SPC 235

RESILIENT BASEPLATES

Version 1.2

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Document control

Version	Date	Summary of change
1.0	October, 2007	First issue as a RailCorp document – includes content from C 3304
1.1	December, 2009	All Sections - Change of format for front page, change history and table on contents, Format change to all pages. Section 3.2 - Correction of typographical error in Table 1. Section 3.5 - Inclusion of reference to Table 4. Section 4.3.3 - Correction of numbering
1.2	June, 2012	Changes detailed in summary table below

Summary of changes from previous version

Summary of change	Section
Control Changes	Document Control
Reformatted to new template	All

Contents

1 Scope and Application

This document details requirements for the design and manufacture of vibration isolating rail baseplate and fastening assemblies for securing rails directly to sleepers, transoms, tunnel inverts or track slabs.

The fasteners are required to moderate noise and vibration transmitted through the rail and to reduce the track stiffness and attenuate impact loads on the track structure.

The structural integrity and operating safety of the fasteners must be maintained under all foreseeable circumstances. Vibration performance, on the other hand, shall be optimised for the specific operating conditions and acoustic requirements at the project site.

The specification is divided into thee sections:

- Design Requirements
- Product approval requirements
- Production Testing

2 Applicable Standards

2.1 Australian and International Standards

AS 1085.14 – Prestressed Concrete Sleepers

AS 1085.19 – Resilient Fastenings

2.2 RailCorp Standards

ESC 210 – Track Geometry & Stability

2.3 Other References

Nil

3 Design Requirements

3.1 General

Two types of fasteners are defined.

Type 1 is primarily required to absorb impact for protection of the rail infrastructure with some environmental benefit. Functional design requirements are primarily related to axle loads and train speeds.

Type 2 is primarily required to absorb noise and vibration for environment protection.

3.2 Operating Environment

This section defines the environment in which the resilient baseplates are expected to perform.

Separate requirements, where appropriate, are specified for Freight lines and Passenger lines. These are generally applicable, however in particularly sensitive areas it may be appropriate to tailor the requirements to give an optimum result.

Operating factor		Requirement	
Rail Type		Normally 60kg/m to AS 1085.1 (53kg/m may be used for a limited period in some cases). For similar rail sections spacers may be used.	
Spacing between Rail Fasteners		Nominal 600mm.	
Design Rail Cant		1:20 (to be provided by the baseplate design)	
Maximum gradient		1:33	
Maximum superelevation		125mm	
Impact Factor		0.5	
Nominal distance between axles		25t axle load: 1.7 m 23t axle load: 1.6 m	*Note: These figures are indicative*
Minimum curvature radius		500m	
Rail Track Gauge (including wear)		In tangent track: 1435mm (±10) In curves <1000m: 1435mm (+20, -10)	
		These figures are indicative of track conditions found in practice. They do not reflect design requirements	
For assembly structural performance	Static Axle Load – Operating Range	Passenger	Freight or Mixed traffic
		150 to 180 kN @ 120 km/h	220 kN @ 120 km/h (h
	Static Axle Load – Maximum	250 kN @ 60 km/h	250 kN @ 100 km/h 300 kN @ 60 km/h
For assembly vibration performance	Maximum static axle load	Passenger	Freight
		171 kN	Established to meet specific location requirements
	Unsprung mass per axle	2190 kg	
	Representative operating speed	115 km/h	
Dynamic Lateral/Vertical Load Ratio (Normal Service)		0.3 to 0.65 applied at rail head	
Track Tonnage		20 million tonnes / annum. (max)	
Design Temperature Range		-10° C to +70° C (rail)	
Installation tolerance compared to adjacent Rail Fasteners		± 2mm in vertical direction ± 2mm in lateral direction	

Table 1 – Operating Environment

3.3 Performance Requirements

This section defines the performance outcomes required.

The vibration performance requirements are defined in terms of the baseplate characteristics (primarily the dynamic stiffness) to be achieved under representative operating conditions detailed in Table 1.

Requirements are also included for all other relevant aspects of fastener performance, to be achieved under the foreseeable operating conditions.

The supplier shall select the appropriate materials and components to achieve the required performance of the baseplate assembly to meet the requirements detailed in Table 2.

<table>
<tr><th colspan="2">Attribute</th><th colspan="2">Performance Requirement</th></tr>
<tr><td colspan="4">Structural Performance requirements</td></tr>
<tr><td colspan="2">Design Service Life</td><td colspan="2">More than 30 years under the operating environment detailed in Section 3.2 of this specification
The baseplate assembly must not suffer any degradation during its service life which will effect the safety of the track in any way or vibration isolation performance to a significant degree (ie rubber becomes much harder or crumbles, serration on adjustable type fail and allow sudden gauge widening).</td></tr>
<tr><td colspan="2">Maintenance</td><td colspan="2">The fastener shall be maintenance-free over its service life</td></tr>
<tr><td colspan="2">Fail Safe</td><td colspan="2">In case of failure of the resilient material or its bond to the base plates the lateral integrity of the rail must be maintained within the elastic range of the resilient material, so that a “fail safe” situation arises.
Fail safe limits shall not be worse than the Damage limits defined in RailCorp standard ESC 210 – Track Geometry & Stability.</td></tr>
<tr><td colspan="2">Clip Toe Load</td><td colspan="2">10.5kN minimum per clip in service (ie after creep).
21kN minimum per rail seat in service (ie after creep)</td></tr>
<tr><td colspan="2">Maximum Vertical Deflection</td><td colspan="2">4.5mm at rail head for the specified operating loads.</td></tr>
<tr><td colspan="2">Maximum Lateral Deflection</td><td colspan="2">1.5mm at rail head for the specified operating loads</td></tr>
<tr><td colspan="4">Vibration Isolation Performance</td></tr>
<tr><td colspan="2">Dynamic/Static Stiffness Ratio</td><td colspan="2">1.3 maximum</td></tr>
<tr><td colspan="2">Maximum Dynamic Lateral Deflection</td><td colspan="2">4.5mm at rail head (when dynamic lateral load = 0.8 of static axle load) with L/V = 0.75. A lesser requirement will be considered if the product is not for use on sharp curves (ie radius < 400m).</td></tr>
<tr><td colspan="2">Vibration Isolation Relative to Direct Fixation Track</td><td colspan="2">Type 1 - typically 6 dB, depending on frequency and structure.
Type 2 - typically 9 dB, depending on frequency and structure</td></tr>
<tr><td rowspan="3">Optimum Vibration Isolation</td><td rowspan="2">static axle load</td><td>Passenger</td><td>Freight or Mixed traffic</td></tr>
<tr><td>137.5 kN</td><td rowspan="2">Established to meet specific location requirements</td></tr>
<tr><td>unsprung mass per axle</td><td>1000 kg</td></tr>
<tr><td colspan="2">Damping</td><td colspan="2">Not less than 5% of critical damping</td></tr>
<tr><td colspan="2">Fundamental Vertical Resonance</td><td colspan="2">45Hertz maximum at optimum vibration isolation.</td></tr>
<tr><td colspan="2">Dynamic stiffness</td><td colspan="2">Low resilient, similar to standard ballast track. Nominal dynamic stiffness 30kN/mm</td></tr>
<tr><td colspan="4">Other Performance requirements</td></tr>
<tr><td colspan="2">Electrical Resistance across Top plate to Bottom Frame</td><td colspan="2">1,000,000 ohm (minimum)</td></tr>
<tr><td colspan="2">Transition</td><td colspan="2">Provision for the transition from one form of track construction to another shall be allowed for. The track stiffness is allowed to change by 50% over a distance of 20 metres.</td></tr>
<tr><td colspan="2">Environmental Resistance</td><td colspan="2">Full service life is to be attained under the following conditions:
– Ultra violet radiation intensity of 800kJ/mm^2 average per day.
– Ozone atmospheric content of one part/100 million
– Location of track 10m from salt water surface at prevailing conditions RailCorp territory
– Contact with oil, grease or distillate dropped from track vehicles.</td></tr>
</table>

Table 2 – Performance requirements

3.4 Configuration Requirements

The assemblies shall meet the configuration requirements in Table 3:

Attribute	Configuration Requirement
Base Dimensions	Standard timber sleepers & bridge transoms are nominally 230mm wide and concrete sleepers are 200mm wide at the rail seat. Installation between existing plates on slab track or tunnel inverts must be achievable.
Vertical and lateral Adjustment	Fasteners are required to have adjustability of the rail perpendicular to the track, on slab track or tunnel inverts. In such cases the adjustability shall be ± 6mm in steps of no greater than 1mm.
System for holding Rail	The rails must be held be resilient fastenings. Separate insulators and rail pads may be used to achieve the required electrical resistance.
Fastening to Tie or Support	A minimum of two 24mm diameter screw spikes or M24 masonry anchors. When fixing to other than timber double helical washers must be used.
Marking	The rail fastening frame is to include identification markings in letters not smaller than 8mm high and raised above the surrounding metal not less than 1mm. These markings shall include the nominal design spacing in mm and the nominal shore "A" hardness or rubber or equivalent. The format is to be as follows: Spacing-Hardness (eg 600-56)

Table 3 – Configuration requirements

3.5 Material

All materials used in the manufacture of the assemblies, both cast in and others, must be proven under service conditions over a period of five (5) years in an existing railway or simulated testing for a similar period.

The material requirements detailed in Table 4 shall apply.

Component	Requirement
Plates	Top plate and bottom frame shall be made from ferrous material or approved alternatives. Cast components shall be cast from spheroidal graphite iron (S G I) according to AS1831 - 1985, Grade 400 - 12 (400mpa and 12% elongation). Steel components shall be fabricated or forged from steel to AS1442. Table 8 and have a ladle analysis of 1.15% C & 0.06%P (max).
Resilient Material	Resilient Material shall be made from high quality natural rubber or equivalent of Shore Hardness "A" not exceeding 68 within the expected tolerance range.

Table 4 – Material requirements

4 Product Approval Requirements

The following product approval requirements apply to new resilient baseplate designs.

4.1 Documentation

Documentation complying with AS.1100 Part 401 is to be provided as part of the design process. Detailed component manufacturing drawings are to be provided as required. This will include:

- Detailed drawing of the fastening assembly
- Detailed drawing of all components used in the assembly
- Material and component specifications including all glues, resins and insulation components
- Manufacturing processes including assembly sequences and procedures, applicable production tolerances, cycle times and curing times of the glues, fillers and paints.
- Quality control and product testing procedures and processes
- One set of design calculations which should include the following:-
  - calculations of rail deflections for the normal operating conditions defined in Section 3.2.
  - an estimate of the “insertion gain” of the baseplate assembly (relative to a very stiff reference track comprising rails on concrete sleepers (via rail pads of stiffness >1000kN/mm) on concrete track slab, and the primary track response frequency under the traffic specified in Section 3.2.
- Installation inspection and maintenance procedures suitable for use by railway maintenance staff.

4.2 Demonstration

The supplier shall:

1. Establish the detailed design requirements (dynamic ratio, damping etc) to meet the required insertion gain and demonstrate this to the satisfaction of the Chief Engineer Track.

2. Demonstrable product performance history in achieving the nominated noise reduction targets.

3. Provide evidence on the basis of product drawings and specifications and other data to demonstrate the fail safe performance of the product against lateral gauge widening.

4. Submit evidence of satisfactory service life performance in the form of evidence of proven in-track service on existing railways, together with an assessment of how the components and operating environment represent those relevant to this specification. (Alternatives or new products may be considered based on the results of extensive testing under a simulated railway environment.

4.3 Type Approval Tests

Type approval tests are conducted to demonstrate that the design, materials and components of the assembly comply with the specified requirements.

The actual requirements for testing may vary depending on the design of the baseplate assembly, the extent to which proven performance can be demonstrated for the assembly design, and the manufacturing process.

For fastener designs that differ in any significant detail from those previously proven (either by simulation testing or by in-track performance), a completed assembly shall be subject to destructive testing and inspection in accordance with procedures to be agreed between the supplier and the Chief Engineer Track.

4.3.1 Laboratory Testing

The supplier shall provide documentation of outcomes of the tests specified in Table 5 below.

	Test	Test Method
1	Static Vertical spring Characteristic	Use method in Sect 4.3.2
2	Dynamic Stiffness	Use method in Sect 4.3.4
3	Dynamic Fatigue Test (3 million cycles)	AS 1085.14, Appendix J AS 1085.19 Appendix G
4	Dynamic Vertical Spring Characteristic (at 2 million cycles in the dynamic fatigue test). Repeat the test at 3 million cycles	
5	Static Vertical Spring Characteristic at 3 million cycles	Use method in Sect 4.3.2
6	Dynamic Test - Slotted Holes for Holding Down Bolts	
	Resilient Fastening Assembly Test	AS 1085.19 Appendix C
7	Assembly Impedence Test- electricity supply available should be in the range 10V to 40V a.c at 50Hz or 60Hz (nominal frequency)	AS 1085.19 Appendix C
8	Longitudinal Restraint	AS 1085.14 Appendix I AS 1085.19 Appendix E
9	Lateral Restraint Lateral defection at the rail head and must not exceed the Dynamic limit.	AS 1085.14 Appendix K AS 1085.19 Appendix C
10	Torsional Restraint	AS 1085.14 Appendix M AS 1085.19 Appendix C
	Fastening Uplift test	AS 1085.19 Appendix F
11	Hold-down bolts (Pull out tests	AS 1085.14 Appendix L
12	Environmental Factors in Specification	
13	Fundamental Vertical Resonance	

Table 5 – Product tests

4.3.2 Visual Inspection

The resilient baseplate assembly shall be inspected after Tests 1 to 6 have been completed, and shall show no evidence of damage or cracking of any part, or fracture of any bond between different materials within the assembly.

4.3.3 Static Stiffness Test Method

The static stiffness (C_{stat}) shall be determined as follows:

1. A new (unloaded) base-plate assembly shall be used for each test
2. A load of 0kN to 85kN shall be applied (at a rate of approximately 2kN/s) three times
3. During the third load cycle, the deflection (in mm) shall be noted at loads of 18kN and 68kN. These values shall be denoted δ_{18} and δ_{68}.
4. The static stiffness shall be evaluated as the secant stiffness according to the formula:

$$C_{stat} = \frac{50}{\delta_{68} - \delta_{18}} [\text{kN/mm}]$$

5. The tests shall be carried out at 0°C, 20°C and 70°C, with the baseplates subjected to a minimum of 2 hours exposure to the test temperature prior to the test.

6. The values of C_{stat} at 0°C and 70°C shall be within ± 15% of the value at 20°C.

4.3.4 Dynamic Stiffness Test Method

In the low frequency region, the base-plate shall be cycled between 18 and 68kN loads at frequencies of 1, 5, 10, 20 and 30Hz. In each case, the tests shall be carried out in a temperature-controlled environment maintained at 20°C and shall be of sufficient duration for the temperature of the elastomer to reach a stable value.

The secant stiffness (between 18 and 68kN applied loads) shall be determined. The primary value to be reported is the dynamic stiffness at 20Hz (denoted $C_{dyn,20Hz}$)

At higher frequencies, tests shall be carried out under a pre-load of 23kN and 40kN with an applied dynamic load sufficient to generate dynamic amplitudes of 0.2mm (peak to peak). The tangential stiffness shall be determined from these tests at a minimum of the following frequencies: 15Hz, 20Hz, 30Hz, 40Hz, 50Hz, 100Hz.

Alternative test methods for deriving high frequency dynamic stiffness (such as an impact test method) may be approved.

5 Production Testing

The supplier shall implement appropriate quality assurance procedures to verify that the manufactured assemblies perform within the design parameters.

The procedures shall take due consideration of the materials and manufacturing processes used to produce the fasteners. For example, if elastomeric materials are produced in batches, each batch of product shall be subject to sufficient testing to verify– with statistical reliability – that the materials are meet the design parameters.

The supplier shall submit details of the proposed testing and inspection procedures (and the suggested acceptance limits).

As a minimum, sample testing of completed assemblies shall include:

- Static stiffness
- Dynamic stiffness (20Hz, room temperature)