Technical Note – TN 004: 2019

Issue date: 21 June 2019
Effective date: 21 June 2019

Subject: Updates to ESC 340 *Tunnels, v2.3*

This technical note is issued by the Asset Standards Authority (ASA) to notify updates to RailCorp standard ESC 340 *Tunnels*, version 2.3.

This technical note replaces the following technical notes:

- TN 062: 2014 *Update to requirements for derailment containment devices in tunnels*
- TN 074: 2016 *Update to infrastructure lighting requirements contained in RailCorp standards*
- TN 019: 2017 *Emergency telephones*
- TN 042: 2017 *Changes to durability requirements arising from the publication of T HR CI 12002 ST Durability Requirements for Civil Infrastructure*

These technical notes will be withdrawn with the publication of TN 004: 2019.

ESC 340 is presented as a legacy RailCorp document and shall be read in conjunction with and interpreted according to the interpretation guidelines published:

**Table 1 – Interpretation guides**

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<th>Version</th>
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<tr>
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<td>Guide to interpretation of organisational role and process references in RailCorp standards</td>
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<td>Interpretation guide RailCorp SMS References within RailCorp engineering standards</td>
<td>1.0</td>
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</table>
1. **Section 4.1 Design standards**

Delete paragraph 3 of section 4.1 and insert the following:

**4.1.1 Durability requirements**

The durability requirements for tunnels, including design life, shall be in accordance with T HR CI 12002 ST *Durability Requirements for Civil Infrastructure*.

2. **Section 5.5 Seepage and drainage**

Insert the following above paragraph 1:

Tunnels shall be undrained.

Delete current paragraph 3 and replace with the following:

Leakage limits for tunnels shall be determined for each project and submitted to the Lead Civil Engineer, ASA for approval.

3. **Section 5.7 Rock anchors**

Delete the first paragraph in section 5.7.

4. **5.11 Guard rails**

Delete the contents of section 5.11 in their entirety and replace with the following:

Guard rails may be used to contain a derailed train in existing tunnels and tunnel portals.

Guard rails shall be in accordance with T HR CI 12071 ST *Guard Rails*.

5. **5.12 Safety refuges**

Delete the contents of section 5.12 in their entirety and replace with the following:

**5.12 Safe places**

Safe places shall be provided in accordance with T HR CI 12073 ST *Safe Places*.

Insert the following as a new section after Section 5.12:

**5.13 Flood immunity**

The flood annual exceedance probability (AEP) for tunnels shall be 0.01% (1 in 10 000 year ARI) and shall be used to establish the flood protection and drainage design of the tunnel portal and other openings, such as underground stations, emergency access and so on.
6. **Section 9.6 Emergency tunnel lighting**

Delete the contents of section 9.6 in their entirety and replace with the following:

Emergency tunnel lighting shall be in accordance with T HR SS 80003 ST *Infrastructure Emergency Lighting*.

7. **Section 9.7 General tunnel lighting**

Delete the contents of section 9.7 in their entirety and replace with the following:

Tunnel lighting shall be in accordance with T HR SS 80001 ST *Infrastructure Lighting*.

8. **Section 9.10 Emergency telephones**

Delete the contents in Section 9.10 and replace with the following:

An emergency telephone system shall be installed throughout a tunnel at a spacing of no more than 90 m.

Emergency telephones shall also be installed at the end of station platforms adjacent to the portal of a tunnel, at cross passages and at emergency access portals.

The emergency telephone system shall comply with T HR TE 61001 ST *Emergency Telephone Systems*.

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**Authorisation:**

<table>
<thead>
<tr>
<th>Technical content prepared by</th>
<th>Checked and approved by</th>
<th>Interdisciplinary coordination checked by</th>
<th>Authorised for release</th>
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<tr>
<td>Date</td>
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ESC 340
TUNNELS

Version 2.3
Issued July 2010
Reconfirmed 26 June 2019

Owner: Chief Engineer Civil
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Technology & Standards
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Document control

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<td>2.3</td>
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<td>Changes detailed in Summary table below</td>
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<tr>
<td>2.2</td>
<td>November, 2009</td>
<td>Format change throughout; minor editing</td>
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<tr>
<td>2.1</td>
<td>October, 2007</td>
<td>Additional requirement re water seeping through the tunnel structure not to drip onto the track; Requirements for rock anchors specified to be consistent with ESC 350; Requirements for maintenance of clearance for elevated walkways.</td>
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<td>2.0</td>
<td>July, 2007</td>
<td>Minor changes to requirements for design standards; approved materials; clearances; services, reference to RailCorp standard construction specifications, design criteria specified for train loads; collision loads, additional criteria for configuration; tunnel invert; seepage and drainage; tunnel fittings; stray currents; platforms; noise and vibration, fire safety requirements updated to be consistent with the International Fire Engineering Guidelines. Replaces CTN 04/16 “Mechanical and Chemical Anchors”</td>
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<td>1.0</td>
<td>March, 2006</td>
<td>First issue as a RailCorp document. Replaces TS 30 000 3 01 SP and TS 34 100 3 01 SP</td>
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Summary of changes from previous version

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1 Purpose, Scope and Application

This document specifies the design requirements for tunnels on the RailCorp network. It includes requirements for structural design of tunnels and for fire safety. The fire safety requirements apply to construction of new tunnels using electric passenger rolling stock.

This Standard is not applicable to fire safety of tunnels to be utilized by freight or diesel train services.

Where the new tunnel is an extension to an existing tunnel, fire safety requirements shall be applied to the existing tunnel to the extent necessary to achieve appropriate levels of fire safety for interfacing with new tunnels.

Refurbishment or upgrade of the fire safety requirements of existing tunnels shall be subject to a separate engineering evaluation and risk assessment process. Where this process determines that particular fire safety systems or fire protection equipment are proposed for installation, the systems and equipment shall comply with the requirements of this Standard.

2 References

2.1 Australian and International Standards

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<td>AS 5100 - 2004</td>
<td>Bridge design</td>
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AS/ACIF S008: 2006 Requirements for customer cabling products
AS/ACIF S009: 2006 Installation requirements for customer cabling (Wiring Rules)
AS ISO 354-2006 Acoustics - Measurement of sound absorption in a reverberation room

2.2 RailCorp Documents

State Rail Authority, Standard Guidelines for Fire and Life Safety in the Construction of Underground Railway Facilities
ESC 200 Track System
ESC 215 Transit Space
ESC 220 Rail and Rail Joints
ESC 230 Sleepers and Track Support
ESC 310 Underbridges
ESG 100.17 Signal Design Principles Track Circuits
ESM 108 Tunnel Emergency Telephones
SPC 301 Structures Construction
FE 103 Fire Safety of Railway Stock
SPG 1010 Cables for Railway Signalling Applications – General Requirements
SPG 1016 Cables for Railway Signalling Applications – Fire Safe High Frequency Screened Track Circuit Cables
SPG 1017 Cables for Railway Signalling Applications – Fire Safe Multiconductor Cables
SPG 1018 Cables for Railway Signalling Applications – Fire Safe Single and Twin Conductor Power Cables
SPG 1019 Cables for Railway Signalling Applications – Fire Rated Twin Conductor Power Cables for Emergency Services
SPG 1571 Light Signals
SPG 1572 Specification for Emergency Telephone Location Lights for Underground Railway

2.3 Other References

NSW Government Rail Safety Act 2002
NSW Government State Emergency and Rescue Management Act 1989 No 165
NSW Government Environmental Planning and Assessment Act
Environment Protection Authority NSW Industrial Noise Policy
Environment Protection Authority NSW Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects
Environment Protection Authority NSW Assessing vibration: a technical guideline
NOHSC:1007 - 2000 National Standard for Occupational Noise
RailCorp Safety Management System SMS-12-PR-0371 “Managing Engineering Design Control”
3 Definition of Terms

ASET/RSET: Available Safe Egress Time/Required Safe Egress Time as defined in the International Fire Engineering Guidelines.

DISPLAN: The NSW disaster plan. The object of DISPLAN is to ensure the coordinated response to emergencies by all agencies having responsibilities and functions in emergencies.

Emergency Services: Police, New South Wales Fire Brigades (NSWFB), Rural Fire Service, Ambulance Service, State Emergency Service, Volunteer Rescue Association or any other agency which manages or controls an accredited rescue unit, and RailCorp Emergency Response Unit. (Note: NSWFB will advise when Rural Fire Service jurisdiction applies).

Fire Safety Engineer: Person who is suitably qualified and experienced and is fully familiar with the nature of fire and of the behaviour of materials, structures and people when exposed to fire hazards when set in a rail context. Fire engineering design activities require the application of professional knowledge, engineering judgement and appropriate understanding of the assumptions, limitations and uncertainties involved. NPER registration in fire safety engineering through Engineers Australia or equivalent is required.

Fire Safety Strategy: A series of fire safety measures that can include systems or procedures to mitigate against fire safety hazards.

Fire Engineering: A design methodology by which engineering principles are applied to the evaluation of fire and life safety hazards that are identified and consequently, to the design of appropriate methods of protection to sufficiently counteract those hazards.

Fire Scenarios: An outline of the salient information regarding a fire (i.e. position, size, rate of growth etc) in order to ascertain its probable effect for a given set of criteria.

Refuge: Area specially set aside in tunnels for personnel to be safely clear of a passing train.

Tunnel: A space through which one or more rail tracks pass, which is continuously enclosed above, below and on both sides. For fire safety purposes, a space through which one or more rail tracks pass, which is continuously enclosed above, below and on both sides and is in excess of 80m in length. An air space development providing enclosure of 80m in length to a previously open track also forms a railway tunnel.

Network Rules: Operational procedures / rules that manage the interface between people and engineering systems on the New South Wales Rail Infrastructure network and are produced by RailCorp.

Ventilation Section: The length of tunnel between a smoke ventilation intake and exhaust point.

Worst Credible Fire Scenarios: For prescribed conditions associated with the ignition, growth, spread, decay and burnout of a fire, the worst credible fire scenario is defined by specifying (or otherwise determined) times of occurrence of critical events relating to each of the sub-systems under investigation and based on the worst possible fire scenarios.
4 General Requirements

4.1 Design Standards
Designs are to comply with the requirements of the relevant Australian Standards, specific site geotechnical parameters and the requirements of this Document.

Relevant standards and documents may include:
- AS 1170 “Structural design actions”
- AS 2159 “Piling – Design and installation”
- AS 3600 “Concrete structures”
- AS 4100 “Steel structures”
- AS 4678 “Earth-retaining structures”
- AS 5100 “Bridge design”
- AS 1726 “Geotechnical site investigations”
- Workcover Code of Practice “Tunnels under Construction”

The design life of tunnels shall be 100 years.

4.2 Drawing Standards
Construction drawings are to comply with RailCorp’s standard procedures and formats, and are to detail the design criteria and any other information that is relevant to ensuring that the new structure is constructed and maintained in accordance with the design.

4.3 Integrated Designs
The design of each tunnel is to be integrated taking into account all associated requirements such as drainage, track, overhead wiring, signalling infrastructure, communications services, fire safety equipment and platforms.

4.4 Approved Materials
Approved construction materials for main structural elements are steel and concrete.

Masonry is approved for existing tunnels.

Timber materials shall not be used in tunnels.

Materials in tunnels shall generally be non-flammable and shall comply with specific requirements for fire safety detailed in this standard.

4.5 Clearances
Horizontal and vertical clearances to rolling stock and fixed structures within the tunnel are to be provided in accordance with RailCorp standard ESC 215 “Transit Space”.

Equipment such as cabinets and signs shall be mounted clear of tunnel walls to prevent damage by or ingress of seepage water from tunnel walls.

4.6 Safety
The design of tunnels is to take into account safety considerations for construction and maintenance personnel, and any other parties including operations personnel who may be required to use the structure.

Designs are to incorporate the requirements of the RailCorp Safety Management System, particularly SMS-12-PR-0371 Managing Engineering Design Control.
Designs are also to comply with the requirements of Workcover NSW Code of Practice “Tunnels under Construction”.

4.7 Protection of the Environment
The design of tunnels is to take into account environmental impacts during construction and maintenance activities, with a view to minimising any impacts.

4.8 Heritage
Heritage considerations and classifications must be observed in tunnel designs. This may have particular application in circumstances where an existing structure is being refurbished or modified, or where a new structure is being proposed in the vicinity of existing heritage items.

4.9 Provision for Services
Provision may be required when designing tunnels for accommodating services owned by RailCorp (e.g. electrical and signalling cables) or services owned by other authorities and utilities.

Services are to be positioned in accordance with the following requirements:
- Transit space standard ESC 215;
- Clear of any walking areas where they might present a trip hazard;
- Not to interfere with or obstruct emergency walkways;
- Not to obstruct access to or reduce the capacity of refuge areas.

The location of any services is also to be selected so that future access for maintenance of the services is facilitated.

Other specific requirements for cabling in tunnels are detailed in Section 10.11 of this Standard.

4.10 Construction
The design of tunnels is to take into account construction constraints, particularly live rail operating conditions and track possession constraints.

RailCorp has a suite of technical specifications covering various aspects of civil construction, e.g. concrete work, shotcreting and rock anchors etc. The specifications are detailed in Engineering Specification SPC 301 “Structures Construction” and are to be incorporated in tunnel design and construction documentation.

4.11 Maintenance
The design of tunnels and tunnel services is to take into account the ability to access components for inspection and maintenance purposes.

Components, materials and finishes should be chosen to minimise future maintenance.

Maintenance requirements are to be specified in the design documentation for tunnels. Requirements are to include examination tasks and frequencies, damage limits, and repair standards, and be supported by documentation showing the basis for these requirements.

5 Specific Requirements

5.1 Design Alternatives
Alternatives for tunnel designs will depend primarily on whether open cut, driven or bored construction methods are adopted to suit the geology and location.

Major design variables will include:
5.2 Design Criteria

Tunnels located within the rail corridor shall be designed to accommodate the train loadings as specified below:

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<th>Operating Class</th>
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<tr>
<td>Passenger Main Line / Light Line</td>
<td>200LA plus Impact</td>
</tr>
<tr>
<td>Mixed Passenger Freight Main Line</td>
<td>300LA plus Impact</td>
</tr>
<tr>
<td>Heavy Freight Option</td>
<td>350LA plus Impact</td>
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The loading is based on the railway traffic load in AS 5100. The ‘Reference Load’ is 300LA. For the other loadings, all axles are to be proportioned by the ratio of the nominated LA load divided by 300.

Operating Classes are defined in RailCorp standard ESC 200 “Track System”.

For loadings less than 300LA, future loading requirements need to be considered. Final approval of the design loads shall be obtained from the Chief Engineer, Civil.

The impact factor shall be in accordance with the dynamic load allowance in AS 5100 with the characteristic length based on either deck slabs or direct rail fixation.

Tunnels shall also be designed for the collision load requirements of AS 5100. Where tunnel walls are not continuous, for example where there is a crossover to the track in the adjacent tunnel, guard rails or concrete upstands are to be provided in lieu of the collision load requirements at the discontinuity.

Tunnels shall be designed for earthquake forces in accordance with AS 5100. The earthquake design category shall be Type III i.e. essential to post-earthquake recovery.

5.3 Configuration

Unless otherwise stated, new rail tunnels are to be designed to accommodate the ‘Extended Medium Electric Vehicle Profile’ as defined in Engineering Standard ESC 215 “Transit Space”.

The tunnel shall be sized to accommodate transit space requirements, services, plant and equipment.

In addition, the tunnel shall incorporate niches where necessary to accommodate refuges, plant and equipment.

Tunnel services, plant and equipment may include:
- overhead wiring system
- signalling equipment including point machines and compressed air supply
- communication cables and equipment including emergency telephones
- electrical supply and services cables
- tunnel lighting and small power outlets
- tunnel walkway
- tunnel ventilation system
- fire protection systems
- noise and vibration mitigation measures
- tunnel drainage including pumping stations and sumps
- under track crossings
- stray current and electrolysis mitigation.

Allowance is to be made for an operational line speed of 115km/h.

The maximum track gradient within the tunnel (after allowances for curve compensation) is to be 3%. The maximum length of continuous track at or close to the maximum grade shall be based on a consideration of the capability of the rolling stock using the tunnel. The design grade profile of the tunnel shall be subject to the approval of the Principal Engineer Rolling Stock.

Where twin tunnels are specified, the tunnels shall be linked with cross passages for the purpose of emergency egress.

Detailed design criteria for fire safety and emergency access in passenger tunnels are detailed in Sections 6 to 9 of this Standard.

### 5.4 Tunnel Invert

The migration of fines into the tunnel from within the rock mass beneath the tunnel invert must be prevented by appropriate invert treatment.

### 5.5 Seepage and Drainage

The rate of inflow of groundwater into the tunnel is to be limited in order to not adversely affect surrounding property and infrastructure caused by changes to the groundwater level and flow regime.

The rate of inflow into the tunnel must also be controlled to avoid impact to any existing surface water courses.

The seepage rate of water into the tunnel shall be limited to a maximum of 0.1 litres/second per any continuous 100 metre length of single track tunnel.

Drainage systems shall be designed to collect and dispose of any seepage and surface water that enters the tunnel in order that the track infrastructure is kept well-drained to minimise maintenance.

The drainage system shall be configured so that in the event of a blockage, any overflow will not affect train operations or the reliability of the infrastructure.

All drainage discharge from the tunnel shall be treated to be of such quality as to meet the requirements of the relevant authority for discharge to the stormwater system.

The drainage system design and configuration shall consider the need for maintenance staff to access adjacent equipment without having to stand in the drain.

No water seeping through the tunnel structure is to drip onto the track.

### 5.6 Tunnel fittings

Seepage of groundwater can cause corrosion to structural elements of the tunnel and overhead wiring. Appropriate measures are to be implemented in the design to protect these components from corrosion.
All fittings and fastenings securing overhead wiring and other services to the tunnel structure are to be stainless steel grade 316 to AS 1449 “Wrought alloy-steels – Stainless and heat-resisting steel plate, sheet and strip”.

Mechanical and chemical anchors should be designed and installed taking into account the long-term strength of the natural ground and tunnel linings allowing for deterioration over time.

5.7 Rock Anchors

Rock anchors shall have a design life of 100 years.

Rock anchors shall comply with the requirements of AS 4678 “Earth-retaining structures” and Technical Specification S38 “Permanent Rock Anchors” in RailCorp Engineering Specification SPC 301 “Structures Construction”.

The design of rock anchors shall include mitigation against the effects of stray currents.

The designer shall specify requirements for testing. Test procedures shall comply with Technical Specification S38.

The designer shall specify requirements for long term monitoring, if any.

Anchor heads shall be protected so as not to be an obstruction. They shall be recessed or protected by a continuous smooth surface of shotcrete, concrete etc.

Rock anchors shall not extend under private property without the approval of the Chief Engineer Civil.

5.8 Stray Currents

Tunnel linings and fittings shall be designed to mitigate the effects of stray currents from the overhead wiring system.

5.9 Underground Platforms

Where provision is to be made for underground platforms, the track gradient through the length of the platform must be constant and not exceed 0.7%.

Unless otherwise specified, provision is to be made for an ultimate platform length of 210 metres.

5.10 Noise and Vibration

The tunnel and associated systems shall be designed to allow acceptable noise and vibration during operation.

Operational noise and vibration issues for rail tunnel projects can include:

- Environmental noise and vibration arising from the operation of trains and from tunnel plant and equipment such as ventilation systems, which can affect occupants of premises outside the tunnel, such as residential buildings
- Noise within the tunnel (and at station platforms) arising from the operation of trains and from tunnel plant and equipment such as ventilation systems, which can affect staff and the travelling public in terms of:
  - comfort of passengers when travelling on trains or at stations
  - noise exposure that may affect the health and safety of staff working in the tunnel, on trains or at stations
  - noise levels that may interfere with effective communication or the use of audible warning systems, both during normal operations and in emergencies.

Environmental noise and vibration criteria are normally detailed in conditions of approval issued under the Environmental Planning and Assessment Act. Health and safety criteria for workplace

Criteria for noise that may affect audible communication and warning systems may vary depending on the type of communication system used. Where criteria are listed in the following sections, they are to be observed in the absence of specific project requirements. In the event of a conflict, the more stringent requirements shall apply.

5.10.1 **Ground-borne noise and vibration**

Operational rail vibration arises at the wheel/rail interface and propagates via the track support system to the tunnel structure, the ground and surrounding buildings. Occupants of nearby buildings may detect “rumble” noise during the passage of trains, called ground-borne noise. In some cases, occupants may directly perceive vibration, called ground-borne vibration. The operation of highly sensitive medical or scientific equipment can also be affected by vibration.

Ground-borne noise and vibration are highly complex issues. ISO 14387-1 “Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General guidance” provides general guidance on prediction and design methods. Where assessment and mitigation of ground-borne noise and vibration is required, methodologies shall be consistent with those defined in ISO 14387-1.

The “Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects” published by the New South Wales Department of Environment & Climate Change provides guidance on ground-borne noise goals.

Ground-borne noise and vibration is likely to have a significant bearing on the tunnel alignment and/or track design. It is also important to consider operational and maintenance issues that may influence ground-borne noise and vibration from tunnels, including:

- Track design features such as curves and crossovers, as these increase levels of ground-borne vibration generated at source,
- Ongoing maintenance of rolling stock, particularly wheels, and
- Ongoing maintenance of track, particularly the rail running surface.

Source vibration levels are dependent on the dynamic interaction of the train with the track support system. It is possible to vary the vibration spectrum generated at source by varying the track support stiffness. Reduction in the track support stiffness results in a reduction in source vibration and a reduction in ground-borne noise and vibration in surrounding buildings. However, the effect of varying track support stiffness actually has a frequency-dependent ("tuning") effect. While there may be vibration reductions at most frequencies, a reduction in track support stiffness actually results in an increase in vibration at certain low frequencies. In other words, “tuning” of the track support system results in redistribution of vibration energy from one part of the frequency spectrum to another.

The selection and design of such track support systems for ground-borne noise and vibration control requires careful consideration of maintenance and performance aspects. Particular consideration shall be given to:

- Modes of vibration of floating slab elements which may lead to a significant increase in low frequency radiated noise
- Transitions between track sections with differing support stiffness characteristics
- Wheel / rail interface issues such as corrugation development
- Access and inspection and maintenance of resilient components.

5.10.2 **Air-borne Noise Performance**

The tunnel is to be designed so that operational, train and ventilation fan noise breakout from the tunnel complies with “NSW Industrial Noise Policy” published by the EPA.
In addition to the requirements of the “NSW Industrial Noise Policy”, the tunnel is to be designed so that the following air-borne noise levels are not exceeded when the tunnel is in operation:

| Concourse and platforms (normal fan operations) | 55dBA |
| Concourse and platforms (emergency fan operations) | 75dBA |
| Concourse and platforms (congested fan operations) | 75dBA |
| Nearest property (train noise breakout from ventilation openings) | 60dBA at commercial façade, 55dBA at residential façade |
| Within 10m of any jet fan (in tunnel for emergency and congested operation) | 90dBA. At a distance of 10m, 85dBA |

### 5.10.3 Sound absorption treatment

Operational air-borne noise levels within tunnels, and consequently within trains and at station platforms, are influenced by the extent of sound absorption. For tunnels with slab track and direct-fix fasteners it is necessary to incorporate sound absorptive linings to replace the effect of conventional railway ballast which has moderate sound absorption characteristics. The sound absorption properties of the lining shall be as defined in the table below.

<table>
<thead>
<tr>
<th>Octave band frequency, Hz</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum sound absorption (metric Sabines*) per 10m of track</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>

* For the purpose of this standard, a metric Sabine is defined as the product of the surface area (in m²) and the sound absorption coefficient derived in accordance with AS ISO 354-2006 : Acoustics - Measurement of sound absorption in a reverberation room.

### 5.11 Guard Rails

#### 5.11.1 Configuration

Guard rails are to be installed in accordance with the following requirements:

- Guard rail shall be new rail manufactured to AS 1085.1 or recycled rail Category 1 (White rail) in accordance with ESC 220 “Rail and Rail Joints”.
- Guard rail section is to be the same as the running rail or one section size less than the running rail.
- Top of guard rail is to be no higher than the adjacent running rail and no more than 50mm below the running rail.
- Each guard rail is to be plated and fastened on both sides at the same spacing as the running rail fasteners.
- Guard rails are to extend parallel for a minimum 20 metres in advance of the area being protected on the train approach side.
- Guard rails are to extend parallel for a minimum of 3 metres beyond the area being protected on the train departure side.
- A tapered nose section (“vee”), minimum 3.6 metres long, is to be installed on the train approach side of the guard rail. The nose of the vee shall be bolted.
- Where rail traffic is bi-directional, the guard rail is to extend 20 metres beyond the area being protected on both approach and departure sides.
- Where rail traffic is bi-directional, the tapered nose section is to be installed on both sides.
- The clearance between the gauge face of the running rail and adjacent face of guard rail is to be 380 mm.
Block-out holes for guard rail fastenings in concrete sleepers shall be grouted with a high strength epoxy grout.

For fixing details, dimensional set-out and componentry detail and sizes, use the standard guard rail drawings for bridges:

- 785-568 Bridge guard rail Ballast top bridge Arrangement for concrete sleepered track
- 785-569 Bridge guard rails Details of concrete guard rail sleepers Concrete sleepered track
- 785-570 Bridge guard rails Ballast / Transom top bridge Arrangement for timber sleepered track
- 785-571 Bridge guard rails Timber sleepered track Details of special plating for tapered nose

**5.11.2 Signalling Interface**

Suitable isolation arrangements are to be made, where required, in track circuited and electrified areas.

The tapered nose section ("Vee") is to be insulated with an approved component - refer to Figure 1. Generally one insulated joint is satisfactory. This insulation requirement applies to new installations and where refurbishment of the guard rails is undertaken.

*Figure 1*

Where guard rails exceed 50 metres in length, additional insulation and bonding arrangements may be required. Design drawings are to specify that insulation and bonding arrangements shall be in accordance with the requirements of the Chief Engineer Signals. See RailCorp Engineering Standard ESG 100.17 - Signal Design Principles Track Circuits.

**5.11.3 Joints in Guard Rails**

Joints in guard rails shall have at least two bolts on each side.
If standard fishplates are used, six bolts are required.

If modified fishplates are used, the four bolts shall all have the nuts on the inside. Fishplates shall be modified by machining, not by oxy-acetylene cutting.

No joints are permitted in the vee.

5.11.4 Direct Fixation

Where the track is on a concrete slab concrete upstands may be provided in lieu of guard rails. The upstands shall generally comply with the requirements of Section 5.11.1.

Track fastenings shall be approved fastenings for track slabs in accordance with ESC 230 “Sleepers and Track Support”.

The maximum height of grout bed under the rail fixings shall be 60 mm. Packers may be used but they shall provide for full lateral restraint to the holding down bolt.

High impact epoxy grouts/mortars or specially developed grouts are to be used under the rails on track slabs to accommodate the high dynamic effects and movement of the slab. There shall be no metallic elements in the epoxy. Standard cementitious grouts shall not be used.

The grout bed shall provide sufficient edge distance to the bolt to avoid cracking of the grout.

The transition from ballasted track to the track slab shall be designed to ensure a smooth transition.

5.12 Safety Refuges

5.12.1 Provision of Safe Areas

Refuges may be provided in tunnels for infrastructure and other authorised staff to stand during the passage of a train.

Where refuges are not provided, tunnels are to have limited clearance warning signage attached. The sign is a warning that there is insufficient clearance to stand when trains are passing.

The sign is to be attached to tunnel portals and at locations along the tunnel where access is available to the tunnel.

If access is only available from the ends of the tunnel, no signs are required along the tunnel.

The sign is to be as shown below:

5.12.2 Location of Refuges

The spacing of refuges, where provided, along a tunnel is not to exceed 20 metres. The spacing at each location is to be determined by a risk assessment, taking account of factors such as train speed, available sighting distances, and existence of warning light systems.
In single track tunnels, refuges may be provided on one side only or staggered on both sides.

In double track tunnels, refuges shall be provided in a staggered pattern on both sides of the tunnel.

5.12.3 Refuge Details

The floor of the refuge is to be at cess level or with a maximum step up above the cess level of 200 mm.

The minimum dimensions of refuges are to be:

- Height: 2000 mm
- Width: 1500 mm
- Depth: 700 mm

If the refuge is to contain telephones, fire extinguishers or other essential items, the width is to be increased to provide the minimum clear floor area.

The floor of the refuge is to be level.

The refuge is to be kept clear of cables, pipes or other obstructions.

Handrails shall be installed in refuges to assist staff in keeping their balance during the passage of a train.

6 Fire Safety Objectives

Tunnels shall be designed, built, operated and maintained in order to:

- Ensure acceptable levels of fire safety are achieved for train crews, rail passengers, other RailCorp staff and contractors, the public and Emergency Services personnel
- Ensure the safety of people outside the tunnel or at connecting stations or other buildings shall not be compromised in order to achieve the required level of tunnel fire safety
- Minimise the impact of fire on rail infrastructure including tunnels and stations, and other buildings or rail rolling stock, and on the continuity of operations of railway operators.

7 General Design Requirements

7.1 Introduction

This Standard is consistent with the Building Code of Australia and the International Fire Engineering Guidelines.

Design, construction and operation of rail tunnels shall comply with the requirements of this Standard.

Fire Safety Engineers shall demonstrate the achievement of an adequate level of safety from fire and related hazards through appropriate documentation and approval by RailCorp and other nominated stakeholders.

The process of fire safety engineering of tunnels encompasses the asset life cycle from feasibility and concept design through to operation and maintenance.

The fire safety objectives as set out in Section 6 will only be achieved through a combination of tunnel design, construction, installation and commissioning; fire safety management and training; a regular program of inspections and maintenance; and, where necessary, fire brigade intervention.

When determining appropriate fire safety provisions for rail tunnel design, this Standard shall be read in conjunction with:
- The “Standard Guidelines for Fire and Life Safety in the Construction of Underground Railway Facilities”, to achieve compatibility between tunnel and station fire safety strategies
- FE 103 “Fire Safety of Railway Stock”, to achieve compatibility between tunnel and rolling stock Fire Safety strategies
- Other relevant RailCorp Standards
- Relevant local, state, national and international Standards and guidance

In applying this Standard, all relevant parties shall:
- Ensure that legislative requirements are met
- Effectively liaise with train and station operators, planning and emergency authorities, and regulators to resolve fire safety and environmental issues that might arise as a result of new tunnel construction or operation.

7.2 Systems Approach
The design of tunnel fire systems shall consider the tunnel system as a whole including rolling stock, stations, tunnel configuration, railway equipment and railway operating and emergency procedures.

7.2.1 Rolling Stock
The design of tunnel fire systems shall consider the types of rolling stock that are proposed to use the tunnel. Consideration shall be given to RailCorp Specification FE 103 on Fire Safety of Railway Stock.

7.2.2 Stations
The design of tunnel fire safety systems shall consider station fire safety systems and emergency plans. Reference shall be made to the current RailCorp fire safety guidance for stations and relevant station evacuation plans to achieve compatibility between tunnel and station fire strategies.

The tunnel systems, evacuation plans and emergency procedures shall be compatible with the station’s systems, evacuation plans and emergency procedures.

7.2.3 Tunnel Configuration
The choice of tunnel configuration is dependent on a number of factors. Design parameters include fire safety, geological conditions, construction techniques, environmental constraints, operational requirements and emergency evacuation requirements.

The choice of single or twin track tunnels should consider all of the relevant factors. For fire and life safety, these factors can include length of tunnel, type of rolling stock, walkways, egress provisions, access for emergency services, emergency and evacuation preparedness plans and other issues.

The extent of tunnel fire safety provisions will be influenced by the choice of tunnel configuration.

7.2.4 Tunnel Infrastructure
The design of tunnel fire systems shall consider railway equipment that will be installed within the tunnel including track, signalling, electrical and communications infrastructure and equipment rooms.

The design shall also include consideration of engineering processes of inspection and maintenance of this equipment; and of electrical operations process.
7.2.5 **Operational Characteristics**

The tunnel fire safety strategy shall integrate with the operating characteristics of the railway system including Network Rules, Network Procedures, Network Local Appendices and Emergency Procedures.

Particular consideration should be given to the Incident Management and Emergency Response Element of the RailCorp Safety Management System and subordinate incident plans and procedures to ensure the tunnel design is consistent with all emergency procedures.

7.3 **Acceptable Level of Safety**

It is intended that the application of this Standard by Fire Safety Engineers will establish acceptable levels of tunnel fire safety for train crews, rail passengers, people at connected stations or buildings, infrastructure staff and contractors, and Emergency Services personnel. However, it shall be the responsibility of the Fire Safety Engineer to demonstrate to the satisfaction of RailCorp that the tunnel, as designed and intended to be operated, will meet this acceptable level of tunnel fire safety for all authorised tunnel users.

The Fire Safety Engineer shall express the acceptable level of safety in terms of ASET/RSET based on recognised feasibility limits and safety margins, as well as in quantified risk terms that are agreed with RailCorp. In the ASET/RSET analysis, a margin of safety of 1.5 (RSET x 1.5) should be factored into the time-line approach.

7.4 **Modifications**

Any modifications or changes to tunnel construction, rolling stock use, fire protection systems or equipment as a result of repair, refurbishments, upgrade or other means shall not reduce the level of fire safety established at the time of new construction.

Where practicable, changes to tunnels should improve fire safety. All modifications or upgrades should form part of a total, integrated fire engineering design.

7.5 **Consultation and Approvals**

7.5.1 **Consultation**

Tunnel designers and their Fire Safety Engineers shall consult with and accommodate the requirements of RailCorp, the Independent Transport Safety and Reliability Regulator, planning authorities, disability groups, and other relevant stakeholders in the preparation of the fire safety design and its documentation.

The Emergency Services, in particular the NSW Fire Brigades, shall be consulted through the concept design and design development process in order to assess and accommodate relevant operational procedures which may impact on the design.

The requirements of the owners and tenants of any connected buildings and stations through which egress, emergency access, or the venting or escape of products of combustion may occur, shall be considered.

7.5.2 **Approvals**

Tunnel designers shall furnish RailCorp with evidence of compliance with general and specific performance requirements of this Standard in a timely fashion as part of the design, construction, commissioning and operation of rail tunnels.

This process shall generally follow the International Fire Engineering Guidelines and the path for analysis, reporting and submission to RailCorp set out under Section 8 of this Standard.

Approvals shall be sought and received in writing from RailCorp at each stage of project development set out in Section 8.
The designer shall ensure approval at the various stages detailed in Section 8 of all relevant bodies, authorities and other stakeholders who have any input to safety including the Independent Transport Safety and Reliability Regulator and Emergency Services.

8 Fire Engineering Process

8.1 Introduction
The process outlined in the International Fire Engineering Guidelines shall generally be followed when developing, establishing, documenting and agreeing the fire safety design for new tunnels or extensions to existing tunnels.

8.2 Feasibility and Concept Design
In the feasibility and concept design stages of a tunnel project, the Fire Safety Engineer shall ensure that the design of the tunnel complies with all the requirements of this Standard.

The process to be adopted in this stage of a project shall be as detailed generally in the International Fire Engineering Guidelines, Figure 1.2 “A process for developing a FEB”.

Before completion of concept design, the Fire Safety Engineer shall furnish RailCorp with a Fire Engineering Brief (FEB) report which shall include, but not be limited to:

- A description of the tunnel or tunnels and all aspects that impact on fire safety, including numbers of tracks, tunnel dimensions, type of rolling stock, adjacent infrastructure, tunnel gradients, environmental constraints, and access.
- A statement of all assumptions and limitations
- A clear statement of the fire safety objectives.
- A review of all fire hazards and mitigation and control measures in a form consistent with the RailCorp Safety Management System and the Hazard Identification, Safety Risk Register and Risk Assessment methods contained within the relevant RailCorp documents.
- Establishment of clear and agreed fire scenarios and design fires proposed for evaluation to determine compliance with this Standard.
- The trial design concept on fire safety strategy for the tunnel.
- A summary of all proposed construction, materials, components, fire safety systems and fire protection equipment and their proposed test methods and Standards for design, installation and commissioning.
- The methods of fire engineering analysis proposed for modelling and system evaluation, including tunnel smoke development and egress models, and all assumptions, inputs, factors of safety and sensitivity analysis.
- The methodology to be adopted for the fire risk assessment.
- The tenability criteria and fire risk assessment criteria against which the overall level of fire safety is to be evaluated and judged to be acceptable.
- A statement as to how the fire safety objectives are to be met.

Detailed design shall not commence until this Fire Engineering Brief report has been reviewed and approved by all relevant stakeholders.

8.3 Detailed Design
The detailed design shall be consistent with the agreed concept design in order that the completed construction and operations can fully achieve the fire safety objectives and acceptable level of safety required by this Standard.

The process to be adopted for the analysis shall be as detailed generally in the International Fire Engineering Guidelines, Figure 1.3.2 “Analysis of trial designs”.

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Before detailed design is complete and construction commences, the Fire Safety Engineer shall furnish RailCorp with a Fire Safety Assessment (FSA) report as detailed in Chapter 1.11 of the International Fire Engineering Guidelines. The report shall include, but not be limited to:

- Confirmation or updating of all details provided in the FEB report.
- Documentation of all systems and fire equipment proposed for inclusion in the fire safety design.
- Details of all fire engineering modelling and analysis, including timelines for all scenarios evaluated, in a form suitable for ease of peer review, including provision of input data, models used, aspects of uncertainty and safety factors, as well as tenability criteria.
- Full details for the fire risk assessment, including frequency data and input data to consequence assessment, as well as analysis and results, expressed in a form suitable for ease of peer review and consistent with the RailCorp Safety Management System.
- Evaluation of the tunnel against the agreed fire safety criteria and fire risk criteria.
- A clear Statement of Compliance that the Requirements of this Standard have been met.

Construction shall not commence until this Fire Safety Assessment report has been reviewed and approved by all relevant stakeholders.

8.4 Construction and Commissioning

At appropriate stages of the construction process, testing and commissioning of the fire safety systems and equipment shall be undertaken by the designer assisted by the Fire Safety Engineer.

RailCorp staff, its representatives, and/or other stakeholders shall be invited to comment upon, attend or witness tests, including hot smoke tests, fire main tests, fire phone and alarm tests, which are undertaken for the purpose of approval by RailCorp. At least seven days notice of such tests being conducted shall be provided in writing to RailCorp, or otherwise the test results may not be accepted by RailCorp.

Where appropriate, the Fire Safety Engineer shall furnish to RailCorp an update to the Fire Safety Assessment report, including the fire risk assessment, should changes have occurred to any feature of the tunnel which in any way impinges on compliance with this Standard or has an impact on the level of fire safety in the tunnel.

Before construction and commissioning is completed, the Fire Safety Engineer shall furnish RailCorp with a Completion Report which shall include, but not be limited to:

- Documentation of all tests witnessed and inspections undertaken of all relevant construction and fire protection systems and equipment
- Copies of all certificates provided for systems certification
- Details of any changes made to the agreed design and fire safety strategy, and confirmation that such changes do not reduce the level of fire safety below acceptable levels
- A fire safety management plan as detailed in Section 8.5
- A clear statement that the fire safety measures as constructed and installed comply with this Standard and are in accordance with the agreed detailed design and FSA report.

Operation of the fire safety system shall not commence until this Completion Report has been reviewed and approved by all relevant stakeholders.

8.5 Fire Safety Management and Maintenance

Appropriate policies, procedures and training regimes shall be developed and documented by the Fire Safety Engineer in association with RailCorp to ensure that satisfactory on-going fire safety management of the tunnels occurs within the broader RailCorp Safety Management System.

These fire safety management arrangements shall be consistent with and complement the fire safety strategy, systems and equipment as constructed and agreed with RailCorp. These
arrangements shall meet the requirements of the Emergency Response Plan contained in Section 10.18 of this Standard.

Maintenance plans shall be developed for fire safety equipment, documented in maintenance manuals and submitted to RailCorp on completion of commissioning.

All equipment shall be maintained in accordance with Australian or other relevant Standards and Specifications. Fire protection equipment shall be maintained in accordance with AS 1851 “Maintenance of fire protection systems and equipment”.

9 Specific RailCorp Requirements

9.1 Introduction
The following sections outline specific RailCorp requirements that shall be adopted when designing new tunnels and extensions to existing tunnels. Alternatives to the requirements may be considered by RailCorp, provided the fire risk assessment can establish that an acceptable level of overall fire safety is still achieved.

9.2 Design Fires

9.2.1 General
Tunnel designers shall consider fire:
− On the train, assumed to be a disabled train
− Within the tunnel
− Due to vandalism.

Fire arising from acts of terrorism is outside the requirements of this Standard.

If other design fires, rolling stock or otherwise, are identified and liable to affect the tunnel fire safety strategy, a separate assessment of their size and impact is required.

9.2.2 Maximum Design Fire Size
The maximum design fire size that shall be used for the design of the tunnel fire safety strategy is a 20 MW steady state heat release rate.

The maximum design fire size (20 MW) is based on assessments of older electric rolling stock operating on the network. The fire performance of newer rolling stock is expected to result in lower design fire sizes than for the older rolling stock.

9.2.3 Minimum Design Fire Size
The minimum design fire size that shall be used for the design of the tunnel fire safety strategy is a 1 MW steady state heat release rate.

The minimum design fire size (1 MW) is a conservative estimate of the size of the ‘small’ fires experienced on the network.

The heat output from this design fire is appropriate to use when loss of smoke buoyancy due to cooling may be the critical design criterion.

9.3 Fire Resistance

9.3.1 General
The fire resistances specified are based on the standard time temperature fire curve as detailed in AS 1530.4 "Methods of fire tests on building materials, components and structures – Fire-
resistance test of elements of construction”. The hydrocarbon curve is not considered appropriate for use.

RailCorp may consider proposals demonstrating equivalent fire resistance performance to the effect of the design fire heat output exposure for the required duration.

9.3.2 Asset Protection

The tunnel structural assembly should be capable of resisting the design fire for a minimum of 4 hours.

Equipment rooms, other than substations, within the tunnels shall be fire separated from the running tunnels and be capable of containing a fire for a minimum of 2 hours.

Substations shall be fire separated from the running tunnels for a minimum of 4 hours.

9.3.3 Life Safety Protection

For life safety protection during evacuation/fire fighting, the fire separation between incident and non-incident areas shall be determined by the fire safety strategy, including egress and emergency service provisions. The minimum criterion is a 2-hour fire separation.

The materials used shall also resist the spread of flame.

9.4 Detection and Suppression

9.4.1 Detection

The provision of a fire detection system in the tunnel shall be determined by the fire engineering design process. If a fire detection system is not provided, train location shall be determined with sufficient accuracy, notwithstanding driver communication, to enable the ventilation system to be automatically configured for safe egress at that location.

Equipment rooms within tunnels shall be provided with a fire detection system.

9.4.2 Suppression

Automatic suppression in equipment rooms shall be provided for asset protection from fire. Design of suppression systems shall be based on current best practice technology.

9.5 Electrical Supply

Electrical supply for railway tunnels must be very secure and shall be designed to minimise the risk of fire ignition and to minimise combustible fire load.

9.5.1 Station and Tunnel Services Supplies

Power supplies into stations must have three sources of supply with sufficient independence and capacity that the loss of any two will still satisfy the rated load. Sectioning of high voltage feeders supplying station and tunnel services are to be remotely operable.

Low voltage distribution within stations and tunnels, including high voltage to low voltage transformers, must be designed using N-1 design principles based on a firm continuous rating under the first level failure condition. Normal feeding conditions must provide supply from at least two physically separated sources.

As far as practicable low voltage loads should be evenly distributed between the two normal sources of supply.

9.5.2 Traction Supplies

Power supplies into traction substations must be designed using an N-1 design principle based on a firm continuous rating under the first level failure condition. This includes AC feeders, rectifiers
and transformers but does not include equipment down stream of the rectifiers. This design is in effect better than N-1, for the case of loss of DC supply from an adjacent substation, due to the overhead wiring connectivity between substations on the DC side. Under this circumstance it provides a reduced rating sufficient to move trains to a safe point of evacuation for passengers and crew.

9.5.3 Overhead Wiring Sectioning

The sectioning of 1500 volt overhead wiring must be coordinated with:
- signal section boundaries,
- ventilation section boundaries,
- fire safety strategy,
- other fire and life safety systems.

Sectioning of the 1500 volt overhead wiring shall be designed to be consistent with the Fire Safety Strategy and shall include the optimum placement of overlaps to the satisfaction of RailCorp.

There must be at least one overhead wiring isolatable subsection for each ventilation section. However, more than one isolatable subsection may be required depending on the fire safety strategy adopted. Each overhead wiring subsection at the boundaries of the ventilation sections must be capable of remote operation so that power can be removed from the minimum number of trains in the event of a fire or power fault.

Each electrical section must include remotely operated rail connection equipment at each end. Remote closure of rail connection switches is only permitted under emergency conditions involving threat to life. Rail connection switches may only be opened after having satisfied normal procedures used for the cancellation of Access Permits.

9.6 Emergency Tunnel Lighting

9.6.1 General

Tunnel emergency lighting is required to provide minimum safe levels of lighting to enable passengers and/or train crews to detrain to tunnel walkways and for safe egress from the tunnel. This shall be achievable under power failure conditions.

Emergency lighting shall be provided in all tunnels exceeding 160 m in length, unless otherwise agreed with RailCorp. The 160 m is based on the length of an 8-car train set where end detrainment is possible beyond at least one portal.

For tunnels less than 160m and greater than 80m, a risk assessment is required to determine tunnel emergency lighting provisions.

An emergency lighting management system shall be installed to manage the operation and performance of the tunnel emergency lighting equipment.

9.6.2 Tunnel Lighting Design Standard

The design of tunnel lighting levels shall generally be in accordance with AS 1680 "Interior lighting" and AS 2293 “Emergency escape lighting and exit signs”, measured at the appropriate working and egress plane.

9.6.3 Tunnel Emergency Lighting Requirements

The emergency luminaries shall be operated in the maintained mode.

The minimum average tunnel illuminance measured at the designated emergency walking surface shall be 3 lux for emergency egress. The maximum lighting levels should not be so great as to cause difficulties for persons in adapting between the maximum and minimum lighting levels.
The minimum lighting levels specified are to be achieved for the end of life condition of lamps.

The maximum to minimum luminance ratio shall be no more than 10:1.

Emergency lighting shall use 4 hour maintained (self-contained) luminaires.

Emergency luminaires and systems shall be powered from a supply that is an independent supply for emergency systems in accordance with AS 3000 “Electrical installations”. Exit lights, essential signs and emergency lights shall also be powered from the emergency lighting supply and shall be part of the emergency lighting management system.

Emergency luminaires shall be installed at a height above the tunnel walkway surface to permit maintenance without the use of a ladder.

The height of all luminaires shall not interfere with drivers signal sighting and shall be positioned to avoid strobe effects arising from the luminaires being at or close to drivers eye level.

The spectrum of light output shall not interfere with identification of signal aspects.

Response to a failed luminaire shall not exceed 72 hours.

9.6.4 Emergency Lighting Management System

The emergency lighting management system shall monitor the state of the power supply to emergency luminaires. The supply shall be monitored at the point most electrically remote from the supply and the system shall be able raise an alarm in the event of a supply loss. If the emergency lighting supply cannot be restored within the 4 hour maintained period the procedures in accordance with the relevant sections of the maintenance and emergency management plans should be implemented.

Unless otherwise agreed with RailCorp, the emergency luminaires shall be capable of being remotely controlled from a Lighting Management System. The system shall also be capable of remotely testing the luminaires and monitoring lamp performance.


Emergency luminaires shall be surface mounted fluorescent battens complete with clear diffusers.

Lamps and fittings shall have quick re-strike capability.

Low pressure sodium lamps shall not to be used.

Access to internals of the luminaires shall not need special tools. The fittings shall be routinely maintainable with minimum use of tools.

The tunnel light fittings and tunnel lighting controls shall be protected to IP65 in accordance with AS 1939 “Degrees of protection provided by enclosures for electrical equipment (IP Code)”. The emergency luminaires shall be vandal resistant.

9.7 General Tunnel Lighting

Lighting shall be provided in tunnels to facilitate infrastructure maintenance work. The minimum lighting level shall be:

- 40 lux for walking
- 160 lux for visual inspections
- 400 lux for detailed inspections involving the use of measuring gauges.
- The lighting can be permanent or a mixture of permanent and mobile.
- The minimum level for permanent lighting is 40 lux.
9.8 **Power Outlets**

Socket outlets providing 240V-15A and 415V shall be provided along the tunnel for maintenance purposes such as lighting, drilling and other special tasks.

Warning notices adjacent to each socket outlet shall be installed stating that only equipment that it is double insulated to be connected.

9.9 **Communications Systems**

The following communications systems shall be provided in the tunnel:

- Emergency telephones as detailed in section 9.10
- Train radio network
- Mobile phone network
- Government Radio Network (GRN). The GRN shall also be provided on platform and station concourse levels. RailCorp will provide the specification for the GRN.
- Police service radio.

9.10 **Emergency Telephones**

An emergency telephone system shall be installed throughout the tunnels at a maximum of 90 m centres.

Emergency telephones shall also be located at the ends of station platforms adjacent to tunnel portals, cross passages and emergency access portals.

The phone system shall comply with RailCorp Communications Standard ESM 108 “Tunnel Emergency Telephones”.

Tunnel emergency telephones shall be able to directly communicate with locations on the rail system agreed by RailCorp.

LED Blue light indicators shall be installed to identify the location of emergency telephones. Such indicators shall meet the requirements of RailCorp specifications SPG 1571 “Light Signals” and SPG 1572 “Specification for Emergency Telephone Location Lights for Underground Railway”, except that the telephone interface shall not cause the lights to flash when the phone is off-hook (due to a call being in progress or otherwise).

9.11 **Cabling**

9.11.1 **General**

Cabling shall be contained in low smoke, low toxicity, halogen free flame retardant sheath and shall be installed to provide a degree of security against mechanical damage.

Where housed in a trunking or conduit system, the housing system shall be low smoke, low toxicity and halogen free.

Where steel cable trays are used, they shall be installed in insulated sections to reduce the effects of electrolysis and stray traction currents.

The cabling shall also be installed to comply with the requirements for Emergency Systems in AS 3000.

9.11.2 **Signal Cables**

Signal cables shall be stranded copper conductors with fire safe sheath and insulation.

The cable shall comply with AS 3013 “Electrical installations – Classification of the fire and mechanical performance of wiring system elements” as applicable and RailCorp Signals Specifications:
9.11.3 **Electrical Cables**
High voltage electrical cabling shall comply with RailCorp Electrical Standard EP 20 10 00 02 SP "High Voltage Cable”.

Cables for emergency lighting and drainage pump systems shall have a fire rating of 1.5 hours in accordance with AS 3013.

9.11.4 **Communications Cables**
Communications cables shall comply with AS/ACIF S008 “Requirements for customer cabling products”.

Emergency telephone cables shall have a fire rating of 2 hours in accordance with AS 3013.

9.11.5 **Segregation of Wiring Systems within Tunnels**
To give a high degree of reliability and security to the power reticulation system and to minimise the likelihood of adverse interference by fire and mechanical damage, the following provisions apply:

- HV cables from one interlinking station shall be segregated from the other interlinking station and the HV feeders shall not be run in the same enclosure. The cable routes should be designed for the maximum possible physical segregation.
- HV cables shall be housed in conduits and draw pits or cable ducts concealed in the ground
- HV and MV/ LV cables shall be segregated
- Cables for signalling, communications and other systems shall be segregated from each other in accordance with AS/ACIF S009 “Installation requirements for customer cabling (Wiring Rules)” and AS 3000
- Power circuits shall be segregated from circuits of fire smoke control equipment, lighting, emergency lighting and telephone system
- Where practicable, cables shall be kept at a low level to reduce the chance of being exposed to heat from a fire.

9.12 **Ventilation**

9.12.1 **General**
A ventilation system shall be provided in tunnels exceeding 160 m in length, unless otherwise agreed with RailCorp.

A mechanical ventilation system shall not be required in a tunnel less than 160 m in length, subject to a demonstration that safe egress is achieved to the satisfaction of RailCorp.

The use of 160m is based on the length of an 8 car set where end detrainment is possible beyond at least one portal. If 4 car sets use the tunnel then a fire engineering analysis shall be carried out to demonstrate that adequate life safety has been met without the provision of a mechanical ventilation system.

9.12.2 **Tunnel Ventilation – Emergency Operation**
Emergency operation is where a train in a running tunnel has caught fire and come to an uncontrolled stop, or there is a fire in a tunnel not involving a train.

When designing a running tunnel ventilation system, consideration shall be given for normal operation, congested mode, degraded modes and emergency situations. A computer simulation shall be carried out for air and smoke movement within the tunnel. Details of the computer simulation program including assumptions and limitations shall be submitted to RailCorp prior to commencing the work.

The tunnel ventilation system shall be part of the environmental control system.

In the event of a fire in the tunnel, the ventilation system shall be able to control the smoke from that fire and limit the air temperature in the exit path for the protection of passengers, staff and emergency services personnel.

### 9.12.3 Mechanical Ventilation

If a mechanical emergency ventilation system is required it shall be designed such that the following provisions apply:

- For any location of a train, a sufficient airflow can be maintained over the length of the train, in either direction, to prevent back-layering of smoke.
- The air temperature in the exit path should not exceed the recommended limiting conditions contained in the International Fire Engineering Guidelines.
- The air velocities in all sections of the tunnel or associated egress areas used by evacuating passengers will be less than 12 m/s where it may affect passenger egress.
- The airflow shall move the smoke in one direction and permit the evacuation of passengers and access by the fire services from the opposite direction.
- The choice of ventilation direction will be automatic and selected to move the smoke in the opposite direction to optimise egress for the escaping passengers. Manual configuration shall also be possible.
- The ventilation flow shall be capable of being reversed.
- The smoke shall be discharged to the atmosphere and shall not enter a station. Similarly, smoke discharged from a station should not enter a tunnel.
- The mechanical emergency ventilation system shall make provisions for the protection of passengers, staff and emergency services personnel from fire and smoke during a fire emergency and shall be designed to maintain the required airflow rates for a minimum of one hour but not less than the anticipated evacuation time.
- The design shall consider the number of trains likely to be in a ventilation section at the time of an incident. If there is to be more than one train in a ventilation section then a fire safety strategy shall be put in place to allow safe egress from non-incident trains.

### 9.12.4 Fan and Control Damper Design in Emergency Usage

The fan and control damper design in emergency usage shall be designed such that the following provisions apply:

- The mechanical ventilation system shall be designed to maintain the required airflow rates for a minimum of one hour but not less than the anticipated evacuation time.
- The mechanical ventilation system shall be capable of reaching full operational mode within 120 seconds of operation.
- As a minimum, fans complete with the drive, flexible connections and control gear shall be designed to operate in hot smoke. They shall be designed and tested to operate continuously for a minimum of one hour at 250 °C. Design temperatures should be maintained below 250 °C.
- Cabling and instrumentation shall be capable of meeting emergency conditions with cable segregation and one level redundancy of equipment. Fire stops will be provided in cable ducts.
9.12.5 Ventilation Shafts

If ventilation shafts are required the following provisions apply:

- All surface shaft openings shall be designed and located to minimise the environmental impact on the surrounding air.
- Whenever exhaust impacts on to an area used by the public, the velocity shall be limited to a maximum of 5.0 m/s.
- Supply shafts shall be arranged such that sources such as road traffic exhausts, re-circulation from other exhaust shafts, etc do not pollute the air.
- Fan shafts and draft relief shafts shall be optimised for pressure losses.
- Provision shall be made to ensure that any hazardous materials resulting from an accident at or near the shaft opening (such as might be released in a fuel tanker collision) shall not enter the underground system by way of the shaft.
- The location of the fan shafts and draft relief shafts will be dependent on the performance requirement of the system and constraints caused by physical obstructions.
- Protection against vandalism and unauthorised access or interference should be considered.

9.12.6 Emergency Ventilation Controls

The emergency ventilation controls shall be provided at a location determined by RailCorp and shall:

- Graphically display the alarm conditions.
- Provide for operating mode control and indication of the impulse/emergency ventilation systems.

9.12.7 Sequence of Operation

The system shall be capable of initiation either if:

- Contact is lost with the train or driver,
- A fire is reported on a stationary train, or
- A fire not involving a train is detected in the tunnel.

The configuration of the system shall be agreed with RailCorp.

9.13 Fire Hydrant System

9.13.1 General

A fire hydrant system shall be installed. The fire mains and hydrants shall be an un-pressurised charged wet system and designed and installed in accordance with the requirements of AS 2419 “Fire hydrant installations”.

The valves to pressurise the main shall be located in consultation with the NSW Fire Brigades.

Fire hydrant mains in tunnels shall be designed to meet the following criteria:

- Single-track tunnels shall have a single fire hydrant main installed.
- Two single-track tunnels that run parallel to each other and contain cross connection passages shall have a single fire hydrant main installed in each tunnel.
- Dual track single tunnels shall have two fire hydrant mains installed on opposite sides of the tunnel.

9.13.2 Location of Hydrant Mains in Tunnels

Fire hydrant mains shall be designed to meet the following criteria:
− Fire hydrant mains shall be designed and installed in accordance with RailCorp clearance requirements.
− Hydrant mains and landing valves shall be located so they do not impinge on means of escape and are easily accessible to the fire service. Hydrants landing valves shall be located conveniently to egress / access points.
− Hydrant mains shall be located in the optimum position to afford reasonable mechanical protection.
− Hydrant mains should be installed with hydrant points at least at each end of cross passages.

9.13.3 Installation of Hydrant Mains in Tunnels
Hydrant mains shall be installed in railway tunnels and in accordance with the approved design.

9.13.4 Hydrant Landing Valves
Hydrant landing valves of an approved type shall be located at intervals of not greater than 120 m.

Valve outlets shall meet the requirements of the NSW Fire Brigades.

Each hydrant outlet shall be fitted with a blank cap attached to the valve body by a suitable metal chain.

9.13.5 Section Isolating Valves
Approved section isolating valves shall be installed in fire hydrant mains at intervals not greater than 120 m and located adjacent to landing valves.

Valves for isolation duty shall be certified by the manufacturer to be of fire resistant construction for fire main pipework.

9.13.6 Electrical Isolation
Approved electrical isolation joints shall be installed in the fire hydrant mains at intervals not greater than 300 m, to reduce the corrosion affects of stray traction currents and transfer potentials along the tunnel.

9.14 Tunnel Access and Egress

9.14.1 General
Access and egress to tunnels shall be via connected stations, tunnel portals or cross passageways between tunnels. Intervention shafts for access or egress shall be considered but shall only be provided in place of the above options if they are demonstrated to RailCorp to be the optimum option.

Tunnel access shall be by the egress route.

Egress provisions are required to provide for safe efficient egress in the event of an emergency requiring detrainment within a tunnel.

Egress points shall be determined taking account of the package of emergency provisions including the ventilation system, egress strategy, communication facilities, emergency lighting, type of walkway provided, passenger characteristics, tunnel configuration and Emergency Services provisions.

Where an existing railway is being extended the evacuation strategy should interface and be integrated with the existing strategy.

The design of egress provisions for tunnels and emergency procedures needs to address a range of other events in addition to fire, but that this Standard only addresses matters of fire safety.
9.14.2 Signage

Emergency exit facilities shall be suitably and clearly identified.

Instructions for use of emergency telephones and emergency stairs and landings shall be provided.

Where cross passages are provided, signs shall be provided at regular intervals indicating the direction and distance to the nearest cross passage.

Details and locations of the emergency signage shall be agreed with the relevant stakeholders.

Other emergency signage requirements shall be agreed with the stakeholders.

Signage shall be designed in accordance with appropriate Australian Standards and relevant RailCorp standards.

All emergency signs shall be of luminous or reflective type material. They shall be fire rated and have an anti-graffiti coating.

9.15 Walkways

A walkway shall be provided within the tunnel and shall meet the following performance criteria:

- Provide a safe, uniform, smooth, slip resistant walking surface and meet the reasonable requirements of Emergency Services personnel.
- Designed to take into consideration the normal function and maintenance of the railway track and associated facilities.
- Allow safe efficient egress from a train in the event of an emergency.
- Where cross passages are provided, walkways shall be provided on the cross passage side of the tunnel for unobstructed access to the cross passage.
- The width of the walkway shall be agreed with the relevant stakeholders, but as a guide 850 mm should be considered as a minimum width. The 850 mm width is based on an average door width (for a building) and represents what is considered a reasonable width for at least single file egress along a walkway.
- The walkway level shall be agreed with the relevant stakeholders but shall be designed to allow the optimum safe efficient egress.
- The 850 mm width should extend in an envelope 2100 mm above the walkway level. The 850 x 2100 mm envelope shall be clear of all services and other obstructions to allow for a clear unimpeded egress.
- Provision of the walkways shall take account of rolling stock types and associated detrainment facilities and the RailCorp evacuation procedures.

If elevated walkways are to be provided the following criteria, in addition to those identified above, also apply:

- Elevated walkways shall be 5 metres clear of platform end to prevent unauthorised access from platforms.
- Elevated walkways shall have a handrail on the tunnel wall side of the walkway that shall not obstruct egress from the train or access to cross passages if provided.
- Elevated walkways are to be of non-combustible material and designed, in the event of a local failure, that no greater than 10m of walkway collapses. As rail carriages are typically 20 m long, the 10m is based on half the length of a typical carriage. Therefore, if local collapse occurred due to the effects of heat weakening the walkway structure, egress would still be available from at least one carriage side door.
- Elevated walkways shall have ladder access from track level at no greater than 90 m centres. 90 m ladder centres are based on the maximum centres of the emergency telephones. If elevated walkways are to be used for maintenance purposes then separate consideration shall be given to track access.
Consideration should be given to the height of the walkway. It may be beneficial to locate elevated walkways a convenient stepping height below the train door opening. This reduces the elevation difference between the walkway and track bed making track bed access easier in an emergency and reducing potential injuries from possible falls from the walkway. Increased headroom is also achieved and may provide better separation between persons evacuating and hot smoke.

Elevated walk-ways shall be installed 100 mm clear of horizontal platform dimension as determined using RailCorp Standard ESC 215 “Transit Space”, based on whether the walkway is at standard or level access platform height. As this is inside the minimum clearance for transit space, the design shall ensure that the 100 mm clearance is maintained throughout the life of the asset without the need for excessive inspection. The inspection system requires approval of the Chief Engineer Track.

Where a crossover to an adjacent tunnel exists, the elevated walkway shall ramp down to the crossover.

Consideration should also be given to the impact of a derailment where elevated walkways are provided and measures taken in the design so the walkways do not constitute an unacceptable risk to passengers and staff.

The design is to take account of the potential for corrosion due to stray traction currents.

Elevated walkways shall not obstruct signal sighting or signal equipment.

### 9.16 Evacuation Stairs

Where elevated walkways are not provided, stairs and landings for detrainment shall be provided within the tunnels. They shall be fitted on brackets to the tunnel walls.

Stairs should be placed in the vicinity of the emergency telephones.

Stairs and landings shall be designed to achieve a minimum detrainment rate of 40 persons per minute. The minimum width of stairs and landings shall be 600 mm.

Materials for the stairs and landings shall be fire rated, such as aluminium.

### 9.17 Air Lines

The main components of air reticulation systems shall be of low smoke toxicity, halogen free flame retardant material. They shall be of a corrosion resistant metal construction or shall make use of fire safe polymeric materials.

Minor items such ball valves and handle coverings shall meet this requirement wherever possible.

Air hose may be non-halogen free.

### 9.18 Emergency Response Plan

New tunnels shall either be part of an existing Emergency Response Plan or have their own Plan in accordance with the requirements of:

- The State Emergency and Rescue Management Act 1989 No 165

The State Emergency and Rescue Management Act requires the preparation of a New South Wales Disaster Plan (DISPLAN).

The Emergency Response Plan is a Sub-Plan of the DISPLAN and requires development with all the relevant stakeholders. The incident management plans that constitute the Emergency Response Plan are required to conform to the RailCorp Safety Management System.

The Emergency Response Plan is required to:
− Provide a coordinated response by all organisations participating in the operation of the tunnel and the agency responsible for controlling the response to any emergency in the tunnel, in the shortest possible time to minimise loss of life / property; and

− Restore the tunnel to normal operations in an orderly manner in the shortest possible time.

The Emergency Response Plan should detail the arrangements for control and coordination of the response to, and recovery from, an emergency in the tunnel. The arrangements in the Emergency Response Plan shall be designed to handle an emergency in the tunnel that requires a significant and coordinated response to the closure of tunnels, stations or the suspension of services.

It is important to note that the Emergency Response Plan is a network wide requirement and is not just confined to tunnels. Designers are required to integrate the relevant Emergency Response Plan into their tunnel fire safety designs.