



CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3] TRANSADELAIDE INFRASTRUCTURE SERVICES		
PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 1 of 21

TRACK AND CIVIL INFRASTRUCTURE

CODE OF PRACTICE

VOLUME THREE - TRAM SYSTEM [CP3]

RAIL STRESS CONTROL



CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3] TRANSADELAIDE INFRASTRUCTURE SERVICES		
PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 2 of 21

TABLE OF CONTENTS

	Page No.
1.0 PURPOSE AND SCOPE	4
1.1 Purpose	4
1.2 Principles	4
1.3 Scope	4
1.4 References	5
2.0 RAIL STRESS CONTROL.....	6
2.1 Track stability and safety	6
2.2 Control of track geometry	6
2.3 Design for stress control	6
2.4 Values of the neutral temperature on the TransAdelaide rail system	6
2.5 Measuring rail temperatures	7
2.6 Special locations	7
2.7 Rail stressing records	7
3.0 CONTINUOUSLY WELDED RAIL (CWR)	8
3.1 Scope	8
3.2 Track configuration	8
3.3 Rail stress adjustment	8
3.4 Limits	8
3.5 Methods of stressing	8
3.6 Checking that rails have not moved	8
4.0 LONG AND SHORT WELDED RAIL	9
4.1 Scope	9
4.2 Track configuration	9
5.0 JOINTED TRACK	9
5.1 Scope	9
5.2 Track configuration	9
5.3 Expansion gaps	9
6.0 HOT WEATHER RESTRICTIONS	10
6.1 Critical temperature	10
6.2 Limitations on track maintenance during hot weather	10
7.0 MONITORING AND MAINTENANCE	11
7.1 Inspection, assessment and maintenance actions	11
7.2 Rail creep.....	13
7.3 Rail creep and expansion gap monitoring	13
8.0 TRACK BUCKLES	14
8.1 Action to be taken	14
8.2 Assisting rail contraction.....	14
8.3 Reports of track buckles	14
9.0 DOCUMENTATION	15
9.1 Reports of track buckles	15
9.2 Rail stressing records	15
9.3 Rail creep and expansion gap monitoring	15



CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3] TRANSADELAIDE INFRASTRUCTURE SERVICES		
PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 3 of 21

A1.0	APPENDIX 1: DETERMINATION OF NEUTRAL TEMPERATURE	16
A1.1	Method determination	16
A1.2	Neutral temperature for TransAdelaide	16
A2.0	APPENDIX 2: CONTINUOUSLY WELDED RAIL – METHODS OF STRESSING	17
A2.1	Method of stressing	17
A2.2	Method 1 – Adjust rail stress	17
A2.3	Method 2 – Maintenance of current rail stress condition	18
A3.0	APPENDIX 3: STRESSING CHART (NEUTRAL TEMPERATURE 38°C) FOR OPEN TRACK	19
A4.0	APPENDIX 4: REPLACING RAIL	20
A4.1	Replace a rail – maintenance of the existing rail stress condition.....	20
A4.2	Reference points	20
A4.3	Replace a rail between two fishplated joints.....	20
A4.4	Replace a short length of rail (< 15m)	20
A4.5	An alternative procedure to replace a short length of rail	21

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 4 of 21****1.0 PURPOSE AND SCOPE****1.1 PURPOSE**

The purpose of this part is to set standards to ensure that:

- a) rail stresses in tram tracks are controlled for all track configurations;
- b) ballasted tram track are safely maintained to minimize the risk of buckling; and
- c) the affected track is restored to a stress controlled condition if buckling does occur.

1.2 PRINCIPLES

This part complies with the principles set out in the "Code of Practice for the Defined Interstate Rail Network", volume 4, part 2, section 1, Rails, and section 6, Track lateral stability.

1.3 SCOPE**1.3.1 Rail stress control**

This part specifies, for each of the configurations defined in CP-TS-980 (Track support systems), general procedures for the design/rating, monitoring and maintenance of rail stress control to provide track that is maintained:

- a) as near as practicable to a stress free condition within the nominated stress free temperature range;
- b) adequately to resist buckling at times of high rail temperatures;
- c) adequately to resist fracture of rail or fishplates at low rail temperatures; and
- d) during periods of high or low rail temperature in a manner not to jeopardise track stability.

1.3.2 Hot weather restrictions

This part specifies temperatures at which hot weather restrictions shall come into effect.

1.3.3 Managing buckles

This part specifies minimum action required if track buckling occurs.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES**

PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 5 of 21

1.4 REFERENCES**1.4.1 Industry codes of practice**

- a) Code of Practice for the Defined Interstate Rail Network, volume 4 (Track, Civil and Electrical Infrastructure), part 2 (Infrastructure Principles), section 1: Rail
- b) Code of Practice for the Defined Interstate Rail Network, volume 4 (Track, Civil and Electrical Infrastructure), part 2 (Infrastructure Principles), section 6: Track lateral stability.

1.4.2 TransAdelaide documents

Motorperson Training Program
CPRD/PRC/046 Records Management

1.4.3 TransAdelaide documents

- a) **Infrastructure Services Management System Procedure Manual**
QP-IS-501 Document and Data Control
- b) **CP2**
CP-TS-973: Part 3, Infrastructure management and principles
CP-TS-975: Part 5, Structural clearances
CP-TS-976: Part 6, Track geometry
CP-TS-980: Part 10, Track support systems
CP-TS-981: Part 11, Rails and rail joints

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 6 of 21****2.0 RAIL STRESS CONTROL****2.1 TRACK STABILITY AND SAFETY**

Although steel rails under normal circumstances would expand or contract with rise or fall of temperature, modern tram track uses long welded rails in which change in rail length is constrained by resilient rail fixings, which grip the rail and hence induce longitudinal stresses in the rails. Since the rails in compression resemble laterally restrained columns, there is a tendency for them to buckle and if they do, the safety of rail operations is affected. The measures described in this part minimize the possibility of buckling by limiting the longitudinal rail stresses and providing adequate lateral restraint to the track.

2.2 CONTROL OF TRACK GEOMETRY

To control track stability at times of high or low temperature, tram track shall comply with the track geometry standards shown in CP-TS-976 (Track geometry), and the track configuration standards shown in CP-TS-980 (Track support systems). Particular attention shall be given to the following.

- a) Restraint of longitudinal movement of rails shall be achieved by ensuring that:
 - 1) all rail anchors, where used, are in place and bearing against the the adjacent sleeper; or
 - 2) resilient fastenings are in place and conform with CP-TS-980 (Track support systems).
- b) Lateral deflection of tracks (i.e. buckles) shall be restrained by ensuring that ballast cross-sections comply fully with the standards shown in CP-TS-980 (Track support systems).

2.3 DESIGN FOR STRESS CONTROL

Rail track stability is affected by extremes of temperature due to the expansion and contraction of the rails at the highest and lowest temperatures to which they are subjected. To minimize this effect, rails shall be adjusted such that they are free of longitudinal thermal load at an intermediate temperature. This temperature is called the neutral temperature. The neutral temperature shall be chosen so that:

- a) the compressive load at the highest summer rail temperature will not buckle the rail; and
- b) the tensile load at the lowest winter rail temperature will not initiate tensile fractures.

2.4 VALUES OF THE NEUTRAL TEMPERATURE ON THE TRANSADELAIDE RAIL SYSTEM

The method of determining the neutral temperature is shown in Appendix 1. However, the neutral temperature on the TransAdelaide rail system shall be 38°C.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES**

PART 14: RAIL STRESS CONTROL	DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07
	Page: 7 of 21

2.5 MEASURING RAIL TEMPERATURES

- a) A thermometer shall be used for measuring the temperature of rails and shall be placed on the web of the rail on the shaded side.
- b) Allowance shall be made for variations due to cuttings, banks, shade, wind or other physical features that may affect rail temperature.
- c) At least ten minutes shall be allowed after placing the thermometer before taking the initial reading.

2.6 SPECIAL LOCATIONS

Track sections prone to (e.g. with a history of) lateral track instability or pull apart failures should be identified and managed as special locations in accordance with CP-TS-973 (Infrastructure management and principles).

2.7 RAIL STRESSING RECORDS

Details of rail stressing shall be recorded.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 8 of 21****3.0 CONTINUOUSLY WELDED RAIL (CWR)****3.1 SCOPE**

This section prescribes the requirements for the adjustment and maintenance of the longitudinal stress in continuously welded rail (i.e. where rails are in excess of 75m in length).

3.2 TRACK CONFIGURATION

Track laid with continuously welded rail shall be restrained from longitudinal movement in accordance with CP-TS-980 (Track support systems).

3.3 RAIL STRESS ADJUSTMENT

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

- a) new or recycled rail is being laid into the track.
- b) a stress check is being carried out.
- c) the rail adjustment is suspect, for example, due to the presence of :
 - 1) buckles
 - 2) break-aways/pull-aparts;
 - 3) mechanical joint failure;
 - 4) significant rail creep.
- d) significant changes in track alignment.
- e) the rail is cut and practices described in Appendix 4, sub-section A4.3 have not been used.

3.4 LIMITS

CWR that is being stress adjusted should be subject to the following limits:

- a) The adjustment length should not exceed 500m. Actual adjustment length may depend on track alignment, and the equipment and practices used to provide an even distribution of the adjustment over the adjustment length.
- b) Finished stress free temperature should be within $\pm 5^{\circ}\text{C}$ of the design neutral temperature.

3.5 METHODS OF STRESSING

Stressing shall be carried out in accordance with Appendix 2. During execution of either of these methods check measurements shall be taken to ensure that the process has been carried out correctly.

3.6 CHECKING THAT RAILS HAVE NOT MOVED

While carrying out the stress adjustment procedure it should be ensured that the rail outside the length being adjusted does not move. This may be achieved by checking against references set up at the isolation points.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 9 of 21****4.0 LONG AND SHORT WELDED RAIL****4.1 SCOPE**

Appendix 4 specifies for long and short welded rail (i.e where rails are between 15m and 75m in length) the actions required to:

- a) replace a rail between two fishplated joints; or
- b) replace a short length of rail (< 15m) welded into the track at each end or at one end if it is at one end of a longer rail.

4.2 TRACK CONFIGURATION

Track laid with long or short welded rail shall be restrained from longitudinal movement in accordance with CP-TS-980 (Track support systems).

5.0 JOINTED TRACK**5.1 SCOPE**

This section specifies the requirements for the adjustment and maintenance of the longitudinal stress in jointed track (i.e. where rails are in lengths of 12m to 15m with non-welded joints).

5.2 TRACK CONFIGURATION

Jointed track shall be restrained from longitudinal movement in accordance with CP-TS-980 (Track support systems).

5.3 EXPANSION GAPS

Rails in jointed track shall be laid or adjusted to provide a gap at the joints of 5mm when the rail is at the neutral temperature. The gap shall be increased by 1mm for each 7°C reduction in the rail temperature and decreased by 1mm for each 7°C increase in the rail temperature.



CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3] TRANSADELAIDE INFRASTRUCTURE SERVICES		
PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 10 of 21

6.0 HOT WEATHER RESTRICTIONS

6.1 CRITICAL TEMPERATURE

- a) Procedures prescribed in this sub-section apply whenever the air temperature reaches 38°C.
- b) If the Bureau of Meteorology forecasts the temperature for the day to exceed 38°C, work for that day shall be planned around the probability that the condition in clause (a) shall occur later in the day.
- c) Whenever the condition in clause (a) occurs, the following shall apply:
 - 1) A Competent Worker shall accompany selected trams. He shall inspect the track from the front of the tram and keep a lookout for track buckles, misalignments or early signs of a possible buckle.
 - 2) In the event of a track irregularity being detected, appropriate assessment and action shall be taken in accordance with CP3 and the TransAdelaide Motorperson Training Program.
 - 3) Monitoring of tracks shall continue until the condition in clause (a) no longer exists.

6.2 LIMITATIONS ON TRACK MAINTENANCE DURING HOT WEATHER

6.2.1 High temperatures

Whenever the condition in clause 6.1(a) occurs or the rail temperature reaches 45°C the following shall apply:

- a) all tamping and lining shall cease;
- b) the opening out of ballast cribs or shoulder ballast, jacking of sleepers, re-alignment of track and any work which requires removal of all the rail fastenings from the track shall not be carried out.

6.2.2 Taking rail temperatures during work

If on a day when maintenance work is in progress, the Bureau of Meteorology predicts a temperature for that day exceeding 28°C, rail temperatures shall be taken frequently between 11.00am and the end of the work period. If the rail temperature approaches 45°C, work shall be stopped and opened out cribs refilled immediately, full ballast shoulders restored, rails refastened, so that track is secure by the time 45°C is reached.



**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES**

PART 14: RAIL STRESS CONTROL**DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 11 of 21****7.0 MONITORING AND MAINTENANCE****7.1 INSPECTION, ASSESSMENT AND MAINTENANCE ACTIONS**

Inspection of track for rail stress control shall include the specific conditions shown in table 7.1:

Table 7.1: Rail stress control inspection, assessment and maintenance actions

Type of inspection or action	Specific conditions or actions to observe
Scheduled inspections	
Walking inspections	<p>a) Walking inspections should report obvious conditions (i.e. indicators of a defect) that may affect, or indicate problems with the lateral stability of the track including:</p> <ol style="list-style-type: none"> 1) poor track geometry such as lateral misalignments including “kicks” in tangent track and curved track sections with sharp or flat curvature; 2) rail breaks (i.e. excessive local tensile rail stresses contributing to pull-aparts); 3) indications of incorrect rail stress, for example: <ol style="list-style-type: none"> i. twists and wriggles in the rail at temperatures well below design neutral, which may indicate the rail is in compression; ii. marks on the rail indicating longitudinal movement of the rail (creep) through the fastening assemblies; iii. track movement such as gaps between sleepers and ballast (laterally and longitudinally); heaped ballast or skewed sleepers; 4) rail, weld and joint misalignment; 5) frozen joints and joint regulation for mechanically jointed track; 6) track structure changes particularly where the interface between two types of track structure may cause a significant change in restraint against rail creep, buckling strength or the temperature stresses induced in the track (e.g. a change from timber sleepers to concrete sleepers, a change in rail size, a change from plain track to a turnout or a change of fastening systems); 7) poor or deficient ballast profile; 8) poorly consolidated ballast; 9) wet and contaminated ballast/formation conditions; 10) generally poor ballast quality; 11) pumping sleepers or other signs of poor track support; 12) poor sleeper/fastening condition; 13) presence of fixed points, e.g. level crossings; 14) recent track maintenance activity; 15) light track structure for alignment and traffic conditions. 16) other obvious defects or conditions that may affect lateral track stability. <p>b) Terminal tracks should be inspected as part of walking inspections.</p> <p>c) Particular attention should be paid to conditions at special locations.</p> <p>d) The interval between these inspections shall not exceed 31 days.</p>



CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3] TRANSADLAIDE INFRASTRUCTURE SERVICES		
PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 12 of 21

Table 7.1 (continued): Rail stress control inspection, assessment and maintenance actions

Type of inspection or action	Specific conditions or actions to observe
Unscheduled inspections	
Hot or cold weather inspections	<p>a) Hot weather inspections shall in general be carried out in accordance with sub-section 6.1.</p> <p>b) Hot or cold weather inspections should be carried out on track sections which have been nominated as special locations (Special locations may extend over significant lengths of track particularly in the early part of the risk season):</p> <ol style="list-style-type: none"> 1) from walking inspections; 2) due to a history of temperature induced track misalignments; 3) due to conditions that have reduced the track's resistance to buckling, for example areas where maintenance of track may have significantly disturbed ballast consolidation (e.g. slewing, ballast cleaning, construction.) <p>c) At these locations rail temperature should be treated as a defined event until rectification or strengthening work is carried out. Ambient air temperature limits should be set at the rail temperature, which is estimated to be the minimum requiring an unscheduled walking inspection to be carried out. The temperatures that trigger hot weather walking inspections and the special locations requiring them should be reviewed as the risk season progresses, for example, consideration may be given to increasing the temperature limit as the hot weather season progresses. Standing or temporary operating restrictions may also be appropriate for some track structures and conditions at some locations.</p> <p>d) Inspections may also be necessary at times of extremely low temperatures in areas prone to lateral shift, pull-aparts (breakaways), curve pull-ins and mechanical joint failures. Such special locations should be treated in a similar way to buckle prone sections of track.</p>
Detailed inspections	<p>These inspections should be carried out to confirm the presence of suspected defects identified from track walking inspections or in response to reported track buckles, track shift or rail pull-apart defects (e.g. by train crews, Traffic Controllers where track circuits indicate rail failure or from hot weather walking inspections) to allow actions to be determined. The condition of the general track structure should be determined in terms of its contribution to the track lateral stability. Sections of track with identified reduced lateral stability should be recorded and managed as special locations until rectification or strengthening work can be carried out.</p>



**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES**

PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 13 of 21

Table 7.1 (continued): Rail stress control inspection, assessment and maintenance actions

Type of inspection or action	Specific conditions or actions to observe
Assessment, method of assessment, maintenance actions and response	<p>a) Following inspections, including those following a defined event, the track should be assessed to verify its capacity to provide adequate lateral stability. Where it is considered the track is inadequate, actions should be determined to manage the risk. This should occur in particular at special locations prone to track lateral stability failure, where significant changes in the condition of the track have been identified (i.e. its ability to deal with events up to the defined event should be assessed).</p> <p>b) Track elements and conditions affecting lateral track stability should be controlled in accordance with the practices described in sections 3.0 to 5.0 and the following parts of CP3:</p> <ol style="list-style-type: none"> 1) CP-TS-976 (Track geometry) – for track geometry; 2) CP-TS-980 (Track support systems) – for sleepers/fastening assemblies and ballast profiles; 3) CP-TS-981 (Rails and rail joints) – for rails and rail joints. <p>c) Prior to the high temperature risk period appropriate actions are to be undertaken such as re-stressing or rail joint adjustment. Rail stress assessment and, if necessary, adjustment, should be carried out when one of the following occurs:</p> <ol style="list-style-type: none"> 1) track buckle or significant heat misalignment; 2) pull-aparts or breakaways; 3) mechanical joint failure; 4) identification of excessive creep. <p>d) Where such defects and failures are detected the operation of trams should, as a minimum, be consistent with the actions for defects in other parts of CP3. Trams should be piloted through the site where necessary, taking into account factors including the following:</p> <ol style="list-style-type: none"> 1) Clearances with respect to structures and other running lines. 2) Track support conditions, in particular where the track has shifted. 3) Track geometry.

7.2 RAIL CREEP

Track construction types that are known to provide very good resistance to longitudinal rail movement (e.g. CWR track with concrete sleepers and resilient fastenings) may not necessitate rail creep monitoring and control measures. Practices for the measurement of rail creep shall be considered and take into account the influence on the track of fixed points, such as level crossings.

7.3 RAIL CREEP AND EXPANSION GAP MONITORING

Details of rail creep and expansion gap monitoring shall be recorded.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 14 of 21****8.0 TRACK BUCKLES****8.1 ACTION TO BE TAKEN**

In the event of a buckle occurring the following minimum actions shall be taken:

- a) Provision shall be made to ensure the safety of traffic including the imposition of a temporary speed restriction.
- b) Trams shall not be allowed to pass over the buckle if:
 - 1) it has moved sideways a distance which leaves one side inadequately supported. On track with a full ballast section in accordance with CP-TS-980 (Track support systems) this distance shall not exceed 300mm;
 - 2) it has buckled into a curvature less than 25m radius, as determined by measuring versines (the versine for a 25m radius curve on a 5m chord is 125mm; on a 10m chord is 500mm);
 - 3) it has lifted off its bed by more than 50mm at any point;
 - 4) the pantograph is likely to lose proper contact with the overhead conductor.
- c) In the event that the tram service is interrupted in accordance with clause 8.1(b), but the track can be slewed or modified to allow the service to resume, a temporary speed restriction shall be imposed provided the pantograph is not likely to lose proper contact with the overhead conductor.
- d) The action prescribed in clause 8.1(c) shall not be taken if clearances to structures in accordance with CP-TS-975 (Structural clearances) are compromised.
- e) Before the temporary speed restriction is removed, the track shall be restored to its design alignment and the track structure, including the ballast section, shall be finished to the requirements of CP-TS-976 (Track geometry) and CP-TS-980 (Track support systems). If necessary rail stressing shall be undertaken.

8.2 ASSISTING RAIL CONTRACTION

To accelerate the cooling of rails and assist buckled rails to contract, the rails may be sprayed with water from a knapsack spray.

8.3 REPORTS OF TRACK BUCKLES

Details of each buckle shall be recorded.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES**

PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 15 of 21

9.0 DOCUMENTATION**9.1 REPORTS OF TRACK BUCKLES**

Details of each buckle shall be recorded in accordance with CPRD/PRC/046 Records Management

9.2 RAIL STRESSING RECORDS

Details of rail stressing shall be recorded in accordance with CPRD/PRC/046 Records Management.

9.3 RAIL CREEP AND EXPANSION GAP MONITORING

Details of rail creep and expansion gap monitoring shall be recorded in accordance with CPRD/PRC/046 Records Management.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 16 of 21****A1.0 APPENDIX 1: DETERMINATION OF NEUTRAL TEMPERATURE****A1.1 METHOD OF DETERMINATION**

The neutral temperature may be determined by the following method:

- a) Determine the expected rail temperature range by subtracting the expected minimum rail temperature from the expected maximum rail temperature.
- b) Determine the upper limit of the design neutral temperature range by adding five sevenths ($5/7$) of the expected rail temperature range to the expected minimum rail temperature.
- c) Determine the lower limit of the design neutral temperature range by subtracting half ($1/2$) of the expected rail temperature range from the expected maximum rail temperature.
- d) The preferred design neutral temperature is in the higher end of the design neutral temperature range i.e three-quarters of the difference between the lower and upper limit of design neutral temperature added to the lower limit.

A1.2 NEUTRAL TEMPERATURE FOR TRANSADELAIDE

On the TransAdelaide system, the neutral temperature is determined using the method in sub-section A1.1 as follows:

- a) The maximum and minimum rail temperatures experienced on the Adelaide metropolitan rail system are 60°C and -5°C respectively. Thus the expected rail temperature range is 60°C minus -5°C equals 65°C .
- b) Five sevenths of 65°C equals 46.5°C hence the upper limit of design neutral temperature is -5°C plus 46.5°C equals 41.5°C .
- c) Half of 65°C equals 32.5°C hence the lower limit of design neutral temperature is 60°C minus 32.5°C equals 27.5°C
- d) The preferred design neutral temperature is then 27.5°C plus three quarters of $[41.5 - 27.5]$ equals $14 \times 0.75 = 10.5$, i.e. 27.5°C plus 10.5 equals 38°C .

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 17 of 21****A2.0 APPENDIX 2: CONTINUOUSLY WELDED RAIL – METHODS OF STRESSING****A2.1 METHODS OF STRESSING**

Stressing shall be carried out in accordance with this appendix. Two methods of stressing are described in clauses A2.2 and A2.3. During execution of either of these methods check measurements shall be taken to ensure that the process has been carried out correctly.

A2.2 METHOD 1 - ADJUST RAIL STRESS

The maximum adjustment length shall be 500 metres. Actual adjustment length will depend on equipment and practices used to ensure an even distribution of the adjustment over the adjustment length. Finished stress free temperature shall be within $\pm 5^{\circ}\text{C}$ from the design neutral temperature. The following principles shall be used:

- a) Select rail length to be adjusted to $\pm 1\%$.
- b) Establish isolation points so that rail outside of the length will not be affected by the process.
- c) Cut the rail and then establish the stress free condition between the isolation points by releasing the rail from the fastening system and vibrating it (e.g. by "rattling" the rail).
- d) Measure the shade rail temperature to $\pm 2^{\circ}\text{C}$.
- e) Either:
 - 1) Determine the extension or rail gap from the charts in (j) (if the rails are to be welded, the weld gap is to be added in determining the required stress free gap).
 - 2) Determine the extension or rail gap by the following equation: (but if the rails are to be welded ensure that the weld gap is taken into account in determining the stress free gap)

$$E = 1000.L. X. T$$

Where

E = extension in millimeters

L = length of free rail to be adjusted in metres

X = 0.0000115 = coefficient of thermal expansion for steel

T = difference between the shade rail temperature (actual) and the design neutral temperature in degrees Celcius.

- f) Measure the actual stress free gap to $\pm 1\text{mm}$.
- g) Carry out the rail length adjustment, for example, by:
 - 1) cutting the rails to achieve the necessary stress free gap (i.e. plus the weld gap);
 - 2) stretching the rails to close the gap to the necessary weld gap. This assumes that the rail is to be welded by the aluminothermic welding process. Where other welding processes are used the stress free gap will need to be specified.
 - 3) weld the rails.
- h) Refasten the rail.
- i) While carrying out the stressing procedure it is necessary that the rail outside the length being adjusted does not move. This shall be achieved by checking against references set up at the isolation (fixed) points.
- j) Charts showing the total of all rail gaps required are shown in appendix 3, for track where neutral temperature is 38°C .

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 18 of 21****A2.3 METHOD 2 - MAINTENANCE OF CURRENT RAIL STRESS CONDITION**

This method may be used where the length of rail to be stressed does not warrant the disturbance of the track required by a full stressing as detailed in sub-section A2.2. It shall be used primarily for the replacement of short sections of rail such as the replacement of insulated joints or defective rails and welds. The length of the rail to be inserted shall not exceed 15 metres. The following principles shall be used:

- a) This operation is best carried out when the rail temperature is between 33°C and 43°C.
- b) Reference (fixed) points shall be established on the rail outside the insert length prior to cutting. The distance between the reference points shall remain the same (ie within tolerance prescribed below) following the stressing procedure. This may be achieved either by direct measurement of the distance or by the use of independent datum points.
- c) Measurement of the length between the two reference points shall be made:
 - 1) prior to cutting the rail;
 - 2) after the rail has been welded into track.
- d) Comparison of these two measurements shall be within $\pm 2\text{mm}$.
- e) If the results of the measurements indicate that the rail adjustment is out of tolerance then the rail shall be readjusted in accordance with sub-section A2.2.



CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3] TRANSADLAIDE INFRASTRUCTURE SERVICES		
PART 14: RAIL STRESS CONTROL		DOC. NO. CP-TS-984
Issue: 1	Date: 22/10/07	Page: 19 of 21

A3.0 APPENDIX 3: STRESSING CHART (NEUTRAL TEMPERATURE 38°C) FOR OPEN TRACK

- DOES NOT INCLUDE WELDING GAP

Rail temperature °C [T]	Rail gap in mm																	
	Stressing length in m. ↘																	
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900
0	22	44	66	87	109	131	153	175	197	219	240	262	284	306	328	350	371	393
1	21	43	64	85	106	128	149	170	191	213	234	255	277	298	319	340	362	383
2	21	41	62	83	104	124	145	166	186	207	228	248	269	290	311	331	352	373
3	20	40	60	81	101	121	141	161	181	201	221	242	262	282	302	322	342	362
4	20	39	59	78	98	117	137	156	176	196	215	235	254	274	293	313	332	352
5	19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342
6	18	37	55	74	92	110	129	147	166	184	202	221	239	258	276	294	313	331
7	18	36	53	71	89	107	125	143	160	178	196	214	232	250	267	285	303	321
8	17	35	52	69	86	104	121	138	155	173	190	207	224	242	259	276	293	311
9	17	33	50	67	83	100	117	133	150	167	183	200	217	233	250	265	283	300
10	16	32	48	64	81	97	113	129	145	161	177	193	210	225	242	258	274	290
11	15	31	47	62	78	93	109	124	140	155	171	186	202	217	233	248	264	279
12	15	30	45	60	75	90	105	120	135	150	164	179	194	209	224	239	254	269
13	14	29	43	58	72	86	101	115	129	144	158	173	187	201	216	230	244	259
14	14	28	41	55	69	83	97	110	124	138	152	166	179	193	207	221	235	248
15	13	26	40	53	66	79	93	106	119	132	145	159	172	185	198	212	225	238
16	13	25	38	51	63	76	89	101	114	127	139	152	164	177	190	202	215	228
17	12	24	36	48	60	72	85	97	109	121	133	145	157	169	181	193	205	217
18	12	23	35	46	58	69	81	92	104	115	127	138	150	161	173	184	196	207
19	11	22	33	44	55	66	76	87	98	109	120	131	142	153	164	175	186	197
20	10	21	31	41	52	62	72	83	93	104	114	124	135	145	155	166	175	186
21	10	20	29	39	49	59	68	78	88	98	108	117	127	136	147	156	166	176
22	9	18	27	37	46	55	64	74	83	92	101	110	120	129	138	147	156	166
23	9	17	26	35	43	52	60	69	78	86	95	104	112	121	129	138	147	155
24	8	16	24	32	40	48	56	64	72	81	89	97	105	113	121	129	137	145
25	7	15	22	30	37	45	52	60	67	75	82	90	97	105	112	120	127	135
26	7	14	21	28	35	41	48	55	62	69	76	83	90	97	104	110	117	124
27	6	13	19	25	32	38	44	51	57	63	70	76	82	89	95	101	108	114
28	6	12	17	23	29	35	40	46	52	58	63	69	75	81	86	92	98	104
29	5	10	16	21	26	31	36	41	47	52	57	62	67	72	78	83	88	93
30	5	9	14	18	23	28	32	37	41	46	51	55	60	64	69	74	78	83
31	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
32	3	7	10	14	17	21	24	28	31	35	38	41	45	48	52	55	59	62
33	3	6	9	11	14	17	20	23	26	29	32	35	37	40	43	46	49	52
34	2	5	7	9	12	14	16	18	21	23	25	28	30	32	35	37	39	41
35	2	3	5	7	9	10	12	14	16	17	11	21	22	24	26	28	30	31
36	1	2	3	5	6	7	8	9	10	12	13	14	15	16	17	18	20	21
37	1	1	2	2	3	3	4	5	5	6	6	7	7	8	9	9	10	10
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: The above table determines the extension or total of all rail gaps required for correct adjustment of rails by the following equation:

$$\text{Extension ("E") in mm} = (L \times T \times 0.0115)$$

where L = the total length of free rail in metres

T = the rail temperature (actual) in °C

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 20 of 21****A4.0 APPENDIX 4: REPLACING A RAIL****A4.1 REPLACE A RAIL – MAINTENANCE OF THE EXISTING RAIL STRESS CONDITION**

The methods specified in this Appendix may be used where the length of rail to be adjusted does not warrant the disturbance of the track, which would be necessary in a full stress adjustment as detailed in Appendix 2.

A4.2 REFERENCE POINTS

During execution of this procedure, measurements should be taken to ensure that the process has been carried out correctly. Reference points should be established on the rail outside the insert length prior to cutting. Measurement of the length between the two reference points should be made:

- a) prior to cutting the rail;
- b) after the rail has been welded into the track.

The distance between the reference points should remain the same within $\pm 2\text{mm}$ following the stressing procedure. This may be achieved either by direct measurement of the distance or by the use of independent datum points.

A4.3 REPLACE A RAIL BETWEEN TWO FISHPLATED JOINTS

To replace a rail between two fishplated joints, the following principles shall be used:

- a) This operation is best carried out when the rail temperature is between 33°C and 43°C.
- b) Monuments shall be established near the ends of the rails outside the rail being changed to enable checks to be made on any movement that takes place (see g).
- c) Adjacent rails shall be well anchored in position with either trackspikes and rail anchors or resilient fastenings prior to removing the rail to be replaced.
- d) A rail puller may be used on one of the joints before removing the fishplates and slowly released to avoid sudden pull back.
- e) The rail to be replaced shall be removed and the replacement rail cut to the same length within $\pm 2\text{mm}$ when both are in the stress free condition.
- f) The rail puller shall be used to close the final rail gap before replacing the fishplates.
- g) While carrying out the stress adjustment procedure it is necessary that the rail outside the length being replaced either:
 - 1) does not move; or
 - 2) is restored to its original position $\pm 2\text{mm}$ by the use of the rail puller. This shall be achieved by checking against the monuments.

A4.4 REPLACE A SHORT LENGTH OF RAIL (< 15m)

For the replacement of short sections of rail e.g. insulated joints or defective rails and welds where the length of the rail to be inserted does not exceed 15 metres, the following principles shall be used:

- a) This operation is best carried out when the rail temperature is between 33°C and 43°C.
- b) Monuments shall be established near the ends of the rails outside the rail being changed to enable checks to be made on any movement that takes place.
- c) Adjacent rails shall be well anchored in position with either trackspikes and rail anchors or resilient fastenings prior to cutting the rail.

**CODE OF PRACTICE - VOLUME THREE - TRAM SYSTEM [CP3]
TRANSADELAIDE INFRASTRUCTURE SERVICES****PART 14: RAIL STRESS CONTROL****DOC. NO. CP-TS-984****Issue: 1****Date: 22/10/07****Page: 21 of 21**

- d) A rail puller may be used where the existing rail is to be cut and slowly released after the cut is made to avoid sudden pull back.
- e) The replacement rail shall be welded into the track at one end. The rail puller shall then be used at the other end to pull up the rail gap until the marks opposite the monuments are restored to their original position within $\pm 2\text{mm}$.
- f) If insufficient time is available to carry out the whole job between trams, a rail may be fishplated into the rail gap and the joints welded in due course, provided the stress adjustment procedure is not compromised.

A4.5 ALTERNATIVE PROCEDURE TO REPLACE A SHORT LENGTH OF RAIL

An acceptable alternative method for replacing a short piece of rail nominally 3m long involves the use of a "long" rail puller as follows:

- a) The long rail puller is placed to hold the rail either side of the piece of rail to be removed.
- b) The rail is cut twice within the restrained length.
- c) A new piece of rail is welded in while the rail is held in its original stressed condition by the rail puller.
- d) The replacement rail will in general be shorter than the rail removed to allow for a welding gap at each end.