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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Procedure for Safety Certification and Technical Clearance of Metro Systems

December 2015

Urban Transport & High Speed Directorate

RESEARCH DESIGNS & STANDARDS ORGANISATION

MANAK NAGAR, LUCKNOW – 226 011

Changes in present version (December 2015) of Procedure for Safety Certification and Technical Clearance of Metro Systems with respect to previous version of February 2015

S.N.	Modification in	Edited/Removed/Added
1	Ann C-1 Clause 3.2	Item (viii) added for gradients
2	Ann C-1 Clause 8.1	Para modified to cater for provisions for single track tunnel
3	Ann C-1 Clause 14	Para added for gradients
4	Ann C-2 Clause 4.1(ii)	Para modified
5	Ann C-2 Clause 4.7 Table 1	Table modified

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

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.

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 and salient feature of Track Structure adopted by Metro Railways **(Annexure C1)**

b) Compliance to Performance criteria of Fastening System for ballastless track on Metro Railways/MRTS and salient feature of Fastening System adopted by Metro Railway **(Annexure C2)**

5.4. **Traction Installation and Power Supply :** as per Annexure D1 and D2

5.5. **Bridges and Structures**

a. A copy of Design Basis Report (DBR) 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.

Notes:

i. A Model DBR has been prepared by RDSO/ MoR and same has been uploaded on RDSO website. Metros should refer it for preparing their DBR.

ii. RDSO has prepared guidelines for carrying out RSI studies and same has been uploaded on RDSO website. This may be referred for doing RSI studies.

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

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

6.1.1. **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

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

6.1.2. **Rolling Stock– Electrical**

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.

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

6.2. The following test certificates are required to be submitted to RDSO for record **before commissioning of the corridor**.

6.2.1. **Signal and Telecommunication:** Completion report of Integrated **Testing and Commissioning Tests** with their results for Signalling/Train Control Systems and Tele Communication Systems.

6.2.2. **Rolling Stock– Electrical:** EMC/EMI compatibility test report to be submitted before commissioning of the corridor.

7. OSCILLATION TRIALS AND ISSUE OF SPEED CERTIFICATEs

7.1. The following types of speed certificates are issued by RDSO.

i. Speed certificate for **conducting oscillation trials** of the rolling stock 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]

ii. 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]

iii. 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 trials 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]

iv. **Provisional speed certificate** for operation and regular use of new design of rolling stock without conduct of detailed oscillation trials. The provisional maximum permissible speed for new design of rolling stock will be determined on the basis of design features and data, and where appropriate also on a comparison of the performance of similar design of stock already in service, generally in line with Policy Circular no. 6 issued by Railway Board.

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

vi. **Final speed certificate** for operation and regular use of rolling stock at the maximum permissible speed based on norms set by Criteria Committee of RDSO (**Annexure F2**), after conduct of oscillation trials over rundown track with worn wheel profile, as soon as available, and with instrumented measuring wheel wherever required.

[Expected Time in issuing this certificate – two weeks]

7.2. Prior sanction of CRS for conducting trials

a) In cases where metro line is yet to be opened for public carriage of passengers, prior sanction of CRS will not be needed for conducting Oscillation, EBD, coupler forces and other such trials of coaches, mentioned in para 7.1 (I, ii and iii). After issue of speed certificate by RDSO for such trial, the concerned Metro will submit the documents already prescribed to RDSO.

b) However, prior sanction of CRS will continue to be mandatory for conducting all the trials mentioned in para 7.1 (i,ii and iii), where the Metro line has already been opened for public carriage of passengers and a new design of Rolling Stock is to be tested or where speed of an existing rolling stock is to be increased. Requisite papers and certificates will need to be submitted by concerned Metros to CRS for this purpose.

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

7.4. 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, if necessary in terms of Para 7.2
vii. An Indemnity Bond by the concerned Metro administration indemnifying RDSO / Indian Railways for damages if any, caused by any accidents/casualties during such trials.
viii. Any other certificate required as per CRS sanction, if necessary in terms of Para 7.2

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

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, if necessary in terms of Para 7.2
e. An Indemnity Bond by the concerned Metro administration indemnifying RDSO / Indian Railways for damages if any, caused by any accidents/casualties during such trials.
f. Any other certificate required as per CRS sanction, if necessary in terms of Para 7.2

Apart from above, details indicated in annexures G1 and G2 for **Emergency /Service Braking Distance trials**, in annexure H for **Coupler Force trial** and in annexure I for **Controllability trial**, following documents will also be required:

7.6. 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.]

7.7. For issuing of Provisional / Interim Speed Certificate, following shall be required:

i. Approved Schedule of dimensions (SOD) and condonation letter from Railway Board for infringements/deviations, if any, from approved Schedule of dimensions (SOD).
ii. Approval of Track Structure and Fastening System as per Annexure C1 & C2 and condonation letter from Railway Board for deviations, if any, from approved Track Structure and Fastening System
iii. Approved Design Basis Report.
iv. In principal approval of Traction System as per Annexure –D1/D2
v. Complete design details pertaining to vehicle dynamics along with drawings of the rolling stock – As per Annexure A & B
vi. 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.)

7.8. After receiving speed certificate for passenger carrying rolling stock, Metro administration shall apply for sanction for the same to the Railway Board /MoR through Commissioner of Railway Safety of the Circle in whose jurisdiction the Metro falls, as per the provision stipulated in "Opening of Metro Railway for Public Carriage of Passenger Rules, 2013" with latest amendment.

7.9. For existing rolling stocks, where there is a case of design modification or speed enhancement, as defined in "Opening of Metro Railway for Public Carriage of Passenger Rules, 2013", with latest amendment, the same procedure, as described above, shall be followed.

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 as under:

i) By Metro through approval of concerned CRS to Railway Board in case of fixed installations.

ii) By Metro through RDSO and CCRS in case of infringements to SOD by Rolling Stock.

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

Part-A: Technical Standards of Track Structure for Metro Railways/MRTS (Compliance to be given)

1. Scope:

To stipulate the desirable technical standards /specifications for track structure for Metro Railways/ MRTS Systems 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 Rail Seat inclination (slope): 1 in 20
2.3 Speed potential – 110 kmph (max.)
2.4 Static axle load –20 T (max.)
2.5 Design rail temperature range – (-)10 degree Celsius to (+) 70 degree Celsius
2.6 Maximum Curvature and ruling gradient - As specified in SOD

3. Track Structure:

3.1 General: The track structure should fulfil the following requirements:

3.1.1 The track structure should conform to/ satisfy Schedule of Dimension requirement and other maintenance instructions of Metro systems.

3.1.2 Ride comfort and running safety of track vehicle dynamics should be satisfied.

3.1.3 The track structure should be designed with Long welded / Continuously welded rail on main line track in case of ballasted as well as ballastless track.

3.1.4 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.

3.1.5 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 including its transition shall not be located at stations within the length of platform. A vertical curve within the length of transition and Turnouts is also not desirable. Vertical curve radius is constrained by the need to limit the vertical acceleration for passenger ride comfort.

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

(i) Rail and Welding
(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) Switch Expansion Joints
(viii) Gradients

4. Rails and Rail Welding:

4.1 Rails:

4.1.1 For Main line Track:

4.1.1.1 The rail used on main line on curves and approaches of Stations shall be 60E1 (UIC 60), 1080 grade Head Hardened.

4.1.1.2 At other locations on straight line of main line, the use of 60E1 (UIC 60), 1080 grade HH / 60E1 (UIC 60), 880 grade rail 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.

4.1.1.3 It is essential to have preventive rail grinding arrangements in case 60E1 (UIC 60), 1080 HH rails are used.

4.1.2 For Depot lines:

The rail used on depot lines can be non- head hardened and shall be 60E1 (UIC 60), 880 grade.

4.1.3 Specification:

4.1.3.1 The rail shall be class 'A' rails as per IRS-T-12-2009 specification with latest amendments. However, any suitable length of rail more than 13 m considered appropriate by metro on consideration of transportation and handling can be adopted, provided the rails are ultimately welded into long welded rails.

4.1.3.2 The rail 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. Metro railways will ensure that the inspection and test plan approved by them strictly conforms to the requirement of IRS specifications.

4.2 Welding of rail:

4.2.1 The welding of rails should conform to Indian Railway specifications and technical instructions issued from time to time.

4.2.2 The present instructions are contained in following documents:

4.2.2.1 Alumino Thermit Welding:

(i) Indian Railway Standard specifications for Alumino Thermit Welding of Rails (IRS/T-19 with latest amendments)

(ii) Manual For Fusion Welding Of Rails By The Alumino-Thermic Process : Revised-2012 with latest amendments

4.2.2.2 Flash Butt Welding:

Manual for Flash Butt Welding of Rails, January 2012 with latest amendments.

4.2.2.3 Special attention is required by metros for provisions of these instructions regarding procurement, execution of works and areas requiring prior approval/ standardisation by RDSO.

4.3 Ultrasonic Testing of Rail and Welds:

The rails and welds shall be ultrasonically tested in field as per requirement of concerned specification/ manual/ instructions. The testing shall be ensured as per provisions of "Manual for Ultrasonic Testing of Rail and Welds- Revised 2012" with latest amendments. The provisions of "IRS specification for Ultrasonic testing of Rails/Welds (Provisional), Revised-2012" shall also be followed.

5. Sleeper and fastening for Ballasted track

5.1 Sleepers:

5.1.1 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).

5.1.2 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 Metro.

5.2 Fastening system:

The elastic fastening system prevalent on Indian Railways shall be used duly ensuring the Inspection protocol for fastening components laid down for IR.

In case of use of elastic fastening other than in use on IR, prior approval shall be obtained from Railways.

6. Track slab for Ballastless track

6.1 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.

6.2 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) Have adequate edge distance of concrete beyond the anchor bolts to provide resistance against edge failure
iii) Provide a level base for uniform transmission of track/rail forces.
iv) Have geometrical accuracy and enable installation of track to the tolerances laid down.
v) Ensure drainage.
vi) Resist weathering.
vii) 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.
viii) Ensure provision for electrical continuity between consecutive plinths/slabs by an appropriate design.

ix) Plinth beam or slab of ballastless track should be suitable for embankment or viaduct or tunnel/Underground structure.
x) Proper design of expansion joints suitable for joints of viaduct structure.
xi) Design should be suitable for curves as per SOD of Metro system.
xii) Design of subgrade/embankment for slab should be furnished to ensure durability and functional stability in service.
xiii) 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 as approved by metro authorities shall be furnished for record.

7. Check Rail / Restraining Rail:

7.1 Check rails/ Restraining Rails should be provided on curves on main line where radius is 218m or less on Broad gauge and radius is 190m or less on Standard gauge. The clearance of check rail/ restraining rails shall be suitably decided after requisite studies. The detailed design calculations/ studies in this regard shall be furnished for record.

7.2 Check rails/ Restraining Rails shall not be mandatory for curves in depots, yards and non-passenger lines where speed is not more than 25 kmph. However decision in this regards may be taken by Metro themselves based on layout and maintenance requirement.

8. Derailment Guards

8.1 The derailment guard should be provided inside/outside of running rail on viaduct as well as in tunnel having multiple tracks and at grade section locations specified by the Metro railway. For single track tunnel, location for providing derailment guard is given in note. In tunnels, the derailment guard should preferably be provided inside the track, so that it permits less sway of coach towards tunnel wall in case of derailment.

NOTE:

Location for providing Derailment Guard in single track tunnel

1. Entry of tunnel: 200 m from tunnel portal outside the tunnel to 50 m inside the tunnel.
2. Exit of tunnel: 50 m from inside of tunnel portal to 200 m outside the tunnel.
3. In curved track having radius 500 m or less including transition portion but excluding locations where check rail is provided.
4. Covering locations of all important installations e.g. Location of any sub-station or hazardous structures inside the tunnel, etc damage to which in the assessment of metro rail administration can result into serious loss of life or/and infrastructure as a result of derailment in tunnel.

The above is subject to the condition that metro railway shall carry out the risk assessment analysis for derailment in tunnels and ensure that the maintenance practices in the maintenance manual are as per the risk assessment mitigation plan.

8.2 The lateral clearance between the running rail and the derailment guard shall be 210 ±30 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.

8.3 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.

The detailed design calculations of derailment guards along with detailed structural drawings shall be furnished for record.

9. Glued Insulated Rail joint

9.1 Normally glued joint should be avoided.

9.2 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 Standards of Turnout:

10.1.1 Main lines:

On main lines, the turnouts and diamond crossing shall be of the following standards:

(i) Standard Gauge

a) 1 in 9 type or flatter turnout (desirable)
b) 1 in 7 type turnout (minimum)
c) Scissors cross-over of 1 in 9 / 1 in 7 type consisting of 4 turnouts and 1 diamond crossing

(ii) 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

10.1.2 Depots and Non running lines:

On depot and other non-running lines, the turnouts and diamond crossing shall be of the following standards:

(i) Standard Gauge

a) 1 in 7 type or flatter turnout
b) Scissors crossover 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

(ii) 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

10.1.3 If any Metro railway decides to use sharper angle layout, they should establish the adequacy of the speed potential of the turnout for the purpose for which it is used and the negotiability of the turn out by the rolling stock with a safety margin.

10.1.4 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 as that of main line towards 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 centres not infringing SOD.

10.2 Type and geometry of turnout

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

(a) Standard Gauge

(i) 1 in 9 turnout:

The design shall be tangential with a switch angle not exceeding 0°20’00’’. It is desirable that the radius of lead rail of turnout is not less than 300m. Lead curve of 190 m radius may be laid as an exception. All clearances shall be in accordance with relevant provisions of SOD.

(ii) 1 in 7 turnout:

The design shall be tangential with a switch angle not exceeding 0°20’00’’. It is desirable that the radius of lead rail of turnout is not less than 190m. Lead curve of 140 m radius may be laid as an exception. 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.

(b) 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 main line. Switches and crossings shall not be located on transition curves or vertical curves.

10.3.1 Speed: The turnout shall be designed for the speed on mainline side equal to the speed as on mainline track. The minimum speed potential of the various turnouts and scissors crossover on the Turnout side should be as follows:

10.3.1.1 Standard Gauge

(i) 1 in 9 type turnout with 300 m radius (speed potential of 45Kmph)

(ii) 1 in 7 / 1 in 9 type turnout with 190 m radius (speed potential of 35Kmph)

(iii) 1 in 7 type turnout with 140 m radius (speed potential of 25 Kmph)

(iv) Scissors crossover 1 in 9 type with 300 m radius (speed potential of 45 Kmph)

(v) Scissors crossover 1 in 9/1 in 7 type with 190 m radius(speed potential of 35Kmph)

(vi) Scissors crossover 1 in 7 type with 140 m radius(speed potential of 25 Kmph)

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

10.3.1.2 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 signalling 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. However, rails used in turnouts on depot and other non-running lines may be of 880 grade.
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) /60E1A4 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.
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 500 mm. The forged 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 (with radius of 300 mts) and flatter turnouts shall be provided with second drive or other suitable arrangement to ensure minimum gap of 60mm at JOH as well as proper housing of switch rail with stock rail up to JoH. 1 in 8.5, 1 in 9 turnout (with radius of 190m) and 1 in 7 and sharper turnouts may not be provided with second drive arrangement, however minimum gap of 60mm at JOH as well as proper housing of switch rail with stock rail up to JoH should be ensured. The normal opening of switch at toe of switch shall be kept as 160mm.
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 signalling 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 on main line 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 signalling 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 signalling 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 as that of main line for the Metro system. Rail seat pads and rail clip etc shall be designed to provide a minimum service life of 15 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 Design Requirements for PSC Sleepers:

(A) The sleepers should satisfy the following design requirement:

Design Parameters

(i) Rail sleeper fastening – Elastic resilient type
(ii) Spacing of sleepers – 600mm (max) for main line and 650 mm (max) for Depots and other non-running lines, 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 suitable cant of the rail, as provided on mainline, (excluding crossing and switch 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.

(iv) The detailed design of Monoblock PSC sleepers for the turnouts along with structural drawings shall be checked and approved by metro railways.

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.

12. Fastening system for ballastless track:

Provisions contained separately in "PERFORMANCE CRITERIA OF FASTENING SYSTEM FOR BALLASTLESS TRACK ON METRO RAILWAYS/MRTS SYSTEM" (Annexure C-2) be referred to.

13. 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.

14. GRADIENTS

14.1 The maximum grade (compensated) shall be 4%.

Note:

(i) There will be no change of gradient in transition portion of curves.
(ii) The gradient will be compensated for curvature at the rate of 0.04% per degree of curve.

14.2 Maximum permissible gradient on turnouts

(i) On Ballasted Track 0.25%
(ii) On Ballastless Track 2.5%

Note :

(i) There shall be no change of grade on and within 15m of any turnout on ballastless track. Similarly, there shall be no change of grade on and within 30 meters of any turnout on ballasted track.
(ii) In case of turnouts on gradient, there shall be no horizontal curve on and within 15 meters of any turnout on ballastless track and 30 meters of any turnout on ballasted track.

14.3 TRACK GRADIENT IN PLATFORM

(a) Maximum 1 in 400
(b) Desirable Level

Note: There shall be no change of gradient in platform track.

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Part-B: Salient features of Track Structure as adopted by Metro

i) Track

s.no.	Components / Items	Provisions / Reference
1.	Gauge	
2.	Axle Load	
3.	Design Speed	
4.	Rail Section and Grade	
5.	Rail Specifications	
6.	Ballasted or Ballastless	
7.	Rail inclination (Canting of Track)	
8.	Check Rails provision	
9.	Provision of Derailment upstand/Gaurd	
10.	Horizontal Clearance of Derailment upstand	
11.	Vertical location of Derailment upstand w.r.t. Rail plane	
12.	Glued insulated Rail Joint provided? If Yes , type of GIRL	
13	Welding Of Rail (LWR /CWR)	
14	Whether SEJ provided? If Yes Type of SEJ	
15	Type of welding	

ii) Turnouts and switches:

S.N.	Components / Items	1	2	3	4
1	Type of turnout , scissors crossovers (crossing angle)				
2	Canted or uncanted				
3	Radius				
4	Length of switch				
5	Type of Switch (Thick web or otherwise)				
6	Switch entry angle				
7	Speed potential				
8	Location of Use (Main line or Depot)				
9	Rail Section used for switch				
10	Second drive provided				

iii) Crossing:

	Components / Items	Provisions / Reference
1.	Crossing: Curved or Straight	
2.	Crossing: Canted or uncanted	
3.	Length of Weldable length extension	
4.	Check Rail section	
5.	Height of Check rail above the rail plane	
6.	Check Rail clearance at the middle	
7.	Check Rail clearance at the end	

Part-C: Check List of submissions while submitting compliance:

1	Compliance of Part-A	
2	Design of subgrade/embankment for slab (Para 6.xii)	
3	Design calculations of track slab /plinth beam along with detailed structural drawings as approved by metro authorities. (Para 6)	
4	Design calculations/ studies with regard to clearance of Check rails/ Restraining Rails. (Para 7.1)	
5	Design calculations of derailment guards along with detailed structural drawings shall be furnished for record. (Para 8)	

Annexure-C2

Part-A: Performance criteria of fastening system for ballastless track on Metro Railways/MRTS system (Compliance to be given)

1. Purpose and Selection:

1.1 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.

1.2 A new fastening system, which is fully compliant to performance criteria and not approved by MoR can also be used by Metro Railways/MRTS system as they are free to choose fastening systems for ballastless track complying with this performance criterion. The detail of such fastening system used shall be submitted to MoR and the same shall be kept in observation by MoR for a period of 2 years under service conditions in association of Metro Railways/MRTS system. The Performa for the monitoring performance shall be advised by MoR to concerned Metros Railways/MRTS system. After successful performance for 2 years, Metro Railways/MRTS system shall process for approval of MoR for further use of fastening system.

1.3 The fastening system already approved by MOR as per previous performance criteria for ballastless track dated 21.5.2010 will not require fresh clearance as per this revised criteria and any of these systems can be used by Metro/ MRTS systems.

1.4 In case Metros Railways/MRTS system opts for a new fastening system for ballastless track which is not fully compliant to these performance criteria, they will approach MoR for approval before finalizing the use of fastening system.

2. Operating Environment:

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

2.1 Gauge –Broad Gauge, 1676/1673mm (nominal) and standard gauge – 1435mm
2.2 Speed potential – 110 kmph(max.)
2.3 Rail section - 60kg(UIC)/60E1, 90 UTS/110 UTS
2.4 Static axle load – BG & SG – 20t(Max)
2.5 Design rail temperature range – 10 degree Celsius to +70 degree Celsius
2.6 Curvature and gradient will be specified in SOD.
2.7 Rail seat inclination (slope) – 1 in 20

In addition, the client Railway may specify any other operating condition such as support spacing etc.

3. Ballastless Track Structure:

Track shall be laid on cast in situ/pre-cast reinforced plinth or slab, herein after referred to as the 'track slab'. The track slab shall be designed as plinth beam or slab type ballastless

track structure with derailment guards. The track slab dimensions and the clearance between rail and derailment guard shall be sufficient to accommodate the base plates of the fastening system and to facilitate easy and convenient replacement of the fastening system. The clearance between rail and derailment guard shall be within the range provided in Annexure-C-1.

In general, track slab on which the fastening and rails are to be fitted shall:

i) Resist the track forces.
ii) Have adequate edge distance of concrete beyond the anchor bolts to provide resistance against edge failure.
iii) Provide a level base for uniform transmission of rail forces.
iv) Have geometrical accuracy and enable installation of track to the tolerances laid down.
v) Ensure adequate drainage
vi) Resist weathering
vii) Be construction friendly, maintainable and quickly repairable in the event of a derailment. The 'Repair and Maintenance methods' shall be detailed in the 'Track Maintenance Manual' to be prepared and made available before the line or a portion of a line is opened for traffic .
viii) Ensure provision for electrical continuity between consecutive plinths/slabs by an appropriate design.

4. Performance Requirement of Fastening System:

4.1 General

i) The fastening system 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 (including thermal forces) and vibrations.

ii) The fastening shall be with a proven track record. The fastening system should have satisfactory performance record of minimum three years in service in regular revenue operation on ballastless track on any two different established railway systems (except exclusive freight tracks) for a length of at least 5km in each metro having speed potential of at least 80 kmph & design axle load 16T irrespective of wheel profile and rail section. In this regard, supplier should submit certificate of performance from user railways administration including proof of use of the fastening system. The supplier has also to submit a certificate that the components of fastening assembly are having same material and specification in case the proven system is having different rail section and wheel profile along with details of test results as per test plan of Table 1.

Note: For any metro system having design axle load <16T, the above criteria shall be applicable for the axle load for which the metro system is designed."

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,& 4.6.

4.2 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 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 10m from salt water source.
   c) Contact with oil, grease or distillate dropped from track vehicles.

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

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

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

Sl	Parameter	Installation (mm)	Maintenance (mm)
1	Gauge	+2,-1	+4,-2
2	XL on straight track	±1.5	±5
3	SE on curved track	±1.5	±3
4	Vertical alignment over 20m chord	±3	±6
5	Lateral alignment over 20m chord on straight track	±2	±6
6	On curves-variation over the theoretical versine on 20m chord	±2	±5

4.3 Anchor bolts/studs used for fixing the bearing plate in concrete shall have splayed ends. Detailed calculations for the number of anchor bolts required on tangent and curved tracks shall be furnished by the supplier and approved by the Metro system

4.4 For all the fastening components as per approved assembly, the supplier shall furnish detail drawings, specifications and inspection& test plan to the Metros. Metros to ensure that components are supplied as per drawings & specifications..

4.5 The supplier should furnish the 'Installation and Maintenance Manual' which shall be approved by the Metro system.

4.6 Any change in component subsequent to the approval of the fastening system by MoR shall be permitted only for specific requirement of the metro. MoR approval of such changes shall be processed by metro with specific recommendations enclosing test report of the component / whole assembly with detailed justification.

4.7 The rail fastening system shall be tested to the following specifications (Table 1) for different technical parameters and should meet the acceptance criteria as mentioned in the following table. Test report of the reputed independent institute / laboratory will have to be submitted. The testing is to be done for Cat B as specified in EN-13481-Part-I 2012 & EN-13481-5 :2012 with rail section to be used in proposed system if other design particulars are meeting the requirement of Cat –B.

Table-1

Test Plan for Fastening system (bonded & non bonded) for Ballastless Track

(As per provisions of latest EN 13481-1:2012 & EN 13481-5:2012)

S.N.	Technical Parameters	Test Method	Acceptance criteria	Remarks
1	Longitudinal rail restraint	EN-13146-1-2012	7kN (min)	This has to be tested before repeated load test
2	Vertical static stiffness of complete fastening assembly	EN-13146-4-2012	35 kN/mm (max)	No sliding, yield or cracking is allowed for the fastener parts.
3	Dynamic/static stiffness ratio	EN 13481-5-2012	1.4 (max)	Ratio is calculated by dividing the dynamic stiffness to static vertical stiffness.
4	Clamping force	EN-13146-7-2012	18kN (min) Perrail seat	This has to be tested before repeated load test
5	Electrical resistance	EN-13146-5-2012	5kΩ (min)	Higher value may be specified if required by Metros for track circuit
6	Effect of severe environmental conditions	EN-13146-6-2012	The fastening assembly shall be capable of being dismantled, without failure of any component & reassembled using manual tools provided for this purpose after exposure to the salt spray test.	-
7	Effect of repeated loading	EN-13146-4- 2012	No wear or deformation	-
7A	On Vertical static stiffness	EN-13146-4- 2012	Variation ≤ 25% of the initial value	No sign of bond failure/ fracture/slippage
7B	On Longitudinal rail restraint	EN-13146-1- 2012	Variation ≤ 20% of the initial value	Except the rail and fastener, no sliding, yield or cracking is allowed for fastener

S.N.	Technical Parameters	Test Method	Acceptance criteria	Remarks
				parts. Longitudinal load/ deformation curve shall fall in the envelope of upper and lower limit which is to be submitted along with the report.
7C	On Clamping force	EN-13146-7-2012	Variation ≤ 20% of the initial value	-

Part-B: Salient features of Fastening System

S.N.	Components / Items	Provisions in Metro
1.	Brief description of fastening system	
2	Axle load	
3	Speed potential	
4	Drawing and their numbers	
5	Specifications and their numbers	
6	Any variation for straight and curve portion? If yes, give detail	
7	Vertical stiffness of complete fastening system	
8	Service life of fastening system.	
9	Reference of Railway Board's approval for proposed fastening system.	

Part-C: Check List of submissions:

1	Compliance of Part - A	
2	Sets of drawings (two numbers)	
3	Performance record of fastening system	
4	Test report of fastening system.	

ANNEXURE-D-1

Documents required for record for traction (OHE) and Power Supply System at appropriate stage.

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

   General arrangement Drawing pertaining to the followings:

   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) Turnouts & 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 Pantographs & Panto pressures.

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

   a) Typical Drawing of OHE at Support i.e. at Mast, Portal etc.
   b) Earthing Drawings for Viaduct/Tunnel (Typical).
   c) Earthing Design for Receiving/Auxiliary Sub-stations (RSS & ASS) (Typical).
   d) Typical Drawing of Cantilever Arrangement for Single Bracket, Multiple Bracket and Fittings.
   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. Specifications showing Electro-mechanical characteristics can be submitted once for every Project).
   f) Conceptual Drawing 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 Electromagnetic Interference current including the effect of Booster Transformer and Return Conductors.
   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 followings:

   a) EIG application with following:
      i. Details of Power Drawl from the Power Grid.
      ii. General Arrangement Details of Sub-stations
      iii. Protection Philosophy and relay setting calculations.
      iv. Earthing Arrangement for the Power Supply Installations (Traction/ Non-Traction Power Transformer, Switching Posts).
      v. Equipment details.
   b) Power Supply Simulation with Electric Loads for peak traffic and under extended feed conditions.
   c) Sizing of Transformers, Conductors, Bus-bars, Instrument Transformers.
   d) Details of Insulating Oils along with their class and technical details.
   e) References for proven-ness 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 cancellation of Permit to Work.

8. Submission of test Certificates of Equipments:-
   a) Type Test of Insulators,
   b) Type Test of Contact & Catenary Wire,
   c) Type test of Booster Transformer, if any.
   d) Type Test of Traction Transformer,
   e) Type Test of Protection Relays,

ANNEXURE-D-2

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 arrangement 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 followings:

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 records 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 proven-ness 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.

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 CBI, 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 equipment 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:

i. 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.
ii. 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.
iii. ** "Independent Safety Assessors (ISAs):
   a) After RDSO notifies a panel of approved ISAs, Metro Rail authorities shall select an ISA from the approved panel for their Metro systems.
   b) Till such time RDSO forms the panel of approved ISAs, Metro Railways shall submit the credentials of ISAs identified /appointed by them to RDSO for scrutiny."

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.*
Note: 1. Safety certifications shall be done on the basis of tests at SN- 1 to 5 *and 9*, other tests are for investigation purposes only. **2.** <u>As per decision by Inter-Ministerial Committee item no. 9 is to be reviewed by the Criteria Committee of RDSO</u>		

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, 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

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:

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

b) Curves sharper than that available in the section covered during an earlier trial or a curve of 2^{o} of about 700-800 m length, if the earlier trial had been conducted on less than this length.

c) Turnout or crossover, if the earlier trial had been conducted without it or with a flatter one.

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

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

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

c) A station yard having turnout or crossover, if available, in which case the trial shall be done on the sharpest 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:

(i) Body level vertical Accelerations
(ii) Body level lateral Accelerations
(iii) Primary suspension spring deflections

(iv) Secondary suspension spring deflections
(v) Lateral forces
(vi) Bolster swing, as applicable
(vii) Bogie rotation, as applicable
(viii) Lateral accelerations at bogie frame.
(ix) In case, the section is having a curve sharper than 190m radius, lateral force at rail-wheel contact point shall also be measured with measuring wheel, to be provided by Metro, to calculate the derailment coefficient for 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 5.0, 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.*

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) Brake Cylinder (BC) Main Reservoir (MR) Auxiliary Reservoir (AR)
DTC	Brake Pipe (BP) Brake Cylinder (BC) Auxiliary Reservoir (AR)
Driving Motor/TC	Brake Pipe (BP) Brake Cylinder (BC) 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/cm².

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.

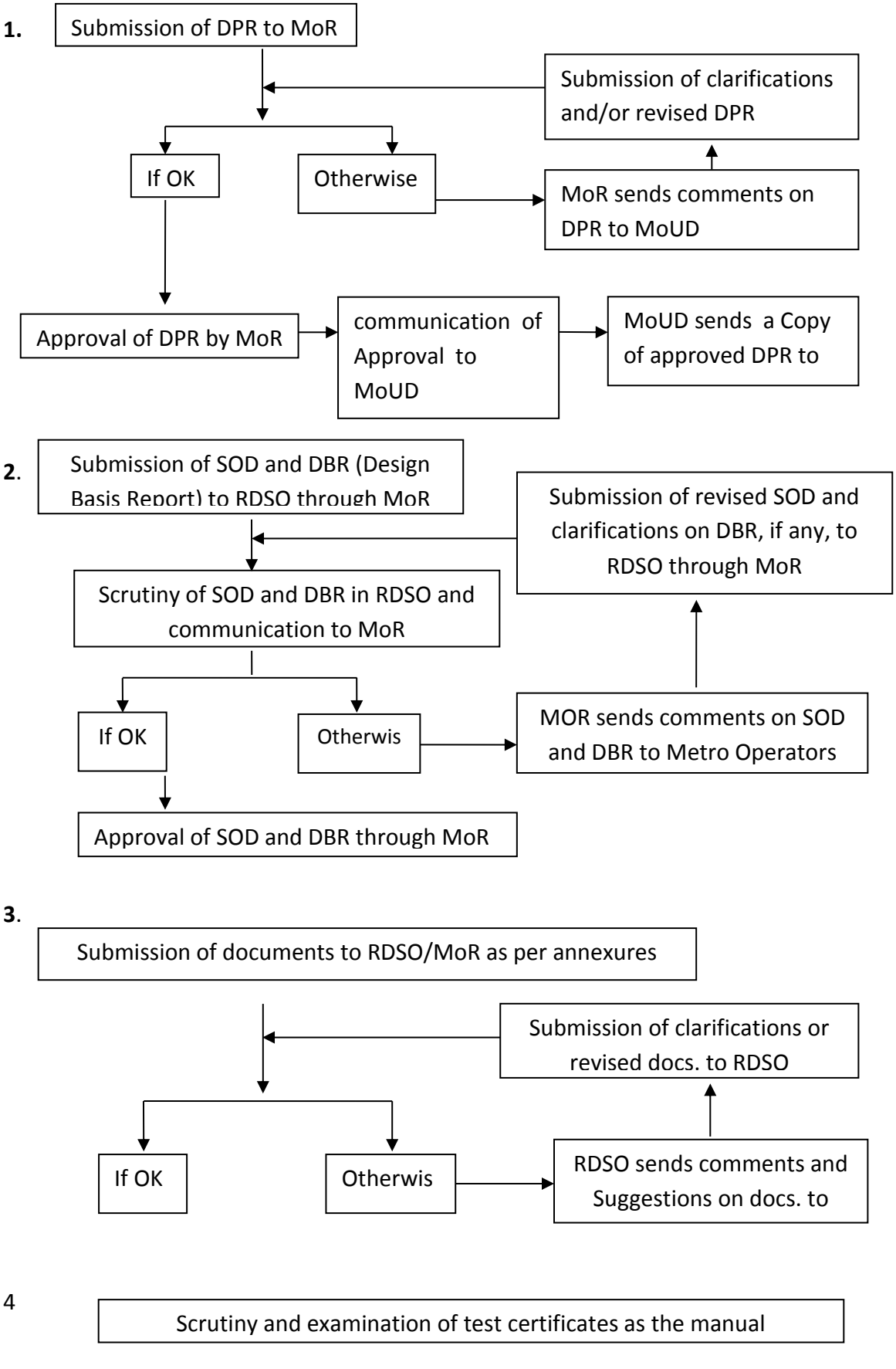
4. **Facilities to be made available by Metro**:

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.

FLOW CHART FOR METRO CERTIFICATION PROCEDURE



5

Issue of speed certificate by RDSO for conducting speed Trial

If Metro line already opened for Public Carriage of Passengers

If Metro line yet to be opened for Public Carriage of

Metro applies to CRS /CMRS for sanction for conducting oscillation trial

Sanction of CRS /CMRS for conducting oscillation trial

6.

RDSO conducts oscillation & EBD trials

RDSO conducts coupler force, controllability and/or any other special test, if required

RDSO issues interim speed certificate for regular use of rolling stock

Metro applies for sanction of Rolling Stock to MoR through CRS

Sanction of MoR /Railway Board of Rolling stock

Action to be taken by the Metro Administration for Opening of Metro, as per “Opening of Metro Railway for Public Carriage of Passenger Rules, 2013” with latest amendment.