AS 7641:2017

Australian STANDARD®

Rail Gauge Corner Lubrication Management

RISSB

RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Infrastructure Standard

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The Standard was approved by the Development Group and the Infrastructure Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

Choose the type of review

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard.

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Paul Daly
Chief Executive Officer
Rail Industry Safety and Standards Board

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Document control

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Approval

Name	Date
Rail Industry Safety and Standards Board	Select Board approval date

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1 Introduction

1.1 Purpose

Friction management using solid or fluid (oil, grease, etc.) substances at the wheel-rail interface is a complex subject and includes the following aspects:

(a) Lubrication of the wheel flange/rail gauge corner (active interface), commonly referred to as 'flange or rail lubrication'.

(b) Friction modification of the top of rail/wheel tread interface, commonly referred to as 'top of rail friction management'.

The objective of this document is to specify friction levels and provide guidance for application for rail lubrication for areas which have been determined by the RIM to require lubrication.

Rail lubrication is primarily aimed at extending the life of rail and wheel assets.

Extensive research has been conducted into the performance of lubricators and lubricants in recent years. This research has been conducted against a background of increasing cost pressures on railways and a need to reduce the cost of installing and maintaining lubrication systems while still providing the benefits of lubrication in terms of–

(a) reducing high rail gauge face wear;

(b) reducing wheel flange wear;

(c) reducing the risk of wheel climb on high rails;

(d) reducing Rolling Contact Fatigue (RCF) initiation on the high rail gauge corner;

(e) reducing rail grinding maintenance on the high rail;

(f) reducing wheel / rail noise; and

(g) reducing energy (fuel / electrical power) requirements of trains.

Lubrication of the wheel rail interface on the gauge face and gauge corner reduces friction energy, which reduces wear. This in turn helps to optimise the life of the rail and wheel assets, and can lead to noise reduction.

Lubrication is required wherever there is potential for significant wear on curves exhibiting gauge face wear on the high rail, risk of wheel climb, or where flanging noise is a problem.

1.2 Scope

This document specifies rail friction levels for lubricated rail curves, and provides guidance on how wayside lubrication systems can be designed to achieve these friction levels.

This document does not cover the use of friction modifiers for top of rail application.

1.3 Compliance

There are two types of control contained within Australian Standards™ developed by RISSB:

(a) Requirements.

(b) Recommendations

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard.

Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred.

Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there may be limitations to the universal application of the control, i.e. the identified control may not be able to be applied or other controls may be appropriate / better.

For compliance purposes, where a recommended control is not applied as written in the standard it may be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it may also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

Controls in RISSB standards address known railway hazards as included in an appendix.

1.4 Referenced documents

1.4.1 Normative references

The following referenced documents are indispensable for the application of this Standard:

AS 1085.1	Railway track material – steel rails.
ISO 9001	Quality management
BS EN 16028	Railway applications. Wheel/rail friction management. Lubricants for train borne and trackside applications.

1.5 Definitions

Friction modification	Friction control at the wheel-rail interface within designed range by applying friction modifier on the top of rail. Friction modifiers are products recommended for top of rail applications to control friction on the rail surface. Key attributes are positive friction (i.e. friction level increases with increasing slip) and providing controlled COF on the wheel/rail interface (0.30 μ to 0.40 μ) to ensure no adverse impacts to train braking / traction.
Gauge	The distance between the inside running (or gauge) faces of the two rails measured between points 16 mm below the top of the rail head.
Gauge corner	The single point in the gauge corner region, the tangent of which is at 45 ° to the horizontal, with or without rail inclination.
Gauge face	The zone of the rail head facing the inside of the track. In the tighter curves the gauge face may be worn due to contact with the wheel flange.
High rail	This is generally the rail on the outside of a circular or transition curve.
Low rail	This is generally the inside rail of a circular or transition curve.
Lubricant	Substance that is designed to lower friction and wear.

Lubricator placement number	A single number metric used to model the carry distance of a lubricator and lubricant combination.
Rail defect	Rail discontinuities greater than a defined minimum size and for which there is an established repair response.
Rail head	This is the region of the rail above the top of rail web.
Rail lubrication	Lubrication of the wheel-rail interface by applying a lubricant to the rail gauge face and gauge corner.
Rail lubrication systems	Refers to the number of lubricant dispensing equipment within a given railway network segment that by their placement, comprised of location, spacing, and lubricant considerations, is designed and maintained to meet defined performance criteria.
Rail Infrastructure Manager	In relation to rail infrastructure of a railway, means the organisation that has effective control and management of the rail infrastructure, whether or not the organisation owns the rail infrastructure; or, has a statutory or contractual right to use the rail infrastructure or to control, or provide access to it.
Tribometer	Measuring tool for friction on rail surfaces.

1.5.1 Abbreviations

AoA	Angle of Attack
CoF	Coefficient of Friction
LPN	Lubricator Placement Number
MSDS	Material Safety Data Sheet
RIM	Rail Infrastructure Manager

2 Rail friction standards

2.1 Lubrication systems

Rail lubrication systems, comprising the type, number, location and spacing of lubricators, and type of lubricant, should be designed and maintained to meet the performance requirements detailed in Table 1.

Table 1 - Rail friction standards

Location	Coefficient of friction
Gauge corner of the high rail, measured at 45 degrees	≤0.25
Top of rail	≥0.3

NOTE: It is recognised that top of rail surface lubricant contamination can exist in the immediate vicinity of the lubricator, but this should not extend more than 50 metres. Measurement should be undertaken with the methodology outlined in Section 3.

Where the RIM has identified rail traffic traction risks, particularly for passenger trains near signals, stations and level crossings, the braking abilities and traction shall not be compromised by lubrication systems causing grease contamination on the top of the rail head.

3 Rail friction measurement

Measurement of rail friction should be undertaken using a rail tribometer.

The tribometer shall be in good working order and calibrated in accordance with a manufacturers' instructions.

The measurement wheel shall be free from grease residue and contaminants at the commencement of each measurement.

A typical hand-propelled tribometer is shown in Figure 1.

Figure 1 – Typical hand propelled tribometer

Friction measurements shall be undertaken on dry track that is free of precipitation, dust, sand or other visually detectable contaminants, and during environmental conditions considered reasonably representative of the region.

Friction shall be measured at –

(a) the top of the high and low rails, measured in the centre of the running surface region (nominally zero degrees); and

(b) the gauge corner of the high rail measured at 45 degrees to the central axis of the rail, whether inclined or vertical, or as near as possible to avoid rail grinding facets.

Measurements should not be taken on large grinding facets on the gauge corner.

Figure 2 illustrates the regions, including gauge corner and running surface on a rail.

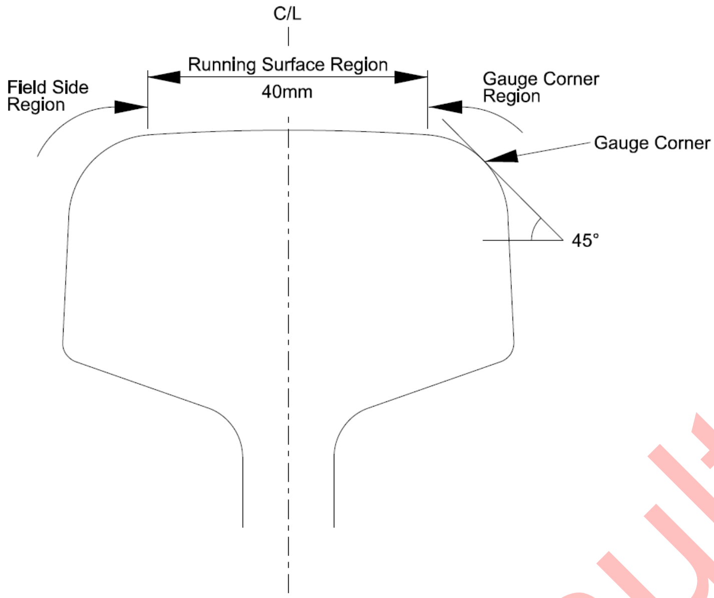

Figure 2 – Rail head friction measurement regions

Rail head profiles specified in AS 1085.1 contain similar regions.

4 Typical measurement method

To account for variability in measurements, at least 10 measurements should be made (in the body of the curve at the location of the highest curvature or wear point) every 50 metres through the area of interest.

The friction measurements should be recorded as required by the RIM. Refer to Appendix B for a sample friction measurement record sheet.

Using at least five readings, and after anomalous friction readings and the highest and lowest 10% of friction readings have been excluded, an average friction level for the top of each rail and the high rail gauge corner should be calculated and recorded.

Additional information that should be recorded at the time of testing includes–

(a) location and track;

(b) date;

(c) time of day;

(d) environmental conditions–

  i. ambient temperature, and

  ii. humidity;

(e) tribometer serial number;

(f) tribometer settings; and

(g) friction measurements.

These records should also include a site sketch showing the lubricator locations, the curves and friction measurement locations and photographs of both rails. Prior to capturing rail photographs within tribometer measurement limits, the location, rail, running direction, gauge face and date should be clearly written on the rail surface.

An example of a rail marked up to show the running direction and gauge face the running direction and gauge face (arrows), kilometrage, track, rail (high or low) and date is provided in Figure 3.

Figure 3 - Photograph of rail to accompany the tribometer measurement

Appendix A Example: lubrication using wayside equipment

A.1 Introduction

Rail lubrication can be applied using a variety of approaches, including wayside lubrication units, hi-rail or rail-vehicle mounted systems. This appendix describes lubrication using wayside equipment, which is commonly used in Australia.

The design process below requires information from the type approval process for lubricator and lubricant combinations to be captured and managed within an asset register in accordance with the organisation's Asset Information Management System. The design process can be applied to all wayside lubricator types, both mechanical and electrical, that have completed the organisation’s type (approval) test process.

A.2 Wayside lubricator placement design approach

The process outlined in this section for the optimal placement of lubricators is based on the concept of a lubricator placement number (LPN). The process for lubricator and lubricant type approval, and the design and implementation of a lubricator system is outlined in Figure 4.

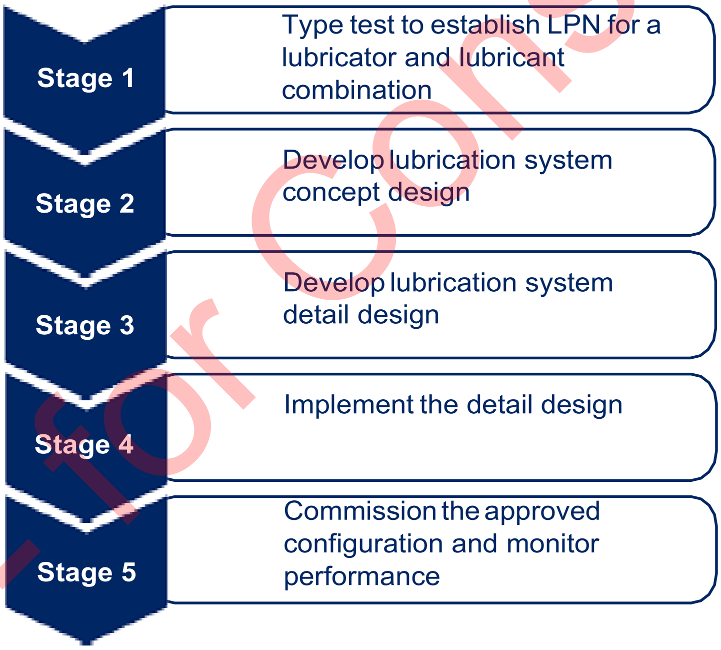

Figure 4 – Lubricator placement design process

Stage 1 involves the establishment of the LPN by field testing for particular lubricator and lubricant combinations.

The LPN can then be applied to different track curvature configurations once Stage 1 has been completed.

A.3 Stage 1: Establishing lubricator placement number

The LPN is established during the lubricator and lubricant type test procedure.

New combinations of lubricators and lubricants may be type approved according to the organisation, prior to their operational installation on the network. Guidance on the type approval process may be obtained from the organisation’s lead track engineer / qualified and competent person. A concession process may be in place which outlines the process for requesting a concession to any localised procedural requirements.

A.3.1 Lubricant standards approval

All lubricants to be type tested should comply with the requirements of BS EN 16028.

A.3.2 Field trials

Lubricator and lubricant combinations should be tested on a working track to establish that they operate effectively, efficiently and safely, and to determine an LPN.

The test site should be a section of track that includes both left and right handed curves of a radius 400m or less, and that carries both freight and passenger traffic.

All tests should be approved by the RIM. Refer to the lead track engineer or qualified and competent person as appointed by the RIM for the application procedure for approval to undertake field trials.

A.3.3 Lubricant and LPN calculation process

The following process should be followed to calculate the LPN during type testing:

(a) The lubrication configuration to be tested should be set up on a section of track that includes both left and right handed curves of varying radii in a position free from contamination from neighbouring lubricators, and from previous lubricator operation.

(b) The track should not be lubricated for at least 20,000 axle passes before the test starts, after which the gauge corner friction levels shall be measured to confirm that no contamination from previous lubrication operation persists.

(c) The lubricator should be operated for 40,000 axle passes under typical traffic conditions before rail friction is measured.

(d) Uni- directional train running:

  i. On one single track of a dual track operation with all trains travelling in the same direction.

  ii. On one single track with more than one train travelling in the same direction followed by more than one train travelling in the opposite direction. For example, in a heavy haul railway operation on a single track the loaded trains travel from mine to port and the empty trains travel from port to mine.

(e) Bi-directional train running:

  i. On one single track with one train travelling in one direction followed the next train travelling in the opposite direction.

(f) Lubrication performance is established using the friction measurement procedure as detailed in Section 3.

  i. Uni-directional train running on one single track with more than one train travelling in the same direction followed by more than one train travelling in the opposite direction. Measurements should be taken after the passage of the heavier trains travelling in the same direction.

  ii. Bi-directional train running on one single track with one train travelling in one direction followed the next train travelling in the opposite direction. Measurements should be taken after the passage of the heavier train.

(g) Friction measurements should be taken on each curve, starting from the lubricator, until the average coefficient of friction (CoF) on the gauge corner of the high rail exceeds or meets the required value contained in Table 1.

(h) The total LPN is then calculated using in Section A.3.4 for the length of track between the lubricator and the point at which the CoF limit was exceeded.

An LPN is calculated separately for each curve between the lubricator and the point where friction exceeds the limit. The total of these numbers is the LPN for that lubricator and lubricant combination. For lubricators serving both rails, the LPN shall be the greater of the individual LPNs calculated for each rail.

Following successful completion of the type approval process for a particular lubricator and lubricant combination, the LPN may be recorded by the RIM organization.

A.3.4 Example lubricator placement number formula

$$LPN = \frac{(C + S)\ x\ G\ x\ D}{T\ x\ M\ x\ BR\ x\ BG}$$

Equation A 1

Where:

(Track factors)

C = the length (metres) of curves in the section, including the transitions. The curve length C for the calculation is the distance between the tangents or the end of transitions before and after the curves. The longer the curve, the more that wheel flanges are in contact with the gauge face of the high rail.

S = 5% of the length (metres) of tangent sections between the lubricator and first curve or between curves. This takes account of the loss of lubricant on straight track due to hunting.

G = the relative performance of different lubricants. This will always be 1 if the lubricator and lubricant combination has been type tested, as any differences in lubrication performance will have been accounted for in the LPN.

D = the degree of curvature. *D* is related to the curve radius *R* by: $D = \frac{1746}{R}$

(Rolling stock factors)

T = the direction of traffic – use values 1 for unidirectional traffic and 2 for bi-directional traffic. True bi-directional traffic refers to one train in one direction and the next train in the opposite direction. If traffic patterns are several trains in one direction, then several trains in the opposite direction, the track should be considered unidirectional.

M = factor to account for misaligned bogies on tight curves.

On shallow curves and tangents:
M = 1

On tight curves:
M = $\frac{1}{1+x}$ (where *x* is the proportion of poorly steering bogies)

BR = factor to account for train braking, that only applies to negative grades.

NOTE: Heat is generated by trains braking down long grades, which displaces lubricant from the gauge corner.

BR = (100 -10* |grade|)/100 for negative gradient, where grade is expressed as a percentage and the |…| operator stands for the absolute value and 1 elsewhere.

For example, if the gradient is -1:50, that is 2% descending, then BR = (100 – 10 * 2) / 100 = 0.8, whereas if the grade was 1:50, that is 2% ascending, then BR = 1.

BG = bogie factor. BG accounts for the greater impact of poorly steering bogies on sharp curves compared to shallow curves.

BG = 2 for tangent and shallow curves

BG = 1 for tight curves

A.3.5 Requirements for a field test report

Type test reports should be submitted in accordance with the relevant type test procedure. Test reports from field trials should include the following:

(a) A description of the product(s) under test, including product specifications and material safety data sheets (MSDS).

(b) A detailed description of the test, including a map of the test site showing the lubricator and measurement locations, the settings used throughout the testing, calibration details for the tribometer and any other instruments used, photos of the test site, lubricator and anything else relevant to the report.

(c) Friction measurement test records, and any other raw results, included in as an appendix.

(d) The lubricant carry distance, the individual curve LPNs and the final cumulative LPN value.

A.4 Stage 2: Lubrication system configuration concept design

The lubricator system configuration concept design establishes the ideal placement of lubricators along a track. The actual placement of the lubricators is then finalised in the stage 3: detail design phase following site inspections.

The following calculation process establishes the ideal placement of lubricators along a track:

(a) Select a point for the placement of the first lubricator in a system to ensure that the first curve is well lubricated.

(b) Select a point on the tangent or transition past the first curve after the first lubricator. Calculate the LPN for the high rail on curve 1 (using Equation A 1**Error! Reference source not found.**).

(c) Repeat this process for the high rail on curve 2.

(d) Continue to repeat the process and calculate the cumulative LPN for each rail after the lubricator until the point where this total for either rail matches the type approval LPN.

(e) Establish a suitable site for a second lubricator near this point and repeat the process to position following lubricators.

A.5 Stage 3 Lubrication system configuration detail design

The lubricator system configuration detail design will establish the final position of lubricators after a site inspection and consideration of a range of factors including the following:

(a) Train operations

i. Lubricators should be located so as to ensure that braking and traction around signals, stations and level crossings are not compromised.

(b) Maintenance access

i. Place lubricators as close as possible to maintenance access roads to enable positioning of maintenance vehicle beside the reservoir to minimise manual handling of lubricants.

ii. The requirement to carry lubricants across live track should be avoided. Where the track being treated is on the opposite side of the corridor to the access road, the reservoir should be positioned adjacent to the access road and hoses should run beneath the intervening rails. The hoses should be run so that they are clearly visible, do not present a trip hazard and cannot move under rail traffic (for example, hoses may be secured to the rail clips or sleeper). Any conducting cables, such as those for wheel sensors, should be enclosed in a protective conduit where it passes under live tracks.

(c) Wheel and rail contact conditions at the site – rail mounted distribution units should be located where the wheel/rail contact conditions at the site will support the optimum pick-up, as evidenced by rail wear and contact band checks. The following conditions should be met:

i. The static gauge at the site is within +/- 3mm of the design gauge;

ii. There is no plastic flow of rail steel on the gauge side to ensure that the distribution units can be properly fitted to the rail and grease will carry onto the gauge corner.

iii. The rail profile is within permitted tolerances of the relevant standard.

iv. There are no poor rail geometry, rail surface defects (i.e. head checks, shelling, engine burns, etc.) or welds in the immediate vicinity of the lubricator bars.

(d) Environmental considerations

i. Where possible, lubricators should be located more than 20m from water courses and other environmentally sensitive sites.

ii. Where it is not possible to be greater than 20m from an environmentally sensitive site, the use of biodegradable lubricants should be considered.

(e) Power

i. Where solar power panels are used, the position should be verified to ensure they have sufficient sun throughout the year, in accordance with manufacturer's guidelines.

(f) Existing infrastructure

i. Lubricators should be located away from existing infrastructure where the operation of the lubricator will interfere with the safe and correct operation of that infrastructure.

Following the site visit and consideration of the above factors, adjust the placement of lubricators on the configuration concept design to reflect on-site realities. Identify all necessary requirements for power and the location of cables.

This adjusted design is the configuration detail design and should be subject to appropriate configuration change approval before it is implemented.

A.6 Stages 4 and 5: Implementation and commissioning

Changes to a lubrication system, including the type, location, interfaces, settings (including the addition of, or removal of rail lubricators and associated equipment), may be considered a configuration change and managed through the RIM's approved configuration change processes as applicable to the situation.

A lubrication performance verification process should be completed prior to commissioning. A suggested verification process for rail lubricator performance is provided in A.6.2 of this document.

A.6.1 Lubrication asset register

A lubrication asset register should be populated and maintained in order to effectively manage the placement and maintenance of all lubrication installations with the RIMs network area. Fields which may be included in a lubrication asset register fields are provided below.

Corridor	This is used as a header to collate and identify entries installed within a specified corridor.
Reference Number	Is the unique number given to an installation, which may consist of more than a single lubricator installation that are in series to meet a required LPN total.
Location	Local place name, commonly used and identifiable on a specified corridor.
Track	Standard TOC reference, Up or Down plus, Main, Local Suburban.
Rail	Down or Up, as identified with back to CBD as normal, down will be the rail on the left and up will be the rail on the right.
Start KM	The start track kilometrage that is the centre of the installed lubricator equipment.
Finish KM	The completion track kilometrage that is the furthest effective range of grease dispersal.
Actuator Type	This should be verified as electric, mechanical or hydraulic.
Manufacturer	Name of the manufacturer of the equipment. Product reference name and number should also be included.
Grease Type	Name of the manufacturer of the lubrication grease. Product reference name and number should also be included.

LPN	Lubricator placement number. This is specific to the individual lubricator installation and may be cumulative to establish full coverage over a series of curves.
Date Installed	The date of installation and effective working.
Date Last Maintained	The date the equipment was last attended for a maintenance service. Not applicable at initial installation.
Remarks	Relevant commentary for condition or performance of the installation. This may also comment on adjacent infrastructure if applicable.

A.6.2 Rail lubricator performance verification process

Verification is an iterative process and should require at least three site visits.

The initial lubricator settings should be those established during the type test. The lubrication performance is checked using tribometer measurements and the lubricator settings adjusted to optimise performance.

Shortly after commencing lubricator operation, and the passage of a small number of trains, the extent of head contamination from the lubricator should be checked using tribometer measurements on each rail starting 75 m from, and measuring towards the unit. The point at which the rail head CoF falls below 0.3 should be no more than 50m from the nearest distribution unit on that rail. If head contamination exists beyond that point the lubricator should be adjusted until contamination is at a reasonable level.

The performance of the lubricator should be checked again after a representative number of train configurations (speed, length and type) have passed. If necessary, the lubricator should be adjusted to minimise head contamination while maximising carry.

After the required performance is obtained, a commissioning report should be prepared which should contain, as a minimum, the following:

(a) Lubricator type, including serial number and bar type.

(b) Grease type.

(c) Exact location of the unit, including the kilometrage and the track, for example 27.365 km Main North up.

(d) Type, number and placement of grease distribution units (for example, two model XYZ grease distribution units on the up rail and two model XYZ grease distribution units on the down rail, spaced at 600 mm).

(e) Photos of the lubricator control unit or reservoir and the distribution units, as installed.

(f) Final friction measurements for all curves in the track section to be serviced by the unit, to include CoF recorded for the high rail gauge corner and the TOR surface for both rails, and the distance at which the required rail head surface CoF was achieved from the unit for both rails.

Exception: In high curvature density areas where track access may be limited and where effective lubrication is visually indicated to be in place, extent of friction measuremets can be reduced to the final 3 curves furthest from the lubricator/ closest to the next lubricator site, plus any additional curves demonstrating poor lubrication quality. Final lubricator settings from which the required performance was achieved, including the position of the distribution units, their height relative to top of rail, the application rate.

(g) Application frequency, the amount of grease (in grams) dispensed per application, and any other settings that will allow the unit performance to be monitored.

Appendix B Sample friction measurement record sheet

An example of a rail friction measurement record sheet is provided below. Refer to Section 4 for rail friction measurement recording requirements.

Friction Measurement Record Sheet			
Operator name:		*Temperature:*	
Run number:		*Relative humidity:*	
Date:		*Product:*	
Time:		*Tribometer serial #:*	
Location km from:		*Location km to:*	
Traffic direction:		*Curve direction:*	
Radius (m):			
Low rail (markers)	*LOW rail top of rail*	*High rail top of rail*	*High rail GC (degrees)*
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
Average			
Comments:			

Appendix C Hazard register

Hazard number	Hazard	Section addressing
6.1.1.3	Excessive noise	2, 3, 4
6.2.1.1	Wheel squeal	2, 3, 4
6.4.1.3	Lubricants, service fluids and consumables	2, 3, 4
6.6.1.4	Derailment	2, 3, 4
6.6.1.7	Excessive rail wear and/or a damaged rail	2, 3, 4
6.6.1.12	Wheels climbing rail heads	2, 3, 4
6.6.1.21	Wheel skidding	2, 3, 4
6.6.1.38	Poor traction control	2, 3, 4

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Once agreed by the Development Groups, Standing Committees and Validator, the drafts are passed to the RISSB Board for approval.

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