400 and 1800 voltages. The test shall be carried out at several values of currents and excitations covering whole range of traction application (10 A to 1.5 times rated current and zero to maximum current for control excitation).

With pulsating current

The test shall be conducted at actual pulsation frequency and ripple factor at 1.1 times the rated voltage of the motor and for several values of current covering the whole range of traction application.

The machine shall withstand the commutation test without mechanical deterioration, flashover or permanent damage.

(*) NOTE: Maximum speed of motor corresponds to the speed obtained during starting under most unfavourable conditions.

11.2.11 Black Band Commutation Test

The test shall be conducted by a standard method to determine the zone of "Black" commutation for full operating range of voltage and current of the motor.

11.2.12 Dielectric Test

The test shall be carried out with the machine hot and after the tests specified in the preceding section. The test voltage shall be alternating and, as nearly as possible, of sine wave form, frequency being 50 Hz.

Same as type test.

The test voltage of rms value 2.25 u + 2000 V (where u = 1800 V) shall be complied for a period of 1 minute between windings of each circuit and the frame with the windings of other circuits connected to the frame. The test shall be conducted as per clause 41 of IEC-349. The insulation resistance of the machine shall be measured before and after the test and there shall be no appreciable difference between the two values.

11.2.13 Weighment (Type Test only)

After all the above type tests, the motor shall be inspected for any damage or abnormality and then the motor weighed in working order.

11.3.10 Impact or shock test

This test shall be carried out in accordance with IS:2106 (Part VIII)-1964. At the end of the test the regulator shall be inspected for any loose connections and then subjected to electrical performance test. The regulator shall function normally.

11.3.11 Insulation resistance test

The insulation resistance between all the terminals and earth shall be measured with a 500 v meggar and it shall not be less than 1 M ohms.

Same as type test

11.3.12 High voltage test

Before conducting this test, insulation resistance shall be measured initially. A voltage of 2.5 kV rms shall be applied between all the terminals and the frame for 1 minute. There shall be no damage whatsoever during the test.
After the high voltage test, insulation resistance shall be measured again. There shall be no appreciable difference between the insulation resistance values measured before and after the high voltage tests.

Same as type test

11.3.13 Regulation test

The regulator shall be connected to the motor alternator set for normal working. The system supply voltage shall be set at 1400 V pc. The alternator output frequency shall be set to 50 Hz by means of the regulator adjustments at no load. The alternator is then loaded to its full capacity and the supply voltage of the system shall be varied from 1000 V pc to 1800 V pc. The alternator output frequency shall be within 50 Hz ± 3% during the test. The test shall be repeated with dc voltages.

Same as type test

11.4 TESTS ON AUXILIARY SMOOTHING REACTOR

11.4.1 The tests specified are to be conducted at the manufacturer's works and based on the latest IEC-310 Publication for "Traction transformer and reactor". The temperature rise limits stated in the above publication shall be reduced by 25°C to cater for higher ambient temperature in India. Any deviation from the test programme given here shall be mutually agreed to between the purchaser and the manufacturer.

11.4.2 Tests are classified as type tests and routine tests. Type tests shall be carried out on one reactor, while routine tests shall be carried out on each reactor.

11.4.3 Preliminary checking and measurements

Type test	Routine test
11.4.3 Preliminary check	
A check shall be made on the terminal markings, polarity and the particulars of the rating plate for correctness.	Same as type test
11.4.4 Measurement of winding resistance	
The resistance of the winding is recorded with direct current at ambient temperature, usual care being taken to minimise self-inductive effects. The measured values shall be corrected by calculation for temperature of 115°C and 25°C.	The measured resistance shall not differ by ± 10% from the declared resistance value.
11.4.5 Measurement of inductance	
This test shall be carried out with pulsating current at 100 Hz. The current shall vary from 0 amps to max. amps in the steps of 25 amps and the inductance shall be recorded. A curve shall be plotted with inductance (in millihenry) vs. current, as the absciss a. Another curve shall be drawn with impedance vs. current. While doing this test the condenser shall be disconnected.	The test shall be carried out with ac at 50 Hz. frequency as per the type test.

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11.4.6 Determination of losses

I^2R loss shall be recorded at rated current and rated voltage and shall be corrected for resistance of the reactor at the reference temperature specified in IEC-310(Clause 22)

11.4.7 Oscillographic test

Oscillograms of the form of voltage and current at the terminals shall be recorded on a time basis while passing various values of currents at various voltages.

11.4.8 Temperature Rise Tests

Rated current at rated voltage of pulsating nature shall be passed through the reactor and temperature rise of the winding and the different parts of the core shall be measured.

Winding temperature shall be recorded at 10 minutes interval till the temperature has attained a steady value for consecutive 3 readings. The temperature shall not exceed the IEC values reduced by 25°C.

Hot spot temperature on the windings shall also be measured by thermocouples. The test shall also be conducted on its 1 hr. rating as above and the temperature shall be recorded.

The test shall be carried out at rated current and rated voltage for one hour rating and temperature shall be recorded.

11.4.9 Di-electric test

The tests shall be carried out in accordance with clause 33 of IEC-310.

The test shall be conducted as per type test.

11.4.10 Weighment

The weight of the smoothing reactor in working order shall be measured and recorded after the tests are completed.

11.5 Running Test on complete motor-alternator system

11.5.1 Test to check that the system is in good running order

The tests to ensure that the assembled system is in running order shall be carried out either on the test bed or on the motive power vehicle. The motor and the alternator system shall be arranged for normal working with all components/parts in position, including starting resistor, contactor and protective devices, if any in the motor. It shall also be ensured that the system gives its normal output under the conditions specified.

After 10 starting tests of 2 minutes interval at full load (of which 5 shall be made at 1800 V and 5 at 1000 V pulsating current), it shall be confirmed that the motor does not attain a temperature rise higher than specified. The commutation shall remain satisfactory during the tests and the commutator shall not show any traces of burning.

These tests shall include three starting tests at 2 minutes interval at full load and maximum system voltage. The last start shall be immediately followed by a 5-minute run under rated condition. The motor shall satisfy the requirements of the type tests.

11.5.2 Interruption and Restoration of voltage test (Type Test only)

The tests shall be carried out on the motor with the resistor and protective gear (if permanently connected) in the circuit simulating the conditions in normal service, both on the test bed and on the motive power vehicle. If, for the test bed, the alternator is not available, an equivalent inertia load shall be coupled to the motor for the purposes of the test.

The supply shall be interrupted and restored five times in succession, allowing

the normal load conditions to re-establish between successive interruptions, the system operating at its maximum voltage and rated load. The time interval between the instants of interruption and restoration of supply shall be approximately 1 second. The motor shall withstand the tests without mechanical deterioration or flashover or permanent damage to the commutator. The test results shall be recorded oscillographically.

11.5.3 Test on sudden variation in the supply voltage to motor

This test shall be made by means of an appropriate resistance connected in series with the motor and provided with a short circuiting switch. This switch shall be opened 10 times and closed 10 times @ 1 operation every 5 seconds, so that the voltage at the terminals of the system varies between the maximum (1800 V) and minimum (1000 V). The motor shall withstand the tests without mechanical deterioration or flashover or permanent damage to the commutator of the motor. The test results shall be recorded oscillographically.

11.5.4 Short Circuit Test for compound-wound motor (Type Test only)

The system shall be fed at 1800 V pulsating current on no-load. When the stable conditions are obtained, the supply circuit shall be rapidly opened and the motor, immediately thereafter, short circuited, the motor, however, being protected by the equipment (relays in the circuit breaking devices, permanent and starting resistors), with which it is normally provided. The test shall be carried out twice at 5 minutes interval. This test shall also be repeated for dc operation

of the motor. The motor shall withstand all these tests without mechanical deterioration or permanent damage to the commutator. The test results shall be recorded oscillographically.

11.5.5 Starting Time Test (Type Test only)

The motor-alternator system shall be arranged for normal working. The motor-alternator system shall be started at the following supply voltages:-

1800 V pulsating current

1400 V pulsating current

1000 V pulsating current

The starting time of the unit to come up to full speed from zero speed shall be measured oscillographically. Record final load current and voltage ratings.

11.5.6 Endurance Test

The motor-alternator system shall be arranged for normal working order and the set running continuously for 48 hours at the rated load conditions. The system shall perform satisfactorily without exceeding the temperature rise of the various windings and other components and shall not show any signs of deterioration in regard to specially the commutation of the motor.

11.5.7 Oscillographic Test

The motor-alternator, frequency regulator and smoothing reactor shall be arranged for normal working conditions. Oscillographic tests shall be conducted so as to record the behaviour of motor armature current, speed of the set, alternator voltage, ripple content of smoothing reactor under various conditions of operation of the system, i.e., starting and running at minimum, rated and maximum voltage.

RNS
15.2.75

Annexure - I

Particulars of Alternator

Continuous output -	220 KVA, 3 phase, 50 Hz at 0.8 P.F. lagging derated to 180 KVA for an ambient temperature of 55°C and a depression of 25 mm water gauge for cooling air.

Output voltage at various loads varies within ± 7% of 400 V over the speed range of 1500 rpm ± 3%.

Transient voltage rise at alternator output terminals when full load is thrown off	20%
Direction of rotation	Anticlockwise when viewed from the driven end.
Mounting dimensions	
Lengthwise	518.00 mm
Widthwise	674.00 mm
Shaft size	80 mm
Shaft extension	170 mm
Weight of the alternator	Bar wound alternator's weight to be given by CLW

Annexure - 2

Particulars of auxiliary winding of locomotive transformer on ac/dc locomotives.

Rating :

No load voltage at	17.5 kV	=	1142 Volts
Overload catenary	19 kV	=	1240 "
voltage of :	22.5 kV	=	1470 "
	25 kV	=	1630 "
	27.5 kV	=	1800 "

Annexure - 3

Schedule of particulars for dc Motor of the Motor-Alternator set

1 Type, Model and make

2 Nominal voltage

3 Rated speed (rev/min)

4 Continuous rating (HP/kW)

5 Rated current -

a) at rated voltage (1400 V)

b) at minimum voltage (1100 V)

6 Class of insulation -

a) Armature

b) Field

7 Type of enclosure

8 Method of ventilation

9 Material specification of the motor ventilating fan

10 Cooling air temperature assumed in the design of the motor

11 Amplitude of vibration of the motor (as per Indian Standards)

12 Type and particulars of the terminal box and cable entry used (enclose sketch)

13 Type and make of bearings, their estimated life and maximum bearing clearances

14 Recommended grease (specify IOC grades), frequency of regreasing and quantity of grease

15 Weight of the rotor

16 Weight of the motor

Contd.

Design Particulars

17 Main Dimensions

a) Dia of armature

b) Gross core length mm

c) Ducts (number and width)

d) Iron length

e) Air gap length

f) Depth of core below slots

g) Commutator dia

h) Commutator length - effective

18 Armature

a) Type of winding connection and number of parallel paths

b) Number and size of slots

c) Number of conductors per slot

d) Coil pitch

e) Conductor size, covering and cross sectional area

f) Slot insulation details

g) Overhang insulation details

h) Inter layer insulation details

j) Current density in amperes/mm^2

k) Ampere turns per pole

l) Resistance at $20^{\circ}C$

19 Field

a) Number of main poles

b) Dimensions of main pole

c) Dimensions of interpole

Contd.

d) Size, covering, cross sectional area of

i) main pole conductor

andii) interpole conductor

e) Resistance per pole of

i) Main field winding at 20°C

ii) Interpole winding at 20°C

f) Permanent field shunt, if any

g) Field ampere turns per pole

20 Commutator

a) Dia of commutator

b) Length of commutator

c) Number and size of commutator segments

d) Commutator surface per pair of poles

e) Commutator pitch

f) Insulation thickness

g) Commutator factor

h) Time of commutation

j) Voltage per bar

k) Reversal of current per milli second

21 Brush

a) Grade

b) Dimensions (Length x Width x Thickness)

c) Current density A/cm^2

d) Brush pressure kg/cm^2

e) Number of sets of brush holders

f) Number of brushes per holder

Contd.

22 Banding

a) Material specification

b) Number of turns on commutator end

c) Number of turns on evolute end

d) Diameter of banding wire

e) Tension of banding wire in kg

23 Design parameters

a) Specific magnetic loading (Wb/m^2)

b) Specific electric loading (amp. conductors/ metre)

c) Air gap flux density (wb/m^2)

d) Ratio $\frac{\text{Field AT}}{\text{Armature AT}}$

at full field

e) Specific power (watts/cm^3)

f) Frequency of flux reversal

g) Ratio of flux density in air gap to current density in arm conductor

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Annexure - 4

Schedule of particulars for Frequency Regulator

(Note: Submit detailed drawings wherever necessary)

1. Type, model and make
2. Nominal voltage and frequency
3. Speed regulation
4. Class of insulation
5. Type of enclosure
6. Particulars of terminal connection and cable entry used.
7. Weight of the equipment
8. Range of the voltage and frequency
9. Circuit diagram and description and its application in the motor alternator system.
10. Mounting arrangement details with drawing.
11. Details of circuit components used.

Annexure- 5

Schedule of particulars for smoothing reactor

GENERAL

1. Type, model and make
2. Maximum continuous
   - Current — amps.
   - Voltage — Volts
3. Class of insulation and its details
4. Short time duty cycle rating
5. Self-inductance at
   - rated current
   - saturation
   - short circuit conditions
6. Calculations for arriving at the value of inductance for the designed ripple factor against mean current.
7. Overall outline dimensions and mounting details with drawing.
8. Assembly drawing of the smoothing reactor
9. Total weight of each unit in working order

WINDING

1. Size of individual conductor
   - Thickness — mm
   - Width — mm
2. No. of conductors in parallel
3. Sectional area — mm^2
4. Current density — amp/mm^2
5. Total number of effective turns
6. Insulation between core and conductors

CORE

1. Quality of the material
2. Sectional area
   - Gross — mm^2
   - Net — mm^2
3. Thickness — mm
4. Flux density — Gua
5. Power loss — Watts

TEMPERATURE RISE

1. At rated current
   - Winding — ^oC
   - Core — ^oC
2. At one hour rating
   - Winding — ^oC
   - Core — ^oC

CHARACTERISTICS

1. Current in amps vs. flux curve
2. Inductance vs. current curve upto 1.7 times the motor current
3. Resistance of winding at 25^oC

Annexure - 6

Schedule of particulars of the cushion couplings used on similar Motor-Alternator sets.

(For Guidance only)

1.	Make	M/s. J.H.Fenner & Co. (India) Ltd., 56-D, Free School Street, Calcutta.
2.	Type	FM-17 coupling
3.	Maximum bore	125 mm
4.	Maximum speed	2000 rpm
5.	HP/rpm	21
6.	Maximum starting torque	3110 lbs-ft
7.	Limits of angular misalignment	3^{o}
8.	Limits of parallel misalignment	1/16"
9.	Limits of end float	5/16"
10.	Recommended service values for 7, 8 & 9 above	1.5