

Doc. No. UTHS/Safety Criteria /Metro/2022	Annexure – F2 Criteria for Oscillation Trial of Metro Rolling Stock	Effective from: May, 2022
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Criteria for Oscillation Trial of Metro Rolling Stock (Rev-3, May, 2022)

Amendment History:

S. No.	Amendment/ Revision No.	DD/MM/YYYY	Reason for Amendment/Revision
1.	Nil	February, 2013	To form the Procedure for Safety Certification and Technical Clearance of Metro Systems, as per the requirement of Metro Act-2009
2.	Rev.1	31.10.2016	Sectional detail elaborated and the curves divided into four groups.
3.	Rev.2	15.12. 2020	The DMRC as reported RDSO that even after 10 (ten) years of operation the Rail wear is very less therefore to review the criteria for selection of track & wheel as worn rail and worn wheel conditions are not expected to be achieved even upto 25 years.
4.	Rev.3	May, 2022	Inclusion of additional Criteria for Metro Departmental/Maintenance Rolling Stock.

Research Designs and Standards Organisation
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BACKGROUND:

Newly designed Rolling Stocks are required to meet certain test criteria before the Metro Rolling Stock can be introduced in Metro Rail Network over Indian Territory.

Standing Criteria Committee of Metro Rolling Stock is consisting of following officials:

S. NO.	DESIGNATION	ROLE
1.	ED/UTHS/CO	CONVENOR
2.	ED/TESTING	MEMBER
3.	ED/MOTIVE POWER	MEMBER
4.	ED/CARRIAGE	MEMBER
5.	ED/TRACK DESIGN -I	MEMBER
6.	ED/B&S	MEMBER

1. NECESSITY OF OSCILLATION TRIALS OF ROLLING STOCK:

Oscillation Trials are to be done for:-

- a) Establishing that the Metro Rolling Stock is Safe to run at the desired speed
- b) Checking the Stability of Metro Rolling Stock at the desired speed (Derailment co-efficient & Off-loading)
- c) Checking Oscillation Behaviour of the Metro Rolling Stock at desired speed
- d) Checking the Riding Comfort of the passengers for the Metro Rolling Stock at desired speed.

2. SELECTION OF TEST TRACK

2.1 For Metro Rolling Stock, on the Metro Systems, the requisite Detailed Oscillation Trials shall be done over a minimum length of 5 kms consisting of the following test zones:

- i. The longest possible stretches of track consisting of straight (tangent) and such curves, where trial can be done at a speed 10% higher than the proposed maximum operating speed (with the Cd 110% of maximum Cd permitted) to obtain maximum number of readings in one run.
- ii. A combination of at least one curve each, if available in the proposed stretch, each curve of longest available length (preferably of length more than 120m) of the following groups of curves at speeds simulating 80%, 100% and 110% cant deficiency. In case, due to operation / other reasons, design speed of a particular curve is not achieved on any range of curves, the clearance of Metro Rolling Stock shall be decided on the basis of performance on other curves in the same range, or in the next sharper range, traversed by the trial train.

Classification of curves in the section:

Sub-clause No.	Description	Range of Radii
ii (a)	Large radius curves	(300m<R≤600m)
ii (b)	Medium radius curves	(190m<R≤300m)
ii (c)	Small radius curves	(150m<R≤190m)
ii (d)	Sharp Curves of radius	(120m<R≤150m)

- iii. A station / location having facing / trailing points if it exists in main line.
- 2.2 For a Metro Rolling Stock, the Detailed Oscillation Trials shall be done over any new section (s) that is subsequently added to the system, if the new section includes features stipulated at 2.1 (ii) and (iii) above, and earlier trial has not been conducted at any such location.
- 2.3 After completion of the Detailed Oscillation Trials over the nominated test zones, a long confirmatory test run shall be done at maximum test speed at which the Metro Rolling Stock has met the criteria. The long confirmatory test run shall be done at the maximum test speed to obtain minimum 10 readings over the stretches of minimum 200m each. If it is not possible in one run, then the readings may be obtained by repeated runs over the same section.
- 2.4 Once the performance of the Metro Rolling Stock has been assessed on the selected test track as described in para 2.1 and para 2.2 above, assessment of stability/riding of the Metro Rolling Stock on each individual curve is not needed and speed on curves should be determined based on radius, cant and cant deficiency etc. subject to such determined speed not exceeding the maximum permissible speed on tangent track.
- 2.5 Initial trial shall be done on the new track with new wheel profile for issue of interim speed certificate (ISC).
- 2.6 For introduction of new stock over existing section, trial shall be done as stipulated in 2.1, 2.3, 2.4 and 2.5 above and if applicable, as per 2.2 also.

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3. **PARAMETERS TO BE MEASURED**

As a part of the Oscillation trials, the following parameters shall be measured and recorded:

Cl. No.	Passenger Carrying Rolling Stock	Departmental/ Maintenance Rolling Stock
3.1	Body level vertical accelerations	Body level vertical accelerations
3.2	Body level lateral accelerations	Body level lateral accelerations
3.3	Primary suspension spring deflections	Primary suspension spring deflections
3.4	Secondary suspension spring deflections	Secondary suspension spring deflections
3.5	Bolster swing, as applicable	Bolster swing, as applicable
3.6	Bogie rotation, as applicable	Bogie rotation, as applicable
3.7	Lateral accelerations at bogie frame	Lateral accelerations at bogie frame
3.8	--	Lateral forces
Note: Riding of the Metro Rolling Stock over bridges and viaducts (resonance or amplitude build-up) will be specifically mentioned in the trial report.		

4. **CALCULATION OF RIDING INDEX (RI):**

Ride Index (RI) shall be calculated as per **Office for Research and Experiments (ORE) of the International Union of Railway document No. ORE C 116/RP/8/E** (Using Fast Fourier Transform (FFT) for calculating **Sperling's Ride Index (RI)**).

5. **METRO ROLLING STOCK CONFIGURATION:-**

5.1 **Passenger Carrying Metro Rolling Stock(PCRS):**

- 5.1.1 For Passenger Carrying Metro Rolling Stock having secondary spring as Air Bellow Spring- Oscillation trials shall be done in empty and loaded condition with inflated and deflated air springs initially using new wheel profile for issue of the "Interim Speed Certificate".
- 5.1.2 Unless otherwise required, the free ends of the leading coach and of the last coach, and also leading/trailing bogie of remaining type of coaches in between, will be instrumented to ensure that at least one coach of each type is instrumented during the Oscillation trials.

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5.2 Departmental/ Maintenance Metro Rolling Stock including Locomotives etc.:

5.2.1 **As individual self-propelled Metro Rolling Stock:** The departmental and maintenance Metro Rolling Stock having features of self-propelled Metro Rolling Stock are to be subjected for oscillation trial in fully loaded condition and its EBD Trial is to be done in wet rail condition.

5.2.2 **As Train formation with locomotive having ATP:** The Metro Departmental & Maintenance Rolling Stocks which are not having self-propelled system and to be hauled by Locomotive are also to be tested in fully loaded condition with locomotive having ATP.

Unless otherwise required, the free ends of the leading Metro Rolling Stock and of the last Metro Rolling Stock, and also leading/trailing bogie of remaining type of Metro Rolling Stocks in between, will be instrumented to ensure that at least one Metro Rolling Stock of each type is instrumented during the Oscillation trials.

6. Extension of Interim Speed Certificate / issue of Final Speed Certificate

6.1 Before completion of initial five years of operations, Metro Authority is to approach RDSO, for the extension of its “Interim Speed Certificate” giving the details of rail wear measurement on critical location of the track and the measurements of its wheel wear. The extension to the initially issued “interim Speed Certificate” will be done, for a further period of 5 years subject to the following conditions:

- a) The wear on the wheels and the rails on critical locations recorded are well within the prescribed limits
- b) Submission of a certificate by the concerned Metro Authority that with these recorded wear on wheels and the rails on critical locations, there is no adverse effect on the riding behaviour of the said Rolling Stock.
- c) The Oscillation Trial shall be repeated with worn wheel profile on run down track conditions, as soon as these become available, for issue of Final Speed certificate’.

6.2 Issue of Final Speed Certificate: For this a Repeat Oscillation Trial will be done on the request of a Metro Authority with worn wheel (refer para 6.2.2) profile on the run-down track conditions.

6.2.1 The condition of ‘Run-down Track’ for Repeat Oscillation Trial for issuance of Final Speed Certificate would be considered to have been complied with in either of the following cases:

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a) Analysis of rail wear vis-a-vis the limiting values – rail wear at some of the critical locations, such as the sharper curves on the section and turnouts, approaching the limiting value

OR

b) Total traffic in terms of GMT achieved on the section is at least 25% of the life of rail in GMT as per Rail Renewal Criteria.

6.2.2 The condition of Worn Wheel, for Repeat Oscillation Trial for issuance of Final Speed Certificate would be considered to have been complied with in either of the following cases:

i) For Disc Brake Type Wheel sets: wheels have completed at least 75% of the service life (average time period between two re-profiling), since the last re-profiling

OR

ii) For Tread Brake Type Wheel sets: wheels have completed at least 60% of the service life (average time period between two re-profiling), since the last re-profiling

6.2.3 Repeat Oscillation Trials may be started at existing Operating Speed of the said Metro Rolling Stock on the Section and speed would be increased in a step of 5 / 10kmph based on the analysis of previous satisfactory result, up to 10% higher than the proposed maximum operational speed of the said Metro Rolling Stock on that section.

7. CRITERIA OF ACCEPTANCE:

7.1 Passenger Carring Metro Rolling Stock:

7.1.1 Ride Index, as per **Office for Research and Experiments (ORE) of the International Union of Railway document No. ORE C 116/RP/8/E** (Using Fast Fourier Transform (FFT) for calculating **Sperling's Ride Index (RI) = (Wz)** should be:-

$$RI \leq 3.00$$

Note: RI should be ≤ 3.0 in inflated as well as in deflated secondary spring condition, in both the vertical and the lateral directions.)

7.1.2 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.

7.1.3 A general indication of stable running characteristics of the Metro Rolling Stock, 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 should be commented upon.

7.1.4 The maximum dynamic wheel loading/unloading

$$\Delta Q/Q \leq 0.5$$

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7.2 Metro Departmental/ Maintenance Rolling Stock:

7.2.1 A lateral force lasting more than 2 metres (where P is the axle load in tonnes.):

Lateral force $\leq 0.85 (1 + P/3)$ tonnes (the Prud Homme's limit)

7.2.2 Isolated peak values exceeding the above limit are permissible provided the record shows stabilising characteristics of the Metro Rolling Stock subsequent to the disturbances.

7.2.3 The derailment coefficient shall be worked out in the form of ratio of lateral force (H_y) and the wheel load (Q) continuously over a period of 1/20th second and limiting value of DC (H_y/Q) shall not exceed 1.

7.2.4 The values of acceleration recorded, as near as possible to the bogie pivot in 8- wheeler Metro Rolling Stock and as near as possible to axle in case of 4 wheelers Metro Rolling Stock shall be limited to 0.55g, both in vertical and lateral directions. The peak values upto 0.6g may be permitted, if the records do not indicate a resonant tendency in the region of peak value

7.2.5 A general indication of stable running characteristics of the Metro Rolling Stock 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.

7.2.6 The maximum dynamic wheel loading/unloading ($\Delta Q/Q$) shall be:-

$\Delta Q/Q \leq 0.5$

7.2.7 In the case of such Metro Rolling Stocks where measurements of forces are not possible, evaluation shall be done in terms of Ride Index (RI) which shall be calculated as per ORE C-116 (Using FFT). Ride Index, in both vertical and lateral directions shall be:-

$RI \leq 4.5$ (preferred limit is 4.25)

8.0 PROCEDURE FOR DATA ACQUISITION FOR OSCILLATION TRIALS

Test data is acquired by Digital Data acquisition Systems, on computer files. The output from various transducers i.e. accelerometers LVDTs etc. after being properly conditioned and filtered by signal conditioners, is transmitted to the data acquisition cards. Brief description of the recording system is given below:

8.1 **SIGNAL CONDITIONERS:** The signal conditioners are either Voltage type or current type, depending upon the output from the transducer. These signal conditioners feed excitation voltage to the transducers, balance the input/output bridge amplify the signal from sensor and filter the oscillations to the required level. The signal conditioners incorporate low pass filters with the required cut off frequencies.

The cut off rate is 18 dB / Octave. The following filter setting shall be used:

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- i) For acceleration recording over pivot level : low pass filter of 20 Hz
- ii) For recording with LVDT/ Optical Displacement sensors and load cells : no filter

8.2 **TRANSDUCERS**: Following types of transducers are used:

- i) For recording accelerations at floor level: Capacitive type accelerometers having maximum range of ± 4 g capable of recording acceleration upto 10 Hz are used. Accelerometers having range of ± 10 g are used for bogie frame level acceleration.
- ii) For recording bolster swing, bogie rotation etc: These measurements are recorded by using Linear Voltage Differential Transformer (LVDT) / optical Displacement Sensors capable of measuring displacement up to max range of 200mm/ ± 100 mm.

8.3 A sampling rate of 200 samples / second shall be used.

The Revised Criteria for Oscillation Trial for Metro Rolling Stock (Rev.3, May, 2022) is put up for the approval of DG/RDSO.

<p>SANJAY KUMAR SRIVASTAVA</p> <p>Digitally signed by SANJAY KUMAR SRIVASTAVA Date: 2022.05.31 12:48:39 +05'30'</p> <p>S.K. Srivastava</p> <p>ED/Track-I</p>	<p></p> <p>Digitally signed by Rupesh Kohli Date: 2022.05.27 15:17:54 +05'30'</p> <p>Rupesh Kohli</p> <p>ED/Testing</p>	<p>NITIN MEHROTRA RA</p> <p>Digitally signed by NITIN MEHROTRA Date: 2022.05.31 11:06:43 +05'30'</p> <p>Nitin Mehrotra</p> <p>ED/MP</p>
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DG/RDSO