AUSTRALIAN RAIL TRACK CORPORATION LTD

Engineering (Track & Civil)	Guideline

Buffer Stops and Restraining Devices for Dead End Tracks

ETH-00-01

Applicability

ARTC Network Wide	✓

Document Status

Version	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.0	02 Jul 12	Standards	Manager Standards	Operational Safety & Environmental Review Group	Safety & Environment Committee 16/07/2012

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	02 Jul 12		First issue of new Guideline.

Contents

1 Introduction

1.1 Purpose

The ARTC Track & Civil Code of Practice (T&C CoP) stipulates that where there is a risk to people or property behind the dead end, adequate protection shall be provided.

This guideline outlines a range of restraining devices (either singly or in combination) which can be used at the end of dead end tracks.

These restraining devices are installed for one main purpose; to protect people and property, adjacent to or beyond the end of the dead end.

Note:

For dead ends where an over run will cause no appreciable damage to persons or property, then consideration should be given to minimising costs of the over run (i.e. cost of damage to the rolling stock itself as well as cost of rerailing). An example would be a site where the dead end runs towards an empty paddock or Nullarbor Plain. In this case,, an over running vehicle would not cause any damage to people or property, only to itself. It is also beneficial to be able to rerail vehicles that have over run the dead ends.

1.2 Site Specific Risk Assessments

It should be stressed that this is a guideline only and each site should be assessed on its merits. Such assessments should focus primarily on the adequate protection of people and property adjacent to or beyond the end of the dead end.

It should also be noted that that any effective arrestor must have some means of absorbing impacts. I.e. it is virtually impossible to stop even a very slow moving rail vehicle instantly. Energy must be absorbed over some distance, or the vehicle deflected away from danger.

1.3 Scope

This guideline covers a range of restraining devices for the end of dead end tracks. The calculations, on which these guidelines are based, are primarily for runaway vehicles i.e. in most cases, they will not be adequate to restrain vehicles pushed into them by a locomotive or powered vehicle. In these locations, heavy stopping structures, engineered sliding buffer stops or a signalling system should be considered.

Another factor to be considered is that some restraining devices will have to be partially or completely rebuilt every time they are struck heavily.

It should be noted that the restraints in this document are for the end of dead ends only. There are other devices (such as catch points and derails) which can be used to prevent vehicles from fouling running lines.

1.4 Philosophy behind Site Specific Risk Assessments

The level of restraint required for rail vehicles is based on two main considerations:

1. Where an over run has the potential to cause significant damage/injury/disruption to people, facilities or equipment, then the restraining device must have the capacity to stop the rail vehicle/s. An example of this would be a dead end that fronts onto a protected level crossing. Hence, an over running vehicle could collide with road vehicle stopped at the crossing and people and vehicles could be injured/damaged. So the over running vehicle MUST be stopped.
2. Where the consequences of overrun would be catastrophic damage to assets behind the dead end then special design of dead end stop is required.

1.5 Relevant Procedure

This guideline supports Section 0: Track and Civil Management System of the ARTC Track & Civil Code of Practice.

1.6 Responsibilities

The Manager Standards is the guideline owner and is the initial point of contact for all queries relating to this guideline.

The Infrastructure Manager, Delivery Manager or nominated delegate for each Corridor is responsible for managing the application, maintenance and documentation of the process.

1.7 Reference Documents

The following documents/systems support this guideline:

- ARTC's Safety Management System
- ARTC's Codes of Practice for Track Maintenance
- TDS 16 'Light Duty' Maintenance Siding Specification
- SDS 14 Points

1.8 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Arrestor bed	A bed of loose material placed at the end of a dead end to stop runaway vehicles. It could consist of ballast, gravel or compacted soil. The bed may just be a compacted graded pile as shown in Appendix C. Sometimes second hand concrete sleepers are used, but they can cause damage to vehicles - see also solid buffer stop.
Away from danger	This is where an arrestor or diversionary method is used to prevent either damage to the runway vehicle, or to rail or road vehicles on an adjoining road or railway. Or to prevent them from striking key equipment like signal cabinets, towers, buildings, etc.
Baulk	A rectangular piece of hardwood timber of approximately 300 by 200 mm which is bolted to the track as shown in the drawings in Appendix D.
Bent track	This is another means of diverting runaway vehicles away from danger – be it danger to them or other facilities. The end of the dead end simply has a short curve placed in it so that it turns any runaway vehicles away from a danger zone.
Buffer stop	A structure erected across and at the end of a dead end track which is intended to stop rolling stock.
Dead end signal or buffer stop lights	Shunting signals applying to short movements from the running line to a dead end siding. Lights are usually behind the stop at a height of 1200 to 1400 mm above rail level.
Derailer	A mechanical device which is attached to the track and is designed to derail a wheel at a designated point by lifting and moving the wheel across the head of the rail. Usually used to protect vehicles from fouling running lines, so is not included as an option in this Guideline.
Friction sliding buffer stops	These are a site specific design which are designed to slide along the rail. After use, they can easily be reset to their original position. See one example in Appendix E.
Heavy stopping structure	A structure that weights so much that it will stop almost any vehicle – even if it damages it in the process. Such structures could include a large steel framed box or gabion type structure filled with ballast or stone. If this was say 3m X 6m X 1.5m it would weight about 40 tonnes and should stop most vehicles, but it may damage them in the process.
Over running vehicle	A rail vehicle that runs over the end of a dead end i.e. its wheels drop off the end of the rails.
Restraining device	Any device or structure that controls the movement of a rail vehicle at the end of a dead end.
Runaway vehicle	An unattached rail vehicle (<u>or vehicles</u>) that travels down a dead end track out of control.
Solid sliding stop	This is a mass of fairly heavy material that sits on the rail. Retardation is gained by friction between the stop and the rail. It could be a mass off concrete or a stack of second concrete sleepers or a steel box full of soil, etc. Can cause damage to vehicles.
Stop block	A structure fixed at the termination of a running line or dead end to arrest very slow moving vehicles. Sometimes known as a “Scotch Block”.

2 Specification

2.1 Outcome

The aim of this document is to provide a series of steps for field staff to proceed through to assess sites and ensure that the aims of this procedure are met.

3 Design

3.1 Steps that should be followed when determining the most appropriate restraining device

Below is a suggested sequence of steps that can be followed to try and ensure that effective, safe arresting devices are installed.

- Step 1: Assess the site for potential risks i.e. will an over running rail vehicle cause any damage to people or property. See Appendix A for guidelines.
- Step 2: Determine the average grade of the dead end - see Appendix B for measuring methods.
- Step 3: Determine the length that the runaway vehicle might reasonably be able to gather speed over.

Note:

This may be from the back of the turnout off the running line, or from a high point in the dead end.

- Step 4: Determine the approximate speed from table 1 below:

Table 1 - Grade/Length/Speed Chart

Distance in metres		**20**	**50**	**100**	**200**	**300**
Grade	**%**	**Speed at end of track in km/h**				
1 in 50	**2**	10	16	22	31	38
1 in 100	**1**	7	11	15	21	26
1 in 200	**0.5**	5	7	10	14	17
1 in 300	**0.33**	3	5	8	11	13
1 in 500	**0.2**	2	4	5	7	9

- Step 5: Apply actions in table 2 for possible type of arrestor:

Table 2 – Actions to take for different types of arrestor

Type of arrestor	Max. speed it is effective for	Is further arrestor required?	Cost range	Comments	Secondary arrestor required – if an over run may cause injury or damage	Repair/replacement when significantly struck
Baulk	1.5 km/h	Probably	Low	Primarily just a marker – provides little resistance	Yes – in most cases	Complete rebuild almost always required
Bent track	20 km/h	Probably	Low	Simple option. Can have baulk as marker	Yes – in most cases. Secondary arrestor likely to be required if site is dangerous	Should be able to just drag vehicles back onto track
Arrestor bed as shown in Appendix C	15 km/h	Not usually	Low	If no asset to be protected then allow wagon to run into paddock	Unlikely	Partial repair usually required – grading, etc
Solid sliding stop	5 to 15 km/h (depending on weight)	Not usually	Moderate – depending on materials	See definitions in 1.8 above	Depends on design	Would have to be pulled back along track
Friction sliding buffer stops	25 km/h (depending on design)	No	High	There are many designs. Need to check with supplier and match to site. See Appendix F for indications of speed and momentum of vehicles	Needs engineering design	Should just need to be reset. May require replacement friction blocks if they are worn.
Heavy stopping structure	25 km/h	No	Moderate	Many designs – concrete structures, gabions, steel boxes filled with ballast or rock, etc	No	Probably not, but likely to damage vehicles
Long arrestor bed or allowing wagon to run off into paddock	>25km/h	No	Low	Used beyond short arrestor or other device when there is no asset behind the dead end. Can build compacted earth ramp off end of track to minimise damage to rolling stock and permit easy rerailing		

4 Inspection

4.1 Frequency

Arrestor devices should be inspected by a competent Track worker when completing normal yard inspections for points and crossings. Reporting of defects or changes in risk profiles, should be by exception.

The item shall be recorded on Asset Registers and have Maintenance Service Orders created in accordance with the required inspection frequency of the Maintenance Plan.

4.2 Change in Risk profile

If during the inspection, there has been some appreciable change in risk levels, then this should be reported to the appropriate ~~Area~~ Manager of the infrastructure. Examples of some such changes could be the following erected/installed just behind the end of the dead end:

- A new road or railway track
- A new structure, especially a building housing people
- A signal cabinet or column
- A pier or support for an overhead bridge, walkway, pipeline, etc
- An embankment with a steep slope, which could result in runaway vehicles accelerating down this grade
- Any other item which a runaway vehicle could collide with.

5 Maintenance

5.1 General

It is impossible to specify limits for deterioration of all the arrestor devices that are possible under these Guidelines. However, a Competent Track worker should be able to exercise reasonable judgement in this regard.

Basically the arrestor device should be maintained at a level that will enable it to perform to give an appropriate level of safety.

5.2 Repairs after usage

After a runaway vehicle has been retarded by the device, in many cases it will require repairs – see last column in Table. At high risk sites these repairs should be completed as soon as practicable, depending on usage.

Alternatively, for high risk sites, the dead end should be closed to all traffic until repairs have been completed.

Certification of the repairs by a person with appropriate competence shall be documented and kept with asset and maintenance records.

6 Decommissioning

In the event of a dead being closed, in many cases the cheapest option may be to just leave the arrestor devices in place. But in some cases there could be reasons to justify their removal. Such reasons could include:

- Economics – can the device be reused at another site?
- Aesthetics – will the deteriorating device be an eyesore?
- Vandalism
- Risk to the public

In these cases, the devices should be removed and the site cleaned up.

7 APPENDICES

APPENDIX A - Risk Factors

Possible risks that could be present beyond the end of a dead end and could require a secondary arrestor device.

People:

- Pedestrian walkway
- Level crossing or road way
- Other railway tracks.

Property:

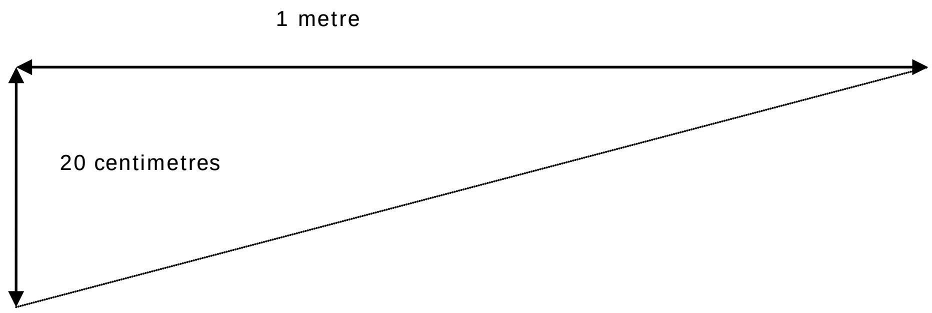
- Signal cabinets
- Other railway tracks
- Buildings, especially those that are regularly inhabited
- Signal towers or structures
- Supports for overhead structures, bridges, walkways, pipelines, etc.

Factors which increase risk level:

- Dead ends at the top of banks, where an over running rail vehicle could run down the bank and strike or foul roads, track, buildings etc.

APPENDIX B – Calculating a Percent Slope

To calculate a ***percent slope*** simply, you apply the following formula:



Measured over 1m (100cm) and rise of 20cm the percentage of slope is 20%.

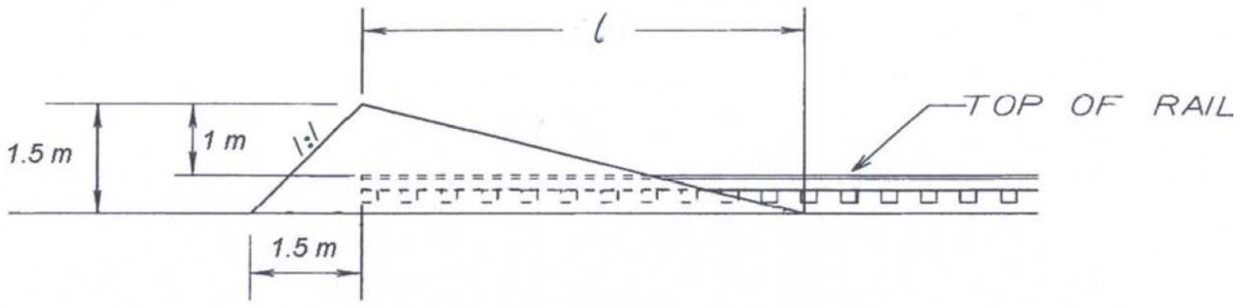
Method:

Take a one metre ruler or straightedge, a spirit level and a plumb line. Put the ruler horizontally to the top of the rail checking with the level, and then write down how long is the plumb or ruler down to the lower section of rail, this distance (drop) will be the percentage. This is straightforward because 1 metre is 100 centimetres.

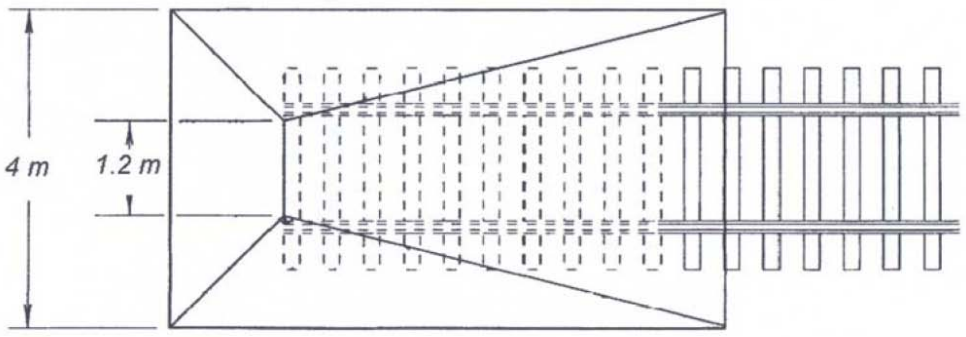
For a 1m ruler or straightedge, slopes will be as follow:

Drop		Grade	
In cm	**In mm**	**Percentage**	**Ratio**
2	20	2%	1 in 50
1	10	1%	1 in 100
0.5	5	0.5%	1 in 200
0.33	3.3	0.33%	1 in 300
0.2	2	0.2 %	1 in 500

APPENDIX C – Granular (soft) arrestor bed



ELEVATION VIEW



PLAN VIEW

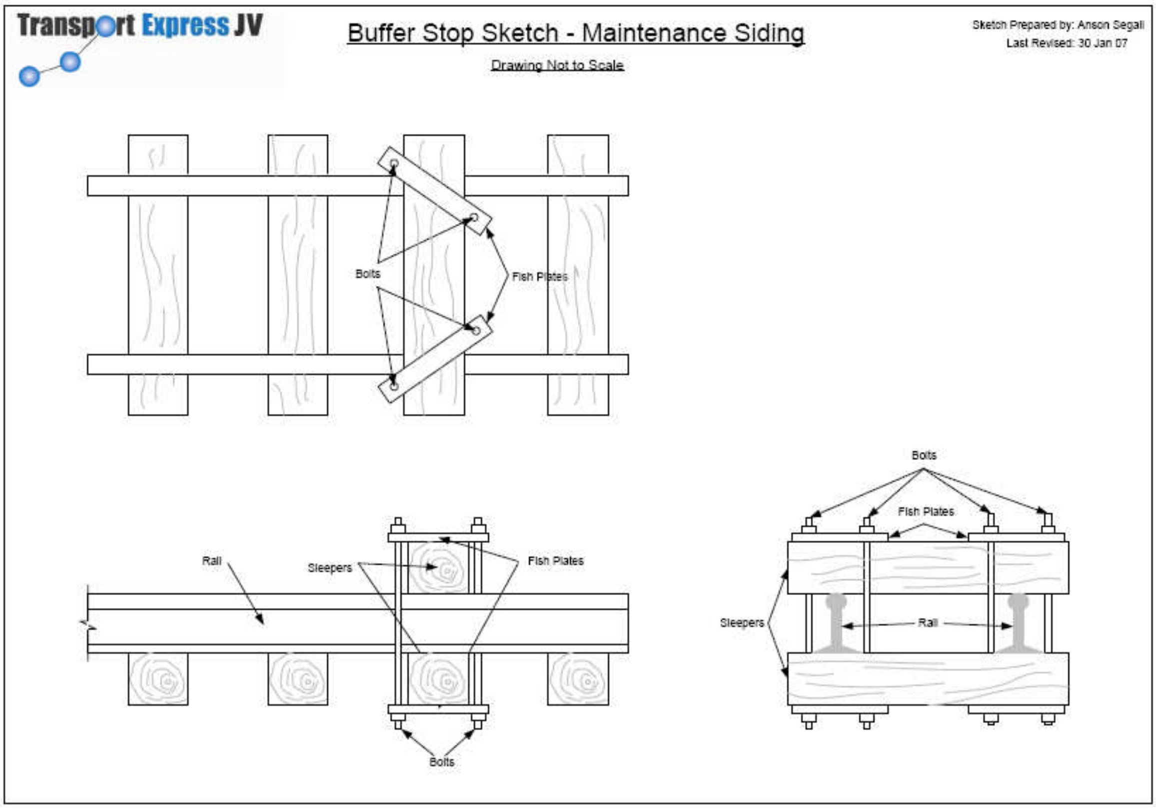
Note:

Length to depend on estimated vehicle speed from Table 1 above. As a guide, a vehicle at 15 km/h requires a length of at least 5 metres.

Material can be anything that will retard vehicles. Should be soft enough for wheels to dig in. Not so hard that wheels ride over the top of the slope.

APPENDIX D – Schematic design details for a timber baulk fastened to a sleeper

Note: Bolts to be at least 19 mm diameter and kept tight.



APPENDIX E – One example of a Sliding or friction buffer stop

APPENDIX F - Runaway vehicles – Grade / Speed / Momentum tables

Grade / Length / Speed Chart

Distance in metres	20	50	100	200	300
Grade	**Speed at end of track in km / h**				
1 in 50	10	16	22	31	38
1 in 100	7	11	15	21	26
1 in 200	5	7	10	14	17
1 in 300	3	5	8	11	13
1 in 500	2	4	5	7	9

Momentum, Empty vehicle (20 tonnes mass)

Distance in metres	20	50	100	200	300
Grade	**Momentum in kg.m / sec x 100,000**				
1 in 50	0.54	0.86	1.22	1.72	2.11
1 in 100	0.37	0.59	0.84	1.18	1.45
1 in 200	0.25	0.39	0.56	0.79	0.97
1 in 300	0.19	0.30	0.42	0.60	0.73
1 in 500	0.12	0.19	0.28	0.39	0.48

Momentum, Loaded vehicle (92 tonnes mass)

Distance in metres	20	50	100	200	300
Grade	**Momentum in kg.m / sec x 100,000**				
1 in 50	2.51.	3.97	5.61	7.94	9.73
1 in 100	1.72	2.73	3.86	5.46	6.69
1 in 200	1.15	1.82	2.57	3.64	4.46
1 in 300	0.87	1.38	1.95	2.76	3.38
1 in 500	0.57	0.91	1.28	1.82	2.23

Momentum, Loco (134 tonnes mass)

Distance in metres	20	50	100	200	300
Grade	**Momentum in kg.m / sec x 100,000**				
1 in 50	3.65	5.78	8.18	11.57	14.17
1 in 100	2.51	3.98	5.63	7.96	9.75
1 in 200	1.67	2.65	3.75	5.30	6.50
1 in 300	1.27	2.01	2.84	4.02	4.93
1 in 500	0.84	1.32	1.87	2.65	3.25

Notes:

1) *Based on formulas developed by Fred Mau (Steelcon Consultants) – June 2011.*
2) *Distance is from where vehicle commences to move, to where vehicle is restrained / strikes arresting device, etc.*
3) *Based on theoretical determinations – see assumptions in calculation.*