AS 7643:2018

Track stability

Infrastructure Standard

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RAIL INDUSTRY SAFETY AND STANDARDS BOARD

This Australian Standard® AS 7643 Track stability was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

ARTC	Pacific National	Queensland Rail Ltd
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Rio Tinto	PTA WA	Westnet (Brookfield)

The Standard was approved by the Development Group and the Infrastructure Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

This standard was issued for public consultation and was independently validated before being approved.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard.

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Paul Daly
Chief Executive Officer
Rail Industry Safety and Standards Board

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Contents

1 Introduction

1.1 Purpose

This document sets out the requirements for managing the stability of tracks for train operations in Australia.

1.2 Scope

Track Stability refers to the capacity of track to resist push out and buckling from compressive forces, curve pull-in and rail breaking from tension forces in the rails, due mainly to changes in rail temperature.

The standard examines factors affecting track stability for the design and maintenance of jointed, long and continuously welded rail.

This standard covers rail networks classified in AS 7630.

Tram tracks, cane railway and monorail networks are not included

1.3 Compliance

There are two types of control contained within Australian Standards developed by RISSB:

(a) Requirements.

(b) Recommendations.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard.

Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred.

Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control can not be able to be applied or other controls can be appropriate / better.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

Controls in RISSB standards address known railway hazards as included in an appendix.

1.4 Referenced documents

1.4.1 Normative references

The following referenced documents are indispensable for the application of this Standard:

(a) AS 7630 Track classification.

(b) AS 7639 Track structure and support.

(c) AS 2758.7 Railway ballast.

1.5 Definitions

Definition of general railway technical terms can be found in the National Guideline - Glossary of Railway Terminology.

Specific terms used in this Standard are defined below:

Design stress free temperature (DSFT): The design temperature at which there is no longitudinal stress in the rail, also known as Design Neutral Temperature (DNT).

Fixed reference points (creep measurement points, creep monuments): Two non-movable points, each located across and transverse to track, used as a reference to measure longitudinal movement of rails, e.g. posts (monuments) or markers on the formation, overhead electric traction masts, bridge parapets, abutments of road over rail bridges etc.

Formation: The earthworks, including capping layer, on which the track and ballast is laid.

Continuous welded rail (CWR): A continuous rail length, welded or a single string, which requires management of residual stress free temperature (SFT) by a rail adjustment procedure to address variance between ambient rail temperature and the design SFT.

The minimum length to be treated as CWR shall be declared by the rail infrastructure manager. (This is generally considered to be for rail lengths greater than 220 metres; however, circumstances may require shorter lengths to be included).

Long welded rail (LWR): A rail, longer than standard production length but less than Rail infrastructure manager defined CWR, joined by fishplates where expansion and contraction may still be managed through rail gap management.

LWR will be of lengths greater than 27.4 metres up to a minimum length stated by the rail infrastructure manager to be CWR.

Jointed rail: Rails of a standard production length, jointed continuously by fishplates. Expansion and contraction is wholly addressed by management of rail gaps prescribed for ambient rail temperature.

Production of standard rail length generally is provided in lengths of 27.4 metres.

Rail shade temperature: The rail temperature as measured on the shady side of the rail web.

Track ballast compaction: The process of bringing together unconsolidated ballast particles by manual or mechanical means and thereby increasing the resistance between ballast and sleeper surfaces.

Track ballast consolidation: The process, over time and loading as determined by the Rail infrastructure manager, for the void ratio and potential future ballast settlement to reduce to an acceptable level for the safe passage of trains at line speed.

Weld gap: The distance between prepared rail ends required by a particular welding process, measured immediately before moulds are positioned.

2 Temperature management

2.1 Calibration of temperature gauge

Temperature gauges are used to measure rail temperature in the field. Good practice is to use three or more thermometers placed throughout the site to account for any variations. Temperature gauges are required to be calibrated, fit for use and used in accordance with manufacturer’s instructions.

2.2 Tolerance of temperature requirements

The design stress free temperature is generally between 35 ºC and 40 ºC. The correct SFT should be chosen to suit the climate, i.e. the maximum and minimum rail temperature as well as the temperature frequency distribution.

The criteria for the selection of the appropriate design SFT and associated tolerances shall be specified by the rail infrastructure manager.

2.3 Type and appropriate use of temperature measurement devices

Rail temperature readings should be taken from the shaded side of the web of the rail. A minimum of three readings should be taken for each stressing length:

(a) near the pulling point;

(b) near both anchor blocks.

Additional temperature readings should be taken where there is potential for temperatures to vary along the stressing length (within cuttings or on embankments). The average rail temperature over the stressing length should be recorded. The final readings used should be taken at the last possible moment before marking the reference points and undertaking the stressing calculation.

The rail infrastructure manager will define authorised types of rail temperature measurement devices.

3 Track design

3.1 General

Consideration shall be given to determining any precautionary restrictions on track work applicable in the summer months during times of high temperature and in the winter months during times of low temperature.

The ability of the track to resist the effects of longitudinal forces (creep, thermal, etc.) varies with rail section, curve radius, DSFT, rail temperature at the time, track misalignment, sleeper and ballast properties and ballast profile.

The following factors should be considered when designing for stability of the track structure:

(a) Rail cross-sectional area.

(b) Fastening type.

(c) DSFT.

(d) Rail stressing during construction and maintenance.

(e) Sleeper material type, mass and spacing.

(f) Ballast profile (cribs and shoulders) and compaction.

(g) Track geometry.

(h) Horizontal and vertical alignment and effects of track shift during maintenance, e.g. tamping and alignment adjustment.

(i) Creep.

(j) Drainage.

Temporary destabilising factors can include:

(a) rail or track creep;

(b) rail laid or maintained at incorrect SFT or where SFT is unknown;

(c) rail not correctly restrained with rail anchors or inadequate toe loads applied by resilient fastenings;

(d) track disturbing work, such as sleeper renewal or tamping;

(e) loss of frictional resistance at the ballast/sleeper interface including lack of ballast in the pods of steel sleepers;

(f) fouled, poor or rounded ballast;

(g) track misalignments;

(h) mud holes or local formation weaknesses and poor drainage; and

(i) in jointed track, rail joint gaps which are out of tolerance.

Permanent destabilising factors can include:

(a) sudden changes in track modulus, such as the junction between timber and concrete sleepered track;

(b) track located at the bottom of descending grades (buckle prone);

(c) track located at the top of ascending grades (pull-apart prone);

(d) track with tight radius curves;

(e) track located adjacent to a fixed structure in the track such as a level crossing, turnout, or a transom decked bridge; and

(f) train braking and accelerating locations.

When designing, constructing or maintaining CWR and/or LWR track, consideration shall be given to track stability aspects.

The track structure should be capable of providing resistance to lateral forces induced by creep, train operations and the rail temperature range applicable to the local area.

The DSFT varies for different jurisdictions and ranges broadly from 30 °C to 45 °C.

3.2 Ballast characteristics and profile

The functions of ballast are to support the sleepers and transfer load to the formation, anchor sleepers against excessive lateral, vertical and longitudinal movement and to provide drainage to the track structure.

To perform its functions, ballast should comply with AS 2758.7 particularly with respect to features that provide resistance to movement.

The track, in areas where ballast is deficient or has become fouled by fine particles, has significantly reduced frictional resistance at the ballast/sleeper interface and hence has significantly lower lateral track resistance.

Particular attention should be paid to ensure that deficiencies in the ballast level in both the crib and on the shoulders are corrected and that the amount of fines within the ballast is properly managed to maintain free drainage.

The ballast shoulder provides a significant contribution to overall track stability and particular care should be taken to ensure that the shoulder width is compliant with design.

The resistance to buckling forces may be enhanced by the provision of a ballast shoulder surcharge (windrow).

The minimum ballast shoulder width should be in the range of 300mm for CWR or LWR track.

3.3 Sleepers and fastening systems

When designing or specifying a track structure, consideration shall be given to the influence of sleeper type on the stability of the track.

Sleepers that are broken, cracked, split, crushed or decayed do not provide effective support.

Fastenings systems shall comply with the requirements of AS 7639.

Resilient fastening systems provide more effective toe load and resistance to horizontal sleeper/rail movement compared to dog spiked track fitted with anchors.

3.4 Rails

Track stability design shall take into account the maximum rail size that may be used.

Due to the increased susceptibility of track buckling on tight radius curves with steel or timber sleepers, there is a need to allow free longitudinal movement of rail within joints to assist with relieving induced stresses in the rail.

Jointed rail can provide additional longitudinal movement on sharp radius curves.

Resilient fastening systems tend to reduce the effectiveness of rail joints.

The design of track structure with CWR or LWR shall consider the effects of potential rail creep on track lateral stability.

4 Track construction and maintenance

4.1 General

The rail infrastructure manager shall ensure that the track remains safe during installation pending final adjustment.

Consideration should be given to the stability of new and incomplete track.

Guidance for the various track stability elements is provided in the following section.

4.2 Temperature stress control

The construction, reconstruction or maintenance of CWR or LWR track, should, where necessary, include adjustment to SFT.

Track located within tunnels (except for the first 50m inside the tunnel portals) is exposed to a limited temperature range and may be welded at prevailing rail temperature.

The rail infrastructure manager shall determine the tolerances to be applied to DSFT.

4.3 Welded track

All tools used in carrying out stress adjustment for CWR and LWR shall be calibrated in accordance with the manufacturers recommendation.

Actual adjustment length will depend on equipment and practices used to ensure an even distribution of the adjustment over the length of the CWR/LWR.

The maximum adjustment lengths shall be determined by the rail infrastructure manager.

Rail stress adjustment shall only be carried out when the rail temperature is within the tolerances, or below the DSFT.

The minimum rail temperature at which adjustment can be carried out will depend on the available tensioning equipment, track curvature and rail support equipment, e.g. rollers.

The stress free rail gap can be determined by using the coefficient of linear expansion in the following formula:

$$\Delta l = WG + 1000\, L\, \alpha\, \Delta T$$

where:

Δl = the gap between the rail ends in the stress free state;

WG = Weld gap as specified by the manufacturer of the welding material and measured just prior to applying the moulds;

L = module or adjustment length;

α = coefficient of thermal expansion for steel; typically, 0.00115 mm/m/°C; and

ΔT = difference between the measured rail shade temperature and the DSFT.

4.3.1 Checking rail movement during adjustment

During the stressing process it shall be ensured that there is no rail movement through the anchor block.

Even stress distribution should be achieved throughout the tension length.

4.3.2 Use of rollers for stress adjustment

The length of the CWR/LWR module for stress adjustment may be increased if rail support rollers are used.

4.3.3 Stress retention during minor rail works in CWR or LWR

The replacement of short lengths of rail (e.g. insulated joints, closures inserted after removal of a defective rail or weld) defect may not warrant stress adjustment of a complete rail adjustment length.

A modified method, known as "Punch tensing" in some states, may be used for the replacement of insulated joints, short defective rails and welds, provided rail stress is not compromised.

Fixed reference points shall be established on the rail beyond each end of the insert length and the distance between these points shall be the same (within the tolerances specified by the rail infrastructure manager) before the work commences and after the work is completed.

The rail infrastructure manager shall specify the parameters to be measured and recorded during the stress adjustment operations.

The maximum length of rail insert for which this method may be applied is generally restricted to one rail length (13.72 m).

4.4 Jointed track

Rail joints are used in long welded or short rail track and in points and crossing work.

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Where it has been determined that rail joint gaps are to be monitored the rail infrastructure manager shall specify the periodic assessment required (including measuring and recording).

The rail temperature at the time of joint gap measurement should be recorded.

4.4.1 Rail gap calculation

The theoretical rail gap can be calculated from the following formula:

$$TRG = RGDSFT + \Delta T\ 0.00115\ L$$

where:

TRG = Theoretical rail gap (mm);
RGDSFT = Rail gap at DSFT (mm);
ΔT = difference between the actual shade rail temperature and the DSFT (°C); and
L = half the sum of the rail lengths each side of the joint being considered (mm).

5 Temperature related restrictions

5.1 Precautionary restrictions due to weather conditions

Rail infrastructure managers should develop appropriate procedures and inspection regimes to manage the possibility of track buckles in summer and pull-aparts or curve pull-ins in winter.

Reducing the speed of trains during periods of extreme temperature reduces the train induced track destabilising forces and also reduces the likelihood and consequences of track/train damage.

Consideration should be given to the need for and determining threshold temperatures for introducing precautionary speed restrictions in extreme weather conditions.

The allowable temperature extremes depend on the robustness of track structure.

The levels and duration of speed restrictions, and the procedures for applying them shall be specified by the Rail infrastructure manager.

When the air temperature reaches or is forecast to reach a specified level, it may be required that all welded track be inspected during the most extreme part of the day for the purpose of detecting signs of lateral track movement.

5.2 Dealing with track after a buckling incident

All buckles should be investigated and appropriate interim infrastructure manager and remedial measures taken.

Stress adjustment of affected track should be carried out after events such as a track buckle.

5.3 Assessment and actions

Where it has been found that the track stability is inadequate, the rail infrastructure manager shall determine the risk, appropriate actions and their urgency.

The risk is managed by a combination of restrictions on traffic and mitigation/repair actions.

(a) Trains may be piloted through the site when necessary and safe to do so, taking into account factors including:

(b) (a) clearances with respect to structures and other running lines;

(c) (b) track support conditions, in particular where the track has shifted;

(d) (c) track geometry and the ability of each vehicle, either individually or as part of a consist, to safely negotiate the defective track.

6 Monitoring processes

6.1 General

The rail infrastructure manager shall develop appropriate track stability monitoring requirements.

If required, SFT can be monitored using an indirect method such as rail creep or a direct method using direct SFT measuring equipment and for curves the lateral location of the track shall be considered.

Other aspects of the track structure contributing to track stability should also be monitored, e.g. ballast profile, and track disturbance.

The rail infrastructure manager should keep a current list of hazard locations and specify any increased frequency of inspections in the region.

Hazard locations should be assessed for deviation from DSFT, using a method approved by the rail infrastructure manager.

Hazard locations may extend over significant lengths of track particularly in the early part of the risk season.

6.2 Rail creep monitoring process

Where creep is used to assess SFT, it shall be carried out at a predetermined frequency as determined by the rail infrastructure manager.

The inspection frequency can be reduced if the track construction type provides good resistance as demonstrated by the absence of destabilising factors and satisfactory actual creep measurement data over a period of time.

A creep monitoring system can be initiated by:

(a) establishing fixed monuments beside the track, at defined intervals for tangent and curved track;

(b) using other fixed locations, such as near open deck (transom) bridges and level crossings, provided that they are stable;

(c) establishing reference marks on the rail;

(d) recording periodically the difference between the reference mark on the rail and the relative position on the monuments; and

(e) determining the overall impact of adjustment of creep including impact of any variation in track alignment in curves.

6.3 Measurement of SFT

The rail SFT can be determined by destructive, partly destructive and non-destructive methods.

Destructive Methods:

(a) require line occupations and are time consuming;

(b) require cutting of the rail;

(c) have the stresses neutralised at the cut location; and

(d) if carried out correctly, allow the rail stress to be accurately determined.

Partly destructive measurement methods are generally based on the relationship between the force required to lift an unfastened rail and the resulting deflection produced.

These methods are partially destructive where dog spikes are used but non-destructive where resilient fastenings are used.

Non-destructive measurement methods of which there are various methods under development.

Any method of measuring the stress free temperature shall be approved by the Rail infrastructure manager.

6.4 Conditions for stress re-adjustment

Rail stress assessment and, if necessary, adjustment, should be carried out whenever any of the following events occur:

(a) new or recycled rail is being laid into track (except for short lengths like closure rails);

(b) the rail adjustment is suspect, due to the presence of, e.g:

  i. track pulling into the curve during cold weather or pull-aparts;

  ii. track pushing out in curves or buckling;

  iii. mechanical joint failure;

  iv. creep;

  v. buckles.

(c) track work or realignment that may have affected the rail stress by an amount considered excessive for the track structure being used.

The rail infrastructure manager shall develop an appropriate assessment and corrective actions process for locations of track instability.

6.5 Procedures for train operations following track disturbance

Any activity which moves or removes sleepers, removes or loosens ballast including tamping or lining can reduce track resistance to movement.

To ensure track safety in hot or cold temperatures, operational restrictions should be considered until the track is satisfactorily compacted and/or consolidated.

Where track has not been dynamically stabilised or has not had the required tonnage pass over the newly installed CWR/LWR to allow consolidation, consideration should be given to applying methods of protecting the track, e.g. operational restrictions or laying additional ballast on the track, as specified by the rail infrastructure manager.

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