Optimising Brake Procedure for Stationary Trains

Nicola Lazaroo

Kecheng Shen
School of Mechanical and Chemical Engineering

Chris Wakeling
CEED Client: Rio Tinto

Abstract

An opportunity has been identified to improve safety and production by revising the Rio Tinto Rail Division's rules and procedures regarding the application of handrakes. Both anecdotal information and data from past work conducted indicate that handbrakes on trains are being applied according to procedure when it is not necessary, as the other train braking systems can be relied upon to secure a stationary train on a range of gradients. The process of applying handbrakes is time consuming, and exposes Rio Tinto personnel to associated safety hazards. Engineering calculations that were performed estimate a reduction in both the number of occasions handbrakes need to be applied, and the number of handbrakes that are required for application. These estimates were verified successfully through field trial work, and as a result, changes to operating rules and procedures can be implemented. This will both reduce the Rio Tinto personnel's exposure to potential safety hazards relating to handbrake application, as well as reducing delays in the transportation of iron ore from mine to port.

1. Introduction

Two departments within Rio Tinto Rail Division, Rail Operations and Rail Engineering, perceive parts of the current operating rules and procedures relating to the application of brakes to secure stationary trains to be inefficient. Anecdotal information and tests that have been conducted in the past indicate that these rules and procedures are currently extremely conservative. Improvements to these operating rules and procedures would result in an improvement in safety and reduction in delays in the transportation of iron ore from mine to port. The locomotives considered in the scope of the project are GE Dash 9 and Evolution locomotives and the wagons are named 'C' and 'S' series. The brake systems available to secure a stationary train are the automatic train air brake system, locomotive independent brake system, and locomotive and wagon mechanical handbrakes. Handbrakes are applied to secure a stationary train when the other brake systems cannot be relied on, and in certain situations, more time than is necessary is spent applying and releasing handbrakes than is physically required to safely secure the train.

The operating rules currently in place state that handbrakes must be applied if a train is to be left without a means of continuously supplying and controlling air to the air brake system for more than 60 minutes (D Stance 2001). Handbrake tables included in the operating procedure state the number of handbrakes that must be applied on different grades (A Third 2011). There is an opportunity to reduce the number of handbrakes required, or to delay the application of handbrakes to a period of time longer than 60 minutes. Doing so will reduce the amount of time that the train driver and other personnel are exposed to hazards associated with handbrake application, including heat stress, trips and slips, and manual handling sprains. A production benefit would also arise as a reduction in time spent applying handbrakes at the dumper is equivalent to an increase in time that the train is available for dumping iron ore from trains and conveying product onto ship.

The project objectives can be separated into two objectives, with end results altering two different instances of operating rules and procedures. The first being the extension of the 60 minute time period where handbrakes must be applied according to rules and procedures if the train is to be stationary for an amount of time longer than the 60 minute period (D Stance 2001). The second is to reduce the number of handbrakes that are required for application according to procedure for varying gradients. Anecdotal information gathered from Rail Operations personnel and past tests that have been conducted give an indication of the improvements that can be made.

Two testing reports carried out by Worley Parsons measure the brake forces relative to the brake cylinder pressure degradation over a twelve hour period to determine the holding ability of brakes of ‘S’ series ore cars over time. Based on the sample of 5 ‘S’ series wagon pairs that were tested, the average of test results indicate that a minimum of 250kPa brake cylinder pressure is required to maintain the brake block force above the minimum theoretical brake holding force for a pair of loaded ore cars on a 2% grade (B Woolridge 2008). To extend the 60 minute time frame in the current rule, this work must be furthered by confirming the maximum amount of time that the brake cylinder pressure remains above the required value to maintain sufficient brake block force to secure the train. The previous tests were performed on ‘S’ series wagons only, however this project will make conclusions for trains of the pooled fleet which use both ‘C’ and ‘S’ wagons. These further tests will also confirm the results for a larger sample of wagons within the train consist, compared to the 5 wagons tested in the previous Worley Parsons report.

A ‘Handbrake Holding Capability Trial’ was held by Rail Engineering to experimentally determine the minimum number of wagon handbrakes to be applied to secure a train on a grade. Results of the trial indicated that there is a linear relationship between the grade on which the train is standing and the number of handbrakes required to secure the train, for both empty and loaded trains. The actual number of handbrakes required to secure a train was found to be significantly less than what was specified in the Operating Procedures, and hence the handbrake tables were revised. However, the holding capability that the locomotive independent brakes provide was not considered in the trial, or in the revision of the handbrake tables. The holding capability of the independent brakes was found to be inconstant, as the additional number of wagon handbrakes that were required when locomotive brakes were not applied ranged between 7 and 28 for loaded trains for the different gradients (D Foo 2010). Further work is needed in this area to quantify the extra holding capability provided by the locomotive independent brakes as this is currently unknown.

This project aims to further previous work that has been conducted and summarise the conditions under which a train can be left on locomotive independent brake or train air brake application only. It will also discuss the implications with the implementation of electronically-controlled pneumatic brake systems and autohaul train fleets, and make recommendations for the implementation for the formal change to the relevant operating rules and procedures.

2. Process

2.1 Procedure 1 – Automatic Train Air Brake

2.1.1 Hypothesis

Data from past work indicates that a stationary train can be secured with train air brakes for up to 24 hours, but as each wagon pair on the train behaves differently and can leak brake pressure at different rates, probability calculations were used to model a time period where the brake pressure of the train remains at a sufficient value. This time period is 10 hours, but constraints arising from operation of the business mean that it was extremely unlikely a train would be available for testing for 10 hours. A shorter and more viable time period of 6 hours for the trial was booked and approved.

2.1.2 Resources

The field trial crew comprised of one trial overseer and up to two ground personnel, depending on availability on the different days. Up to two vehicles were used for transport of the field crew to the road the train was located, and for transport along the length of the train while measurements were being taken. Radio transmitters were used to communicate between the ground crew personnel and Train Control. Pressure gauges were carried by the personnel to take the necessary measurements.

2.1.3 Procedure

This trial took place on the 8th and 9th of August on 5 road and 52 road within the 7 mile yard at Dampier. A briefing session was held with the trial crew each day before the trial took place. The briefing session included an explanation of the trial from the trial overseer, allowed time for questions to be asked, and finished with the completion of a "Take 5" to ensure all hazards and controls were identified.

The trial procedure lists the steps that were followed to gather results from the point that the field trial crew received possession of the train, to when the train was returned to its normal operation state and possession was handed back to train control.

Step 1	Stop train on nominated location using train air brake and locomotive independent brake
Step 2	Apply emergency train brake application
Step 3	Set up work area in accordance with Operating Procedures, attaching work tag
Step 4	Monitor and record train air brake pressure for duration of trial using manual pressure gauges
Step 5	If train movement occurs re-apply train air brakes
Step 6	At completion of trial, ensure train returned to pre-trial state for return to service
Step 7	Hand back possession to Train Control

Table 1 Automatic Train Air Brake Trial Procedure

2.2 Procedure 2 – Locomotive Independet Brake

2.2.1 Hypothesis

Engineering dynamics calculations were performed using data from the previously conducted 'Handbrake Holding Capability Trial' to give an estimate of the range of gradients at which two locomotive independent brakes would hold for. This value was found to be between 0.64% and 1.09%, and therefore the Locomotive Independent Brake Trial was performed at selected locations starting from a 0.645% gradient to verify this estimation.

2.2.2 Resources

The field trial crew comprised of one trial overseer, two train drivers, one mainline supervisor, and two members for ground support. Two vehicles were used for transport of the field crew to each location, and radio transmitters were used to communicate between the driver, ground crew personnel and Train Control during trials. Handbrake release tools were carried by personnel to ensure the safe and complete release of all handbrakes during the trial.

2.2.3 Procedure

This trial took place over two days from the 10th to 11th of July on sections of mainline track with the first location between Dove and Dugite from the 54 to 61 kilometre point, and the second location from the 86 to 90 kilometre point, between Galah and Gecko. The same locations were used over the two days so that measurements could be repeated with different trains to ensure consistency in results.

A briefing session was held with the trial crew each day before the trial took place. An explanation was given, questions asked, and a Job Hazard Analysis listing hazards that were identified during the risk assessment was signed on to so that all in the field trial crew were aware of controls in place to prevent harm during the trial.

The trial procedure lists the steps that were followed to gather results from the point that the train stopped at the trial location to when it was returned to its normal operation. A summary of the trial procedure is shown in the following table.

Step 1	Stop train on nominated location using train air brake and locomotive independent brake
	Request permission from train control
Step 2	Apply full service train brake application
Step 3	Apply number of handbrakes required to secure train according to handbrake tables
Step 4	Release train air brakes
Step 5	Cut out independent brake on 3rd locomotive and attach Out of Service Tag
Step 6	Release wagon handbrakes
Step 7	If train movement occurs apply train air brakes
Step 8	Apply train air brake and cut in 3rd locomotive independent brake
Step 9	Remove Out of Service Tags and check brake pistons extended and all handbrakes released
Step 10	Driver advise Train Control ready to depart for next trial location
Step 11	Field personnel conduct 'roll by' of train

Table 2 Locomotive Independent Brake Trial Procedure

3. Results

Results from both trials indicate the expected behaviour predicted by the mathematical calculations aligned with what occurred in the field during trials.

3.1 Trial 1 – Automatic Train Air Brake Trial

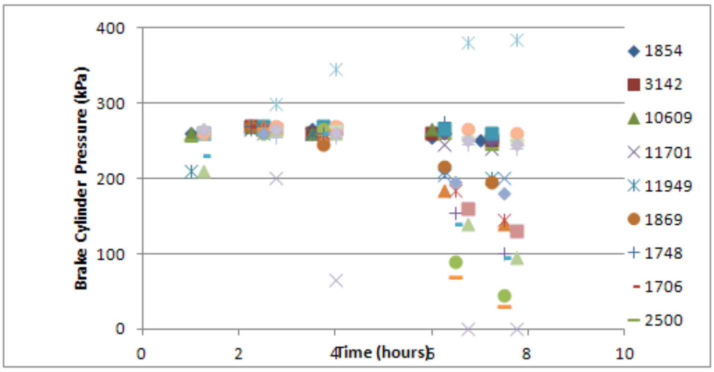

Figure 1 Automatic Train Air Brake Trial Results: Empty Train

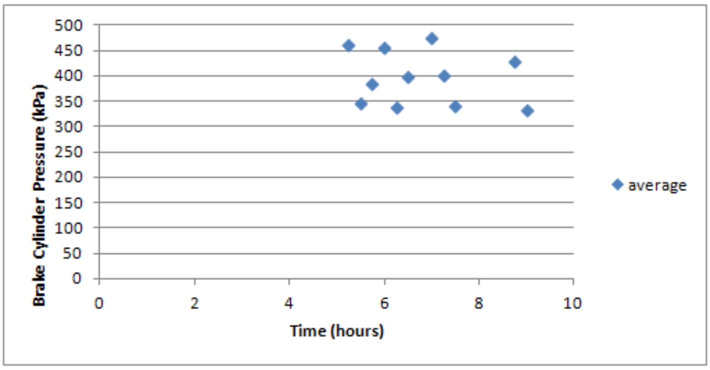

Figure 2 Automatic Train Air Brake Trial Results: Loaded Train

In Figure 1, which shows results for an empty train, it is obvious that the kilopascal value of the brake pipe pressure only begins to decrease once a 6 hour time period has elapsed, for all values measured but one. Though we cannot see the behaviour of the brake pressure of the loaded train for the first 5 hours as values were not measured, by viewing Figure 2, we can still observe that the brake pressure is well above the minimum 250kPa value required to secure a loaded train.

3.2 Trial 2 – Locomotive Independent Brake Trial

The table below lists the result for each location the trial, with gradients listed in ascending order. Focusing on the fourth column, which lists the results when two locomotive independent brakes were applied, we can conclude that no wagon handbrakes are necessary to secure an empty train on a gradient of 0.778% as the two locomotive independent brakes that were applied were sufficient to secure the train. The threshold value is somewhere between 0.799% and 0.829% gradient as one train could be secured with locomotive brakes on a 0.829% gradient but the other could not.

Location (km)	Gradient (%)	3 locos	2 locos	HB required by tables	HB required when 2 loco brake applied
60.0	0.645	P	P	30	0
60.2	0.724	P	P	33	0
60.25	0.752	P	P	34	0
60.3	0.778	P	P	35	0
86.75	0.779	P	F	34	1
60.4	0.829	P	F	36	1
60.5	0.878	P	F	38	1
60.7	0.896	P	F	39	1
60.8	0.902	P	F	39	1
61.0	0.914	P	F	40	1
90.0	1.581	F	-	64	-

*P=Pass, F=Fail, B=Borderline

Table 3 Locomotive Independent Brake Trial Results

4. Conclusions and Future Work

The Automatic Train Air Brake Trial confirmed the prediction that the train air brakes can secure a train for periods longer than the 60 minutes currently stated in the operating rules. For the empty train tested, the estimated 6 hour period was verified, and for the case of the loaded train, the train air brakes held for a period of time far exceeding the estimated 6 hours. Benefits from changes made to an extension of the 60 minute rule to a 6 hour period would arise at the dumper as delaying the need for application of handbrakes will mean that more trains can move through the dumper. The Locomotive Independent Brake Trial confirmed that no handbrakes are necessary to secure an empty stationary train on a grade of up to 0.77%. A proposed change to the rule was discussed with Rail Operations supervisors using this result. The scenario which would receive the most benefit due to a change in this rule is when a locomotive fault occurs on the mainline and a reboot is needed.

Results from both trials verify the proposed changes to operating rules and procedures, and these changes will be made once necessary safety factors are included, and after further discussion with Rail Operations. Once implemented, these changes reduce the amount of time Rio Tinto personnel spends applying handbrakes, resulting in the project objectives of reducing exposure to hazards relating to handbrake application, as well as making the transport process more efficient due to the time saved by reducing the need to apply handbrakes.

5. References

B Wooldridge, 2008. *Railway Division "S" Series Ore Car – Brake Block Force Testing*, Australia: Rio Tinto Railways Division

D Foo, 2010. *Handbrake Holding Capability Trial*, Australia: Rio Tinto Railways Division

D Stance, 2001. *Railway Operating Rules*, Australia: Rio Tinto Railway Division

A Third 2010, *Operating Procedure – Application and Release of Handbrakes,* Australia: Rio Tinto Railway Division