Engineering Standard

L1-CHE-STD-033
RAIL LUBRICATION STANDARD

Version: 2
Approval

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Amendment Record

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<tr>
<th>Approval Date</th>
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<tr>
<td>25/08/2017</td>
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Metro Trains Melbourne (MTM) Standards have been developed to ensure common approaches are employed when designing, constructing or testing any part of the Melbourne Metropolitan Rail Network. It is important to understand that Standards are living documents which take into account learnings to achieve best practice.

All MTM Standards are periodically reviewed and new versions published which incorporate learnings and Technical Notes (TNs). TNs are issued between editions which correct any errors or ambiguities contained in an MTM Standard. Standards may also be withdrawn and replaced. As Standards are uncontrolled once printed, it is imperative to check the currency of the Standard on the MTM Intranet or MTM External Document Portal.

In the event of conflicts or discrepancies between Documents, refer to the order of precedence as defined in ‘Chief Engineer’s Guideline Engineering Standards Listing’ (L1-CHE-GDL-005).

**Note:** Any clarification described in a TN shall take precedence over the impacted clause or clauses in the associated MTM Standard.

In the event a clause within a Standard is not achievable a waiver must be raised in accordance with ‘Engineering Waiver Procedure’ - L1-CHE-PRO-001.

**Note:** MTM does not have the authority to grant waivers to any Standards which relate to Government Regulations or Legislation, e.g. Disability Discrimination Act.

**Application of this Standard**

*This Standard is applicable from the approval date. It shall also be applied to projects and renewals works that are in the delivery phase where there is an existing requirement for rail lubrication identified within the MTM Final Operations Requirements document, or where the MTM asset management strategy requires the use of electronic lubricators.*
Table of Contents

1 Purpose ................................................................................................................................... 5
2 Scope....................................................................................................................................... 5
3 Abbreviations and Acronyms ................................................................................................. 5
4 Definitions ................................................................................................................................ 5
5 References & Legislations ........................................................................................................ 6
   5.1 General ............................................................................................................................. 6
   5.2 MTM References ............................................................................................................. 7
   5.3 Industry References ......................................................................................................... 7
   5.4 Australian References and Legislation ............................................................................ 8
6 Related Documents .................................................................................................................. 8
7 Safety & Environmental ......................................................................................................... 8
8 Functionality ............................................................................................................................ 9
9 General Principles .................................................................................................................. 9
   9.1 System Configuration ...................................................................................................... 9
   9.2 Site Specific Requirements ............................................................................................ 11
   9.3 Lubricants ....................................................................................................................... 11
10 Electronic Lubricators .......................................................................................................... 12
   10.1 General ........................................................................................................................ 12
   10.2 Lubricator Effectiveness Number (LEN) ...................................................................... 13
   10.3 Lubricator Location ....................................................................................................... 14
   10.4 Commissioning ............................................................................................................ 15
11 Mechanical Lubricators ....................................................................................................... 15
   11.1 General ........................................................................................................................ 15
   11.2 Lubricator Location ....................................................................................................... 15
   11.3 Commissioning ............................................................................................................ 16
12 Appendix A – Documentation Requirements ....................................................................... 17
   12.1 General Requirements .................................................................................................. 17
   12.2 Specific Requirements .................................................................................................. 17
13 Appendix B – Lubricator Effectiveness Number (LEN) Formula ......................................... 18

List of Figures

Figure 1 – Lubrication regions for 60 kg/m rail ................................................................. 10
Figure 2 – Process for electronic lubricator placement ....................................................... 12
Figure 3 – Electronic Lubricator Configurations ................................................................. 13
1 Purpose

1.1 The purpose of this document is to provide functional and technical requirements for wayside rail lubricators introduced onto the MTM Infrastructure Lease.

2 Scope

2.1 This standard sets out MTM requirements for rail lubrication assets installed within the MTM Infrastructure Lease.

2.2 The requirements for rail lubrication specified in this standard shall apply to the design of new lubrication systems, and the modification or optimisation of existing systems within the MTM Infrastructure Lease.

2.3 This standard is mandatory for all mainline tracks on the MTM Infrastructure Lease.

2.4 This standard shall be applied to all lubricator types that have been accepted for use through the MTM Type Approval process. A list of current type approved lubricators and relevant product information is available from MTM Engineering upon request.

2.5 This standard does not cover the use of train or vehicle-mounted rail lubricators, or friction modifiers for top of rail application.

3 Abbreviations and Acronyms

CoF Coefficient of Friction
DMS Drawing Management System
DPN Design Practice Note
LEN Lubrication Effectiveness Number
MTM Metro Trains Melbourne
MURL Melbourne Underground Rail Loop
PTV Public Transport Victoria
RCF Rolling Contact Fatigue
RSNL Rail Safety National Law
SFAIRP So Far As Is Reasonably Practicable

4 Definitions

5-foot Area between two rails on a broad gauge track.
6-foot Area between two tracks.
Bi-directional Track Track where train can travel in either up or down direction.
Cant The vertical distance that the outer rail is raised above the inner or grade rail of a curve. Also known as superelevation.
Cant Deficiency Cant deficiency relates to an amount of superelevation used to achieve a balanced condition for passenger ride quality when determining the cant to be applied to a curve for a particular speed.
Danger Zone
All space within three metres horizontally from the nearest rail and any distance above or below this three metres, unless a safe place exists or can be created.

Down Track
Track where train is travelling away from Flinders Street Station (City).

Down Rail
When facing away from City, this is the rail on the left.

Electronic Lubricator
Electronic lubricators operate by controlled pumps to apply lubricant to the rail when a vehicle wheel is detected by a wheel sensor. Units typically consist of a reservoir, pump, distribution blocks, applicator bars, power supply and computer telemetry.

Inspection and Test Plan
Inspection and Test Plans set out critical control points or ‘hold points’ at various stages within a process. Each control point is a scheduled inspection or verification activity where you will make sure that things are progressing as they should be.

Mechanical Lubricator
Mechanical lubricators utilise the action of wheels operating a plunger to pump lubricant to a distribution bar. The lubricant reservoir is lightly pressurised by a backing piston and spring.

Shall
The term Shall is used to express a clause that is mandatory to achieve conformance to the standard.

Should
Is used as the descriptive word to express a requirement that is recommended in order to achieve compliance. ‘Should’ can also be used if a requirement is a design goal but not a mandatory requirement.

Shuttle
A service that runs back and forth between two stations.

Up Track
Track where train is travelling towards Flinders Street Station (City).

Up Rail
When facing away from City, this is the rail on the right.

5 References & Legislations

5.1 General

5.1.1 Rail lubrication systems shall be designed and constructed in accordance with this standard, other relevant MTM and Australian standards and MTM requirements documents.

5.1.2 Where a conflict arises between documents, or where clarification on the applicability of a standard, specification or a part of either is required, the matter shall be referred to the MTM Chief Engineer for determination.
5.2 MTM References

<table>
<thead>
<tr>
<th>Document Number</th>
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<tr>
<td>L0-HMR-MAN-001</td>
<td>Business Rules Manual For The Contracting Rail Safety Worker</td>
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<td>L0-SQE-PLA-005</td>
<td>MTM Environmental Management Plan.</td>
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<td>L0-SQE-PRO-014</td>
<td>Safety &amp; Environmental Requirements for Third Parties Working on MTM Premises.</td>
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<td>Engineering Change Procedure</td>
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<td>L1-CHE-PLA-005</td>
<td>OCS Industrial Control Systems Strategy</td>
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<td>Engineering Drawings Management Policy (IFC/As Built)</td>
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5.3 Industry References

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<tr>
<td>T HR TR 00111 ST</td>
<td>Transport for NSW Rail Lubrication Standard</td>
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<td>Railway applications - Wheel/rail friction management - Lubricants for trainborne and trackside applications</td>
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5.4 Australian References and Legislation

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<tr>
<th>Document Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>.R. No. 54/2007</td>
<td>Victorian OHS Regulations 2007</td>
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6 Related Documents

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<td>L1-CHE-STD-039</td>
<td>Track Design and Construction</td>
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<td>L2-TRK-PRO-057</td>
<td>Electronic Lubricators – Maintenance and Inspection</td>
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<tr>
<td>L2-TRK-MAI-005</td>
<td>Rail Lubricator – Examination and Servicing</td>
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7 Safety & Environmental

7.1 The general requirements in relation to safety are included in MTM’s Safety Management System Manual (L0-SQE-MAN-002).

7.2 The design and construction of infrastructure required for the rail lubrication system shall comply with the MTM Environmental Management Plan (L0-SQE-PLA-005).

7.3 All rail safety workers shall comply with Business Rules Manual for the Contracting Rail Safety Worker (L0-HMR-MAN-001) and have the appropriate competencies to undertake their role.

7.4 Under RSNL (s46) MTM is required to:
   a. Eliminate risks to safety so far as is reasonably practicable (SFAIRP); and
   b. If it is not reasonably practicable to eliminate risks to safety, to minimise those risks so far as is reasonably practicable.

7.5 Under RSNL (s47), reasonably practicable means that at a particular time, MTM were able to reasonably demonstrate how the risk/s can be managed to ensure safety, taking into account and weighing up all relevant issues including:
   a. The likelihood of the hazard or the risk concerned occurring;
   b. The degree of harm that might result from the hazard or the risk;
   c. What the person concerned knows, or ought to reasonably know, about:
      i. the hazard or risk, and ways of eliminating or minimising the risk;
      ii. the availability and suitability of ways to eliminate or minimise the risk; and
   d. After assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

7.6 Under RSNL (s50), rail safety is a shared responsibility of:
   a) Rail transport operators; and
   b) Rail safety workers; and
c) Other persons who:
   i. Design, commission, construct, manufacture, supply, install, erect, maintain, repair, modify or decommission rail infrastructure or rolling stock; or
   ii. Supply rail infrastructure operations or rolling stock operations to rail operators; or
   iii. In relation to the transport of freight by railway—load or unload freight on or from rolling stock.

7.7 Safety and risk assessments shall be undertaken to inform the design. It shall take into account safety considerations for construction and maintenance personnel and any other parties, including operations personnel who may be required to use the track. Risk assessments shall be conducted in accordance with the MTM Enterprise Risk Management Procedure L0-SQE-PRO-031.

7.8 Where new equipment or systems are proposed to be introduced, the materials and equipment shall be subject to MTM Type Approval processes for use on the metropolitan train network.

8 Functionality

8.1 The primary function of rail lubrication is to extend the life of rail and wheel assets. It can also reduce the risk of a wheel climb derailment in tight radius curves.

8.2 Lubrication of the wheel rail interface on the gauge face and gauge corner of the rail reduces friction, which reduces wear and in turn helps optimise the life of rail and wheel assets.

8.3 Project specific functional requirements related to rail lubrication shall be described in the appropriate MTM Final Operational Requirements document and Final Impact Statement for the project.

9 General Principles

9.1 System Configuration

9.1.1 Rail lubrication systems, comprising the lubricator and lubricant combination, and the number, location and spacing of lubricators, shall be designed to provide effective long term lubrication to rails.

9.1.2 Rail lubrication should be provided where there is potential for significant rail wear. Typically this includes:
   - Curves of 600m radius or less.
   - Curves with a radius greater than 600m where rail/wheel flange contact is apparent or expected.
   - Curves exhibiting gauge face wear on the high rail or where flanging noise is a problem. Note: If curve exhibits evidence of RCF, RCF shall be removed prior to lubrication.
   - Curves with a history of RCF.

9.1.3 The configuration of the lubrication system should be reviewed to ensure there is sufficient lubrication provided when:
   - New track infrastructure is added to the MTM Infrastructure Lease.
The alignment of existing track infrastructure is altered to include new curves that may alter the upstream or downstream lubrication effectiveness.

Reducing the curve radii, altering cant or altering the design speed of existing curves.

Maintenance staff report excessive wheel or rail wear following inspections or noise complaints.

Train service frequencies or routes are altered.

9.1.4 The location and spacing of lubricators can be affected by a number of factors. Effective lubrication shall be determined based on visual inspection by competent personnel. The use of a tribometer or other friction measuring device is permitted. Where a friction measuring device is used, the following friction coefficients should be achieved.

<table>
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<tr>
<th>Location</th>
<th>Coefficient of friction</th>
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<tr>
<td>Gauge corner of the high rail, measured at 45 degrees</td>
<td>≤ 0.25</td>
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<tr>
<td>Top of rail (TOR), running surface region</td>
<td>≥ 0.35 (&gt;0.4 preferred), &gt;0.4 on grades steeper than 1 in 50. ¹, ²</td>
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1 - Lower friction levels are acceptable on the rail surface only in the immediate vicinity of the lubricator (within 50m).

2 - It is desirable that the difference between the average running surface friction between the high and low rail be no more than 0.15.

Figure 1 below illustrates the definitions of regions on a cross-section of rail, including gauge corner and running surface.

Figure 1 – Lubrication regions for 60 kg/m rail
9.1.5 Lubrication system configuration shall consider rolling stock operational patterns including:
- Bi-directional tracks that can have alternating traffic directions
- Network entry points where traffic enters or exits a track section e.g. stabling sidings, maintenance depots
- Turn-back locations where disruptions or occupations can alter traffic patterns
- Junctions where traffic can carry lubricant in more than one direction.

9.1.6 Electronic lubricator units shall be located in a place of safety in order to minimise the risk to maintainers working in the danger zone, and provide improved monitoring capability.

9.1.7 Where it is not possible to install an electronic lubricator, a mechanical lubricator should be installed.

9.1.8 Lubricators shall not be located closer than 20m from water courses and other environmentally sensitive sites without approval from the MTM Manager Environment.

9.2 Site Specific Requirements

9.2.1 Electronic and Mechanical lubricators shall be positioned in accordance with the requirements of this standard outlined in Section 10 and Section 11 respectively.

9.2.2 Design of lubricator positions shall also consider and mitigate risks SFAIRP:
- The location relative to sensitive or safety critical equipment or assets such as signalling assets, stations and relationship to steep grades.
- The ability for maintainers to access the site to complete maintenance and inspections.
- Elements of the lubrication system susceptible to vandalism.
- Location of the applicator bars to any walkways, pedestrian or road crossings to prevent splatter and slipping hazards.

9.2.3 The design shall ensure compliance with the structure gauge envelopes applicable to the category of asset as outlined in L1-CHE-STD-025.

9.2.4 The designer shall provide documentation in accordance with Appendix A of this standard.

9.3 Lubricants

9.3.1 Lubricant performance will vary depending on the lubricant type and the application to the network. The resulting performance is subject to field trials to determine actual performance.

9.3.2 Lubricant should exhibit certain preferred characteristics including:
- Ability to be applied and transferred along a track through adhesion to wheels and rail but also without undue splatter and wastage.
- Ability to be retained on the gauge face of the rail over a reasonable time under traffic in the event of a lubricator failure, including resistance from water.
• Ability to withstand the pressures that occur at the wheel flange/rail gauge face contact.
• Ability to function within the required rail temperature range.
• Consideration of impact on environment.
• An appropriate level of electrical conductivity to prevent impacts on track circuits.

Further guidance for specific values of lubricant characteristics can be found in EN 16028 - Railway applications - Wheel/rail friction management - Lubricants for trainborne and trackside applications.

9.3.3 Lubricant application rates shall be controlled to minimise the risk of affecting traction of the rail head, and minimise risk to the environment.

10 Electronic Lubricators

10.1 General

10.1.1 The process outlined in this standard for the placement of electronic lubricators is based on the concept of a lubricator effectiveness number (LEN). A summary of the process for lubricator and lubricant Type Approval, and the design and implementation of a lubricator is included in Figure 2.

Figure 2 – Process for electronic lubricator placement
10.2 **Lubricator Effectiveness Number (LEN)**

10.2.1 The LEN for specific lubricator and lubricant combinations shall be established during a trial completed in accordance with the MTM Type Approval Procedure (L1-CHE-PRO-004) and Engineering Change Procedure (L1-CHE-GDL-031).

10.2.2 For MTM Type Approved electronic lubricator/lubricant configurations, a maximum LEN of 8200 shall be adopted unless approved otherwise.

10.2.3 When determining the location of lubrication devices on the MTM network, the LEN shall be calculated using:

- The formula detailed in Section 13.1;
- General requirements outlined in section 9; and
- The approved configuration types shown in Figure 3.

10.2.4 Direction sensing types should be avoided if possible due to the complexity and practicality of balancing lubrication rates in different directions.

10.2.5 When making changes to the existing lubrication system, registers containing details of existing lubricator location settings and configurations are available from MTM Engineering.

10.2.6 The LEN shall be calculated separately for each rail. The LEN shall be the greater of the individual LENs calculated for either the Up or Down rail for lubricators serving both rails of a track.
10.3 Lubricator Location

10.3.1 The position of electronic lubricator applicator bars shall ensure the LEN outlined in 10.2.2 is not exceeded.

10.3.2 Applicator bars should be located in tangent track at a suitable distance (nominally 50m), from the start of a curve, but preferably as far as possible, from the curve transition in the direction of traffic. Where site constraints are present, it may be approved for lubricators to be located within a curve or transition of curve.

10.3.3 Electronic lubricators shall be installed within a secure compound in accordance with standard drawing STD_C0043.

10.3.4 Lubricator compounds shall not be placed more than 10m from applicator bars without a site specific design confirmed by the supplier.

10.3.5 Lubricator compounds shall be located outside the danger zone so that maintenance tasks and adjustments can be completed during normal train operations and minimise safeworking requirements.

10.3.6 Lubricator compounds should be placed as close as possible to maintenance vehicle access to minimise manual handling of lubricants.

10.3.7 Where site constraints prevent the installation of a standard size compound, alternate designs may be proposed. Alternate designs are subject to approval by the MTM Chief Engineer or delegate.

10.3.8 Wherever practicable, mains power shall be provided to each lubricator to minimise maintenance requirements and maximise reliability. Solar panels may be used. Where solar panels are used as the power source, they shall be provided with an appropriate battery backup capacity to ensure uninterrupted operation.

10.3.9 Lubricators should be located to ensure that braking and traction around signals, stations and level crossings are not compromised. Braking distances shall be calculated using L1-CHE-FOR-098 Train Dynamics – Acceleration and Braking Performance. Where this is not possible, locations shall be risk assessed to ensure that lubricator locations and settings minimise risks SFAIRP.

10.3.10 Lubricators shall be located away from existing infrastructure where the operation of the lubricator may interfere with the safe and correct operation of that infrastructure.

10.3.11 The telemetry system shall provide a safe and secure remote monitoring system to check the health and operational status and function of the lubricator such as:

   a. Sending alert emails and/or SMS for each electronic lubricator. Technical Maintenance Representative.

   b. The units should be set up to send alerts for the following issues:
      - Access door open/closed to check for unauthorised access.
      - Power source disconnected/connected.
      - Battery low status, level of charge (if applicable).
      - Lubricant usage.
      - Hydraulic failure, pump fault or lubricant not dispensed during cycle.
      - Missing Reports, internet connection issues between lubricator and server.
The telemetry system shall comply with requirements in OCS Industrial Control Systems Strategy (L1-CHE-PLA-005).

10.4 Commissioning

10.4.1 Prior to commissioning, lubricator settings shall be determined by the installer in conjunction with MTM Engineering. These shall be documented in an Inspection and Test Plan and included as part of the Engineering Change request.

10.4.2 Electronic lubricators have two variables which can be changed to control the rate of lubricant to each rail.

- Rate – is the variation of the lubricant volume applied per number of axles passing the unit. This parameter is controlled electronically and remotely via the unit telemetry.
- Block Balance – is the balance of the lubricant distribution valves that control the distribution of lubricant between bars for Up and Down rails. This is a physical property that is achieved on the unit by adjustment of the lubricant block pins.

10.4.3 The LEN in section 10.2.2 is based on rate of 1 cycle every 24 axles. If the full LEN is not required to reach the downstream lubricator the rate should be adjusted by increasing the number of axles per 1 cycle.

10.4.4 The maximum block balance shall be set at 65% to limit lubrication splatter and risk of rail head contamination.

10.4.5 The supplier shall provide any special adjustment required to tuning settings due to the placement of the wheel sensor relative to the applicator bar and document in the Inspection and Test Plan.

10.4.6 Lubricant carry and/or coefficient of friction on curves, designed to be serviced by the lubricator, are to be monitored post-commissioning to ensure the lubricator performs as per LEN concept or adjust the settings if required.

11 Mechanical Lubricators

11.1 General

11.1.1 Mechanical lubricators shall be installed in accordance with the requirements defined in Section 9.

11.1.2 Mechanical lubricators shall be positioned in accordance with the requirements detailed in Section 11.2.

11.2 Lubricator Location

11.2.1 Mechanical lubricators should be located at the beginning of moderate radius feeder curves ahead of the tighter radius curves, which are the main target. The alternative locations for lubricator placement are:

- For medium radius curves with radii in the range 400m-600m the lubricator should be placed at the beginning of a curve, within the transition and in the direction of travel. The ideal position within the transition is where steady wheel flanging is just beginning to occur.
This will usually be closer to the Transition of the curve (TS) than the tangent point. Positioning of lubricators within the curve proper, where heavy wheel flanging can occur, may lead to excessive wear of the lubricator blades.

- For flatter radius curves, with radii greater than 600m and up to 1000m the lubricator should be placed within the body of the curve, as long as there is some indication of minor wheel flanging and no indications of heavy wheel flanging.

- Where the desirable flat radius curves that require lubrication are not available the flattest radius curve available should be selected. Carry distances and lubrication effectiveness will, however, be reduced.

11.2.2 Mechanical lubricators should not be positioned in or near very sharp curves with radius below 300m. This generally leads to very inefficient and often excessive lubrication, and increases the potential for running surface contamination, loss of traction, and the development of wheel burns/skids and rail gauge corner defects.

11.2.3 Lubricators should be located to ensure that braking and traction around signals, stations and level crossings are not compromised. Braking distances shall be calculated using L1-CHE-FOR-098 Train Dynamics – Acceleration and Braking Performance. Where this is not possible, lubricator locations shall be risk assessed to ensure that selected locations minimise risk SFAIRP.

11.2.4 Lubricators shall be located away from existing infrastructure where the operation of the lubricator may interfere with the safe and correct operation of this infrastructure.

11.3 Commissioning

11.3.1 To avoid running surface contamination, special care is required in setting up the lubricators so that excessive lubricant is not dispensed. Pin heights should be set at a low level and increased until effective rail lubrication is achieved.

11.3.2 Mechanical lubricators shall be monitored post-commissioning to ensure that curves designated to be serviced by a specific lubricator receive adequate coverage of lubricant.
12 Appendix A – Documentation Requirements

12.1 General Requirements

12.1.1 Design Documentation will be prepared in accordance with the MTM Design and Technical Review Procedure L1-NAM-PRO-002.

12.1.2 All Design Drawings shall be produced in accordance with the conventions detailed in MTM Documentation L1-CHE-POL-001 Engineering Drawings Management Policy (IFC/As Built), and PTV’s Infrastructure Drafting Standards.

12.2 Specific Requirements

12.2.1 Design documentation should be provided to include the following:

a. PTV DMS compliant drawings. The drawings shall:
   - Specify the lubricator type and configuration
   - Show location of applicator bars
   - Show location of compound (if applicable)
   - Show extent of earthworks (if applicable)

   The final number of Lubricators required to meet the operational requirements based on the configuration of rail assets will be determined by the system design of the network. The final design may include a combination of Electronic and mechanical lubricators

b. Detailed design calculations which shall include all LEN calculations and detail all assumptions and considerations regarding placement and configuration of lubricators.

c. Inspection Test Plan detailing installation settings including:
   - Flow rate of lubricant to each applicator bar
   - Number of axles detected to activate application of lubricant to lubricator bars for each applicator bar.
   - Any special tuning adjustment considerations for wheel sensor placement.
13 Appendix B – Lubricator Effectiveness Number (LEN) Formula

13.1 The LEN shall be calculated as follows:

\[ LEN = \frac{(C + S) \times D}{T \times M \times BR \times BG} \]

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.

If applicator bar is installed on the down rail, only right hand curves are to be considered for the calculation of LEN on down rail. If applicator bar is installed on the up rail, only left hand curves are to be considered for the calculation of LEN on up 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.

- \( D = \) The degree of curvature where \( D \) is related to the curve radius \( R \) (metres) by:
  \[ D = \frac{1746}{R} \]

**Rolling stock factors:**
- \( T = \) Description for direction of traffic, 1 for unidirectional traffic and 2 for bi-directional traffic.

- \( M = \) Factor to account for misaligned bogies on tight curves (radius less than 350 m). \( M \) is \((1/1.08)\) for tight curves and 1 on shallow curves and tangents.

- \( BR = \) Factor to account for train braking. Heat is generated by trains braking down long grades, which displaces lubricant from the gauge corner.
  \[ BR = \frac{(100 - 10\times|\text{grade}|)}{100} \text{ for negative gradient, where grade is expressed as a percentage and the } |\ldots| \text{ operator stands for the absolute value and 1 elsewhere. For example, if the gradient is } -1:50 \text{ (2%) descending, } BR = \frac{(100 - 10\times2)}{100} = 0.8, \text{ whereas if the grade was } 1:50 \text{ (2%) ascending, } BR = 1. \]

- \( BG = \) Bogie factor. \( BG \) accounts for the greater impact of poorly steering bogies on sharp curves compared to shallow curves. \( BG \) is 2 for shallow curves \((R > 350 \text{ m})\) and 1 for sharp curves \((R \leq 350 \text{ m})\).

**Note:** The LEN formula does not take into account the applied cant on a curve. Where there is excess cant deficiency on any curves serviced by a lubricator, monitoring post commissioning will be required to assess impact of excess deficiency on lubrication performance.