Buffer Stops – Train System

Engineering Standard

Rail Commissioner

CS1-DOC-001639

Government of South Australia
Rail Commissioner

DOCUMENT CONTROL

Document Status

DOCUMENT OWNER			
Action	**Name and Position**	**Signature**	**Date**
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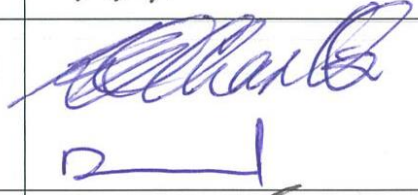
Reviewed By:	Name: Keith Charlton Title: Rail Technical and Operational Assurance Manager Name: David Ogucha Title: Rail Network Engineer		29/9/20 29/09/20
Approved By:	Name: Mark Pronk Title: Unit Manager Track and Civil Engineering		29/09/2020
Document Review Schedule:		This document is due for review as required	

Document Amendment Record

REVISION	CHANGE DESCRIPTION	DATE	PREPARED	REVIEWED	APPROVED
0	Initial Issue	September 2020	Mark Pronk	Keith Charlton David Ogucha	Mark Pronk

TABLE OF CONTENTS

1. Introduction

The Department of Infrastructure and Transport (the Department) operates and maintains the Adelaide Metropolitan Passenger Rail Network (AMPRN) under the Rail Accreditation assigned to the Rail Commissioner.

Buffer stop infrastructure is generally provided at the end of tracks and/or sidings. It is used to prevent rolling stock from running off the end of track and colliding with adjacent structures thereby minimizing risk to passengers and damage to rolling stock so far as is reasonably practicable.

This standard supersedes Section 5.0 Buffer Stops of the CP-TS-962 Volume 2 Train System Part 12 Guard Rails, Buffer Stops & Derails.

2. Purpose

This standard specifies the requirements for buffer stop equipment installed on the AMPRN train system.

3. Scope

This standard applies to all new and reconfigured buffer stops installed on the AMPRN.
This standard may be used to rate the existing buffer stops on the AMPRN.

4. Application

Personnel providing services based on this standard are required to possess appropriate expertise and competence related to this standard.
If it is considered that the intent of stated requirements is not clear, a clarification should be sought from the Unit Manager Track and Civil Engineering.

5. References

5.1. Department Standards

DOCUMENT NAME	DOCUMENT NUMBER
Structural Clearances – Design and Rating	PTS-MS-10-TR-STD-00000047
Track Geometry - Train	TC1-DOC-000448
Structures - Train	TC1-DOC-001642
Rail and Rail Joints	CP-TS-961
Track Support	CP-TS-960
Drafting Standard for AutoCAD Drawings	AM4-DOC-000364
Rail Safety Risk Management	PR-RC-RM-004
Guidelines for Protective Provisions Related to Electrical Earthing and Bonding for the Adelaide Metro Electrified Rail Network	AR-EL-STD-0102
Development and Approval of Engineering Waivers	PR-AM-GE-807
Type Approval for Railway Products	AM4-DOC-000466

5.2. Department Drawings

DOCUMENT NAME	DOCUMENT NUMBER
Friction Element Buffer Stop Type 6 ZEB/2	10-716-000 (KNet # 9525354)
PRE Modular Sliding Friction Buffer Stop	144375 – Sheet 1 (KNet # 7133892)
Mass Concrete Buffer Stop with Red Light	724-A1-2008-634 (KNet # 7747311)

Red Stop Disc Signal	323-A3-2011-2423 (KNet # 8803547)
Diagram Passenger Power Unit 3100 Class (Even Nos)	200-A1-87-1901 (KNet # 11312846)
Diagram Passenger Power Unit 3100 Class (Odd Nos)	200-A1-87-1902 (KNet # 11312873)
Diagram Passenger Power Unit 3000 Class	200-A1-87-1900 (KNet # 11312896)
GA DMA Car Adelaide EMU	3EAM908614 (KNet # 11330389)
GA DMB Car Adelaide EMU	3EAM908618 (KNet # 11552886)
GA T Car Adelaide EMU	3EAM908616 (KNet # 11616611)

5.3. Maintenance Documents

DOCUMENT NAME	DOCUMENT NUMBER
Assembly / Installation & Maintenance Manual for Friction Buffer Stop Installed at "Seaford Extension Project – SA AS 50kg Broad Gauge (1600 mm)"	KNet # 7133877

5.4. Australian Standards

DOCUMENT NAME
AS 1720 Timber Structures
AS 2700 Colour Standards for General Purpose
AS 3600 Concrete Structures
AS 4100 Steel Structures

5.5. Legislation

DOCUMENT NAME
Rail Safety National Law (South Australia) Act 2012
Rail Safety National Law Regulations 2012

6. Acronyms

ACRONYM	FULL NAME
AMPRN	Adelaide Metropolitan Passenger Rail Network
SFAIRP	So Far As Is Reasonably Practicable
SIA	Safety Impact Assessment
OHW	Overhead Wiring

7. Terms and Definitions

TERM	DEFINITION
Buffer Stop	A structure; generally provided near the end of a main line or siding track; which is intended to prevent rolling stock from running off the track, impacting on adjacent infrastructure and being provided to absorb the impact of rolling stock.
End of Track	The location where the rail track is terminated and rolling stock can no longer travel safely.

8. General Requirements

- Buffer stops shall be designed with a minimum life of 40 years.
- The design shall:
  - be compatible with the signalling, electrical and overhead wiring systems;
  - consider access for inspection and maintenance of components; and

- select components, materials and finishes that will minimise maintenance during the life of the structure.

- Approved structural materials are steel and concrete (which could incorporate hardwood timber).
- The material selection shall comply with the relevant Australia standards.

9. Approved Configurations

The approved configurations for buffer stop devices are as follows:

- Energy Absorbing Buffer Stops (preferred)
- Fixed Buffer Stops (non-preferred)

Energy absorbing buffer stops provide greater protection for people and rolling stock than the fixed buffer stops as they can absorb greater amounts of energy and reduce effects of collision on passengers and rolling stock.
Proposed buffer stop configuration shall only be permitted with written approval from the Unit Manager Track and Civil Engineering.

9.1. Energy Absorbing Buffer Stops

Selection of buffer type shall be based on the following order of priority:

1) **Friction Type**
2) **Hydraulic type**
3) **Combination of friction and hydraulic**

9.1.1. Friction Buffer Stops

Friction buffer stops shall be designed to absorb the impact of rolling stock at low speeds and stop the rolling stock by using friction between the buffer and the connections to rails.

These buffer stops shall be used in locations where there is sufficient distance for gradual braking of trains as the friction shoes enable buffer stops to slide along the rails.

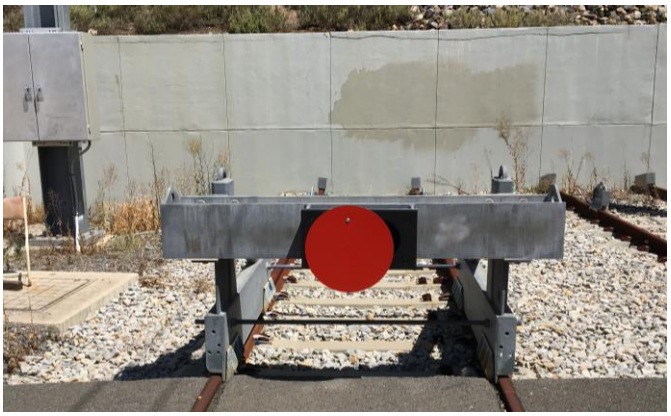


Figure 1: Friction buffer stop

9.1.2. Hydraulic Buffer Stops

These buffer stops dissipate the energy, after a collision, through the hydraulic arms that move in the direction of the train's travel and gradually slow it down to a stop. Hydraulic type buffers should be avoided due to the high cost of maintenance and repairs after a collision.

Figure 2: Hydraulic buffer stop

9.1.3. Combined Friction and Hydraulic Buffer Stops

These buffer stops can be installed to reduce the overall activation length for the buffer stops. The initial impact of the train after collision is taken by hydraulic arms. Residual energy is transferred to the buffer frame and then friction shoes which bring the train to a stop.

Figure 3: Combination of friction and hydraulic buffer stop

9.2. Fixed Buffer Stops

Fixed buffer stops shall only be used within Stabling Yards, Sidings or Depots, when space constraints exist and it has been proven to be not economically feasible for reconfiguration of the location to provide for an energy absorbing type. At such locations a risk assessment, as described in Section 12, shall be carried out to ensure the residual risk is acceptable.

Fixed buffer stops shall be constructed in accordance with 724-A1-2008-634.

Figure 4: Fixed Buffer Stop

10. Location Criteria

Table 1 below summarises the minimum requirements for the provision of buffer stops.

This table does not negate the requirement for risk assessments and SIA's as noted in this standard.

Table 1: Minimum buffer stop treatments

MAINLINES AND TURNBACKS	STABLING YARDS, SIDINGS AND DEPOTS
• Energy Absorbing	• Energy Absorbing (preferred) • Fixed (non-preferred) [1]

[1] The Unit Manager Track and Civil Engineering shall provide the final endorsement if a non-preferred buffer stop is proposed.

11. Type Approval Requirements

Type approval shall be obtained for any buffer stops not previously type approved for use (or those approved prior to the Departments type approval process being implemented).

AM4-DOC-000466 details requirements for type approval.

As a minimum, the following information shall be submitted as part of the application when requesting type approval of a buffer stop design:

- risk assessment
- design vehicle speed and mass
- compatible rail types and sizes
- performance under specific design criterion
- drawings
- design calculation results (including design criteria buffer stop activation length and various assumptions)
- rolling stock being catered for
- range of couplers and coupler heights allowed for in the design
- test results from impact trials
- assembly and installation procedures
- resetting procedures
- spare parts list and product availability
- maintenance plan including details of failure modes, inspections (routine and post incident) and procedures manual
- protective coating specification

It is recognised that the first seven items in the list immediately above are site specific and will vary for future installations of the type approved buffer stop.

12. Risk Assessment

A risk assessment for each location shall be carried out to determine the design performance criteria for the location. The risk assessment shall assess against the risk criteria defined in PR-RC-RM-004 *Rail Safety Risk Management.*

It shall include factors associated with the trains approach to the buffer stop and areas of risk behind the buffer stop. The risk assessment shall be site specific and shall consider the following issues:

- potential speed of rail vehicles approaching the line or siding termination point
- the type and mass of rail vehicles
- track usage
- effective gradient at the termination point
- consequences of rolling stock hitting a buffer stop (potential proximity of personal or the public)
- proximity and criticality of adjacent structures (for example bridges, tunnels and OHW structures), facilities and properties such as concourse areas and buildings
- location of adjacent roads, pedestrian areas, other tracks, ditches, embankments or water courses

In order to establish the nature and extent of damage upon collision, the risk assessment for the buffer stop design shall consider the possibility of a train travelling at a speed higher than the design speed and the expected consequential damage upon collision. In the SFAIRP justification, an indication shall be provided to indicate the following:

- Up to the design speed that no permanent damage will occur to the train. The buffer stop will be fully recoverable, either automatically or within simple maintenance actions.
- Up to the 'worst case speed' that the damage will be easily reparable; for example, easy repair or replacement of buffer stop parts.
- Beyond the worst case speed, irreparable damage is expected to the buffer stop; however the collision damage is expected to be contained to the immediate vicinity as far as practicable.

The risk assessment shall also consider any other relevant site specific criteria. Additional safety measures that could be adopted include the following:

- construction of end impact walls
- improvement of lighting conditions within the buffer stop approach
- installation of signs displaying distances on the approach to a buffer stop
- limitation of train speeds
- identification and removal of sighting obstructions

It should be noted that the minimum distance at which a train should stop shall be 5m before the buffer stop.

13. Design Criteria - Energy Absorbing Buffer Stops

The following design criteria shall be provided as below:

13.1 Train mass

The design of buffer stops shall consider both the minimum (tare) mass and the maximum (loaded) mass of trains.

For each location the risk assessment process shall determine the appropriate minimum and maximum masses based on the type of rolling stock, train set combinations and whether empty or loaded trains are proposed to operate at the site.

Table 2 shows nominal train masses estimated on the range of rolling stock across the network.

Table 2, Indicative train loadings and masses

VEHICLE TYPE	TARE MASS (t)	LOADED MASS (t)	ADDITIONAL DETAIL
Class 4000	136.9	178.5(1) 190.1(2)	Based on a 3 car set
	273.9	357(1) 380.2(2)	Based on a 6 car set
Class 3000	47.5	65.0	Based on a 1 car set
	285.0	390.0	Based on a 6 car set

Note:
(1) Normal Operating Mass
(2) Exceptional Operating Mass
These loadings and masses shall be confirmed by the Departments Rolling Stock Engineering Unit during the buffer stop design phase.

13.2 Train speed

The minimum design speed shall be 15km/h, however may be a 'more probable' higher speed (or 'worst case speed') as determined by the risk assessment.

13.3 Deceleration rate

Rolling stock shall be brought to a stop; from the maximum determined impact speed (as drawn from Section 13.2 and the Risk Assessment); at a deceleration rate of not exceeding 1.5m/s².
In situations where site constraints make it unavoidable (i.e. where space is limited), lightweight trains may be subject to higher rates of decelerations, up to a maximum of 2.5m/s².
The above values shall be subject to compliance with Section 13.6.

13.4 Track requirements

The buffer stop track shall include track at least 20m in front of the buffer stop, the frame length (buffer stop components) and the activation length required for the buffer to stop a train at the design speed and shall include the following minimum requirements:

- New AS50kg rail (unless the buffer stop requires a heavier rail section)
- New concrete sleepers and resilient fasteners (unless slab track)
- Full ballast profile for ballasted track
- No mechanical rail joints

A length of straight track, at least equal to the length of the longest vehicle permitted to operate on that track (with a minimum length of 20m), shall be provided wherever reasonably practicable on the approach to a buffer stop.

The rail surface shall be clear of any obstructions and continuous; without any welds that may cause the rails to deform; especially where attachments related to friction only or combined friction and hydraulic buffer stops are required to travel along the track.

No raised embossing on the rail is allowed within the activation length L_A (refer Figure 5).

When designing buffer stops, it is necessary to take the vertical alignment into account. Tracks having a negative approach gradient (descending) when running in the direction of the buffer stop increase the kinetic energy released by the trains while tracks having a positive gradient (ascending) decrease it.

It is preferred that buffer stops are placed on tracks with a positive approach gradient (ascending) towards the buffer stop, however if this is impractical then a zero approach

gradient shall be achieved.

The design shall consider how the buffer stop track interfaces with other tracks.

13.5 Buffer stop activation length

This relates to friction only or combined friction and hydraulic buffer stops.

The buffer stop activation length (L_A) is essential to accommodate the backward movement of the buffer stop. This distance depends on the buffer stops braking forces and is the distance required to ensure the gradual deceleration of a train which has collided with a friction or combined friction and hydraulic buffer stop and associated friction shoes. The concept of the buffer stops L_A in relation to the buffer stop total length (L_T) and frame length (L_F) is given in Figure 5.

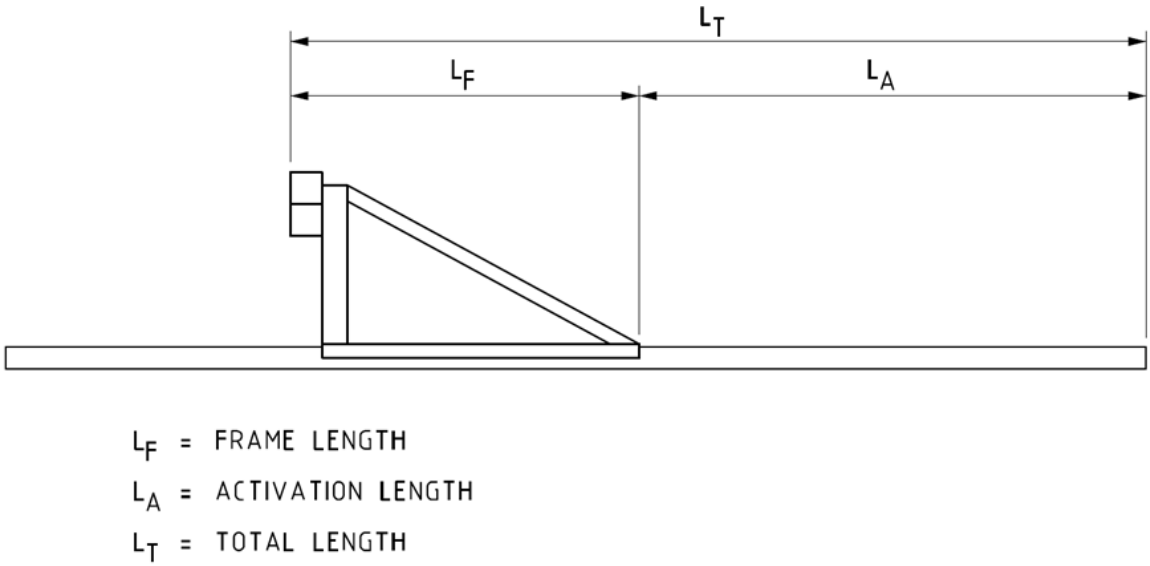


Figure 5: Buffer stop total length, frame length and activation length

13.6 Maximum force to minimise train damage

To prevent damage to the rolling stock the buffer stop shall exert a maximum force of 1500 kN on the rolling stock.

Recent rolling stock procurement specifications include the requirement for progressive energy absorbing components at the impacting end of the set. However, older rolling stock do not have this allowance for progressive energy dissipation and may begin to suffer structural damage at forces in excess of 1000 kN.

Structural damage to couplers occurs for:

- Class 3000 rail vehicles at impact forces of greater that 540 kN; and
- Class 4000 rail vehicles at impact forces of greater than 1500 kN. h

Rolling Stock Engineering shall be consulted during the Risk Assessment phase to confirm the impact force values.

13.7 Coupler compatibility

Rollingstock Engineering shall be consulted when designing for coupler compatibility. Refer to Section 5.2 for a number of relevant rollingstock drawings.

14 Signage

All permanent buffer stops shall be provided with a Red Stop Disc Signal mounted on the face of the buffer stop.

Buffer stops installed under OHW shall have signs attached warning of 25kV AC OHW.

15 Overhead Wiring Requirements

The design shall incorporate requirement noted in the Guidelines for Protective Provisions Related to Electrical Earthing and Bonding for the Adelaide Metro Electrified Rail Network (AR-EL-STD-0102) document.

Buffer stops shall not be located under overhead wiring sectioning equipment such as insulators, overlaps and air gaps.

Overhead wiring shall extend along the buffer stop activation length, such that pantograph run-off is mitigated.

16 Construction

The design location of the buffer stop shall take into account construction constraints, particularly any construction activities identified under live traffic as well as any restrictions associated with construction during track possession.

The buffer stop shall be constructed in accordance with the manufacturer's requirements.

17 Monitoring and Maintenance

Buffer stops shall be inspected:

- during track walking inspections; and
- following the report of a collision.

Buffer stops shall be maintained in accordance with the manufacturer's requirements.

18 Decommissioning, Re-use or Disposal

The decommissioning or disposal of an asset is the final stage of the asset life cycle. Proper planning of this part of the life cycle is an integral part of the strategic life cycle process.

Decommissioning is the process of withdrawing an asset from operational service on the network whilst disposal is the process of physically removing a decommissioned asset, for example, demolition of a buffer stop followed by removal and recycling.

The asset database shall be updated to reflect network changes following decommissioning or disposal.

Where a buffer stop is removed and reused at another location a risk assessment shall be undertaken to ensure compliance with this standard.