

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION
FOR
TRACTION ALTERNATOR
FOR
AC-DC BG DIESEL ELECTRIC LOCOMOTIVE

SPECIFICATION NO. MP.O.2402.14
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TECHNICAL SPECIFICATION FOR TRACTION ALTERNATOR
FOR 3100 HP
AC-DC BG DIESEL ELECTRIC LOCOMOTIVE

1.1 FOREWORD

1.1.1 This specification covers the design, manufacture, testing, supply and commissioning of traction alternator and associated parts for use on 3100HP BG diesel electric locomotives.

1.1.2 The traction alternator covered by this specification is, in the first instance, for use on various High Power High Speed BG DE locomotive namely WDM2C, WDM1, WDP2 etc.

1.1.3 The drive for the traction alternator is obtained from diesel engine by coupling it directly with the engine crank shaft.

1.1.4 The assembled alternator offered against this specification shall be freely interchangeable with the existing alternators on WDM2 locomotives in respect of physical dimensions and mounting.

1.1.5 In the existing system a gear box is mounted on the slip ring end of the alternator to provide a means of mounting the auxiliary generator, exciter and PTU. The alternator covered by this specification shall be provided with a bull gear on the rotor shaft and a gear box such that the existing auxiliary machines and PTU can be mounted on gear box and driven by the existing gear and pinion drive.

1.2 SCOPE

1.2.1 The traction alternator shall be supplied complete with bull gear, gearcase and along with any other accessories that may be required for its correct assembly and commissioning as well as reliability and maintainability on the locomotive. The tenderers shall however indicate the price of bull gear and gearcase separately.

1.3 GOVERNING SPECIFICATION

1.3.1 In preparation of this specification, assistance has been taken from IEC publication 349. The

equipment offered under this specification shall generally conform to IEC publication 349 with a specific variation in that, on account of higher ambient temperatures obtainable in India, the temperature rise specified in IEC recommendation shall be suitably reduced.

1.3.2

In case any deviation is proposed from the relevant International Standards or from this specification, the standards followed in the design, manufacture, assembly and testing of these equipment, shall be clearly indicated by the tenderer. In the absence of any such indication, it shall be assumed that the offer complies fully with this specification.

1.3.3

Any deviation from this specification, incorporated by the tenderer to improve the performance, durability, reliability and maintainability of the equipment or to reduce its cost significantly, may be favourably considered provided full particulars of the anticipated benefits along with technical data supported by drawings and calculations, are furnished in the tender offer.

1.3.4

The tenderer will furnish English version of all those standard specifications referred to in their tender offer but not called for in this specification.

1.4

SCHEDULE OF PARTICULARS, DRAWINGS AND AS-MADE TRACINGS

1.4.1

The tenderer shall furnish all relevant design data, calculations, technical specifications, test results, and relevant equipment drawings, and descriptive write-up etc. necessary for correct appreciation of the offer. The technical data and alternator particulars shall be generally in line with the proforma given in the Test Programme No.MP.TP - 032(Rev.1) March, 94. As many of these data as would be relevant and applicable should be incorporated in the corresponding drawings themselves.

1.4.2

Complete manufacturing drawings will be supplied, after acceptance of the tender, for the replaceable wearing out components such as rotor shafts, slip ring, bearing housing, end fittings, brush holders, carbon brushes, rubber components, insulations scheme of rotor & stator assemblies etc.

1.4.3 The successful tenderer shall prepare and submit to the purchaser complete working drawings in duplicate for scrutiny and approval of the purchaser, i.e. Indian Railways/RDSO, before taking up manufacture of the equipment.

1.4.4 Approval of the drawings would mean approval of general adaptability of design features to local conditions of service. The purchaser, i.e. Indian Railways will not be responsible for the correctness of the dimensions in the drawings, the material used, the adequacy of the designs for the satisfactory performance of the equipment, etc. for which the supplier will be wholly and completely responsible.

1.4.5 Photographs shall be taken at various stages of manufacture and assembly of the traction alternator and included in the Maintenance Manuals.

1.4.6 After all drawings have been finalised including any modifications found necessary as a result of prototype testing and trials, five complete sets of 'as made' tracings shall be supplied for use of the Railways and RDSO and shall include fully dimensioned drawings of all assemblies, sub-assemblies, component parts including proprietary fittings.

1.4.7 The drawings of the traction alternator and components shall be fully detailed and self explanatory. All important dimensions shall be figured. The drawings shall contain all essential data, material specifications, explanatory notes including limiting values in service etc.

1.5 SPARES AND TOOLS

The successful tenderer shall submit a list of spares required for the operation and maintenance of the traction alternator with any accessories as offered by them.

1.6 MAINTENANCE MANUALS

1.6.1 Maintenance manuals complete with necessary drawings and photographs for guidance in the installation, operation and maintenance of traction alternator shall be supplied free at the rate of one manual for each alternator.

1.6.2 Rewinding/Rehabilitation of the traction alternators shall be taken up by Railway units whenever necessary after expiry of warranty. Complete technical information shall be provided by the successful tenderer in the form of 'Rewinding Manual' for satisfactory rewinding/rehabilitation of the traction alternators.

1.6.3 A lubrication chart shall also be enclosed containing the manufacturer's recommendations on indigenously available lubricants, quantity and periodicity of lubricants, etc.

1.7 TESTING, COMMISSIONING AND PROTOTYPE TRIALS

1.7.1 The traction alternator and its accessories covered by this specification shall be subjected to type and routine tests at the manufacturer's works before shipment/dispatch, in the presence of an Indian Railways' representative, as per a test programme conforming with the test programme no. MPTP - 032(Rev.-1), March, 1994 (copy enclosed). All the tests given in this test programme shall be carried out except in case RDSO is satisfied that a particular test is not required.

1.7.2 One prototype alternator after tests will be first dispatched to examine its correct fitment on any of the 2600HP or 3100 HP locomotives namely WDM2, WDM2C, WDG1 or WDP2 and any modifications if required will be checked up and carried out accordingly by the manufacturer.

1.7.3 This locomotive will be subjected to extensive service trials for a period of three months or more as deemed necessary by the purchaser to prove the design, equipment performance, maintainability and reliability. All modifications found necessary based on these limited service trials to improve upon the alternator design and physical construction and as mutually agreed shall be incorporated in the prototypes and in the series supplies of the equipment, at the cost of the supplier and in the manner approved by the purchaser. The service trials shall generally cover the following :-

- i) Observations of the mechanical and electrical condition of the equipment including wear and tear.
- ii) Temperature rise of the various parts of alternator.
- iii) Overall reliability and maintainability aspects

- 1.4.3 The successful tenderer shall prepare and submit to the purchaser complete working drawings in duplicate for scrutiny and approval of the purchaser, i.e. Indian Railways/RDSO, before taking up manufacture of the equipment.
- 1.4.4 Approval of the drawings would mean approval of general adaptability of design features to local conditions of service. The purchaser, i.e. Indian Railways will not be responsible for the correctness of the dimensions in the drawings, the material used, the adequacy of the designs for the satisfactory performance of the equipment, etc. for which the supplier will be wholly and completely responsible.
- 1.4.5 Photographs shall be taken at various stages of manufacture and assembly of the traction alternator and included in the Maintenance Manuals.
- 1.4.6 After all drawings have been finalised including any modifications found necessary as a result of prototype testing and trials, five complete sets of 'as made' tracings shall be supplied for use of the Railways and RDSO and shall include fully dimensioned drawings of all assemblies, sub-assemblies, component parts including proprietary fittings.
- 1.4.7 The drawings of the traction alternator and components shall be fully detailed and self explanatory. All important dimensions shall be figured. The drawings shall contain all essential data, material specifications, explanatory notes including limiting values in service etc.
- 1.5 SPARES AND TOOLS
- The successful tenderer shall submit a list of spares required for the operation and maintenance of the traction alternator with any accessories as offered by them.
- 1.6 MAINTENANCE MANUALS
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- Rainfall : Very heavy in certain areas.
- Atmosphere during hot weather. : Extremely dusty and desert terrain in certain areas.
- Coastal area : Locomotive and equipment shall be designed to work in coastal areas in humid and salt laden atmosphere.

3.0 SYSTEM AND SERVICE CONDITIONS

3.1.0 A three phase synchronous alternator separately excited through the DC exciter mounted on the alternator gearbox of 3100 HP locomotive shall be offered. The alternator stator shall be provided with the main 3 phase AC winding, while the rotor shall consist of the main excitation field winding.

3.1.1 The alternator offered shall be mounted directly on the diesel engine by bolting the stator on engine block. The rotor shall be coupled rigidly with the engine crank shaft on the drive end and shall therefore be supported by the crank shaft bearing at this end. On the non drive end an end shield shall be provided and the rotor supported on a bearing. The drawing no. SK.DP - 3287 showing the relevant details of engine block and crank shaft flange is attached. In this arrangement, the engine crank shaft supports approximately half the weight of the rotor while the other half is supported on alternator bearing.

3.1.1.1 While the diametrical limitation is as given in the drawing quoted above, the total length of the alternator measured between the crank shaft flange face and slipping end alternator gear box face should not exceed 1069mm.

3.1.2 The excitation to the rotor winding shall be supplied by the exciter mounted on the gear box and directly driven by the alternator through gear train. The exciter used, which is not a part of supplies against this specification, shall be of BHEL make type AG 2702 AZ whose rating is given in Annexure A. This exciter supplies a variable amount of excitation current for control of alternator output as per the pre-determined settings, the exciter field itself being fed with DC output from E type excitation control system fitted on 2600 HP and 3100 HP diesel electric locomotives.

3.1.3 The system shall be designed for a high voltage high current operation such that the alternator is

designed for a voltage at rated engine output of the order of 1130 V on HV point and continuous current operation of the order of 3750 Amps. on LV point.

3.1.4 The alternator weight complete with gear box, bull gear and accessories if any shall not exceed 6400 kg. However the weight of the alternator alone shall also be indicated and it should not exceed 5300 Kg.

3.2 The traction alternator offered shall be used primarily on a 3100 HP locomotive fitted with six traction motors type BHEL 4906 AZ. The motor connections across the alternator shall be 2S-3P at start transitioned to 6P at a suitable road speed. The desired alternator characteristics on full load at top RPM after rectification by a three phase rectifier shall be as given in Annexure B. The desired TE Vs Speed curve obtained with the above system is given in Annexure C. The characteristic curve of TM 4906 AZ is placed at Annexure D.

3.2.1 The desired alternator characteristics is obtained on the existing BHEL alternator with the alternator field current as plotted in the Annexure B. The alternator rotor resistance and impedance value at 25 deg.C is 0.312 ohms. and 9.5 ohms. respectively. It is necessary that the traction alternator offered should be so designed that the desired characteristics are obtained without changing the field current level obtained by existing exciter alongwith the E type control system.

3.3 The traction alternator offered may also be used on 2600 HP WDM2 locomotives provided with BHEL DC generator 10931, BHEL AC alternator 10102 AZ & AY, GE DC generator GT-586 and GE(Canada) alternator GTA-11. The representative alternator and tractive effort curve for these applications is given in Annexure B and C. This system is provided in the motor field weakening also and three transitions are provided changing the motor connections from 2S-3P to 2S-3P WF to 6P to 6P WF. The field is reduced to 49% FF in WF configuration.

3.4 Matching of the traction alternator offered with the systems detailed above shall be done so that

- a) Transition speed can be selected to ensure smooth transition without considerable jerk or current jumps in machines.
- b) Maximum attainable speed is 160 kmph or more with a 22: 61 gearing on the traction motor.

- c) Continuous locomotive speed is not above 30 kmph.
- d) The alternator current does not exceed 3750 amps. at any speed above the continuous speed specially at the backward transition stage.

3.5 The alternator shall be designed such that its output when rectified by a three phase bridge rectifier does not result in a ripple factor more than 5 - 6%

3.6 The temperature of the cooling air at the inlet of the traction alternator shall be 55 deg. C maximum with relative humidity varying upto 100% saturation.

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

Maximum vertical acceleration	1.0 g
Maximum longitudinal acceleration	3.0 g
Maximum transverse acceleration	0.5 g

3.8 The maximum service speed of the diesel engine with which these alternators may be used is 1050 rpm. However, the alternator offered should be mechanically and electrically capable of trouble free operation upto a service speed of 1100 rpm.

3.9 The tenderer may also offer a alternator of a superior design which may not be fully interchangeable with the existing alternators but would fit on the existing locomotive, to be powered from the existing engine without any modification in the existing diesel engine and with minor modifications in the locomotive under-frame.

3.10 The tenderer should preferably may offer a standard and well proven alternator which is in current production. Full particulars regarding the number of units in service and present application rating should be submitted for such a alternator.

4.0 DESIGN, MATERIALS AND RATING

4.1 GENERAL

4.1.1 Easy access for inspection and maintenance requiring minimum attention shall be given special consideration in the design and layout.

The materials used as insulations for the components shall be non-combustible and non-hygroscopic.

ic and shall withstand the service conditions specified.

- 4.1.2 Standard metric hardware shall be provided.
- 4.1.3 All nuts and screws shall be securely locked and shall not loosen in service due to the excessive vibrations to be met in service.
- 4.1.4 All hardware components including bolts, nuts, washers and screws etc., shall be suitably protected against corrosion and rust.
- 4.1.5 Wherever welding is done, the welded portion will be finally ground off to give a smooth finish and to remove the notch effect at the toes of the welds. Fillet welds as far as possible would be avoided and butt welding shall be preferred.
- 4.1.6 All normal wearing and consumable items such as carbon brushes, roller bearing /gearing lubricating oil etc shall be selected to the same grades/specifications as are already in use on the existing stocks on Indian Railways.
- 4.1.7 Clearances and creepage distances shall conform to the values given in table below. In case it may not be possible to comply with these values at some locations due to restriction of space, etc., adequate insulation shall be provided at such locations. Use of protective coatings such as varnishes etc., shall not warrant reduced clearances and creepage distances.

CLEARANCE AND CREEPAGE DISTANCES

	Air clearance	Creepage distance
Clean	15	40
Dirty	25	55

4.2 STANDARD SPECIFICATIONS FOR DESIGN

In addition to IEC - 349 following is the list of Standards referred to in this specification for design and performance of the traction alternator.

*IEC50 Definition terminology.

- IEC 216 (I & II) Guide for the determination of thermal endurance properties of electrical insulating materials, Parts I & II.
- IEC 349 Rules for rotating electrical machines for rail and road vehicles.
- IEC 505 Guide for the evaluation and identification of insulation systems of electrical equipment.
- IEC 563 Permissible limiting temperature in service for components of electrical equipment of traction vehicles.
- IEC 165/1963 Rules for the testing of electric rolling stock on completion of construction and before entry into service.
- **IEEE-11 American standard for rotating electric machinery.
- IEEE304 IEEE test procedure for evaluation and classification of insulation system for DC machines.
- IEC 356/1971 Dimensions for commutators and slip rings.
- IEEE 429 Test procedure for the reevaluation of sealed insulation systems for AC electric machinery employing form wound stator coils.

* International Electro-technical commission.

** Institute of Electrical and Electronics Engineers (An American National Standard).

4.3

HANDLING ARRANGEMENT

Suitable lugs for lifting the alternator with crane shall be provided on the stator frame similarly resting flanges shall also be welded to the stator.

4.4

VENTILATION

The alternator shall be self ventilated such that air is fed on the bearing and leaves on the engine end.

4.5 RATING

4.5.1 The rating of the alternator shall be adequate to meet the performance requirements detailed in

clause 3.2, 3.3 & 3.4 but in no case shall be less than the rating given in this clause.

4.5.2 Low Voltage Current Rating (At DC terminals) :

	Continuous	One hour	RPM
Voltage (V)	350	325	1050
Current (Amps.)	3700	3800	1050

4.5.3 High Voltage Continuous Rating (At DC terminals) :

1125V at 1050 RPM with 2800 HP input to alternator

4.5.4 Efficiency : Efficiency of the traction alternator shall be same as in the efficiency characteristics given in the existing characteristics curve at Annexure B or excel it.

4.5.5 Maximum starting current - 4500 Amps. for 5 min. and duration.

4.5.6 Insulation Level : The alternator insulation level will be provided for 1200 V between power to ground.

4.6 STATOR

4.6.1 The alternator stator shall be manufactured of rolled plate fabricated type with reinforcing ribs. Covers for force ventilation should also be provided to suit any future modification for adopting forced ventilation..

4.6.2 The stator core shall be built up from low loss steel stampings (Typically, the lamination material used has watt loss 2.5 W/Kg for traction application). The clamping of the stamping between end rings and welding of the end rings with stator ribs shall be done by using superior welding techniques such as to eliminate any danger of clamps/fingers giving way due to vibration and damaging the coil insulation. The stator core shall be laminated with a suitable inorganic insulation between laminations.

4.6.2.1

Each slot formed by laminations & end plates shall accommodate identical armature sections of the AC winding.

4.6.2.2

The end plates shall have stepped-back design to facilitate the use of U-piece in the slot to avoid mechanical damage of the coil insulation.

Moulded plastic wedges shall be used, whose properties shall not change appreciably upto 200 deg.C.

4.6.3

The main terminal box with silver plated copper A-C busbars shall be mounted on the side of the stator frame such that the cable connection to rectifier can be made easily. The terminal box shall be made suitable to accept terminal ends of crimped type similar to Dowell's cat.no CUS/50. The fasteners used shall be zinc plated and passivated. The exact location of the box shall be decided after placement of order. It shall however be ensured that at the stator frame cut-outs where the three terminals of the AC windings are brought out in the terminal box, the insulation of the bus-bar is specially reinforced. Following shall be ensured

(a) The insulating material used for the terminal board shall be impervious to moisture.

(b) The terminal block shall be fixed to the board by an independent fastener and not by the fastener used for making connections.

(c) Suitable locking shall be provided with the fastener.

(d) The temp. rise of terminal block shall not exceed 70 deg.C at cont. rated current.

(e) The terminal blocks shall not rotate when tightening/loosening the terminal screws.

(f) The cover of the terminal box shall be firmly secured and terminal block assembly shall be provided with cable glands/bushing to ensure water tightness.

4.6.3.1

Suitable anchoring arrangement shall be made for the main AC cables such that stress is not transferred to the termination points in the terminal box.

- 4.6.4 Easily accessible field connections shall be ensured by providing side mounted junction box, ~~generally in line with the provision of clause 4.6.3~~
- 4.6.5 A drain hole/opening shall be provided in the stator frame to drain out the solvent whenever the alternator is cleaned by spray application of a cleaning agent.
- 4.7 ROTOR
- 4.7.1 A forged steel barrel/rolled steel drum, with the driving flange for coupling with engine crank shaft welded at one end, shall be used as the rotor hub.
- 4.7.1.1 The mounting arrangement of the rotor poles on the rotor hub shall be designed such as to eliminate any danger of pole lifting even at 1.2 times the maximum alternator rotational speed. The rotor poles shall be of laminated steel, bolted in place for easy maintenance. The coil to coil and field to slip ring connections shall preferably be of brazed type.
- 4.7.2 The rotor field coils would preferably be edgewise wound with copper wire.
- 4.7.2.1 The rotor field coil fitment on the salient pole piece shall be done such that the chances of the coil loosening on the pole are minimised. This shall be achieved by following a roller consolidation process such that the desired height of the coil is achieved with a high degree of tolerance.
- 4.7.3 The rotor slip ring assembly should be of stainless steel for corrosion resistance and firmly secured to shaft assembly.
- 4.7.3.1 The rotor slip ring assembly would be dynamically balanced such that the residual unbalance is not more than 20 gram meter.
- 4.7.3.2 Suitable arrangement shall be provided for dynamic balancing of the complete rotor assembly by means of adjustable weights.
- 4.7.4 Tolerances on dimensions of the slip ring shall be as per IEC 356/1971.

4.7.5 The rotor and slip ring assembly shall be so mounted on the rotor shaft so as to facilitate reshafting, during maintenance, without disturbing the rotor windings and slip ring connections.

4.7.6 The slip ring shall have a safe wearing depth to allow for a sufficient number of resurfacing operations.

4.7.7 The interconnections of the rotor field shall be supported by securing/tying with tie ring, staples or projecting clamps etc. which in turn shall be firmly secured with the rotor hub such that any chance of the connectors rubbing against a metallic part are eliminated. However, the support points of inter connections shall be provided with 50% higher insulation level than that on field coils.

4.7.7.1 The coil to coil connection shall preferably be provided on the slipring end.

4.7.7.2 Connections of sliprings with motor field coil shall be done preferably by using flexible cables.

4.7.8 Air inlet flange matching with the existing WDM2 arrangement shall be provided on the slip ring end. The cooling air shall flow through axial holes in the slip ring hubs and rotor core before being let out through out let openings provided in the end shield on pinion end.

4.8 INSULATION SYSTEM

4.8.1 The complete stator coils and connections assembly shall be vacuum pressure impregnated with solventless resin. Rotor and stator coils should be provided with suitable moisture impervious sealing insulation.

4.8.2 Kapton covered conductors on stator preferably of heat sealed type shall be used. The stator conductors so insulated shall be assembled in polycoils of uniform size and shape. The slot portion shall be insulated using Nomex channels with U-pieces at slot ends. Entire coil shall be protected by suitable armour tapes.

4.8.3 The coil insulation shall be moulded in such a manner that the correct coil contour related with the pole profile is achieved. The rotor coil surface mating with the pole shoe shall be pro-

vided with a smooth surface by special treatment during moulding or otherwise to ensure proper heat transfer.

4.8.4 The insulation at star point shall be specially strengthened in a star connected alternator.

4.8.5 The stator and field coil shall be given an anti-tracking coat by spray application of a suitable furnishing varnish to obtain a smooth surface.

4.8.6 The insulation system to be employed shall be particularly designed to withstand the adverse environmental conditions. The materials comprising this system and preferably the system itself shall have been proved to be of the highest reliability in traction application.

4.8.7 The evaluation of the insulation system for thermal endurance shall be made with fabricated test model by way of accelerated ageing tests as per the test programme drawn up in accordance with the norms specified in IEEE 429. The value of the proof voltage for electric test prescribed in IEEE 304 for determining the end point after each ageing cycle shall correspond to 85% of the dielectric test voltage on new machine prescribed in IEC 349 and NOT 2E as laid down in IEEE 304. Evaluation of insulation system for sealing against moisture shall also be done in accordance with IEEE 429.

4.8.8 Various ageing parameters, such as heat, vibration mechanical/compressive stresses, special environmental effects of humidity, dust, etc. will be incorporated to simulate the actual working conditions as closely as possible.

4.8.9 The temperature at which an extrapolated life of 20,000 hours is obtained shall be treated as the thermal endurance limit (Temperature Index) of the insulation system.

4.8.10 The exact test programme and agency employed for evaluation of insulation system followed by the tenderer shall be indicated along with the offer.

4.8.11 Having regard to the system of insulation adopted and the environmental conditions, the manufacturer shall provide maximum possible margins in temperature rise, for prolonged life of the traction alternator.

4.8.12

The temperature rise of traction alternator during type/routine tests shall be limited to $T_I - 80$ deg C for both stator and rotor, it being clearly understood that no alternator exceeds this limit. The permissible temperature rise shall be 85 deg.C on slip ring.

T_I is the established temperature index for the insulation system as determined by tests prescribed above.

4.8.13

The alternator shall be designed such that the "hot spot" temperature under any condition of loading in any winding (rotor or field) remains at least 25 deg.C below the thermal endurance limit.

4.8.14

Alternatively, if the tenderer offers an alternator with a proven insulation scheme for which the determination of temperature index has not been done, the temperature rise shall be limited to:-

- i) IEC-349 minus 30 deg.C for rotor windings.
- ii) IEC-349 minus 30 deg.C for field windings.
- iii) 85 deg.C for slip ring.

The evaluation of the insulation system in such a case shall be completed within a specific time frame decided mutually between the successful tenderer and the purchaser. The temperature rise limit shall be limited to those given in clause 4.8.12 after determination of the temperature index.

4.8.15

Special protection shall be taken in strengthening the insulation, electrically and mechanically, at bends of the coils and edges of slot etc.

4.8.15.1

The overhang portion of the coil shall not only be reinforced at the coil noses and bends but the complete coil overhangs shall be additionally insulated.

4.9.0 END SHIELD & BEARING

4.9.1

The general arrangement of end shield and bearings as on existing alternators is shown in Annexure E. Similar arrangement shall be provided using a fabricated end shield which shall be of robust construction to avoid deformation. The end shield shall be spigoted and bolted to the stator frame. The bearing housing shall be provided in the end shield and the auxiliary drive gear box shall be mounted on it.

4.9.2 The rotor shall be mounted on anti-friction roller bearing of standard make and dimensions which is splash lubricated from the auxiliary drive gear unit. The idler gear assembly fitted in the gear unit provides the continuous circulation of lubricating oil.

4.9.3 The bearings shall have the basic life rating L10, as calculated vide ISO 281 recommendation, of at least 2 million kms. (ISO-International Standards Organisation).

4.9.4 Provided that the static and dynamic loadings are well within the permissible limits, the roller bearings type NH 320 and C4 clearances should preferably be adopted for the alternator.

4.9.5 Maximum permissible speed of the rotor shall be matched with the catalogue limiting speed of the bearing. The rolling elements and lubrication arrangement will be so designed that the working temperature of the bearings shall be well within the cataloged limits under worst operating conditions.

4.9.6 The lubricant to be used shall be SERVO RR 407 which is in use at present in the gear box of all the traction alternators.

4.9.7 Baffle plates shall be used to prevent lubricating oil leaks.

4.10 BRUSH GEAR

4.10.1 The brush holder provided in the alternator shall generally conform to RDSO specification no. MP.0.2400.09. However, any deviations from this specification to improve the performance of the brush gear on the alternator offered shall be acceptable.

4.10.2 The brush box design shall be such that the brushes always ride in the centre of the slip rings, this being achieved by easy adjustments provided for in the drawings.

4.10.3 The brush holder mounting stud shall be rigidly attached to the stator and provided with PTFE insulation to give the necessary protection against creepage to earth. The mounting of the brush holder on stud shall be such as to maintain it square against the slip ring in all conditions. Suitable provision for radial adjustment of the

brush holder to correct for slip ring wear shall be provided.

4.10.4

Brush holder spring shall be conical spiral type such that the spring pressure remains fairly constant over the entire working length of the brushes.

4.10.5

It shall be possible to remove and put back the brushes easily during inspections. Separate spring rests will be included to hook the spring in released position for attending to the brushes. The spring shall be simple and spiral type.

4.10.6

Duplex carbon brushes of the following grades shall be used

ACPL - HM 6

ELCA - --

4.11

ALTERNATOR INSPECTION COVER

4.11.1

The end shield shall be provided with perforated detachable covers which shall act not only provide air inlet but also be used for inspection of alternator.

4.11.2

Light weight inspection covers shall be provided on the slip ring end for inspection/airblowing/cleaning.

4.11.3

The inspection covers shall be of spring latch hinged or screwed type.

4.12

BULL GEAR & GEAR CASE

4.12.1

The general arrangement of gearing and gear case shall be similar to the sketch at Annexure F.

4.12.2

The bull gear wheel and shall conform to RDSO drg no. SKDP-3116 and mesh with the aux. machines and PTU pinions to RDSO drg.no. SKDP-3117.

4.12.3

Gear case fabricated from MS sheets shall be of leak proof design. Although the gear case offered shall preferably be same as existing as per RDSO drg.no. SKDP-3303, a different design may be offered provided the mounting of idler gear, auxiliary machines and PTU is possible in the same manner as used on existing gear case. This gear box not only is the gear case for the gear pinion drive but the

auxiliary machines and PTU are mounted on it. Since the load of these machines are approximately 300 kg. for aux. machines and 100 kg. for PTU, is cantilever type, the gear box shall be provided with strengthening ribs to avoid cracking or deformation.

4.12.4 The gear case shall be mounted in position preferably by direct screwing into the stator end shield.

4.12.5 A dip stick for checking lubricant level will be provided to measure the level towards the middle of the gear case. The dip stick shall be chained to the gear case exterior.

4.13 ALTERNATOR FAN

4.13.1 An alternator fan for self ventilation of the alternator, fixed on to the rotor by spigoting and bolting to the hub shall be provided.

4.13.2 The fan shall be designed such that it can be gripped by a barring handle used for rotating the crank shaft manually for engine inspection.

4.13.3 The tenderer shall establish by providing suitable data/curves that fan is designed for the correct air delivery with some margin without resulting in excessive power consumption.

4.13.4 The alternator fan shall be dynamically balanced so that it shall be interchangeable with the fan on any other alternator rotor.

4.14 MARKING/RATING PLATE

4.14.1 Each alternator shall be provided with a suitable rating plate giving usual information including the following:

- Manufacturer's name
- Type and serial number of stator and rotor
- Rated voltage.
- Rated current.
- Speed.
- Insulation.
- Date of manufacture.
- Rated KW/HP. (Input)
- Rated KW/HP. (Output)

- 4.14.2 The rating plate shall be clearly visible when the alternator is installed in position.
- 4.14.3 Identification numbers shall also be suitably stamped on non-interchangeable matched components to facilitate assembly and to prevent mixing up.

5.0 TECHNICAL DATA & CALCULATIONS

- 5.1 In addition to the specific requirement of submission of data /curves & calculations stipulated in this specification, complete data/curves and design calculations stipulated in this specification. Complete data and calculations shall be submitted as per the proforma given in RDSO Test programme no.032(Rev.1), March 1994.
- 5.2 In case the tenderer is unable to submit some particular data/calculations the reason for not doing so shall be clearly stated. It may be mentioned that the availability of the information is generally required for technical evaluation of the offer.

6.0 ATTACH-ON AUXILIARY ALTERNATOR(OPTIONAL)

- 6.1. The alternator shall be provided with an attach-on auxiliary alternator for supplying variable voltage variable frequency AC supply to electrically driven radiator fan motor and electrically driven traction motor blower motor (optional). This attach-on auxiliary alternator shall be designed such that its stator is bolted on to the main stator and the field coils are provided on the extension of the main alternator rotor. This alternator should be excited through a separate DC source, without any intermediate control such that its output is 415V at 50 Hz on the top speed of 1050 RPM. The output at lower engine speeds shall be in accordance with $V/f = \text{constant}$ control.
- 6.2 In case this attach-on alternator is offered the same shall be fitted to the main alternator on the engine end and the mounting/coupling arrangement with the engine suitably modified. The overall length of the alternator may be increased by 200 mm in such a case.

TECHNICAL DATA

The following data/description shall be supplied by the manufacturer :

1. Description of alternator : Make & Type
2. Classification : No. of poles, phases & phase connections.
3. Application : Class of loco./loco HP
4. Excitation : Mode of excitation
5. Max. permissible speed :
6. Winding resistance & impedance at 50 Hz (at 25 deg.C/115 deg.C)
 - a) Stator winding/phase :
 - b) Rotor winding :
7. Ratings
 - a) LV One hour :
 Continuous :
 - b) HV One hour :
 Continuous :
 - c) Short circuit current (max.) :
8. Design Ratings
 - a) At max. permissible RPM.
 Max. input to traction :
 Max. voltage :
 - b) At 1050 RPM.
 Max. input to traction :
 Max. voltage :
 - c) At 1100 RPM.
 Max. input to traction :
 Max. voltage :
 - d) Max. design rating (LV) :
 Max. design rating (HV) :

- e) Short circuit current(max) :
- f) Max. permissible RPM :
- g) Continuous current rating
at 700 V :
- 8. Class and type of insulation :
- Stator winding :
- Rotor winding :
- 10. Insulation & securing details
for stator winding connectors.
coil to coil connector & coil
to slip ring connector :
- 11. Temperature rise limit.
- Stator winding :
- Rotor winding :
- Slip ring :
- 12. Alternator power take off gear
trains & gear case details. :
(if applicable)
- 13. Slip Ring Details.
- a) No. of slip rings :
- b) Dia. of slip ring(new) :
- c) Maximum permissible ovality :
- 14. Brushgear details.
- Number of brush arms :
- Number of brush holder/arm :
- Number of brush/brush holder :
- Brush size :
- Brush grade :
- Spring pressure on new brush :
- Minimum length (length at which
brush becomes inoperative) :
- Clearance between brush and
slipring :
- 15. Stator details,
- Overall dimensions :
- Core length :
- Weight :
- No. of slots :
- Slot size :
- Punching O.D. :

Punching ID
Punching thickness

Winding details

Conductors per slot

Conductor size.....area.....insulation covered

Flux density at cont.rating.

Tooth LV.....HV.....

Core LV.....HV.....

Air gap LV.....HV.....

Core volume.....cm³

Amp.conductor/cm stator periphery.

Continuous.....for.....amps.

1 hour.....for.....amps.

Current density (Amp./mm²).

Continuous.....for.....amps.

1 hour.....for.....amps.

Turns per coil.....

Coil throw.....

Length mean turn.....

Weight of the copper.....kg.

Tooth volume.....cm³

1c. Rotor details.

Type of poles

No. of poles

Length of rotor

Pole strength

Rotor OD

Rotor ID

Air gap

at pole center.....

at pole tip.....

Pole securing arrangement.....

Type of winding

Type of connections

Rotor pole run-out

Slip-ring run-out

Distance between coupling flange and
bearing abutment face.....

Rotation.....

17. Type and particulars of terminal box :

18. No. and type of bearing :

Diametrical slackness of free bearing when new :
 Fit between inner race & shaft :
 Fit between outer race and bearing housing :
 Minimum diametrical clearance when assembled in machine :
 Lubricant :
 Grease capacity :
 (initial filling) :

19. Magnetic circuit

HV rating
 Cont. --- One nr.

LV rating
 Cont. --- One nr.

AT/pole of stator core
 AT/pole of stator teeth
 AT/pole of air gap
 AT/pole of rotor poles,
 AT/pole of rotor run

20. Cooling

: Type of cooling (self/forced) :
 CFM.....at 1000 RPM

21. Weight of alternator.

(a) Stator :
 (b) Rotor :
 (c) Fan :
 (d) Alternator complete w/o gear box :
 (e) Alternator complete with gear box :
 (f) Alternator complete with gear box, gear train and auxiliaries :

22. Mass moment of inertia

: HP consumed by fan..... at 1000 RPM

(a) Without auxiliaries
 (b) With auxiliaries

23. (a) Resistance at max. RPM,

Direct Axis

Quadrature Axis

Stator winding
 Field winding

Damper winding (solid poles)
Armature reaction
Synchronous
Transient
Sub-transient

(b) Time Constant,

Open circuit

Short circuit

Field winding
Damper winding (solid poles)
Arm.S.C.time constant

(c) Fault Details.

Maximum short circuit fault
current at.

- (i) Alternator loaded on full
RPM at top corner voltage :
- (ii) Alternator loaded on full
RPM at cont. rating :

24. Characteristic curves :-

- a) Constant HP curve
- b) Excitation current Vs. load current
- c) Efficiency Vs. load current
- d) OCC and SCC at rated speed
- e) Load saturation curve
- f) Natural load curves
- g) VI regulated curve with the proposed rectifier
- h) Output wave form (AC-non rectified) at first notch and top notch RPM.

25. Drawings. ←

- a) Out line & assembly
- b) Longitudinal & cross section
- c) Stator assembly
- d) Stator star connection & bus bar arrangement
- e) Rotor assembly including mounting of poles & pole coils
- f) Rotor cross section
- g) Insulation details of stator & rotor
- h) Rotor coil to coil & coil to slip ring connections layout
- i) Rotor shaft
- j) Slip ring and brush gear

- k) End fitting / bearing housing
- l) Cooling fan drawing
- m) Gear case
- n) Stator core stampings

26. Bus bar and mounting arrangement (give details)

27. Material Specifications.

Indicate material specifications in the drawings esp. specially for rotor shaft, rotor pole steel, stat stampings, slip ring, stator copper, rotor copper.

28. Calculations.

- a) Strength of pole bolts
- b) Moment of inertia
- c) Shaft strength
- d) Bearing - Load carrying capacity & rating life at rated load
- e) Estimation of temp. rise at cont. ratings (LV & HV) thermal time constant
- f) Estimation of leakage reactance, armature reaction synchronous impedance
- g) Magnetic circuit analysis & estimation of E_f & V_f cont. rating (LV & HV)
- n) Estimation of losses & efficiency at cont. ratings & LV)

29. Service Experience.

Year of manufacture
 Loco types to which applied
 No. of machines supplied
 Mean time between failures
 Periodicity of maintenance
 Periodicity of overhaul
 Expected service life

ANNEXURE -A

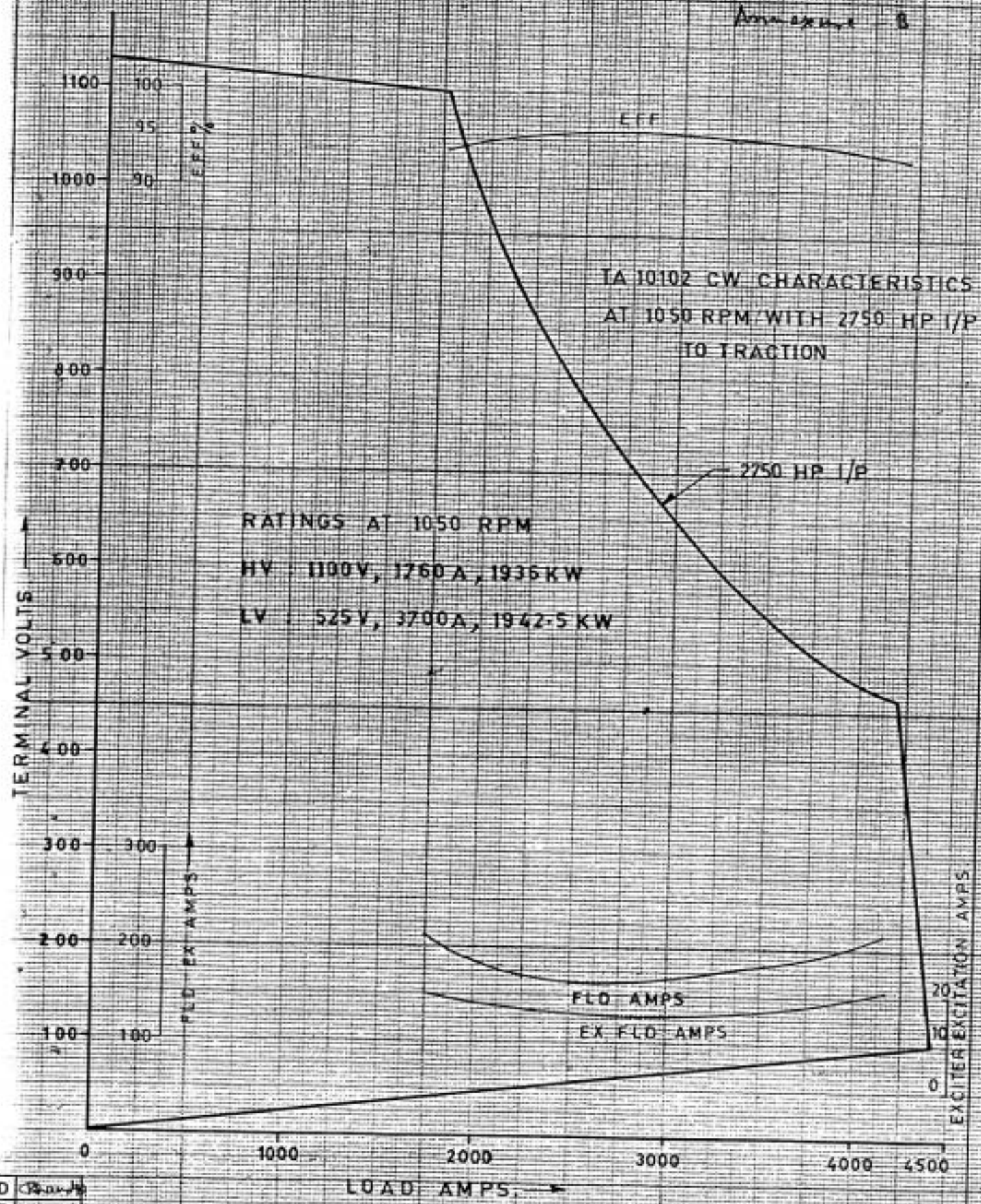
RATING OF EXCITER SERIAL MAKE TYPE AG 2702AZ

Machine	- 4 Pole, wave wound, self ventilated, DC machine.
Application	- 3100 HP Diesel -Electric locomotive with AC/DC system.
Direction of rotation	- CW from commutator end.
Rating	- 95V, 220 Amp, 2500 RPM (As Exciter). - 75V, 160 amps, (950-2500) RPM (As Aux. Gen.). - 72V, 120 amps, 760 RPM (As Aux. Gen. for low idling operation)
Insulation	- Class H

Annexure B

TA 10102 CW CHARACTERISTICS
AT 1050 RPM WITH 2750 HP I/P
TO TRACTION

RATINGS AT 1050 RPM
HV : 1100V, 1760 A, 1936 KW
LV : 525V, 3700A, 1942.5 KW



D *[Signature]*
T *[Signature]*
C
TC *[Signature]*
APPD *[Signature]*
Dt 10/93

RDSO (MP)	G.DP-1049
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PERFORMANCE OF 3100HP WDM2C B.G.D.E. LOCOMOTIVE

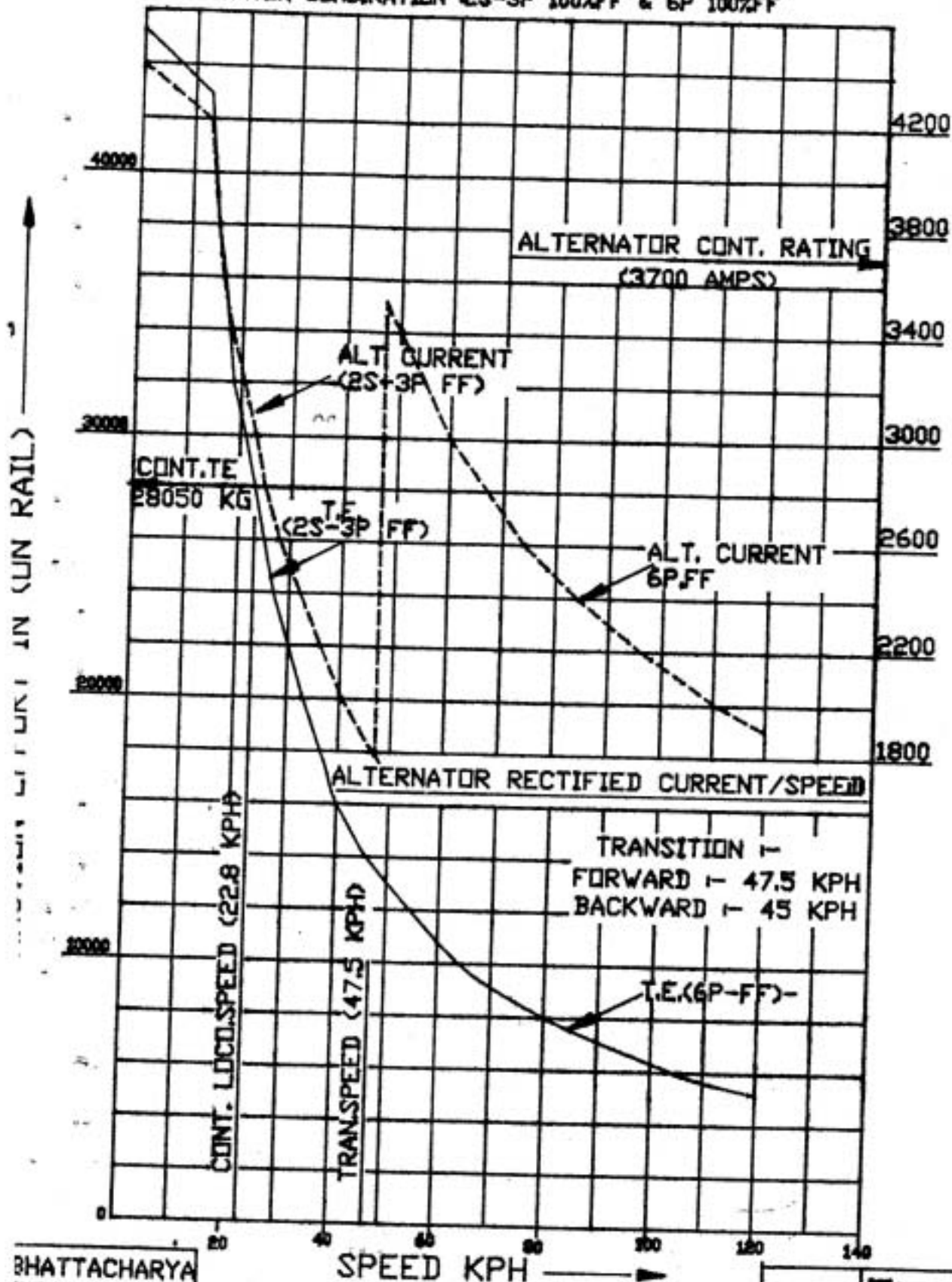
2750H.P. INPUT TO TRACTION AT 1050RPM (8TH NOTCH)

1-TA 10102 CW ALTERNATOR, 6-TM 4906AZ TRACTION MOTOR

WHEEL DIA (HALF WORN) 1055MM GEAR RATIO : 1065

MOTOR COMBINATION 2S-3P 100%FF & 6P 100%FF

Annexure-C



RECTIFIER OUTPUT CURRENT AMPS(D.C.)

BHATTACHARYA
BHATTACHARYA

RDSO (MP)	G.D.P.- 1034
FIRST ISSUED	REVISIONS

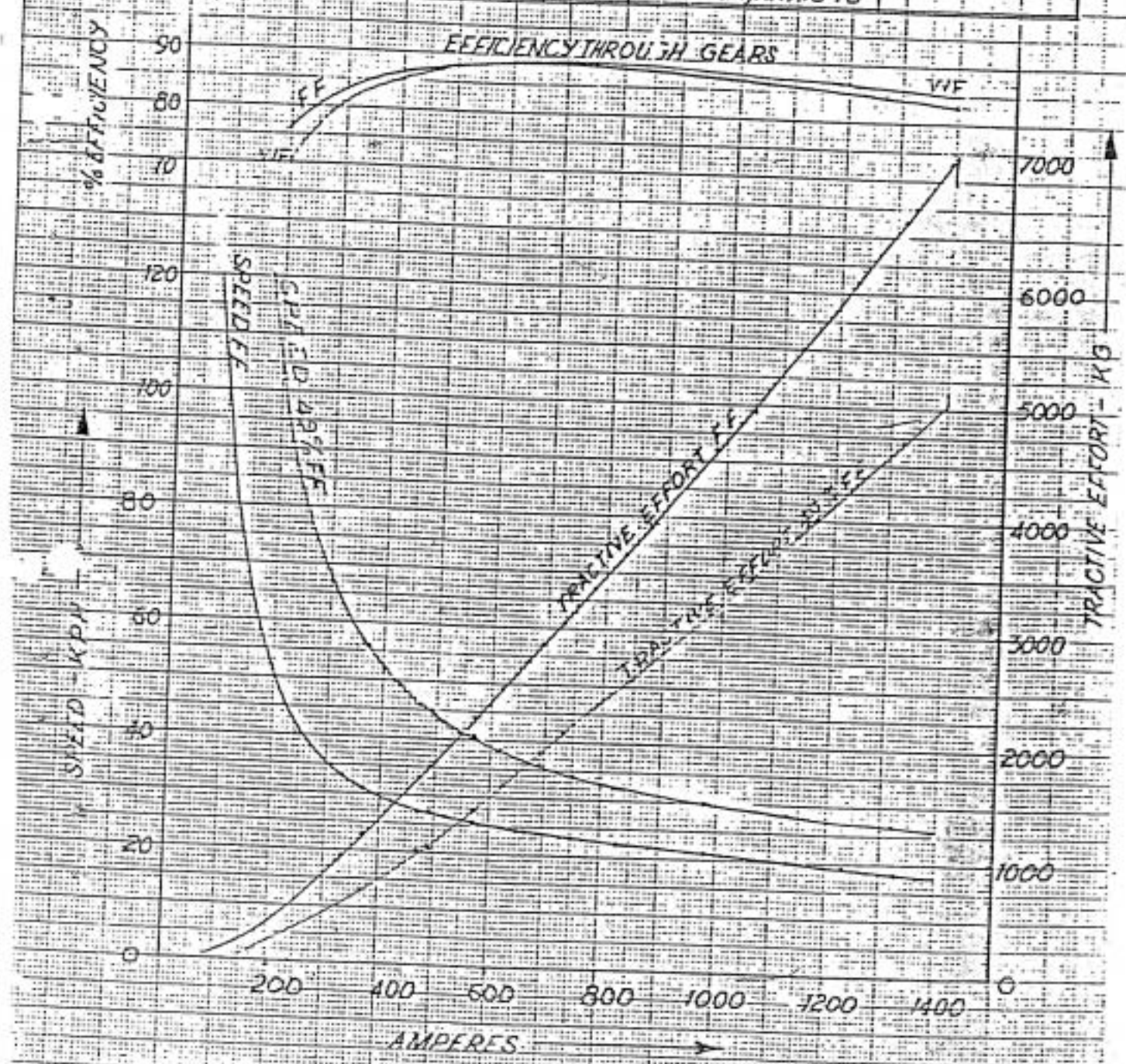
BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL
TRACTION ENGINEERING DEVELOPMENT CENTRE
PERFORMANCE CHARACTERISTIC FOR TM-4906AZ MOTOR

ANNEXURE-D

CURV NO.
TM/400890A

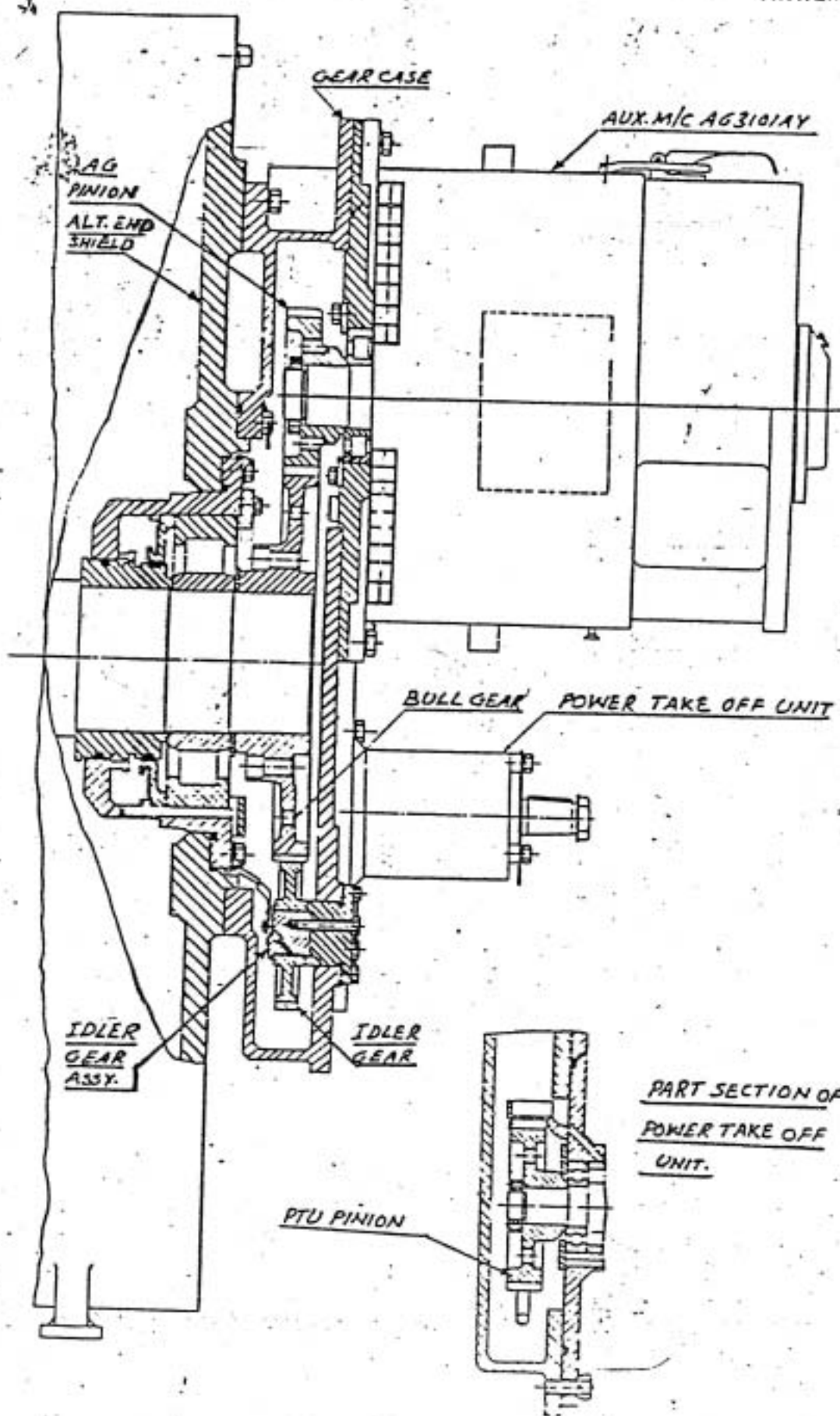
RESISTANCE AT 115°C (OHMS)	
ARMATURE + COMPOLE	0.221
SERIES FULL FIELD	0.007

FULL FIELD RATING		(CLASS H)		TRACTION MOTOR TYPE - TM-4906AZ	
	AMPS	VOLTS	KW	RPM	PERFORMANCE AT 300 VOLTS
CONTINUOUS	980	285	248	360	WHEEL DIA. 1055MM GEAR RATIO 18/65
ONE HOUR	1050	265	242	320	RPM-KM/HR X 18.16



CURV NO. TM/400890A
REV. 1.0
DATE 10/10/80

OP. VERMA
10/10/80



GENERAL ARRANGEMENT OF BULL GEAR AND GEAR CASE

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TEST PROGRAMME FOR TRACTION ALTERNATORS
USED ON
DIESEL ELECTRIC LOCOMOTIVES

TEST PROGRAMME NO. MP.TP - 032/92 (Rev. = 1)
MARCH, 1994

RESEARCH DESIGNS AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW - 225011.

TEST PROGRAMME FOR TRACTION ALTERNATORS USED ON DIESEL ELECTRIC LOCOMOTIVES

SCOPE

This test programme covers the tests required on traction alternators for diesel electric locomotives.

GOVERNING SPECIFICATIONS

The tests shall be done in accordance with the IEC publication No.347 (latest revision) except for deviations given in this programme or as agreed to by RDSO.

Assistance has been taken from the following specifications

- (i) IEEE - 11
- (ii) IEEE - 115
- (iii) IS : 7132
- (iv) IEEE - 43
- (v) IS : 4887 - 1968
- (vi) IS : 7306 - 1974

LOCATION

All the type and routine tests shall be done at the manufacturer's premises. The manufacturer shall provide all the facilities/instrumentation etc. for the tests. Type tests shall be carried out on one machine before the commencement of regular production of the alternators. However RDSO reserves the right to repeat the type tests whenever felt necessary even after regular acceptance of the alternator for diesel electric loco. application. Further, till the machine performance is well proven in the field, RDSO may decide to conduct the type tests, in part or in full, on more than one machine with the scope of the test worked out mutually between RDSO and the manufacturer.

This test programme has been made as a guideline for testing of all traction alternators. The manufacturer shall submit a separate test programme for a particular machine/application for RDSO's clearance.

4. TECHNICAL DATA

Technical data of the alternator to be tested shall be supplied in advance to RDSO as per performa attached as Annexure 'A'.

5. RECTIFICATION & EXCITATION

The tests shall be done with the rectifier assembly with which the alternator is to be fitted on the locomotive. The tests shall be done after mounting the auxiliary machines on the alternator. The alternator shall be aligned on the test bed. The excitation of the alternator can be supplied by any suitable source.

6. TESTS

Following tests shall be conducted :-

S.N.	DESCRIPTION	TEST PROCEDURE & VALUES/REMARKS
1	Preliminary check	
2	Dimensional check (stator bore, rotor dia, gaps & run outs, slip ring out etc.) Stator & Rotor.	Should conform to the technical data supplied by the manufacturer.
3a	Winding resistance	Measurement by Kelvin Bridge during type test & by micro-ohm meter during routine test.
3b	Winding Impedance	Measurement by VI method at 50 Hz; should conform within $\pm 5\%$ of design values given in the technical data for both rotor & stator.
4	Insulation resistance (cold) of stator & rotor	With 1000 V megger should not be less than 100 mega-ohms.
5	Phase sequence	IS : 7132. Clause 11.
6	Open circuit characteristics	IS : 7132. Clause 21.1 with alternator output terminals open circuited and connection to rectifier disconnected.

S.N	DESCRIPTION	TEST PROCEDURE & VALUES/REMARKS
		With machine hot approx. 150 deg.C (IEC - 349, 1991 Clause 4.3.2) Measurement shall be done both in ascending & descending order of excitation. Machine shall be allowed to run for several minutes at each voltage point to allow the speed to stabilize. Characteristic tolerances as per IEC - 349, 1991 Clause 7.2
7	Short circuit characteristics	IS : 7132, Clause 21.2 with machine hot approx. 150 deg.C. Characteristic tolerances as per IEC - 349, 1991 Clause 7.2 Verification of transient synchronous parameters shall be done to the extent possible.
8	Determination of synch. machine parameters	IS : 7306 - 1974. The quantities shall be derived corresponding to the two continuous DC ratings. Verification of transient syn. parameters shall also be done to the extent possible.
9	Temp. rise test(cont.)	IEC - 349, 1991 Clause 5.1. The alternator shall be tested along with the rectifier for heat run at both the HV & LV ratings. Even in case, test on full load is replaced by a test on short circuit, continuous heat run with rectifier at the guaranteed cont. alt. alternator current is mandatory. Temp. limit for stator = Temp. index - 70 deg.C Temp. limit for rotor = Temp. index - 70 deg.C Temp. Index shall be determined by standard motorette test. The temperature index of the machine shall be established by the manufacturer. Till this exercise is completed, Temp. rise test may be done with RDSO's approval only & the temp. rise shall not exceed IEC-349-30 deg.C for stator, rotor & slip rings.

S.N.	DESCRIPTION	TEST PROCEDURE & VALUES/REMARKS
		Bearing temp. shall also be recorded. It shall not exceed 85 deg.C at an ambient of 55 deg.C. Surface temperature of stator and expected hot zone shall also be recorded. During the temp.rise tests thermal equilibrium shall be considered to have been reached when the following is observed :- a) Difference between inlet and outlet temperature has stabilised. b) Bearing temp.has stabilised. c) Surface temp. of stator and expected hot zone has stabilised.
10	Temp. rise test (one hr)	IEC-349-1991, Clause 7.1, temperature limits as item 9.
11	(a) Overload Test	IEEE-11, Clause 3.7. May be done on short circuit (indirect method). Overload shall be applied when extrapolation of cooling curve made, vide item 9, indicates initial temp.rise of 75 deg.C & shall be maintained for a period estimated to reach a temp. rise as per item 9
	(b) Short time overload test	Load current corresponding to the current limit of the alternator shall be applied for five minutes and the temp.rise and general condition of the alternator shall be checked.
12	Overspeed Test	IEC-349-1991, Clause 7.4
13	Efficiency Test	IS:4889:1968. at least, the full rated RPM for both HV & LV cont. ratings. Also at 5th notch RPM at HV & LV points should not vary by more than $\pm 1\%$ of the declared values.
14	VI characteristics	IEC-349-1991, Clause-7.2.5. Excitation current of alternator field & excitor field for various

S.N.	DESCRIPTION	TEST PROCEDURE & VALUES/REMARKS
		DC load points on full load RPM shall be recorded. The test shall be repeated from 5th to 7th notch RPM.
15	Dielectric Test	IEC-349-1991, Clause 7.5. The machine shall pass the test at item 4 both before & after the application of high potential.
16	Check of protective devices.	As agreed to between RDSO & manufacturer.
17	Shaft current & measurement of bearing insulation resistance.	IS:7132. Clause 10
18	Cooling air test	Inlet & outlet temp. of cooling air shall be recorded with thermometers placed at locations as per IEC-349-91, clause 0.1.3.2. Volume of air flow both at inlet & outlet shall be measured at points mutually agreed between RDSO & the manufacturer.
19	Moment of inertia	IS : 7132. Clause 15.
20	Weight measurement	Shall be determined with and without aux. machines but without the rectifier.
21	Natural load characteristics	The characteristic curve of terminal voltage with DC load amps. at various excitation shall be determined on full load RPM. The characteristic curve of excitation amps. with DC terminal volts at constant load amps. & full rated RPM shall be determined. The tests shall be done to cover the entire range of alternator operation.
22	Polarisation Index	IEEE-43. Ratio of IR values after 10 min. to that after 1 min. of continuous application of test voltage. shall be recorded.

23. Endurance Test :

An endurance test shall be carried out on prototype alternator with auxiliary machines mounted on the alternator or otherwise the alternator to be tested should be excited separately. The test shall be conducted for 12 hours each at low and high voltage continuous rating of the alternator followed by one hour test and over load test for half an hour.

At the end of the test the alternator shall be examined in general. The hot and cold quality of the slip rings shall be recorded.

24. Short Circuit Test on Load :

Main alternator shall be subjected to tests which simulate fault conditions using a test circuit which includes the protection and means of excitation provided in service or their equivalents.

Each test shall consist of a short circuit applied for five seconds with the machine operating at its rated load with the rated value of excitation current.

At the conclusion of the test, it shall be shown that the protection has operated and that the machine has suffered no electrical or mechanical damage.

One test shall be made with the full rectifier bridge short circuited and another with one bridge arm short circuited.

In case of an alternator provided with protection in the alternator field circuit, tripping time and efficiency of this protection shall be established by a suitable test. The manufacturers shall also establish the fault current/energy level encountered in fault conditions like IM flash over, diode failure etc.

25. Tan Delta Test (Stator) :

Characteristics of tan delta Vs voltage and tan delta Vs temperature (at 1100 V) to be determined for alternator stator windings. The value of capacitance and AC leakage current should not exceed specified values.

26. Vibration Test :

Vibration level in horizontal, vertical and axial direction (both on fan and gear box side) shall be measured at maximum service speed and over speed with sensitive instruments. The

test shall be conducted without and with auxiliary machines fitted. During the test peak to peak amplitude should not exceed 50 microns in any direction and at any point.

27. Noise Measurement :

Noise level on the traction alternator shall be measured in accordance with IEC-349 (1991). The alternator shall be fitted with auxiliary machines and PTU. The test shall be carried out at locations on the machine as shown in sketch -1 and at maximum operating speed and lower operating speed as agreed between the manufacturer and RDSO. The results shall be expressed in the form of dB(A).

28. Determination of Alternator Output Waveform and Harmonic Content Analysis :

The alternator output waveform shall be determined using special equipment and CRO's at the HV and LV rating operating points. A special test scheme shall be drawn mutually by the manufacturer and the RDSO. Similarly, harmonic analysis on no load determining the content between lines and between lines and neutral shall be done by a suitable method.

29. Determination of Maximum Continuous Current Rating at LV :

This test shall be done by trial and error such that the maximum permissible temperature rise is attained on continuous LV heat run.

30. Determination of Heating Time Constants :

This test may be done by conducting a special heat run test starting from cold following a mutually acceptable scheme.

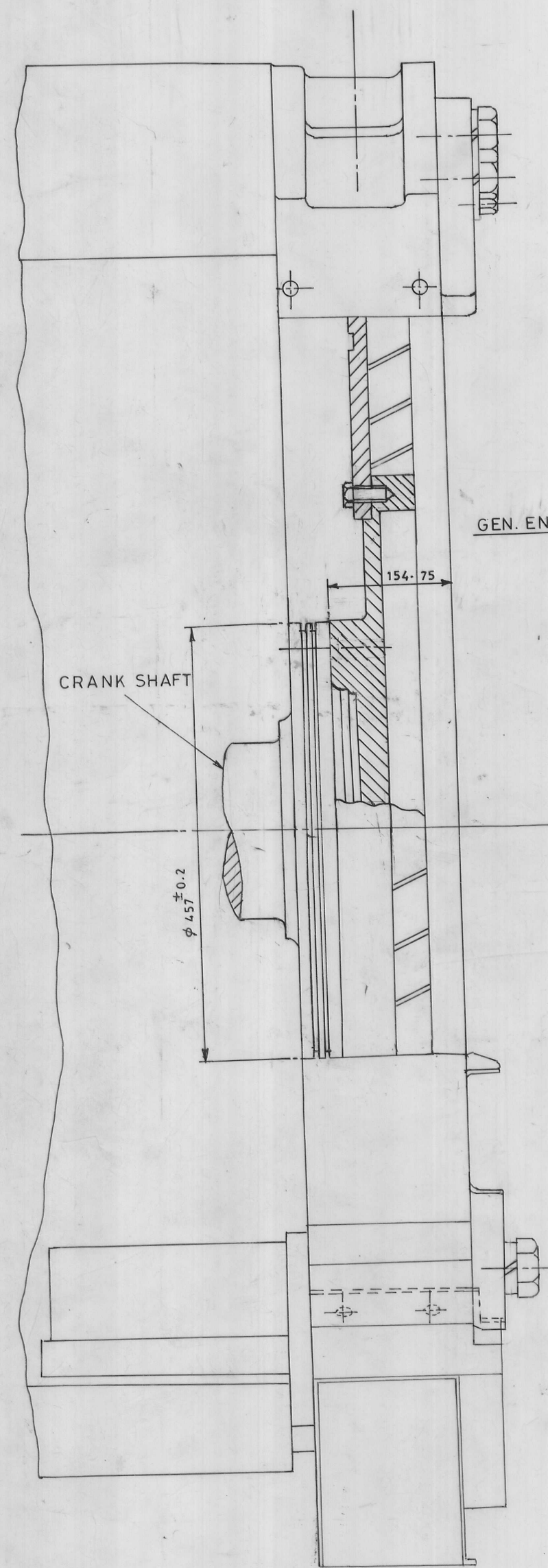
31. Measurement of Hot Spot Temperature :

The hot spot temperature of the stator winding shall be determined at LV continuous rating. The test shall be done by conducting a heat run at this rating and measuring temperatures at pre determined locations by installing special temperature sensing devices. The detailed test scheme shall be finalised in consultation with RDSO.

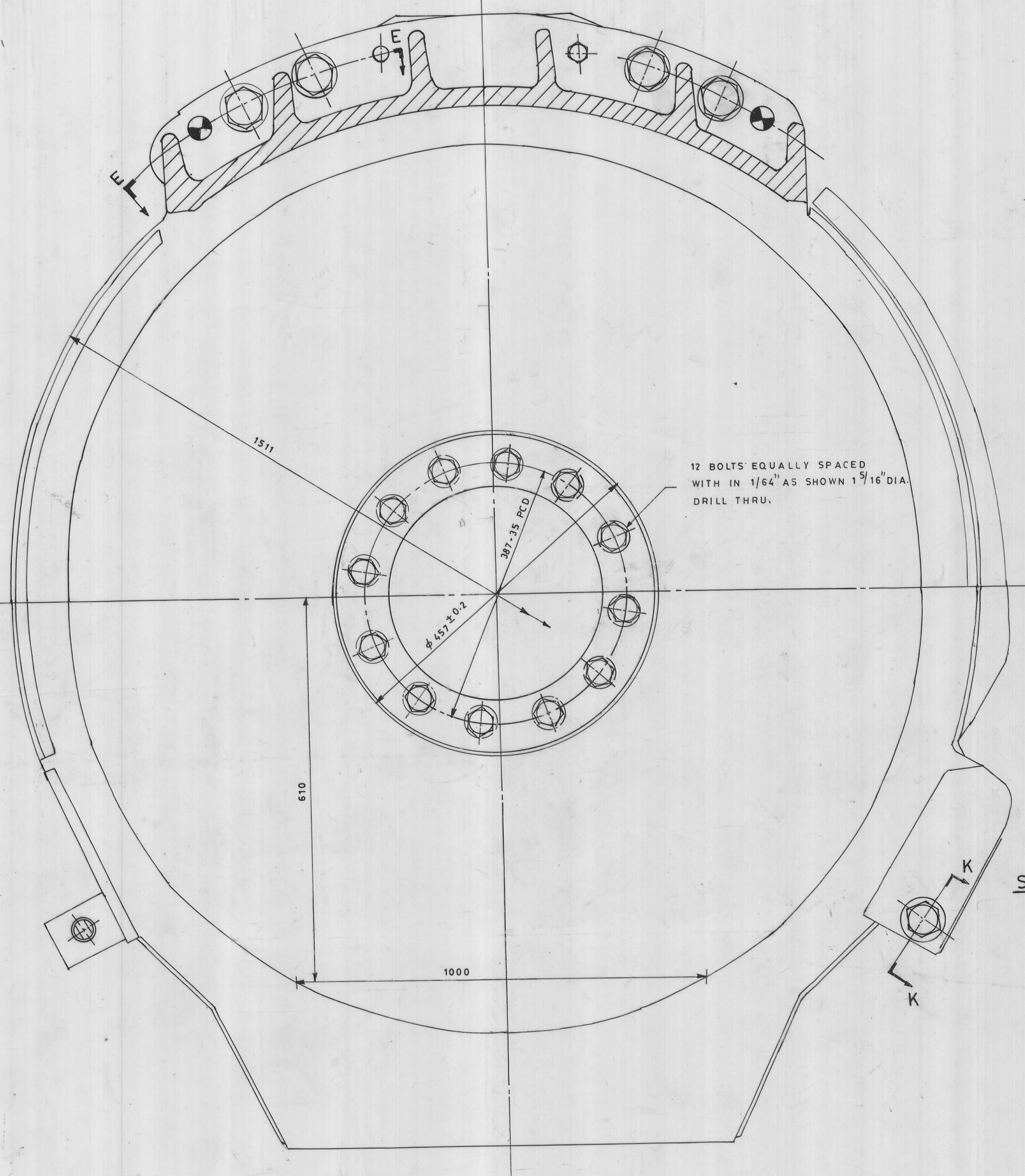
4.1 All the tests appearing in the clause c shall constitute the type tests.

4.2 Tests appearing in si. no. 1.2, 3, 4, 5, 10, 12, 14 and 15 of clause c shall constitute the routine tests.

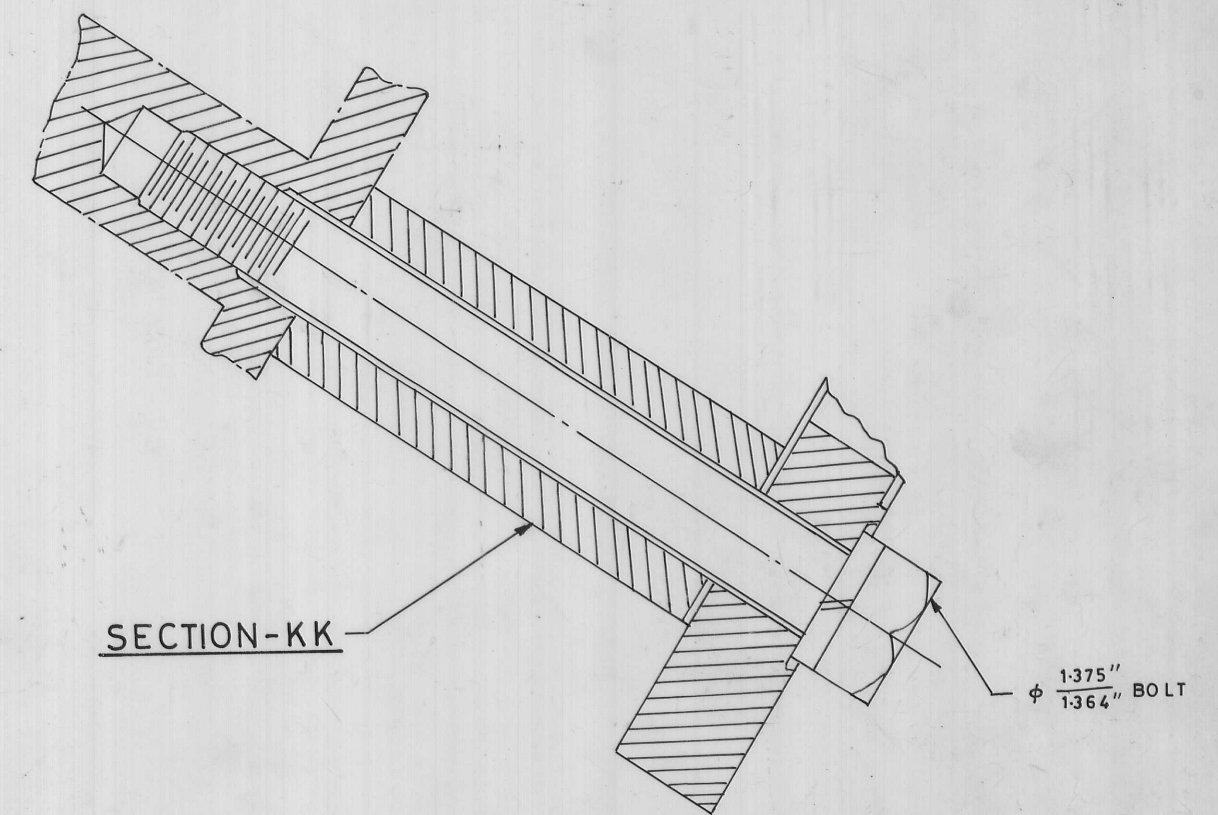
- 6.3 The VI characteristics test at sl.no.14 of clause 5 shall form the basis for freezing the excitation used for the declared characteristics curve. These excitation values shall be maintained for all subsequent tests.
- 6.4 The VI characteristic curve shall be determined as the average of tests on first three alternators of a series including the prototype/type tested alternator. The voltage/current point for continuous HV. LV. maximum current and one hour current rating on the full power declared characteristic curve so determined shall not vary by more than $\pm 5\%$ with the specified curve submitted along with the technical data.
- 6.5 The declared VI characteristic curves established as per clause 6.4 shall form the basis of routine test. The comparison of the characteristic curves determined in the routine tests shall be made with the declared VI characteristic curve and extent of variation as brought out in clause 6.4 shall be $\pm 5\%$ maximum.
- 6.6 Only the full power characteristics shall be determined in the test at sl. no. 14 of clause 5 for routine testing, depending with the characteristic curve determination for 5 th to 7 th notch.
- 6.7 Some of the tests appearing under 'type test' are not included in international standards. These tests may be done as special tests also as agreed to between the manufacturer and RDSO.
- 6.8 Tests on brushless and special alternators. In case a brushless alternator with rotating rectifier or a special alternator with aux. winding for auxiliary/consumer load is to be tested, this test programme shall be suitably modified and increased in scope as agreed to mutually between the manufacturer and RDSO.



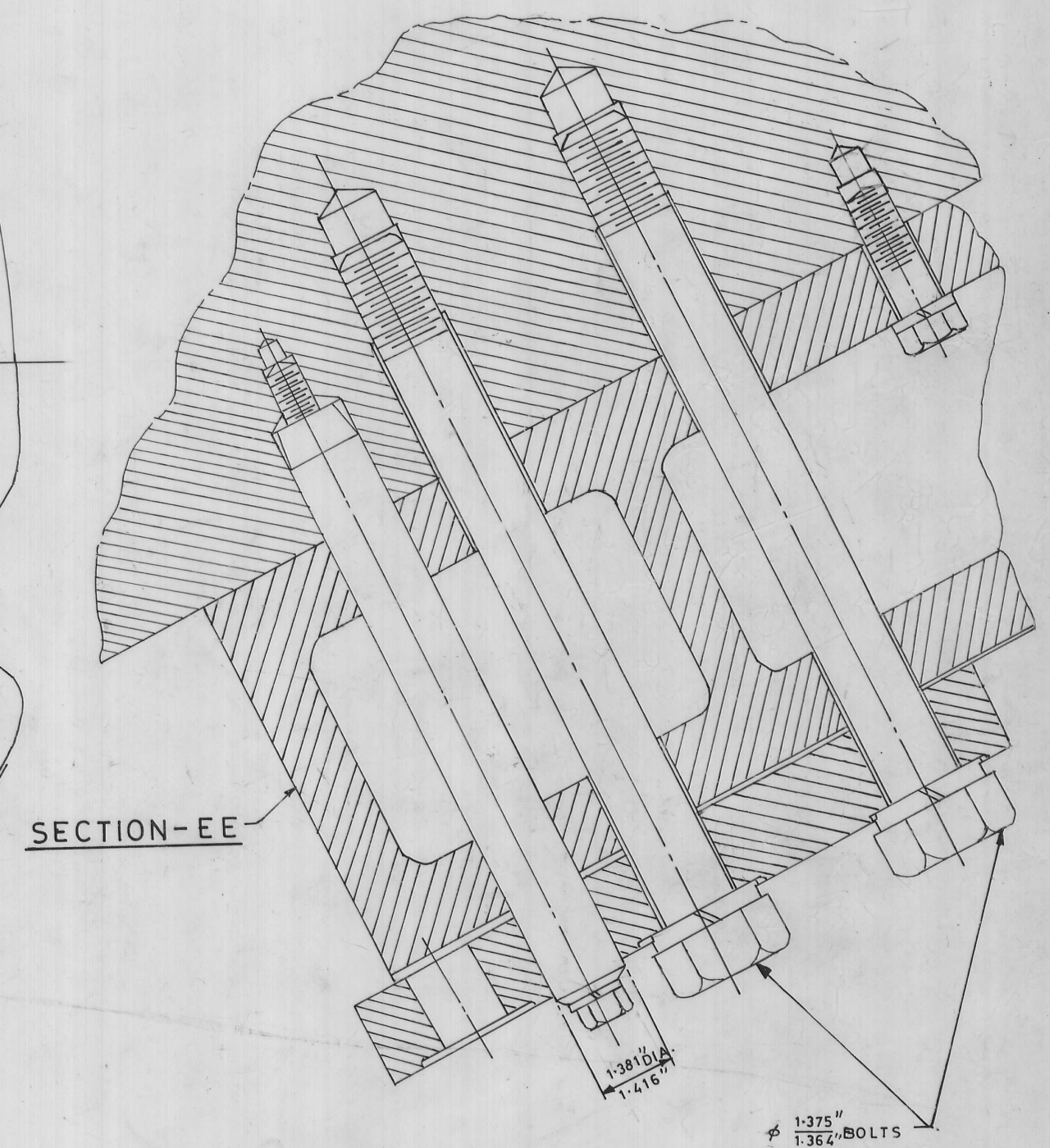
SECTION - AA



12 BOLTS EQUALLY SPACED
WITH IN 1/64" AS SHOWN 1 5/16" DIA.
DRILL THRU.



SECTION-KK

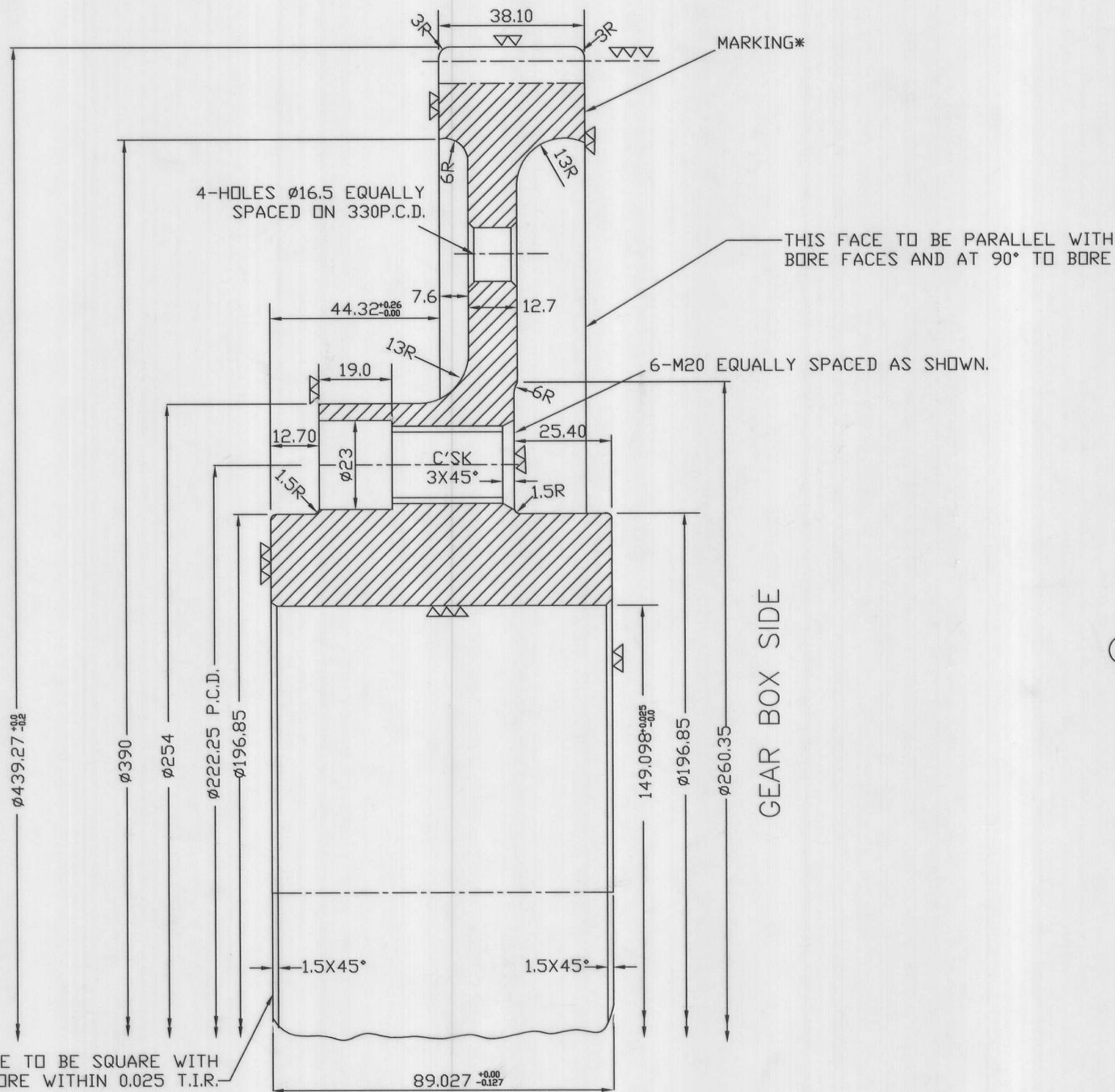
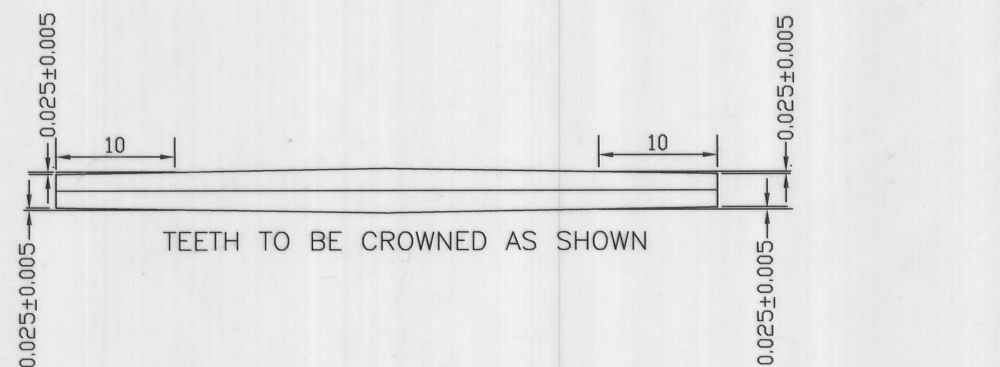


SECTION-EE

D	Shandee
T	Shandee
C	H. Shandee
TC	Shandee
APPD	
Dr.	7/94

ALT.	NO OF PLACES	REF. NO.	DESCRIPTION	ALT. NOTE NO.	SIGN.	DATE
------	--------------	----------	-------------	---------------	-------	------

REF. NO.	I. R. PART NO.	DESCRIPTION	NO. OFF.	WT. KG.	MATL. & SPEC.
APPLICABLE FOR		TRACTION ALTERNATOR MOUNTING ARRANGEMENT ON ALCO 251 B ENGINE			
SCALE: N.T.S.	REF:	INDIAN RLYS RDSO (MP)			FIRST ISSUED
		DRG. NO. SK.DP. 3287			SUPERSEDES
					SUPERSEDED BY



1. GEAR PARTICULARS

BASIC RACK	B.S. - 235 - 1987
NO. OF TEETH	102
MODULE (m)	4.233
PRESSURE ANGLE	20°
ADDENDUM MODIFICATION (x.m)	-0.477
BASE TANGENT LENGTH OVER 12 TEETH	149.289 MIN/ 149.339 MAX.
TOOTH WIDTH	38.1mm
PITCH CIRCLE DIA (REF):	431.766
CLASS (ACCURACY GRADE)	7
CENTRE DISTANCE WITH 43TEETH PINION	306.4
CENTRE DISTANCE WITH 38TEETH IDLER GEAR	296.875
NUMBER OF TEETH OF MATING GEAR	43TEETH & 38TEETH
DRAWING NO OF MATING GEAR	SKDP-3117 & SKDP-2988

- FOR OTHER TECHNICAL REQUIREMENTS REFER TO R.D.S.O.SPECIFICATION No.MP-0.2800.16 REV.0.1(JUNE 2007) FOR MATERIAL, MANUFACTURING TECHNIQUE AND HEAT TREATMENT REFER TO CLAUSE 2,3,4,5 & 8 RESPECTIVELY OF THE ABOVE SPECIFICATION.TOTAL DEPTH SHALL CONFIRM TO THE REQUIREMENTS OF PROTUBERANCE CUTTER VIDE CLAUSE 9.4 OF SPECIFICATION NO. MP-0.2800.16(REV.01) OF JUNE-2007.

* 3. MARKING :

ALL GEARS SHALL BEAR THE FOLLOWING MARKINGS WHICH SHOULD BE INDELIBLE AND CLEARLY LEGIBLE.

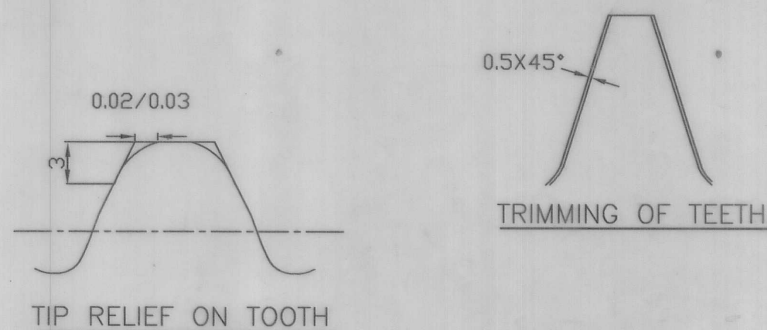
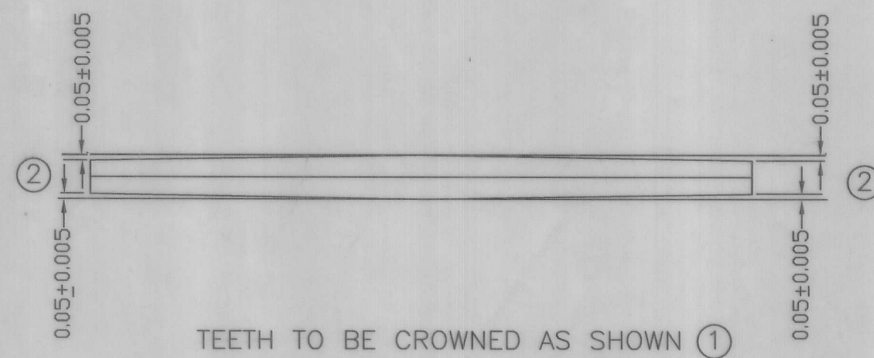
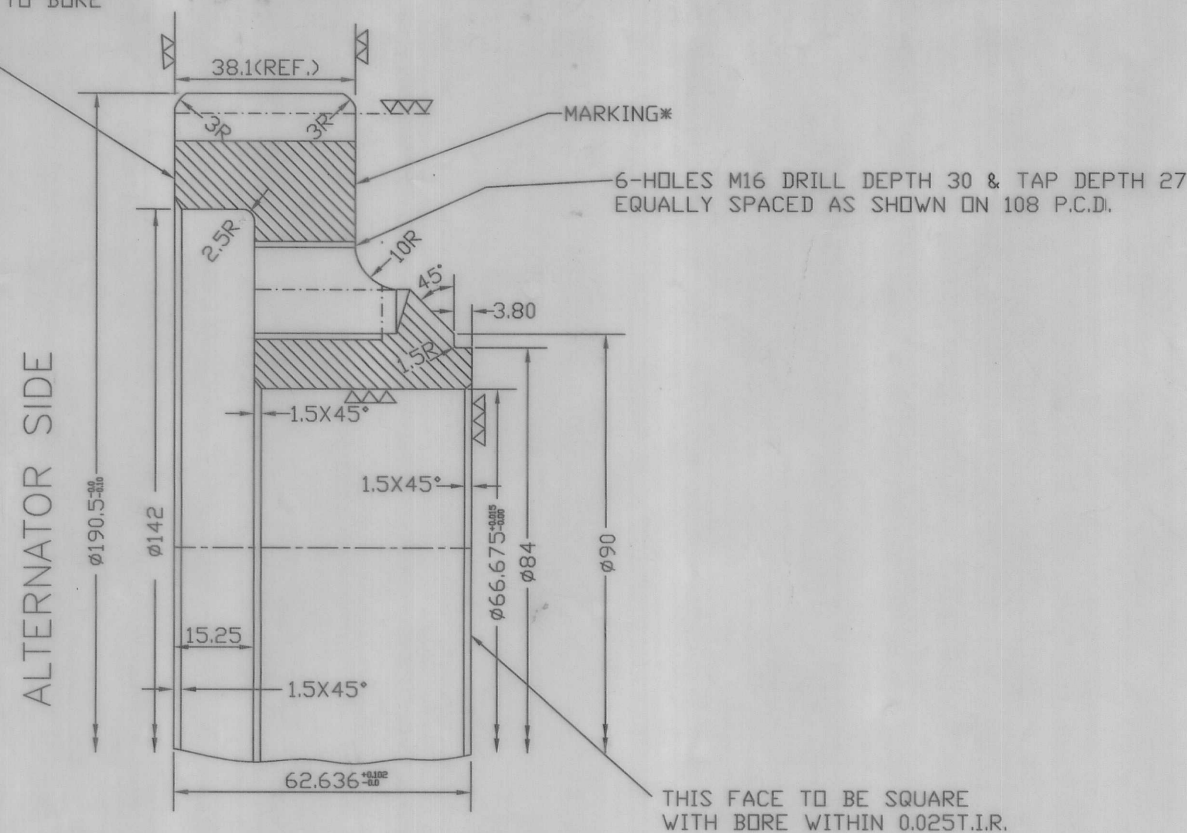
- NAME OF SUPPLIER/MANUFACTURER.
 - NUMBER OF MONTH AND LAST TWO DIGITS OF THE YEAR OF MANUFACTURE e.g. 6/2007 , & GEAR RATIO.
 - MATERIAL AND SPECIFICATION OF STEEL.
 - DRAWING NUMBER OF THE PART.
 - MANUFACTURER/CONSECUTIVE NUMBER OF THE PART.
- ALL OVER UNLESS OTHERWISE STATED.
 - ALL BURRS TO BE CAREFULLY REMOVED FROM ENDS OF TEETH AFTER CUTTING,CARE BEING TAKEN THAT THE INVOLUTE IS NOT DESTROYED.
 - ALL SHARP CORNERS AND EDGES SHOULD BE REMOVED.
 - MACHINING
THE TEETH SURFACE SHALL BE FINISHED BY GRINDING & SATISFY THE FOLLOWING:-
TOOTH ACCURACY :-
INDIVIDUAL PITCH ERROR 0.015
CONSECUTIVE PITCH ERROR 0.027
TOOTH ALIGNMENT ERROR 0.011
PROFILE ERROR 0.011
RADIAL RUN OUT 0.050
 - TEETH SHALL BE CASE HARDENED & EFFECTIVE CASE DEPTH SHALL BE 1.0mm TO 1.25mm.
 - HARDNESS ON TEETH SHALL BE 55.2RC TO 59.2RC OR 600HV TO 680HV.
 - SHOT PEEN, TEETH & ROOT SECTION OF TEETH BEFORE TEETH GRINDING.USE SHOT SIZE SAE-170 TO OBTAIN 90% MINIMUM COVERAGE IN ROOT AREA & PEENING INTENSITY SHOULD BE 0.010 - 0.012A.
 - MAGNAFLUX INSPECT AS PER IS -3703

D	A.K.BRAMHANE	50
C	PRAKASH KUMAR	25
APPD.		6.3
		0.8
		0.1
SYMBOL	Raum	TOLERANCES ON UNTOLERANCED DIMENSIONS TO IS:2102(MEDIUM)
	(MAX.)*	
Dt	07-06-2007	

①	2	MATERIAL SPECIFICATION REVISED NOTE NO. 7 TO 11. ADDED AND DRAWING REDRAWN.	L3-122	15-06-07
ALT.	NO.OF PLACES	REF.NO.	DESCRIPTION	ALT. NOTE NO.
				SIGN.
				DATE

-	-	BULL GEAR	1	-	SEE NOTE-2
REF.NO.	I.R.PART NO.	DESCRIPTION	NO./LOCO	VI (g) EACH	MATERIAL SPEC.
APPLICABLE FOR WDM2A,WDM3A, WDP3A AND WDG3A (AC/DC LOCOS)					
102TEETH BULL GEAR FOR TRACTION ALTERNATOR (TYPE BHEL TA-10102)					
SCALE: 1 : 1 REF: BHEL DRG. NO. 2.430-16.23.002					
INDIAN RLYS. DRG. NO. SK.DP.-3116					
R.D.S.O. (MP)					
FIRST ISSUED					
SUPERSEDES					
SUPERSEDED BY					

THIS FACE TO BE PARALLEL WITH BORE FACES AND AT 90° TO BORE FOR TOOTH CUTTING.



1. GEAR PARTICULARS

BASIC RACK	B.S. - 235 - 1987
NO. OF TEETH	43
MODULE (m)	4.233
PRESSURE ANGLE	20°
ADDENDUM MODIFICATION (x.m)	-0.0126
BASE TANGENT LENGTH OVER 5 TEETH	58.610 MIN/ 58.661 MAX.
TOOTH WIDTH	38.1mm
CENTRE DISTANCE	306.4
PITCH CIRCLE DIA (REF):	182.019
CLASS (ACCURACY GRADE)	6
NUMBER OF TEETH OF MATING GEAR	102
DRAWING NO OF MATING GEAR	SKDP-3116

2. FOR OTHER TECHNICAL REQUIREMENTS REFER TO R.D.S.O. SPECIFICATION No. MP-0.2800.16 REV.0.1 (JUNE 2007) FOR MATERIAL, MANUFACTURING TECHNIQUE & HEAT TREATMENT REFER TO CLAUSE 2,3,4,5 & 8 RESPECTIVELY OF THE ABOVE SPECIFICATION. TOTAL DEPTH SHALL CONFIRM TO THE REQUIREMENTS OF PROTUBERANCE CUTTER VIDE CLAUSE 9.4 OF SPECIFICATION NO. MP-0.2800.16 (REV.01) OF JUNE 2007.

3. MARKING :

ALL GEARS SHALL BEAR THE FOLLOWING MARKINGS WHICH SHOULD BE INDELIBLE AND CLEARLY LEGIBLE.

- NAME OF SUPPLIER/MANUFACTURER.
- NUMBER OF MONTH AND LAST TWO DIGITS OF THE YEAR OF MANUFACTURE e.g. 5/2007, & GEAR RATIO.
- MATERIAL AND SPECIFICATION OF STEEL.
- DRAWING NUMBER OF THE PART.
- MANUFACTURER/CONSECUTIVE NUMBER OF THE PART.

4. ∇ ALL OVER UNLESS OTHERWISE STATED.

5. ALL BURRS TO BE CAREFULLY REMOVED FROM ENDS OF TEETH AFTER CUTTING, CARE BEING TAKEN THAT THE INVOLUTE IS NOT DESTROYED.

6. ALL SHARP CORNERS AND EDGES SHOULD BE REMOVED.

7. MACHINING

THE TEETH SURFACE SHALL BE FINISHED BY GRINDING & SATISFY THE FOLLOWING:-

TOOTH ACCURACY :-

INDIVIDUAL PITCH ERROR	0.010
CONSECUTIVE PITCH ERROR	0.019
TOOTH ALIGNMENT ERROR	0.014
PROFILE ERROR	0.019
RADIAL RUN OUT	0.045

8. TEETH SHALL BE CASE HARDENED & EFFECTIVE CASE DEPTH SHALL BE 1.0mm TO 1.25mm.
9. HARDNESS ON TEETH SHALL BE 55.2RC TO 59.2RC OR 600HV TO 680HV.
10. SHOT PEEN, TEETH & ROOT SECTION OF TEETH BEFORE TEETH GRINDING. USE SHOT SIZE SAE-170 TO OBTAIN 90% MINIMUM COVERAGE IN ROOT AREA & PEENING INTENSITY SHOULD BE 0.010 - 0.012A.
11. MAGNAFLUX INSPECT AS PER IS -3703

D	A.K. BRAMHANE	50
C	PRAKASH KUMAR	25
TQ		6.3
APPD.		0.8
Dt	22-06-2007	0.1

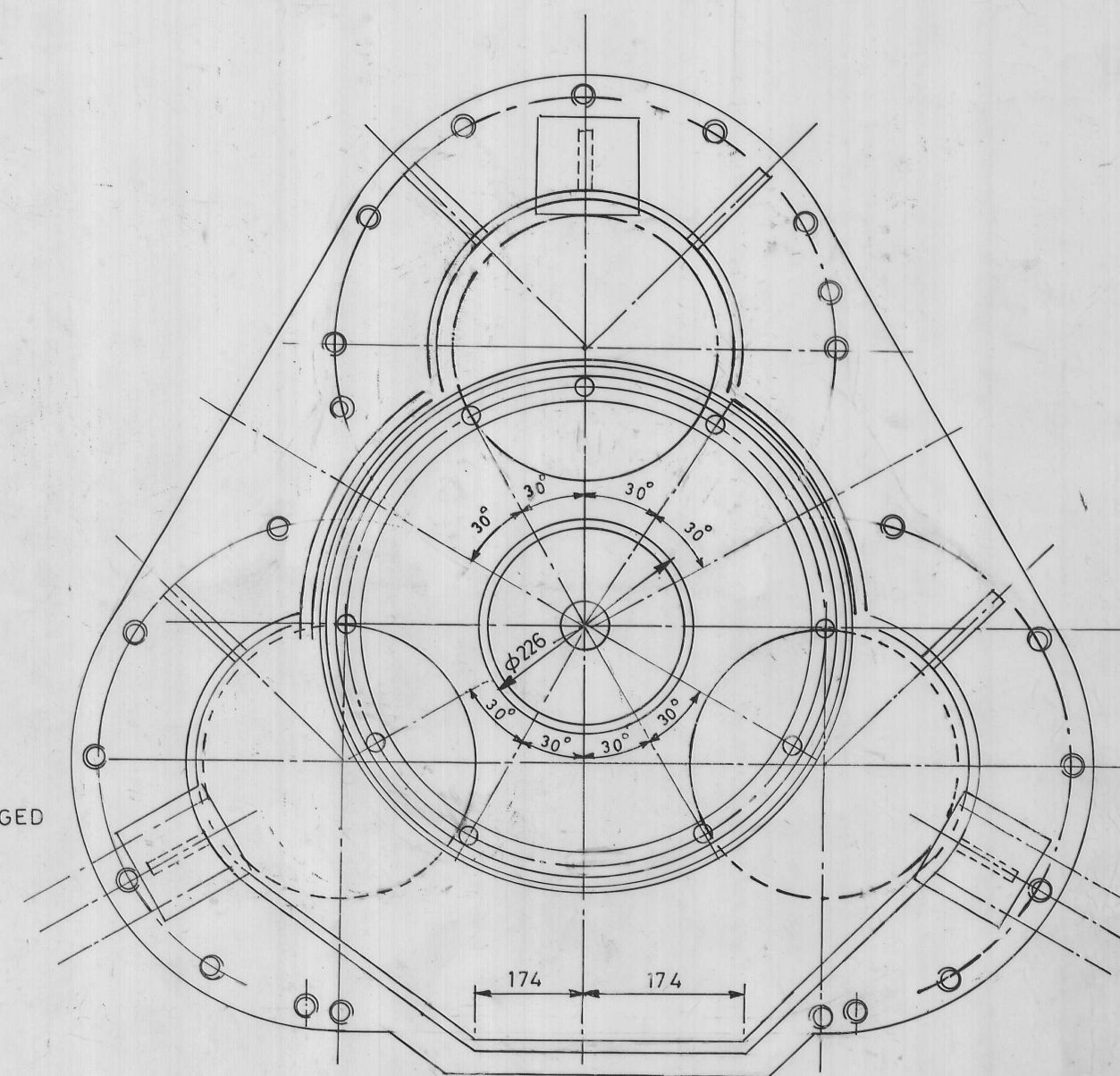
* SURFACE ROUGHNESS TO IS:3073

WELDING SYMBOLS TO IS:813

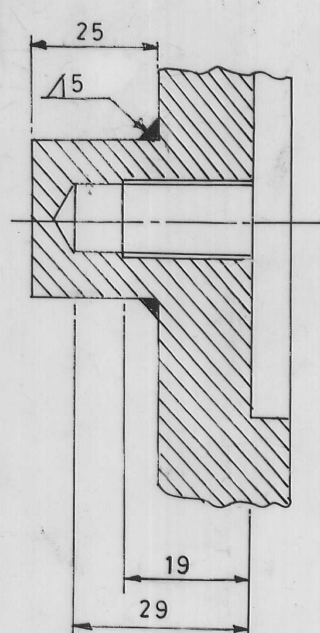
TOLERANCES ON UNTOLERANCED DIMENSIONS TO IS:2102 (MEDIUM)

③	2	MATERIAL SPECIFICATION REVISED NOTE NO. 7 TO 11 ADDED, AND DRAWING REDRAWN.	L3-123	15.06.2007
②	4	CROWNING 0.05 WAS 0.025	L3-507	22.7.1999
①	1	CROWNING PROVIDED	L3-380	04.05.1994
ALT	NO. OF PLACES	REF. NO.	DESCRIPTION	ALT. NOTE NO.

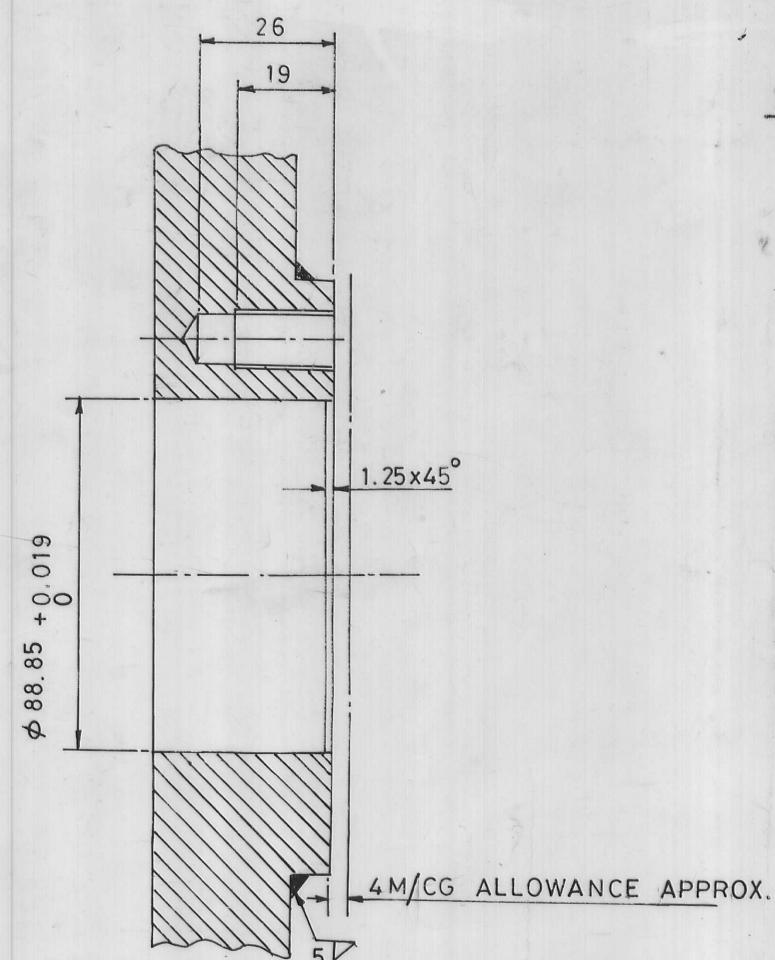
-	-	AG / EG - PINION	2	-	SEE NOTE-2
REF. NO.	I.R. PART NO.	DESCRIPTION	NO./LOCO	VT NO. EACH	MATERIAL SPEC.
APPLICABLE FOR WDM2A, WDM3A, WDP3A & WDG3A. (AC/DC LOCOS)					
43 TEETH PINION (FOR AG-3101 & PTU - PT 70 AZ.)					
SCALE: 1 : 1 REF: BHEL DRG. NO. 24301623007					
INDIAN RLYS. DRG. NO. SK.DP.-3117					
R.D.S.O. (MP)					
FIRST ISSUED					
SUPERSEDES					
SUPERSEDED BY					



SECTION-DD



ENLARGED VIEW



MACHINE ALL OVER

REF. NO.	I.R PART NO.	DESCRIPTION	NO OFF	WT. KG.	MATL. & SPECN.
APPLICABLE FOR ALTERNATOR 10102 CW		GEAR CASE ASSEMBLY WITH AG 2702 AZ			
SCALE		REF:-			FIRST ISSUED
INDIAN RLYS. R DSO (MP)		DRG. NO. SK.DP - 3303			SUPERSEDES
TE					SUPERSEDED BY

ALT. NO.	REF. NO.	NO OFF PLACES	DESCRIPTION	ALT. NOTE NO.	SIGN.	DATE
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D	<u>Khande</u>
T	<u>Khande</u>
C	<u>H</u>
TC	
APPD	<u>G</u>
Dt.	8 / 94