GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(Railway Board)

INDIAN RAILWAY STANDARD SPECIFICATION FOR INVERTER FOR RAILWAY SIGNALLING INSTALLATIONS FOR "ON LINE" APPLICATIONS

Serial No.S: 82-92

0. FOREWORD

0.1 This specification is issued under the fixed serial No.S-82-92 followed by the year of adoption as standard or in the case of revision, the year of latest revision.

ADOPTED-1992

0.2 This specification requires reference to the following Indian Railway Standards (IRS) and Indian Standards (IS) specifications:

IRS:S 23	Electrical Signalling & Interlocking Equipment.
IRS: S 76-89	Specification for PVC insulated cables and wires for Indoor Railway Signalling.
IS: 1248	Direct Acting Analogue Indicating Electrical Measuring Instruments and their accessories.
IS: 2086	Carriers and bases used in Rewirable type Electrical fuses up to 650V.
IS: 2208	HRC Cartridge fuse links upto 650V
IS: 2419	Dimensions for panel mounted indicating and recording Electrical Instruments.
IS: 2628	Rotary Wafer Switches
IS: 2786	Ceramic Dielectric Capacitors, type 2

IS: 2959	Contactors for voltage not exceeding 1000V A.C or 1200V D.C.
IS: 3895	Monocrystalline / semiconductor rectifier cells and stacks.
IS: 4064	Air brake switches, air-break disconnectors, air-break Switch-disconnectors and fuse combination units for Voltages not exceeding 1000V AC or 1200V DC.
IS: 5786	Fixed resistors general purpose low power
IS: 2147-1962	Degrees of protection provided by enclosure for low voltage switch gear and control gear.
IS: 9224 (Pt.IV) – 1980	Specification for Low Voltage fuses for the protection of semiconductor devices.
IS 6297 (pt. I & II)	Transformers and inductors (power audio pulse and switching) for electric equipment.
IS: 8083	Ceramic Dielectric Capacitors of the plate type.
IS: 8828	Miniature air-break circuit breaker for AC circuits for voltage not exceeding 1000V.
IS: 8909	Fixed resistors, general purpose power.
IS: 9000	Basic environmental testing procedures for electronics and electric items.
IRS:S 78-92	Specification for non-deteriorating type low voltage fuses
IS: 9638	Fixed polyester film-dielectric capacitors for Direct Current.

RDSO/SPN/121/91 – Specification for printed circuit boards to be used in Railway Signalling and Telecommunication applications.

0.3 Whenever, in this specification, any of the above mentioned specifications is referred by number only, without mentioning the year of issue, the latest issue of that specification is implied, otherwise, the particular issue referred to is meant.

0.4 This specification is intended chiefly to cover the technical provisions and does not include all the necessary provisions of a contract.

1. SCOPE

1.1 This specification lays down the requirements and tests for static type solid state inverters for use in railway signalling installations.

1.2 This specification lays down the requirements for continuous rated inverters for "ON LINE" applications. The inverter will switch over to commercial supply only in case of inverter failure.

1.3 The preferred rated input voltage to the inverter shall be as follows or as specified by the purchaser.

12, 24, 48, 60, 110 and 120 volts DC.

The input voltage of 12V and 24V shall be restricted to inverters of capacity up to 250 and 500VA respectively.

1.4 The rated output voltage of the inverter shall be 110V or 230V AC as specified by the purchaser.

1.5 The preferred VA ratings for inverters shall be as follows or as specified by the purchaser.

100, 250, 500, 750, 1000, 1500, 2000, 2500, 3000, 3500, 4000 and 5000 VA.

2. TERMINOLOGY

2.1 For the purpose of this specification, the terminology given in IRS:S 23 shall apply.

3. GENERAL

3.1 The inverter shall conform to drawings, dimensions and layout, if any, specified by the purchaser.

3.2 The inverter shall be completely static without any moving parts. It shall incorporate solid state components like thyristors, power transistors, field effect transistors or Ferro Resonant CVT for producing the AC output from DC input either through conventional inverter bridge or by using PWM technique.

3.3 The inverter shall be of natural air cooled type and shall be suitable for continuous indoor use in the cabins where the maximum ambient temperature may reach 60 deg. C. Forced cooling shall be used for inverters of capacity more than 1 KVA only. In case the inverters are force cooled, the AC cooling fan used shall be continuously rated and temperature controlled. The

manufacturer shall ensure that the failure of fan does not cause any fire hazard. The cooling fan shall have MTBF of greater than 70,000 hrs at 40 deg.C. For type test, manufacturer shall submit the MTBF certificate from any national / international lab.

3.4 The inverters of all output ratings shall be of floor mounting type.

3.5 The inverters shall be of robust construction. They shall be housed in shelf supporting cubicles made of cold rolled closed annealed mild steel sheet of thickness not less than 1.5 mm. The cubicles shall be adequately ventilated. Ventilating openings shall be less than 3 mm size for protection against entry of lizards etc. The cubicle shall conform to IP-31 type of protection as specified in table 1 of specification no. IS: 2147-1962.

3.6 The inverter cubicles shall be treated with Zinc chromate primer surface cleaning through seven-stage process followed by electrostatic epoxy powder coating paint finish. Passivation shall be done through seven stage process. Small metal parts such as nuts, bolts and washers shall be either galvanized or chrome plated to protect against corrosion. All other metal parts of the regulator shall be plated for protection against corrosion.

3.7 The layout of the components and wiring shall be such that all parts are easily accessible for inspection, repairs and replacement.

3.8 The AC input (commercial supply) and output terminals shall be accessible only when the cover of the cubicle is removed and shall be marked ‘L’ & ‘N’. All terminals shall be clearly, neatly and indelibly marked to correspond with the wiring diagram for easy identification. For smaller units of capacity 250VA, the input and output terminals can be brought out and covered with an insulated cover.

3.9 All the cables and wires used for wiring shall conform to specification no. IRS:S 76-89 and shall be procured from RDSO approved suppliers. The cables and wires used shall be neatly secured in a position by bunching and strapping. Aluminium wires shall not be used. The gauge of wiring shall be such that the current density does not exceed 3Amp / mm square. The colour scheme employed for wiring shall conform to normal conventions and be shown in the suppliers instruction’s manual.

3.10 All connections shall be made through crimped eyelets and shall be numbered with PVC cable marker rings corresponding to the numbers / letters shown in the schematic wiring diagram. Soldering shall be used only where use of crimped eyelets is not possible.

3.11 The schematic wiring diagram referred in clause 8.1 (e) shall show details of wiring used for inter-connecting the main components of the inverter. This

diagram shall be firmly fixed on the inner side of the cover of the unit. This diagram shall be drawn on an anodised aluminium plate of thickness not less than 1 mm and size less than 150 mm x 100mm or screen printed of similar size.

3.12 All non-current carrying metal parts shall be bonded together and adequately earthed.

3.13 The switch over to battery and vice-versa shall not cause any interruption to the inverter output AC power.

3.14 Incoming and outgoing wire outlets shall be fitted with suitable bushing to protect cable from damage so that no space shall be left out around the cable.

3.15 The components like Transformer / Choke / Contactor / Power Relay / Control Transformer shall not be mounted on wire mesh or bottom plate directly.

3.16 It is preferable that the commissioning of the inverters be carried out by the manufacturer. Railway may advise the manufacturer in advance for commissioning of the inverter.

3.17 DO & DON'T'S shall be screen printed on front panel.

4. COMPONENTS

4.1 Transformers and Inductors

4.1.1 The main transformer shall be double wound and shall conform to category 3 (Cl 3.1) of IS: 6297 (Pt. I) – 1971 and grade 2 (Table 1) of IS: 6297(Pt.II) – 1973. Class F or better class insulating material shall be used.

4.1.2 The transformers and chokes shall be vacuum impregnated.

4.1.3 When tested in accordance with Cl. 6.2.1.6 of IS: 6297 (Pt. I)-71, the transformer shall show an insulation resistance of not less than 100 Meg ohm when measured at temperature of 40 deg C and relative humidity of 60% (Cl. 9.8). This value shall not fall below 50 Meg ohms at the end of climatic tests as per Cl. 9.14.4 of IS: 6297. In case the temperature and humidity prevalent at the time of measurement are different, the IR values shall be derived from table 'A' of Cl. 9.8.1.

4.1.4 The maximum permissible rise in temperature above ambient shall be 65 deg. C for transformers and chokes.

4.1.5 The current density of transformer and choke shall be less than 2A / mm.sq for PWM based inverter and 1.6 A / mm.Sq for CVT based inverter.

4.2 Printed Circuit Cards and Electronic components

4.2.1 Glass epoxy, copper clad laminates, conforming to RDSO/SPN/121/91 shall only be used for printed circuit control cards. The thickness of laminates shall not be less than 1.6 mm and the thickness of the copper foil shall not be less than 35 microns (corresponding to a weight of 305 grams of copper per square metre).

4.2.1.1 The track on the PCB shall not be destroyed even after heating /burning of MOSFETS or failure of any components on the PCB. The PCB shall be provided with slow blow type glass fuse. One set of all type of fuses shall also be kept inside the inverter in a polythene pack.

4.2.2 The printed circuit cards shall be fitted with plug in arrangement by using gold plated harp / Euro / hartinge connectors to JSS specification. These shall be procured from RDSO approved sources.

4.2.3 Solid state industrial grade components of high reliability and suitably derated to not more than 50% of the rated value shall only be employed for mounting on the printed circuit cards. Components shall conform to IS: 2628, IS: 2786, is: 5786, IS: 8083, IS: 8909, IS: 9638.

4.2.4 Semi-conductor power devices used in the inverters shall not be operated at more than 50% of the rated maximum peak voltage and at not more than 50% of the rated maximum average current under any prevailing conditions specified in this specification. Temperature rise in case of darlington pairs power transistors and diodes shall not be more than 70 deg. C and in case of SCRs 50 deg. C.

4.2.5 No extra wires shall be used for inter connections of components on the PC cards. Soldering of components shall be done with meticulous care so that joints are not dry.

4.2.6 The manufacturer's name or trade mark shall be engraved or printed on the cards. If more than one PCBs are used, each one shall be identified by a separate code to distinguish the cards. The cards shall be provided with testing points and the corresponding voltages / wave forms shall be indicated in the fault diagnosis procedure in service manual to facilitate testing and fault tracing.

4.2.7 The printed cards shall suitably be located so that the cards and their components are not adversely affected by heat radiated by other components and sub-units of the inverter.

4.2.8 After mounting and soldering of all the components and card testing, the printed circuit cards shall be coated with transparent epoxy paint to provide environmental protection against humidity, fungus and corrosion.

4.2.9 The control, annunciation, power supply and supervisory control circuit shall be suitably designed on one PCB and shall be rigidly fixed and shall not rest on connector. Only firing card can be separated and placed near to switching device.

4.2.10 The power supply for control PCB shall be suitably protected against the input surges/ ripple.

4.3 Meters

4.3.1 A true RMS digital 3½ digit ± 3 count AC voltmeter and AC ammeter of accuracy class better than 1% of the IS: 1248-1968 shall be provided on the front panel to indicate RMS voltage and current at the output. The meters shall also conform to clause 1.1.1 (c) of IS: 2419.

4.3.2 The dimensions of the meters shall conform to IS: 2419.

4.3.3 The voltmeter shall have a range of 0-300V, the scale length being not less than 84 mm. A distinct green marking shall be provided at the rated output voltage. The voltmeter shall be protected by a suitable device against over voltage.

4.3.4 The ammeter shall have a range of 150% to 200% of the rated output current. Scale length shall not be less than 84mm. A red line shall be provided from rated output current to full scale of the ammeter.

4.4 Switches, Terminals and Indicators

4.4.1 Inverters shall be provided with two-pole isolator of 1.5 times rating as per IS: 8828 on the front panel for disconnecting output side.

4.4.2 Inverters shall be provided with non-deteriorating low voltage fuses conforming to specification no. IRS:S 78-92 in the DC input circuit and the AC output circuits.

4.4.3 Rotary switch conforming to IS: 4064 along with high speed fuse shall be provided on the input side.

4.4.4 The following 10 mm size LED indication shall be provided on front panel and shall be placed in one row vertically.

1.Input power ON	- Green
2.Output ON / inverter on load	- Green
3.Manual bypass switch ON	- Amber
4.Load on mains	- Amber
5. Inverter trips	- Red

4.4.5 An earth terminal suitable for connecting 4 mm dia wire and with suitable marking shall be provided.

5. PERFORMANCE REQUIREMENTS

5.1 The inverter shall be designed for continuous operation up to and including the rated load over an ambient temperature range 0 –60 deg. C and at a relative humidity up to 95% at 40 deg. C.

5.2 The inverter shall work satisfactorily with DC input voltage variation from 90% to 135% of the rated input voltage.

5.3 The inverter shall be capable of delivering any output from no load to full load of the rated capacity. Power factor of the load shall not be worse than 0.7 lagging.

5.4 i) The steady state AC output voltage shall come within ± 2% of the set value (rated) over the range of conditions specified in clause 5.1 to 5.3. It shall be free from modulation and hunting. For PWM type inverter, the output of inverter shall be continuously settable at any value between 220 to 240V, the adjustment shall be provided on the control card inside the inverter. For CVT based inverter suitable tapping at 220 and 240V shall be provided.

ii) Over-shoot and under-shoot in the first five cycles for complete load shut off shall be restricted to 20%.

5.5 Frequency of the output voltage shall be 50 Hz ± 1 Hz, over the range of conditions specified in clauses 5.1 to 5.3.

5.6 The output voltage waveform shall be sinewave. Total harmonic distortion of the output shall not exceed **5%** for PWM based and 8% for CVT based inverter under any condition specified in clauses 5.1 and 5.3.

5.7 The no load current at rated input voltage shall not exceed 5% of the full load input current for inverters of PWM type and the no load current for ferro resonant voltage regulator based inverter shall not exceed 20% of the full load input current.

5.8 Efficiency of the inverter at all input range and load of power factor between 0.7 and unity shall not be less than

For PWM		For CVT	
50-100% load	25-49% load	50-100% load	25-49% load
>85%	>75%	>70%	>55%

5.9 The inverter shall be capable of delivering 125% of rated full load at any ambient condition specified in para 5.1 for a period of 4 hours.

5.10 The inverter shall incorporate an auto change-over arrangement for change-over of load from inverter AC output to commercial supply within 250 ms in case of inverter failure. For auto change-over the contactor of minimum 2.5 times the rating shall be used.

5.11 A manual bypass switch shall be provided in addition to the auto change-over so that the inverter output can be bypassed for getting commercial AC supply.

5.12 Inrush current: It shall be possible to start the inverter on no load or any load up to full load. Inrush current to the inverter may be up to three times the steady state value for period not more than 500 ms. The voltage shall not dip more than 20% of its set value without battery at the input.

5.13 There shall not be any tendency to hunt of the inverter under any input and output conditions.

5.14 Noise / Sound Power: The inverter at no load and at commercial input supply shall not contribute more than 10dB for inverter of capacity upto 1 KVA, 15 dB for inverter of capacity >1KVA upto 3 KVA & 20 dB for inverter of capacity >3KVA weighted to the ambient lowest level taken as 45dBA. It shall be measured at a distance of 1 metre from the unit in all the sides including top in the full audio range upto 3.4 KHz. The correction factor for total noise when the ambient noise level is more than 45dBA shall be as given below:

Ambient Noise (dBA))	Correction factor (dB)	Ambient Noise (dBA))	Correction factor (dB)
45	0	53	2.07
46	0.18	54	2.43
47	0.39	55	2.82
48	0.61	56	3.25
49	0.86	57	3.69
50	1.12	58	4.17
51	1.41	59	4.68
52	1.73	60	5.21

Note: The correction factor shall be added to the limit of 55, 60 and 65 dBA to arrive the limit of greater than 45 dBA. The measurement to be recorded after 2 hours of switching on the unit.

5.15 In case of CVT based inverter the resonant voltage across the capacitor bank must not exceed 480V at all input voltage and no load. AC metal can capacitor of 600V grade with built in wire shall be used for resonance purposes.

6. PROTECTION AND ADDITIONAL FACILITIES

6.1 The inverter shall be provided with means for protection and visual indication for the following conditions:

6.1.1 Pole reversal of DC input voltage
6.1.2 Under voltage of DC input
6.1.3 Over voltage of DC input
6.1.4 Over load/ short circuit of AC output
6.1.5 Output over voltage
6.1.6 Output under voltage.

6.2 The inverters of output ratings of 500 VA and above shall also be provided with both audible and visual alarm for conditions mentioned at clause 6.1.1 to 6.1.6.

6.3 Suitable surge voltage protection shall be incorporated in the circuit.

6.4 A reset key shall be provided to enable the cutting off the audible alarm. The visual alarm indication will however, continue to glow to attract the attention of maintenance staff and shall extinguish only after the alarm condition is cleared by pressing the alarm reset key.

6.5 In case of conditions mentioned in clause 6.1.2, 6.1.3 & 6.1.4 the inverter shall start automatically when the conditions are normalised. Auto start, in case of DC under voltage, shall be effective at 2.2V / cell.

6.6 In case of clause 6.1.5 and 6.1.6 the PWM based inverter shall trip in the event of output voltage exceeding 10% or goes below 10% of the set output voltage for more than 2 second, with an inverse characteristics between load voltage and switch off time. It shall also have the feature of self-resetting for these conditions. The CVT based inverter shall trip in the event of output voltage goes below 207V.

7. MARKING

7.1 All markings/ indications shall be legible and long lasting fixed conspicuously. They shall withstand all climatic tests.

7.2 The words 'INDIAN RAILWAY PROPERTY' shall be indelibly etched, engraved or embossed on the inverter at the conspicuous position. The size of the letters shall be chosen depending upon the size of the inverter cubicle but shall not be less than 20 mm high in any case.

7.3 Each inverter shall be provided with an anodized aluminium rating plate fitted at a conspicuous position. The rating plate shall be indelibly marked with the following information:

a) Name or trade mark of the manufacturer.
b) IRS specification number
c) Rated KVA
d) Rated DC input voltage range
e) Rated AC output voltage
f) Serial number
g) Year of manufacture

8. INSTRUCTION MANUAL

8.1 Two copies of the instruction manual duly approved by RDSO shall be supplied along with each inverter. The manual shall include the following information.

a) Installation instructions.
b) Explanatory notes on operation, maintenance and adjustment procedures.
c) Guaranteed performance data and technical and other particulars of the inverter.
d) Trouble shooting procedures.
e) Detailed wiring diagrams showing all components and their values.
f) Schematic block diagram showing general mounting arrangements of various components.
g) List of components used, their make, values and ratings.
h) Any other information which the manufacturer may like to give.

9. TESTS AND REQUIREMENTS

9.1 Conditions of tests – Unless otherwise specified, all tests shall be carried out at ambient atmospheric conditions.

9.1.1 For inspection of material, relevant clauses of this specification shall also apply.

9.2 Test equipments:- The ammeters and voltmeters used in the tests shall be of an accuracy class equal to at least 0.5 of IS: 1248-1968

9.3 Type tests:- The following shall comprise type tests and shall be carried out once in three years in the given sequence

a) Visual inspection (Cl. 9.6)
b) Applied high voltage test (Cl. 9.7)
c) Insulation resistance test (Cl. 9.8 & 4.1.2)
d) Tests for output regulation and performance characteristics (Cl. 9.9)
e) Temperature rise test (Cl. 9.10, 9.10.1, 9.10.2)
f) Tests on protection and additional facilities (Cl. 9.11)
g) Climatic tests(Cl. 9.13)
h) Vibration test (Cl. 9.14)
i) Test for continuous operation (Cl. 9.12)
j) Overload and in-rush current test (Cl.5.9 & 5.12)

9.3.1 Only one inverter of each type and output rating shall be tested for this purpose. The inverter shall successfully pass all the type tests for proving conformity with this specification. If the inverter fails in any of the type tests, the purchaser or his nominee at his discretion, may call for another inverter of the same type and output rating and subject it to all tests or to the test (s) in which failure(s) occurred. No failure shall be permitted in the repeat test (s).

9.3.2 At the end of the validity period of 3 years for type approval or earlier if necessary, the testing authority may call for fresh samples for type testing.

9.4 Acceptance tests - The following shall comprise acceptance tests.

a)	Visual inspection	(Cl 9.6)
b)	Applied high voltage test	(Cl. 9.7)
c)	Insulation resistance test	(Cl. 9.8)
d)	Tests for output regulation and performance characteristics	(Cl. 9.9)
e)	Temperature rise test	(Cl. 9.10 and 9.10.2)
f)	Tests for protection and other facilities	(Cl. 9.11)
g)	Overload test and In-rush current test	(Cl. 5.9)

9.4.1 The following sampling plan shall adopted. There shall not be any failure during acceptance test.

Lot size	Sample size for performance test as per Cl.9.9.	Sample size for other than performance test
2-8	2	1
9-15	3	1
16-25	5	2
26-50	8	2

51-100	13	3
101-150	20	3
151-200	32	3

9.4.2 One of the inverters shall be tested for performance test at 60 deg. C, during acceptance test as per Cl. 9.9.

9.5 ROUTINE TESTS

The following shall constitute routine tests and shall be carried out on every inverter and test results will be submitted by manufacturer to the Inspecting Authority at the time of inspection.

a) Visual inspection (Cl 9.6)
b) Applied high voltage test (Cl. 9.7)
c) Insulation resistance test (Cl. 9.8)
d) Test for continuous operation (Cl. 9.12)
e) Tests for output regulation and performance characteristics (Cl. 9.9)
f) Tests on protection and additional facilities (Cl. 9.11)

9.6 Visual Inspection

The inverter shall be examined for provisions of all facilities stipulated in this specification, correct wiring, proper mounting of components, marking, workmanship and finish for which no tests have been specified.

9.7 Applied High Voltage Test

The inverter shall withstand for one minute without puncture and arcing a test voltage of 2000 V AC rms applied between power components and the body of the unit which shall be earthed. The test voltage shall be approximately sine wave form and of any frequency between 50 and 100 Hz. Any electronic component (s), which are likely to get damaged by the application of high voltage, shall be disconnected during the test.

9.8 Insulation Resistance test

This test shall be carried out

a) Before the high voltage test.
b) After the high voltage test
c) After the temperature rise test when the equipment has attained ambient temperature and
d) After the climatic tests have been completed.

The measurements shall be made at a potential of not less than 500 V DC. The insulation resistance shall be measured between

a) Input line terminals and the body of the equipment.
b) Output line terminals and the body of the equipment.

Value of the insulation resistance shall not be less than 10 Meg ohms for the equipment and 100 Meg ohms for the transformers and inductors measured at a temperature of 40 deg. C and Relative Humidity of 60%. There shall be no appreciable change in the values measured before and after high voltage test and after temperature rise test.

After the completion of climatic tests, the values shall not be less than 5 Meg ohms for the equipment and 50 Meg ohms for the transformers and inductors measured at a temperature of 40 deg. C and Relative Humidity of 60%. In case the prevalent values of temperature and RH at the time of measurement are different from those specified above, the IR values shall be obtained from table 'A' of Cl. 9.8.1.

9.8.1 **Table 'A'**

Value of IR at different temperature and Relative Humidity

RH	*25 deg. C*	*30 deg. C*	*35 deg.C*	*40 deg.C*
60%	100 M.Ohm	100 M.Ohm	100 M.Ohm	100 M.Ohm
65%	100 M.Ohm	90 M.Ohm	85 M.Ohm	80 M.Ohm
70%	80 M.Ohm	70 M.Ohm	65 M.Ohm	60 M.Ohm
75%	60 M.Ohm	53 M.Ohm	47 M.Ohm	43 M.Ohm
80%	42 M.Ohm	36 M.Ohm	33 M.Ohm	30 M.Ohm
85%	29 M.Ohm	25 M.Ohm	22 M.Ohm	18 M.Ohm
90%	20 M.Ohm	16 M.Ohm	13 M.Ohm	10 M.Ohm
95%	15 M.Ohm	10 M.Ohm	7 M.Ohm	5 M.Ohm
100%	10 M.Ohm	6 M.Ohm	3 M.Ohm	1 M.Ohm

Note 1. The value of insulation resistance has been taken as 100 M. ohms at a temperature of 40 deg. C and RH of 60% values of IR at different temperature and RH may be obtained from the table.

2. To obtain the value of IR, corresponding to 50 M. ohms or 10 M. ohms or 5 M. ohms at 40 deg. C and 60% RH, a multiplying factor of 0.5 or 0.1 or 0.05 respectively may be used.

3. The value of insulation resistance for extreme conditions of temperature and RH shall not be less than 1 M. ohm even if the value at 60% RH and 40 deg. C temperature is less than 100 M. ohms.

9.9 Test for output regulation & performance characteristics:

The inverter shall be tested to check for regulation with respect to output load and DC input, no load current, total harmonic distortion, frequency and efficiency to verify the provisions of Cl 5.2 to 5.11 from lagging PF of 0.7 to Unity PF.

9.9.1 For routine tests, requirements given under clauses 5.2 to 5.11 shall be verified.

9.10 Temperature Rise Test

The cold resistance of transformer winding shall be measured after conditioning the unit until three consecutive temperature readings taken at 30 minutes intervals are constant and the constant temperature shall be taken as reference temperature T1.

The unit shall be operated at full rated load, the input voltage being set at the value at which lowest efficiency has been obtained during output regulation and performance characteristics test as per Cl 9.9. The test shall be continued until thermal equilibrium is reached i.e. temperature variation between three successive readings taken at an interval of 30 minutes is less than 1 deg.C. Throughout the test the rated load shall be maintained. Once the thermal equilibrium is reached, the unit shall be switched off and the hot resistance of the windings shall be measured within 1 minute of switching off.

The temperature rise of the winding shall be computed by the following formula-

$$\text{Delta } T = (R2 - R1)/R1 * (234.6 + T1) - (T2 - T1)$$

Where Delta T = Temperature rise of the winding.

R1 = Resistance at the beginning of the test at temperature T1
R2 = Resistance at the end of the test
T1 = Reference room temperature at the beginning of the test
T2 = Room temperature at the end of the test.

Maximum temperature rise above ambient temperature (T2) shall not be more than 65 deg. C.

9.10.1 For type test, temperature rise test shall be conducted during dry heat climatic test at 65 deg. C (Cl. 9.13.1 (i) and temperature rise shall be measured at the end of 16 hours test duration.

9.11 Test for protection and additional facilities

The tests shall be conducted to verify the provisions specified under clauses 6.1 to 6.4.

9.12 Test for Continuos operation (Endurance test)

9.12.1 The inverter shall be subjected to a continuous operation for 1000 hrs at rated input and 0.7 PF inductive output load with a 30 minutes change over between inverters / standby supply, the lamp load shall also be switched between 100% to 125% after every 30 minutes alternatively. Charger will also be switched off for 30 minutes in an hour. After endurance the unit shall satisfy the requirement of clause 5.0

9.12.2 For routine test inverter shall be subjected to continuous operation for 8 hours at rated input and output with a 30 minute changeover between inverter and stand by supply. Output voltage and current shall be recorded after every changeover.

9.13 Climatic Tests

9.13.1 Climatic tests shall consist of :

i) Dry heat test at 65 deg. C ± 2 deg. C at full rated output for 16 hours duration as per IS: 9000 (Pt. III) section 5, during which the maximum temperature rise shall not exceed 50 deg.C During last half an hour of this test, the inverter shall be checked to meet the requirements of clauses 5.2 to 5.6

ii) Damp heat (cycle) tests for variant 1 for 7 cycles at upper temperature range of 40 deg. C ± 2 deg.C as per IS: 9000 Pt.V section 2.

iii) Cold test at 0 deg. C for two hours duration as per IS: 9000 (Pt. II). During last half an hour of this test, the inverter shall be checked to meet the requirements of clauses 5.2 to 5.6.

9.14 Vibration Test: The inverter shall be subjected to the vibration test(sinusoidal) as per IS:9000 Pt. VIII with following severities :

a)	Frequency range	:1-35 HZ
b)	Amplitude	:0.15mm or 2g whichever is less
c)	No. of Axes	:3
d)	No. of sweep cycle	:10
e)	Total duration	:1 hour 45 minutes
f)	If resonance is observed, vibration test at each resonant frequency	:10 minutes

After the test the inverter shall be visually inspected for any mechanical damages. The electrical parameters shall be measured as per Cl. 5.0.

10 PACKING AND LEVELLING

10.1 The complete unit shall be packed in suitable strong boxes / crates strong enough, without additional packing to prevent damage or loss to the unit during transit. Loose space inside the box / crates shall be filled with thermocole.

10.2 The fragile components such as meters and PC cards shall be separately and individually packed to prevent damage. Thermocole cushioning or bubble-sheet shall be provided in the packing box.

10.3 Each box shall be legibly marked at one end with code numbers, contents, quantity and name of manufacturer / supplier.

10.4 The front panel of the inverter shall be fitted with moulded thermocol to suit the front cover shape of the inverter and tightly fixed and other sides shall be covered with plain thermocol.

ANNEXURE – 'A'

INFORMATION TOBE SUPPLIED BY THE PURCHASER

1. IRS specification number.
2. Drawings, dimensions and layout if desired (Cl. 3.1)
3. Rated DC input voltage (Cl. 1.3)
4. Rated AC output voltage (Cl. 1.4)
5. Rated VA (Cl. 1.5)
6. Whether the inverter being procured is:
   a) Ferro –resonant type inverter or
   b) Solid state PWM based inverter.