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Track Stability Hand Book

ETN-06-01

Applicability

ARTC Network Wide

SMS

Publication Requirement

Internal

Primary Source

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Document Status

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Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	30 Jan 17	All	Initial Issue

Table of Contents

1 Introduction

1.1 Purpose

The purpose of these guidelines is to provide background information relating to the management of track lateral stability.

The guidelines are applicable to CWR and LWR in main lines.

1.2 Document Owner

The Manager Standards is the Document Owner and is the initial point of contact for all queries relating to this procedure.

1.3 Reference Documents

This procedure is to be read in conjunction with the following documents:

- ETM-06-08 Managing Track Stability
- ETW-01-05 Stressing Plain Line CWR

1.4 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Buckle	A buckle (also known as a misalignment) occurs when the *compression* generated in the rails exceeds the ability of the track structure to hold itself in place and the track is displaced laterally. Lateral displacement of track in high temperature shall be treated as a buckle.
Compression	The compressive (squeezing) force generated in *CWR* when rail temperature increases above the *stress free temperature*, and the rail cannot expand.
Creep	Longitudinal movement of rail (or rail plus sleepers) over time, resulting in changes to *stress free temperature*.
CWR (Continuously Welded Rail)	Rail lengths welded end to end into strings greater than 400m without rail joints.
Design SFT	The stress free temperature to which CWR is to be adjusted during stressing. The current design SFT is 38°C but track installed before the current requirement was installed at 35°C design SFT.
Fixed point	A section of track, such as through a turnout or road crossing, which offers greater resistance to longitudinal rail movement than elsewhere.
LWR (Long Welded Rail)	Rail lengths welded end to end into lengths between 55 m and 400 m.
Misalignment	See *buckle*.
Pull-apart	A rail break and contraction of rail ends, when in tension during cold weather.

Term or acronym	Description
Pull-in	Lateral track movement towards the centre of a curve, resulting from *tension* in the rails.
Rail temperature	The average of temperatures recorded on the web of the rail, on the shaded side, as measured by several thermometers.
Resilient fastenings	Fastenings which exert a toe load on the rail foot, inhibiting *creep*.
Special location	For the purposes of this procedure, a location which has an increased risk of track instability.
Stress free	Rail which has no axial thermal forces, it is neither in *compression* nor in *tension*.
Stress free temperature (SFT)	The temperature at which the rail in *CWR* is *stress free*. If the rail were to be cut, the gap created would remain constant. It would neither close nor would it widen unless the rail temperature was to change.
Stressing	The process of adjusting *CWR* to the correct *stress free temperature*.
Tension	The tensile (pulling) force generated in *CWR* when rail temperature decreases below the *stress free temperature* and the rail cannot contract.
Welded rail	Rail which is either *CWR* or *LWR*.

2 General

2.1 Track Stability

The standard track structure of formation, ballast, sleepers, fastenings and rail is designed to interact to provide a structure that resists the lateral forces generated by compressive or tensile forces in the rail.

This is achieved by:

- Resilient fastenings, being properly installed, and effective in providing a ladder track structure
- Sound sleepers, firmly fastened to the rails and firmly bedded in the ballast
- A full profile of clean, free draining, and firmly compacted ballast.

The approximate contributions of each component to overall track stability are as follows:

- Rails: 10%;
- Fastenings: 30%
- Sleepers and ballast: 60%.

In other words, 60% of the resistance to lateral movement is provided by the sleeper in the ballast, which is comprised of:

- Bottom of sleeper approximately 25%
- Sides of the sleeper approximately 25% (full crib)
- Shoulder ballast approximately 10%.

Under traffic, the wave action of the track reduces the resistance of the ballast beneath the sleeper, increasing the importance and contribution of shoulder ballast.

2.2 Track Buckles

High temperature is NOT the cause of track buckles. Properly constructed and maintained track will not buckle in the normal range of temperatures experienced during days of high temperature.

The most common causes of buckles are:

- Track not correctly adjusted to be stress free at 38°C
- Loss of rail adjustment due to uncorrected rail creep, or addition of steel when repairing rail defects
- High rail stresses near fixed points, such as level crossings or turnouts
- Loss of ballast grip, and of compaction, following disturbance during maintenance work e.g. tamping, resleepering
- Localised initiators such as pumping track, peaks in curves, or misaligned welds.

Buckles will occur at the weakest point. This may only be a short isolated piece of track in an otherwise very stable section.

3 Rail Behaviour

3.1 Temperature Effects

Rails which are free to move, expand and contract (get longer or shorter) as the rail temperature increases or decreases.

Rails will expand and contract 0.115 mm for every 1 m length for every 10°C change in rail temperature.

For example, a 110 m length of unrestrained rail will get 13 mm longer when the rail temperature increases 10°C. The rail will get shorter by the same amount if the rail temperature decreases 10°C. An unrestrained 110 m rail will grow 19 mm if the rail temperature increases from 20°C to 35°C.

When rails are laid in track they cannot expand or contract by this amount, because they have been welded to other rails, connected with bolted joints, etc.

In the case of track with jointed rails, the potential for free movement is only 13 mm, which is the gap at each joint. In CWR there is no potential for free movement because there are no joints.

3.2 Rail Forces

If the rail cannot expand or contract in response to changes in temperature, forces are created in the rail. There are two types of force :

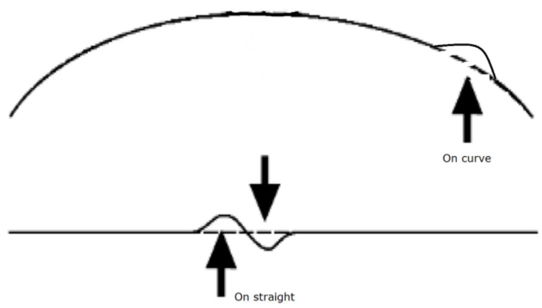
- Compression: .As rails expand with heat, any free movement is taken up. When there is no more movement left, a force is built up in the rail by expansion. This is called compression.
- Tension: When the rails cool any free movement is taken up by contraction. When all movement is taken up, and the rails continue to cool, a force is built up in the rails. This is called tension.

3.3 Effects of Compression

When rail is in compression it tries to relieve the compression by getting longer. It will try to move sideways to get longer.

Compression can be contained within the track structure (the assembly of rails, fastenings, sleepers and ballast) under normal conditions, i.e. when the track structure is to standard.

The track structure is designed to resist a certain amount of sideways thrust that comes from the compressive stress in the rails. When, however, the amount of compression generated in the rails exceeds the ability of the structure to hold itself in place, track movement occurs. This movement is known as a buckle – see diagram below.



Typical buckles

Note: In some curves, buckling often occurs in the transition, rather than in the body of the curve.

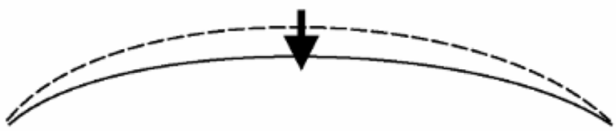
3.4 Effects of Tension

On curved track, tension may have a similar, but less dramatic effect on the track.

When rail is in tension it tries to relieve the tensile stress by getting shorter. It will try to move sideways to get shorter.

Tension stress can be contained within the track structure (the assembly of rails, fastenings, sleepers and ballast) under normal conditions, i.e. when the track structure is to standard.

If the amount of tension generated in the rails is greater than the resistance offered by the track structure, a curve will pull in towards its centre – see diagram below.



Typical curve pull-in

This track movement is less dramatic than a buckle, because the track movement occurs over a much longer distance. The movement may not be obvious but it can be extremely dangerous when clearances are affected.

Other indications of excessive tension in rails are broken rails, bent or broken bolts, or pull-aparts.

The adjustment of rails, therefore, is a most necessary and essential part in effective track maintenance. Rails, ballast, sleepers, fastenings and rail adjustment all interact to provide a stable track structure.

4 Managing Rail Stresses

4.1 Control of Expansion and Contraction

Rails experience both cold and very hot temperatures in track and will, therefore, experience both expansion and contraction, or compressive and tensile stresses.

These stresses are managed by:

- Establishing and maintaining correct rail adjustment
- Providing and maintaining lateral resistance to movement
- Controlling the additional forces that can initiate misalignments or pull-ins.

4.2 Establishing Rail Adjustment

Rails have to be adjusted so that they do not generate excessive compression or tension. Correct adjustment is achieved ensuring that each rail will be stress free (no compression or tension) at the design SFT.

This temperature has been specified for rails in ARTC infrastructure as a balance between the extremes of heat and cold experienced on the network. If rails anywhere on the network have been correctly adjusted to the design SFT, the normal range of operating temperatures will not generate excessive compression or tension.

In CWR, the rails will always be in compression when the rail temperature is greater than the design SFT, provided the rails are correctly adjusted. When the rail temperature is less than the design SFT, correctly adjusted CWR will always be in tension.

Jointed rails will be in compression if the joints are closed up to zero gap. The rail temperature at which this occurs depends on the length of the rail between successive joints. For example, correctly adjusted 110 m rails will be in compression at 5°C rail temperature above design SFT. Shorter 13.72 m rails, however, do not go into compression until the rail temperature reaches 40°C above design SFT.

Likewise, rails will be in tension if the joints are fully open to 13 mm. Again, the rail temperature this occurs at depends on the length of the rail. For example, correctly adjusted 110 m rails will be in tension at 5°C rail temperature above design SFT. Shorter 13.72 m rails however do not go into tension until the rail temperature reaches 40°C below design SFT.

The methods of adjusting rail are detailed in ARTC Work Instructions.

4.3 Rail Creep

Rails in service are subject to longitudinal forces from:

- The braking action of the train pushing the track in the direction of travel
- The acceleration of the trains pulling the rail in the opposite direction
- Wave motion caused in the rails by the passage of the train wheels, pushing the rails in the direction of travel.

These forces can result in the rails moving. If the rails move longitudinally the rail adjustment will be affected irrespective of the type of rail (jointed rail or CWR).

To illustrate this point, consider an example where jointed track is on a steep grade. If traffic continually runs downhill, the rails will tend to run downhill as well. This will result in wider rail gaps at the top of the grade and narrower gaps toward the bottom, with the result that there will be too little steel at the top of the hill and too much steel at the bottom.

CWR behaves in the same way; steel will bunch up in one location and be stretched at another, altering adjustment.

Standard track consisting of formation, ballast, sleepers, fastenings and rail is designed to interact to resist the longitudinal movement of rail.

Creep should be monitored as set out in ETM-06-08 Managing Track Stability.

Creep is more rapid in loose ballast; newly ballasted track should be carefully watched for signs of movement.

5 Track Structure Components

5.1 Rails

When welding short closures into curves, it is essential that the closure be cut from rail which conforms as closely as possible to the curve wear on the existing rails.

For curves of radius 800 m and under, both the closure and each adjacent rail are to be crowed to the correct curvature.

Crows or rail benders may be used at welded joints. Bending of rails must always be done to produce a smooth progressive curve rather than a sudden change of direction.

5.2 Ballast

Adequate ballast is essential for welded track stability, and must be maintained to the standard section.

Ballast provides a flexible base for the track, transmitting wheel loads to the formation, and providing the vertical and lateral support to the sleepers to maintain track geometry. Ballast also provides resistance to the longitudinal movement of sleepers.

The angular shape of the ballast serves to lock the sleepers in place.

In order to do its job effectively, ballast must have the following qualities:

- Grading: a specified shape and size to effectively lock together – rounded or poorly graded ballast will not provide the designed resistance to movement
- Cleanliness: ballast that contains fine contamination, weeds, etc., will not provide effective interlocking or resistance to sleeper movement
- Profile: ballast not to the standard profile will significantly reduce resistance to sleeper movement.

Ballast should be compacted using mechanical compactors whenever such equipment is available.

5.3 Sleepers

In addition to holding the rails to gauge and transmitting the wheel loads from the rails to the ballast, sleepers provide resistance to longitudinal movement of the track by holding the rails in position through the fastenings, and by engaging the faces of the ballast.

5.4 Fastenings

Fastenings are used to connect rails together (fishplates and bolts), tie the rails to the sleepers (clips or spikes, and pads or sleeper plates) and to restrict longitudinal movement of rails relative to the sleepers (resilient fastenings or anchors).

Resilient fastenings and anchors are installed to prevent longitudinal rail movement (creep), and to maintain even distribution of stresses along the full rail length. Without resilient fastenings or rail anchors, the rails would creep until restrained at fixed points (e.g. turnouts), resulting in incorrect rail stress.

Resilient fastenings must be kept driven fully home (not overdriven) into their fittings or housings, using the method appropriate to the type of fastening. If a special tool is necessary to fit and/or remove resilient fastenings, then they should not be fitted or removed without use of such tool.

5.5 Mechanical Joints

If mechanical joints on LWR are open in hot weather or closed in cold weather the condition should be investigated. Irregular joint behaviour may be due to creep or frozen joints (the rails not moving in the fishplates due to rust or excessive tightness of bolts). In this case the fishplates should be taken off and correctly greased, but this must not be done when the rail temperature is below 30°C as there is a danger of the rails 'jumping'.

Joints must be properly packed. The weakness of the mechanical joint transmits vibrations to the ballast. This causes deterioration which is more rapid than elsewhere.

5.6 Glued Insulated Joints

Glued insulated joints are not expansion joints but are designed to act as part of the adjacent welded rail.

Once a glued insulated joint has failed mechanically, it should be programmed for replacement since its electrical failure is also likely.

5.7 Rail Anchors on Dogspiked track

Rail anchors are provided to prevent creep and limit the movement of rails with the rise and fall of temperature. Standard of anchoring is usually sufficient to prevent creep, but in certain locations, such as approaching stations, signals, or on heavy down grades, additional single anchors against creep may be necessary.

Anchors must be maintained against the sleeper. Anchors found away from the sleeper should be removed and refixed against the sleeper. Anchors must not be hammered along the rail.

5.8 Drainage

Effective drainage is a major factor in minimising maintenance work necessary on welded track.

Special attention must be given to drainage. Where sub-drainage work has been carried out; the outlets must be kept clean to allow water to run off.

The cesses in cuttings must be kept formed so that the water will run at the toe of the batter. On banks the cesses must be graded away from the track.

6 Providing and Maintaining Lateral Resistance

6.1 Inspection of Track Stability

Requirements for inspection and assessment of track lateral stability are detailed in ETM-06-08 Managing Track Stability, and for timber sleepered track in ETM-06-09 Welded Track Stability Analysis.

These inspections are critical before the onset of hot summer weather.

6.2 Prevention of Buckles

ARTC has established a number of requirements that if used correctly and in combination reduce the likelihood of buckles occurring in the hotter months of the year. These requirements include:

- Inspection and assessment of CWR track, including measurement of SFT
- Close control of rail stressing and of the repair of welded rails
- Special precautions for work carried out during the hotter months of the year
- Speed restrictions and/or special inspections on very hot days.

6.3 Special Locations

Consideration is to be given as to whether the impact on the lateral stability posed at special locations is due to buckling force or buckling resistance issues. This will impact on the way the location will be assessed and hence the actions that may be recommended as a result.

7 Track Maintenance

7.1 General

Effective maintenance of welded track requires a high standard of workmanship because the rise and fall of temperature acting on the long lengths of rail or continuously welded rail causes forces in the rails, sleepers and ballast.

By following the guidelines for good track maintenance, safe and good quality track will result.

7.2 Stressing of CWR Track

The stress adjustment process for CWR track, as set out in the applicable Work Instruction, is the only approved method of CWR stressing that reliably produces correctly adjusted CWR track.

Any work on CWR track which causes a broken rail will change the adjustment of the rail and make readjustment necessary at the completion of the work.

During the adjustment of CWR track, particular emphasis must be placed upon initial destressing of the rail and subsequent equalisation of adjustment stresses.

7.3 Broken Rails and Welds

When a rail breaks in welded track it must be properly secured with fishplates and reported immediately.

If the break is such that traffic cannot be safely allowed over it, a closure must be cut or welded in. The closure rail is to be cut to a tight fit without expansion. A rail saw is to be used for cutting of rails and great care taken to see that the ends are cut square and (where applicable) the holes correctly drilled.

Where possible, as soon as staff and equipment is available, the closure rail is to be welded in, and in CWR track, stressed as detailed in the applicable Work Instruction.

Before cutting out the broken portion on dogspiked track, all anchors on adjacent rails must be securely fixed in each direction, and, if available, additional anchors should be fixed to prevent the rails moving.

In the event of a weld breaking or developing a crack, action must be taken, such as:

- Replacement with a closure rail
- Wide gap weld
- Temporary plating.

The matter must be reported to the Team Manager, who will advise what action is required and arrange for a rail flaw report.

If the welded joint is to be cut out, it is to be treated as a broken rail and the piece of rail 75 mm long on each side of the weld is to be forwarded for testing if directed.

Broken or cracked welds are to be reported similarly to broken or defective rails as required by the rail flaw report.

When considered necessary a speed restriction should be imposed.

7.4 Line, Top and Superelevation

To ensure track stability, line, top and superelevation must be maintained in compliance with the applicable standards.

7.5 Gauge

Gauge should be uniform.

When gauge exceeds the applicable limits, regauging is to be arranged.

On timber sleepered curves with sleeper plates and sound sleepers, the high rail is to be allowed to wear to condemning gauge, without regauging, providing the 'foot to foot' gauge is maintained correctly, including where necessary by reboring of the timber sleepers. Where the sleepers are not sound, tying up and regauging is to be carried out where needed.