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Adjusting Plain Line Jointed Rail

ETM-06-11

Applicability

ARTC Network Wide SMS

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1.0	02 Mar 21		Document renumbered from ETW-01-04, reclassified as procedure and document owner updated.

Table of Contents

1 Introduction

1.1 Purpose

This Procedure details the methods necessary to measure and adjust jointed rail to ensure the track is in correct adjustment to provide a stress free rail condition at design stress free temperature.

1.2 Scope

This Procedure outlines the requirements and procedure for stressing Jointed Rail track on ARTC network.

1.3 Relevant Procedure

This Procedure is complimentary to or expands on:

- ARTC Track and Civil Code of Practice (T&C CoP) Section 1 – Rail, and its supporting documents
- ARTC T&C CoP Section 6 – Track Lateral Stability, and its supporting documents.

1.4 Responsibilities

The General Manager, Technical Standards is the owner of this document. Queries should be directed to standards@artc.com.au in the first instance.

The Team Manager/Project Manager is responsible for the implementation of this procedure.

The Team Leader/Work Group Leader/Project Supervisor is responsible for managing the process and ensuring that all necessary reports are completed.

1.5 Reference Documents

This Procedure should be read in conjunction with the following documents:

- ETE-00-01 Calibration of Track Inspection and Testing Equipment
- ETE-01-03 Non-Destructive Testing of Rail (for Internal and Surface Defects)
- ETM-01-01 Rail Weld Geometry Standard
- ETN-01-01 Installing CWR at Design Stress Free Temperature.

1.6 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Anchor length	The lengths of CWR track beyond the ends of the stressing length, which are monitored during stressing, to manage any rail movements that occur at the outer ends of the stressing length.
Anchor point	The interface location between the stressing length and the anchor length. The anchor point sleeper is the first sleeper in the anchor length.
Ambient	Air temperature i.e. NOT rail temperature

Term or acronym	Description
Compression	The force generated in CWR when rail temperature increases above the stress free temperature, and the rail cannot expand.
DSFT (Design Stress Free Temperature)	The design temperature at which there is no longitudinal stress in the rail, also known as Design Neutral Temperature (DNT).
Extension gap	The amount by which the rail in a stressing length and at a particular rail temperature must be extended with a tensor to be stress free at the design SFT.
Fixed point	A section of track which offers greater resistance to longitudinal rail movement than elsewhere for example through a turnout, road crossing or transom bridges
Free weld	A weld formed without the use of a tensor, and without stressing the rail.
LWR (Long Welded Rail)	Track where the rails are welded into lengths of 55m to 400m, with the ends of these lengths connected by mechanical rail joints.
Jointed Track	Rails that can move through the rail/sleeper fastenings and which have standard joints with 6mm gap installed at neutral temperature. Rail adjustment is assessed using gap and temperature measurements.
Natural/Neutral Stressing	The clipping down of rail, without tensors being used, when the rail temperature is within the permitted limits for SFT.
Pulling length	The distance from the pulling point to the anchor point.
Pulling point	The location at which the rail is to be cut for stressing, a pulling force applied by a tensor, and rail extension calculated.
Rail Temperature	The average of temperatures recorded on the web of the rail, on the shaded side, as measured by several thermometers.
Reference point	A location where the stressing length is monitored to ensure correct extension and contraction during stressing.
Relaxing the rail	The process of releasing and vibrating the rail, until it is in a stable, stress free state.
Stress free	Rail which is neither in compression nor in tension.
Stressing length	The length of rail which is to undergo stressing.
Tell-tale Inner tell-tale (ITT) Outer tell –tale (OTT)	A reference point located at the end of an anchor length. The tell-tale inside the stressing length adjacent to the anchor point. The tell-tale at the opposite end of the anchor length to the anchor point.
Tensor (or rail tensor)	A hydraulic pulling device for extending or holding rails during stressing. For this instruction a set of tensors refers to sufficient equipment to tension both rails at the same time.
Tensor Stressing	The process of stretching rail with rail tensors so that the stress-free temperature of the rails is at upper permitted limit for SFT.
Thermal stressing	Method of stressing where the rails are heated to the upper permitted limit for stress free temperature and secured.
Weld gap	The gap between rail ends required for formation of an aluminothermic weld.
Vibrating or rattling the rail	Hammering the web of the rail over the entire stressing length, to induce rail movement towards a stress free state

1.7 Equipment

Required equipment for stressing includes:

- Tools for fastening and unfastening track
- Consumables and gear for welding
- Tensor with tonnage or pressure gauge
- Measuring wheel to mark out stressing lengths and anchor lengths
- A minimum of four calibrated rail thermometers.

2 Specification

2.1 Qualifications

The person in charge of stressing shall hold a valid Certificate of Competence for adjusting rail or equivalent.

2.2 Design Stress Free Temperature

Design SFT shall be as per Section 5 Appendix 1a and 1b.

2.3 Adjustment Temperatures

2.3.1 Work Planning

During hot weather, stressing should be planned for completion either in the early morning (before rail temperature reaches design SFT), or in the evening (when rail temperature falls below design SFT).

2.3.2 Measuring Rail Temperature

Check Rail temperatures by placing a thermometer on the shady side of the rail.

Approved thermometers or other rail temperature measuring devices shall be calibrated in accordance with ARTC Standards for Calibration of Track Inspection and Testing Equipment.

As a minimum, three readings must be taken for each stressing length:

- Near the pulling point
- Near both anchor lengths.

The readings from each thermometer are averaged.

In addition, the thermometers being used should be placed on the rail together prior to commencement of stressing to compare the readings. If one reads different then it shall not be used. Spare thermometers shall be kept to replace any thermometer that reads incorrectly.

2.3.3 Minimum Rail Temperature to Adjust

The minimum rail temperature for adjustment depends on rail length, rail size and how the rail is fastened. The procedures in this instruction relate to standard rail lengths (220/250m in straights and large radius curves and 110/125m in sharper curves). These lengths cannot be adjusted with rail tensors at rail temperature below 10°C.

These limits are set to ensure that the rail tensors are not over stressed.

Adjusting outside these limits may overstress the tensors and lead to failure and serious injury.

On curves with resilient fastenings, rails may pull sideways out of plates because there is nothing to hold them.

On long adjustments rails must be vibrated excessively to pull up.

Restraining strap must be placed on the rail tensors to prevent arms from “springing” if the tensor lets go.

If it is necessary to adjust rails below 10°C, the rail lengths MUST be shortened to a length that can be adjusted safely.

2.3.4 Maximum Rail Temperature to Adjust

In Jointed Rail the maximum rail temperature depends on the rail length. Since you cannot put the rails in compression by pushing them apart the maximum adjustment temperature will be the rail temperature at which the joint gaps will be zero in correctly adjusted rails.

2.3.5 Varying Rail Temperatures during Adjustment

If design SFT is exceeded during stressing, the pulling point should be plated and stressing deferred until the rail temperature is lower.

If rail temperature is varying significantly during stressing, the thermometers should be monitored frequently, and the stressing calculations continually adjusted to suit.

2.4 Stressing Through Joints

2.4.1 Mechanical Joints (MJs)

The stressing length and anchor lengths must not contain any mechanical joints.

2.4.2 Glued Insulated Joints (GIJs or IRJs)

Stressing may be carried out through glued insulated joints in good condition.

It is preferable that such joints be located within, or close to, the anchor lengths, to reduce longitudinal movement and keep the joints centrally located between sleepers.

The condition of the joint should be checked after the adjustment has been completed. Joint failure by pull-apart may become an issue if the track is adjusted at low temperatures.

2.5 Check Alignment

Prior to adjusting any rail on curved track, the track alignment should be reviewed. Any requirement for alignment correction should be reviewed by the Delivery Manager or nominated representative before the commencement of work.

Before and after alignment measurements must be taken and recorded.

2.6 Adjustment Length

Adjustment is restricted to 220m on straights (maximum pulling length 110m) and shallow curves and 110m on curves sharper than 600m radius (maximum pulling length 55m). This is restricted because jointed track has maximum rail lengths of 220m if adjustment is to be assessed with confidence.

2.7 Measurement Considerations

2.7.1 Measure the gap, with rail gap gauge or tape where rail ends are the closest

Take care not to include any lipping as part of the gap measurement and ensure that this is removed before the joint is set.

2.7.2 What Gaps are to be measured?

All gaps are to be measured in mechanical joints. Glued insulated joints, mechanical insulated joints, swage fastened insulated joints and joints in a turnout are not to be measured, only the joint before and after the turnout.

All joints except mechanical joints must be secure.

2.7.3 What is the best temperature for measurement of rail gap?

Rail gaps must be open (more than zero) but not fully open (less than 13mm) to be sure that the measurement is correct. The best temperature to measure at will depend on the rail length.

2.7.4 What happens if the rail gaps are closed?

If the rail gaps are closed and cannot be measured, you have no way of knowing how far the rail is out of adjustment.

If this happens, you must return when the rail temperature is lower, when there is a gap and measure and record the rail gaps and the rail temperature again.

2.7.5 What happens if the rail gaps are open?

If the rail gaps are fully open (13mm or more if bolts are bent and bolt holes worn), you have no way of knowing how far the rail is out of adjustment. You must return when the rail temperature is higher, when the gap is less than fully open, and measure and record the rail gaps and the rail temperature again.

This is the only way the rail adjustment can be correctly assessed.

2.7.6 What about frozen joints?

The joints may be frozen (i.e. not moving) and so it would not be possible to measure the gaps correctly. The joint needs to be repaired before the gap can be measured.

It is very important that the gaps are measured correctly for adjustment analysis.

2.8 Field Welding for long welded track

2.8.1 Associated Track work

When converting short rail lengths to Jointed Rail, the condition of the track structure is important. Ballast, ties, rails, fastening and track geometry all interact to provide safe stable track.

Ballast profile must be to the standard required of welded track.

Fastenings (dogs, anchors, resilient fastenings, insulators and sleeper plates) must be in good condition and correctly applied.

Sleepers must be in good condition to hold the track in position when interacting with the ballast and to hold track to correct gauge.

2.8.2 Method of Welding

Welding into long welded lengths is carried out on a face in one direction.

Generally, both UP and DOWN rails should be welded as the welded work along the face.

Free welding must be carefully staged to address any variations in temperature in order to prevent misalignment of unadjusted track.

2.8.3 Temperature Restrictions

Welding into long lengths must not be carried out if the rail temperature is higher than the rail temperature at which the rail length you are welding will close.

If the rail temperature is lower than 10°C, adjustment is only possible in short lengths. Welding into 220m lengths (110m in sharp radius curves) must not be carried out if the rail temperature is lower than 10°C.

The temperature restrictions do not apply if thermal stressing.

2.9 Using Rail Tensors with Welding

When using rail tensors ensure the correct type and loading is used, restraining strap must be placed on the rail tensors to prevent arms from “springing” if the tensor lets go.

2.9.1 Delay after Welding

When welding is required as part of the adjustment process, a time delay of 20 minutes must be allowed after the excess head metal has been removed from the weld to allow it to cool and gain strength, before rail tensors are operated to pull the rail ends at the joint together.

2.9.2 Punch Marks and Tensors

If tensors will be installed with saddle (yoke) over the rail head and adjustment is being maintained using punch marks, measurement of the distance between punch marks may be difficult. When installing closures measure and record the distance between punch marks after removing the rail section, then, after the first weld, transfer the change in measurement to new punch marks across the remaining gap and within the tensors.

Example:

Original distance between punch marks 5,000mm

Distance after removing rail section 5,020mm

Change in distance +20mm

Transfer to new punch marks 200mm + 20mm = 220mm

Final measurement to be 200mm ± 3mm.

2.10 Checking Rail Movement

Quarter points are established to ensure even tensioning when “pulling up” the rail.

Establish quarter points ¼, ½ and ¾ of the distance from each anchor point towards the adjustment point using measuring wheel and placing reference marks on the rail foot and sleeper plates (or sleepers) with chalk or permanent marker. If the rail length between anchor points is less than 110m, it is only necessary to mark ½ points.

Check progress of tensioning along the rail by comparing the movement against the reference marks. The fully tensioned length will have moved ¾ of the appropriate extension for the length at the first marker from the tensor ½ at the next and ¼ at the third.

The correct extension for the length between the tensor and one anchor point is half of the specified adjustment gap. Additional vibration is to be given to any section of insufficient movement until correct adjustment is achieved as near as practically possible.

Note: If ¼ points do not show the same movement on both sides, check for reasons why and fix – i.e. sleepers twisted, plate lock or anchors on, then continue vibrating till an even result is obtained.

On no account must welded rails be bumped back into position by striking the rail end or by driving a wedge in the expansion gap.

2.11 Replacing Anchors and Fastenings

To achieve effective anchoring the following points must be remembered:

- Maintain the standard anchor pattern. (i.e. box anchor every second sleepers for 32 ties at mechanical joints and box anchor every fourth tie along the rail). Standard anchor Additional anchors are sometimes installed to control creep on steep grades
- Make sure the anchors fit hard against the sleeper
- Make sure the anchors are not overdriven. Overdriving anchors will ‘spring’ them (destroy spring action) and make them ineffective
- Monitor rail creep by punch marking rails in relation to fixed points.

For effective anchoring with resilient fastenings (e.g. Pandrol and Traklok clips):

- Do not overdrive clips
- Replace any “sprung” clips.

3 Procedure

3.1 Adjustment Methods

The following processes provide methods to control the adjustment of rail in the installation and maintenance of welded and non-welded track. Maintenance of adjustment to be carried out at the design stress free temperature the track was installed.

3.1.1 Anchor Length

The anchor length is a monitored section of well fastened track, intended to minimise the amount of rail movement into or out of the stressing length during stressing. The anchor length is a minimum 32 sleepers outside the area to be adjusted and is created on either side of the rails to be adjusted.

3.1.2 Anchor Point

The Anchor Point is the first fastened sleeper beyond the end of the stressing length.

When an adjustment has been completed the anchor points can be removed, or reversed and next section adjusted.

Remove the anchor point at the start of the first length adjusted and reverse the anchor point at the end, so that it becomes the starting point for adjustment of the next length.

The new anchor point is to be established before removing the old anchor point. This is necessary to avoid the possibility of the unadjusted rail section being drawn into the adjusted rail section, destroying the adjustment.

Common anchor points are NOT to be used, since this would result in short sections of unadjusted track. This is particularly important in resilient fastened track and has been the cause of numerous misalignments.

3.1.3 Vibrating Rails

Remove any resilient fastenings/anchors between anchor points.

Anchors or resilient fastenings restrict or stop longitudinal movement (creep) of rails i.e. lock rails to sleepers, therefore they must be removed – not just loosened.

On curves with elastic fastenings, to prevent the rail from rolling in, reinstall one clip on the outside of the curve every 25 sleepers. This clip is to be installed without the shoulder insulator in place.

Vibrating the rail to ensure a stress free condition is an important aspect of the stressing process.

Vibrating the rail involves tapping the web of the rail over the entire stressing length. Vibration is to continue until there is no more rail movement.

The head of the rail must not be hammered, as fractures may occur in the rail.

3.1.4 Method of adjustment of Jointed Rail at single joints

This is the standard method for the adjustment of Jointed track by measurement and adjustment at a single joint. The method is also used when increasing rail lengths by free welding intermediate joints.

1. Check rail temperature to ensure it is within allowable range for adjusting rail.

In Jointed Rail, the rail length determines the maximum rail temperature at which adjustment can take place. You cannot adjust after the joint closes up.

2. Determine Adjustment point and Mark Anchor Points.
3. Create anchor points at points A and C (110m either side of joint B).

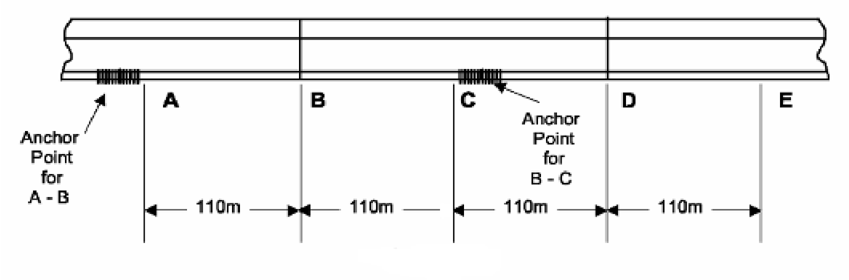

Figure 1

4. Remove fishbolts and check joint for condition and free movement. Replace bolts in one end only so the rail can move freely (i.e. Butterfly the Joint).

   Remember – the joint will be left in the track so the joint must be broken apart and inspected for any defects, i.e. elongated holes, cracked rail, cracked plates, bent bolts. If necessary, renew the joint.

5. Oxy cut the rail a minimum of 4.0m from the joint.

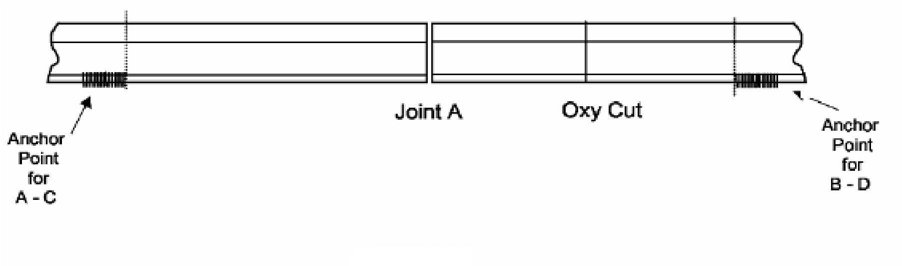

Figure 2

6. Remove any resilient fastenings/anchors between anchor points.
7. Vibrate rail, anchor point to anchor point to relieve the stresses and to make the rails stress free, ready to be adjusted.
8. Measure the rail gaps at the joint and at the oxy cut after vibrating is complete and record the figures.
9. Measure the rail temperature.
10. Calculate and record correct total gap required for Jointed Rail.
11. Cut the rail to achieve the correct gap.

    Note: If, after vibrating the rails, the rail ends opened up to more than the required gap (+ welding gap), steel must be added by welding in another closure.

12. Weld the oxy cut rail ends.
13. Establish quarter points.
14. Attach rail tensors around the joint and pull the rail ends at the joint together while vibrating.
15. Check progress of tensioning along the rail.
16. When the bolts will fit through plates, replace bolts and tighten.

17. Replace fastenings/anchors.
18. Remove rail tensors.
19. Remove anchor points.

3.1.5 Method of adjustment of Jointed Rail at more than one joint

This is the standard method for the adjustment of Jointed Rail track by measurement and adjustment at multiple joints.

It is possible to adjust more than one joint at a time as long as the maximum adjustment length is not exceeded.

This method is used for rail lengths between 24.7m and 110m.

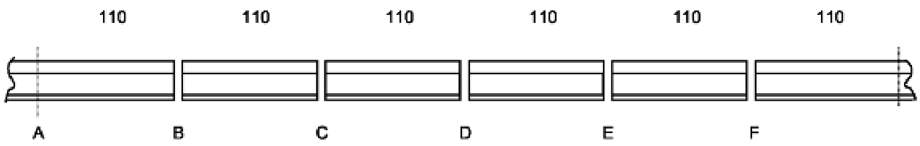

Figure 3

In the figure above Joints “B” and “C” can be adjusted together.

1. Check Rail temperature to ensure it is within allowable range for adjusting rail.
2. Determine the adjustment point and mark anchor points. The adjustment point will be halfway between the anchor points.
3. Create anchor points on either side of the area to be adjusted i.e. at points AP midway between “A” – “B” and “C” – “D” giving us a 220m length with 2 joints to adjust.

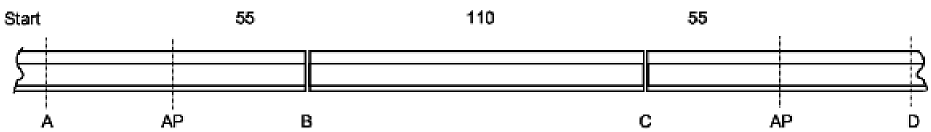

Figure 4

4. Check joints for condition and free movement. Replace bolts in both ends of joints but do not tighten.

   Remember – the joint will be left in the track so the joint must be broken apart and inspected for any defects, i.e. elongated holes, cracked rail, cracked plates, bent bolts. If necessary, renew the joint.

5. Oxy cut the rail midway between joints “B” and “C” – this will be the adjustment point.

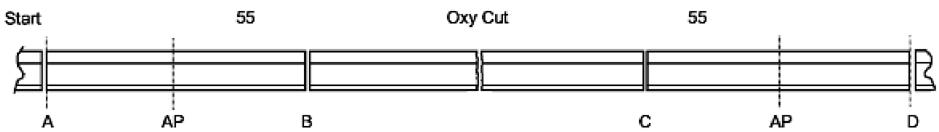

Figure 5

6. Remove fastening/anchors between anchor points.
7. Vibrate rail, anchor point to anchor point to relieve the stresses and to make the rails stress free, ready to be adjusted.
8. Measure the rail temperature.
9. Measure and sum up the rail gaps at the joints and at the oxy cut, after vibrating is complete and record the figures.
10. Calculate and record correct gap required.

    To calculate the total gap required, remember that the rail gap table only takes into account one joint in the total length to be adjusted. We have to add 6mm for every joint being adjusted after the first.
11. Cut the rail to achieve the correct gap.
12. Attach rail tensors around the oxy cut rail ends and pull to required welding gap while vibrating and checking quarter points to ensure even movement.
13. Install Aluminothermic weld at the oxy rail ends.
14. Reinstall fastenings/anchors to minimum standard anchor pattern, and ensure bolts are tight at Joints “B” & “C”.
15. Remove rail tensors.
16. Anchor points can now be removed or reversed and next 220m section adjusted.

3.2 Measurement of rail adjustment in Jointed Rail

3.3 Measurement of adjustment

At best rail gaps can only be an indication of satisfactory rail adjustment. It is, however, an indication that can and must be used to advantage.

The amount of expansion or contraction of rail depends on its length as well as changes in temperature. A standard rail joint is open 6mm at the design stress free temperature. It will be fully open at 13mm and closed at 0mm.

Remember not to try to measure rail gaps outside the recommended temperature range.

Rail gaps must be open (more than zero) but not fully open (less than 13m) to be sure that the measurements are correct.

Rail adjustment in jointed rail is assessed by measuring rail temperature and rail gaps, then comparing these values to the jointed Rail Gap Tables in appendix 1 (a & b).

3.3.1 At One Joint in Jointed Rail

1. Check Rail Temperature.
2. Check fish plates are on, bolts in good condition and the joints are effective (not frozen).

1. Measure the Gap.
2. If the joint gap is not the same as the required theoretical gap, the rails are not in correct adjustment.

3.3.2 At More than One Joint

This process is carried out to determine the state of the adjustment of longer sections of rail with more than one joint in the section, e.g. a 500m section of rail with 5 joints.

We can measure the state of the adjustment of the complete 500m.

Check WTSA requirements for the minimum joints for long lengths.

3.3.2.1 Where Joints are Equally Spaced

The principles are the same as measuring one joint, but now we must:

1. Determine the number of joints.
2. Determine how far apart the joints are (length of adjustment).
3. Take the rail temperature and measure actual joint gaps.
4. Add the actual joint gaps.
5. Multiply the number of joints by the theoretical gap (refer to the Rail Gap Tables).
6. Compare the total actual joint gaps to the total theoretical gaps to find out if the rails are:
   i. Correctly adjusted;
   ii. Incorrectly adjusted; or
   iii. Cannot tell the state of the adjustment (if the gaps are closed or fully open).

3.3.2.2 Where Joints Not Equally Spaced

Where odd lengths of rail exist in the section you are measuring for adjustment, the best way to measure the state of adjustment is as follows:

1. Determine the number of joints in the section of rail being measured.
2. Take the rail temperature and measure actual joint gaps.
3. Add the actual joint gaps.
4. Determine the theoretical gap for one (1) joint (that is assume the section of rail you are measuring has only one joint) (refer to the Rail Gap Table).
5. Add 6mm for every joint after the first to calculate total theoretical gaps required.
6. Compare the total actual joint gaps to the total theoretical gaps to find out if the rails are:

- Correctly adjusted;
- Incorrectly adjusted; or
- Cannot tell the state of the adjustment (if any of the gaps are closed or fully open).

4 Measure

4.1 Rail Gap calculations

The theoretical gap can be calculated from the following formula:

$TRG = RG_{DSFT} + \Delta T \; 0.0000115 \; L$

Where

TRG = Theoretical rail gap (mm)

RG_{DSFT} = Rail gap at DSFT (mm) (normally 6mm)

ΔT = Difference between the actual shade rail temperature and the DSFT (°C)

L = Rail length (mm)

4.2 Rail Gap Table

For 35^0C DSFT installations and rail lengths not shown in the tables, it will be necessary to use the formula in clause 4.1 to calculate the correct theoretical rail gap. The table for 38^0C DSFT is provided in appendix 5.1.1. See also clause 2.2.

5 Quality Management

5.1 Records

Records, containing the following information, should be kept for each stressing length:

- Name of person in charge
- Location of stressing length
- Rail temperature during stressing
- Pulling lengths
- Calculated gaps
- Required and achieved gaps at each reference point
- Pulling tonnage measured on the tensor immediately prior to replacing bolts and tightening; if excess tonnage is pulled then rattle the rail to ensure the rail is not binding along the stressing length
- Welding records.

Quality test records should also be kept:

- SFT measurement
- Weld geometry testing
- Weld ultrasonic testing.

5.1.1 Appendix 1a – Rail Gap Table for 38°C Design Stress Free Temperature

	JOINTED RAIL - ADJUSTMENT GAP SIZE (mm)								
	Rail Length (m)								
Rail Temperature °C	13.7	27.4	55	82	96	110	125	165	220
0	12	18	30	42	48	54	61	78	102
1	12	18	29	41	47	53	59	76	100
2	12	17	29	40	46	52	58	74	97
3	12	17	28	39	45	50	56	72	95
4	11	17	28	38	44	49	55	71	92
5	11	16	27	37	42	48	53	69	89
6	11	16	26	36	41	46	52	67	87
7	11	16	26	35	40	45	51	65	84
8	11	15	25	34	39	44	49	63	82
9	11	15	24	33	38	43	48	61	79
10	10	15	24	32	37	41	46	59	77
11	10	15	23	31	36	40	45	57	74
12	10	14	22	31	35	39	43	55	72
13	10	14	22	30	34	38	42	53	69
14	10	14	21	29	32	36	41	52	67
15	10	13	21	28	31	35	39	50	64
16	9	13	20	27	30	34	38	48	62
17	9	13	19	26	29	33	36	46	59
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22	9	11	16	21	24	26	29	36	46
23	8	11	15	20	23	25	28	34	44
24	8	10	15	19	21	24	26	33	41
25	8	10	14	18	20	22	25	31	39
26	8	10	14	17	19	21	23	29	36
27	8	9	13	16	18	20	22	27	34
28	8	9	12	15	17	19	20	25	31
29	7	9	12	14	16	17	19	23	29
30	7	9	11	14	15	16	18	21	26
31	7	8	10	13	14	15	16	19	24
32	7	8	10	12	13	14	15	17	21
33	7	8	9	11	12	12	13	15	19
34	7	7	9	10	10	11	12	14	16
35	6	7	8	9	9	10	10	12	14
36	6	7	7	8	8	9	9	10	11
37	6	6	7	7	7	7	7	8	9

5.1.2 Appendix 1b – Rail Gap Table for 38°C Design Stress Free Temperature

	JOINTED RAIL - ADJUSTMENT GAP SIZE (mm)								
	Rail Length (m)								
Rail Temperature °C	**13.7**	**27.4**	**55**	**82**	**96**	**110**	**125**	**165**	**220**
38	6	6	6	6	6	6	6	6	6
39	6	6	5	5	5	5	5	4	3
40	6	5	5	4	4	3	3	2	1
41	6	5	4	3	3	2	2	0	
42	5	5	3	2	2	1	0		
43	5	4	3	1	0	0			
44	5	4	2	0					
45	5	4	2						
46	5	3	1						
47	5	3	0						
48	4	3	0						
49	4	3							
50	4	2							
51	4	2							
52	4	2							
53	4	1							
54	3	1							
55	3	1							
56	3	0							
57	3	0							
58	3	0							
59	3								
60	3								
61	2								
62	2								
63	2								
64	2								
65	2								
66	2								
67	1								
68	1								
69	1								
70	1								
71	1								
72	1								
73	0								