EFFECTIVE USE OF DERAILERS AND CATCHPOINTS TO PROTECT RAIL OPERATIONS

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SUMMARY

An incident at Temora in July 2009 occurred when a run-a-way wagon travelled 7.8kms across seven level crossings (NSW Country Rail Network) and came to rest. Fortunately no one was injured during the incident. There were several safety precautions in place that day to prevent such a situation, all failed to do so. A derailer was under construction on the siding and not properly operational. But at what speed would the run-a-way wagon be controlled by the Derailer? There was no definitive information available to answer this question.

Theoretical modelling and validation testing was carried out using a SIEMENS (Invensys Rail) D150 Derailer and C150 Crowder at Canberra Railway Museum to test the capabilities/limitations of the derailing equipment that is currently in use on the ARTC network (same equipment used at Temora).

This paper details the findings, conclusions and recommendations from the tests that were carried out and alternative solutions to ‘permanently’ derailing rolling stock.

INTRODUCTION

There are two mechanical options to purposely derail rollingstock on the ARTC Network; a derailer or a catchpoint.

A derailer is a device used to prevent fouling of a rail track by unauthorised movements of unattended rolling stock. It works (as the name suggests) by derailing the equipment as it rolls over or through the derailing equipment.

Derailers work by lifting the flange of the car wheel up and over the rail and dropping it clear of the rail. Simultaneously, the wheel opposite the derailer is guided off the rail by a ‘Crowder’ (if installed). Once the car wheels leave the rail, forward movement is greatly impeded (ballast drags are commonly used to increase the retardation effect).

Catchpoints are used to guide rollingstock away from the rail track in a more precise manner. There are five configurations of catchpoints to cover various situations. The derailed trajectory of rollingstock can be tailored with far more accuracy. The use of catchpoints has higher performance in protecting unauthorised train movements but it is a fixed installation and significantly more expensive than the derailer.

The derailment of any rail traffic is a last resort in protecting the safety of the railway. It is used when all other safety measures have failed i.e. SPAD due to driver error, wagon run-a-ways or unauthorised rail movements.

Theoretical calculations are often used to determine what potential run-a-way speeds the rollingstock can attain. These calculated values are then used to determine if a derailer could be used instead of a catchpoint in a given location. Lack of practical results or modelling of equipment choice in such a vital situation can have ineffective results! An engineered approach/solution is therefore required, modelling is one such tool. Testing is then required to validate the model.

THEORETICAL MODELLING

In 2011 Max Shuard was commissioned by ARTC to produce varying theoretical tables for use in understanding what rolling stock capabilities/limitations are in certain circumstances. Circumstances could be runaway wagons (the speed they can achieve over varying inclines and declines), derailers and their ability to derail rolling stock or not, and rolling drag calculations (the distances rolling stock can achieve once derailed onto varying surfaces). The spread sheets and the data he produced enabled rolling stock variables to be inputted into complex equations easily and unambiguously.

The spread sheets provided theoretical answers to the inputted variables. The tables regarding the rolling drag calculations and the ability for the
A derail to derail were theoretical and required testing and validation.

In November 2012 tests were carried out to validate the theory employed by some of these tables. The measurements taken during the derailment tests were used to validate the accuracy of some of Max Shuard’s theoretical models.

### THEORETICAL TABLES/MODELLING

Three models are discussed in this paper, the first (Figure 1) ‘Run-a-way Distance Calculator’ is yet to be tested, but plays a significant part in the decision making of whether to use a derailor or not. The accuracy of the other tested models produced by Max Shuard gives confidence in the accuracy of this model ‘Run-a-way Distance Calculator’.

The models shown in Figures 2a & 2b are used to calculate if rollingstock shall derail or not, there are two sections, Part B & C. Variables are inputted into both sections by the designer, a singular result detailing if the rollingstock will derail or not is provided as an output.

The model shown in Figure 3 is used to calculate the distance travelled by the derailed rollingstock.

The models shown in Figures 2a, 2b and 3 were validated by testing, some of the results are detailed in the following sections.

#### Run-a-way Distance Calculator Model

The spreadsheet shown in Figure 1 is designed to enable easy and unambiguous inputting of rollingstock, track and gradient variables. The complex formulae combined with the inputs can calculate the speed of rolling stock at any given point and also give the total distance run-a-way rollingstock will travel from either a standing or shunted start.

The model enables signal designers to make an informed decision on whether to install a derailor or catchpoint. The information provided by the model goes some way towards controlling the risk of unknown run-a-way wagon speeds. The information can also be used to override project costing decisions, using proven engineering standards/guidelines to ensure the correct equipment is installed based on a safety case and not costing case.

The provision of this model although extremely useful does not provide information to the performance limitations of derailers. Knowing the performance limitations of a derailor combined with the potential run-a-way rollingstock speed will ensure the correct equipment choice is made.

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### Calculation of Wagon Rolling on Multiple Grades

**Assumptions**

- Still air - no wind
- Straight track - no curves
- Zero limiting friction

**Inputs**

- Track Characteristics
  - Grade
  - Length (m)
- Track Condition
  - Good = straight geometry, clean rail, good gauge
  - Fair = reasonable alignment and gauge, rusty rails, joints
  - Poor = poor geometry and gauge, rusty rails, joints

**Grades**

- Enter Grade 1 - 2
- Enter Grade 1 - 2
- Enter Grade 3 - 4
- Enter Grade 3 - 4
- Enter Grade 4 - 5
- Enter Grade 4 - 5

**Results**

- Speed at the end of each grade
- Distance travelled
- Momentum at the end of each grade
- Time taken to stop

**Instructions**

- Enter date in green cells only
- Enter data in green cells only
- First grade must be away from the mainline. Subsequent grades can be + or -
- Note “DIV 0” indicated resistance greater than acceleration and wagon will not roll.

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![Figure 1: Run-a-way Distance Calculator](image)

**Derail Model**

Figure 2 is made up of two sections, Part B and Part C. The sections work together at combining the inputted variables supplied by the signal designer to display if rollingstock will derail or not, two unambiguous messages are displayed at the base of Part C, either ‘Wheel will climb’ or ‘Wheel will derail’. “Wheel will climb” means the wheels of the wagon will contact the derailor and climb over the deflector bar and continue along the rail (not derailed), “Wheel will derail” means exactly what is implied, the wheels will contact the derailor and derail.
Rollingstock comes in different lengths, weights, in varying conditions and with varying wheel configurations and conditions. All these variables play a part in whether or not a wagon will deraile. The signal designer when deciding whether or not to install derailers or catchpoints must consider all rolling stock characteristics and the types of rollingstock that will use the line, this coupled with the “Run-a-way Distance Calculator” will enable designers to choose the right equipment type.

Part B concentrates on the wagon and derailer specifics i.e. expected speed of the wagon at the deraile, the axle load and deraile deflector bar angle and deraileor slope angle. Part C concentrates on the wheel specifics i.e. flange angle and coefficient of friction which is inputted in varying scales based on wet/greasy to dry clean steel.

In all situations the theoretical tables as detailed require knowledge or understanding of the types of rollingstock that are going to use that section of railway. For example changes in axle type, axle loads or flange characteristics will all play a part in the accuracy and reliability of the theoretical tables.

The tables enable a theoretical view of how rollingstock will interact with the infrastructure and how this information can be better used to design a safer railway.

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**Part B - Derailer**

**Nadal's Formula**

\[
F_v = \frac{m+i}{\sin \beta} \cdot \frac{V}{\tan \psi} = m + i \cdot F \cdot \frac{V}{\tan \psi}
\]

Where:
- \( m \) = mass (kg)
- \( i \) = impact factor
- \( V \) = forward speed (m/s)
- \( \tan \psi \) = angle of derailer
- \( \beta \) = angle of the ramp (degrees)
- \( F \) = coefficient of friction

**Inputs**
- Enter forward speed (kph)
- Enter axle load (tonnes)
- Enter impact factor (use 0.4 if unsure)
- Enter ramp angle of derailer (degrees)
- Enter angle of derailer (degrees)
- Enter length of derailer (m)

**Outputs**
- Time to traverse derailer (seconds)
- Lateral wheel velocity (m/s)
- Vertical velocity (m/s)
- Vertical force due to change in impact force (kN)
- Lateral wheel force (kN)
- Lateral Vertical force ratio

**Result**

If the lateral force is greater than the vertical force, the deraile is likely to fail and the wheel to climb.

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**Part C - Derailer**

**Nadal's Ratio**

The ratio compares the vertical and horizontal forces. A ratio greater than one indicates the wheel will climb and the deraile will fail.

\[
\text{Nadal's Ratio} = \frac{V \cdot \sin \bigg( \frac{\beta - \psi}{\Delta t} \bigg)}{V \cdot \cos \bigg( \frac{\beta - \psi}{\Delta t} \bigg)}
\]

Where:
- \( V \) = forward speed (kph)
- \( \beta \) = angle of the ramp (degrees)
- \( \psi \) = horizontal angle of contact between the back of the wheel flange
- \( \Delta t \) = time (seconds)

**Inputs**
- Enter wheel flange angle (degrees)
- Enter coefficient of friction (use 0.4 if unsure)
- Convert to radians

**Outputs**
- Vertical wheel velocity (m/s)
- Lateral wheel velocity (m/s)
- Vertical wheel force (kN)
- Lateral wheel force (kN)
- Nodal's Ratio

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**Figure 2a: Part B Derailer**

**Figure 2b: Part C Derailer**

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**Effective Use Of Derailers And Catchpoints To Protect Rail Operations**
Rolling Drag Distance Calculator

The model shown in Figure 3 is used to calculate how rollingstock will perform once derailed by either a derailer or catchpoint. It is understood that rollingstock once derailed will generally continue in the direction it was derailed in unless physically altered by deliberately or un-deliberately placed infrastructure i.e. guide rails. The distance it will travel has always been an unknown figure, and in most situations a good “guesstimate” was all the signal designer could do.

Distances are dependent on several factors, initial velocity, mass, the surface derailed on to and the grade of runoff i.e. falling/rising. Part D – “Rolling Drag Distance Calculator” (refer to Figure 3) enables these known variables to be inputted into the table to produce a theoretical distance that a derailed wagon will traverse. The results table (circled in red) details the speed the derailed wagon will be travelling in incremental distances of 5m, starting at 10m out from the derailler site. The distance taken for the derailed wagon to come to rest is shown when zero kph is read on the table; the corresponding distance shown to the left of the table details the traversed distance by the wagon. In the example given (Figure 3) the wagon is travelling at 25.714kph, once derailed it will theoretically come to rest (with a 0% gradient) between 15 and 20 metres from the derailler site.

The information provided by this table can enable more accurate placement of derailing equipment, ensuring there is sufficient distance between the derail site and the line being protected. Signal Designers placing derailers on sidings have either erred on the side of caution or under estimated the run-off distance. They had no means of knowing how far rollingstock could travel (“guesstimating”). This could lead to sidings reducing in length to accommodate for the additional run-off space, which in turn would reduce the train lengths able to use that siding. Alternatively the wagon would be foul of the running line. The Rolling Drag Distance Calculator will ensure only the required space is used for run-off areas, meaning derailers can be placed at the correct distance from the line they are protecting.

The resulting table can be used to assess how far rollingstock could travel. The table below shows the results for a single wheel.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Number of Wagons</th>
<th>Decel Rate (m/s²)</th>
<th>Speed (kph)</th>
<th>Time (sec)</th>
<th>Number of Wheels Derailed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0.90</td>
<td>10.14</td>
<td>1.14</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>1.80</td>
<td>20.28</td>
<td>2.28</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>2.70</td>
<td>30.42</td>
<td>3.42</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>3.60</td>
<td>40.56</td>
<td>4.56</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
<td>4.50</td>
<td>50.70</td>
<td>5.70</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
<td>5.40</td>
<td>60.84</td>
<td>6.84</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>7</td>
<td>6.30</td>
<td>70.98</td>
<td>7.98</td>
<td>0</td>
</tr>
</tbody>
</table>

Average Deceleration: 1.65 m/s²

Table 1 - Distance travelled by a progressively derailing train.
TYPES OF DERAILER

Derailers can be categorised in to either fixed or temporary installations. Derailers can be either bi-directional or uni-directional with the option to fit crowders. Fixed derailers can be motorised, remotely controlled or manually thrown. Temporary derailers are only used for short periods of time e.g. for the protection of work sites.

PERFORMANCE

Derailers are not a new piece of equipment; they have been in use for many years, although there is very little performance data with regards to them. It appears to have been accepted that placing a derailer on to the surface of the rail will “derail”, possibly because the name sounds so convincing and that they have been in service so long that no-one has challenged their effectiveness.

Most manufacturers when contacted could not give any performance thresholds for their equipment. Those that did could only recommend their use based on computer generated testing, with no actual physical testing having taken place and were reluctant to justify their performance recommendations.

DERAILING EQUIPMENT TESTED

The derailer tested was the SIEMENS (Invensys Rail) D150 Derailer and C150 Crowder, the equipment can be used on either 47/50/53 or 60kg rail in either right or left hand throw. Refer to Figure 4 for a picture of the actual tested equipment.

![Figure 4: Derailer and Crowder Tested](image)

<table>
<thead>
<tr>
<th>Speed (Kph)</th>
<th>Derailed</th>
<th>Actual Distance Travelled (Metres)</th>
<th>Theoretical Distance will Travel (Metres)</th>
<th>Difference in distances (Metres)</th>
<th>Theoretical distance from Derailer (Metres)</th>
<th>Within theoretical distance Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.182</td>
<td>Yes</td>
<td>2.65</td>
<td>2.61</td>
<td>.04</td>
<td>&gt;10</td>
<td>Yes</td>
</tr>
<tr>
<td>13.846</td>
<td>Yes</td>
<td>7.2</td>
<td>7.48</td>
<td>.28</td>
<td>&gt;10</td>
<td>Yes</td>
</tr>
<tr>
<td>25.714</td>
<td>Yes</td>
<td>15.3</td>
<td>12.822</td>
<td>2.478</td>
<td>&gt;20</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Figure 5: Derailer and Crowder Results*

TEST RESULTS – DERAILER WITH CROWDER

With reference to Max Shuard’s tables (reference Figure 3) the ‘Results Table’ associated with Part D sets out theoretical distances for the wagon to come to rest from the derailer or catchpoint.

The results taken showed the actual distance travelled by the derailed wagon at the lower speeds of 8.2kph and 13.8kph were within tolerance of the theoretical distances predicted by the model. With all the variables at play i.e. track condition, bearing conditions, ballast drag condition etc. the results were surprisingly accurate and showed the theory to be sound.

The higher test speed of 25.7kph did have a greater difference in actual distance travelled compared to the theoretical distance predicted by the model, as shown by the red text in Figure 5. Although this is not in keeping with the accuracy of the lower speed measurements taken, it is still within the accuracy of the ‘Results Table’. The table stipulates that the wagon should not travel any further than 20 metres out from the derailer and should not travel any less than 15 metres. The actual distance travelled was 15.3 metres which is within this threshold.

The test results show there is a high degree of accuracy with regards to the theoretical distance and actual distance travelled at the lower speeds (under 15kph).

A higher speed test to continue this theory would be useful to ensure the ongoing accuracy of the ‘Results Table’ within the model. It should be noted that the common place for derailing equipment is within sidings and yard areas, which are commonly restricted to 25kph running speeds. The higher speed test would therefore just back up the theory.

8.2KPH & 13.8KPH TEST OBSERVATIONS

Evidence from play back of the HS video footage and Figure 6 (grooves in derailer surface) show at lower speeds the derailer does not contribute to the lateral movement of the wheels. The grooves (Figure 6) in the top of the derailer plate (8.2kph...
and 13.8kph) show the flanges of the wheels never contact the deflector bar. Video footage shows the crowder exerts all the lateral movement to the wheels. The derailer exerts the vertical force to lift the wheel up onto the deflector plate. The grooves (made by the flanges) are seen arcing away from the rail due to the lateral force applied by the crowder that acted simultaneously on the opposing wheel. The arc of the lower speed is slightly more acute than the higher speed, due to less momentum acting against the lateral movement of the wagon.

Heavy damage can be seen at the initial strike point of the crowder (Refer Figure 7). This is where the wheel flange makes first contact and not at the derailer deflector bar as was expected. This initial contact at the crowder forced the opposing wheel to simultaneously adjust its angle, which meant it was then directed over the rail head using the flat surface of the derailer.

Depressions can be seen where the wheel flanges initially contact the derailer (Figure 6). At both speeds the depressions are roughly the same size. The impacts at these lower speeds were sufficient to move the derailer laterally and vertically. The forces applied are substantial and have to be absorbed. Playback of the video shows these forces are transferred to the mechanism of the derailer. The resultant transfer of energy would probably damage the mechanical linkages within the derailer. Prolonged derailments (multiple wagons) may mean the mechanism could fail and should be inspected prior to re-use.

The higher speed test of 25.7kph derailed the wagon. At the slower speeds the crowder did the work of laterally moving the wagon off the rails with the derailer exerting the vertical movement to the wheels. At the higher speed the deflector bar of the derailer exerted a lateral force onto the wheels as well as the vertical force, this combined with the crowder’s lateral action forced the wheels to leave the rail and derail. The vertical force exerted by the derailer had an unexpected outcome on the opposing wheels; the wheels rode up onto the crowder (Figure 8) as can be seen by the grooves left in the crowder head.
Further investigation of the video footage and images captured show a correlation between the scuff marks on the derailer (where the vertical force would be applied) and where the groove marks left by the wheel flange are on the crowder head. Reference to Figure 10 (green line) shows where the groove begins on the crowder head and where the scuff marks begin on the derail deflector bar. The vertical application of force to the wagon wheels was initially created at the derailer, this vertical movement was transferred/exerted on to the opposing wheel lifting it onto the crowder head. The crowder/derailer combination provided greater lateral force than vertical force resulting in the derailment, even though the wheel’s climbed the crowder. It is assumed that if the later was inverted (greater vertical force than lateral force) then the result would have been different and the wagon would have re-railed itself.

Max Shuard’s theoretical calculations as detailed in Parts B & C Calc Rev 9 (refer Figure 2 extracts) confirm that the wheel would derail at this speed, as with the lower speeds tested. The theory suggests that in order to climb and not derail at the higher speed tested the ramp angle needs to be reduced to below 8 degrees, compared to the tested 12.23 degrees. Note: The theory is based on the derailer only and not the crowder as well.

The yellow line on Figure 10 tries to illustrate that at 25.7kph where the first impact point was at the face of the crowder. It was expected that scuff marks would be seen directly opposite on the derailer deflector bar by the opposing wheel impacting with it, but this was not the case. The actual scuff mark left by the wheel flange on the derailer is several centimetres past this point (as noted by the second impact point note on Figure 10) (refer to Figure 9 for actual scuff mark). After later review it was realised that the wheels will not contact the derailer and crowder at the same instant. The factors affecting whether they contact the crowder or derailer are:

- Whether the track is wide or tight to gauge. A tight gauge fault will cause the wheel to contact the crowder, or
- New wheels would cause the wheel to contact at the crowder where worn wheels may contact the derailer.

The initial impact of the crowder instantly forces the wheels to laterally move, this combined with their forward motion (speed) means the scuff marks created by the opposing wheel flange appear not in line with the crowders first contact point but slightly after.
This again suggests that the crowder provides a lot of the initial lateral movement to the wheel and that the derailer deflector bar then carries this transfer of force on. The crowder continues to force the wheel’s lateral movement as can be seen by the significant wear on the crowders leading edge (Figure 8). Significant quantities of metal burs were found on the crowder footplate after each test run.

When the second wheel derails the crowder/derailer ‘straightens’ the bogie by moving the back axle laterally to outside the rail. The bogie then travels almost parallel to the track offset from the track by approximately 480mm. The implication here is that the derailer location must be designed to ensure the vehicles will not travel in the derailed condition to be foul of the adjacent track they are protecting and that the velocity of the derailed rollingstock is suitably impeded to reduce its traveling distance i.e. use of ballast drag.

TEST RESULTS – DERAILER ONLY

The results of the test carried out were not as expected considering the derailer is supposed to “derail”, as its name suggests. The wagon wheels at 17kph climbed the derailer and re-railed themselves after running along the rail head for several metres. Figure 11 clearly shows the flange groove marks left in the rail head after the derailer. The grooves can be clearly seen curving out from the derailer then back to gauge. This is in accordance with simple geometry.

Play back of the HS footage and review of the images (refer Figure 11) shows that the wheels at 17kph contacted the leading edge of the derailer (leaving significant wear marks) and were lifted up approximately 30mm before reconnecting with the derailer. The green arrows indicate on Figure 11 the distance between where the wheels left the derailer and where they recontacted. As the wheels traversed the derailer they climbed the deflector bar (at the chamfered section). The height of the deflector bar combined with the momentum of the wagon ensured the wheels were air born momentarily before they landed on the surface of the rail head.

It was noted that the derailer’s deflector bar has a chamfered end section (Figure 11). Review of the images and video footage taken shows the wheels climb this section. The chamfering and positioning appears to be the main contributing factor to the issue of the wheels climbing over the derailer.

A recent incident occurred when a wagon was pushed over a derailer without derailing. After the incident it was noted that the derailer was not sitting flush with the rail head and was sat back from the inside edge of the rail. This would have contributed to the ineffectiveness of the derailer and highlights the need for correct fitment.

CATCHPOINTS

There are five types of catchpoint used on railways, they are Single Blade, Double Blade, Independent Blade, Constrained Blade and Double Blade and Frog with optional run off track. The traditional catchpoint most often used is the Single Blade catchpoint (see Figure 12).
requirements, the position and type of infrastructure in the derailment zone, derailment zone gradients and the expected train speeds traversing the catchpoint.

In most cases the Single Blade catchpoint will provide the protection required. In some situations the Double Blade catchpoint (Figure 13) is used to ensure that run-a-way or SPAD trains are fully deflected away from the running line as it will maintain the clearance to the running line. They are also used in areas of gradient where the train may sag back.

**Figure 13: Double Blade catchpoint**

The constrained catchpoint (Figure 14) has a check rail to limit the movement of the derailed wagon or train. They are used where clearance to the running line or other obstruction limits the movement of the wagon or train for safety reasons. Typically there will be damage to the sleepers from a derailed wagon(s) or loco. There is also limited retardation from the ballast as the wagon/loco will ride over the sleepers. Constrained catchpoints are very useful for derailing where there is an obstruction or steep gradient parallel to the track. The constraint ensures the derailed wagon/loco does not encroach on the area that is being protected.

**Figure 14: Constrained catchpoint**

**COMPARISON BETWEEN CATCHPOINTS AND DERAILERS**

Both equipment types are designed for one purpose, to derail, but the means in which they do this is very different. The use of catchpoints has higher performance in protecting against unauthorised train movements but it has greater cost than a derailer. Cost as always plays a significant part in the decision making process as to whether to install catchpoints or derailers. In some situations a Catchpoint must be installed, but where there is an option then most railways would lend themselves to the cost effective option (providing there was no “added” risks).

When set up correctly both equipment types will derail, but with different performance characteristics. A catchpoint will derail at any speed in a controlled manner with a high certainty of where the derailed rollingstock will travel to. Catchpoints can be configured to suite different physical areas i.e. wide run off areas free of infrastructure will enable derailed rollingstock to be angled away from the line, constricted busy high traffic areas will require derailed rollingstock to be captured and stopped within a short space away from the fouling point of other running lines.

Derailers have limitations on the speeds and the type of rollingstock they will derail. These performance limitations mean consideration must be given to their usage and positioning in every situation. Further consideration must be given to later changes to line usage (e.g. increased line speed, rollingstock changes and changes to track geometry) that will impact on the efficiency of the derailing equipment and can effected the safety of that section of line. Derailers are a cost effective alternative to catchpoints, but with reduced pricing comes reduced performance. Unfortunately the performance limitation of every type of derailer is not fully understood, and manufacturers are unable to give a definitive set of performance characteristics. It is hoped the tests carried out by ARTC go some way to mitigate against these risks and aid the safe design and installation of all future derailer applications.

**PLACEMENT OF DERAILEING EQUIPMENT**

In both cases the placement of the derailing equipment must be considered. The point of derailing a wagon or train is to protect the running line. Poor placement may still lead to fouling of the running line or possible damage, injury or death to the train drivers or the travelling passengers.

Poor placement of catchpoints can be seen in the following images. Although the train was clear of the running line (Figure 15) it was perilously close...
to toppling over. This could have resulted in extensive damage and/or possible injury to the occupants of the locomotive.

**Figure 15: Flemington**

Figure 16 clearly shows a derailed passenger train (Homebush 2009). The catchpoints performed their task and derailed the train, but poor placement meant the train was still foul of the running line. In this case the catchpoints were constrained by OHW stanchions and other equipment. The design was not correct as it did not achieve the intended outcome (protect the running line).

**Figure 16: Homebush**

### CONCLUSION

The derailment tests carried out have provided an insight into the performance and limitations of derailers with and without a crowder. They also demonstrate the importance of ballast drags in the retardation of rolling stock. The results have also proven that the theoretical tables produced by Max Shuard could be used as inputs to future design and placement of derailing equipment.

The derailer/crowder combination proved that derailing is possible at 25kph, although the equipment appeared to be nearing its limits of operation; approval to operate with rollingstock speeds of 25kph probably would not be given. The derailer only failed to derail at 17kph which was confirmed by the theoretical tables. The theoretical tables predict the derailer will derail up to speeds of 15-16kph. Based on the accuracy of the theoretical tables this calculation could be relied upon. Further testing would be advantageous to further prove this.

Based on the results of the tests carried out the application of a derailer with crowder should be used in every case when the requirement for derailment of rollingstock is considered as protection (when a derailer is considered and not a catchpoint). The tests proved the combination of derailer and crowder worked at varying speeds with the same result. The crowder appears to provide a great amount of lateral force to the wheels and the derailer offers lateral movement plus the vertical movement to lift the wheel flange up and over the rail head.

The ballast drag plays an integral part in the retardation of the derailed rollingstock. Based on the findings and visuals of the tests carried out, all derailers/crowder and catchpoint sites should have a ballast drag associated with them. The ballast drag and position of the derailer/crowder or catchpoint should also be considered in every situation as safety critical. The ballast drag must be good quality and positioned such that it can drain easily and remain free of contaminates that can bind the ballast together; the ballast drag should be maintained to ensure its effectiveness.

I also conclude that derailers are a viable alternative to catchpoints but their use must be fully investigated and considered in every application.

### RECOMMENDATIONS

Recommendations were made to the manufacturer of the derailer/crowder to improve the performance limits, the recommendations made were:

- To fully extend the deflector bar across the rail head,
- Remove the chamfered end section,
- Extension of the ramp to facilitate a smoother transition from rail to derail. (The length should be commensurate to the distance between the tire of the wheel and the leading edge of the flange).
- Removal of the squared leading edge to reduce impact damage and reduce the bobbing effect created by the wheel striking the derail.

Two general recommendations were also made, they were:

- All future and existing derailment sites should include a ballast drag of appropriate length (referencing Part D – Rolling Drag) spread sheet, and
- To incorporate the calculation spread sheets into an ARTC standard for use by signal designers and ARTC maintainers.