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SPECIFICATION FOR TRAIN PROTECTION & WARNING SYSTEM (TPWS)

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1.0 FOREWORD

- 1.1 This specification covers the general, functional, technical and performance requirements of Train Protection & Warning System (TPWS) for the Indian Railways.
- 1.2 TPWS will be provided on sections equipped with Multi Aspect Colour Light Signalling and train driver will follow Line Side signals as per prevalent operating rules. Provision of TPWS will be an additional safety aid to the train driver to prevent consequences arising out of **Signal Passing At Danger (SPAD)** and to control train speed within specified limits.
- 1.3 In the event of a conflict between this Specification and any other standards or specifications quoted herein, the requirement of this Specification shall prevail.
- 1.4 The operation of TPWS shall, in no way, infringe/ overrule the rules of normal train operations on Indian Railways.
- 1.5 This specification supersedes previous versions & amendments of specification no. RDSO/SPN/183.

2.0 APPLICABLE DOCUMENTS

- 2.1 This specification requires reference to the latest approved documents on ETCS/ ERTMS of UNISIG, EEIG, UIC, EC and EU, together with the following documents –

1	EN 50126	Railway Applications- Specifications and demonstration of Reliability, Availability, Maintainability & Safety.
2	EN 50128	Railway Applications-Communications, Signalling and processing systems-Software for Railway Control and Protection Systems.
3	EN 50129	Railway Applications-Communications, Signalling and processing systems- Safety Related Electronics Systems for Signalling.
4	EN50159-1	Railway Applications-Communications, Signalling and processing systems - Safety related communication in closed transmission systems.
5	EN50159-2	Railway Applications-Communications, Signalling and processing systems - Safety related communication in open transmission systems.
6	EN 50121	Railway Applications - Electromagnetic compatibility (EMC)
7	EN50238	Railway applications – Compatibility between rolling stock and train detection systems
8	EEIG: 97s066	ERTMS/ETCS Environmental requirements
9	IEC 60571	Electronic Equipment Used on Rail Vehicles
10	IEC 61373	Railway Applications – Rolling stock equipment – Shock and vibration tests
11	ELRS/SPEC/SI/0015	Reliability of electronics used in rolling stock application

12	RDSO/SPN/144	Safety and reliability requirement of electronic signalling equipment.
13	IRS: S 36	Relay Interlocking systems.
14	IRS: S 23	Electrical Signalling and Interlocking Equipment
15	RDSO/SPN/192	Electronic Interlocking

2.2 Wherever in this specification, any of the above mentioned specifications are referred, the latest version/ issue of the same is implied.

3.0 TERMINOLGY

3.1 List of abbreviations:

Abbreviation	Full Form/ Description
AC	Alternating current
BTM	Balise Transmission Module
CENELEC	European Committee for Electrotechnical Standardization
DC	Direct Current
DEMU	Diesel-Electric Multiple Unit
DMI	Driver Machine Interface
EC	European Commission
ECR	Lamp Checking Relay
EEIG	European Economic Interest Group
EMU	Electrical Multiple Unit
EOA	End Of Authority
EPROM	Electrically Programmable Read Only Memory
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
FRS	Functional Requirement Specification
G&SR	General & Subsidiary Rules
JRU	Juridical Recording Unit
IB Signal	Intermediate Block Signal
IEC	International Electrotechnical Commission
Kmph	Kilometers Per Hour
LEU	Line side Electronic Unit
MEMU	Mainline Electrical Multiple Unit
MTBF	Mean Time Between Failures
MTBSF	Mean Time Between Service Failure
MTBWSF	Mean Time Between Wrong Side Failures
OBC	On Board Computer
RAM	Random Access Memory
RAMS	Reliability, Availability, Maintainability & Safety
RDSO	Research Designs & Standards Organisation
RE	Railway Electrification

Abbreviation	Full Form/ Description
ROM	Read Only Memory
RS	Release Speed
SIL	Safety Integrity Level
IRDMI	Indian Railways Driver Machine Interface
SPAD	Signal Passing at Danger
SRS	System Requirements Specification
TIU	Train Interface Unit
TPWS	Train Protection & Warning System
UIC	International Union of Railways
UNISIG	European Signalling Industries

3.2 For the purpose of this specification, the terminology given in ERTMS/ETCS latest FRS & SRS shall apply.

3.3 Definitions:

- 3.3.1 **Acceptance Tests:** Tests carried out on the equipment/ system for the purpose of acceptance of the equipment/ system.
- 3.3.2 **Cross Approval:** A process of approval of foreign firms for their proven products/ systems through their Indian counter parts or supplier.
- 3.3.3 **Driving Cab:** The cab where controls etc. are provided for the Driver to run the locomotive/ train.
- 3.3.4 **Driving Position:** The position in the locomotive from where driver runs the locomotive/ train. Electric locomotives, some diesel locomotives, EMU, MEMU, DEMU etc. have separate driving cabs for either direction driving and therefore have one driving position in each cab. However, most diesel locomotives have only one cab having two driving positions i.e. one for each direction driving.
- 3.3.5 **Dynamic speed profile:** The speed-distance curve which a train may follow without violating the static train speed profile and the end of movement authority. This curve depends on the braking characteristics of the train and the train length.
- 3.3.6 **End of Authority (EOA):** Location to which the train is permitted to proceed and where target speed is zero.
- 3.3.7 **ETCS/ ERTMS Level-2:** ETCS/ ERTMS conforming to Level-2 operation.
- 3.3.8 **Functional Acceptance Tests:** Tests carried out by installing some equipments in the field to prove that the system performs in accordance with this specification & the local configuration data is acceptable.
- 3.3.9 **Locomotive:** The word 'locomotive' wherever used in this specification shall also mean the driving cab of EMU, MEMU, DEMU or any other self-propelled vehicle running on Indian Railways.

- 3.3.10 **MTBSF:** Mean Time between such failures which require restart/ maintenance/ repair of system.
- 3.3.11 **National Values:** These values are the values of different parameters such as maximum permitted speed, speed in shunting mode, speed in OS mode, overlap distance, permitted roll away/ reverse movement distance etc. which are based on rules of train operation.
- 3.3.12 **'Off' aspect of a Signal:** Any aspect other than 'On' aspect of a signal.
- 3.3.13 **'On' aspect of a Signal:** It is the most restrictive aspect of the signal. In case of stop signal, Red (or Danger) aspect is the 'On' aspect.
- 3.3.14 **Overlap Distance:** The length of track in advance of a stop signal, which must be kept clear, either for clearing the stop signal next in rear or for the purpose of granting permission to approach. The overlap distance may be different for different types of signals & signalling.
- 3.3.15 **Routine Tests:** Tests carried out on the equipment/ system by the manufacturer before offering for inspection.
- 3.3.16 **Schedule of Dimensions (SOD):** Indian Railways Schedule of Dimensions. SOD can be purchased from IR.
- 3.3.17 **Static speed profile:** The Static Speed Profile (SSP) is a description of the fixed speed restrictions for a part of track sent from track to train.
- 3.3.18 **Type Tests:** Tests carried out to prove conformity with the specification. These are intended to prove the general qualities and design of the equipment/ system.

4.0 GENERAL REQUIREMENTS

4.1 Unless otherwise specified in this specification, TPWS covered in this specification shall generally conform to latest approved FRS & SRS issued for ETCS/ ERTMS Level-1. It shall work on the principle of target distance and target speed. The TPWS shall consist of following:

- i) **Track side system** comprising of
 - a. Balises:
 - **Switchable balises** – This balises are interfaced to signal aspect through LEU. The telegrams/ data transmitted by these balises depend on the aspect of the signal. These are provided at a location near the signal. The Permanent Speed Restriction & track topography related information is also transmitted by these balises within the telegram/data related with signal aspect.
 - **Infill balises** – These balises are also interfaced to signal through LEU. The telegrams/ data transmitted by these balises depend on the aspect of the signal. These are provided in advance of the signal to update the movement authority in advance. These balises cannot effect change of mode of On board system.

- **Fixed balises** – These balises are provided wherever required. These balises transmit fixed telegrams/ data only. These can be used for enforcing Temporary speed restriction etc.
 - **Repositioning data balises** – These balises are provided wherever required to correct the previously given information.
- b. Line side electronic unit (LEU), its power supply & interfacing system with signalling
 - c. Communication link (data cable) between the LEU & the balise
- ii) **On board system** comprising of
 - a. On Board Computer (OBC)
 - b. Juridical Recorder Unit (JRU) for data logging for investigation (Optional).
 - c. Data logger for diagnostics (either part of OBC or separate)
 - d. Indian Railways Driver Machine Interface (IRDMI), indications & and non-resettable counters.
 - e. Balise Transmission Module (BTM)
 - f. Balise antenna fixed to the under frame
 - g. Speed and distance measurement unit
 - h. Train Interface Unit (TIU)
 - i. Interface to existing brake control system which in turn controls application of service/ emergency brakes **or** interface to existing brake system directly.
 - j. Power supply arrangement
 - k. System Isolating Unit (Both Electrical & Mechanical)
- 4.2 The system shall be capable of working satisfactorily up to speeds of 200 Kmph. The manufacturer shall mention the maximum speed up to which their system shall work satisfactorily.
 - 4.3 The On board equipment of TPWS shall work on the DC power supply available in the locomotive.
 - 4.4 The track side system of the TPWS shall work on AC or DC power supply & shall have power backup.
 - 4.5 TPWS shall be universally suitable for all types of sections of Indian Railways e.g. Sections/ Stations equipped with Relay interlocking, Electronic interlocking, Multi-aspect Colour Light Signalling, Automatic Signalling, Intermediate Block Signalling Sections.
 - 4.6 TPWS shall be suitable for all types of EMUs, MEMUs, DMUs, electric and diesel locomotives, Distributed Power wireless control of locomotive (Locotrol), including all types of microprocessor based locomotives, running on Indian Railways.
 - 4.7 TPWS shall be capable of being correctly & effectively interfaced to existing Air/Vacuum/Dual/Electro-pneumatic brake system of Diesel and Electric Locomotives as well as other self-propelled vehicles treated as train.

- 4.8 TPWS shall be capable of working in all electrified as well as non-electrified territories. It shall be suitable for use on AC/DC EMUs/DMUs/MEMUs/single or multi-headed electric/diesel locomotives.
- 4.9 The system shall be suitable for single, double or multiple line sections on Suburban/ Non-suburban section.
- 4.10 TPWS shall be capable of functioning in 25 KV AC RE, 1500V DC RE, 750V DC RE areas as well as in DC/AC RE areas where some lines may be working on AC RE while other lines on DC RE.
- 4.11 The track side and on-board equipment shall not in any way infringe the schedule of dimensions being followed by the Indian Railways.
- 4.12 TPWS shall have two levels of brake commands
- i Service brake command
 - ii Emergency brake command
- 4.13 The brake commands generated by the TPWS shall be used for application of service & emergency brakes of locomotives.
- 4.14 Deleted.
- 4.15 Deleted.
- 4.16 The fixing arrangement of the balise on the sleeper shall be such that it does not require any drilling and does not cause any damage to the sleeper. The routing/fixing arrangement of its cable normally shall not restrict the use of track maintenance machines. However, if required, the manufacturer/ supplier shall specify the precautions needs to be taken by the Purchaser during use of track maintenance machine.
- 4.17 The TPWS track-side system shall interface with the signalling system without affecting normal working & safety of signalling system. It shall take input regarding signal aspect through potential free contacts of the Lamp Checking Relays (ECRs).
- 4.18 Deleted.
- 4.19 The TPWS shall conform to the Safety Integrity Level (SIL) 4 as per CENELEC standards or equivalent.
- 4.20 The system shall be compatible & interoperable with the existing TPWS on Indian Railways. The manufacturer shall also submit certificate mentioning the systems working on world railways with which their system is interoperable. The certificate shall include systems of those manufacturers also whose TPWS are already working on IR.
- 4.21 (i) The size of the entire on-board equipment (excluding IRDMI) which is to be provided inside locomotive's machine room shall not be more than 1350 x 560 x 550 mm (Height x width x depth). The IRDMI to be provided in Driver's cab shall not exceed in size by 360mm x 450mm x 150mm (Height x width x depth).
- (ii) Suppliers shall specify the number of sub-systems in which their On-board system can be split. Supplier shall also submit sizes of such sub-systems.
- (iii) There is severe constraint of space in the locomotives and therefore the equipment shall be compact & modular in design with possibility of

distributing it into sub-systems to facilitate its accommodation in the locomotive.

- (iv) The supplier/manufacturer in consultation with the purchaser shall identify space in the locomotive for installation of on-board equipment of TPWS. The installation of on-board equipment of TPWS in space so identified shall not affect the access to the loco equipments for maintenance/ operation purpose. The supplier /manufacturer shall obtain RDSO approval for space so identified for fitment of on-board equipment of TPWS prior to manufacture/supply.

4.22 The programming/ feeding of data to track side or On board equipment shall be suitably protected against unauthorised use.

4.23 The on board system shall be upgradeable to ETCS/ ERTMS level-2 with additional hardware & changes in the software. The supplier shall give details of such additional hardware & changes in the software.

5.0 FUNCTIONAL REQUIREMENTS

5.1 **Healthy condition of system:** 'System Healthy' in green colour shall be displayed on IRDMI indicating that TPWS is in working condition. This shall change to 'System Fail' in red colour on IRDMI at location 'B' when any fault is detected by TPWS and an audible alarm shall sound to attract attention of driver which shall stop on acknowledgement by the driver. However, the 'System Fail' display in red colour on IRDMI shall remain till such time fault persists. In case of 'System Fail', Emergency brake shall be applied by the TPWS and the train shall be able to move only after the TPWS is isolated.

5.2 **Data from balise:** TPWS on board equipment shall act on the data it receives when it passes over a balise. This data shall consist of information on movement authority, balise linking distances, topography of track section ahead, mode profile, speed restrictions related information, release speed etc.

5.3 **Calculation of Speed & its accuracy:** The system shall incorporate the necessary hardware and software module for accurate calculation of the train speed duly accounting for wheel slip/skid corrections. Manufacturer shall submit the details of the speed calculation module along with the supporting international standards/practices being followed world over for the same. Calculation of speed shall be with an accuracy of ± 2 KMPH for speed lower than 30 KMPH, then increasing linearly up to ± 6 KMPH at 200 KMPH. Further, the variation in wheel diameter due to normal wear during time period between two loco maintenance schedules shall not affect accuracy beyond the limits specified in this clause.

5.4 **Calculation of speed profile:** On board computer shall calculate the static & dynamic speed profile for the track section ahead based on data received from balise and data available on board of the train characteristics.

5.5 **Calculation of permitted speed:** Based on all relevant data (available on board & as received from balise), the TPWS shall calculate permitted speed, warning speed, a service braking curve and an emergency braking curve for the train for all locations on the section.

5.6 Release speed:

- 5.6.1 A release speed shall be calculated on-board to allow the train to approach the target (i.e. stop signal at ON) with such speed so as to ensure that the train stops before reaching the danger point (overlap distance beyond the stop signal at ON) upto which train movement is considered safe, based on data received. The release speed shall be calculated on board based on safety distance including signal overlap, deceleration performance of the train & any other relevant considerations.
- 5.6.2 The release speed shall be programmed as a fixed value & transmitted to on-board equipment via the track side equipment. The release speed shall be based on the aspect of the signal, route of the train (main line or turnout route) on which it is going to travel, gradient ahead & any other relevant considerations.
- 5.6.3 Purchaser may decide to use any of the arrangement mentioned in 5.6.1 or 5.6.2 depending upon the requirement. However, the value of release speed, in any case, should always be such that even in worst conditions, it is possible to stop the train within the signal overlap distance on application of emergency brakes by the TPWS if train passes the signal at Danger at or below the release speed.

5.7 Deleted.

5.8 Monitoring of speed:

- 5.8.1 TPWS shall continuously compare the current speed of train with the permitted speed at all locations in all those modes in which speed monitoring is required. However, in case of release speed monitoring, clause 5.8.2 shall apply. A warning must be given to the driver to enable him to react and avoid intervention from TPWS before the application of service brake. The following actions shall be taken by TPWS depending upon the difference in current train speed & permitted speed:

SN	Current train speed exceeds the speed permitted at the moment, by	Warning to the Driver	Command for traction cut-off	Braking/ Brake Command	Event logging
1.	Upto 5 kmph	Intermittent audio & visual warnings which will be stopped once train speed is reduced to permitted speed.	No	No	No
2.	Above 5 kmph & upto 10 kmph	Continuous audio & visual warnings.	Yes	Service brake is applied by the TPWS. The	Yes

				service brake command will be withdrawn only when the current train speed is reduced to or below the permitted speed.	
3.	Above 10 kmph	Continuous audio & visual warnings	Yes	Emergency brake is applied by the TPWS. There shall be following two programmable options for release of emergency brake (a) When the current train speed is reduced to or below the permitted speed. (b) When train comes to a halt. Purchaser shall program one of the above options as per requirement	Yes

The system shall have provision of configuring the speed limits/ slabs as mentioned in column 2 of the above table, by the purchaser. However, these speed limits shall be in multiples of 5 KMPH or less.

5.8.2 Monitoring of Release speed: The Release Speed (RS) monitoring applies to the section near the EOA, where the speed is monitored against a constant value, the Release Speed. If the current train speed exceeds the Release Speed, emergency brake is applied by the TPWS & the train is brought to a halt. It shall be possible to release the emergency brake only after train stops.

5.9 Application of Emergency brake when passing Manual Stop Signal/ IB Signal/ Gate Signal at ON (Train Trip): When Manual Stop Signal without calling on signal/ Manual Stop Signal with calling on signal at ON/ IB Signal/ Gate Signal is passed at ON, TPWS shall apply emergency brake irrespective of the speed of train & will bring train to a halt. It shall be possible to release the emergency brake only after acknowledgement by the driver after the train has stopped. The events of such brake application & the acknowledgement shall be logged. The 'Train Trip' event shall also be recorded in 6 digit non-resettable electro-mechanical counter. It shall

be possible to override Train Trip function when passing such signals at ON as described in para 5.10.1

5.10 Passing of Manual Stop Signal/ IB Signal/ Gate Signal at ON:

5.10.1 The TPWS equipment shall have provision to enable passing of a manual stop signal (without calling on signal)/ IB Signal/ Gate Signal at ON by carrying out EOA override operation on the IRDMI. The EOA override operation shall be done by the driver after following the procedure as prescribed in relevant paras of G&SR for passing such signals at ON. This override operation shall be possible only after the train has come to a stop. The override control must be protected against inadvertent operation. This action shall be logged by the system.

5.10.2 **If Manual Stop Signal is at ON but its calling on signal is OFF**, the system shall permit passing of such signal without EOA override operation. However, on passing such signal, a visual indication shall be lit up on the IRDMI & TPWS shall request for an acknowledgement from the driver. If driver doesn't acknowledge within 5 secs, the service brake shall be applied till driver acknowledges. However, if while passing such signal, the speed of the train is more than the speed configured in the system to be followed after passing such signal then brake shall be immediately applied to bring the speed to the restricted speed configured in the system, without waiting for driver's acknowledgement. The indication shall remain lit up until the train passes the switchable/ signal balise (not the in-fill balise) connected to next signal ahead. This indication reminds the driver that he should proceed ahead cautiously at the specified restricted speed as per G&SR. The driver shall pass such signals at ON after following the procedure as prescribed in relevant paras of G&SR & follow the restricted speed as defined in G&SR. In case the train speed exceeds the restricted speed configured in the system, TPWS shall take action as described in para 5.8.1 above. Provision should be made in the system to enable changes in the configured restricted speed limit to any value (which can be in multiples of 5 KMPH) at a later date to comply with the changes in Operating Rules of the Indian Railways.

5.11 **Passing of Semi auto/ auto signal at ON:** In automatic signalling territory, when the automatic signal with "A" marker plate or the semi-automatic signal with illuminated "A" marker light displaying ON aspect is passed, a visual indication shall be lit up on the IRDMI & TPWS shall request for an acknowledgement from the driver. If driver doesn't acknowledge within 5 secs, the service brake shall be applied till driver acknowledges. However, if while passing such signal, the speed of the train is more than the speed configured in the system to be followed after passing such signal then brake shall be immediately applied to bring the speed to the restricted speed configured in the system, without waiting for driver's acknowledgement. The indication shall remain lit up until the train passes the switchable/ signal balise (not the in-fill balise) connected to next signal ahead. This indication reminds the driver that he should proceed ahead cautiously at specified restricted speed as per G&SR. The driver shall pass such signals at ON after following the procedure as

prescribed in relevant paras of G&SR & follow the restricted speed as defined in G&SR. In case the train speed exceeds the restricted speed configured in the system, TPWS shall take action as described in para 5.8.1 above. Provision should be made in the system to enable changes in the configured restricted speed limit to any value (which can be in multiples of 5 KMPH) at a later date to comply with the changes in Operating Rules of the Indian Railways.

5.12 **Balise Tracking / Balise Linking:** The TPWS equipment shall be capable of identifying missing balise and give suitable audio & visual indication to driver accordingly. This event shall be logged by the system. The System shall be capable of taking following actions under such condition:

- (a) Apply service brake to bring the train to a halt;
- (b) Apply emergency brakes to bring the train to a halt.

Purchaser shall be able to program one of the actions as mentioned in (a) & (b) above, to be taken by the system in case of missing balise.

5.13 **Brake application:**

5.13.1 The system shall generate service & emergency brake commands according to the situation and apply respective brakes of locomotives in one of the following manners:

5.13.1.1 On the locomotives having conventional brake system, for each type of brake command, separate electro-pneumatic valve with feedback contacts shall be provided in the pneumatic circuit of the existing brake system of the locomotive. A Main Reservoir (MR) cut-off valve shall also be provided to cut off MR whenever any of the brake command is issued by TPWS.

5.13.1.2 On the locomotives provided with electrical/ electronic/ microprocessor controlled brake system, the brake commands of TPWS, through an electronic/ electrical interface, shall be given to the existing brake control system of locomotive and based on these commands given by the TPWS, the existing brake control system shall apply the corresponding brakes.

5.13.1.3 On the rolling stock having electro-pneumatic brake system like in EMU/ MEMU etc., brake commands of the TPWS shall be interfaced electrically to the existing brake system.

5.13.2 However, in all cases, the driver shall be able to apply brakes as normal over & above TPWS control. If so required, the driver should be in a position to apply more intense brakes through his normal brake control system when application of brake by TPWS is not upto the level of emergency brake. The brake interface shall not result in change of existing brake characteristic of the locomotive/ train. The brake commands generated by the TPWS shall also cut-off traction to the locomotive.

5.13.3 In case of brake interface arrangements as described in clauses 5.13.1.2 & 5.13.1.3, an additional Emergency Brake Valve in pneumatic brake circuit with feedback contacts and a Main Reservoir Cut-off Valve shall also be provided, if required to achieve fail safe requirements of TPWS.

- 5.13.4 A non-resettable type electro-mechanical 6 digit counter shall be provided to record in the form of counter reading, the instances of application of emergency brake and this record shall not be affected by interruption of power supply to the system. Acknowledgement from Driver is required for releasing the emergency brake in case of Emergency brake application due to Train Trip (Clause 5.9).
- 5.13.5 It shall not be possible to mute the warning and to stop automatic brake applications by prior operation on IRDMI.
- 5.13.6 It shall not be possible to cancel the brake application by interrupting the power supply to the system.
- 5.14 **Isolation of TPWS:** On board system shall have provision for isolation to cater for failure situation which shall result in disconnection of the system from the locomotive braking system. This shall be indicated to the driver by means of a visual indication which shall be available even if IRDMI has failed. To avoid accidental/ unwarranted use, the isolation arrangement of the equipment must be protected and sealed. Isolation of system must be recorded by the system as well as recorded in a non-resettable type electro-mechanical 6 digit counter.
- 5.15 **Modes:** The current mode of TPWS on-board equipments shall be indicated to the driver by means of suitable indications on the IRDMI. The various modes and their descriptions shall be as per ETCS/ ERTMS FRS/SRS. However it shall be possible to programme on board equipment to block one or more modes, if required under the rules for train operations. Brief description of mode is given below:
- 5.15.1 **Isolation**-This mode is entered by the TPWS on-board equipment when Isolation switch is operated by the driver to isolate from the on-board system physically from the brakes. In this mode, TPWS on-board equipment has no role/ responsibility for its functionality. However, under this mode TPWS shall not affect the normal working of locomotive including its brake system.
- 5.15.2 **No Power**-This mode is entered by the TPWS on-board equipment when it is not powered. In this mode the TPWS on-board equipment has no responsibility except commanding the emergency brake.
- 5.15.3 **System Failure**- The TPWS on-board equipment shall switch to the System Failure mode, in case of a fault, which affects safety and shall permanently command the Emergency Brake.
- 5.15.4 **Sleeping**-In this mode, the TPWS on-board equipment of a slave engine is remotely controlled by the leading engine.
- 5.15.5 **Stand By**-In this mode, TPWS on-board equipment shall perform its self-test and the test of the external devices. Results of tests shall be displayed to the driver by means of suitable indications on the IRDMI.
- 5.15.6 **Shunting**-In this mode, the TPWS on-board equipment supervises the train movements against the shunting mode permitted speed limit.
- 5.15.7 **Full Supervision**-When all train and track data, which is required for a complete supervision of the train, is available on board, the system shall be in Full Supervision mode. In this mode, the TPWS on-board

equipment shall display the train speed, the permitted speed, the target distance and the target speed to the driver (this list is not exhaustive).

- 5.15.8 **Unfitted-** In this mode, Train movement is allowed in the sections not equipped with TPWS track side equipment
- 5.15.9 **Staff Responsible-**This mode allows the driver to move the train under his own responsibility in a TPWS equipped area under certain situations e.g., after the TPWS on-board equipment starts up, to pass a signal at danger etc.
- 5.15.10 **On Sight-** This mode enables the train to enter into a track section that could be already occupied by another train, or obstructed by any kind of obstacle. The authority to use this mode shall come from track-side only (this mode cannot be selected by the driver).
- 5.15.11 **Trip-**The TPWS on-board equipment enters into this mode when train passes manual stop signal at ON without following the procedure as described in 5.10, in this mode, emergency brake shall be applied to stop the train.
- 5.15.12 **Post Trip-** This mode shall be entered after TRIP (refer 5.15.11) is acknowledged by the driver.
- 5.15.13 **Non Leading-** This mode is selected by the driver of non leading/ slave engine on his TPWS on-board equipment that is not electrically coupled to the leading engine (and so, not remote controlled).
- 5.15.14 **Reversing-** In this mode, the driver is permitted to change the direction of movement of the train and drive from the same cab. This mode shall be permitted by trackside.

5.16 Data Logging & Diagnostics:

- 5.16.1 On board as well as Track side system shall be provided with data logging for diagnostic functions. The data can be accessed through PC/ laptop and a standard interface. Memory capacity of system shall be sufficient to keep log of minimum last one-week train running data. The memory shall keep log on First-In-First-Out basis. Atleast, following information shall be recorded in On board system:
- Any transition of Level and of operational status,
 - The driver's confirmation of transition to shunting shall be recorded.
 - train supervision data
 - information received from trackside system,
 - actual speed,
 - service brake intervention,
 - emergency brake intervention,
 - train trip function,
 - use of EOA override control,
 - override of the route suitability function,
 - isolation of on board ETCS equipment.
 - Data entered, received or indicated to the driver
- 5.16.2 Diagnostic/Analytical software will be provided to analyse the events logged in Log File. Diagnostic software shall perform following minimum functions:

- a) it shall be possible to download data of logged events and selectively sort this data regarding emergency brake application, service brake application, speed overshoots of more than 5 kmph than permitted speed, missing balise, defective telegram, passing of manual stop signal at ON (use of EOA override), train trip, system isolation, system failure etc. Every recorded event shall be with real date and time stamp of OBC and the balise ID.
 - b) it shall be possible to download data of failures of sub-systems .
 - c) it shall be possible to download and display different Balise telegrams and parameters of vehicle data.
 - d) The downloaded log shall be in standard file format like text, html, excel etc.
- 5.16.3 Deleted.
- 5.16.4 Software shall be provided to download data from JRU through standard interface to PC/ laptop for investigation purpose.
- 5.16.5 JRU shall conform to the latest specification issued by UIC/ UNISIG.
- 5.17 **Multiple traction units:** It shall be possible to use TPWS in multiple traction units by keeping the mode of on board system of other than leading unit in sleep or non-leading or isolation mode.
- 5.18 **Speed Restrictions:**
- 5.18.1 It shall be possible to enforce Permanent Speed Restrictions (PSR) by feeding the information through switchable balises.
- 5.18.2 It shall be possible to enforce temporary speed restrictions by installing additional fixed balises on track.
- 5.19 **Interoperability:** The On Board system of a manufacturer shall be compatible & interoperable with Balise of another manufacturer & vice versa. Similarly, Balise and LEU of different manufacturers shall be interoperable with each other.

6.0 TECHNICAL REQUIREMENTS

General:

- 6.1 The design of the system shall be robust and of state-of-art technology. The design shall be modular up to card level for ease of maintenance and fault troubleshooting.
- 6.2 All the cards shall be suitably protected and enclosed to avoid dust ingress. Suitable housing/cabinet shall be provided to withstand shocks, vibrations, electromagnetic induction and electrical surges etc.
- 6.3 The equipment shall be so constructed as to prevent unauthorised access to the system both at track side and on board.
- 6.4 All equipments shall be provided with easily accessible test points to facilitate fault localisation. Provision shall be made for isolating functional areas with each module to assist with testing and fault localisation.
- 6.5 Application software of on board & Trackside / Line side equipments shall have user-friendly design tools to enable carrying out of configuration changes by the Railways.

Immunity to Interference/EMI/EMC/Surge/Transients etc.:

- 6.6 The on board as well track side systems of TPWS shall be immune to following interference currents generated by locomotive/EMU etc.

SN	Interference Current	Overall Limit
1.	Psophometric current AC traction	10.0A
2.	Psophometric current DC traction	2.0A
3.	DC Component in AC mode	4.7A
4.	Second Harmonic Component(100 Hz) in AC traction	8.5A
5.	1400Hz to 5000 Hz	400mA
6.	More than 5000Hz upto 50000 Hz	270mA
7.	50 Hz component in DC mode	2.4A

The track side system shall be immune to electro-magnetic interference generated by thyristor/chopper-controlled locomotives, traction return currents.

- 6.7 Electromagnetic compatibility of the entire On-board equipment as well as track side equipments including interlinking cables shall comply with European Standards EN 50121 for Railway Applications – Electromagnetic Compatibility, as applicable and on-board equipment shall also comply with EN50238 for Railway Applications – Compatibility between rolling stock & train detection system. Adequate provisions should be made in the design for suppression of internal transients, spikes and to withstand external transients, spikes and surges as per limits laid down in IEC-60571.
- 6.8 The track-side system shall be Electro Magnetically Compatible to work in conjunction with the relay based interlocking, electronic interlocking, field signalling equipment, signalling cables and power supply arrangements as laid down in specification IRS: S 36 & IRS: S23.
- 6.9 The manufacturer/ supplier shall acquaint themselves with the control system of locomotives/ EMUs & signalling systems. They shall carry out the EMI/EMC measurement and accordingly finalize the scheme with adequate protection arrangement for installation of on board as well as trackside systems for their reliable operation.
- 6.10 Surge suppresser and proper earthing arrangement shall be provided in power supply system of On board as well as track side systems to protect against transient voltages, lightning and spikes etc. as per site/ local requirements in addition to their compliance to Clause 6.7.

On-Board System:

- 6.11 The On Board Computer (OBC) shall be capable of being connected to driver's IRDMI provided in each cab/ each driving position (where there is only one cab in the locomotive having two driving positions) of the locomotive. It shall be interfaced with Driver Control Switch so that at a time only one IRDMI is active & other gets locked. On EMU/MEMU/DMU, OBCs with individual driver's IRDMI shall be provided in each of the driving cabs. The train characteristics, wheel diameter etc. shall be

loadable into OBC through the respective ports on the OBC module using special software tool.

- 6.12 The On board equipment shall work on the DC power supply available in the locomotive (which is normally 72V DC in Diesel locomotives & 110V DC in Electric locomotives/EMU/MEMU, with a variation of -30% / +20% over nominal voltage and a ripple factor of upto 15%) as input & shall derive other voltages required for the working of its sub-systems.
- 6.13 The balise antenna of on board system shall be so located and mounted on the appropriate part of the locomotive relative to centre of the track that it would function correctly over the Indian Railways' limits of transverse and vertical movement. Mounting arrangement of antenna shall be secured against severe vibrations.
- 6.14 Whenever an OBC is replaced, the normal operation shall be possible only when complete vehicle data has been re-entered.
- 6.15 It shall be possible to program various parameters in on board computer required for its functioning via diagnostic PC. The data for example, may include date, time, wheel diameter, number of impulses per wheel revolution, emergency braking deceleration rate, maximum train speed etc.
- 6.16 Fail safe relay shall be used for performing emergency brake operation. The status of this relay shall be continuously monitored & any change in the status shall be logged with date & time. The arrangement shall be such that failure of relay or its associated wiring shall be on safer side i.e. system shall apply EB in such failures.
- 6.17 The manufacturer/ supplier shall submit the maximum power drawn by the On board system which shall not exceed 350 watts.

6.18 Driver's indication-cum-control panel:

Each driving cab/ each driving position (where there is only one cab in the locomotive having two driving positions) shall be provided with Driver's interface to TPWS. It shall consist of:

- 6.18.1 Indian Railways Driver Machine Interface (IRDMI) as per layout & guidelines in Annexure-I.
- 6.18.2 Non-resettable type electromechanical counters for recording instances of Isolation, Train Trip & emergency brake application.
- 6.18.3 An indication for displaying Isolation mode of TPWS even in case of failure of IRDMI.

Track-side System:

- 6.19 Balise shall conform to latest approved specifications issued by UIC/UNISIG. Balise shall be guaranteed for operational compatibility with balise manufactured by different manufacturers.
- 6.20 Line-side Electronic Unit (LEU) shall also conform to the latest specifications issued by UIC/UNISIG and shall be suitable to work with Indian Railways' Signalling System. LEU shall be capable of receiving minimum 10 signal inputs. It shall be capable of delivering minimum four separate channels so that at least four data balises may be driven upto 2500m. The manufacturer/ supplier shall mention the maximum number of inputs & maximum number of channels an LEU can handle. Balise

controlling interface cable shall meet the requirement mentioned in UNISIG specification for balise.

- 6.21 The balise shall be either class-A or class-B based on the limits of debris on the top of the balise as per following table:

Material	Description	Layer on top of Balise (mm)	
		Class B	Class A
Water	Clear	100	200
	0.1 % NaCl (weight)	10	100
Snow	Fresh, 0°C	300	300
	Wet, 20 % water	300	300
Ice	Non porous	100	100
Ballast	Stone	100	100
Sand	Dry	20	20
	Wet	20	20
Mud	Without salt water	50	50
	With salt water, 0.5 % NaCl (weight)	10	50
Iron Ore	Hematite (Fe ₂ O ₃)	20	20
	Magnetite (Fe ₃ O ₄)	2	20
Iron dust	Braking dust	10	10
Coal dust	8 % sulphur	10	10
Oil and Grease		50	50

Purchaser shall select the class of the balise depending upon the requirement.

- 6.22 It shall be possible to provide additional balises as infill for updating the movement authority in advance.
- 6.23 On common loop lines or single line sections on which bi-directional movement is permitted, there shall be provision so that balise pertaining to opposite side signal/ movement are not read by the On-board system as per the direction of movement. For this, each signal on such lines shall be provided with two balises viz. One fixed balise & one switchable balise.
- 6.24 Design of trackside system shall be such that in the event of simultaneous display of two conflicting aspects caused by defective components like signal lamp, information corresponding to either the more restrictive of the two aspects or the most restrictive aspect of that signal shall be passed on to the OBC. Likewise, in the case of blank signals, the information corresponding to most restrictive aspect of that signal shall be transmitted to OBC.
- 6.25 LEU and Balise constituting track side system shall be designed in such a way that for any disconnection, low insulation or short circuit fault in connecting cable, a visual indication shall be given to the OBC and the information corresponding to most restrictive aspect of that signal shall be transmitted to OBC. These failures shall be on safe side.
- 6.26 For the track side system of the TPWS, a nominal 230V or 110V AC 50 Hz power supply (with variation of +20%, -30% and a ripple factor of upto 15%) shall be made available by the purchaser. Conversion from 230V/

110V AC supply to work the track side system shall be provided by the supplier. There shall be a suitable power back-up for the minimum duration of half an hour. Purchaser shall specify the duration of backup in case it is required for more than half an hour.

- 6.27 The Manufacturer/ supplier shall submit the health monitoring scheme of LEUs.
- 6.28 The manufacturer/ supplier shall submit the maximum power drawn by the track side system which shall not exceed 100 watts.

7.0 PERFORMANCE, DOCUMENTATION & TRAINING REQUIREMENTS

- 7.1 The MTBF of each sub-system of track side as well as On board system shall be as under:

Sub-System	Minimum MTBF (Hrs.)
OBC	25,000
IRDMI	20,000
BTM	25,000
Balise Antenna	1,00,000
Speed & Distance Measuring Unit	25,000
TIU	15,000
LEU	60,000
Balise	1,00,000

However, manufacturer shall have adequate redundancy to achieve the MTBSF of entire on-board system of more than 20,000 hrs.

- 7.2 MTBF of each card, each sub-system and reliability figure of complete system shall be furnished.
- 7.3 TPWS shall have minimal impact on operations while providing accurate & reliable speed enforcement.
- 7.4 The operational availability of the system shall be 98% & shall be calculated on weekly basis for a TPWS equipped section of approximately 100 KMs as follows:

$$\text{Availability} = (B/A) * 100\%$$

A = No. of TPWS working train trips in a week including those trips in which the TPWS is isolated either at the start of journey or during the run due to any reason.

B = No. of TPWS working train trips out of 'A' in a week in which there was no spurious braking on account of TPWS equipment or TPWS was isolated on Railway account.

- The train trips having TPWS in isolated/ off condition due to TPWS isolated in previous trip(s) shall not be counted in A.
- The train trips with TPWS in isolated/ off condition on account of failure of TPWS shall not be more than 1% of the 'A'.

- 7.5 Deleted.

7.6 Manufacturer or supplier shall provide sufficient training in operation, maintenance & troubleshooting of the system to railway personnel as nominated by the purchaser railway.

Manufacturer shall guarantee availability of spares throughout the life of the equipments.

8.0 ENVIRONMENTAL CONDITIONS

8.1 The PCBs shall meet the requirements clause 6.8 of RDSO/SPN/144/2006.

8.2 Balise and LEU shall have minimum protection code of IP 67 and IP 54 respectively.

8.3 On-board (external) equipment shall have minimum protection code of IP 67.

8.4 Deleted.

8.5 The design of on board & track side systems shall take into account switching transients that may occur, in either the system or outside, of any magnitude, upto and including interruption due to short circuit of 25 KV system. The design shall also take into account supply related surge & transient.

8.6 On board as well as track side systems and system design shall take into account effect of lightning.

8.7 The on board system shall be capable of operating efficiently inspite of dust, dirt, mist, torrential rains, heavy sand or snow storms, presence of oil vapors and radiant heat etc., to which rolling stock is normally exposed in service. The system shall be suitable for traction application under the following environmental conditions:

➤ Atmospheric temperature	Maximum temperature of metallic surface under the Sun: 75 degree celsius and in shade: 55 degree celsius Minimum temperature: - 10 degree celsius (Also snow fall in certain areas during winter season)
➤ Humidity	100% saturation during rainy season
➤ Reference conditions site	i) Ambient temperature: 50 degree celsius ii) Humidity: 100% iii) Altitude: 1776 m above mean sea level
➤ Rain fall	Very heavy in certain areas.
➤ Atmospheric conditions	Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 1.6 mg/m ³ . In many iron ore and coal mine areas, the dust concentration is very high affecting the filter and air ventilation system
➤ Coastal area	humid and salt laden atmosphere with maximum pH value of 8.5, sulphate of 7 mg per liter, maximum concentration of chlorine 6 mg per liters and maximum conductivity of 130 micro siemens / cm
➤ Vibration	The vibration and shock levels recorded on various sub-systems in existing locomotives of IR

	are generally more than the limits given in IEC 61373 particularly at axle box, and traction motor Accelerations over 500 m/s ² have been recorded at axle box levels during run. Vibrations during wheel slips are of even higher magnitude High level of vibrations above 30g have been measured at traction motor on IR's locomotives, which increase up to 50g with worn gear-pinion.
➤ Wind speed	High wind speed in certain areas, with wind pressure reaching 150 kg/m ²

9.0 TESTS AND REQUIREMENTS

9.1 The firm should have all essential Testing Equipments as per latest 'Schedule of Technical Requirements' (STR).

9.2 Unless otherwise specified, all tests shall be carried out at ambient atmospheric conditions. For inspection of material, relevant clauses of IRS: S 23 and RDSO/SPN/144 shall also apply.

9.3 Type Tests:

9.3.1 Following tests shall constitute type tests:

- a) Visual inspection as per clause 10.2;
- b) EMC as per European Standard EN 50121.
- c) Sub system/ Card level functional test as per format approved by RDSO;
- d) System level functional tests as per format approved by RDSO;
- e) System Diagnostics test;
- f) Fail-Safety tests on one card of each type as per CENELEC 50129 standards;
- g) Deleted.
- h) Interoperability Test– The inter-operability of offered on-board system shall be tested with existing track-side system & inter-operability of existing on-board system shall be tested with offered track-side system. (This shall be done only at the time of Initial Type Approval & when there is any design change which may affect the interoperability).

9.3.2 For track side system, following tests shall also constitute type tests:

- (a) Insulation Resistance test as per relevant clause of RDSO/SPN/144;
- (b) Applied High Voltage test as per relevant clause of RDSO specification no. RDSO/SPN/144;
- (c) Environmental/ climatic tests as per RDSO specification no. RDSO/SPN/144.;
- (d) Vibration tests as per RDSO specification no. RDSO/SPN/144.

9.3.3 For on board system, following tests shall also constitute type tests:

- (a) Performance Test as per clause 10.2.2 of IEC 60571
- (b) Cooling Test as per clause 10.2.3 of IEC 60571

- (c) Dry heat test as per clause 10.2.4 of IEC 60571
 - (d) Damp heat test as per clause 10.2.5 of IEC 60571
 - (e) Supply over voltage, Surges and electrostatic discharge test as per clause 10.2.6 of IEC 60571
 - (f) Transient burst susceptibility test as per clause 10.2.7 of IEC 60571
 - (g) Insulation test as per clause 10.2.9 of IEC 60571
 - (h) Salt mist test as per clause 10.2.10 of IEC 60571
 - (i) Vibration and shock test as per IEC 61373
 - (j) Water tightness test for on board external components as per clause 10.2.12 of IEC 60571
 - (k) Tests for reliability of electronics used in rolling stock as per RDSO specification no. ELRS/SPEC/SI/0015 of Oct 2001.
- 9.3.4 Any other tests as considered necessary by RDSO in consultation with the supplier/ manufacturer.
- 9.4 **Acceptance Tests:**
- 9.4.1 Following shall comprise acceptance tests:
- 9.4.1.1 For Track-side system/ equipments
- a) Visual inspection as per clause 10.2;
 - b) Insulation Resistance test as per relevant clause of RDSO/SPN/144;
 - c) Sub system/ Card level functional test as per format approved by RDSO;
 - d) System level functional tests as per format approved by RDSO;
 - e) System Diagnostics test;
- 9.4.1.2 For On-board system/ equipments
- a) Visual inspection as per clause 10.2;
 - b) Insulation Resistance test as per Clause 10.2.9 of IEC 60571 for On-board equipments;
 - c) Sub system/ Card level functional test as per format approved by RDSO;
 - d) System level functional tests as per format approved by RDSO;
 - e) System Diagnostics test;
- 9.4.2 Deleted
- 9.5 **Routine tests:** Manufacturer/supplier shall carry out routine tests on every equipment and the test results shall be submitted to the inspecting authority before acceptance tests. Following tests shall constitute routine tests:
- a) Visual inspection as per clause 10.2;
 - b) Insulation Resistance test as per relevant clause of RDSO/SPN/144 for track side equipment & as per Clause 10.2.9 of IEC 60571 for On-board equipments;
 - c) Sub system/ Card level functional test;
 - d) System level functional test;

- e) System diagnostics test.
- f) Environmental Stress Screening (ESS) tests as per RDSO specification no. RDSO/SPN/144.

9.6 Deleted.

9.7 **Functional acceptance test:** After carrying out acceptance tests, one set of onboard system and 10 sets of trackside side systems shall be installed on the section and detailed trials shall be conducted by the purchaser for Functional Acceptance Test. The Functional Acceptance Tests shall cover sequence through all required operations by means of purchaser approved static & dynamic scenarios, acceptance tests on balance equipments/ systems shall be undertaken.

10.0 TEST PROCEDURES

10.1 The test procedure shall be based on the system design. The methodologies to be adopted for various tests shall be decided taking into account the system design/configuration and shall be approved by RDSO.

10.2 Visual Inspection

The equipments shall be visually inspected to ensure compliance with the requirements of this specification. Visual inspection shall also be carried out after type tests have been performed to check whether any damage has occurred resulting from the test. The visual inspection will broadly include –

10.2.1 System level checking:

- 10.2.1.1 Constructional details.
- 10.2.1.2 Dimensional check.
- 10.2.1.3 General workmanship.
- 10.2.1.4 Configuration.
- 10.2.1.5 Mechanical polarisation on cards.

10.2.2 Card level checking:

- 10.2.2.1 General track layout.
- 10.2.2.2 Quality of soldering and component mounting.
- 10.2.2.3 Conformal coating.
- 10.2.2.4 Legend printing.
- 10.2.2.5 Green masking.

10.2.3 Module level checking:

- 10.2.3.1 General shielding arrangement of individual cards.
- 10.2.3.2 Indications and displays.
- 10.2.3.3 Mounting and clamping of connectors.
- 10.2.3.4 Proper housing of cards.

11.0 INFORMATION/ DOCUMENTS TO BE FURNISHED BY THE MANUFACTURER / SUPPLIER:

- 11.1 Manufacturer shall furnish following information at the time of initial type approval:
- i. Approach for RAMS as per CENELEC - 50126 containing detailed analysis of equipment and complete system
 - ii. The certificate of verification and validation of safety, reliability & availability etc. as per relevant standards (SIL 4 or equivalent) from reputed agency having experience in this field. The agency to be engaged for validation shall be got approved from RDSO. The certificate of proof of safety giving complete tests & their results that have been undertaken by the manufacturer or independent safety assessor shall also be submitted.
 - iii. Estimated analytical MTBF & MTBWSF (Mean Time Between Wrong Side Failures) figures for each sub-system and system as a whole.
 - iv. Details of software algorithm flow chart along with test/validation procedure used and the results thereof.
 - v. The manufacturer shall submit details of all components, its part Nos., Temp range, tolerance etc.
 - vi. Details of Hardware e.g. schematic diagrams of the system circuits/components, details for each type of assembled PCB.
 - vii. Version No. of equipments & Software checksum of EPROM(s) shall be provided as per RDSO/SPN/144.
- 11.2 Following manuals shall be submitted by the supplier/ manufacturer for on-board as well as for track side system separately-
- 11.2.1 Installation Manual with pre-commissioning check list.
 - 11.2.2 Maintenance Manual with Diagnostics procedure including troubleshooting charts.
 - 11.2.3 User manual with Do's & Don't with Diagnostics procedure including troubleshooting charts.
- 11.3 In case of Cross Acceptance/ Approval, the manufacturer/ vendor shall submit documents as per the prevailing guidelines in this regard which may be obtained from RDSO. In addition, the manufacturer shall also be required to submit the certificates (preferably from user railways) certifying the interoperability of their TPWS (track side as well as on board system) with the TPWS (track side as well as on board system) of the manufacturers whose TPWS are working on Indian Railways. Version No. of Signalling equipment as per manufacturer's practice may be accepted.
- 11.4 The manufacturer/supplier shall submit list of recommended spare parts.
- 11.5 Manufacturer shall submit the expected life of the system/ sub-system.
- 11.6 Manufacturer/ Supplier shall submit the complete details of the items which are finalized/ decided by the manufacturer (e.g. utilization of spare bits of various packets & spare packets transmitted from track to train for various purposes to meet customer's requirements) permitted under the ETCS/ ERTMS specifications.
- 11.7 **Documents for Approval:**
- 11.7.1 The brake interface arrangement alongwith the train interface arrangement shall be got approved from RDSO.

11.7.2 RDSO shall supply the data of weight, rotating mass, and Braking effort of various types of locos, coaches and wagons. Values of EBD, SBD and max acceleration with $\pm 10\%$ accuracy for different train formations shall also be supplied by RDSO. The working out of correct train parameters shall be the responsibility of the supplier based on this information. The braking algorithm along with the input parameter values for various train configurations shall be furnished & demonstrated to the satisfaction of RDSO by the manufacturer/supplier before implementation in the section.

11.7.3 The national values to be adopted shall be got approved from the purchaser.

12.0 QUALITY ASSURANCE & WARRANTY

12.1 All materials and workmanship used in manufacture of TPWS equipments shall be of good quality. Since the quality of the equipment bears a direct relationship to the manufacturing process and the environment under which it is manufactured, the manufacturer/supplier shall ensure Quality Assurance Program of adequate standard.

12.2 All test instruments shall be available with the manufacturer/supplier.

12.3 The manufacturer/supplier shall submit along with prototype sample for type test, the Quality Assurance Manual.

12.4 The entire TPWS including all its equipments and subsystems shall be under warranty for one year from the date of commissioning of complete system. Purchaser shall specify the duration of warranty, if required for more than one year.

13.0 PACKING

13.1 The equipment and its sub assemblies shall be wrapped in bubble sheet and then packed in thermocole boxes and the empty spaces shall be filled with suitable filling material. All PCBs shall be enclosed in anti-static shield cover. The equipment shall be finally packed in a wooden case of sufficient strength so that it can withstand bumps and jerks encountered in a road/ rail/ Air/ Ship journey.

13.2 Each box shall be marked with code numbers, contents and name of manufacturer/supplier. 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.

13.3 Printed circuit boards shall be separately and individually packed to prevent damage.

14.0 INFORMATION TO BE SUPPLIED BY PURCHASER

- a) Type of locomotives and their brake system on which the TPWS is to be installed.
- b) Brake interface in terms of clause 5.13.1.
- c) Type of signals where TPWS is to be installed.
- d) Available braking distance in the section

- e) The voltage of input power supply available for On board and track side system.
- f) The duration of battery backup required for LEU, if required for more than half an hour.
- g) Relevant G & SR rules applicable alongwith speed restriction limits.
- h) Class of balise in terms of clause 6.21.
- i) Period of warranty, if required for more than one year.
- j) Deleted.
- k) Purchaser shall specify the details of section, signaling details, type of locomotive and brake system to be used in the section in terms of clause 4.5 to 4.10.
- l) Details mentioning the UIC/UNISIG SRS/FRS version of existing TPWS system with which the TPWS as per this specification is required to be interoperable.
- m) Requirement of Juridical Recording Unit (JRU) in terms of Clause 4.1 (ii) (b).
- n) After award of contract, following information shall also be provided by the purchaser:
 - (i) Availability of potential free contact of lamp proving relays
 - (ii) Details of the section like gradients, permanent speed restrictions, maximum sectional speed and route details of the section etc. where TPWS is to be installed.
 - (iii) Location of Signals.
 - (iv) Location for installation of LEU.
 - (v) Arrangement of release speed in terms of clause 5.6.3.
 - (vi) Potential free contact of Cab active, forward direction and reverse direction of locomotive.
 - (vii) Details regarding type of locomotive such as Train control circuit with details of traction cut-off, battery terminal, brake system, details of existing wheel slip protection device etc.
 - (viii) The train parameters like length of the train, weight, deceleration factor, reaction time etc. in connection with programming of braking characteristics in the OBC
- o) Any other relevant information.

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