Draft Functional Requirement Specification of High Integrity Integrated LED Signal Lamp for MAIN COLOUR LIGHT SIGNALS FOR RAILWAY SIGNALLING

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SIGNAL DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISATION
LUCKNOW-226011

TABLE OF CONTENTS

0. FOREWORD

0.1 *This* Draft FRS *is proposed for High Integrity LED Signal*

0.2 This Draft FRS requires reference to the following Indian Railway Standards / British Standards / International Standards specifications:

i) RDSO / SPN / 144 / 2006 Rev. 2: Safety and reliability requirement of electronic signaling equipment

ii) STS/E/Relays/AC Lit LED Signal/09-2002: Tentative specification for universal plug-in type, tractive armature AC lamp proving relay (metal to carbon) for 110V AC LED signal lamp

iii) IRS:S23: Indian Railway Standard specification for electrical and electronic based signalling and interlocking equipment

iv) BS 1376:1974: Specification for colours of light signals

v) CENELEC Standard EN 50126: Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

vi) CENELEC Standard EN 50129: Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signaling

vii) IEC 127: International Standard for miniature fuses

0.3 Wherever in this Draft FRS any of the abovementioned specification is referred to by number only without mentioning the year of issue, the latest issue of the specification is implied, otherwise the particular issue referred to is meant.

0.4 This Draft FRS is intended to cover the technical provisions and it does not include all the necessary provisions of a contract.

1.0 SCOPE

1.1 This Draft FRS covers the general and technical requirements of LED signal lamps for main colour light signals for railway signaling application in RE& Non RE areas of Indian Railways for use without Cut in relays and with direct feed. Draft FRS also include accessories of LED Signal Lamp like suitable Lamp proving device OR any other external device, if required to achieve the Functional requirement. Wherever LED Signal Lamp is referred in FRS it may be treated as including accessories.

2.0 ABBREVIATION USED

RDSO: Research Designs & Standards Organisation

CENELEC: European Committee for Electrotechnical Standardisation

IEC: International Electrotechnical Commission

BS: British Standards

RE: Railway Electrification

MTBF: Mean Time Between Failure

CLS: Colour Light Signalling

ECR: Lamp Proving Relay

LED: Light Emitting Diode

UV: Ultra Violet

OK: Okay

PCB: Printed Circuit Board

ABS: Acrylonitrile Butadiene Styrene

NO/NC: Normally Open/Normally Close

AC/DC: Alternating Current/Direct Current

3.0 TERMINOLOGY

3.1 The terminology used in this Draft FRS is covered by the definitions given in IRS:S 23.

3.2 The terms referred to in this Draft FRS but not covered in IRS: S 23, are defined below:

Blanking & Non-Blanking failure modes of LED signal lamps-

In **blanking mode**, an LED signal lamp shall extinguish when input current drawn by the LED Signal Lamp falls outside specified limits of**rated input current**or illumination falls to a value which is not less than 40% of nominal illumination due to a failure or any other reason. In such case, LED Signal Lamp should not draw input current more than **15 mA(OR any modified value as per suitable and compatableLamp Proving Device)** at maximum rated voltage to ensure dropping of AC LED ECROR any other suitable and compatible Lamp Proving Device .

In **non-blanking mode**, an LED signal lamp shall remain lit when input current drawn by the LED Signal Lampfalls outside specified limits of rated input current or illumination falls to a value which is less than 40% of nominal illumination due to a failure or any other reason. In such case, input current drawn by LED Signal Lampshall be limited to less than **40 mA (OR any modified value as per suitable and compatable Lamp Proving Device)** to ensure dropping of AC LED ECROR any other suitable and compatible Lamp Proving Device. Limit on input current shall apply when illumination has deteriorated to a value which is not less than 40% of nominal illumination.

4.0 GENERAL REQUIREMENTS

4.1 The minimum visibility distance of LED signal lamps for main colour light signals shall be 1000m. in clear daylight with peak sunrays at rated voltage.

4.2 Day and Night feature shall be available which will work according to ambient light sensing.

4.3 LED signal lamps shall also be visible to a driver stopping at the foot of the signal.

4.4 LED signal Lamps shall be so designed that they fit in the existing colour light signal housings as per Table-I given below as applicable or as specified by the Purchaser

Signal	Main Signal
Reference Drawing No.	SA : 23002 S 23024 / M

Table-I

4.5 LED signal lamps shall be compatible with AC LED ECRs as per STS/E/Relays/AC Lit LED Signal/09-2002 OR any other suitable and compatible Lamp Proving Device.

4.6 If any other suitable Lamp Proving Device other than AC LED ECR is used, it shall be so designed that they fit in the existing base of AC LED ECR and having same contact configuration as per AC LED ECR.

5.0 TECHNICAL REQUIREMENTS

5.1 Colour Co-ordinates

Colour co-ordinates of LED Signal lighting Units shall be as follows:

Red & Green: Class 'C'of BS: 1376

Yellow Aspect: Class 'B' of BS: 1376

Colour co-ordinates graph as per BS: 1376 is given in Annexure I.

5.2 OPERATING PARAMETERS

Operating parameters of various types of LED Signal lamps when used with AC LED ECRs OR any other suitable and compatible device for Lamp Proving.

LED Signal Lamps shall be as per Table- II given below:

Sl. No.	Parameter	Main Signal		
1.	Rated voltage at Input terminals of LED Signal lamp	110V ±25 %		
2	Current at rated voltage per unit at Input terminals of LED Signal lamp	110 to 150 mA (rms) * OR Any Suitable Current range may be decided as per proposed design		
3.	Illumination measured at 1.5m from LED Signal Lighting Unit in axial direction at rated voltage Suitable LUX value may be decided to meet visibility requirement upto 1000 m.	~~150 LUX 10% + 40%~~	~~175 LUX 10% + 40%~~	~~150 LUX 10% + 40%~~
4.	Colour	Red	Yellow	Green

Table II

Note: * Input current shall be within the specified limits in all design conditions of lighting except for non-blanking failure mode Complied

6.0 DESIGN CRITERIRA

6.1 The Lamp Proving Device should have capability to interface with EI and Datalogger.

6.2 The LED Signal Lamp shall be so constructed as to prevent unauthorized access.

6.3 The short circuit and over voltage protection of self-restoring type shall be provided.

6.4 Suitable surge protection shall be provided to protect against transient voltage, lightening and spikes etc as per RDSO /SPN/144/2006 Rev. 2 or latest.

6.5 The requirements laid down in relevant clause of latest version of RDSO /SPN/144/2006 and CENELEC standards shall be complied.

6.6 Suitable protection shall be provided against Electromagnetic interference (EMI) and Electromagnetic compatibility (EMC) as per Cl 5.2 and 9.4 of RDSO /SPN/144/2006 Rev. 2 or latest and relevant clause of CENELEC standards.

6.7 Turn on/Turn off time of LED Signal Lamp should be less than 200 ms.

6.8 LED signal lamp shall be so designed that in all designed conditions of its lighting, except for failure in non-blanking mode, it should ensure pick up of AC LED ECRs OR any other suitable and compatible device for Lamp Proving and input current drawn should be more than specified maximum pickup current of ECR or Lamp Proving Device with ECR or Lamp Proving Device connected in circuit.

6.9 Design should follow Six Sigma Standards.

6.10 LED signal lamp shall remain lit (for Non Blanking failure mode) or extinguish (for Blanking failure mode) in case of deterioration of illumination or when input current falls outside specified limits of rated input current due to a failure or any other reason as stipulated in Cl.3.2.

6.11 LED signal lamps of Green aspect shall be configured in blanking mode and LED signal lamps of Red aspect shall be configured in non blanking mode. LED signal lamps of Yellow aspects shall have selectable option for blanking and non-blanking.

6.12 Fluctuation in input voltage shall not result in latching of signal to Blanking/ non blanking failure mode.

6.13 The LED signal lamp shall not reflect sunlight/headlight of loco as it may give misleading aspect to the driver. Unique optical arrangement that reduces the possibility of signal phantoms.

6.14 Necessary protection shall be provided to protect from any malfunctioning due to false feed.

6.15 LED signal lamp shall withstand fail safe Noise Immunity Including Induced Voltage and shall be suitable for length of direct feed up to 3 km.

6.16 Design should be done in such a way so that only corresponding ASPECT is lit for which feed has been given from Relay Room. It should not get lit by any false feed/induced Voltage.

6.17 Design should be done in such a way so that LED Signal Lamp and AC LED ECR OR any other suitable and compatible device for Lamp Proving should not generate any of the following Unsafe/undesirable condition due to any reason:

I. Lamp Proving Device Picked up and aspect not displayed/unlit.
II. Lamp Proving Device Picked up and Wrong aspect Displayed.
III. Aspect not Selected by Interlocking, Lamp Proving Device not Picked UP, False Lighting of Aspect with Noise/Induced Voltage.

6.18 Power factor of LED signal lamp shall be 0.8 or better.

6.19 Voltage total harmonic distortion over full operating voltage range shall be less than 20%.

6.20 Dispersion angle of LED signal lamp, measured as per Annexure II, shall be $\geq 8^0 \leq 10°$ at 50% power points. Optics should be designed so that visibility does not fall below 600 m at dispersion angle in horizontal direction.

6.21 Light from LED signal lamp, when projected on a white target at 1.5 m from LED signal lamp the target shall be uniformly illuminated within half power points and shall be free from dark circles.

6.22 The LED signal lamp shall work satisfactorily (Input current will remain in the limits as specified in Clause 5.2) in ambient temperature varying from -10°C to +70°C and a relative humidity upto 95%. at 40°C $\pm$ 2°C as specified in RDSO/ SPN/144/2006 Rev.2 or latest.

6.23 Number of LEDs used should not be less than 60 (OR any suitable number as per latest Technology) for Red and Yellow, 30 (OR any suitable number as per latest Technology) for Green LED signal lamp.

6.24 LED signal lamp shall have a display area of 125 mm $\pm$2 mm diameter.

6.25 LEDs in the lamp shall be arranged in more than one array so that in the eventuality of failure of an array, whole unit does not become blank. LEDs in the arrays shall be interleaved so that effect of failure of any array is spread out.

6.26 It shall be ensured that LED signal lamp is lit and producing illumination while drawing current more than specified for blanking mode signal. The method of achieving of the above shall be advised in detail. For this function testing should be done from NABL accredited Lab and test report should be submitted at approval stage.

6.27 Design shall be such that failure of a LED shall not vary illumination by more than 5 % of nominal illumination.

6.28 Sensing of illumination shall activate after LED signal lamp is completely lit to prevent hunting.

6.29 Current regulation of current to LED arrays shall be within 2% for input voltage range as specified in Cl. 5.2.

6.30 Design shall be such that normally LEDs of a LED array are driven within average drive current range recommended by the LED manufacturer and in no circumstances LEDs of an array shall be driven by current more than the maximum current recommended by the LED manufacturer. Details of the same shall be submitted at approval stage.

6.31 SMD/Discrete Components used shall comply with relevant clause of latest version of RDSO /SPN/144/2006 and should be commercially available.

6.32 Power circuit and heat dissipating components shall be provided in a separate compartment in LED signal lamp with adequate heat dissipation arrangement through heat sink with fins. Current regulation circuit for LED arrays and LEDs shall be kept in a separate compartment with heat dissipation arrangement through heat sink.

6.33 Isolation or step down transformer with line filter circuit. should be provided at input stage of LED signal lamp in failsafe manner to filter power surges.

6.34 At input stage of LED signal lamp two bridge rectifier circuit in parallel with each limb having two diodes in series should be provided. Electrolytic capacitors should also be used in series-parallel combination to achieve failsafe redundancy, fail safety shall be in compliance of clause 3.2 and 3.10 of RDSO /SPN/144/2006 Rev. 2 or latest.

6.35 Resistance used to dissipate power should be a series-parallel combination of standard SMD resistances to achieve failsafe redundancy and better heat dissipation.

6.36 LED signal lamp shall be provided with a curved transparent cover of UV stabilized polycarbonate material having a thickness of 2.5 mm ± 0.5 mm.

6.37 Body of LED signal lamp shall be made of metallic or industrial grade plastic like ABS or fibre glass. Metallic body parts may be used where these facilitate heat dissipation. LED signal lamp shall get fitted securely on the existing signal housings without any modification on them.

6.38 In case of metallic body, Signal Lamp Housing should be manufactured with corrosion-resistant aluminium. The surface of the body are painted with UV-resistant paint as per aspect/colour that does not fade in the sunlight.

6.39 Parts of body of LED signal lamp as visible from front after fitting in CLS unit shall be black. Colour of the body of the LED signal lamp shall be that of the aspect displayed to indicate aspect colour for LED signal lamp.

6.40 Body of LED Signal Lamp shall fulfill IP-67 requirement as per international standard.

6.41 Eight (4 pairs, sequentially two terminals should be connected in parallel) terminals of Phosphorous bronze or 8 (4 pairs, sequentially two terminals should be connected in parallel) RDSO approved disconnect type terminal shall be provided on back of the lamp. On inner two pairs of terminal MOV of 475V(OR any suitable value to directly feed 3 km in RE area)rating shall be provided. Outer pairs of terminals shall be marked as 'input' terminals and used for input termination.

6.42 All LED signal lamps shall meet the requirements as relevant clauses 2.0, 5.0 , 6.0 & 9.0 of RDSO /SPN/144/2006 Rev 2 or latest.

6.43 Material for the printed circuit board shall be copper clad glass epoxy of grade FR-4 or equivalent.

6.44 Outsourcing if any, of any sub-modules or PCB shall be indicated in the Quality Assurance Plan and approval of RDSO, Lucknow shall be obtained. Any outsourcing of safety related sub-modules or PCB shall be from ISO-9001 or ISO-9002 certified manufacturers only.

6.45 LEDs used in LED signal lamp shall be of high-performance quality and from reputed manufacturers AVAGO, NICHIA and OSRAM. The maximum junction temperature of a LED shall not be less than 100 deg. and epoxy used in the LED shall have UV inhibitors. SMD LED may be used subject to stipulated dispersion angle as per Cl. 6.1.9 above, Colour coordinate as per Cl. 5.1 and with proper focusing, visibility and uniform brightness.

6.46 The electronic components, switches and connectors used shall be of Industrial grade and shall comply Cl. 5.1 of RDSO/ SPN/144/2006 Rev. 2, as applicable. High life electrolytic capacitors with $\geq$8000 hours life and capacitance tolerance within ±20% shall be used for power conditioning. The operating temperature rating of all electrolytic capacitors used shall be more or equal to 105 deg. C. Coils/ transformers wherever used should be fire retardant and conform to 'H' class.

6.47 Manufacturer shall maintain proper accountal of LEDs and other critical components being used. The record shall include various details like bill of material, source of supply, procurement invoice no. & date, quantity, incoming rejection, lot-wise consumption etc. which may be verified by inspecting officials.

6.48 Atleast 10% LEDs and other critical components of every procured lot shall be tested before use to check electrical/optical characteristics as per LED manufacturer's data sheet. Lot-wise test record shall be maintained, which may be verified by inspecting officials.

6.49 Number of LEDs and their Part no. shall not be changed without prior approval of RDSO.

6.50 A rail mountable fuse terminal block with fuse link of 400ma rating and a RDSO approved disconnect type terminal block as per RDSO specification No. RDSO/SPN/ 189/2004 (latest) and 475V (OR any suitable higher value to directly feed 3 km in RE area) MOV shall be provided with a LED signal lamp. Terminal blocks shall be 3/4 conductor type (1/2 input and 2 output terminals) for terminating MOV on output side. Mounting rail of suitable length (12 inches length with supply of every 20 Signal Lamp or part thereof.

7.0 TESTS & PERFORMANCE CRITERIA

7.1 LED signal lamp shall pass the climatic tests as per Sl. No. 1, 2, 3, 4, 5, 6, 7 & 12 of Cl. 9.3 of specification RDSO / SPN / 144 / 2006 Rev 2 or latest as applicable for out-door track side electronic equipment upto& including 75 Kg. weight category.

7.1.1 LED signal lamp shall pass driving rain test as per Sl. No. 9 of Cl. 9.3 of specification RDSO / SPN / 144 / 2006 Rev 2 or latest. These units shall be tested after fixing in an enclosure similar to colour light signal housing without hood and with backdoor open.

7.1.2 After test as per every Sl. No. of Cl. 9.3 of specification RDSO / SPN / 144 / 2006 Rev 2 or latest, as specified above, no LED should fail, there should not be any damage in the unit or visual change in colour. Also input current and illumination will not change by more than ± 5% of original values and will be within specified values as per clause 5.2. After completion of all tests, colour co-ordinates shall remain within specified class as per clause 5.1.

7.2 Applied high voltage test for LED signal lamp: The lamp shall withstand for one minute without puncture and arcing a test voltage of 2000Volts rms applied between body and all AC line terminals looped together.
(For testing with part of body which is used as heat sink, test voltage shall be 1500Volts rms)
The test voltage shall be alternating of approximately sinusoidal waveform of any frequency between 50 Hz and 100 Hz. LED signal lamp should not glow during the test.

7.2.1 During type test, HV test should also be carried out on a lamp with body in open condition to observe sparking, if any generated during HV test. In case of sparking lamp should be treated as failed.

7.3 Insulation Resistance Test for LED signal lamp, this test shall be carried out-

(a) Before the high voltage test
(b) After the high voltage test
(c) After completion of the climatic test

The Insulation Resistance shall be measured between the body and the current carrying terminals looped together at a potential of 500 V DC. There shall not be appreciable change in the values measured before and after high voltage test and these values shall not be less than 100 Mega ohms. After completion of climatic test, the insulation resistance shall not be less than 10 Mega ohms for the equipment at a temperature of 40°C and relative humidity 60%.

7.4 Dispersion Angle test: This shall be measured as per Annexure II.

7.5 FAIL SAFETY

7.5.1 The requirement laid down in relevant clause in latest version of RDSO /SPN/144/2006 Rev. 2 or latest and CENELEC standards shall be complied.

7.5.2 LED signal lamp shall be so designed that any short/open or any other defect in any of the component will not lead to unsafe / undesirable situation.

Unsafe/ Undesirable Condition for LED Signal are as follows-

I. Lamp Proving Device Picked up and aspect not displayed/unlit.
II. Lamp Proving Device Picked up and Wrong aspect Displayed.
III. Aspect not Selected by Interlocking, Lamp Proving Device not Picked UP, False Lighting of Aspect with Noise/Induced Voltage.

There shall be no possibility of any of the above due to any reason (Inside as well as outside LED Signal Lamp):

7.5.3 Spike protection shall be provided in the LED signal lamp. This shall be achieved by reliable means. The MOV used shall cut in above 475 VAC OR any suitable value to meet the requirement may be decided.

7.5.4 There shall never be any possibility of change in colour of signal light unit with variation in temperature, current, voltage and ageing to unsafe side i.e. in any usual / unusual circumstances.
Red to Yellow or Green
Yellow to Green
Lunar White to Yellow or Green
The unsafe failures giving display of Yellow or Green in place of RED and Green in place of Yellow is not permitted, Cl. 4.6 of Specification No. RDSO /SPN/144/2006Rev.2requires “The equipment shall be so constructed so as to prevent unauthorized access”. CENELEC standards below require safety against systematic failures. Wrong colour aspect display is not permitted.

7.5.5 LED signal lamp shall comply Cl. 3 & 4 of specification RDSO / SPN / 144 / 2006 Rev.2 or latest, as applicable.

7.5.6 Fail safety validation shall be done by an independent agency which has credentials & experience for similar validations. Fail safety validation shall be done as per CENELEC standards EN 50126 & EN 50129 for Safety Integrity Level 4. RAMS shall be taken into account.

7.5.7 The manufacturer shall be provide the following certifications from NABL accredited lab/Govt. lab at the time of initial approval or type testing.

(a) Expected MTBF
(b) Expected MTBWSF
(c) Expected MTTR

7.5.8 MTBWSF of LED Signal Lamp alongwith Lamp proving device should be minimum 10^9 Hrs.

7.5.9 MTBF of components shall be more than one lac hours. System availability (Operational availability of complete system including power supply, wiring etc.) shall be 99.98% or better. The supplier to give the detailed calculation to achieve this.

7.6 Burning in test: LED signal lamp shall be kept continuously ON for minimum 168 hrs. at 60°C at rated voltage. There shall not be any difference in operating parameters before and after burning in test.

7.7 Thermal cycling and power cycling tests: All PCBs and power supply modules shall be subjected to thermal cycling and power cycling tests respectively as per Cl. 9.3 of specification RDSO / SPN / 144 / 2006Rev. 2 or latest. Proper test record having traceability to respective PCB/module shall be maintained by the manufacturer.

8.0 INSPECTION CRITERIA

8.1 TYPE TEST

For type test, two prototype samples each of red, yellow and green aspects shall be subjected to following tests:

(i) Visual inspection & dimensional check

(ii) Colour co-ordinates (Clause 5.1)

(iii) Operating Parameters (Clause 5.2,)

(iv) Output current regulation (Clause 6.29)

(v) Compatibility with AC LED ECRs OR any other suitable and compatible device for Lamp Proving.

(vi) Ambient temperature test (Clause 6.22)

(vii) Climatic tests (Clause 7.1, 7.1.1, & 7.1.2)

(viii) UV Stabilization test on cover (Clause 6.36)

(ix) Effect of reflected light (Clause 6.13)

(x) Visibility test (Clause 4.1, 4.2,4.3)

(xi) Fail safety Validation (Clause 7.5)

(xii) MTBF, MTBWSF and MTTR Calculation (Clause 7.5.7, 7.5.8 & 7.5.9)

(xii) Applied high voltage test (Clause 7.2)

(xiv) Insulation resistance test (Clause 7.3)

(xv) Dispersion Angle test (Clause 6.20, 7.4)

(xvi) Fluctuation in input voltage (Clause 6.12)

8.1.1 An open blown out model of offered LED signals shall also be submitted for initial type test.

8.1.2 Documents as per Cl. 13.0 shall be submitted alongwith samples.

8.2 ACCEPTANCE TEST

8.2.1 Out of a lot, 20% of the samples shall be subjected to following tests:

(i) Visual inspection & dimensional check

(ii) Operating Parameters (Clause 5.2,)

(iii) Compatibility with AC LED ECRs OR any other suitable and compatible device for Lamp Proving.

8.2.2 Minimum six samples (Two sample of each type/colour of aspects if offered) from those which have passed tests as per Cl. 8.2.1 shall be subjected to following tests-

(i) Temperature severities test (Clause 6.1.22 except humidity)

(ii) Colour co-ordinates (Clause 5.1)

(iii) Insulation resistance test (Clause 7.3 (a))

(iv) Dispersion Angle test (Clause 6.20, 7.4)

(v) Fluctuation in input voltage (Clause 6.12)

8.2.3 Acceptance tests as per Cl. 8.2.2 (ii) to (v) shall be conducted after temperature severities test. Operating parameters, minimum lighting voltage and compatibility with ECR OR any other suitable and compatible device for Lamp Proving tests shall also be conducted after temperature severities test.

8.2.4 Failure in any of the tests is not acceptable.

8.3 ROUTINE TEST

8.3.1 Following routine tests besides other tests, as deemed fit to ensure quality, reliability and compliance of this specification, shall be done by the manufacturer on all the lamps:

(i) Thermal cycling & power cycling tests (Clause 7.7)

(ii) Visual inspection & dimensional check

(iii) Burning in test (Clause 7.6)

(iv) Colour co-ordinates (Clause 5.1)

(v) Operating Parameters (Clause 5.2,)

(vi) Output current regulation (Clause 6.29)

(vii) Compatibility with AC LED ECRs OR any other suitable and compatible device for Lamp Proving.

(viii) Insulation resistance test (Clause 7.3 (a))

(ix) Dispersion Angle test (Clause 6.20, 7.4)

8.3.2 Tests as per Cl. 8.3.1 (iv) to (ix) shall be conducted after Burning in test. Proper record of routine tests shall be maintained by the vendor.

9.0 DESCRIPTION TO BE GIVEN BY PURCHASER

9.1 LED signal lamp-Red, Green or Yellow aspect (as required) for main colour light signal as per RDSO specification No. (No. will be given at the time of issue.)

10.0 SCOPE OF SUPPLY

Scope of supply shall also include terminal blocks fuse links and mounting rail as per Cl. 6.50.

11.0 WARRANTEE

The vendor shall give a warrantee of 60 months for LED signal lamps as given below:

11.1 In case, LED signal lamps fail within 24 months of supply, vendor will jointly inspect the defective lamps with the railway after getting telephonic/ written information from the railway. Defective lamps will be collected and replaced by the vendor free of cost by new lamps within 45 days of information by the railway. New lamps will be supplied after RDSO inspection.

11.2 In case, railway does not inform the vendor about the defective lamps within 60 days of expiry of 24 months, vendor's liability will be limited to rectification of the defective lamps.

11.3 During rest of the warranty period, the defective lamps shall be sent by the railway to the vendor which will be rectified by the vendor and tested by the vendor for routine tests as per Clause 8.3.1 (ii) to (x). Rectified lamps will be returned by the vendor within 45 days of receipt of defective lamps along with their routine test reports. Rectification/ replacement record and failure analysis

of ALL rectified / replaced lamps shall be maintained by the vendor and submitted to RDSO every quarterly.

12.0 MARKING

12.1 Clauses 12.1 and 12.2 of specification RDSO / SPN / 144 / 2006 Rev. 2 or latest shall be complied.

12.2 The words Indian Railway Property shall be engraved /embossed on every unit in letters of 5mm size (minimum) at a conspicuous place.

12.3 The anodized name plate shall be firmly attached to every unit and shall show the following information:

a) Name or trademark of the manufacturer
b) Serial number of the unit
c) Version No. of the unit*
d) RDSO's specification number
e) Name and aspect of the signal
f) Operating voltage- 110V AC
g) Month and year of manufacture

*In case of an alteration in the design of a unit, new version number shall be assigned

13.0 DOCUMENTATION

Following documents shall be supplied-

(a) Two copies of Installation and maintenance manual. This should also include following information:
   (i) Guaranteed performance data, technical and other particulars
   (ii) Schematic block diagram showing mounting arrangement of various components & details of each type of assembled PCB
   (iii) Details of Hardware e.g. schematic diagrams of the system circuits/ components, details for each type of assembled PCB and part list
   (iv) Mechanical drawings of every unit
   (v) Part no. and manufacturer's data sheet of LEDs used
   (vi) Trouble shooting procedure alongwith test voltages and waveforms at various test points in the PCBs
   (vii) Dos & Don'ts (Pocket size laminated cards)

(b) Pre-Commissioning check list

14.0 PACKING

14.1 All LED signal lamps shall be individually wrapped in bubble sheet and packed in individual card board boxes. The empty spaces shall be filled with suitable filling material. Alternatively, these may be packed in thermocole boxes. The units shall be finally packed in a wooden case or card boxes of sufficient strength so that it can withstand bumps and jerks encountered in a road/ rail journey.

14.2 Every box shall be marked with code numbers, contents and name of manufacturer. The upside shall be indicated with an arrow. Boxes should have standard signages to indicate the correct position and precaution "Handle with Care'' with necessary instructions.

14.3 The units and their sub assemblies shall be so packed as to permit convenient handling and to protect against loss or damage during transit and storage.

15.0 INFRINGEMENT OF PATENT RIGHTS

Indian Railways shall not be responsible for infringement of patent rights due to similarity in design, manufacturing process, use of components used in design, development of manufacturing of LED signal and any other factor which may cause such dispute.

16.0 ISO PROCEDURES

16.1 All the provisions contained RDSO's ISO procedures laid down in Document No. QO-D-8.1-11 Ver 2.8 (Vendor- Changes in approved status) and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendors in the contracts floated by Railways to maintain quality of products supplied to Railway.

NOTE: Any deviation/modification may be considered if found suitable for Indian Railways.

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Annexure I

BS 1376 : 1974

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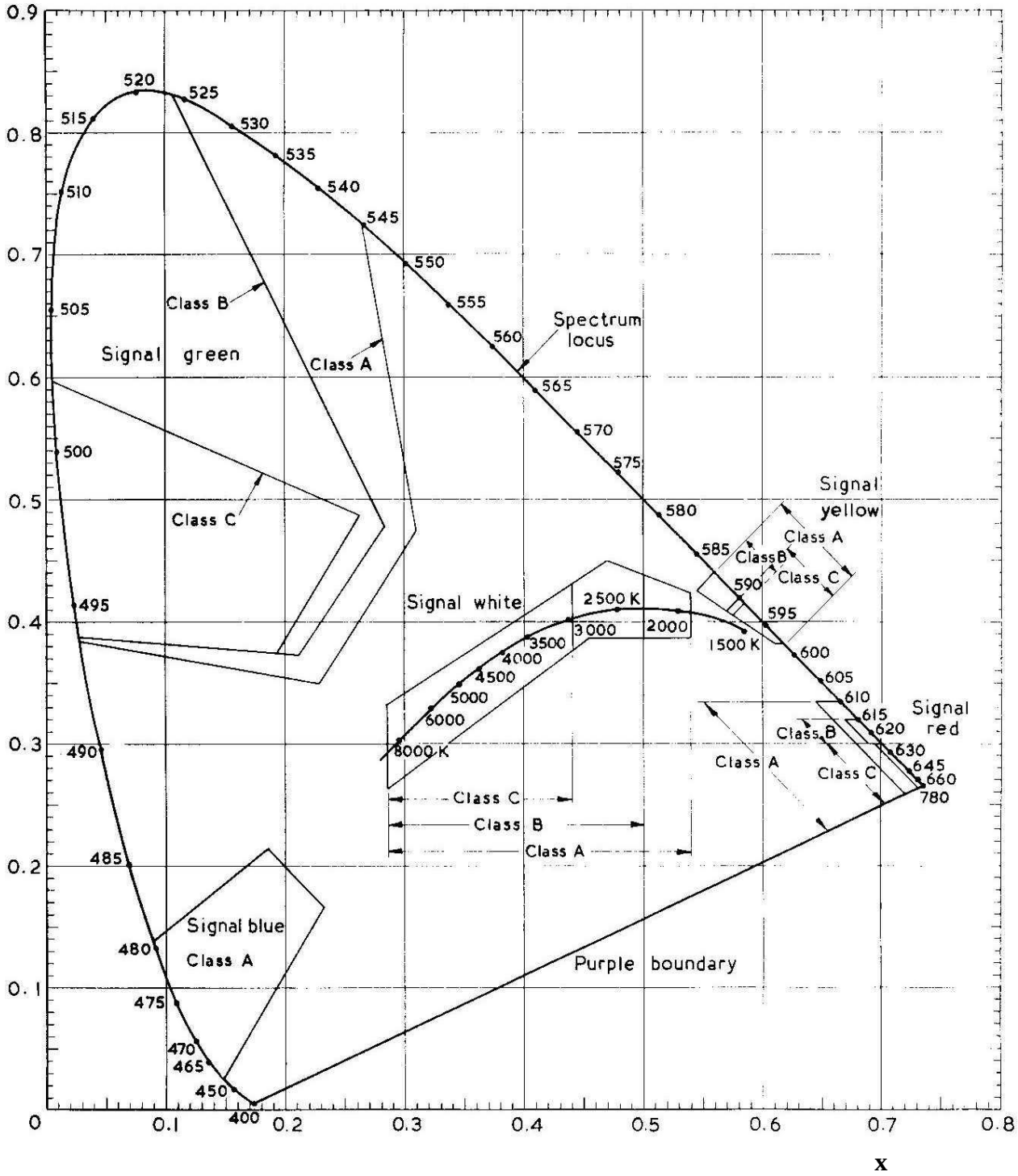
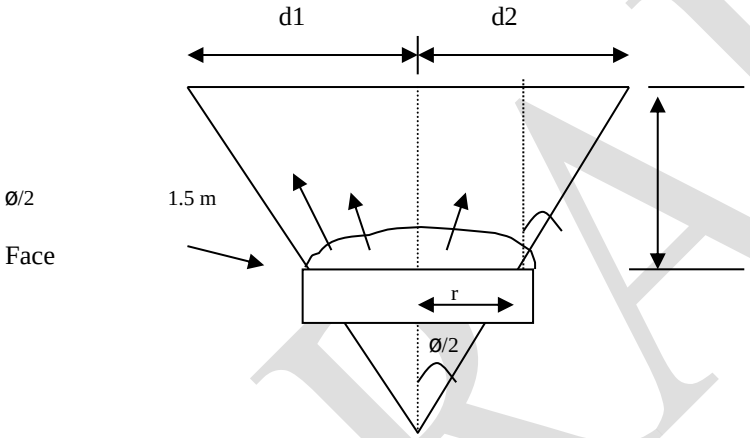


Chromaticity limits for signal colours

Annexure II

Measurement procedure for Dispersion Angle

1. Light up the aspect at the nominal voltage on 110 V and place it on the test bench.
2. The Dispersion Angle shall be calculated by measuring the half intensity points of the dominant wavelength at 1.5 m from LED signal lighting unit in axial direction on both the sides and taking average of the distances, d_1& d_2 in metres ($d = (d_1 + d_2) / 2$)
3. The half intensity, point is where half of the normal illumination at rated voltage falls. The Dispersion Angle shall be calculated using the formula
   $\tan^{-1}\frac{d - r}{1.5} = Ø/2$
4. 'r' is the distance from centre of the unit to the outer most LED provided in the unit.



5. **Dispersion Angle =Ø**

Annexure III