

Category 1 Standard

S1177 Track - Managing temperature- dependent risk

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1 Purpose

- 1.1 The purpose of this standard is to describe the actions necessary to prevent track buckling and distortion caused by environmental temperature variations, by ensuring that:
- a) rail is maintained stress-free at a rail temperature within the nominated range;
 - b) track is maintained with adequate lateral stability;
 - c) track is maintained adequately to resist fracture of rail or fishplates at low rail temperatures;
 - d) maintenance activities during periods of high or low rail temperature do not jeopardise track stability.
- 1.2 This standard sets requirements for track monitoring and speed restrictions in hot weather.
- 1.3 This standard also includes the minimum action required in the event of a track buckle occurring.
- 1.4 This standard does not cover rail stressing methods in detail. Instead, reference is made to Network Rail standard NR/L2/TRK/3011 where this is applicable to LU track.
- 1.5 This standard is supported by Track Handbook 6 (G3206), which may be referred to for further information and guidance.

2 Scope

- 2.1 This standard covers all ballasted flat bottom and bull head track (continuous welded rail, long welded rail and short rail) and conductor rail.
- 2.2 Subject to the length limits given in standard S1157, short lengths of CWR do not require stressing. Requirements in this standard regarding stressing, SFT and CRT do not apply to this “unstressed welded rail”.

3 Requirements

3.1 Checks and preparation prior to Hot Weather Period

3.1.1 Stress Free Temperature

- 3.1.1.1 The SFT for CWR and LWR in Open sections shall be between 21C and 27C. Exceptionally, the SFT for LWR sites in Open sections is permitted to be between 18C and 27C, subject to the conditions described in clause 3.1.5.2.
- 3.1.1.2 In locations with a limited temperature range (tunnels) an appropriate SFT may be obtained by allowing the rails to reach ambient temperature before installation.

Note: Maintenance of the SFT within the stated limits is critical to track stability in hot weather. Knowledge of the SFT is required for the assessment of Critical Rail Temperature.

3.1.2 Work prior to the Hot Weather Period - General

- 3.1.2.1 Any remedial work necessary to ensure that the following items are in accordance with S1159 and S1164 shall be completed by 31 March each year:
- a) the ballast and its profile condition;

- b) vertical and horizontal track alignment;
- c) bolted joint condition;
- d) fixings and fastenings condition;
- e) expansion and adjustment switch settings and condition.

Notes: Completion of this work by 31 March reflects a historic requirement, albeit one month later than the start of the Hot Weather Period, defined in clause 5.3.

Particular attention should be paid to the settings of expansion switches adjoining bullhead rail, as the rail-end movement may be greater than that of the flat-bottom rail for which expansion switches were originally intended. This may result in the gaps and overlaps breaching the limits in S1159.

3.1.2.2 By 31 March each year locations shall be noted and rectified where the following conditions occur:

- a) movement at datum marks or tell-tales, inconsistent with rail temperature, indicates that restressing is necessary;
- b) the SFT is outside the nominated range;
- c) rail creep (affecting adjustment and expansion switch openings, or causing fishplate binding with chairs, axle-counter displacement, uneven rail gaps in short rail sites).

3.1.2.3 Where it is not possible to rectify any sub-standard areas, action in accordance with sections 3.3, 3.4, 3.5, 3.6 and 3.7 shall be taken to minimise the possibility of track buckling and to control the risks should the track move under the action of thermally-induced forces.

3.1.3 Work prior to the Hot Weather Period – CWR and LWR

3.1.3.1 Expansion switch gaps and overlaps shall be checked and the information recorded on the appropriate form (Attachment 1) and if necessary reset in accordance with standard S1159.

3.1.3.2 Expansion switches shall have accessible sliding contact surfaces lightly oiled once a year, preferably during the autumn period. The supporting timbers shall be correctly spaced and the two strapping bars shall be present and screwed tight to their timbers.

3.1.3.3 In expansion switches, the opening at each end of the switch rail shall not be less than 60mm at any time. The end of each switch rail shall be within the clamp plate by not less than 60mm and there shall be at least 30mm of the full rail section supported on the baseplate. Remedial work in accordance with clause 3.1.3.1 if required shall be carried out before these limits are reached. See diagram and location of measurements in Attachment 1.

3.1.3.4 Adjustment switches (LU switch rail type) shall be checked and the information recorded on the appropriate form (Attachment 1) and if necessary reset in accordance with standard S1159.

3.1.4 Stressing new and restressing existing CWR and LWR

3.1.4.1 Sections of CWR and LWR shall be restressed where the SFT is unknown or is known to be outside the range 21C to 27C for FB rail or 18C to 27C for BH rail (see also clause 3.1.5.2).

3.1.4.2 Reference should be made to Network Rail standard NR/L2/TRK/3011 for details of stressing procedures, except that anchor lengths shall be as shown in Table 2. Subject to the Note at the foot of Table 2, these anchor lengths may be used when stressing up to expansion or adjustment switches.

Table 2: Anchor lengths	
Track conditions	Minimum anchor length
Where all rail fastenings are e-plus, e2000 series or Fastclip, all present, installed with the correct tools and in good condition with all pads and insulators in place and good consolidated ballast conditions	30m or three sleepers per degree C temperature difference, whichever is greater
As above but PR or e1800 series fastenings	40m or four sleepers per degree C temperature difference, whichever is greater
Where ballast and/or fastening conditions are poor	135m
Cast crossing welded or tight-jointed to adjacent rails	Anchor point
Note: Any disturbance to an expansion or adjustment switch beyond the outer tell-tale, during stressing, indicates that the anchor is too short. The switch must be reset and a longer anchor established before stressing is resumed.	

3.1.4.3 When a part of the site requires restressing, the length to be stressed shall extend 90m into the rail at each side of the disturbance.

3.1.4.4 Stress adjustment work shall be recorded on the form shown in Attachment 2.

3.1.4.5 When an adjustment switch or an expansion switch is removed stressing shall be carried out over a minimum 90m beyond the original anchor lengths.

3.1.4.6 If an SFT outside the range shown in clause 3.1.1.1 is known to exist in an Open section, it shall be rectified to the following timescales:

- SFT below the range in clause 3.1.1.1 The rail should be re-stressed prior to the onset of the Hot Weather Period, or else as soon as is reasonably practicable, so that the risk of the rail temperature exceeding CRT threshold values is minimised. The stressing should be prioritised so that sites with lower CRT values are dealt with sooner than those with higher values.
- SFT above the range in clause 3.1.1.1 The rail should be re-stressed prior to the end of the Hot Weather Period, or else as soon as is reasonably practicable, so that the risk of rail tensile failure is minimised.

Note: In sub-clause (a) above, "or else" refers to the situation where a low SFT is created or detected after the onset of the Hot Weather Period. Likewise, in sub-clause (b), "or else" refers to the situation where a high SFT is created or detected after the end of the Hot Weather Period.

3.1.4.7 When an alignment no longer complies with its design or as-built position it shall be restored. The rail shall be restressed unless all the following criteria are met:

- the line and level were previously determined by fixed references and the original line and level are restored to within the limits shown in Network Rail standard NR/L2/TRK/3011 (see clause 3.1.4.8 below);
- the rail was previously correctly stressed and has not been cut; and
- expansion switches are absent or can be confirmed not to have been affected.

3.1.4.8 Criteria for restressing when line and/or level are altered are given in Network Rail standard NR/L2/TRK/3011. Attachment 9 summarises the criteria and gives worked examples.

3.1.5 Particular requirements for stressing and restressing of LWR

3.1.5.1 Early in February and again early in August the distribution of SFT within each length of LWR shall be assessed:

- a) Where monuments are used the movement shall be recorded using Attachment 4 and the SFT calculated using Attachments 5 and 6.
- b) Alternatively the SFT may be assessed, using the information recorded on the latest stressing certificate, any valid Stress Restoration Certificates following authorised maintenance works (rail defect removal) or valid information on adjustment switch / expansion switch dimensions.

Any corrective action identified shall be completed no later than the second week in March and September respectively.

3.1.5.2 Extension of the permitted SFT range down to 18C (from 21C) is permitted only when it is calculated from rail movement at monument blocks.

3.1.5.3 Where the SFT is found to be outside the permitted range, the LWR shall be restressed and new steel keys (or clips if the rail is FB) installed.

Note: Sites fitted with wooden or Panlock keys are unlikely to retain their SFT.

3.1.5.4 If an LWR site is disturbed by work on an abutting site, the affected track shall be assessed and if necessary restressed.

3.1.5.5 Where major disturbance to an LWR site is planned for the longer term and stressing is not practical the following must be undertaken:

- a) Panlock keys shall be installed in the temperature range of 21C to 27C. Sites installed outside this range shall be managed with reduced CRT, depending on the track condition.
- b) Sites shall be unclipped and refastened within the range of 21C to 27C between 1 January and 31 March.
- c) Ballast condition and ballast shoulders shall be maintained to LWR requirement.
- d) All other relevant standards shall be complied with.

3.1.6 Work prior to the Hot Weather Period - Short Rail sites

3.1.6.1 Temperature-induced stresses in short rails shall be controlled by providing adequate rail gaps and ensuring proper freedom for rail movements at the joints.

3.1.6.2 Rail gaps and rail temperatures shall be measured and recorded on the form shown in Attachment 7. These forms shall be completed prior to 31 March each year.

3.1.6.3 The total of all the rail gaps in each section of short rail track shall be recorded on the form shown in Attachment 7 for the six foot and cess rails separately.

3.1.6.4 Insulated rail joints shall be clearly indicated on the form shown in Attachment 7.

3.1.6.5 The total length of track and total expansion in each section of track shall be added up from this form and compared with standard S1159.

3.1.6.6 Where the total of existing expansion gaps is less than that shown in standard S1159, a rail shall be cut or a short rail installed before the hot weather period so that adequate expansion is obtained.

- 3.1.6.7 If there are more than six consecutive joints, including insulated rail joints, without expansion, the rails shall be adjusted before the Hot Weather Period ("10-10" joints to count as one joint only).
- 3.1.6.8 Where the total of existing expansion gaps for any length of rail is the same or more than that shown in standard S1159, the gaps shall be adjusted if necessary to make them evenly distributed.
- 3.1.6.9 In March in 'even' years fishplates shall be removed and the fishing angles of the plates and rails cleaned and oiled and the rail ends examined for fractures, and the joint re-assembled.
- 3.1.6.10 In March in 'odd' years fishplates shall be slackened and knocked loose, and then re-tightened.
- 3.1.6.11 When re-laying or adjusting short rails with the use of expansion irons, expansion irons shall be provided in sets of the following thicknesses: 1.5mm; 3.0mm; and 6.0mm. Expansion irons may be combined to achieve the different thicknesses required.
- 3.1.6.12 When re-laying or adjusting short rails or re-sleepering, expansion irons shall be used over the applicable range of rail temperatures shown in Table 3.

Table 3: Adjustment of joints using expansion irons	
Rail temperature For 18.3m or 36.6m rails	Use expansion irons of thickness:
above 35C	Nil
34C to 28C	1.5mm
27C to 21C	3.0mm
20C to 13C	4.5mm
12C to 5C	6.0mm
4C to -1C	7.5mm
-2C to -8C	9.0mm
below - 9C	10.5mm

- 3.1.6.13 Table 3 assumes that rails are free to expand and contract only over the 9m adjacent to a joint. The middle half of a 36.6m rail is assumed not to expand or contract.
- 3.1.6.14 Where rail creep in jointed track is known to occur, the expansion gaps shall be regulated or adjusted and then action taken to prevent further rail creep by installing rail anchors. Rail anchors shall be installed hard against the chair or baseplate with the hook end in the four foot and should be placed at closer intervals at the running-on end of each rail than in the middle and at the running-off end.
- 3.1.6.15 If a short-rail site is disturbed by work on an abutting site, the affected track shall be assessed and, if necessary, gaps adjusted.

3.1.7 Work prior to the Hot Weather Period – conductor rail

- 3.1.7.1 Steel conductor rails shall be inspected prior to 31 March each year to ensure that the following conditions are met:
- rails shall be able to expand or contract freely at both ends;
 - anchors shall be in good condition and securely fastened in accordance with S1164;
 - sleepers carrying the anchors shall be well-packed and, if timber, securely strutted;

- d) insulators shall be more than 300mm away from welds, bonds or other conductor rail attachments;
- e) bonds between rails and out-of-gauge rails shall be in positions which allow for expansion;
- f) fiddles shall accommodate expansion without making contact with switch gear;
- g) nuts and bolts on anchors shall be kept oiled;
- h) where insulators are fitted with metal caps, the caps of the six insulators at each end of each rail shall be greased to allow easy movement of conductor rail ends;
- j) the conductor rail shall be clear of the ears of the insulators. Insulators shall be changed or the conductor rails crowded, so that this requirement is satisfied prior to the hot weather period.

3.1.7.2 Composite conductor rails shall be inspected prior to 31 March each year to ensure that the following conditions are met:

- a) rails shall be able to expand or contract freely at both ends;
- b) anchors shall be in good condition and securely fastened in accordance with S1164;
- c) insulators shall be more than 300mm away from welds, bonds or other conductor rail attachments.

3.2 Limitations when undertaking track maintenance during hot or cold weather

- 3.2.1 Planned track maintenance work, especially that which potentially destabilises the track (e.g. tamping and lining, or ballast or sleeper replacement), is normally carried out in engineering hours, when rail temperatures are unlikely to create any immediate risk of track buckling. However, those responsible for planning the work shall consider any risks which may arise from high rail temperatures during the following days. In particular, the possibility of the rail temperature exceeding the CRT (which may be lower as a result of the work – see section 3.5) shall be allowed for.
- 3.2.2 In the event that work of an emergency nature has to be undertaken during traffic hours in hot weather, suitable mitigation in the form of a Watchman or speed restriction shall be applied according to the rail temperature and any altered CRT.
- 3.2.3 Track renewal work may be carried out regardless of rail temperature, but an appropriate CRT for the site shall be determined and action taken to protect traffic as necessary after re-opening of the line.
- 3.2.4 Tamping and lining done at the time of track renewal is not limited. Where rail temperature exceeds 32C and/or there is a probability of the rail temperature rising above 38C within the three days following tamping, follow-up or maintenance tamping and lining of plain line CWR and LWR sites may take place only where a risk assessment indicates a net benefit compared with leaving the track in its existing condition.

The risk assessment must be reviewed and agreed by the responsible Track Manager / Zone Infrastructure Manager. Where the assessment indicates tamping should be undertaken, wherever practicable the operation should be carried out at night when rail temperature is lower.

Notes for guidance:

As a minimum a risk assessment carried out to satisfy the requirements of clause 3.2.4 should take account of:

- a) track configuration and traffic speed (for example, track disturbance to bullhead track on higher speed routes introduces significantly more risk than disturbance to concrete sleeper track on lower speed sections);
- b) any deficiencies in ballast condition and profile, and track support (which increase the risk of distortion if tamping work is carried out);
- c) the current geometrical condition of the track especially where alignment is poor and/or deteriorating (increasing the risk of distortion if corrective work is not executed);
- d) the degree of track deterioration likely if the work was to be cancelled and re-planned for a future date when access is available;
- e) the extent to which the work will lower the Critical Rail Temperature and consequently:
 - I) require resource to carry out track monitoring where rail temperature exceeds CRT(W);
 - II) disrupt train services by speed restrictions imposed to mitigate the risk of track distortion where rail temperature exceeds CRT(25).

3.2.5 The following processes may be carried out at any time:

- a) tightening down chair or baseplate fastenings;
- b) renewing chair or baseplate fastenings one at a time;
- c) shimming fishplates.

3.2.6 In the case of CWR and LWR, no maintenance work which will affect rail stress shall be carried out without completing the form in Attachment 8 and having it approved by an authorised person.

3.2.7 In the case of short-rail track, when re-sleepering or spot reballasting is carried out during the hot weather period joints and ballast conditions shall be monitored until the track concerned has been fully boxed in.

3.2.8 If it is necessary to disturb the shoulder ballast profile during the hot weather period the following shall be complied with:

- a) track shall be in good alignment with all sleepers tightly packed with ballast;
- b) expansion gaps at rail joints shall be in correct adjustment over the length of the site plus a further five rail lengths either side;
- c) BH rail shall be steel keyed for the length of the work plus a further five rail lengths either side.

3.2.9 Unless subject to a site-specific work management plan setting out risks and appropriate mitigations, work which reduces the stability of CWR or LWR shall not be undertaken when the rail temperature is at or below -7C, or at or below 0C and falling, or if the ballast is frozen.

3.2.10 Guidance on precautions to be taken in cold weather is set out in Attachment 11.

3.3 Precautions during hot weather period - Measuring and recording rail temperature

- 3.3.1 During the Hot Weather Period, rail temperatures shall be measured every two hours between 1100 hours and 1500 hours at a number of locations (nominated by an authorised person) throughout the LU system and reported to the Fault Reporting Centre.
- 3.3.2 Where site-specific rail temperatures need to be taken, consideration shall be given to features such as cuttings, embankments and bridges, and to the effect of shade and wind.
- 3.3.3 Thermometers shall be placed on the shaded side of the rail if they could give misleading readings on exposure to direct sunlight.
- 3.3.4 Sufficient time as specified by the manufacturer shall be allowed after placing a thermometer before taking the initial reading (see TOP 02-02 Measurement of Rail Temperature).
- 3.3.5 An approved automated system may be used to measure and record rail temperatures.
- 3.3.6 Thermometers shall be of an approved type and shall be calibrated in accordance with the approval.
- 3.3.7 Unless otherwise specified in approval documentation, thermometers shall be checked twice a year in accordance with standard S1171.

3.4 Precautions during hot weather – short-rail track

- 3.4.1 Patrolling shall be carried out if the rail temperature reaches 35C by 11.00 hrs and is still rising or if it reaches 37C at any time. If it is impractical to carry out patrolling on foot (e.g. owing to lack of access during traffic hours), cab-riding is permitted subject to its effectiveness and practicability; if cab-riding is considered ineffective or impractical a speed restriction of 25 mph shall be imposed.

3.5 Precautions during hot weather – CWR and LWR – Critical Rail Temperature

- 3.5.1 The critical rail temperature is the rail temperature at which precautionary measures shall be taken. Two CRT levels shall be used:
 - a) CRT(W) : a Watchman shall be placed to monitor the site or length of track concerned in accordance with clause 3.6.
 - b) CRT(25) : a 25mph speed restriction shall be applied. On ATO lines an appropriate speed code shall be applied.
- 3.5.2 The CRT shall be calculated by using the values set out in Tables 4, and 5 based on a knowledge or assessment of the actual SFT. If the SFTs of the two rails are different, the lower SFT value shall be used.
- 3.5.3 The SFT value may be derived as follows:
 - a) From Stressing Records: a loss of original SFT of 3C shall be allowed for.
 - b) Or, using an approved direct measurement method.
- 3.5.4 When an 18.3m closure rail is installed the SFT may be considered as unaltered provided that the surrounding rail is reinstated to tell tale datums.

Note: Repeated use of 18.3m closure rails may lead to a loss of SFT.