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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

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# PROCEDURE FOR SAFETY CERTIFICATION AND TECHNICAL CLEARANCE OF METRO SYSTEMS BY RDSO

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**URBAN TRANSPORT & HIGH SPEED DIRECTORATE**
**RESEARCH DESIGNS & STANDARDS ORGANISATION**
**MANAK NAGAR, LUCKNOW – 226 011**

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# ANNEXURES

**PROCEDURE FOR SAFETY CERTIFICATION AND TECHNICAL CLEARANCE OF METRO SYSTEMS BY RDSO (JAN-2013)**

## 1. GENERAL

As per Amendment to Metro Railway (Operation and Maintenance) Act 2009, Indian Railways have been unambiguously given the responsibility of technical planning and safety of Metro Systems being implemented in India. Since a number of Metros are coming up in various cities of India, considering the fact that some technical and safety related issues can best be dealt with at the planning stage itself, a comprehensive document has been prepared giving the details of procedure for Safety Certification and Technical clearance of Metro Systems by RDSO, Ministry of Railways.

## 2. SCOPE

This is a reference document defining the procedure and the various steps to be taken for safety certification and technical clearance of Metro Systems being implemented in India. This will provide guidance to the authorities who intend to plan, construct and operate a Metro System in India. After deliberations in the Inter-Ministerial Committee on Metro issues, it was decided with general consensus, that Ministry of Railways should confine its role to according in principle approvals of broad technology as chosen and proposed by the metro railway administrations in the following areas:

**(i) Schedule of Dimensions**

**(ii) Design Basis Report**

**(iii) Track structure**

**(iv) Oscillation trials of rolling stock as required**

**(v) Issue of Speed Certificate**

**(vi) Technology for signalling**

**(vii) Technology for traction**

**(viii) Rules for opening of the metro railway and General Rules**

## 3. OVERVIEW OF THE PROCEDURE

3.1. The complete exercise of Safety Certification and Technical Clearance for commissioning a Metro System for passenger service is broadly divided into the following parts:

1. Submission and Scrutiny of Schedule of Dimensions (SOD)
2. Submission and Scrutiny of technical documents like specifications, design and test certificates.

3. Tests of selected sub-systems.
4. Oscillation trials and issue of speed certificates.

3.2. However, before the actual start of process for Safety Certification and Technical Clearance, it is advisable that Metro administration keeps RDSO generally informed about the project developments and starts liaison well in advance. To make this a part of the system, a copy of the Detailed Project Report (DPR) approved by Ministry of Railways and Ministry of Urban Development may be sent to RDSO[C].

3.3. The Metro administration shall submit the required documents to Executive Director Works (Planning) Railway Board, and also send a copy of the same to Executive Director, Urban Transport and High Speed Directorate, RDSO, Manak Nagar, Lucknow. UTHS directorate will co-ordinate within RDSO and with the Metros for scrutiny of documents and certification of Metro.
These steps have been explained in detail in the following paragraphs:

## 4. SUBMISSION AND SCRUTINY OF SCHEDULE OF DIMENSIONS (SOD)

[Expected Time for examination and clearance of SOD - Three months]

Initially Metro Administration is required to submit its **SOD** for approval. It should comprise of general alignment and clearances, rolling stock dimensions, kinematic envelope and structure gauge, clearances at stations and platforms, type of electric traction and clearances from live parts. If a Metro is being extended, then fresh SOD will not be required to be approved.

## 5. SUBMISSION AND SCRUTINY OF DOCUMENTS.

[Expected Time for scrutiny of documents –six weeks]

Metro Administration is required to submit documents, duly approved by Metro Administration as per annexures mentioned below. Sub-system wise break up of these documents is as follows:

5.1. **Rolling Stock(Mechanical Part):**as per **Annexure A**

5.2. **Rolling Stock (Electrical Part)**: as per **Annexure B**

5.3. **Track**: The following documents are required
   a) Compliance of Standards for track structure for Metro Railways as per Railway Board's letter No. 2010/Proj./Genl./3/3 dated 23.12.2011. **(Annexure C1)**
   b) Compliance to Performance criteria of fastening system for ballastless track on Metro Railways/MRTS issued by Ministry of Railways in May 2010. **(Annexure C2)**

5.4. **Traction Installation and Power Supply :** In principal approval will be given based on the relevant details as per **Annexure D1 & D2**

5.5. **Bridges and Structures**

a. A copy of design basis report for viaduct and other bridges duly approved by the metro authorities is required to be submitted prior to taking up design work by the Consultant. This shall require approval of Ministry of Railways before start of physical work.

b. It should include load model, provisions of various Codes and Manuals to be followed with preference (Justification should also be furnished if other than IRS Code are proposed to be followed), type of construction material etc.

5.6. **Signalling**

a. Documents are required for various sub-systems duly approved by Metro authorities as per **Annexure E1.**

b. A Broad description of the systems in line with already approved system of Metro Signalling System and & telecommunications system is available at **Annexure E2**. For Technical clearance, minimum provisions to be adopted for Signalling systems & telecommunications systems are outlined in this annexure. Deviations, if any, shall be pointed out clearly.

## 6. SUBMISSION OF TEST CERTIFICATES / Reports

[Expected Time in scrutiny and examination of these certificates – four weeks]

The following test certificates are required to be submitted to RDSO for record before conducting oscillation trial:

6.1. **Rolling Stock –Mechanical**

i. Type test of coupler
ii. Type test of brake system
iii. Type test of wheels and axles
iv. Prototype test of Bogie frame
v. Endurance test of Bearing
vi. Compliance certificate for crashworthiness standard

6.2. **Rolling Stock– Electrical**

i. Dynamometer car test certificate giving starting and rolling resistance of the Prototype Rolling Stock and verifying the “tractive effort-speed” and “regenerative braking effort/speed” characteristics; along with methodology of acquisition of data and calculation method. If Dynamometer car test is not being conducted for the rolling stock, then test results by manufacturer for similar test done earlier to be provided.
ii. EMC/EMI compatibility test report to be submitted before commissioning of the corridor.

6.3. **Signal and Telecommunication:** Completion report of Integrated **Testing and Commissioning Tests** with their results for Signalling/Train Control Systems and Tele Communication Systems to be submitted before commissioning of the corridor.

## 7. OSCILLATION TRIALS AND ISSUE OF SPEED CERTIFICATE

7.1. The following types of speed certificates are issued by RDSO. Based on each of these certificates the Metro administration shall apply for sanction of Commissioner of Railway Safety of the Circle in whose jurisdiction the Metro falls. Thereafter, sanction of Railway Board shall be obtained by the Metro administration by applying to Executive Director (Works Planning) Railway Board, Rail Bhawan, Raisina Marg, New Delhi-10001.

a. One time movement / Interim certificate for temporary movement of rolling stock at lower than the designed speed, as judged by RDSO based on design scrutiny and vehicle dynamics simulation.
NOTE: i) This certificate shall be required for temporary movement of a new rolling stock over a Metro System on which passenger traffic has already commenced so as to ensure safety of the already running Metro trains and passengers.
ii) If the movement mentioned in note (i) above is to be done in non-revenue hours, this certificate will not be required.
[Expected Time in issuing this certificate – two weeks]

b. Speed certificate for getting oscillation trials of the rolling stock done by RDSO to ascertain its maximum speed potential.(Test methodology and criteria for the test are enclosed as **Annexure F1& F2** respectively).
[Expected Time in issuing this certificate – two weeks]

c. Speed certificate for conducting Emergency Braking Distance trial for the complete train formation intended to be operated. (Test methodology is enclosed as **Annexure G1** and parameters required are at **Annexure G2**).
[Expected Time in issuing this certificate – two weeks]

d. Speed certificate for conducting COUPLER FORCE, CONTROLLABILITY or any other special trial. Coupler force trials shall be necessary for sections having sustained up gradient steeper than 1 in 100. Controllability trials shall be necessary for sections having sustained gradient steeper than 1 in 100. (Test methodology for coupler and controllability are enclosed as **Annexure H** and **Annexure I** respectively).
NOTE: These tests may be dispensed with by RDSO, if Metro Authorities submit adequate details of design calculations and Type test reports of couplers and brake system certifying their suitability for use in the worst operating conditions, which shall also include failure of ATP/CBTC.
[Expected Time in issuing this certificate – two weeks]

e. Provisional and Final speed certificates for regular use of rolling stock at the maximum permissible speed as determined in oscillation trials based on norms set by Criteria Committee of RDSO (**Annexure F2**) and in EBD trials.

[Expected Time in issuing this certificate – two weeks]

7.2. Except for One time movement / Interim certificate at sr no "7.1 a" and Provisional and Final speed certificates for regular use of rolling stock at sr no "7.1 e" - the Metro administration shall apply for authorisation of Commissioner of Railway Safety of the Circle in whose jurisdiction the Metro falls for such trials. After getting authorisation of CRS, Metro administration will approach RDSO for the respective trials.

7.3. Provisional and Final speed certificates for regular use of rolling stock at sr no "7.1 e" will be issued after successful oscillation trial by RDSO. After that Metro administration shall apply for authorisation of Commissioner of Railway Safety of the Circle in whose jurisdiction the Metro falls. Thereafter, sanction of Railway Board shall be obtained by the Metro administration by applying to Executive Director (Works Planning) Railway Board, for starting commercial services.

7.4. For existing rolling stocks, where there is a case of design modification or speed enhancement, the same procedure as in para 7.1 shall be followed.

7.5. For speed certificate and oscillation trial of metro rolling stock as described above, the concerned metro corporation shall apply to Executive Director (Works Planning) Railway Board with a copy to Executive Director (Urban Transport & High Speed), Research Designs and Standards Organization, Manak Nagar, Lucknow-226011.

7.6. The application for **Provisional** Speed Certificate shall be accompanied by the following documents:

i. Complete design details pertaining to vehicle dynamics along with drawings of the rolling stock – As per Annexure A & B
ii. Condonation letter from Railway Board for infringements, if any, from Standard Schedule of dimensions (SOD).
iii. Complete design details along with drawings of Track - as per Annexure C1 & C2
iv. Complete design details of OHE. (Format enclosed as Annexure D1&D2)
v. Report of Vehicle dynamics simulation done including Vertical acceleration values, Lateral acceleration values, Vertical Ride Quality, Lateral Ride Quality, Vertical force, Max. Lateral force, Derailment Coefficient (Lateral force/ Instantaneous wheel load.)

7.7. Application for getting oscillation trial done shall be accompanied by the following documents:

i. Performance report of the existing operation.
ii. Full details of the rake composition & section on which trial is proposed.
iii. Joint Safety certificate issued by concerned Metro

iv. Track certificate issued by concerned Metro
v. Bridge Certificate issued by concerned Metro
vi. After issue of Speed Certificate, CRS sanction for conducting the trial
vii. Any other certificate required as per CRS sanction.

7.8. Application for getting special trials done shall be accompanied by:

1. **Emergency /Service Braking Distance trials**
Apart from details as per Annexure 'G', following documents will be required:

a. Joint Safety certificate issued by concerned Metro
b. Track certificate issued by concerned Metro
c. Bridge Certificate issued by concerned Metro
d. After issue of Speed Certificate, CRS sanction for conducting the trial.
e. Any other certificate required as per CRS sanction

2. **Controllability**
Apart from details as per Annexure 'J', following documents will be required:

a. Joint Safety certificate issued by concerned Metro
b. Track certificate issued by concerned Metro
c. Bridge Certificate issued by concerned Metro
d. After issue of Speed Certificate, CRS sanction for conducting the trial.
e. Any other certificate required as per CRS sanction.

3. **Coupler Force**
Apart from details as per Annexure 'I', following documents will be required:

a. Joint Safety certificate issued by concerned Metro
b. Track certificate issued by concerned Metro
c. Bridge Certificate issued by concerned Metro
d. After issue of Speed Certificate, CRS sanction for conducting the trial.
e. Any other certificate required as per CRS sanction

7.9. In addition to the above mentioned documents, any other detail required by RDSO after due examination of the case, shall be intimated to the concerned metro.

[Expected Time in conducting oscillation trial by RDSO – four weeks. Additional 2 weeks for EBD trial and 2 weeks for coupler force trial if needed.]

## 8. CONDONATION:

8.1. Any deviation from the standards prescribed by and acceptable to MOR, either pointed out by MOR/RDSO or brought to the notice of MOR/RDSO by the Metro, will be required to be condoned by MOR. For any such condonation Metro will submit detailed justification each case wise well in advance.

8.2. Any infringement or deviation to approved SOD will also require condonation from MOR. However the case is to be processed by Metro through approval of concerned CRS to Railway Board.

## 9. MAINTANCE AND OTHER MANUALS

Before commencement of the commercial services, the Metro Administrations should ensure that all the following manual are in place:

a) Operations Manual
b) Safety Manual
c) Disaster Management Manual
d) Maintenance Manual of various sub-systems

**10.** The expected time stipulated is tentative and does not include the time taken by Metros in providing any clarification asked by RDSO.

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**Annexure-A**

## Documents required for issue of speed certificate of Rolling Stock - (Rolling Stock - Mechanical)

1. **Brake System**
   i. System description of air supply and brake system, Standards followed.
   ii. Train brake calculation and parking brake details.
   iii. Emergency braking distance.
   iv. Air consumption calculation.
   v. Brake and piping diagram.

2. **Bogie System**
   i. System description of bogie.
   ii. Drawings and Design Data for Bogie
   iii. Finite Element Analysis Report of Bogie Frame.
   iv. Fatigue test data of bogie frame and endurance parameters calculations
   v. Thermal calculation of wheel.
   vi. Axle strength calculation-Powered axles.
   vii. Axle strength calculation- Non - Powered axles.
   viii. Life rating calculation of axle box bearing.
   ix. Suspension drawing and design parameters.

3. **Vehicle Dynamic Analysis on Track Data as Specified by Metro Administrations**
   i. Vehicle model.
   ii. Natural frequencies of the suspension.
   iii. Stability / safety of bogie
   iv. Wheel / track off-loading.
   v. Bogie rotational resistance.
   vi. Wheel wear index at the tread and flange.
   vii. Lateral force and derailment quotient.
   viii. Ride index.
   ix. Acceleration values of car body and bogie frame.
   x. Criteria for assessment of riding behaviour of vehicle.

4. **Finite element Analysis of car body structure as per manufacturer**
5. **Relative movement between coaches/coach and bogie**
   i. Coupler movement calculation
   ii. Gangway movement calculation for specified radius
   iii. Calculation of relative movements between coach and bogie on different degrees of curvature.
6. **Passenger Saloon Door description & Drawing for record purpose**
7. **Coupler – Technical description and drawings**.

8. **Fire load calculation and emergency evacuation of passengers**
   i. Design calculation of Fire load above and below body frame.
   ii. Fire Protection System and compliance to relevant International Standards.
   iii. Measures for emergency evacuation of passengers.

9. **Crashworthy Simulation as per EN 15227 and GMRT 2100**

10. **Layout of DMC and TC and pay load calculation.**

11. **Weight particulars of stock.**

12. **Test Procedure of Brake System, Bogie, Coupler, Wheel & Axle to be given for information.**

**i. Brake System**
   **a.** Dynamometer test.
   b. Brake calliper unit.

**ii. Bogie System**
   a. Static and Fatigue tests of bogie frame
   b. Bogie rotational resistance test
   c. Oscillation trials
   d. Wheel offloading test

**iii. Coupler System**
   a. Test specification of coupler

iv. **Wheel & Axle**
   a. Test procedure of Wheel.
   b. Test procedure of Wheel set.
   c. Test procedure of Solid Axle.

**Annexure – B**

## Documents required for Rolling Stock – (Rolling Stock – Electrical)

1. Technical specification on rolling stock covering its electrical sub systems for information.

2. Following Design Calculations to be furnished for records sake:-
   (i) Adhesion calculation
   (ii) Gear pinions, analysis of stresses, selection of bearing, gear case and transmission assembly
   (iii) Tractive and braking effort vs speed curves showing balancing speed.
   (iv) Curves of efficiency, power factor, frequency, slip as a function of speed.
   (v) Traction Motor performance curves.
   (vi) Harmonic calculations.

3. Following drawings to be furnished for information:-
   (i) Schematic diagram of power, dynamic braking, control and auxiliary circuits including multiple operations
   (ii) Tractive effort transmission diagram.
   (iii) Brake system schematic diagram.
   (iv) Drawing showing mounting arrangement of traction motor.
   (v) Motor suspension arrangement.
   (vi) Power converter cooling arrangement.
   (vii) General arrangement for wheel slip detection and correction system.
   (viii) Drawings for third rail current collector.
   (ix) Air conditioning arrangement.

4. EMI/EMC compatibility, test plan & results.

5. Simulation results for TE, BE, Performance curves for rolling stock for identified section of Metro.

6. Details of electrical protection system of metro unit, various equipment and their sub-assemblies.

7. Safety plan and standards followed and references for provenness of major assemblies and sub-assemblies.

**Annexure-C1**

## Technical Standards of Track Structure for Metro Railways

### 1. Purpose

To develop technical standard/specification for track structure for Metro Railways including details of curvature, gradients, turnouts, switch expansion joints etc. for use on metro system in the country.

### 2. Operating Environment:

Track Structure should fulfil generally the following conditions:

2.1 Gauge – Broad gauge- 1676/1673mm (nominal) and standard gauge – 1435mm.
2.2 Speed potential – 110 kmph (max.)
2.3 Static axle load –20 T (max.)
2.4 Design rail temp. range – (-)10 degree Celsius to 70 degree Celsius
2.5 Curvature and Gradient will be specified in SOD.

### 3. Noise and Vibration

Metro system shall be designed to ensure that noise emitted is well within the prescribed limits for the particular area. Each Metro system shall specify the prescribed limits of permissible Noise and vibration parameters as per legal and statutory requirement of India.

### 4. Track Structure

The track structure should fulfill following requirements:

(i) The track structure should conform to/ satisfy Schedule of Dimension requirement and other maintenance instructions of Metro systems.
(ii) Ride comfort and running safety of track vehicle dynamics should be satisfied.
(iii) The track structure should be designed with Long welded / Continuous welded rail on main line track in case of ballasted as well as ballastless track.
(iv) The horizontal alignment shall consist of a series of straights joined to circular curves generally with transition curves. Curvature and cant shall be calculated based on the train speed for each train type on the section. Compound and reverse curves are acceptable, provided they are connected by an adequate transition curve.
(v) The vertical alignment should be designed to achieve a smooth profile line with gradual changes. Changes in the profile should be connected by vertical curves, which shall be as generous in length as the location allows. Vertical curves shall not be located at stations within the length of platform. A vertical curve within the length of transition is also not desirable. Vertical curve radius is constrained by the need to limit the vertical acceleration for passenger ride comfort.
(vi) Check rail should be provided on curves where radius is 218m or less on Broad gauge and radius is 190m or less on Standard gauge.

The technical standards for Track structure deals with the following components-

(i) Rail
(ii) Sleeper and fastening for ballasted track
(iii) Track slab for ballastless track
(iv) Fastening system for ballastless track
(v) Insulated Glued joint
(vi) Turnout, scissors crossover
(vii) SEJs

## 5. Rail

(i) The rail used in Metro shall be 60E1 (UIC 60), 1080 grade Head Hardened on curves and approaches of stations for main line track. The rail used on depot lines shall be 60E1 (UIC 60), 880 grade. The use of 60E1 (UIC 60), 1080 grade HH / 60E1 (UIC 60), 880 grade rail on straight line of main line shall be decided by Metro Railway depending upon speed, axle load and other factors pertaining to safety and life of rail. However on curves with small straight track in between, the 60E1 (UIC 60), 1080 grade Head hardened rail should be continued on straight patches also. It is essential to have preventive rail grinding arrangements in case 60E1 (UIC 60), 1080 HH rails are used.

(ii) The rail shall be class 'A' rails as per IRS-T-12-2009 specification and it shall be manufactured and tested in accordance with IRS-T-12-2009 (with latest amendment). The chosen manufacturers shall be required to submit their inspection and test plan for approval by Metro railway as per IRS-T-12-2009.

(iii) Welding of rail should conform to Indian Railway specifications and technical instructions issued from time to time.

## 6. Sleeper and fastening for ballasted track

### Broad Gauge

The PSC sleepers shall be used in accordance with RDSO drawing no. T-2496 and specification IRS-T-39 (revised from time to time) and compatible fastening system with minimum toe load of 1045 kg and approved by Indian Railway shall be used.

### Standard Gauge

PSC sleeper for standard gauge will be designed by Metro Railways following in principal guidelines of Indian Railway and the same shall be approved by Indian Railway. The compatible fastening system with minimum toe load of 1045 kg and approved by Indian Railway shall be used.

## 7. Track slab for ballastless track

Track shall be laid on cast in situ/precast reinforced plinth or slab, herein referred to as the 'track slab'. The track slab shall be designed as plinth beam or slab type ballastless track structure with derailment guards. It shall accommodate the base plates of the fastening system. In general, track slab (including sleeper, if any) on which the fastening and rail are to be fitted shall perform the following functions:

i) Resist the track forces. (static and dynamic)

ii) Provide a level base for uniform transmission of track/rail forces.

iii) Have geometrical accuracy and enable installation of track to the tolerances laid down.

iv) Ensure drainage.

v) Resist weathering.

vi) Be construction friendly, maintainable and quickly repairable in the event of a derailment. The 'Repair and Maintenance methods' shall be detailed in a Manual to be prepared and made available.

vii) Ensure provision for electrical continuity between consecutive plinths/slabs by an appropriate design.

viii) Plinth beam or slab of ballastless track should be suitable for embankment or viaduct or tunnel/Underground structure.

ix) Proper design of expansion joints suitable for joints of viaduct structure.

x) Design should be suitable for curves as per SOD of Metro system.

xi) Design of subgrade/embankment for slab should be furnished to ensure durability and functional stability in service.

xii) Design should be suitable and incorporate provision of utilities e.g. cable, wires, ducts, water channels, etc.

The detailed design calculations of track slab along with detailed structural drawings shall be furnished.

### 7.1 Derailment Guards

The derailment guard should be provided inside/outside of running rail on viaduct as well as tunnel and at grade section locations specified by the Metro railway. The lateral clearance between the running rail and the derailment guard shall be 250 ±40 mm. It shall not be lower than 25 mm below the top of the running rail and should be clear of the rail fastenings to permit installation, replacement and maintenance. Derailment guard shall be designed such that in case of derailment:

(i) The wheels of a derailed vehicle under crush load, moving at maximum speed are retained on the viaduct or tunnel.

(ii) Damage to track and supporting structures is minimum.

**8.Fastening system for ballastless track**

The performance criterions for fastening system of ballastless track is already specified separately vide Railway board letter no. 2009/Proj/MAS/9/2 dated 21.05.2010.

**9.Glued Insulated Rail joint**

Normally glued joint should be avoided. Wherever inescapable, G3 (L) type of glued insulated rail joint shall be used as per RDSO drawing no.T-5843. The glued joints shall be manufactured and tested in accordance with RDSO's 'Manual for Glued Insulated Rail Joints-1998' with all amendments.

**10. Turnouts, Scissors Crossover**

**10.1 General**

(i) **A**. On main lines, the turnouts and diamond crossing shall be of the following types:

**Standard Gauge**

a) 1 in 9 type turnout
b) 1 in 7 type turnout
c) Scissors cross-over of 1 in 9 type consisting of 4 turnouts and 1 diamond crossing

**Broad Gauge**

a) 1 in 12 type turnout
b) 1 in 8.5 type turnout
c) Scissors cross-over of 1 in 12 type consisting of 4 turnouts and 1 diamond crossing

**B**. On depot lines, the turnouts and diamond crossing shall be of the following types:

**Standard Gauge**

a) 1 in 7 type turnout
b) Scissors cross-over of 1 in 7 type consisting of 4 turnouts and 1 diamond crossing
c) 1 in 7 derailing switches / 1 in 7 type symmetrical split turnout

**Broad Gauge**

a) 1 in 8.5 type turnout
b) Scissors cross-over of 1 in 8.5 type consisting of 4 turnouts and 1 diamond crossing
c) 1 in 8.5 derailing switches /1 in 8.5 type symmetrical split turnout

(ii) The requirement for turnouts as specified in the following clauses shall include switch devices, crossings and associated check and lead rails as appropriate.

(a) Turnouts (switches, lead, crossings and associated closure & check rails) shall be suitable for installation on PSC sleepers for ballasted track or concrete slab for ballastless track.
(b) Turnouts shall be manufactured to allow for installation of continuously welded track.
(c) Turnout shall be compatible with proposed rolling stock and its operational characteristics.
(d) The assembly must ensure continuous electrical contact with the train and all the points shall be operated by electric motors.
(e) The CMS crossing to be used on mainline shall be subjected to explosive hardening.
(f) All turnouts shall be laid with cant with a rail slope of 1 in 20 toward centre of track.
(g) All turnouts and their components shall be designed to minimize electrical leakage from running rails to the ground.
(h) Scissor crossover should be designed for Track centers not infringing SOD.

## 10.2 Type and geometry of turnout

Detailed design of all turnouts, scissors crossover should comply the following geometrical parameters.

**Standard Gauge**

### (i) 1 in 9 turnout

The design shall be tangential with a switch entry angle not exceeding 00 20’00’’. The radius of lead rail of turnout shall not be less than 300 m. All clearances shall be in accordance with relevant provisions of SOD.

### (ii) 1 in 7 turnout

The design shall be tangential with a switch entry angle not exceeding 00 20’00’’. The radius of lead rail of turnout shall not be less than 190 m. All clearances shall be in accordance with relevant provisions of SOD.

### (iii) Scissors Crossover

The basic geometry of the turnouts of scissors crossover shall be same as that of corresponding ordinary turnouts as mentioned in clause 10.2 (i) (ii) above.

**Broad Gauge**

**(i) 1 in 12 turnout**

The design shall be tangential with a switch entry angle not exceeding 00 20’00’’. The radius of lead rail of turnout shall not be less than 410m. All clearances shall be in accordance with relevant provisions of SOD.

**(ii) 1 in 8.5 turnout**

The design shall be tangential with a switch entry angle not exceeding 00 20’00’’. The radius of lead rail of turnout shall not be less than 218m. All clearances shall be in accordance with relevant provisions of SOD.

**(iii) Scissors Crossover**

The basic geometry of the turnouts of scissors crossover shall be same as that of corresponding ordinary turnouts as mentioned in clause 10.2 (iv) & (v) above.

**10.3 Operating requirement of turnout, scissor crossover:**

Track layout design shall permit trains to operate at maximum capability wherever possible. Turnouts and crossover shall be selected such that they do not form a restriction to the operating speed on the diverging route. Switches and crossings shall not be located on transition curves or vertical curves.

**Speed:**

The turnout shall be designed for 110 Kmph on Mainline side with speed restrictions on curves if required.

The minimum speed potential of the various turnouts and scissors crossover on the Turnout side should be as follows:

**Standard Gauge**

(i) 1 in 9 type turnout (speed potential of 45Kmph )

(ii) 1 in 7 type turnout (speed potential of 35Kmph )

(iii) Scissors crossover 1 in 9 type (speed potential of 45Kmph )

(iv) Scissors crossover 1 in 7 type (speed potential of 35Kmph )

(v) 1 in 7 type symmetrical split turnout (speed potential of 45Kmph)

**Broad Gauge**

(i) 1 in 12 type turnout (speed potential of 50Kmph)

(ii) 1 in 8.5 type turnout (speed potential of 30Kmph )

(iii) Scissors crossover 1 in 12 type (speed potential of 50Kmph)

(iv) Scissors crossover 1 in 8.5 type (speed potential of 30Kmph)

(v) 1 in 8.5 type symmetrical split turnout (speed potential of 40Kmph)

## 10.4 Technical Specification

### 10.4.1 General

(a) All the points shall be capable of being operated by electric motors in accordance with the signaling specification.

(b) The top surfaces of PSC sleeper/RCC slab supporting rail seat of turnouts and scissors crossover shall be flat without any cant/slope.

(c) The track form of the turnout shall have uniform resilience as that of the adjoining track form.

(d) The fixation of turnouts, scissor cross-over on track slab shall be through base plates/bearing plates.

### 10.4.2 Rails

1. The rails used in turnouts shall be 1080 grade Head Hardened.
2. The rails used for manufacturing of turnouts shall satisfy the following conditions:
   a. The rails shall be manufactured and tested in accordance with IRS/T-12-2009 with latest amendment.
   b. The section of rails shall be 60E1 (UIC60) for stock, lead and 60E1A1 (ZU1-60) for switch rail.
   c. The rails shall qualify as Class ‘A’ rails as per IRS/T-12-2009.
   d. The rails shall be with ends un-drilled.
   e. The rails shall be of grade 1080HH and be suitable for being welded by alumino-thermic or flash butt welding technique.

### 10.4.3 Switches

1. Each switch device shall consist of two stock rails, one left hand and one right hand and two switch rails, one left hand and one right hand. Switches shall be manufactured to suit to special asymmetrical section switch rail type 60E1A1 (ZU1-60).
2. The switch rail shall be one piece with no weld or joint within the switch rail length.

3. The end of the asymmetrical switch rail shall be forged to 60E1 (UIC60) rail profile with minimum length of 60kg profile for 500 mm. The forged 60E1A1 (ZU1-60) switch rail end shall be suitable for welding or installation of insulated rail joint.
4. Slide chairs in the switch portion shall be coated with an appropriate special coating, so as to reduce the point operating force and to eliminate the requirement of lubrication of sliding surfaces during service.
5. Switches shall provide suitable flange way clearance between the stock rail and the switch rail with the switch rail in open position (minimum 60mm). The 1 in 12 and 1 in 9 turnout shall be provided with second drive or other suitable arrangement to ensure minimum gap of 60 mm at JOH as well as proper housing of switch rail with stock rail up to JoH 1 in 8.5 and 1 in 7 turnouts may not be provided with second drive arrangement, however minimum gap of 60 mm at JOH as well as proper housing of switch rail with stock rail up to JOH should be ensured. The nominal opening of switch at toe of switch shall be kept as 160 mm.
6. The switch manufacturer shall include provision for all holes required to main drive machines, stretcher bars and detection equipment to suit the requirements of the signaling and switch operating system duly chamfered to avoid stress concentration at the edge of the holes.
7. The switches shall be designed with an anti-creep device at the heel of switch to withstand thermal forces of the CWR track.
8. The switches and all slide chairs shall be same for ballasted and ballastless turnouts.

**10.4.4 Crossings**

1. All crossings shall be cast manganese steel (CMS) crossings with weldable rails of minimum 1.2m length undrilled for welding into the overall turnout.
2. The CMS crossings shall be manufactured from Austenitic Manganese steel as per UIC 866.
3. All CMS crossings shall have welded leg extensions of 60E1 (UIC60) rails. This shall be achieved by flash butt welding of buffer transition rail piece of suitable thickness to CMS crossings and rail leg extension.
4. All CMS crossings shall have a minimum initial hardness of 340 BHN.
5. All CMS crossings and their welded leg extensions for all scissor crossovers shall be suitably dimensioned so as to eliminate the necessity of providing small cut rail pieces for the purpose of inter-connection. However, the need for providing insulated glued joints from signaling requirement point of view shall be taken care of in the design, if required.
6. The provision of rail cant shall be taken care of on the top surface of the CMS crossing and the bottom surface of all CMS crossing shall be flat.

### 10.4.5 Check Rails

1. The check rail section shall be 33C1 (UIC33) or similar without any direct connection with running rails.
2. Check rails shall have the facility for the adjustment of check rail clearances up-to 10mm over and above the initial designed clearance.
3. Each check rail end shall be flared by machining to have minimum clearance of 62mm at end.
4. The check rail connections in turnouts shall be through specially designed bearing plates / brackets.
5. All the check rails shall be higher by 25mm above running rails. The lengths and positions of the check rail in diamond crossings shall provide safety and be compatible with the overall track layout.

### 10.4.6 Sleeper for Turnouts, Scissor crossover (Ballasted Track)

10.4.6.1 Sleeper shall be of pre-stressed concrete, mono-block, suitable for installation in track both with and without signaling circuits and with and without electrification.

10.4.6.2 Sleepers shall be designed to provide a minimum service life of fifty years under nominal axle load of 20 tonnes and a maximum speed of 110 Kmph. Rail seat pads and liners shall be designed to provide a minimum service life of 10 years.

10.4.6.3 The sleeper base surface shall be rough cast while the top and side surface shall be smooth to prevent retention of moisture and foreign materials.

10.4.6.4 Sleepers must be suitable for installation by track laying machines and sleeper insertion equipment of a type used for isolated sleeper laying.

10.4.6.5 The sleeper must be able to transfer all the relevant track forces generated by train operations and the forces of rail expansion and contraction to the ballast.

10.4.6.6 (a) The sleepers should satisfy the following design requirement:

**Design Parameters**

(i) Rail sleeper fastening – Elastic resilient type

(ii) Spacing of sleepers – 600mm (max) – Except at few locations such as near point machine locations where it may be varied to meet the design requirements.

(iii) Ballast cushion – 300 mm for mainline and 250mm for Depots and sidings

(iv) Ballast profile suitable for LWR/CWR.

**Specifications and Drawings** (With latest amendment)

(i) Special Cement – IRS T 40 1985

(ii) HTS wire plain and strand – BIS – 1785 (Pt-1) 1983 and BIS 6006

(iii) Polyethylene dowels – Provisional 1997 Drg. No. RDSO 3002 Alt-3

(iv) IRS Specification for Turnout Sleeper T- 45 1996

(v) IRS Bridge code 1982

(vi) Code of Practice for Pre-stressed Concrete IS-1343

(b) The design should satisfy the following additional requirements-

(i) The connections of the slide chairs and bearing plates/special bearing plates/brackets shall be designed for easy installation and maintenance. All the fittings shall be suitably designed to ensure full compatibility & also to ensure interchangeability of slide chairs between ballasted and ballastless turnouts.

(ii) For attaining 1 in 20 cant of the rail (excluding crossing portion), suitably designed pads of appropriate material shall be provided between rail pad & PSC sleeper. Also fastening system should be designed to get the desired Toe Load.

(iii) The detailed design of Monoblock PSC sleepers for the turnouts along with structural drawings shall be furnished.

**10.4.7 Monitoring System:**

1. Safety and maintenance relevant functions of a turnout shall be monitored by a monitoring system. In case of irregularity in track or lack of maintenance, the monitoring system shall send online messages about problems.
2. The monitoring system shall have a modular system structure for being easily expandable.
3. It shall automatically generate error messages.
4. It shall have a continuous data acquisition with facility for storage of data.

**11. Switch Expansion Joint-**

1. The SEJ for ballasted track shall be laid on PSC sleepers whereas the SEJs for ballastless track, if required, shall be laid on reinforced concrete slab.
2. The rail section for all SEJs shall be UIC 60, 1080 HH grade as per IRS-T-12-2009.
3. The SEJ for ballasted track shall be designed for a maximum gap of 80 mm.
4. The SEJ for ballastless track should be designed for the maximum gap required as per design.

5. The ballasted SEJ shall be as per RDSO drawing T-6902 &T-6922.
6. The ballasted SEJ for BG shall be laid with PSC sleepers as per RDSO drawing T-4149. For Standard Gauge, PSC sleeper shall be designed such that SEJ to RDSO drawing along with its bearing plates/chairs may be accommodated for installation of SEJ.
7. Sleepers used for SEJs shall be flat and cant will be provided through CI chair.
8. The SEJ shall be suitable for two way directional traffic.

**ANNEXURE-C2**

PERFORMANCE CRITERIA OF FASTENING SYSTEM FOR BALLASTLESS TRACK ON METRO RAILWAYS/MRTS SYSTEMS (PROVISIONAL)

May, 2010

1. Purpose

   The performance criteria define the performance standard of fastening system for ballastless track of Metro Railway System. Apart from other things, the fastening system is required to moderate vibration and noise transmitted through the rail and to reduce the track stiffness and the impact on the track structure, so as to obtain the parameters as detailed in the ensuing paragraphs.

2. Operating Environment:

   Fastening system is expected to perform generally in the following conditions:

   2.1 Gauge – Broad gauge, 1676mm (nominal), standard gauge-1435mm.

   2.2 Speed potential – 110kmph

   2.3 Rail section – 60kg, UIC, 90 UTS, 110UTS

   2.4 Guard rail – Inner guard rail on viaduct and double/multiple line tunnels

   2.5 Static axle load – BG & SG – 20t (max.)

   2.6 Design temperature range – 10degree Celsius to +70 degree Celsius (rail)

   In addition, the client railway may specify the other operating condition such as minimum radius of curve, super elevations, cant, ruling gradient & support spacing.

3. Ballastless Track structure:

   Track shall be laid on cast in situ/precast reinforced plinth or slab, herein after referred to as the 'track slab'. The track slab shall be designed as plinth beam or slab type ballast less track structure with derailment guards. It shall accommodate the base plates of the fastening system. The minimum depth of concrete below the base plate should be decided based upon characteristics of underlying bas and the design of the fastening system. In general, track slab on which the fastening and rail are to be fitted shall:

   i. Resist the track forces.
   ii. Provide a level base for uniform transmission of rail forces.
   iii. Have geometrical accuracy and enable installation of track to the tolerances laid down.
   iv. Ensure drainage.
   v. Resist weathering.
   vi. Be construction friendly, maintainable and quickly repairable in the event of a derailment. The 'Repair and Maintenance methods' shall be detailed in a Manual to be prepared and made available.

vii. Ensure provision for electrical continuity between consecutive plinths/slabs by an appropriate design.

4. Derailment Guards:

The lateral distance measured perpendicular to between the running rail and the guard rail shall be 250 to 300 mm. It shall not be lower than 50mm below the top of the running rail and should be clear of the rail fastenings to permit installation, replacement and maintenance. Derailment guard shall be designed such that in case of derailment;

i. The wheels of a derailed vehicle under crush load, moving at maximum speed are retained on the viaduct or tunnel.
ii. Damage to track and supporting structures is minimum.

5. Performance Requirement of Fastening system:

5.1 General:

i) The fastening shall be designed to hold the two rails of the track strongly to the supporting structure in upright position by resisting the vertical, lateral and longitudinal forces and vibrations.
ii) The fastenings shall be with a proven track record. Fastening system should have satisfactory performance record of minimum five years in service in ballastless track on any established railway system. In this regard, supplier should submit certificate of performance from user railways administration including proof of use of the fastening system.
iii) The fastening shall provide insulation to take care of return current of traction system.
iv) Fastening should satisfy the required performance norms as stated in para 4.2 4.3,4.4 & 4.5.

5.2 Following are the technical performance requirements of fastenings: The Fastening shall

i) Have design service life of 30 years in general. However, its components such as rubber pad, rail clip etc. can be designed for 300 GMT or 15 years whichever is less. Anchor bolts or studs used for fixing base plate to the concrete should not be required to be replaced during service life. Its components must not suffer any degradation during its service life to a degree so as to affect the performance and safety of the track. Full service life is to be attained under the following conditions:
   a) Atmospheric ultra violet radiation
   b) Proximity of track up to 10 m from salt water source.
   c) Contact with oil, grease or distillate dropped from track vehicles.

ii) Hold the rails to gauge and at the correct inclination within tolerance laid down against horizontal forces generated by vehicles in motion especially on curves, wheel set hunting, alignment irregularities and thermal forces.

iii) Permit quick and easy installation and replacement with special tools.

iv) Be capable of vertical adjustment during service life upto 12mm using shims.

v) Permit the attainment of the following tolerances when installed and later, during service.

| S.N. | Parameter | Installation | Maintenance |
|---|---|---|---|
| 1. | Gauge | +2, -1mm | ± 4, -2mm |
| 2. | Cross level on straight track | ± 1.5 mm | ± 5mm |
| 3. | Super elevation on curved track | ± 1.5 mm | ± 3 mm |
| 4. | Vertical alignment over a 20m chord | ± 3 mm | ± 6 mm |
| 5. | Lateral alignment over a 20m chord on straight track | ± 2 mm | ± 6 mm |
| 6. | On curves-variation over the theoretical versine on 20m chord | ± 2 mm | ± 5 mm |

vi) Have dynamic /static stiffness ratio of 1.4 (max.) {Dynamic stiffness to be tested as per EN 13481 – 5 Annex B. Ratio can be calculated by dividing the dynamic stiffness to static vertical stiffness (to be calculated as per S.No. 2 of para 4.5)].

vii) Have clip toe load 18 kN per rail seat in service (i.e. even after creep etc.)

5.3 Where anchor bolts or studs are used for fixing the base plates, they shall have splayed ends. The designer of the rail fastening system shall submit detailed calculations to establish the diameter and number of anchor bolts/studs used as also the quality/grade of their steel, loads applied to the fastenings in operating conditions, factor of safety etc. Number of bolts to be provided on resilient base plate depends upon axle load, speed and radius of curve also, therefore, the supplier should indicate the proposed number of bolts per plate, as per the requirement of the location, along with calculations.

Anchor bolts shall be fixed rigidly in concrete. Fastener supplier shall specify the process to achieve this requirement.

5.4 Fastening system (bonded or non-bonded) assembly shall be designed for static vertical stiffness of less than 35 kN /mm (in the secant range 5-80kN) as a whole

when tested using the specification EN-13146-4:2002 Railway application-track-test methods for fastening. Effect of repeated loading.

5.5 The rail fastening system shall be tested to the following specification for different technical parameters and should meet the acceptance criteria as mentioned in the following table. Any other similar test method needs approval of Indian Railway for the same parameters. Test report of the reputed independent institute/laboratory will have to be submitted.

| S.No. | Technical Parameter | Test Method | Acceptance criteria | Remarks |
|---|---|---|---|---|
| 1. | Determination of longitudinal rail restraint | EN-13146-1 (latest version) | 7 kN (min.) | This has to be tested before repeated load test. |
| 2. | Vertical stiffness of complete fastening system | EN-13146-4 (latest version) | 35 kN/mm (max.) | No sliding, yield or cracking is allowed for the fastener parts. |
| 3. | Determination of clamping force | EN-13146-7 (latest version) | 18 kN (min.) | This has to be tested before repeated load test. |
| 4. | Determination of electrical resistance | EN-13146-5 (latest version) | 5 kΩ (min.) | The user may specify a higher value for use with certain track circult. |
| 5. | Effect of severe environmental conditions | EN-13146-6 (latest version) | The fastening system shall be capable of being dismantled, without failure of any component, using manual tools provided for this purpose after exposure to the salt spray test. | |
| 6. | Effect of repeated | EN-13146-4 (latest version) | No wear or deformation | Test load & fastening position will be taken as per |

| | | | | |
|---|---|---|---|---|
| | loading | | | EN-13481-6 |
| 6A | On Vertical stiffness | EN-13146-4 (latest version) | Variation less than 25%of the initial value. | No sign of bond failure/ fracture/slippage. |
| 6B | On Longitudinal rail restraint | EN-13146-1 (latest version) | Variation less than 20%of the initial value. | Except the rail and fastener, no sliding, yield or cracking is allowed for fastener parts.<br>Longitudinal load/deformation curve shall fall in the envelope of upper and lower limit which is to be submitted along with test report. |
| 6C | On Clamping force | EN-13146-7 (latest version) | Variation less than 20%of the initial value. | |

**Annexure – D1**

## Documents required for record for 25kV AC OHE and Power Supply System

The following records will be submitted at appropriate stage before submitting application to CMRS:

1. Details of General Arrangement of OHE duly approved by Metro Authorities.

General Arrangement Drawing pertaining to the following:

a) Catenary Wire, Contact Wire, Aerial Earth Wire, Buried Conductor, Buried Rail, Booster Transformer, Return Conductor
b) Cantilever Assemblies, Droppers, Schedule, Jumpers
c) Insulated Overlaps, Un-Insulated Overlaps
d) Turn-outs and Crossover arrangements
e) Anti Creep Arrangement. Termination, Anchoring Arrangement (along with Auto Tensioning Device)
f) Feeding and Sectioning Arrangement including Traction Feeding Diagram.
g) Position and details of Neutral Section

2. Basic Design Data approved by Metro Authorities related to followings:-

a) Pre-sag of Contact Wire at mid-point
b) Gradient of Contact Wire (relative and Absolute)
c) Tension length, Spans, Stagger
d) Height of Contact Wires in Tunnels Bridges and in Open Routes
e) Wind Load & Seismic zones
f) Electrical Clearances (Longitudinal/Lateral & Vertical – Static & Dynamic)
g) Sweep zone of Pantograph and Panto pressures

3. Design Details approved by Metro Authorities related to the following:

a) Typical Drawing of OHE at Support i.e. at Mast, Portal etc.
b) Earthing Drawing for Viaduct/Tunnel (Typical)
c) Earthing Design for Receiving / Auxiliary Sub-station (RSS and ASS). (Typical)
d) Typical Drawing of Cantilever Arrangement for single Bracket, Multiple Bracket and Fitting
e) Make wise Drawing of Stay Insulator, Bracket Insulator, Tensioning Insulator, Disc Insulator, Section/Core Insulator, Post Insulator, Operating Rod Insulator. (These are one time design and are not repeated for every Project/Section. Specification showing Electro-Mechanical characteristic can be submitted once for every project).
f) Conceptual Drawings for Traction Return Current including Longitudinal continuity and Integral Transfer Links
g) Design Calculations, Simulation, Drawings for Earthing and Bonding (including Earth Conductors and Connection)
h) Simulation report of Electro-Magnetic interference current including the effect of Booster Transformer and Return Conductor
i) Detail of Feeder Protection:

(i) Protection of Phase Gaps / Neutral Sections
(ii) Extension of Power in case of Emergency

4. Details of Power Supply Arrangement duly Approved by Metro Authorities related to following:

a) EIG application with following:
- Details of Power Drawl from the Power Grid
- General Arrangement Details of Sub-stations
- Protection Philosophy and relay setting calculations,
- Earthing arrangement for the power supply installations
- Equipment details

b) Power Supply Simulation with Electric Loads for Peak Traffic and under extended feed conditions

c) Sizing of Transformer, Conductors, Bus-Bar, Instrument Transformer

d) Details of Insulating oils along-with their class and Technical details

e) References for provenness of various assemblies / Sub-assemblies / Equipments used in Overhead Traction Equipment

5. EIG report.

6. Conceptual scheme of Supervisory Control and data acquisition system.

7. Safety Circulars, procedures for grant and cancellations of permit to work.

8. Submission of Test Certificates of Equipments:

a) Type test of Insulators

b) Type test of Contact and Catenary wire

c) Type test of Booster Transformers, if any

d) Type test of Traction Transformer

e) Type test of Protection Relays

**Annexure – D2**

**Documents required for record for third rail traction system and Power Supply System at appropriate stage.**

1. Details of General Arrangement of Third Rail Traction System duly approved by Metro Authorities.

General arrangements drawing pertaining to the following:

a) Third Rail
b) Bridgeable & Non-Bridgeable Gaps
c) Third Rail Ramps at Turnouts
d) Mid Point Anchor
e) Expansion Joints
f) Insulated Joints (IJ)
g) Third Rail Brackets
h) Power Feed Assemblies
i) Splice Assemblies
j) Vertical & horizontal clearances of Third Rail
k) Feeding and Sectioning Arrangement including Traction Feeding Diagram

2. Basic Design Data approved by Metro Authorities for the following:

a) Third Rail Characteristics, Material & Electrical Properties
b) Third Rail current carrying capacity & Temperature Rise
c) Electrical resistance
d) Peak Current Temperature Rise
e) Short Circuit Level
f) Third Rail Bracket Spacing
g) Horizontal & Vertical Clearances of Third Rail
h) Shroud for Third Rail
i) Third Rail mounting insulator

3. Design Details for Third Rail System approved by Metro authorities should also be given for record as under:

a) Design calculations of Third Rail, Bracket, Insulated Joints, Expansion Joints, Ramps, Third Rail current carrying capacity & Temperature Rise
b) Thermal Expansion
c) Conductor Rail Deflection
d) Bracket Loading Calculations
e) Bracket mechanical validation
f) Bracket Welding Validation
g) Design Calculations for traction Return Current
h) Design Calculations for Earthing and Bonding for Receiving Substation, Traction Substation and Auxiliary Substation Calculations of Electromagnetic Interference / Electro Magnetic Compatibility
i) Bridgeable & Non-Bridgeable Gaps
j) Extension of power in case of emergency

4. Details of Power Supply Arrangement duly approved by Metro Authorities for the following:

a) Details of Power Drawl from the Power Grid.

b) General Arrangement Details of Sub-stations. Documents shall adhere to latest Indian Electricity Rules & Statutes in force.

c) Protection Philosophy, Engineering Details along with calculations for High Voltage Circuits, Low Voltage Circuits and Transformers which shall include Traction and non-traction loads.

d) Power Supply Redundancy for all loads (Traction and Non-Traction Loads)

e) Earthing Arrangement for the Power Supply Installations (Traction/Non-Traction Power Transformer, Switching Posts)

f) Earthing, Bonding and Stray current mitigation, monitoring and control

g) Philosophy, Stray Current Control, EMC Validation Arrangement for Power Supply Installations (Traction/Non Traction Power Transformation, Switching Posts), Power Supply Simulation with Electric Loads for peak traffic and under extended / diverted Feed.

h) Power Supply Simulation / Calculations with Electric Loads for peak traffic and under extended / diverted Feed as case to case basis.

i) Short Circuit levels unbalance, Voltage Drop Calculations.

j) Sizing of Transformers, Conductors, Bus-bars, Instrument Transformers, Surge Protection.

k) Details of Insulating Oils along with class and technical details.

l) Details of Auxiliary Power Distribution including transformation details from grid to point of consumption, layout of Auxiliary Power Lines, Redundancy and Protection.

m) References for provenness of various Assemblies / Sub-assemblies / Equipments used in Third Rail System.

5. EIG Report

6. Details of Supervisory Control and Data Acquisition System.

7. Declaration of Safety Policy, Procedures for grant and cancellation of permit to work.

8. Submission of Type test certificates applicable to Third Rail system as under:
   a) Third Rail including assembly and accessories
   b) Power cable, DC Cable, Control Cable & Optical Fibre Cables
   c) Rectifier Traction Transformer
   d) Auxiliary Transformer
   e) DC Equipments ( Rectifier, HSCB Panel, BY Pass Panel, Dis-connector Switch, Short circuit device at Sub-stations, Negative Return Panel)
   f) Sandwich Bus-duct
   g) C&R Panels
   h) Switchgear Panels
   i) SCADA & Related Equipments
   j) Battery, Battery Charger, UPS
   k) Alternating Current Distribution Board and Direct Current Distribution

**ANNEXURE - E1**

Following Documents are required for various sub-systems of signalling, duly approved by Metro authorities at appropriate stage:

1. Independent Safety Assessor's assessment of vital signalling equipment like CBI, ATP, track detection system etc. (all the items being used for vital functions shall be covered). Regarding ATO & ATS if provided ISA certification shall be done to required safety level as decided by metro.

2. Submission of the following:

   (a) Relevant system details as may be necessary to give full particulars of principle of Operations and safety features incorporated for CSI, ATP, Track Vehicle Detection etc. Including ATO/ ATS if provided.

   (b) Report of EMI/EMC interface with rolling stock/traction, as applicable for track Detection, on-board and other related equipments.

   (c) Typical schematic of earthing/ bonding of signalling equipment.

   Final comments of RDSO regarding technical planning and safety shall be forwarded to Metro within 28 days, after the receipt of final sets of documents.

3. Verification and validation and certification by the ISA of adherence to SIL-4 process from design to testing and commissioning stages of signalling system, including application data of vital equipments for the Signalling system. This shall include hazard analysis, its mitigation and acceptance of the same by competent authority for the concerned Metro Railway.

Note:

Documents listed in Sr. No. (1) & (2) shall *not* be required in case there is an extension to an existing fine incorporating no new type of signalling equipment.

Also documents listed in Sr. No. (1) & (2) shall *not* be required-if an equipment having same hardware and software version and approved earlier by Railway board is already in use on any Metro in India, however, safety and operational performance shall be submitted by Metro authorities for the equipments from user of metro/railways who are using the same equipment.

**Annexure-E2**

PROVISIONS TO BE ADOPTED FOR SIGNALLING& TELECOMMUNICATIONS SYSTEMS

It may be noted that the given criteria is based upon systems already adopted by the existing Indian Metros. However, in case Metro Authorities are adopting a new technology, then the same shall be advised and in principle concurrence of RDSO should be obtained in principle.

**Signalling systems**

| SN | Description | Minimum requirement |
|---|---|---|
| 1. | Type of Signalling | Cab Signalling, CATC (ATP, ATO, ATS). ATP and ATS are essential, ATO is optional. |
| 2. | Back up Signalling | Line side (CLS) at entry and exit at all interlocked stations. |
| 3. | Interlocking | EI with built-in block working facilities |
| 4. | Train control system | CATC(ATP, ATS, ATO optional) |
| 5. | Type of Track Circuits | Coded Audio Frequency Track Circuits (AFTC) |
| 6. | Point machine | |
| | i) For Main Line | i) Non-Trailable high thrust, high performance point machine |
| | ii)For Depot | ii) Trailable high thrust, high performance point machine |
| 7. | Redundancy in cab equipment for ATP (Cab Sig.) | 1+1(hot standby) |

**Telecommunication systems**

| SN | Description | Minimum requirement |
|---|---|---|
| 1. | Tele communication | Integrated system with OFC, Train Radio, CCTV, Centralised clocks, PA system, with the additional provision that Train Display Boards at stations should also be integrated in the system. Regarding Train Radio system, it should be fully digital and duplex system, the standards may be chosen based on techno-economic considerations. |
| 2. | Positive Train Identification | Provided with interface between ATS and Train Radio |

**Annexure – F1**

## METHODOLOGY FOR OSCILLATION TRIALS

Oscillation trial is conducted on a new or modified design of rolling stock, which is proposed to be cleared for running on Metro track. The purpose of oscillation trial is, thus, acceptance of a railway vehicle by conducting dynamic behaviour tests in connection with safety, stability and quality of ride.

The conduct of Oscillation trials is, generally, guided by 'Policy Circular No.6' issued by Railway Board and Standing Criteria committee's report as applicable at the time of trial, along with the trial scheme given by the Design Directorate.

**1. Test Train formation and Runs :**

The test train shall consist of at least 1 unit/ consist having one prototype representative coach of each type. The oscillation trial runs shall commence from the provisional speed/speed as laid down in the speed certificate issued for trial and increased in increments up to maximum test speed or up till running is safe whichever is lower. The increase in speed will be authorized by the officer in charge of the trial on the basis of results of preceding runs.

The trial is conducted in empty and different loading conditions. Additionally, in case of Rolling stock with air springs, the trials are also conducted for air springs in inflated and deflated conditions.

**2. Instrumentation:**

Unless otherwise required by the design directorate, the free end bogie of the vehicle will be instrumented. The prototype will thus be the last vehicle, of each type, in the formation. The Test Vehicle will be instrumented by testing directorate as per the test scheme, if required by welding suitable plates at the required locations. The following Transducers may be used for the trial:

(1) Accelerometers
(2) Optical displacement Sensors/String Pot displacement Sensors/LVDT
(3) Pressure Sensors.
(4) Optical Speed Sensors/ Wheel pick up device.
(5) GPS.
(6) Inclinometers/Gyroscopes
(7) Any other transducers required for the trial.

**3. Data Acquisition/ Analysis:**

Data is acquired by using a Digital data acquisition system, connected to the transducers provided on the prototype vehicle as given in para 2. Band pass filter of

0.4-10 Hz of fourth order is used. RI is calculated for 200m blocks. Speed being constant, time taken for 200m for each speed is calculated and according samples are taken for RI evaluation. Sampling rate used is 200 samples /sec.

The following parameters are recorded/calculated for evaluation:

| SN | Parameter | Conditions & method |
|---|---|---|
| 1 | Maximum vertical acceleration on Coach Body | Measured on Car Floor of Car body as near to bogie Centre as possible. Maximum value should not exceed the prescribed limit |
| 2 | Maximum Lateral acceleration on Coach Body | |
| 3 | Maximum Dynamic wheel Loading/ Unloading - ΔQ/Q ratio | Maximum value of loading/unloading, calculated from spring deflection, should not exceed the stipulated value. |
| 4 | Maximum Value of RI | Calculated on the basis of acceleration values recorded as above (SN-1 & 2) as per ORE C-116 para 2.1(2a) (using FFT method with Zero padding) , should not exceed the specified value |
| 5 | A general indication of stable running characteristics of the carriage as evidenced by the movement of the bogie on a straight and curved track, and by the acceleration readings and instantaneous wheel load variations/spring deflections. | |
| 6 | Damping factor | Using wedge of 18 mm thickness. For evaluation by design directorate |
| 7 | Bogie Rotation and Lateral Movement w.r.t Car body | By Measuring Lateral displacement between Bogie frame and Car body. Recording must establish that the bogie can move without undue constraints. |
| 8 | Safety of running | By measuring Lateral accelerations on Bogie Frame. Evaluation by simplified method as given in Para 10.1.3.1(4) of UIC-518 of October -2005 |
| 9 | Derailment Coefficient (Y/Q) over a period of 1/20th second | *Derailment coefficient, if required, worked out in the form of ratio between the lateral force (Y) and the instantaneous wheel load (Q) continuously over a period of 1/20th second, measured by a measuring wheel or any other suitable means.* |
| Note: Safety certifications shall be done on the basis of tests at SN- 1 to 5 *and 9*, other tests are for investigation purposes only. | | |

Band pass filter of 0.4-10 Hz is used. RI is calculated for 200m blocks. Speed being constant, time taken for 200m for each speed is calculated and according samples are taken for RI evaluation. Sampling rate used is 200 samples /sec.

**4. Facilities to be made available by Metro:**

The Metro shall make the following facility available for conducting of trial:

(i) Competent Crew for operating the Test Special.

(ii) Prototype test rake, made suitably fit for trial, for instrumentation and trial runs.

(iii) 220V AC Power supply on board the test special.

(iv) Instrumented Measuring wheel or any other suitable means, if required.

(v) Facility for fixing/mounting for instrumentation, including Welding equipment and manpower, if required.

(vi) Any other facility as required by the officer in charge of the trial for the conduct of the trial.

**Annexure-F2**

## CRITERIA FOR OSCILLATION TRIALS OF METRO ROLLING STOCK
## (To be re-phrased for the sake of clear understanding by Metro authorities; Criteria committee also to review item no. 2 (ix) as decided by Inter-Ministerial Committee)

### 1.0 SELECTION OF TEST TRACK

1.1 For new metro system, oscillation trial shall be done over the complete section before introduction of first train; and over any new section that is subsequently added to the system if the new section includes any of the following:

I. A tangent (straight) track of 1 km if the earlier trial had been conducted on less than this length.

II. Curves sharper than that available in the section covered during an earlier trial.

III. A curve of about $2^{o}$ of around 700-800 m length, if the earlier trial had been conducted on less than this length.

IV. Turnout or crossover, if the earlier trial had been conducted without it or with that of a different design.

For introducing a new stock over the existing sections, trial shall be done over

I. The longest tangent (straight) track subject to a maximum of about 1 km length. Trial shall be conducted over two stretches, if available.

II. A Curve of about $2^{o}$ if available, preferably of about 700-800m length and the sharpest curve available in the system.

III. A station yard having turnout or crossover, if available, in which case the trial shall be done on the most critical one.

1.2 Initial trial shall be done on the new track with new wheel profile for issue of provisional speed certificate. Repeat trials will subsequently be done on a rundown track as soon as available with worn wheel profile for issue of final speed certificate.

1.3 In case of metros, the long confirmatory run shall be done to obtain at least 25 readings over at least 50 m sections. If not possible in one run, the readings may be obtained by repeatedly running over the same section.

Riding of the vehicle over bridges and viaducts (resonance or amplitude build-up) will be specially mentioned in the trial report.

## 2.0 MEASURED QUANTITIES

As a part of the Oscillation trials, the following quantities shall be measured:

2.1 Body level vertical Accelerations
2.2 Body level lateral Accelerations
2.3 Primary suspension spring deflections
2.4 Secondary suspension spring deflections
2.5 Lateral forces
2.6 Bolster swing, as applicable
2.7 Bogie rotation, as applicable
2.8 Lateral accelerations at bogie frame**.**
2.9 On curves sharper than 250m radius or turnouts sharper than 190m radius on passenger carrying lines, forces at rail-wheel contact point shall also be measured by instrumented measuring wheel, or any other suitable means, to be arranged by the Metro, to calculate the derailment coefficient before issue of final speed certificate.

## 3.0 CALCULATED QUANTITIES

Ride index shall be calculated as per ORE C-116 (Using FFT). Maximum dynamic wheel loading/unloading (ΔQ/Q) shall also be calculated. Derailment coefficient(Y/Q) over a period of 1/20th second, if required as per Para 2.0, shall also be calculated.

## 4.0 ROLLING STOCK CONFIGURATION

Usually, trials shall be done in empty and loaded condition initially using new wheel profile. To be repeated with worn wheel profile, as soon as available.

Unless otherwise required by the designer, the free end bogie of Metro coaches will be instrumented. The prototype will thus be the last vehicle in the formation of test special.

## 5.0 CRITERIA

5.1 Ride index, as per ORE C-116 using FFT method, shall not be greater than 3.00 in inflated and deflated condition in both vertical and lateral directions.
5.2 The values of acceleration recorded, as near as possible to the bogie pivot shall be limited to 0.27g, both in vertical and lateral directions, in inflated and deflated condition.
5.3 A general indication of stable running characteristics of the carriage as evidenced by the movement of the bogie on a straight and curved track, and by the acceleration readings and instantaneous wheel load variations/spring deflections.
5.4 The maximum dynamic wheel loading/unloading (ΔQ/Q) shall not be greater than 0.50.
*5.5 A derailment coefficient, if required as per Para 2.9, should be worked out in the form of ratio between the lateral force (Y) and the instantaneous wheel load (Q) continuously over a period of 1/20th second, the value Y/Q shall not exceed 1, if measured by a measuring wheel or any other suitable means.*

**Annexure – G1**

## METHODOLOGY FOR EMERGENGY BRAKING DISTANCE TRIALS

Emergency Braking trial is conducted on a new or modified design of rolling stock, which is proposed to be cleared for running on Metro track. The purpose of Emergency Braking trial is, to determine braking characteristics of test train, under load conditions with different modes of operations.

**1. Test Train formation and Runs :**

The test train shall consist of at least 1 unit/ consist having one prototype representative coach of each type. The trial runs shall be conducted at the maximum speed proposed for operation. The trial is conducted in different loading conditions with dry and wet condition of the rail.

**2. Instrumentation:**

Unless otherwise required by the design directorate, the free end bogie of the vehicle will be instrumented. The prototype will thus be the last vehicle, of each type, in the formation. The Test Vehicle will be instrumented by testing directorate as per the test scheme, if required by welding suitable plates at the required locations. The following Transducers may be used for the trial:

(1) Pressure Sensors.
(2) Temperature Sensors
(3) Optical Speed Sensors/ Wheel pick up device.
(4) GPS.
(5) Any other transducers required for the trial.

**3. Data Acquisition/ Analysis:**

Data is acquired by using a Digital data acquisition system, connected to the transducers provided on the prototype vehicle as given in para 2. Sampling rate used is 20 samples /sec. The following parameters are recorded/calculated for evaluation:

**STATIONARY TESTS**

Following parameters are to be found -

- Initial charging time
- BP charging time after complete draining of AR.
- Brake propagation rate during full service and emergency application
- Brake Application and Release characteristics different application mode.
- Any other test specified by design directorate in trial scheme.

CONDUCTING THE TEST

During stationary test, Continuous pressure records of the following air spaces are made on time basis during stationary tests-

| | |
|---|---|
| Driving Motor/TC | Brake Pipe (BP)<br>Brake Cylinder (BC)<br>Main Reservoir (MR)<br>Auxiliary Reservoir (AR) |
| DTC | Brake Pipe (BP)<br>Brake Cylinder (BC)<br>Auxiliary Reservoir (AR) |
| Driving Motor/TC | Brake Pipe (BP)<br>Brake Cylinder (BC)<br>Auxiliary Reservoir (AR) |

The pressure recordings are made with different positions of Driving Cab brake handle order to evaluate various brake characteristics detailed in the test scheme. Before commencement of the stationary test, the following checks / settings are made on the train –

- The brake pipe pressure is at as specified.
- The brake cylinder pressure of the locomotive is set to specified value when brakes are applied through drivers automatic brake handle
- The percentage operative cylinders during stationary test are kept 100%

INITIAL CHARGING OF MAIN RESERVOIR

Before start of the initial charging of main reservoir, the engine is shut down and the air reservoirs are completely drained out by opening the drain cocks. Time taken to charge the MR from zero to maximum pressure is noted with engine running at idle notch.

LEAKAGE RATE

After the pressure in MR and BP is stabilised at the maximum value, the lead /trial switch is turned to lead 'cut-out' position, for putting the pressure maintaining feature of automatic brake out of action to check the leakage in train line brake pipe. Continuous record of MR, BP and FP is taken for 5 minutes to get the leakage rate.

BRAKE APPLICATION

The brake pipe is charged to stabilize for 2 minutes. Using the Master controller handle in the driving Cab, brake is applied and continuous record of various parameters is done. Brake application time for 95% of BC pressure build-up, from the instant of brake application, is worked out to get the brake application time.

BRAKE RELEASE TIME

Release time is defined as the time interval between the driver puts his brake/Master controller handle in release position to the instant the brake cylinder pressure reduces to 0.4 kg/cm$^2$.

BRAKE APPLICATION FROM LAST VEHICLE AND SIMULATED TRAIN PARTING

The test train is charged for brake pipe pressure of up to designed value and allowed to stabilise for 2 minutes. Brake application is made from the Last Vehicle.. The train parting simulation is done by opening the angle cock from first, middle and rear Vehicle of the train and various parameters are recorded to get an idea of the extent of indication to the driver.

**RUNNING TESTS**

The following brakes are available on the train

- Emergency brakes (controlled by the Master Controller and the push Button)
- Parking Brake (Controlled by parking brake toggle switch)
- Pneumatic auto Train Brakes (Controlled by a switch)
- Regenerative/Rheostatic Brake and EP Brakes (Controlled by master controller through Electronic control.

Emergency Brake:

Under following emergency conditions data are also recorded

1. Through Anti wheel skid device
2. Through emergency stop push button
3. Through Auto Brake controller

4. Operation of Dead man device
5. Guard's direct emergency brake handle

CONDUCTING THE TEST

For measurement of braking distance, an Optical speed sensor/wheel revolution pick up device is mounted on one axle of the coach for measuring the distance travelled.

The speedometer fitted in the cab is used for guidance in regulating the train speed. The actual speed at the instant of brake application is, however, determined from that recorded by DAQ.

Suitable locations on level track, free from gradient and curve, are pre-selected. Emergency /full service brake application is made, from driver's automatic brake handle from the driving cab, followed by emergency brake application.

Before commencement of running test, the test train is examined and the following is ensured -

- The pressure setting of the brake pipe of the Driving cab is at design value.
- All audible leaks are arrested

**4. Facilities to be made available by Metro:**

The Metro shall make the following facility available for conducting of trial:

(i) Competent Crew for operating the Test Special.
(ii) Prototype test rake, made suitably fit for trial, for instrumentation and trial runs.
(iii) 220V AC Power supply on board the test special.
(iv) Facility for fixing/mounting for instrumentation, including Welding equipment and manpower, if required.
(v) Fitment of Speed sensor/wheel pick-up device on the vehicle.
(vi) Simulation of wet rail conditions during trial.
(vii) Tapping's for fitment of pressure sensors in the brake system as required.

Any other facility as required by the officer in-charge of the trial for the conduct of the trial.

NOTE: <u>This test procedure is only for general guidance. Nomenclature of various sub-assemblies may be different from those used in this document. Also there may be minor differences in brake systems on different Metros.</u>

**Annexure-G2**

**Parameters required for calculation of Emergency Braking Distance (EBD), Service Braking Distance (SBD) & controllability of Metro's**

1. Type of rolling sock and its composition.
2. Brake rigging diagram including tare & gross weight, brake power, rigging & cylinder efficiency, no. of brake cylinder, maximum brake cylinder pressure (Automatic & Independent) of individual rolling stock.
3. Coefficient of rolling resistance for individual rolling stock (Values of a, b & c in equation $a+bV+cV^2$ (Kg/T) where V is speed in kmph).
4. Type of brake system.
5. Time lag in brake application (Automatic & independent).
6. Emergency & service brake application time of individual rolling stock (Automatic). Also brake development time during independent application.
7. Brake development time in leading, first trailing car & last car in case of emergency and service application.
8. Type of brake rigging (Single shoe, clasp type, TBU or disc brake), brake block & brake block area.
9. Curve of coefficient of friction (Instantaneous & average).
10. Percentage of operative cylinders in train.
11. Speed of operation & amount of maximum down gradient
12. Dynamic brake effort curve for individual power car.
13. Maximum brake cylinder pressure during automatic (Emergency & service) & independent brake application for different type of cars.
14. No. of wheels in individual rolling stock & maximum allowable heat input (Kw) in wheels during controllability.
15. Maximum amount of BP pressure and drop in BP pressure during different stages of automatic brake application & maximum BC pressure corresponding to each stage of application.

**Annexure - H**

## METHODOLOGY FOR COUPLER FORCE TRIALS

Coupler Force trial is conducted on a new or modified design of rolling stock, which is proposed to be cleared for running on Metro track for sections having sustained up gradient steeper than 1 in 100. The purpose of Coupler Force to measure the coupler forces under different operating conditions of a train of newly designed coaches. This test is done to ensure that the coupler forces do not exceed the design limits under actual operating conditions.

The conduct of Coupler Force trial is, generally, guided by the trial scheme given by the Design Directorate.

1. **Test Train formation and Runs** :

   The test train shall consist of at least full train length, which is proposed to be run. The trial runs shall be conducted at the maximum speed proposed for operation. The trial is conducted in loaded conditions.

2. **Instrumentation**:

   Unless otherwise required by the design directorate, the coupler between the 1st and the 2nd vehicle will be instrumented. The prototype will thus be the last vehicle, of each type, in the formation. The following Transducers may be used for the trial:

   (1) Pre-calibrated strain gauged coupler
   (2) Strain gauges
   (3) Optical Speed Sensors/ Wheel pick up device.
   (4) GPS.
   (5) Any other transducers required for the trial.

3. **Data Acquisition/ Analysis**:

   Data is acquired by using a Digital data acquisition system, connected to the transducers provided on the prototype vehicle as given in para 2. Sampling rate used is 20 samples

   A pre-calibrated strain gauged coupler is fitted on the test vehicle between first and second coach and coupler forces and the speeds are recorded under the following operating conditions -

   - Starting of fully released train using maximum tractive effort followed by the alarm chain pulling from last coach after 15 seconds of start
   - Starting of fully released train using maximum tractive effort followed by guard's van valve application after 15 seconds of start

- Alarm chain pulling from last coach when the train is running at the maximum permissible speed

4. **Facilities to be made available by Metro**:

The Metro shall make the following facility available for conducting of trial:

(i) Competent Crew for operating the Test Special.
(ii) Prototype test rake, made suitably fit for trial, for instrumentation and trial runs.
(iii) 220V AC Power supply on board the test special.
(iv) Facility for fixing/mounting for instrumentation, including Welding equipment and manpower, if required.
(v) Fitment of speed sensor / wheel pick- up device on the vehicle.
(vi) A pre-calibrated strain gauged coupler, along with calibration certificate, as per test requirement.
(vii) Fitment of pre-calibrated strain gauged coupler in the test rake.
(viii) Any other facility as required by the officer in charge of the trial for the conduct of the trial.

NOTE: <u>This test procedure is only for general guidance. Nomenclature of various sub-assemblies may be different from those used in this document. Also, there may be minor differences in brake systems and other features related with coupler force trials on different Metros.</u>

**Annexure -I**

## METHODOLOGY FOR CONTROLLABILITY TRIALS

Controllability Trial is conducted on a new or modified design of rolling stock, which is proposed to be cleared for running on Metro track sections having sustained up gradient steeper than 1 in 100.

The purpose of Controllability Trial is, to determine the controllability of the train on gradient section and temperature increase of the wheel/brake block, under load conditions with different operating conditions.

The conduct of Controllability Trial is, generally, guided by the Test scheme given by the Design Directorate.

1. **Test Train formation and Runs** :
   The test train shall consist of full train length which is proposed to be run. The trial runs shall be conducted starting from the minimum speed up to the maximum speed proposed for operation and on the maximum gradient sections. The trial is conducted in maximum loading conditions with dry and wet condition of the rail.

2. **Instrumentation**:
   The Test Vehicle will be instrumented by Testing Directorate as per the test scheme. The following Transducers may be used for the trial:

   (1) Pressure Sensors.
   (2) Temperature Sensors
   (3) Optical Speed Sensors/ Wheel pick up device.
   (4) GPS.
   (5) Any other transducers required for the trial.

3. **Data Acquisition/ Analysis**:
   Data is acquired by using a Digital data acquisition system, connected to the transducers provided on the prototype vehicle as given in para 2. Sampling rate used is 20 samples. The following parameters are recorded/calculated for evaluation:

**STATIONARY TESTS as per Annexure H**

**RUNNING TESTS**

Following are to be determined -

- Braking distance on maximum gradient section on application of emergency brakes.
- Controlling of train with brake application and dynamic brakes within prescribed B.P. drop.

- Wheel/Brake disc and Brake block / brake disc temperature.
- Dynamic current of the driving current.
- Holding of train with Independent driving cab brakes.

CONDUCTING THE TEST

For measurement of braking distance, a Optical speed sensor/wheel revolution pick up device is mounted on one axle of the vehicle for measuring the distance travelled.

The speedometer fitted in the cab is used for guidance in regulating the train speed. The actual speed at the instant of brake application is, however, determined from that recorded by DAQ.

Independent driving cab brakes, are worked in conjunction with train brakes and Suitable locations on maximum gradient track are pre-selected. The brake block and disc temperatures are also recorded along with dynamic current in the driving cab. The wheel temperature and BP pressure drop should be within prescribed limits for safe operation.

The Emergency / full service brake application is made, from driver's automatic brake handle from the driving cab, followed by emergency brake application in conjunction with dynamic brake application. The EBD should be such that train running at maximum permissible speed can be stopped short of signal after sighting the stop signal. On stopping on the maximum gradient section, the holding test of the train with independent driving cab brakes, with train brakes in released position, shall be carried out. A number of such readings are taken, depending on the section length.

Before commencement of running test, the test train is examined and the following is ensured -

- The pressure setting of the brake pipe of the driving unit is at specified value.
- All audible leaks are arrested.

4. **Facilities to be made available by Metro**:

The Metro shall make the following facility available for conducting of trial:

i. Competent Crew for operating the Test Special.
ii. Prototype test rake, made suitably fit for trial, for instrumentation and trial runs.
iii. 220V AC Power supply on board the test special.
iv. Fitment of Speed sensor/wheel pick-up device on the vehicle.
v. Simulation of wet rail conditions during trial.
vi. Tapping's for fitment of pressure sensors in the brake system as required.

vii. Any other facility as required by the officer in charge of the trial for the conduct of the trial.

NOTE: This test procedure is only for general guidance. Nomenclature of various sub-assemblies may be different from those used in this document. Also there may be minor differences in brake systems on different Metros.

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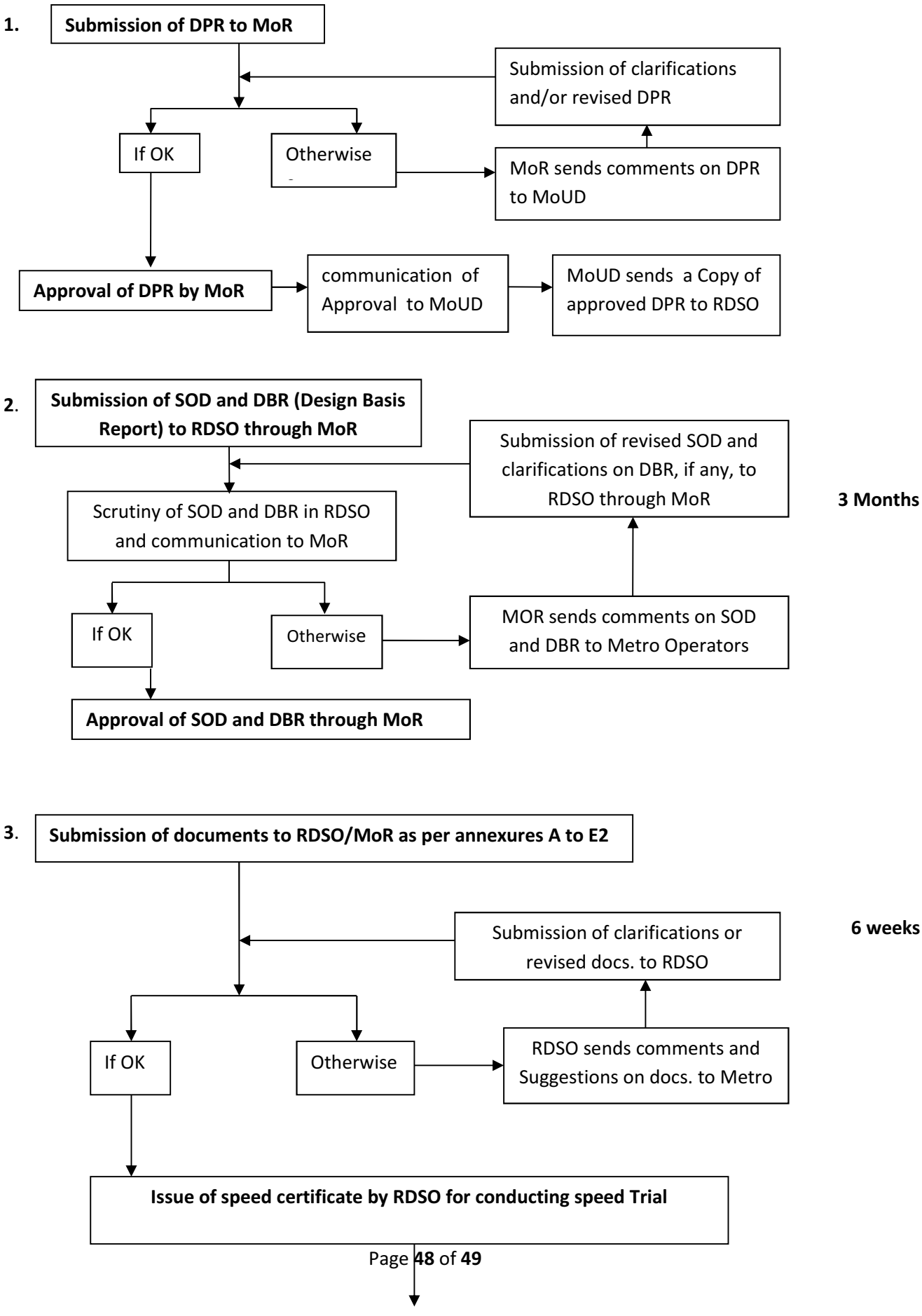
**FLOW CHART FOR METRO CERTIFICATION PROCEDURE**



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