

APPENDIX 6

TRANSPORTATION CANADA ATTACHMENTS

TC 1 ATTACHMENT 1: KLTR SITE PHOTOS







*TC 2 ATTACHMENT 1: MARY RIVER EXPANSION
PROJECT - RAILWAY DESIGN CRITERIA AND DESIGN
RATIONAL*

Mary River Expansion Project

Railway Design Criteria and Design Rational

2019-01-11	1	Approved for Use	 G. Johnstone	 F. van Biljon	 F. van Biljon	 F. Pittman
2017-11-28	0	Approved for Use	A. Aquil	F. van Biljon	F. van Biljon	F. Pittman
Date	Rev.	Status	Prepared By	Checked By	Approved By	Approved By
HATCH						Client

Table of Contents

1. General	1
1.1 Introduction	1
1.2 Jurisdictional Authority	1
1.3 Project Scope Definition	1
1.4 Project Objectives	2
1.5 Project Language	2
1.6 Rail Classification	2
1.7 Design Context	2
1.8 Scope	2
1.9 Safety	2
1.10 Units of Measure	3
1.11 Limits of Project	3
1.12 Assumptions and Exclusions	3
2. References, Acronyms, Design Codes, Standards and Regulations	4
3. Site Conditions	6
4. Operations	6
4.1 Traffic	6
4.2 Axle Load	7
4.3 Speed	7
4.4 Ore Trains	7
4.5 Design Train Length	8
4.6 Other Trains	8
4.7 Passing Tracks and Tracks at Terminals	8
4.8 Hi-Rail Refuges	11
5. Rail Alignment	12
5.1 General	12
5.2 Horizontal Alignment	12
5.3 Vertical Alignment	14
6. Geotechnical Recommendation and Earthworks	16
6.1 Geotechnical Data	16
6.2 Embankment Stability	16
6.2.1 Sub-grade Properties	16
6.2.2 Recommended Cross Sections for Embankments	16
6.2.3 Recommended Cross Sections for Excavations	18
6.3 Line Sections to Apply Typical Cross Sections	20
6.4 Settlement Considerations	20
6.5 Rock Fill Criteria	21
7. Hydrology	22
7.1 Introduction	22
7.2 Methodology	22
8. Bridge and Culvert Design Criteria	23
8.1 Introduction	23

8.2	Title Block	23
8.3	References for Design Standards	24
8.4	Bridge Geometry	24
8.4.1	Design Requirements	24
8.4.2	Datum.....	24
8.4.3	Control Line.....	25
8.4.4	Coordinate System	25
8.4.5	Span Lengths.....	25
8.4.6	Horizontal and Vertical Clearance from Obstructions	25
8.4.7	Vertical Clearance of Water Crossings.....	29
8.4.8	Walkways.....	29
8.4.9	Fixity.....	29
8.5	Bridge Design Parameters and Loading	29
8.5.1	Ballasted Deck.....	29
8.5.2	Vertical Displacements and Camber	30
8.5.3	Lateral/Longitudinal Displacements.....	30
8.5.4	Live Load	31
8.5.5	Centrifugal Force	31
8.5.6	Fatigue Stress Cycles.....	31
8.5.7	Braking and Traction Forces.....	31
8.5.8	Bearing Friction Forces.....	32
8.5.9	Walkway Loads.....	32
8.5.10	Snow Loads	32
8.5.11	Snow and Walkway Combination	32
8.5.12	Ice Accretion Loads	32
8.5.13	Wind Load on Structure	32
8.5.14	Wind Load on Live Load	33
8.6	Other Lateral Forces.....	33
8.6.1	Temperature Range.....	33
8.6.2	Earth Pressure	34
8.7	In Stream Ice Loads	34
8.8	Stream Forces	35
8.9	Seismic Effects	35
8.9.1	General	35
8.9.2	Load Combinations for Structural Check – Concrete Elements	35
8.10	Load Combinations for Structural Check – Steel Elements	37
8.10.1	General	37
8.10.2	Bearing Replacement	38
8.10.3	Utilities.....	38
8.11	Bridge Materials.....	39
8.11.1	Concrete	39
8.11.2	Concrete Protection for Reinforcement	39
8.11.3	Structural Steel	39
8.11.4	Corrosion Allowance	39
8.11.5	Bolts.....	39
8.11.6	Joints.....	39
8.11.7	Bearings.....	39
8.11.8	Waterproofing	40
8.12	Bridge Geotechnical Parameters	40
8.12.1	Ad Freeze Piles	40
8.13	Other Bridge Design Considerations.....	40

8.13.1	Guard Rails	40
8.13.2	Fish Passage	40
8.13.3	Scour Protection	40
8.14	Bridge Options	40
8.15	Culvert Geometry	41
8.15.1	Dimensions	41
8.15.2	Vertical Clearance	41
8.16	Culvert Design Rational	42
8.16.1	General	42
8.16.2	Typical Culvert Sections	42
8.16.3	Requirements for Fish Bearing Crossings	44
9.	Track	44
9.1	Design Standards	44
9.2	Track Structure Design Conditions	45
9.2.1	Train Loading	45
9.2.2	Sub-grade Loading	45
9.2.3	Key Track Structure Parameters	45
9.3	Rail	47
9.3.1	General	47
9.3.2	Rail Dimensions and Tolerances	47
9.3.3	Steel Quality	47
9.3.4	Rail End Drilling and Hardening	48
9.4	Ties	48
9.4.1	Yards, Mainline and Sidings	48
9.4.2	Spacing Tolerance	48
9.5	Fastenings	48
9.5.1	The fasteners for fixing rails shall be as outlined below:	48
9.6	Ballast	48
9.7	Turnouts	49
9.8	Joints	51
9.8.1	Standard Joint Bars	51
9.8.2	Insulated Joints	51
9.8.3	Welded Joints	51
9.9	Other Track Materials	51
9.9.1	Guard Rails	51
9.9.2	Derails	51
9.9.3	Stop Blocks (Bumping Posts)	52
9.10	Track Signs	52
9.11	Crossings	52
9.11.1	Crossings and Refuges (Set-offs)	52
9.11.2	Animal Crossings	53
9.12	Clearances	53
9.12.1	Clearance Diagrams	53
9.12.2	Track Spacing	54
9.12.3	Right-of-Way Fencing	54
9.13	Track Construction	54
9.14	Track Maintenance	54
9.14.1	Track Maintenance Conditions	54
9.14.2	Maintenance of Way Vehicles	54

9.14.3 Maintenance Bases and Sidings	54
10. Rolling Stock.....	55
10.1 Locomotives	55
10.2 Ore Cars.....	55
11. Rolling Stock Facilities	57
11.1 Functional Design Criteria for Diesel-Electric Locomotive Depot	57
11.2 Main Workshop Facility for Diesel-Electric Locomotives.....	57
11.3 Main Workshop Facility for Iron Ore Cars	58
11.4 Rolling Stock Maintenance Facility Stores and Offices.....	60
11.5 Wayside Condition Monitoring.....	60
12. Design Criteria Summary.....	60
Annexure A – Delineation of Existing Ground Conditions	65

1. General

1.1 Introduction

- 1.1.1 This revised document incorporates the adjustments made to the rail and embankment designs subsequent to the value improvement processes (VIP) workshop conducted on the outcomes of the initial pre-feasibility capital requirements for the project and should be read with document H352034-300-200-210-0001 – Rev. 0 as initial baseline for design.
- 1.1.2 It outlines the adjusted Design Criteria that govern the design for the Railway between the Iron Ore Mine at Mary River and Milne Port to the North and inclusive of the loading, discharging and maintenance facilities and rail infrastructure at each end. This project is specifically associated with the optimization of the Expansion Study – Stage II rail studies for Baffinland Expansion 12 million tonnes per annum (Mtpa) Mine Option.
- 1.1.3 The design codes and standards referenced in this document, engineering and other work done on the Steensby Project, the Tote Road, the Concept Scoping Studies for the rail line to Milne Port and the twice a day optimization progress calls with BIM, subsequent to the pre-feasibility VIP workshop, guided the optimization measures for the railway system's capital requirements.

1.2 Jurisdictional Authority

- 1.2.1 As part of the Mary River Phase 2 Expansion Project, Baffinland Iron Mines Corporation (Baffinland) is proposing to construct a railway line from the Mine Site to Milne Port. The proposed railway is not contained within the confines of the mine but extends out to cross public lands for a distance of almost 110 km and thus, it is not considered a mine railway. Furthermore, the Nunavut Act does not devolve authority to incorporate railways to the territory and the railway will therefore be regulated by the Federal Government under the Railway Safety Act[1].
- 1.2.2 Accordingly, the railway will fall under the jurisdiction of the Canadian Transportation Agency and Transport Canada, and will be subject to regulatory requirements for submissions to obtain approvals to construct, commission and operate the railway.

1.3 Project Scope Definition

- 1.3.1 The Mary River Expansion Study – Stage II Phase has been planned as a means to further develop the Mary River deposit and in an effort to curb high operating cost of the Tote road operation.
- 1.3.2 The adjusted aligned 110 km standard gauge rail line and railway system will be designed to allow year round railing of iron ore from Mary River Mine to Milne Port using the rolling stock and support equipment that will be able to remain functional in these extreme conditions in a sustainable manner.
- 1.3.3 Due to the unknowns regarding train operations in extreme weather for the site, provision has been made for the loss of 21 operating days per calendar year in designing train plans and operating plans and considering capacity issues.

1.4 Project Objectives

- 1.4.1 The objective of the project is to provide a reliable, all-season transport system to move 12 million tonnes per annum (Mtpa) of iron ore from the Mary River mine site to Milne Port, considering potential upgrades in future to exploit the full potential of the mine and the logistics chain. In an effort to optimize the capital requirements, the transport system will initially not make provision for the transportation of fuel, supplies, equipment and waste.

1.5 Project Language

- 1.5.1 The project language will be Canadian English.

1.6 Rail Classification

- 1.6.1 The railway system is classified as a standard gauge heavy haul system for permitting purposes, although other traffic might be operated on the line in future, the traffic allowed for in this optimized Mary River Expansion Study – Stage II, will be iron ore operating unit trains.

1.7 Design Context

- 1.7.1 The Rail Design Criteria will be based in general on AREMA but also following a “best practices” approach based on the Consultant’s experience in rail design to incorporate other applicable codes and practises as well as on instruction from the client, BIM and their officials, inside the best practise approach for safe and optimized rail system operations. Section 2 to follow provides a representation of the codes, standards and practises consulted and applied in the design process.

1.8 Scope

- 1.8.1 The criteria in this document apply to the civil engineering and operational design of the railway system between Mary River Mine and Milne Port including all relevant and related infrastructure, equipment and facilities at the end points and potentially on route.
- 1.8.2 It includes an occupancy control system and the existing telecommunications back bone. The Tote road is supported by full coverage communications by microwave towers as back bone and repeaters along the road for full coverage. The Mary River Expansion Study – Stage II will need to assess if more repeaters are required for the rail route deviations, considering fiber optic connections between towers and repeaters as enhancement of the backbone, especially deviation 8 around km 67 hill, to support full rail coverage for crew to control room communications and uninterrupted support for the radio distributed power (RDP) for the locomotives on the ore unit trains.

1.9 Safety

- 1.9.1 The consideration of personnel safety in all stages of the design, construction and operation is paramount. Prime consideration will be given to safety and reliability to:
- Maximize health and safety for all personnel using the railway system and other systems adjoining and running in parallel to the railway system.

- Minimize environmental impacts during the design process to assist in construction and operation.
- Maximize the security of equipment.
- Maximize continuity and sustainability of service (i.e. minimize time any element in the rail system is out of service).
- Special attention is required by BIM to formalize operating rules regarding the access to failed trains for in-service inspection and repairs along the rail alignment.
- Ensuring safe layout and user rules for crossings at grade.

1.10 Units of Measure

- 1.10.1 The International System (SI) will be used as the project standard.

1.11 Limits of Project

- 1.11.1 The project limits of the rail system are from the Milne Port off-loading area and port yard facilities to Mary River Mine Site loading facilities, dead-end spur.
- 1.11.2 This includes construction of refuges for Hi-Rail on-track maintenance equipment, crossings and wayside condition monitoring equipment.

1.12 Assumptions and Exclusions

- 1.12.1 The design criteria for the standard gauge rail are based on the following assumptions:
- The primary usage of this railway is for transporting of primary crushed iron ore from the mine site loading facility to an off-loading facility above the stockyard for the crusher at Milne Port. Although other commodities will potentially be transported between the mine and port in future after further upgrades, such other usage is not considered for the optimization of the pre-feasibility design.
 - The operating speed for all trains, loaded or empty, will be 60 km/h in both directions. Operating speeds are unlikely to be adjusted upwards in future. The geometric design criteria for safe operation is based on these operational requirements and loading factors. Where these geometric design criteria cannot be met, due to site conditions imposed by impacts of permafrost, topography and cost, minimum acceptable geometric design criteria and mitigating operating rules like speed restrictions will be proposed.
 - The typical heavy haul Diesel Electric Locomotives (3,280kW) that will be used on the line will have 32.7 tonnes axle loads (TAL), whilst the typical standard gauge gondola ore cars will have a practical capacity to carry 107 tonnes iron ore with a tare weight of 23 metric tonnes or 32.5 TAL.
 - The railway will be operated and maintained by BIM as a federally regulated railway.
 - The train operating plan, crew strategy and related functions are covered in Section 4.
 - Rolling Stock and facilities are covered under Sections 9 and 10.



2. References, Acronyms, Design Codes, Standards and Regulations

2.1 Unless specifically stated elsewhere, the rail will be designed in accordance with this criteria read along with applicable sections of the latest revisions of the codes, specifications and standards listed alphabetically below. If there is any conflict between this criteria and other relevant design standards, the discrepancies will be assessed and recommended to include practical best practice for the extreme weather conditions and experienced based best practice on a case by case basis.

- AASHTO - American Association of State Highway and Transportation Officials.
- ACI - American Concrete Institute.
- All applicable federal, territorial and local laws and regulations.
- AREMA - American Railway Engineering and Maintenance-of-Way Association, Manual of Recommended Practice.
- AREMA - Communications and Signals Manual of Recommended Practice.
- ASTM - American Standards for Testing and Materials.
- AWS - American Welding Society.
- CAN/CSA-S6 Canadian Highway Bridge Design Code.
- CENELEC - European Committee for Electrotechnical Standardisation, Standards for Railway Signalling.
- CSA - Canadian Standards Association.
- *Developing and Managing Transportation Infrastructure in Permafrost Regions, TAC-ATC; 2010.*
- Fisheries Act (Canada).
- FRA - Federal Railway Administration (USA).
- IEC - International Electrotechnical Commission.
- ISO - International Standards Organization.
- Northern Land Use Guidelines: Access Roads and Trails, Indian and Northern affairs Canada; Volume 5; 2010.
- Ontario MoE, Stormwater Management Planning and Design Manual, 2003. 2.1.2 In addition, the design must comply with all laws and regulations of local authorities; in the event of conflicting requirements, the most stringent will govern as confirmed with the Engineer. TSB Transportation Safety Board (Canada).
- RTC – Rail Traffic Controller (modeling software).
- UFC - Unified Facilities Criteria, Subarctic Construction.
- USACE - United States Army Corp of Engineers Mine Health and Safety Act.

2.2 Other Regulations

2.2.1 All applicable federal, provincial and local laws and regulations apply to the Mary River Expansion Study – Stage II:

- INAC - Indian and Northern Affairs Canada.
- OSHA - Occupational Safety and Health Administration.
- OSHR - Occupational Health and Safety Regulations.
- NBCC - National Building Code of Canada.
- NFPA - National Fire Protection Association.
- CFEM - Canadian Foundation Engineering Manual.
- MNR - Ontario Ministry of Natural Resources.
- MOE - Ontario Ministry of the Environment.
- MSHA - Mine Safety and Health Administration Handbook Number PH99-I-4.

2.3 Other Project Design Criteria

2.3.1 This Design Criteria must be read in conjunction with other documents which may already exist or will be developed as the project proceeds. These documents include the following:

- Canarail: Railway Design Brief Report dated November 2011 to Baffinland Iron Mines Corporation, Steensby Project, Revised Feasibility Study.
- Hatch: Baffinland Iron Mines Corporation - Mary River Project, Optimization Study Report 28 March 2012.
- Sub-sections of design criteria and specifications, linked to these two studies as well as that of the Tote road.

2.4 Reference Documents

2.4.1 Reference will be made to the following documents when reading these criteria:

- Baffinland Rail Scoping Study.
- H353004-00000-200-078-0008, the standard specification for Site Data, dated 2016-12-14.
- NB102-00181/39-A.01, Updated Design Peak Flow Assessment, by Knight and Piésold dated, 2016-12-13.
- H352034-3000-228-030-0001, the Project Hydrology Review Memo on the assessment of the Tote road Hydrology, dated 2016-08-18.
- H353004-00000-200-024-0001, Hydraulic Design of Drainage Structures, dated 2017-02-02
- H352034-3000-224-030-0003, Rail Tie Type Trade-off for Extreme Cold Weather Heavy Haul Operations.

3. Site Conditions

- 3.1 The standard gauge rail line follows the Tote road alignment between Mary River Mine and the Milne Port to a large extent with 10 pertinent deviations of which deviation 8 around/over the hill at 67 km is the most challenging due to the nature of the topography and the non-cohesive sands and sand and gravel of the undulated hills.
- 3.2 Site conditions are referenced from document H353004-00000-200-078-0008, the standard specification for Site Data, dated 2016-12-14.
- 3.3 Refer to the Site Conditions Specification for design temperatures, design wind parameters, seismic parameters, hydrology and snow load design parameters.

4. Operations

The operating requirements dictate the design parameters and criteria for the track, supporting infrastructure and systems that need to be developed inside the environmental and other constraints to support a sustainable operating model irrespective of the optimizing measures taken.

Operating conditions are extreme for equipment, infrastructure and personnel. Consensus has been reached that an initial reasonable operating plan needs to be adapted now with the view to exploit the learning curve of operations experience and the behaviour of the optimized infrastructure to consider adjustment for better efficiencies.

4.1 Traffic

- 4.1.1 The primary usage of this railway is for transporting of primary crushed iron ore from the mine site loading facility to an off-loading facility above the stockyard for the crusher at Milne Port. Other commodities initially considered for transportation by rail between the mine and port, will continue to be road transported over the Tote.
- 4.1.2 The ore trains will be unit trains dedicated to ore traffic configured to remain as a complete train-set throughout the operation cycle with at least one locomotive at each end. Trains will only be uncoupled for other than daily provisioning for planned or emergency maintenance purposes on cars or locomotives. "Not-to-go" (bad order cars) will be replaced as required, mainly port side. Train sets and locomotives need to be turned at the portside triangle on a frequency to be determined to ensure even wheel wear.
- 4.1.3 The railway will transport 12Mtpa of dry primary crushed iron ore equivalent to approximately 12.24Mtpa of wet iron ore (2% moisture content).
- 4.1.4 The mixed other traffic will be road transported over the Tote road during at least the first 5 years of operation, when further upgrading of the rail line can potentially be considered.

4.2 Axle Load



4.2.1 The typical heavy haul Diesel Electric Locomotives (3,280 kW) that will be used on the line will have 32.7 tonnes axle load (TAL), whilst the ore cars to be procured will have capacity to carry 107 metric tonnes iron ore with a tare weight of 23 tonnes or 32.5 TAL. During the ramp-up phase cars can be loaded to a payload of 98 tonnes per car or 30 TAL while the track and formation settles in after which full capacity loading will be considered and authorised.

4.2.2 The system and support infrastructure will be designed for 32.5 TAL.

4.3 Speed



4.3.1 The operating speed for all trains, loaded or empty, will be 60 km/h in both directions.

4.3.2 Higher operating speeds are not recommended due to the very small impact faster running times will have on the total cycle time. RTC modelling indicated that a 10 minute saving on running time applies at 65 km/h relative to 60 km/h for the loaded train as an example, as the loaded train can't maintain 60 km/h or 65 km/h continuously over the whole line due to the topography and the alignment. Higher speeds increase the maintenance effort on the track exponentially, so the higher speed value trade-off is debateable, whilst terminal dwell time makes up the largest part of the cycle time in any way.

4.3.3 The geometric design criteria for safe operation is based on these operational requirements and loading factors. Where these geometric design criteria cannot be met, due to site conditions imposed by impacts of permafrost, topography and cost of earthworks, minimum acceptable geometric design criteria and mitigating operating rules like speed restrictions are proposed.

4.3.4 During the spring/summer thaw period there is a possibility that temporary speed restrictions might be imposed over sections of the line if the effects of the permafrost prove to be a concern. This will be determined by intensified track and substructure inspection and monitoring on a daily basis or even on a train by train basis where the maintenance engineer can decide to what speed the operating speed could be reduced or even to suspend operations for a determined period.

4.4 Ore Trains



4.4.1 A specific train configuration is recommended for the optimized alignment and facilities as a workable and sustainable solution. This configuration, as do all the others analyzed, requires three sidings and a departure siding at each terminal.

4.4.2 Operate 2 train sets of 80 cars and 2 locomotives. Required car fleet is 180 ore cars and 5 Locomotives (1 spare/exchange locomotive and 20 cars) (3,280 kW). One locomotive at each end of the train.

4.4.3 It is assumed that BIM will start off operating trains at slower speeds during the ramp-up period to solve all operating challenges, potential distributed power test trains, crew training and to allow for ballast and formation consolidation before the full train configuration is implemented.



4.5 Design Train Length

- 4.5.1 The train design length is 900 m (80 x 10.56 (including stretch) + 2 x 22.7).
- 4.5.2 Gross Train Weight Loaded (80) = 10770 tonnes
- 4.5.3 Gross Train Weight Empty (80) = 2189 tonnes
- 4.5.4 Net Weight - Payload (80) = 8581 tonnes
- 4.5.5 All sidings and clearances have been designed for a 1100m clearance able to accommodate potential future expansion.

4.6 Other Trains

- 4.6.1 Only ore trains are considered for the optimized rail system proposed and other trains will only be considered during potential future upgrading phases.

4.7 Passing Tracks and Tracks at Terminals

4.7.1 Passing Loops (Sidings)

- 4.7.1.1 The RTC modeling concluded the location of a passing loops close to 25km, 56 km and 84km chainages, based on running times of the loaded and empty trains.
- 4.7.1.2 The mid-way passing loop is located between 55,646 km and 56,867 km, providing a clearance of 1100 m, fit for maximum 80 car train length. The switches need to be installed on tangent track and not inside vertical curves.

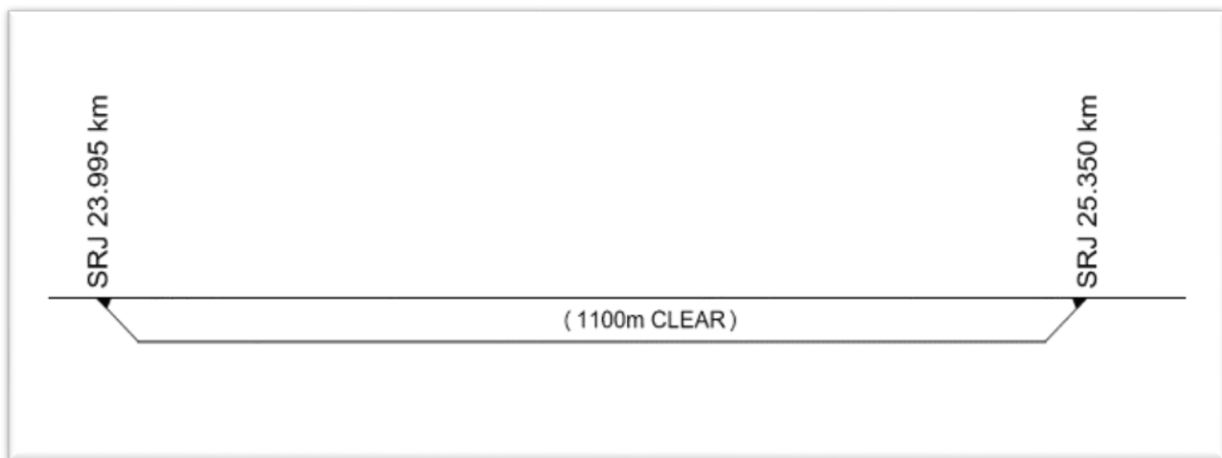


Figure 4-1: Siding No 1

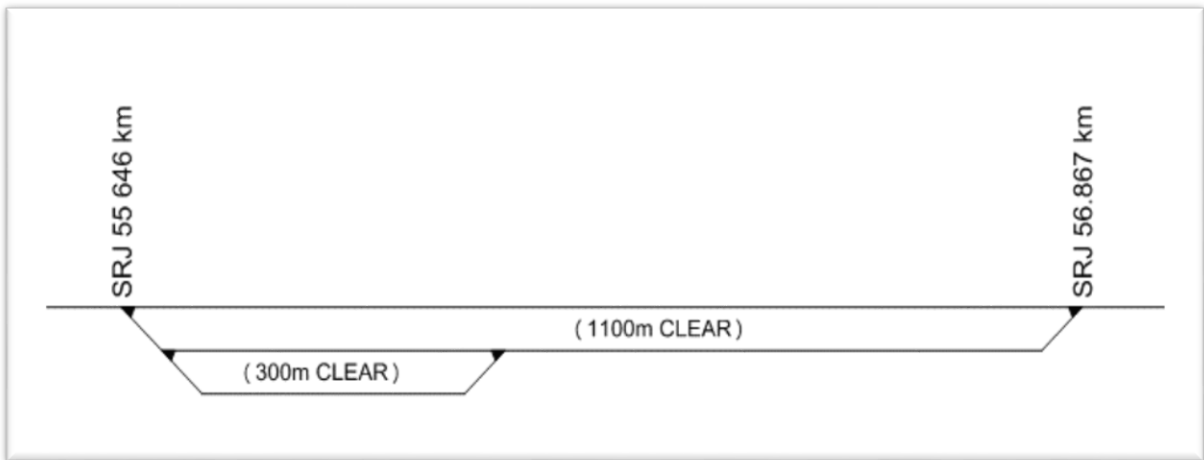


Figure 4-2: Midway Siding and Backtrack

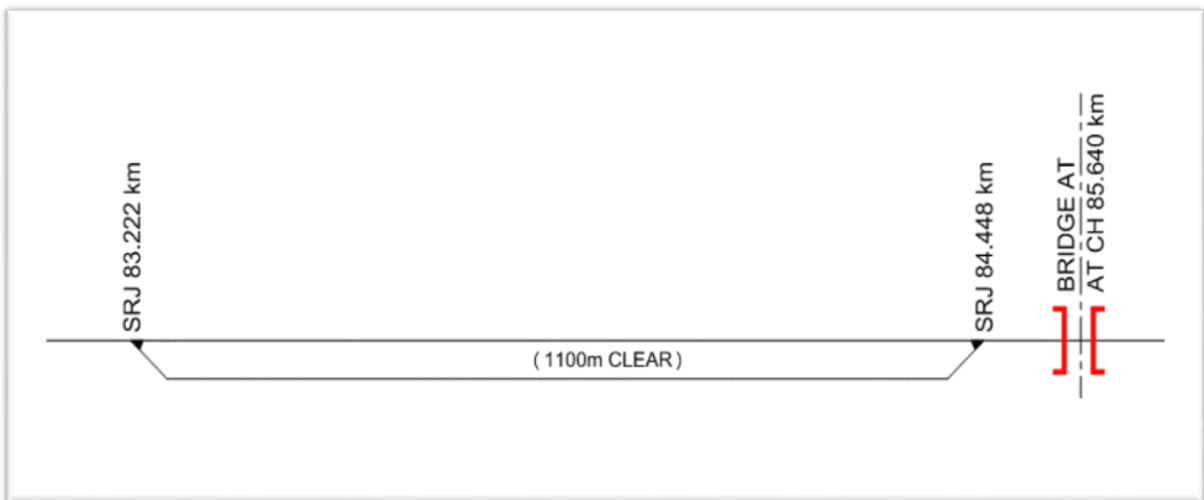


Figure 4-3: Siding No 2

4.7.2 Mine Side Track Layout

4.7.2.1 The Mine side track facilities have been rationalized and are represented in Figure 4-4 below:

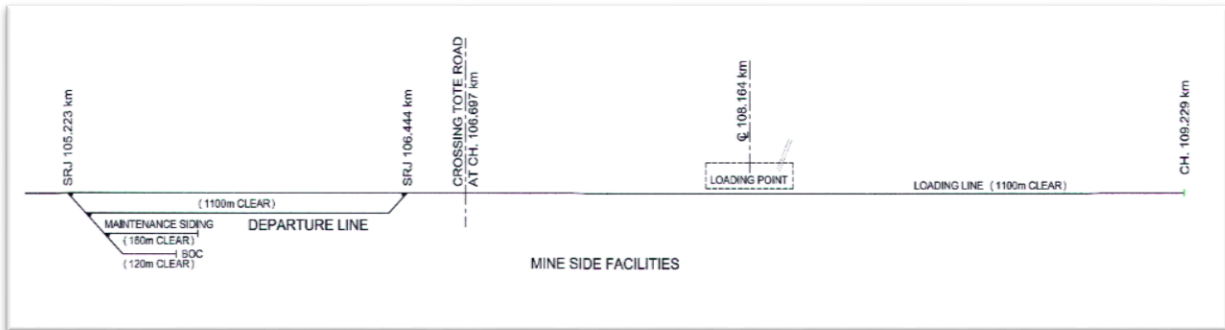


Figure 4-4: Mine Track Diagram

4.7.2.2 The mainline runs past the front-end loader loading bank into a dead-end.

4.7.2.3 A siding of 1100m clearance is also required, located in the vicinity where the freight siding was recommended initially.

4.7.2.4 The loading bank operations are based on 3 front-end loaders in the Static and Dynamic analysis.

4.7.3 Port Side Track Layout

4.7.3.1 The port side terminal and yard layout have been optimized and is presented in Figure 4-5 below:

4.7.3.2 The mainline will run straight into the elevated area adjacent to the quarry (Q1), through the off-loading facility into a dead-end. Clearances on both sides of the dumper must allow for 900m maximum train lengths, incorporating the tippler run-around section for empty train returns. The run-around section will tie back to the mainline in front of the dumper but will also run straight into a departure siding with 1100m clearance to allow a newly arrived loaded train to position in front of the tippler with an empty train waiting in the siding for inspection before departure back to the mine and for shunting movements if bad order cars need to be exchanged etc. Daily service and provisioning will be done by mobile units to the stationary train on the departure siding in order to enable the locomotives to be provisioned while still coupled to the empty cars.

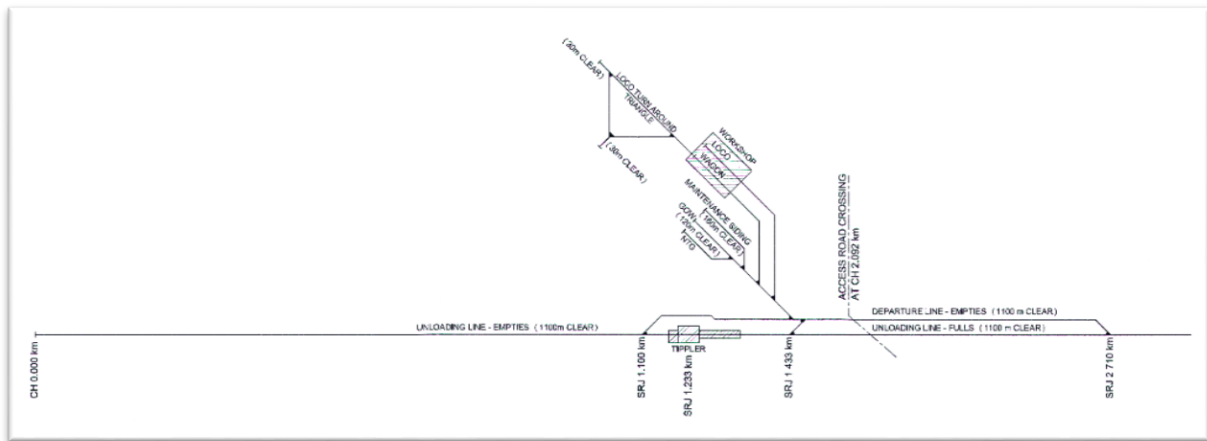


Figure 4-5: Port Side Track Diagram

- 4.7.3.3 An additional gather will tie onto the departure siding with four spurs that will go into the Locomotive and car maintenance facilities, for bad-order cars and good order cars for car exchange. Space for a second potential future line adjacent to the dumper empty car spur is provided as a shunting spur that could take a full train length for shunting and operational flexibility in future.
- 4.7.3.4 Provision for a ballast siding into the quarry area has been allowed for with another connection back to the departures siding that could serve as a triangle for cars and locomotives to be rotated for change of direction of travel and in support of wheel wear management.
- 4.7.3.5 The cycle time through the port terminal, including all these activities, has the most prominent impact on the train plan.
- 4.8 Hi-Rail Refuges**
- 4.8.1 Track maintenance personnel and on-track maintenance machinery, must clear the line to let trains pass to minimize train operations interference and delays.
- 4.8.2 All track-bound equipment use the passing loop back track or the sidings at the terminals for this purpose. However, vehicles used for regular inspection and daily light maintenance are utility vehicles equipped with road/rail functionality, or referred to as “Hi-Rail” equipment.
- 4.8.3 These vehicles can clear the track at any location provided with a level surface at rail level of approximately 4 m wide, typically at level-crossings or purpose made refuges.
- 4.8.4 The locations for such refuges or grade crossings should be carefully planned with the rail operations and maintenance contractor and will typically be at not more than 10 km intervals where geometric conditions are practical and safe and can coincide with normal grade crossings at grade such as the access roads or track maintenance access roads as well as the Tote Road grade crossings.

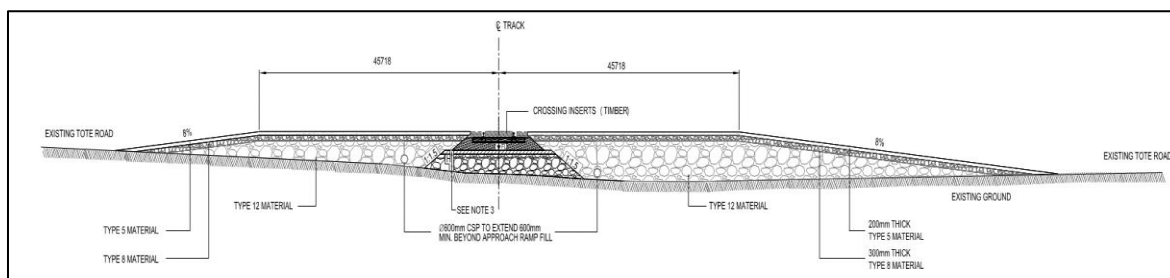


Figure 4-6: Typical Arrangement for Grade Crossing

5. Rail Alignment

5.1 General

5.1.1 The design criteria relevant to the rail alignment has been based on design criteria related to heavy haul railway operations and support infrastructure.

5.1.2 The basic objective is to have the gradients as flat as possible and the radii as large as possible. In some locations this is not possible due to the topography and the geotechnical considerations.

5.1.3 The emphasis for the optimizing actions was on an alignment that promotes operational safety and low maintenance, applying minimum design standards for optimizing purposes. The operating speed is 60 km/h. The commonly used design standard for North America heavy haul industrial track design and upgrades forms the basis of the design standards followed, unless alternative standards are specifically referenced.

5.2 Horizontal Alignment

5.2.1 The rail will predominantly be on an embankment of Type 12 rock fill between 700 mm and 1500 mm minimum thickness, above the natural ground level (NGL), measured on the high end of the cross fall under the ballast toe. The 1500 mm thick section had been designed for ice rich soil sections on the alignment.

5.2.2 Unevenness or cross fall in the NGL will be smoothed out with more run of quarry backfill Type 12 of varying thickness.

5.2.3 There will be no benches between top side of the embankment to the toe of the rock fill. There is a 300mm shoulder on the sub ballast layer and the ballast shoulder will vary from 300 mm to 600 mm depending on the curve radius for lateral support for the continuously welded track on timber ties.

5.2.4 On these curves where the outside leg of the track gets super elevated the top of formation or top of sub-ballast is widened from the standard 2624 mm to accommodate the wider ballast shoulder as well as the effect of the super elevation.

5.2.5 *Tote Road Interface*

- 5.2.5.1 Road accidents on the Tote Road should be prevented from having an impact on rail operations and vice versa.
- 5.2.5.2 For the optimized preliminary design the rail centerline will be off-set at 15 m from the Tote road centerline where the track and the road are at the same grade. Where the track embankment height increases or where the track is lower than the road, each case should be evaluated on its merits to determine the off-set of the embankment toes or cut-line of cuttings to maintain a safety barrier in which safety measures can be installed to keep impact between the two modes isolated.

5.2.6 *Curve Radius*

- 5.2.6.1 The approach for a heavy haul line, or any rail line for that matter, is to install the largest radii possible while still balancing the required earthworks and other design and cost parameters. Large curves (or straight track) are better for rail/wheel interaction than small radii curves and therefore better for maintenance purposes.
- 5.2.6.2 The design brief from BIM for the Mary River Expansion Study – Stage II phase railway, was initially that the horizontal alignment should stay alongside the Tote road and as far as possible inside the previously demarcated areas in which the development was scoped for permitting purposes. This brief was still respected during the optimization efforts except for locations where rock is present for cut to fill and where obvious geometric optimizing opportunities can be exploited.
- 5.2.6.3 The approach is therefore to design for a nominal radius of 500 m as the rule. (speed restriction will apply to curves with radii which require permanent speed restrictions to ensure safe operations).

5.2.7 *Spiral Curves (Transitioned Curves)*

- 5.2.7.1 Spiral lengths of horizontal curves (transition curves from tangent track to circular track) are calculated for each radii according to the AREMA manual for spirals, as follows:

Spiral Length (m)	Curve Radii Range (m)
300	230 to 249
270	250 to 274
240	275 to 299
210	300 to 399
180	400 to 424
150	425 to 549
120	550 to 699

- 5.2.7.2 In areas with difficult topographical challenges and constraints AREMA allows spiral lengths to be compromised to the following:

Spiral Length(m)	Curve Radii Range(m)
150	230 to 274
120	275 to 324
90	325 to 474
60	475 to 949
30	>950

- 5.2.7.3 These spirals are normally staked in 30 m stations for construction purposes, hence the lengths of multiples of 30.

- 5.2.7.4 As AREMA bases these calculations amongst others on “passenger comfort” it was already recommended for the pre-feasibility design to follow the adaption of constant transitional curve lengths. This approach is applied for the optimizing efforts for the rail alignment.

- Spiral Length = 80 m for curve radius $R > 300$ m.

- 5.2.7.5 These spirals will be staked in 20 m stations for construction purposes in preparing and shaping the sub-grade, formation and track.

5.2.8 *Minimal Tangent Length*

- 5.2.8.1 Minimum tangent track between spirals of reverse curves is 30.5 m in order for the bogies of one car to settle and to prevent them from being on cant applied in opposite grades. Transition curves can be butted in compounded and circular curves on running lines.

- 5.2.8.2 No spirals are required in yard track.

- 5.2.8.3 Apply the full applicable super elevation (cant) over the length of the spirals on both ends of the circular curve in order to have the full and constant cant on the circular section of the curve. Cant will be applied for 60 km/h operating speed and less cant based on the actual speed profile, for curves where the train goes slower due to gradients or speed restrictions.

5.3 *Vertical Alignment*

5.3.1 *Curve Lengths*

- 5.3.1.1 Vertical curvature will be applied between different grades according to AREMA:

- $L = D \times V^2 \times K / A$
- L = Length of vertical curve
- D = Absolute value of the difference in rates of grades expressed as a decimal
- V = Train velocity in mile per hour
- K = Conversion factor to give L in feet
- A = Vertical acceleration in feet/sec/sec, for freight operations $A = 0.1$ feet/sec/sec

- 5.3.1.2 Vertical curves are to be avoided in horizontal curves, however if it cannot be avoided and any other design criteria is compromised, vertical curves can be fitted to the circular sections of horizontal curves.

5.3.2 ***Ruling Gradient***

- 5.3.2.1 A ruling grade of 1.5% (1 to 66.7 – 1:66.7) facing loaded ore trains will be designed for. Grades on curves must be compensated to allow for an equivalent lesser gradient in curves.
- 5.3.2.2 Exceptional Grades: A ruling grade of 2.5% (1:40) facing empty ore trains or loaded general freight- and mixed trains (material and equipment) will be designed for as an absolute maximum and as an exception, for grades on inclines/declines less than an ore train length. Grades on curves will be compensated to allow for an equivalent lesser gradient in curves.
- 5.3.2.3 Grades on curves must be compensated to allow for an equivalent lesser gradient in curves in order to compensate for the higher rolling resistance of rail/wheel interaction through curves in relation to the radius of any specific curve.
- 5.3.2.4 The relatively steep gradients are necessary to adjust to the very challenging topography in the relevant corridor footprint and an effort to minimize the need for extensive excavations in the extreme permafrost conditions of Baffin Island and also to prevent extensive new permitting applications and environmental impact.
- 5.3.2.5 These gradients fall outside the relevant “range” of gradients normally associated with heavy haul rail operations but has been thoroughly analyzed with our in-house traction and adhesion tools to prove sustainability with the optimized alignment as base.
- 5.3.2.6 Allow in general one vertical grade direction change over one ore train length of track and as an exception 2 grade direction changes over one ore train length of track in places where the other vertical- and civil design criteria will be compromised if this exception is not allowed for.
- 5.3.2.7 The train design length of 900m now makes provision for the maximum number of 80 cars per train with 2 locomotives on RDP.
- 5.3.2.8 Gradients in other locations:
- Gradients in passing tracks: 0-0.25%.
 - Gradients in yard tracks: 0-0.125%.
 - Unloading facilities: 0-0.1%.
 - Loading facilities and attended trains: 0 – 0.25%

5.3.3 ***Grade Compensation***

- 5.3.3.1 The measure of elevation for a ruling grade (1:X) = (20/X)m per 20 m of track; the reduction in elevation for a curve of radius (R) and a ruling grade (1:X) = (14/R)m/20m; so the measure of elevation for compensated ruling grade = ((20/X)-(14/R))m/20m. Therefore compensated equivalent ruling grade in such a curve = $1: 20/((20/X)-(14/R))$.

6. Geotechnical Recommendation and Earthworks



Report number H352034-3000-229-230-0001, a summary of the preliminary geotechnical recommendations for the railway embankment design, based on the existing Tote Road geotechnical investigation data, as part of the Mary River Expansion Study – Stage II, served as basis for the preliminary earthworks design criteria for the purpose of the estimation of earthworks quantities for the Mary River Expansion Study – Stage II. These recommendations had been revised for the optimizing exercise subsequent to another site assessment by Hatch that coincided with the VIP workshop. Further optimization and detailing can be considered for the feasibility study as geotechnical drilling and testing are currently conducted on the optimized alignment footprint.

The following paragraphs provide a record of optimizing decisions related to the earthworks.

6.1 Geotechnical Data

- 6.1.1 The site assessment report and various daily calls are referenced and linked to the cross sections for embankments and excavation on/in ice rich soils, rock and rock plates.

6.2 Embankment Stability

6.2.1 *Sub-grade Properties*

As part of the Tote road upgrade project in 2007/2008, Knight Piesold identified four categories of frost/thaw susceptibility to delineate the road bed foundations and the foundation conditions along the Tote Road.

These views were further enhanced by the site visit and assessment by Hatch and the following typical cross sections were recommended and applied for the MTO's to specific sections on the optimized alignment:

6.2.2 *Recommended Cross Sections for Embankments*

Two standard embankment sections were introduced as per the schematic in Figure 6-1

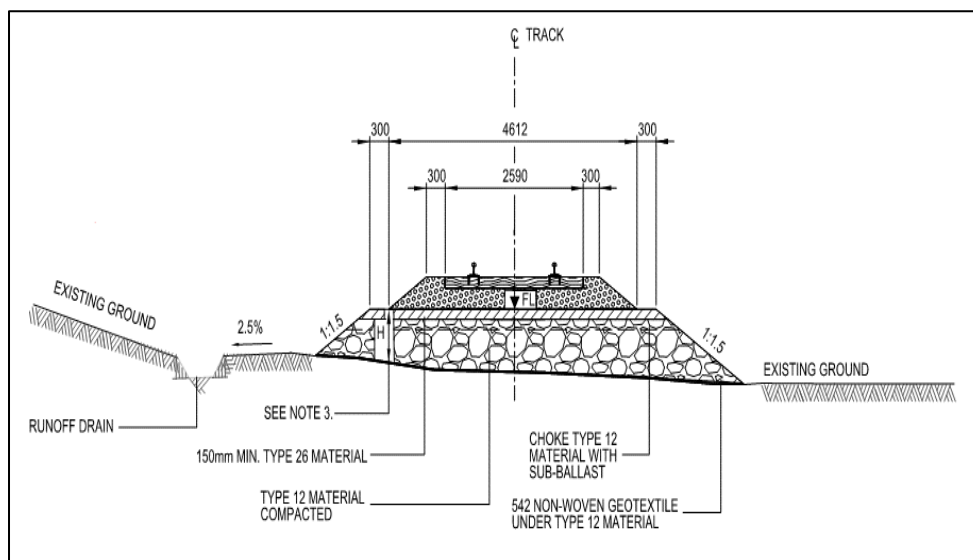


Figure 6-1: Typical Cross Section Embankments

The following observations apply:

- 6.2.2.1 For radii (R) > 800 m and tangent track the top of formation is 4612 mm, which is the top of sub ballast and base of ballast, therefore no sub ballast shoulder;
- 6.2.2.2 For $400 \text{ m} < R \leq 800 \text{ m}$ the top of formation is 4900 mm, which is the top of sub ballast and base of ballast, therefore no sub ballast shoulder. The ballast shoulder is increased to 400 mm to the outside rail of the curve and this outside rail is super elevated between 38 mm and 54 mm, hence the top of sub ballast increases from 4612 mm to 5012 mm to the outside of the curve;
- 6.2.2.3 Material Definition:
 - Type 12: Minus 1 m run of quarry rock fill.
 - Type 25: Minus 75 mm crushed rock for ballast layer.
 - Type 26: Minus 50 mm crushed rock for sub ballast layer and to choke top of Type 12 fill.
 - Minimum Embankment Thickness (H) (Type 12 Plus Sub Ballast):
 - Measured under the ballast toe on the high-end of the cross fall.
 - $H = 700 \text{ mm}$ standard dimension.
 - $H = 1500 \text{ mm}$ on ice rich permafrost.
 - 524 g/m^2 non-woven geotextile under Type 12 material on ice rich Silt.

6.2.3 *Recommended Cross Sections for Excavations*

- 6.2.3.1 Excavation in ice rich permafrost needs to be avoided. In locations where excavation is not avoidable the excavation should be daylighted to the low side of the side slope as illustrated in the schematic in Figure 6-.
- 6.2.3.2 In locations where daylighting is not possible the side slope on the other side will be a mirror image of the slope in the figure to a height where it cuts the natural ground level. Snow trap mitigation will need to be detailed for Expansion Study – Stage II phase.
- 6.2.3.3 The side slopes of 1V:2H of the excavation is covered by a layer of 500 g/m² non-woven geotextile and a 500 mm cover of selected Type 12 material.
- 6.2.3.4 The layerworks for the embankment is the standard 700 mm under the ballast toe plus 100 mm polystyrene layer for a total of 800 mm from top of sub ballast to top of excavated permafrost.
- 6.2.3.5 The polystyrene layer is overlain by a 542 g/m² geotextile for protection.
- 6.2.3.6 The standard widths of the top of formation apply for tangent track to curves of less than 400m radii i.e 4612, 5012 mm and 5212 mm.

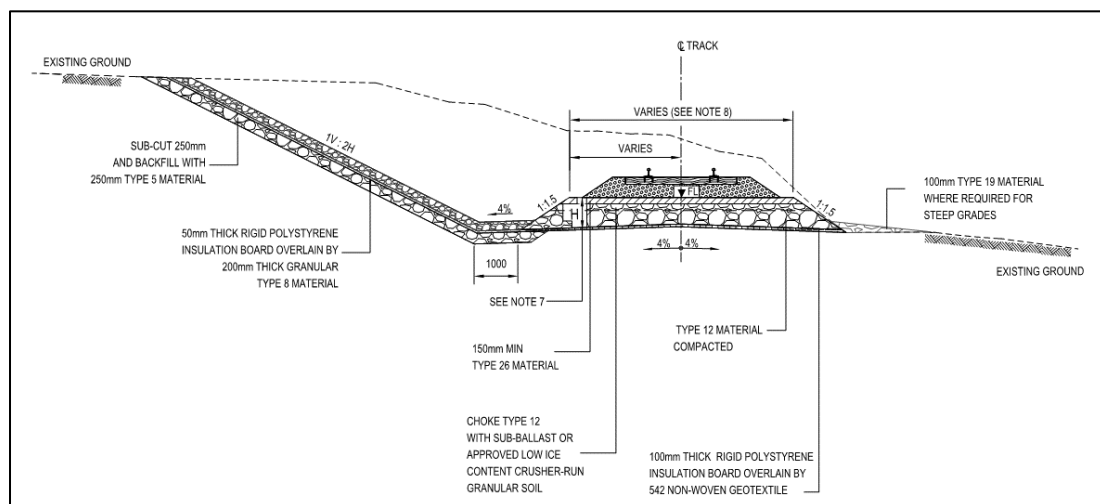


Figure 6-2: Typical Cross Section in Ice Rich Permafrost

- 6.2.3.7 Excavation in sedimentary bedrock ledges is illustrated in Figure 6-3 below:

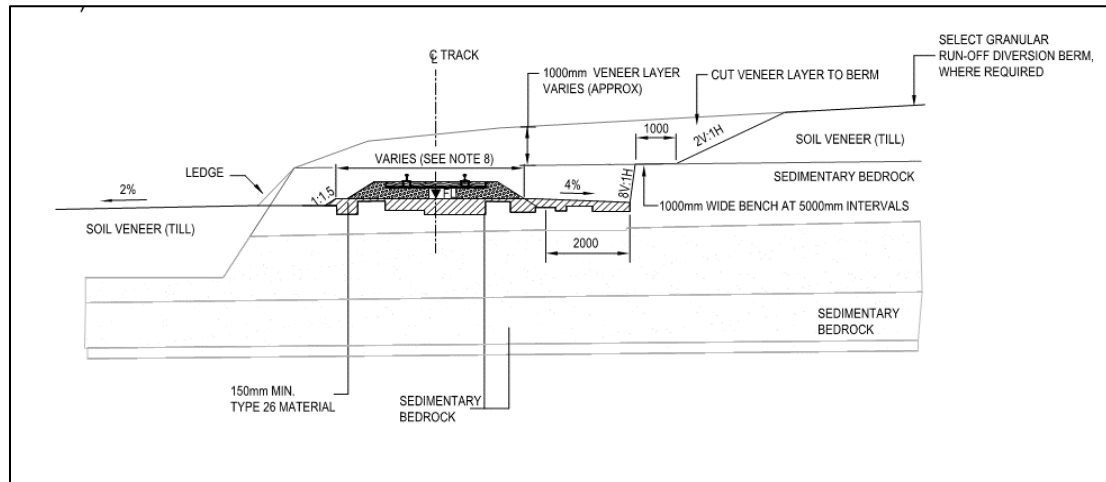


Figure 6-3: Typical Cross Section of Cut in Sedimentary Bedrock Ledges

- 6.2.3.8 The side slopes of the cut through the sedimentary bedrock is 8V:1H and through the soil veneer (till) 1V:2H.
- 6.2.3.9 The Type 26 sub ballast thickness is a minimum of 150 mm and the unevenness of the cut in the bedrock is smoothed with sub ballast Type 26.
- 6.2.3.10 The standard widths of the top of formation apply for tangent track to curves of less than 400m radii i.e 4612, 5012 mm and 5212 mm.
- 6.2.3.11 Excavation in for cuts in granitic rock is as per Figure 6-4 below:

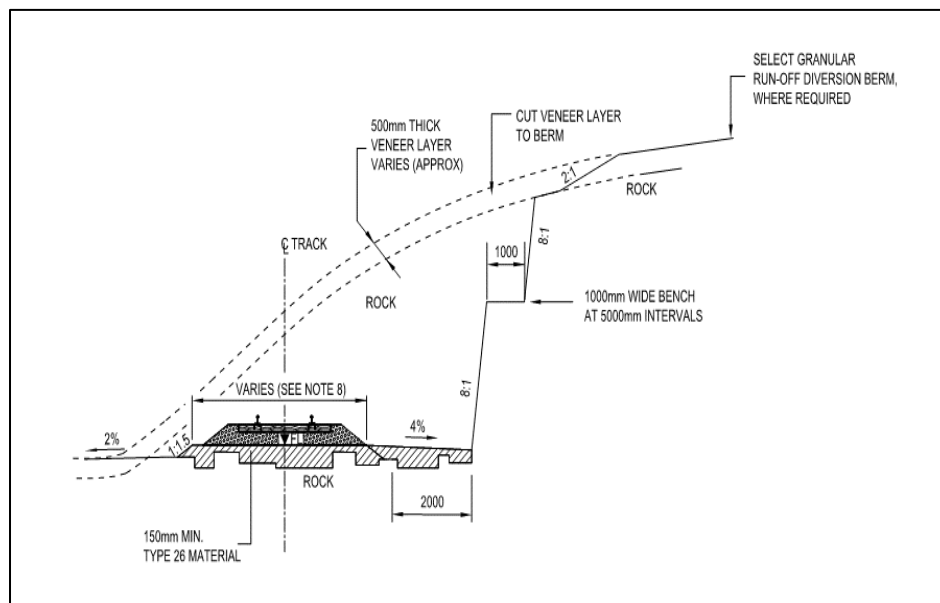


Figure 6-4: Typical Cross Section of Granitic Rock Cut

- 6.2.3.12 The side slopes of the cut through the granitic rock is 8V:1H and through the soil veneer (till) 1V:2H.
- 6.2.3.13 The Type 26 sub ballast thickness is a minimum of 150 mm and the unevenness of the cut in the rock is smoothed with sub ballast Type 26.
- 6.2.3.14 The standard widths of the top of formation apply for tangent track to curves of less than 400m radii i.e 4624, 4900 mm and 5100 mm.
- 6.2.3.15 A typical cut-off drain will be required in some instances where there a stream crossing the rail alignment but where the positioning of a drainage culvert is impossible due to the rail alignment being in a cut and the daylighting of such a culvert is imposiosble or cost prohibitive. The figure below illustrates what this typical detail will entail.

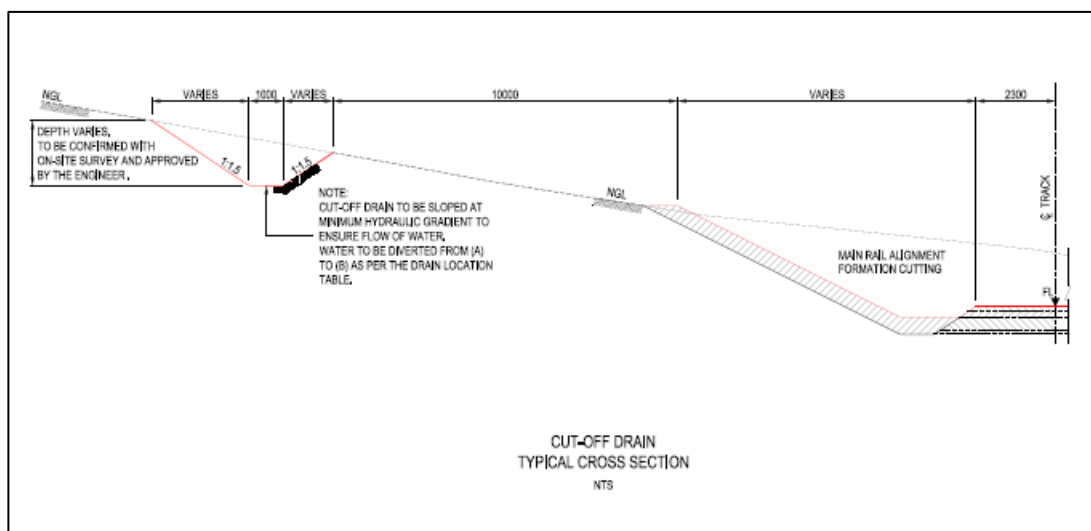


Figure 6-5: Typical Cross for a Cut-off Drain

6.3 Line Sections to Apply Typical Cross Sections

- 6.3.1 Chainages where to apply the different configurations of the typical cross sections are summarized in Annexure A. The rail chainages in the table offer potential further optimization of better sub grade conditions for the feasibility study and subsequent to the outcome of the geotechnical evaluation currently underway.

6.4 Settlement Considerations

- 6.4.1 Settlement of embankments in permafrost and thaw circumstances offer a challenge in the embankment design process. The requirement is to define settlement allowances during the design process. Careful construction planning to prioritize high embankments to exploit the early settlement under load before the final layer works is one measure to mitigate settlement disruption, as well as strategies to correct settlement during maintenance interventions.
- 6.4.2 Preloading of the formation will be managed by considering the use of the formation by construction equipment and road vehicles where appropriate.

- 6.4.3 Table 6-1 provides a summary of the condition of the sub-grade discussed above and linked to certain line sections. It also indicates the estimated settlement considerations linked to these sections.

Table 6-1: Summary of Embankment Recommendation and Estimated Settlement

Embankment Section	Ground Frost/Thaw Susceptibility	Ground Ice Content	Classification	Thaw Settlement Estimate (mm)	Typical Section
Fill Cut	Non Susceptible	Non to low	Segregated ice is not visible by eye ¹	<20	Figure 6-1
	Potentially Susceptible	Low to Mediate	Segregated ice is visible by eye, less than 25 mm (1") in thickness ¹	20-100	
Fill Cut	Moderately Susceptible	Mediate to High	Ice greater than 25 mm (1") thickness ¹	100-300	Figure 6-1
	Highly Susceptible	Very High	Ice greater than 0.3 m ₂	>300	

Notes:¹- Classification is based on Unified Soil Classification System of Frozen Soils; ²- Based on Roujanski et. al. (2010).

6.5 Rock Fill Criteria

- 6.5.1 The geotechnical recommendation is to use rock fill Type 12 for the embankment support under the sub ballast layer for backfill and to smooth the natural ground level (NGL) or to fill where the NGL has a cross fall. Type 26 is the recommended good crushed and graded stone/rock for the sub ballast layer and a choke layer between sub ballast and the Type 12 rock fill. The grading for Type 25, recommended for ballast, is too fine and an alternative grading is provided, more common for use for heavy haul rail lines.
- 6.5.2 The following is a summary of the gradations for materials to be used for railway embankment fill in Expansion Study – Stage II stage. Types 12 fill is recommended for use as fill material to be placed over the weak native sub-grade to prepare an appropriate foundation for embankment fill construction. The gradation for Type 12 run of quarry fill is shown in Table 6-2.

Table 6-2: Type 12 Fill - Run of Quarry

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
1000	100
600	95 - 100
300	50 - 100
150	0 - 80
19	0 - 30
4.75	0 - 10

- 6.5.3 Table 6- and Table 6- summarize materials for ballast and sub-ballast. It should be noted that the grading for ballast had been changed from the Type 25 grading considered by the geotechnical team based on a track design basis. The appropriate "Type" to be confirmed, but ballast is further specified under Section 9.5.1.

Table 6-3: Type – Ballast

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
73	100
63.0	90 – 100
53.0	40 – 70
37.5	10 – 30
26.5	0 – 5
19.0	0-1
13.2	0

Table 6-4: Type 26 Fill – Sub-ballast

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
50	100
13.2	60 – 80
4.75	20 – 45
1.18	0 – 15
0.075	0 – 5

7. Hydrology

7.1 Introduction

- 7.1.1 The hydraulic design for culverts and bridge structures for the Tote road was based on 1 in 5 years return flood period, whilst normally 1:50 for culverts and 1:100 return floods and intensities for major structures are considered for railway line designs. For this project the design was for 1:200.
- 7.1.2 The hydrologic analysis for the Tote road had been reviewed refer to document H352034-3000-228-030-0001 titled the In-Principle Review of Previous Tote Road Hydrology Assessments, dated 2016-08-18.
- 7.1.3 Baffinland Iron Mine requested Knight Piésold to complete an update of previous studies concerning the design peak flows for the region and to incorporate the most recent stream flow data. Refer to Knight Piésold document number NB102-00181/39-A.01.

7.2 Methodology

7.2.1 Design Peak Flows

- 7.2.1.1 In the Hatch memo referenced in 7.1.3 Hatch raised queries with regard to the method used to derive the design peak flows. Following the updated design peak flows as presented in the report referenced in 7.1.4 the following methodology would be adopted by the project for the design of drainage structures.
- 7.2.1.2 Drainage structure locations will be identified along the proposed rail alignment, some of these structures will be to facilitate cross-drainage and others will be to perform the function of balancing culverts to balance the water that may collect in a low spot from either side of the rail alignment.

- 7.2.1.3 Catchments will be delineated by the project for all drainage structures, excluding the rail over river bridges which will be delineated by the responsible engineer to be appointed under procurement package CC003.
- 7.2.1.4 The delineated catchments will be used in conjunction with the formulas presented as output from 7.1.4 to calculate the associated run-off flows for a 1:200 year flood.
- 7.2.1.5 The flow volumes calculated in 7.1.5.3 will be used to determine the ultimate sizing of the culvert structure in terms of number and size of barrels.
- 7.2.1.6 Baffinland Iron Mine supplied information concerning which drainage structures are located in fish bearing streams. BIM will also supply stream flow data for fish bearings streams which, have been monitored on site so as to enable the project to determine the 3-day delay for a 1:10 year flood. This information will then be used to size the drainage structures. It is impossible to have stream flow data for every fish bearing stream. Thus the project will use ratios based on the known flow in monitored stream to scale the flow up or down for other fish bearing streams where no stream flow data is available.

7.2.2 **Flood Return Period**

- 7.2.3 One in two hundred year return period.

7.2.4 **Design Velocities**

- 7.2.5 Velocities of water flow through culverts less than 3 m/s subcritical flow. Normal culvert, embankment and stream side slopes treatment against erosion will be applied.
- 7.2.6 For velocities determined as more than 3 m/s and less than 5 m/s applicable treatment to normalize the flow will be recommended for erosion protection and/or fish bearing streams.
- 7.2.7 For flows higher than 5 m/s special treatment must be considered on a case by case approach.

8. **Bridge and Culvert Design Criteria**

8.1 **Introduction**

- 8.1.1 This section describes the design elements and criteria for the railway bridges and major culvert structures that are to be designed and constructed for the Project.
- 8.1.2 This section will be a live document that will be revised once outstanding information becomes available. The values and information not yet available is highlighted in the relevant sub sections. Additional geotechnical investigations and drilling work as well as bathymetry data will be obtained in the first and second quarter of 2018.

8.2 **Title Block**

- 8.2.1 Each structure will be referred to by a prefix of either BR (for bridges) or CV (for culverts), an ID number indicating the kilometer station and a serial number that identifies multiple structures within the same kilometer of track. E.g. BR-68-1, CV-34-3. Zero km is Port Side and 107km Mine Side.
- 8.2.2 Where a bridge or culvert is located at a kilometer station, the lower km station will be used.



8.3 References for Design Standards

Table 8-1: Type 26 Fill – Sub-ballast

Design	Design Method	Code
Steel Design	Service load design (working stress design)	Chapter 15 of the Manual for Railway Engineering (MRE), as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).
Concrete Design	Service Load design (working stress design)	Chapter 8 the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA)
Prestressed Concrete Design		Part 17 of Chapter 8 of the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).
Seismic design		Chapter 9 the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

8.3.1 The standards addressed above will be supplemented by the CSA Standard S6 “Canadian Highway Bridge Design Code” (S6). The use of this code and the requirements will be highlighted in the relevant sections below.

8.4 Bridge Geometry

8.4.1 Design Requirements

- Number of tracks = 1
- Number of service roads = 0
- Number of walkways = 2 (1 each side of bridge)
- Design life = 20 years

8.4.2 Datum

8.4.2.1 The geographical coordinate system used is:

- Name: UTM84-17N
- Description: WGS 1984 UTM, Zone 17 North

8.4.3 **Control Line**

- 8.4.3.1 The horizontal control line used for the basis of the project is the centre line of track and all transverse dimensions will be taken relative to this control line. The transverse dimension will NOT be taken from the centreline of the structure.
- 8.4.3.2 The vertical control line used for the basis of the project is the top of the sub-ballast layer.

8.4.4 **Coordinate System**

- 8.4.4.1 The structures will be dimensioned in ground coordinates and stationing provided in grid coordinates.
- 8.4.4.2 The conversion between ground and grid coordinates is currently undefined and each structure will be located relative to a single grid point located along the control line at the low station centreline of bearing.

8.4.5 **Span Lengths**

- 8.4.5.1 The Span length of a bridge is defined by the distance between the bearing centrelines on the foundations and measured along the control centreline. Span lengths are provided in metres. Standard span lengths has been considered for similar girder type bridges.
- 8.4.5.2 For fabrication purposes, "Girder Lengths" are specified at temperatures of 20°C.
- 8.4.5.3 "Span Lengths" are set according to bearings being centred at a temperature of -15°C.
- 8.4.5.4 As measurements are being taken between foundation units, not along the superstructure, the "Span Lengths" are equally correct at any temperature.
- 8.4.5.5 The following relationship therefore results:
- 8.4.5.6 $\text{Span Length} = \text{Girder Length} \times (1 - (20 + 15) \times 12e-6) = 0.99958 \times \text{Girder Length}.$
- 8.4.5.7 A minimum allowance of 20 mm will be provided on each Girder Length in order to allow for the temperature difference as well as grid to ground conversions.

8.4.6 **Horizontal and Vertical Clearance from Obstructions**

- 8.4.6.1 For each single track structure, the minimum clear width of the ballast zone is 2.850 m, as measured at the top of concrete/steel deck level. The side walls of the ballast pan will be sloped outwards at a slope of 2V:1H.

- 8.4.6.2 Minimum clearance box required for trains is as follows:

Width (Horizontal):

- For plan curvature up to 3 degrees ($R \geq 600\text{m}$): 5715 mm:

This value is based on the AREMA clearance box width of 5486 mm plus an allowance of 78.2 mm per degree of curvature, in accordance with Table 28-1-1 in Part 1 of Chapter



28 of the 2009 edition of the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA), at a maximum curvature of 3 degrees. Structure may intrude into a triangle at the bottom corners. The triangle is 1219.2 mm high by 914 mm wide at the base. See sketch below.

- For tangent track: 5486 mm:

An allowance is defined by the distance of the obstruction to the curved tangent track. This increase is given per degree of curvature. The allowance will be applied if the tangent track is curved within 24.384 m of the obstruction. At the bottom corner's, structure may intrude into a triangle that is 1219 mm high by 914 mm wide at the base. This is in accordance with Part 1 of Chapter 28 of the 2009 edition of the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA). See sketch below.

Height (Vertical):

- For plan curvature up to 3 degrees ($R \geq 600$ m) and tangent track the height clearance is required to be 7010 mm from top of rail.

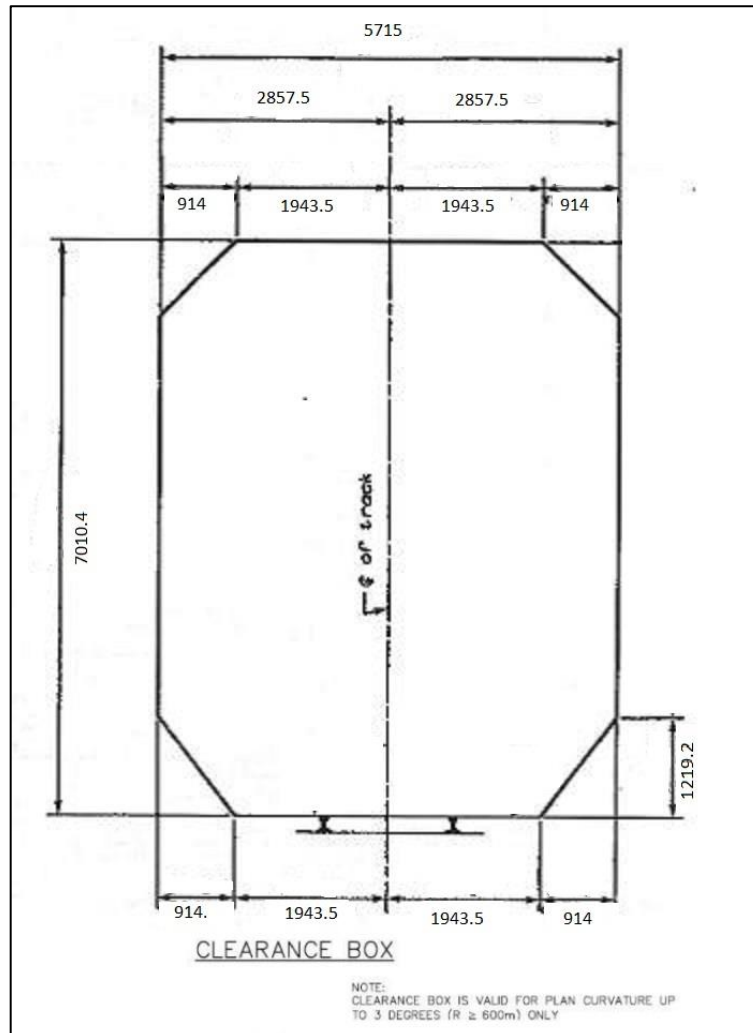


Figure 8-1: Clearance Box for Plan Curvature up to 3 Degrees ($R \geq 600$ m)

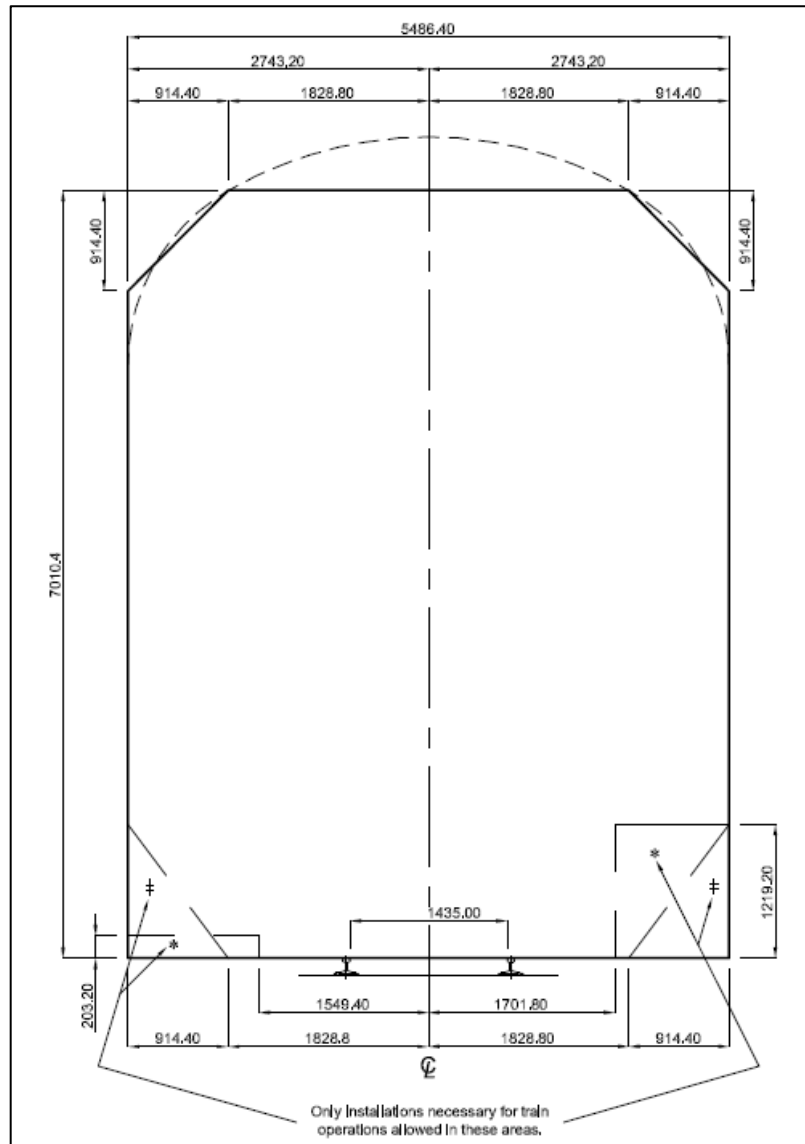


Figure 8-2: Clearance Box for Tangent Track

8.4.7 Vertical Clearance of Water Crossings

8.4.7.1 The freeboard of the bridge is defined as the open space from the soffit of the bridge to the top of the water level at a given flow. The minimum allowable freeboard will be 0.30 meters.

8.4.7.2 For the purpose of this the design the following freeboard must be maintained for water crossings:

- All Streams:
 - ♦ 0.30 meters above 1 in 200 year flow elevation (High water level).
 - ♦ 0.60 meters above the 1 in 25 years flow elevation.
- Navigable streams only:
 - ♦ 1.5 meters above the average annual high water elevation (Normal Water Level), unless noted otherwise.

8.4.8 Walkways

8.4.8.1 Where required on bridges for maintenance access, walkways will be provided on both sides of the structures. Walkways will have a minimum width of 700 mm.

8.4.8.2 Guardrails will be provided on the exterior side of the walkway. The guardrails may not be inside of the required clearance box. The guardrail height will be 1050 mm above the walking surface of the walkway.

8.4.8.3 There will be no permanent fixtures inside of the clearance box. Refuge bays will be provided, where pedestrians on the walkway would be located inside the clearance box, at a maximum spacing of 45 meters.

8.4.9 Fixity

The fixity on the spans will be as follows:

- One end fixed translationary (X, Y, Z).
- One end will be fixed transversely (Y).

8.5 Bridge Design Parameters and Loading

8.5.1 Ballasted Deck

8.5.1.1 Bridges will be assessed on a case by case basis as whether the bridge will have a ballasted deck or open deck.

The criteria basis for this will be:

- Environmental Constraints
- Axle Loading
- Bridge Strength

8.5.1.2 • Settlement of piles due to permafrost and alignment of track.

Elevations will be set based on an assumed ballast depth of 478 mm below base of rail for wooden ties and the ties will extend as far as the extension of the guardrails, and as such also serve as a transition section between the timber ties on the mainline and the hardwood ties on the bridges. 

8.5.1.3 For the design of the bridge, the load due to ballast will be based on a depth of 750 mm (approximately 1.5 x design depth from below base of rail), allowance includes for a maintenance tamp. Ballast pans and ballast retaining structures will be designed for a ballast depth of 750 mm.

8.5.1.4 Storm water run-off from the ballast pan will be designed to drain directly below the bridge. 

8.5.2 *Vertical Displacements and Camber*

8.5.2.1 The allowable vertical displacements under live load and impact will be less than:

8.5.2.2 • Span / 800

Spans must be cambered as defined in AREMA Chapter 15 Part 1 Article 1.2.10. All girders longer than 27.43 m must be cambered for dead load. All cambering of spans must be subject to the Contractor's designer's discretion. 

8.5.3 *Lateral/Longitudinal Displacements*

8.5.3.1 The allowable lateral displacement within a span shall be less than:

- For tangential track

$$0.028L^2$$

- For curved sections

$$0.066L^2$$

Where:

The resulting deflection is in mm.

L = span length (m).

The allowable lateral displacement at a pier shall be less than:

- For tangential track

$$0.028D^2$$

- For curved sections

$$0.066D^2$$

Where:

The resulting deflection is in mm.

D = sum of the two span lengths adjacent to the pier (m).

The allowable longitudinal displacement of the superstructure shall be less than:

- 50 mm for load combinations including seismic loads
- 28 mm for all other load combinations.

Note: for load combinations including seismic loads, the allowable deflections are for serviceability level.

8.5.4 Live Load

8.5.4.1 The defined live load model in AREMA Clause 15-1.3.3 is Cooper E-80. For the purposes of the design of the structures for this project, the live load will be based on Cooper E-90 (Cooper E-80 + 12.5%).

8.5.4.2 The impact loading shall be applied in accordance with AREMA Clause 15-1.3.3.

8.5.4.3 The alternate live load on the 4 axles shown in AREMA Figure 15-1-3 shall also be checked.

8.5.4.4 AREMA Clause 15-1.3.4 shall be used to distribute the live loads between the load-carrying members.

8.5.4.5 In accordance with AREMA Clause 15-1.3.3 pattern loading will be used on multi span bridges to achieve the greatest live load stress. For single span bridges the greatest live load stress will be determined by applying different scenarios of the Cooper E-100 and alternative live load on 4 axles.

8.5.5 Centrifugal Force

8.5.5.1 Centrifugal forces shall be applied in accordance with AREMA Clause 15-1.3.6 to structures located on curves.

8.5.5.2 The design speed of 75 km/h shall be assumed when applying the equations.

8.5.6 Fatigue Stress Cycles

8.5.6.1 AREMA Clause 15-1.3.13 shall be used to design the steel structures for fatigue resistance.

8.5.6.2 All elements shall be designed for more than 2,000,000 stress cycles.

8.5.7 Braking and Traction Forces

8.5.7.1 Longitudinal forces shall be determined in accordance with AREMA Clause 15-1.3.12.

8.5.8 ***Bearing Friction Forces***

- 8.5.8.1 The longitudinal forces due to bearing friction will be based on an assumed coefficient of friction of 15%.

8.5.9 ***Walkway Loads***

- 8.5.9.1 For design purposes, any area extending beyond the ballast trough or open deck bridge tie shall be considered to be walkway. 

- 8.5.9.2 Walkway load = 5.0 kPa.

8.5.10 ***Snow Loads***

- 8.5.10.1 The ground snow load in the area is approximately 2.0 kPa in accordance with the 2005 National Building Code of Canada.

- 8.5.10.2 A snow load of 3 kPa will applied to all structures. The additional 1 kPa is to account for any unforeseen weather and for any uncertainty in the National Building Code of Canada.

8.5.11 ***Snow and Walkway Combination***

- 8.5.11.1 Snow and walkway loading will not be considered to occur simultaneously.

- 8.5.11.2 Snow and walkway load cases will be considered as follows:

- a) 5.0 kPa over the walkway areas (any areas outside the clearance box width) in combination with train loads.
- b) 3.0 kPa over the entire width of the bridge, not in combination with train loads.

- 8.5.11.3 The above indicates that load case a) will govern the design. Thus explicit consideration of snow load is not required.

8.5.12 ***Ice Accretion Loads***

- 8.5.12.1 S6 Figure A.3.1.4 is used for to determine the ice accretion load.

- 8.5.12.2 The figure indicates that 12 mm of ice thickness is required. A safety of 1.25 is used on the value.

- 8.5.12.3 Ice thickness = 15 mm.

- 8.5.12.4 Ice load = 15 mm $\times$ 9.81 kN/m³ = 0.15 kN/m².

- 8.5.12.5 Ice accretion load will be considered a dead load for the purpose of load combinations.

8.5.13 ***Wind Load on Structure***

- 8.5.13.1 Wing load on structures will be determined in accordance with AREMA Clause 15-1.3.8.

8.5.14 **Wind Load on Live Load**

8.5.14.1 Wind load on live load shall be determined in accordance with AREMA Clause 15-1.3.7 (a).

8.6 **Other Lateral Forces**

Any other additional forces that result from equipment and maintenance shall be determined and applied in accordance with AREMA Clause 15-1.3.9.

8.6.1 **Temperature Range**

8.6.1.1 CSA S6 Figure A3.1.1:

- Maximum mean daily temperature = 10°C

8.6.1.2 CSA S6 Figure A3.1.2:

- Minimum mean daily temperature = -35°C

8.6.1.3 Two types of superstructures are provided below in accordance with CSA S6 Clause 3.9.3.

8.6.1.4 Type A: steel or aluminum beam, box, or deck truss systems with steel decks and truss systems that are above the deck.

8.6.1.5 Type B: steel or aluminum beam, box, or deck truss systems with concrete decks.

8.6.1.6 For a Type 'A' superstructure:

- Maximum effective temperature: $10^{\circ}\text{C} + 25^{\circ}\text{C} = 35^{\circ}\text{C}$
- Minimum effective temperature: $-35^{\circ}\text{C} - 15^{\circ}\text{C} = -50^{\circ}\text{C}$

8.6.1.7 CSA S6 Figure A3.1.1:

- Assumed structure depth = 1 m
- Reduction to maximum effective temperature = 3.5°C
- Increase to minimum effective temperature = 5.5°C
- Maximum Temperature = $35^{\circ}\text{C} - 3.5^{\circ}\text{C} = 31.5^{\circ}\text{C} \approx +35^{\circ}\text{C}$
- Minimum Temperature = $-50^{\circ}\text{C} + 5.5^{\circ}\text{C} = -44.5^{\circ}\text{C} \approx -45^{\circ}\text{C}$
- Range = $35^{\circ}\text{C} + 45^{\circ}\text{C} = 80^{\circ}\text{C}$

8.6.1.8 For a Type 'B' superstructure:

- Maximum effective temperature: $10^{\circ}\text{C} + 20^{\circ}\text{C} = 30^{\circ}\text{C}$
- Minimum effective temperature: $-35^{\circ}\text{C} - 5^{\circ}\text{C} = -40^{\circ}\text{C}$

8.6.1.9 CSA S6 Figure 3.5:

- Assumed structure depth = 1.5 m
- Reduction to maximum effective temperature = 3.5°C
- Increase to minimum effective temperature = 5.5°C
- Maximum Temperature = 30°C – 3.5°C = 26.5°C ≈ +30°C
- Minimum Temperature = -40°C + 5.5°C = -35.5°C ≈ -35°C
- Range = 30°C + 35°C = 65°C
- The thermal coefficient of steel = $12 \times 10^{-6}/^{\circ}\text{C}$
- The thermal coefficient of concrete = $10 \times 10^{-6}/^{\circ}\text{C}$

8.6.1.10 The design temperatures above will be used for the structural design of the bridges according to the type classification.

8.6.1.11 The material requirements will be governed by the site Climatic Data. This information indicates that the average temperature is -15°C and will be used as the temperature that the bearings are centred at.

8.6.2 *Earth Pressure*

8.6.2.1 The active pressure will be determined using the following parameters:

- Unit weight for soil = 20.0 kN/m³
- 'at rest' coefficient = 0.50

8.6.2.2 The above is to be confirmed with the geotechnical engineer during the project.

8.7 *In Stream Ice Loads*

8.7.1 The requirement of ice loading on the structure will be determined during the project based on hydrological information.

8.7.2 Where in stream ice loads are required, these shall be determined in accordance with CSA S6 clause 13.12.



8.8 Stream Forces

8.8.1 Stream forces will be calculated by the following formula:

$$P_a = K \times V_a^2$$

P_a = average stream pressure (kPa)

V_a = average stream velocity (m/s)

K = drag constant:

= 0.725 for square-ended pier

= 0.360 for semi-circular pier

= 0.400 for a wedge-shaped nose <90°

8.8.2 Forces will be distributed to the pier assuming a triangular pressure distribution of $2P_a$ at water surface and 0 at riverbed.

8.9 Seismic Effects

8.9.1 General

8.9.1.1 Seismic analysis will be carried out using a linear elastic analysis. Response spectra will be based on AREMA Clause 9.1.4.4.3.

8.9.1.2 The peak ground acceleration (PGA) proposed value is 0.4g and is to be confirmed from the following website:

<http://earthquakescanada.nrcan.gc.ca/hazard/interpolator/>

8.9.1.3 AREMA Clause 9-1. The Site Coefficient (AREMA Clause 9-1.4.4.1) shall be taken as 1.0 for all locations, subject to confirmation by the geotechnical engineers.

8.9.2 Load Combinations for Structural Check – Concrete Elements

8.9.2.1 Service Load Design

8.9.2.2 The load combinations contained in the table below will be checked. The last column of the table indicates the allowable multiplier to be applied to the working stresses for each combination depending on the specified code.

8.9.2.3 The table below indicates the group loading combination for SERVICE LOAD DESIGN.

8.9.2.4 Groups I-VIII taken directly from AREMA Clause 8-2.2.4 Table 8-2-4.

8.9.2.5 Group IX is adapted from a combination specified in AREMA Clause 9-1.4.6, this specifies requirements for load factor design (LFD) only. The combination has been determined by comparison with other working stress combinations specified in AREMA Chapter 8 and with load combination specified in AREMA Clause 8-1.4.6 for steel structures.

8.9.2.6 Group IX only applies to the “Serviceability” seismic load case. For other seismic load cases, yielding is assumed to occur and these checks not based on material stresses but are based on displacement demands.

Table 8-2: Group Loading Combination – Service Load Design
(AREMA Clause 8-2.2.4 Table 8-2-4)

Group	D+	LL+I	LL Min	LF	CF	WL	WU	WLL	ICE	EQ	%
I	1	1			1						100
II	1					1					125
III	1	1		1	1	0,5		1			125
IV	1	1			1						125
V	1					1					140
VI	1	1		1	1	0,5		1			140
VII	1	1			1				1		140
VIII	1					1			1		150
IX	1									1	150

Note:

D+ includes D (dead load), E (earth pressure), B (buoyancy) , SF (stream force) and the weight of accreted ice.

LL+I = train loads + impact + 5.0 kPa walkway loads outside of clearance box.

LL Min = Minimum live load per MRE 15-1.3.10 “Stability Check”.

LF = longitudinal force (braking and traction) + bearing friction effects

CF = centrifugal force

WL = wind on loaded structure

WU = wind on unloaded structure

WLL = wind on live load

ICE = ice loads (down drag and impact – not accretion)

EQ = seismic loads

8.9.2.7 Load Factor Design

- The load combinations contained in the table below will be checked.
- The table below indicates the group loading combination for LOAD FACTOR DESIGN.
- The load factors provided below are only intended for designing structural members by the load factor design concept. The actual loads should not be increased by these factors when designing for foundations, checking foundation stability.

Table 8-3: Group Loading Combination Load Factor Design
(AREMA Clause 8-2.2.4 Table 8-2-5)

Group	D+	LL+I	LL Min	LF	CF	WL	WU	WLL	ICE	EQ
I	1.4	2.33			1.4					
IA	1.8	1.8			1.8					
II	1.4					1.4				
III	1.4	1.4		1.4	1.4	0.5		1.4		
IV	1.4	1.4			1.4					
V	1.4					1.4				
VI	1.4	1.4		1.4	1.4	0.5		1.4		
VII	1									1
VIII	1.4	1.4							1.4	
IX	1.2					1.2			1.2	

Note:

D+ includes D (dead load), E (earth pressure), B (buoyancy), SF (stream force) and the weight of accreted ice.

LL+I = train loads + impact + 5.0 kPa walkway loads outside of clearance box.

LL Min = Minimum live load per MRE 15-1.3.10 "Stability Check".

LF = longitudinal force (braking and traction) + bearing friction effects

CF = centrifugal force

WL = wind on loaded structure

WU = wind on unloaded structure

WLL = wind on live load

ICE = ice loads (down drag and impact – not accretion)

EQ = seismic loads

8.10 Load Combinations for Structural Check – Steel Elements

8.10.1 General

8.10.1.1 The load combinations contained in the table below will be checked.

8.10.1.2 The last column of the table indicates the allowable multiplier to be applied to the working stresses for each combination depending on the specified code.

8.10.1.3 The table below indicates the load combinations with Groups I-III modified from Chapter 8.



- 8.10.1.4 Group II applies to only to the members which are subjected to wind load only.
- 8.10.1.5 Group IX is taken from AREMA Chapter 9 with consistency being maintained with the concrete load combination in the previous section with regard to the naming.
- 8.10.1.6 Group IX applies only to the “Serviceability” seismic load case. For other seismic load cases, yielding is assumed to occur and these checks not based on material stresses but are based on displacement demands.

Table 8-4: Group Loading Combination (AREMA Chapter 8)

Group	D+	LL+I	LL Min	LF	CF	WL	WU	WLL	ICE	EQ	%
I	1	1			1						100
IA	1		1		1						100
II							1				100
III	1	1		1	1	1		1	1		125*
IIIA	1						1		1		125*
IX	1									1	150*

*The specified increase in allowable stress shall not be applied to floor beam hangers or bolts.

Notes:

D+ includes D (dead load), E (earth pressure), B (buoyancy) , SF (stream force) and the weight of accreted ice.

LL+I = train loads + impact + 5.0 kPa walkway loads outside of clearance box.

LL Min = Minimum live load per MRE 15-1.3.10 “Stability Check”. Walkway load not included.

LF = longitudinal force (braking and traction) + bearing friction effects

CF = centrifugal force

WL = wind on loaded structure

WU = wind on unloaded structure

WLL = wind on live load

ICE = ice loads (down drag and impact – not accretion)

EQ = seismic loads

8.10.2 **Bearing Replacement**

- 8.10.2.1 The structure will be designed taking into account the bearing replacement or shimming. Jacking points on the structure will be indicated. This will avoid the future requirements for additional foundations or support frames.

- 8.10.2.2 The jacking points will be designed for dead load only.

8.10.3 **Utilities**

- 8.10.3.1 Where required, ducts shall be installed on the bridges for the passage of utilities. Ducts will be surface mounted. The size, location and number of, will be determined during the project.

8.11 Bridge Materials

8.11.1 Concrete

8.11.1.1 Cast in-situ concrete will be avoided where possible due to the constraints on construction. However, if the design requirement does not allow for steel or precast concrete, cast insitu shall be used.

8.11.1.2 The following shall apply:

Cast in-situ Concrete Design: 28-day compressive strength of 35Mpa
Sika Grout Arctic 100 material is to be used or
Air entrapment design is to be used

8.11.1.3 Precast reinforced concrete design: 28-day compressive strength of 45 MPa.

8.11.2 Concrete Protection for Reinforcement

8.11.2.1 The minimum clear cover for reinforcement shall be as described below:

- Cast against/permanently exposed to earth: 75 mm
- All other locations: 50 mm

8.11.3 Structural Steel

8.11.3.1 All exposed Fracture Critical Members structural steel is to be atmospheric corrosion resistant (weathering steel) Grade 350AT, Category 4 or approved equivalent and shall conform to CSA Standard G40.1. Primary Non-Fracture Critical Members shall be atmospheric corrosion resistant (weathering steel) Grade 350AT, Category 3 and remaining miscellaneous steel shall be atmospheric corrosion resistant (weathering steel) Grade 350A.

8.11.4 Corrosion Allowance

8.11.4.1 A corrosion allowance of 1.5 mm (1/16") shall be deducted from the nominal thickness for sheet products only.

8.11.5 Bolts

8.11.5.1 All bolts will be 7/8" diameter (22 mm) type A325 (weathering steel).

8.11.6 Joints

8.11.6.1 Integral abutments with no joints will be considered for bridges with spans less than 50 m.

8.11.6.2 Where integral abutment joints are not possible, standard expansion joints will be designed.

8.11.7 Bearings

8.11.7.1 Bearings shall be self-lubricating bronze bearings with Copper Alloy UNS No. C86300.



- 8.11.7.2 The coefficient of friction at expansion locations is assumed to be 15% for the design. No additional factor of safety is required on the 15%.
- 8.11.7.3 The friction forces due to temperature movements are assumed to arise from dead load only. Live load is not included.
- 8.11.7.4 If self-lubricating spherical bearings are selected then the friction forces will arise as a result of live load rotation.
- 8.11.7.5 For multi-span bridges, the worst loading case will arise when a single span is loaded. This is due to the bearings on adjacent span at any pier acting in different directions. For this load case, the 15% coefficient of friction will be used in combination with the total dead load and live load reaction.

8.11.8 ***Waterproofing***

- 8.11.8.1 No waterproofing membrane will be used.
- 8.11.8.2 For all steel deck joint cover plates that are susceptible to crevice corrosion will be galvanised.

8.12 **Bridge Geotechnical Parameters**

8.12.1 ***Ad Freeze Piles***

- 8.12.1.1 Geotechnical parameters relating to the foundations will be completed when further investigations and details become available.
- 8.12.1.2 The proposal for the adfreeze piles is to incorporate a welded steel grade beam as a pile cap or a concrete pile cap determined in conjunction with the erecting contractor. 

8.13 **Other Bridge Design Considerations**

8.13.1 ***Guard Rails***

- 8.13.1.1 Guard rails shall be provided on all tracks installed on bridges and shall extend 20 m beyond either side of the structure.

8.13.2 ***Fish Passage***

- 8.13.2.1 The bridge crossings will be assessed to determine if the crossing is over a fish habitat. Where bridges are crossing over fish habitats, the environmental recommendations and hydraulic report will provide the requirements.

8.13.3 ***Scour Protection***

- 8.13.3.1 Scour protection will be determined on a case by case basis and will be determined by the hydraulic report.

8.14 **Bridge Options**

- 8.14.1 The rail girder bridge that has been considered for the structure:

- Through Plate Girder (TPG)

8.14.2 The rail bridge deck that has been considered for the structure:

- Ballasted Deck that comprises of a concrete deck or steel deck to contain the ballast.

8.15 Culvert Geometry

- The hydrology in terms of flows, peak flows and intensities for the related catchment areas for each river or stream, the new rail alignment will cross, had been reviewed and determined for 1 in 200 year return periods. This will guide bridge and culvert basic hydraulic sizing and the necessary adjustments (over compensation) to accommodate the uncertainties associated with arctic hydrology and the influence of ice and snow on the hydraulics.

- The Expansion Study – Stage II costing are based on using galvanised corrugated steel pipes.



8.15.1 Dimensions

8.15.1.1 Culvert diameter or size will be standardized to maximum 4 standard sizes that will either be used as single or multiple culvert combinations for each water way or run-off path where culverts need to be installed. Single pipe culverts will be favored where possible. Dimensions will vary depending on:

- Peak flow volumes.
- The hydraulic gradient of the stream crossing at the track location.
- The proximity to the Tote road culvert in the same stream or run-off path, implying potential downstream mitigating protection of the rail formation for back damming.
- Minimum cover over the culvert and support bedding under the culvert; and
- Fish passage considerations.

8.15.1.2 The four standard sizes $\varnothing 900$ mm, $\varnothing 1200$ mm, $\varnothing 1500$ mm and $\varnothing 1800$ mm will then be installed as single or multiple culverts rounded up to the next full size to determine number of pipes or pre-fabricated units required per location. For grade crossings and caribou crossings $\varnothing 600$ mm will be used to ensure there is drainage underneath crossings of the rail alignment.

8.15.2 Vertical Clearance

8.15.2.1 The vertical clearance for culverts shall be determined by considering the 5 dimension drivers above, the upstream storage conditions and the potential damming effect in closer proximity to the Tote road culverts for the water course, by providing mitigating protection for the rail formation on the downstream side with geotextile or anti-seepage walls.

8.15.2.2 The risk of overtopping shall be assessed for the design criteria employed with the purpose to mitigate storm water damage to the rail embankment by anti-seep walls or membranes on both sides or appropriate other measures where required.

8.16 Culvert Design Rational

8.16.1 General

8.16.1.1 Culvert design shall consider the following:

- Prevent water accumulation on the sides of embankments.
- Divert water and ice away from the toe of the embankment.
- Provide cut-off drains or berms for dispersed flow and accumulate through appropriate culvert in the proximity.
- Provide appropriate embankment protection where required.
- The culvert shall be sloped in the direction of flow at the same grade as the water path grade, such that the centre of inlet- and the centre of outlet is as close as possible to the centre of the water path and the direction/orientation of the water path.
- Provide appropriate inlet and outlet protection and treatment, linked to the water flow velocity to prevent piping through the embankment and erosion of the water path sides and the embankment.
- The water shall be channelled with a down chute at such low spots in cuttings into the drop inlet or calming pond.
- Provide culvert barrel treatment, scour holes, wing walls and drop inlets where grades are too steep and water velocity >5 m/s.
- Provide oversized culvert with weirs, cut-off collars both ends and natural stones inside culverts where water velocity <5, but >4 m/s.
- Provide wing walls both ends where water velocity is <4, but >3 m/s.
- Provide basic inlet and outlet protection where water flow velocity is subcritical (<3 m/s).

8.16.2 Typical Culvert Sections

8.16.2.1 The culvert dimension considerations in 8.15.1 will guide culvert sizing. Culvert bedding, support, cover and backfill measures are as important. Differential settlement under the embankment weight and train loading as per 8.5.4 and 8.5.5 needs to be prevented. The following Figures provide the basics for culvert configurations and are excerpts of drawings H353004-30000-224-294-0001 and H353004-30000-224-294-0002.

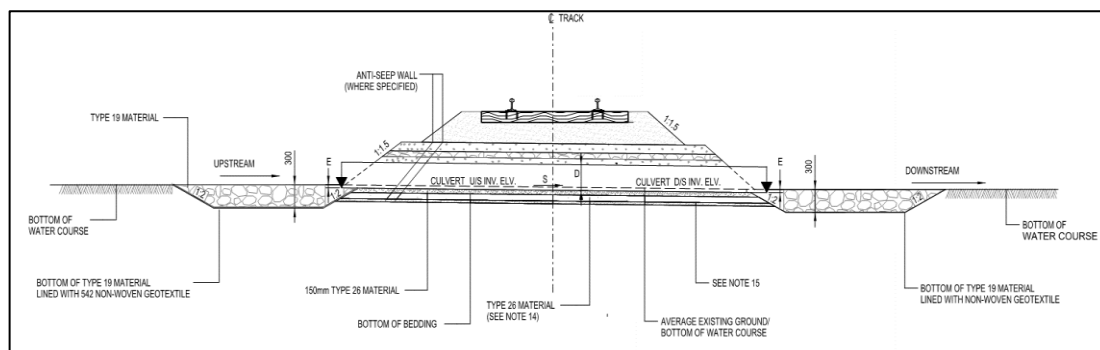


Figure 8-3: Culvert Section with Erosion Protection

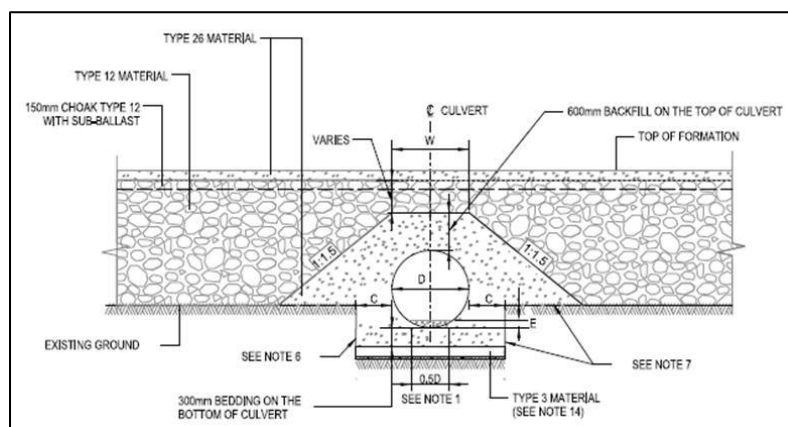


Figure 8-4: Single Pipe Culvert with Minimum Backfill Requirements

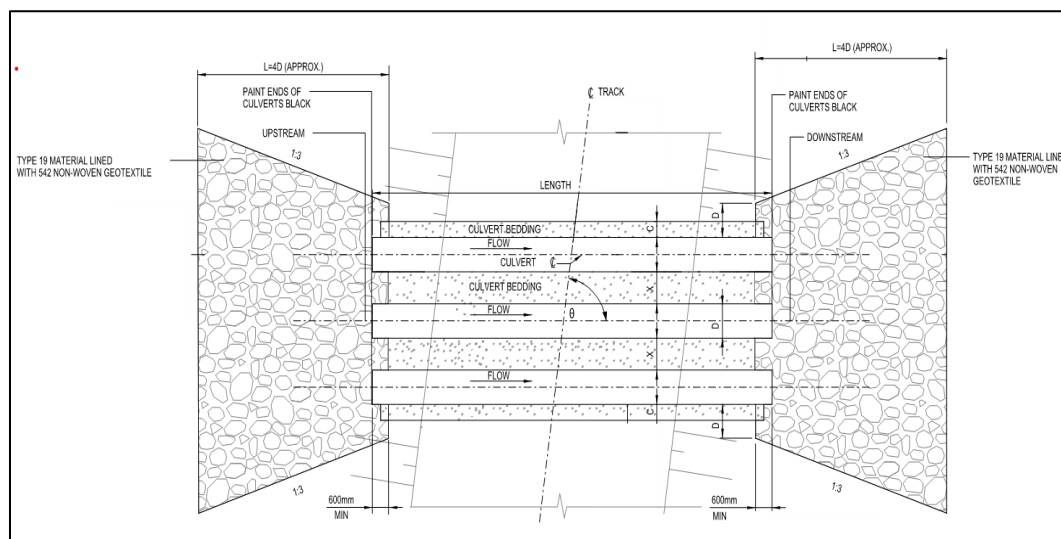


Figure 8-5: Plan – Multiple Pipe Culvert with Erosion Protection

8.16.3 Requirements for Fish Bearing Crossings

8.16.3.1 The following criteria shall apply to fish bearing streams to ensure the protection of fish habitats where culverts need to be installed:

- Identify culverts located in fish bearing crossings.
- Design to assist in minimum disruption of fish migration or movement with reference to over sizing, 20% of diameter below natural stream grade (Figure 8-6), light and appropriate measures to control water velocity through culvert.
- In multiple culvert configurations provide at least in a single culvert the fish passage promoting measures.
- Fish bearing culverts will be assessed on a case by case basis to install appropriate fish passing promoting measures where required.

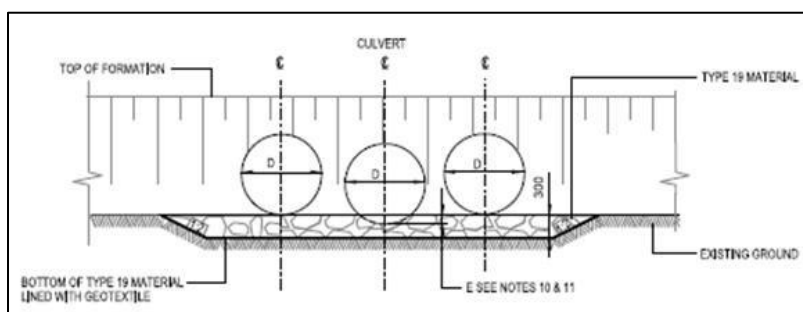


Figure 8-6: Multiple Pipe Culvert with Fish Passing

9. Track

The track design standards have been carried over from document "FULL DESIGN BRIEF 2-04-2012", the Steensby Report, being the property of BIM and reviewed to be a good application of the North American Standards by Consultants experienced in North American and Canadian railway design. A few adjustments have been made which will be highlighted where applicable. Further adaption to minimum standards has been followed to optimize the rail design.

9.1 Design Standards

9.1.1 The operating conditions described in Section 4, guide and dictate what standards and procedures is required to provide the infrastructure to support sustainable capacity delivery- and operations for the rail system.

9.1.2 The design of the components is mainly based on AREMA standards and codes of practice and shall conform to CN standards for Class 3 track and the standards and guidelines set forth by Transport Canada (TC) and the Canadian Transportation Agency (CTA). In the absence of a suitable AREMA standard, other international standards (i.e. UIC, etc.), may be used.

9.1.3 A full list of all the codes and procedures to consider is provided as Section 2 of this document.

9.2 Track Structure Design Conditions

9.2.1 Train Loading

9.2.1.1 The train loadings (design speeds and axle loads) on the track structure associated with the railway are summarized as follows:

Maximum design speed : All trains both directions; 60 km/h (loaded and empty)

Annual Traffic : Iron Ore Traffic (Dry) 12 Mtpa; (Humid) 12.24 Mtpa

Axle Load : Ore Train* 32.5 tonnes (all trains)



9.2.2 Sub-grade Loading

9.2.2.1 The track structure shall be designed to dissipate train loads through the track structure to produce a maximum loading on the sub-grade of 170 kPa as per Chapter 16 – Section 10.3.2.1 of AREMA.

9.2.3 Key Track Structure Parameters

9.2.3.1 The track structure required for the described heavy haul operation can be configured as follows:



- Rail 136 lb RE (67.4 kg/m))
- Welded/jointed CWR except siding connections, spur and yard track
- Ties Timber (178 mm x 229 mm x 2.6 m).
- Tie spacing (mm) 540mm c/c
- Fastenings: 16" Standard Rolled Tie Plate
Pandrol "e" clip
Screw spikes
- Ballast depth (mm) 300mm
- Ballast + tie depth (mm) 478mm
- Ballast shoulder width (mm) Tangent/curves 300/700 to 900
- Ballast shoulder slope 1V : 1.5H
- Sub-ballast cross-slope 0.00% (Top) 0.00% (Bottom)
- Minimum sub-ballast shoulder width is 300mm
- Typical cross-sections for main track, siding and yard tracks are shown in the sections below, Figure 9-1 and Figure 9-2 (Drawing H353004-30000-224-294-0003-0001).

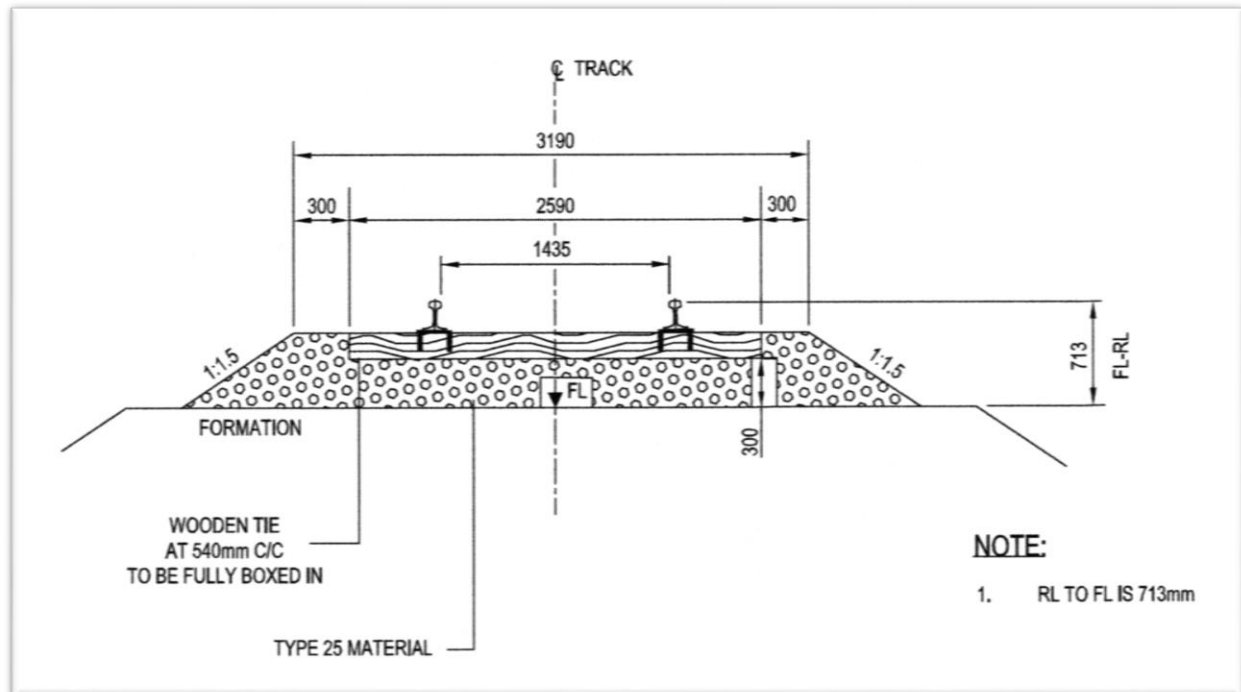


Figure 9-1: Typical Cross Section – Superstructure

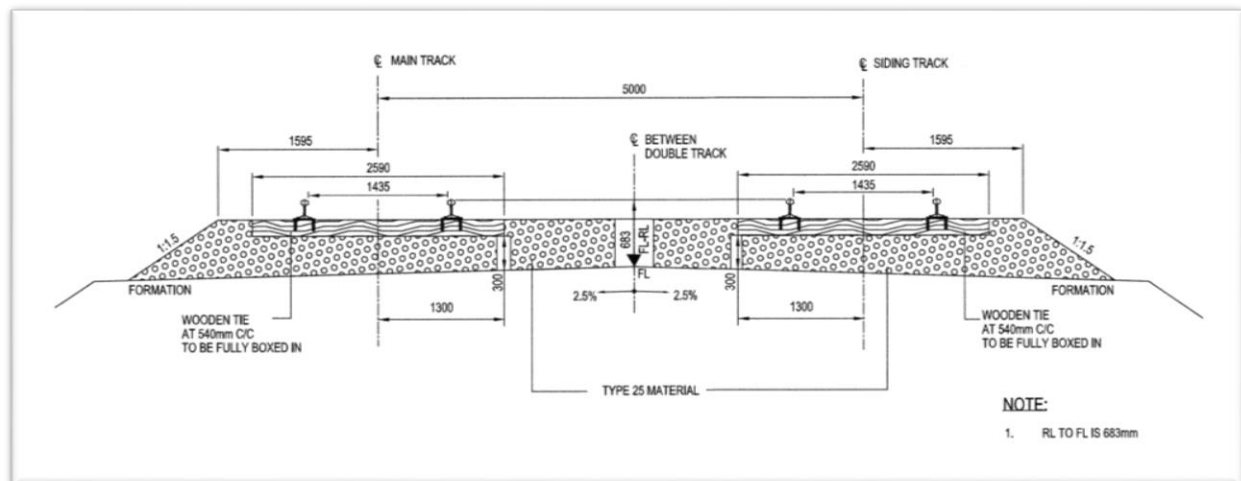


Figure 9-2: Typical Cross Section – Double Track in Sidings – Superstructure

9.3 Rail

9.3.1 General

9.3.1.1 Selection of a rail section for the Baffinland Iron Mines Railway System between Mary River and Milne Port is based on the following criteria:

- Design axle loads.
- Annual tonnage.
- Alignment curvature and gradient.
- Maximum Train design speeds.
- Extreme climate conditions.
- Type of rolling stock.
- Maintenance requirements are somehow compromised with the absence of sub ballast shoulder.
- Ease of welding.

9.3.2 Rail Dimensions and Tolerances

9.3.2.1 The rail shall be 136 RE (67.4 kg/m) profile for the entire network in accordance with AREMA, Chapter 4. 

9.3.2.2 The rail shall be purchased in minimum lengths of 24 m (80 ft.) to support a modular panel installation concept, if necessary. 

9.3.3 Steel Quality

9.3.3.1 AREMA, Manual for Railway Engineering, Volume 1, Chapter 4, Sections 2.1.4.1 and 2.1.4.2 list two types of steel, namely, standard chemistry and low alloy chemistry. In addition, the respective tables identify the chemical composition, hardness and tensile properties. With respect to hardness the standard chemistry rail lists two types; standard and high strength rail, while the low alloy chemistry lists three types; standard, intermediate and high.

9.3.3.2 The rail shall be 136 RE (67.4 kg/m); AHH grade with minimum yield strength of 130,000 psi, for both mainline track and yard track. The low alloy steel is being recommended on the basis of improved welding characteristics, improved wear characteristics at weld joint areas and superior resistance to wear (longer life). 

9.3.3.3 All rails shall be rolled using clean regular carbon steel with an emphasis on the cleanliness of the steel and reduction of inclusions in the rail during the manufacturing process. Premium steel has not been considered due to its predisposition to brittle fracture during extreme cold weather.

9.3.3.4 A major criterion in the selection of a Rail Fabricator shall be their ability to roll rails using clean steel and guarantee the durability and cleanliness of the steel in sub -50°C temperatures. 

9.3.4 ***Rail End Drilling and Hardening***

- 9.3.4.1 Rail for use in continuously welded sections shall be supplied undrilled.
- 9.3.4.2 Rail for use in jointed track shall be drilled to accommodate a 90 mm long, 6-hole joint bar (fishplate). Jointed rail shall only be used in yards and sidings and as such end hardening is not required.

9.4 **Ties**

9.4.1 ***Yards, Mainline and Sidings***

- 9.4.1.1 All ties shall be untreated hardwood No. 1 timber ties.

9.4.2 ***Spacing Tolerance***

- 9.4.2.1 The tolerance on the tie spacing shall be +/- 10 mm along the mainline and +/- 15 mm in yards and along sidings with no cumulative tolerance over any distance (if in one crib the tie spacing is above the nominal spacing the adjacent crib shall not be above nominal to facilitate continuous action tamping).
- 9.4.2.2 Tie spacing in the yards and mainline is 540 mm c/c.

9.5 **Fastenings**

- 9.5.1 The fasteners for fixing rails shall be as outlined below:
- Standard rolled 16" tie plate for timber hardwood ties for 136RE rail
 - Track screw spikes for timber hardwood ties
 - Pandrol "e-clip" for timber hardwood ties.



9.6 **Ballast**

- 9.6.1 Ballast shall be composed of crushed rock or a material of comparable character and shall be in accordance with AREMA, Chapter 1, Part 2. The ballast material shall be a hard, dense, strong and angular material with a durable particle structure providing sharp corners and cubicle fragments with a minimum of flat and elongated particles. It shall be free from clay, shale or an excess dust or other undesirable substances or materials. The ballast must have high wear and abrasive qualities to withstand the impact of traffic loads and track maintenance by heavy tamping machines without excessive degradation. The ballast must also provide high resistance to temperature change, chemical attack, low absorption properties and should be free of cementing properties.
- 9.6.2 Testing procedures will be in accordance with the AREMA, Chapter 1, Section 2.8 and conform to ASTM specifications and associated testing procedure, the ballast requirements are prescribed by the code and the Ballast Grading Requirements (AREMA size No. 4) or as in Figure 9-1 below:

Table 9-1: Ballast Crushed Stone Grading

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
73	100
63.0	90 – 100
53.0	40 – 70
37.5	10 – 30
26.5	0 – 5
19.0	0-1
13.2	0

Table 9-2: Ballast Physical Specification

Laboratory Test	Standard	Values
Los Angeles Abrasion Test (LAA)	ASTM C 535-69	< 35% weight loss
Mill Abrasion Test (MA)	Non-standard test	<5% weight loss
LLA + 5(MA)	–	<50%
Degraded Aggregate Cement Value (CV)	Non-standard test	<(1.0 +0.2xMA)
Bulk Specific Gravity	ASTM C127	>2.6
Magnesium soundness test	ASTM C88-76 x 5 cycles	≤8% weight loss
Water Absorption	-	≤1.5%

9.6.3 Design ballast depth and shoulder dimensions:

- Ballast Depth below ties (mm) 300 mm (for timber ties)
- Ballast depth (Ballast + Tie) (mm) 478 mm
- Ballast shoulder width (mm) Tangent = 300; Curves = 700 to 900
- Ballast shoulder slope 1V : 1.5 H
- Minimum sub-ballast shoulder (mm) 300

9.7 Turnouts

9.7.1.1 Turnout for use on the rail system shall be referred to under the designation relating to the “frog (crossing) number” as described on pages 6-35 and 6-36 in Section 6.5 – Turnouts of the Practical Guide to Railway Engineering, AREMA 2003. Without limiting their completeness, the turnouts shall consist of the following components:

- Turnouts to conform to the 136 lb (67.4 kg/m) RE rail profile
- Switch and crossing assemblies
- All special and running rails
- All rail braces, stretcher bars, castings, check rails, other track material, track appurtenances, and miscellaneous items required to make the turnout installation complete
- Ergonomic switch stand (yard track).

9.7.2 **General**

- The design of the turnouts shall conform to the most recent edition of AREMA Plans and Specifications. They shall be designed to support the operating conditions.
- No. 9 and No. 12 switches shall conform to the 136 RE rail profile.
- AREMA standards permit 32 km/h and 43 km/h operating speeds through the diverted track for No. 9 and No. 12 lateral turnouts, respectively.
- Maximum operating speed on the mainline is 60 km/h.
- No. 9 turnouts shall be used in yards and for back track sidings.
- No. 12 turnouts to be used on mainline to access sidings and at the entry and exit switches for the yards at the mine and port.

9.7.3 **Main Line, Sidings, Yard and Backtracks**

- 9.7.3.1 All switches shall meet either No. 9 or No. 12 standard geometry depending on the location as identified below.

9.7.4 **Turnout Ties**

- 9.7.4.1 Track ties for all turnouts within the yard shall be untreated, timber ties in accordance with an AREMA No. 9 turnout.
- 9.7.5 Track ties for all turnouts on the mainline shall be untreated, timber ties in accordance with an CN Plan No TS-271 L/R No. 12 turnout.

9.7.6 **Mainline**

- 9.7.7 The No.12 turnout shall have geometry conforming to CN Plan No TS-271 L/R with the associated tie spacing as set out in the same drawing. The ties shall be untreated hardwood with Pandrol fasteners appropriate for the design.
- 9.7.8 The tie spacing and lengths shall be in accordance with CN Plan No TS-271 L/R.
- 9.7.9 These switches should be upgradable to an automated switch design and should be supplied as such with ties long enough to allow for the installation of automation equipment. The base design will be hand operated switches as a final decision on the automation has not been made.

9.7.10 **Yards and Backtracks**

- 9.7.10.1 The No. 9 turnout shall have geometry conforming to AREMA Plan No. 910-41 with 5,030mm (16 feet 6 inches) straight Samson switch points for standard gauge track. The ties shall be untreated hardwood with Pandrol fasteners appropriate for the design.
- 9.7.10.2 The tie spacing and lengths shall be in accordance with AREMA Plan No.912-58 as described in the AREMA, Portfolio of Trackwork Plans for the No. 9 Switches, latest edition.

9.7.11 **Snow Elimination**

- 9.7.11.1 All mainline and yard turnouts shall be capable of equipping with automatic cold air blowers.

9.8 Joints

9.8.1 *Standard Joint Bars*

9.8.1.1 Joint bars shall be toeless and conform to the profile presented in AREMA, Chapter 4, Part 3, Fig. 4-3-3 for 136RE rail section with the following bolt hole properties:

- Oval shaped with 1-5/16" diameter.
- Track bolts: 1 1/8" x 5 7/8" oval shape.

9.8.1.2 Rail drilling, bar punching and bolts shall be in accordance with AREMA, Chapter 4, Part 3, Table 4-3-1. All nuts and bolts shall be manufactured in accordance with AREMA, Chapter 4, Section 3.5.

9.8.2 *Insulated Joints*

9.8.2.1 Insulated joints are not considered as the signaling and train control systems will be radio order controlled for a dark territory system operations approach.

9.8.3 *Welded Joints*

9.8.3.1 Where a modular installation concept is utilized, the panels will be continuously welded with an on-track butt welding machine. The process shall conform to the requirements of AREMA, Chapter 4, Section 3.1.12. All welds for CWR shall be electric flash-butt welds.

9.8.3.2 Aluminothermic (exothermic) welds may be used where space does not permit flash-butt welding and for closure welds when de-stressing rails. Exothermic rail welds shall be made using full preheat welding kits (molds, charges, etc.), designed for 136RE rail with the metallurgical properties described in the applicable sections.

9.9 Other Track Materials

9.9.1 *Guard Rails*

9.9.1.1 Track installed on bridges shall be equipped with bridge (guard) rail. Guard rail shall be installed on the track for the length of the bridge and extend 20 m beyond either side of the structure. They shall also be provided in locations such as running in close proximity to sensitive water bodies.

9.9.1.2 Guard rails shall be designed in accordance with AREMA, Chapter 7, Section 3.6.2. They shall consist of 2 additional rails located inside the running rails. All guard rails shall be fastened using 12" tie plates for 5 1/2" rail base width as per AREMA, Chapter 5, Part 1, Section 1.3, Figure 5-1-4 and standard spikes. It is not required for guard rails to have the same section as the running rails and may be second hand rail with the same base of rail dimension.

9.9.2 *Derails*

9.9.2.1 Derails shall be installed wherever the possibility exists that equipment left standing on tracks, other than main tracks or sidings may be moved by wind, or gravity, or both, so as to obstruct a main track or siding. Derails shall be installed on both ends of tracks where unattended locomotives are regularly stored.

9.9.2.2 The sliding derail shall be the preferred derail, as it provides derailing protection for all types of cars and units that are stored on sidings or backtracks regardless of the grades involved.

9.9.2.3 The model, size and hand of derail shall be selected to fit 136RE rail sections. A right hand or left hand derail shall be used where derailing protection is required (a right hand derail is one which derails to the right when looking in the direction of the movement to be controlled).



9.9.3 **Stop Blocks (Bumping Posts)**

9.9.3.1 Bumping posts shall be provided at the ends of all dead end tracks. All bumping posts shall be steel fabricated triangle units compatible with 136RE rail sections. In addition, they shall be equipped with a strengthening “middle rail” and a shock-free cushion head.

9.10 **Track Signs**



9.10.1 The design of the line shall make provision for appropriate way-side signs required for the safe operation of trains. Signs shall be provided for:

- Whistle posts.
- Kilometer and half kilometer point markers.
- Permissible running speeds.
- Bridge structure and major river identification.
- Station (siding) names.
- Registered clearance and bridge markers.
- Snow and flangers.
- Derails.
- Yard limits.
- Grade crossings (Snowmobile and animal crossing signs); and
- Other miscellaneous signs required for safe operation.

9.10.2 Way-side signs shall be provided in English and Inuktitut. The design of all signs shall follow the guidelines in AREMA, Chapter 1, Part 7.

9.10.3 Optimization and appropriate elimination of track signs will be pursued further in the final design.

9.11 **Crossings**

9.11.1 **Crossings and Refuges (Set-offs)**

9.11.1.1 At various locations along the rail line, refuges or set-offs and vehicle crossings are required to accommodate the entrance and exit of track maintenance vehicles. All set-offs shall be constructed using a set of 205 mm (8 in) x 205 mm (8 in) wood planks fastened to the ties using suitable hook bolts. A minimum of 76 mm (3”) shall be maintained between the gauge face of the rail and the nearest wood plank to ensure the wheel flange of rail cars will not be impeded.

- 9.11.1.2 The track structure shall remain the same as the typical cross-section shown in the cross section drawings and Figure 4-6 in Section 4 above. Road base Type 26 fill material shall be used as an approach material and shall be graded flush with the timber planks between the rails on top of the ties.
- 9.11.1.3 Where crossings are required in yards, wooden track ties shall be substituted for the ties in the standard yard track structure.

9.11.2 *Animal Crossings*

- 9.11.2.1 To assist the caribou in crossing over the track the following typical detail illustrates the proposed crossing. One animal crossing every 10 km for a total of 11 crossings has been included in the preliminary design. Final crossing locations will be confirmed during the final design stage.

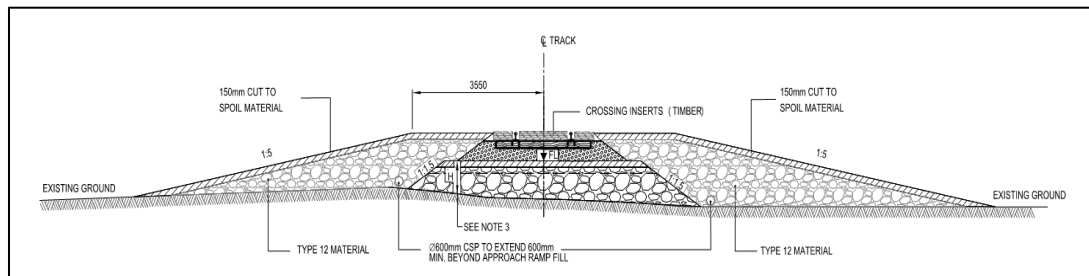


Figure 9-3: Typical Cross Section – Caribou Crossing

9.12 Clearances

9.12.1 Clearance Diagrams

9.12.1.1	The clearance envelope developed shall be based on Transport Canada's <i>Standards Respecting Railway Clearances</i> (TC E-5) and the general clearance envelope outlined in AREMA, Chapter 28, Section 1.2, Figure 28-1-1.
9.12.1.2	The TC E-5 also requires a lateral allowance for track curvature of 25.4 mm per degree of curvature.

Table 9-3: Lateral Clearance Requirements for Curved Track

Curve Radius (m)	Curve Radius (degrees)	Additional Lateral Clearance (mm)
1746	1	25.4
873	2	50.8
582	3	76.2
436	4	101.6
349	5	127
291	6	152.4
249	7	177.8
218	8	203.2

9.12.2 *Track Spacing*

9.12.2.1 The design of all tracks shall respect the track spacing defined in Table 9-4.

Table 9-4: Track Spacing

Facilities	Minimum Track Spacing - TCE-5(m)	Design Spacing (m)
Tangent Tracks between Mainline and Sidings	4.27	5.00
Yard Tracks	4.11	≥ 5.0 (Purpose made)
Parallel Ladder Tracks	5.49	5.50

9.12.2.2 The minimum distance between track centers shall be increased by 50.8 mm (2") per degree of curvature. A 5.0 m track spacing shall be used to provide an allowance for curves up to 4 degrees (R=436 m). If a siding curve adjacent to a mainline track exceeds 4 degrees then an additional track spacing of 50.8 mm per degree is required.

9.12.3 *Right-of-Way Fencing*

9.12.3.1 The rail system mainline, yard and terminal rights-of-way will not be delineated with fencing.

9.13 *Track Construction*

9.13.1 The specific requirements shall be in accordance with AREMA, Manual of Railway Engineering, Volume 1, Chapter 5, Part 4 and Part 5. These shall be developed and detailed in the specifications. The requirements shall consider the current, most appropriate construction practices and methods that are expected of an international contractor. The use of heavy automatic mechanized machinery will be required. It is expected that bidders will be provided an opportunity to propose alternate methods to construct the track structure that meets the requirements at the most economic cost.

9.13.2 The preferred rail laying temperature will be calculated in accordance with the AREMA requirements as set out under Section 5, Part 5.2.4.

9.14 *Track Maintenance*

9.14.1 *Track Maintenance Conditions*

9.14.1.1 The rail alignment formation, super structure, monitoring equipment and related infrastructure shall be inspected and maintained in accordance with Transport Canada's Track Safety Rules (TC E-54).

9.14.2 *Maintenance of Way Vehicles*

9.14.2.1 All track maintenance vehicles must be equipped for cold-weather conditions including supplemental heating (portable heaters) and storage for arctic survival equipment. A list of the maintenance of way (MoW) vehicles required is shown in the Operating Plan.

9.14.3 *Maintenance Bases and Sidings*

9.14.3.1 Railway System infrastructure maintenance teams shall be based at both Mary River and Milne Port. The principal MoW shop shall be located within the Consolidated Maintenance Facility at Milne Port.

- 9.14.3.2 A mainline passing loop (siding) shall be incorporated into the final design between chainage 55km and 57km. This siding shall be 1100m clear between switches and connected to a 300m back track siding for MoW use.
- 9.14.3.3 Two maintenance/construction sidings will be located at km 23 and km 83, respectively. These sidings shall be 1100m in length (clear) between switches.

10. Rolling Stock

10.1 Locomotives

- 10.1.1 The locomotives must be diesel-electric locomotives and be able to operate in the harsh and extreme cold environment. Locomotives that are successfully operated under these extreme cold conditions are the EMD SD70 ACEM and the General Electric (GE ET44AC) locomotives. The new AC traction motor configuration provides more optimized energy consumption and will be the preferred locomotives for this application.
- 10.1.2 The locomotives shall be standard gauge configuration in order to run on 1435 mm standard gauge track. The locomotives shall be equipped with dynamic braking capability as well as distributed power (cable and radio control capability) in order to run multiple locomotives on the train.
- 10.1.3 Each locomotive to be connected with the back to the train and cab facing forward, as there is no runaround at the port or the mine sites for the train to turn around. The locomotives shall be equipped with F-type couplers that can absorb the maximum pull and compression force of 1600 kN. The locomotives shall be equipped with airbrake braking system.
- 10.1.4 The locomotive shall have a Co-Co bogie configuration. The locomotive gross vehicle weight shall not exceed 196 gross tonnes and 32.7 tonnes per axle.
- 10.1.5 The locomotives must be equipped with an onboard toilet facility.

10.2 Ore Cars

- 10.2.1 The ore cars shall be of standard gauge configuration with 1435 mm gauge and be a open top gondola type car that can be tipped by means of a rotary tippler. The cars shall be coupled by means of a rotating coupler on each side of the car. This will enable the off-loading of a single car per cycle through the single cell rotary tippler.
- 10.2.2 The cars shall be equipped with an air-brake braking system and the drawbar and coupler configuration must be the F-type coupler.
- 10.2.3 The ore cars shall be designed to accommodate a maximum loaded axle load of 32.5 tonnes per axle and must be equipped with self-steering bogies.
- 10.2.4 The car shall have a tare weight not exceeding 23 metric tonnes.
- 10.2.5 The cars must fit within the minimum rail structure gauge tolerances at a width of 5750 mm. This value is based on the AREMA clearance box width of 5486 mm plus an allowance of 80 mm per degree of track curvature at a maximum curvature of 3 degrees. At the bottom

corners, structure may intrude into a triangle that is 1220 mm high by 915 mm wide at the base.

10.2.6 Height: 7010 mm from top of rail.

10.2.7 The rail structure clearance gauge for both locomotives and cars are indicated by the drawing below:

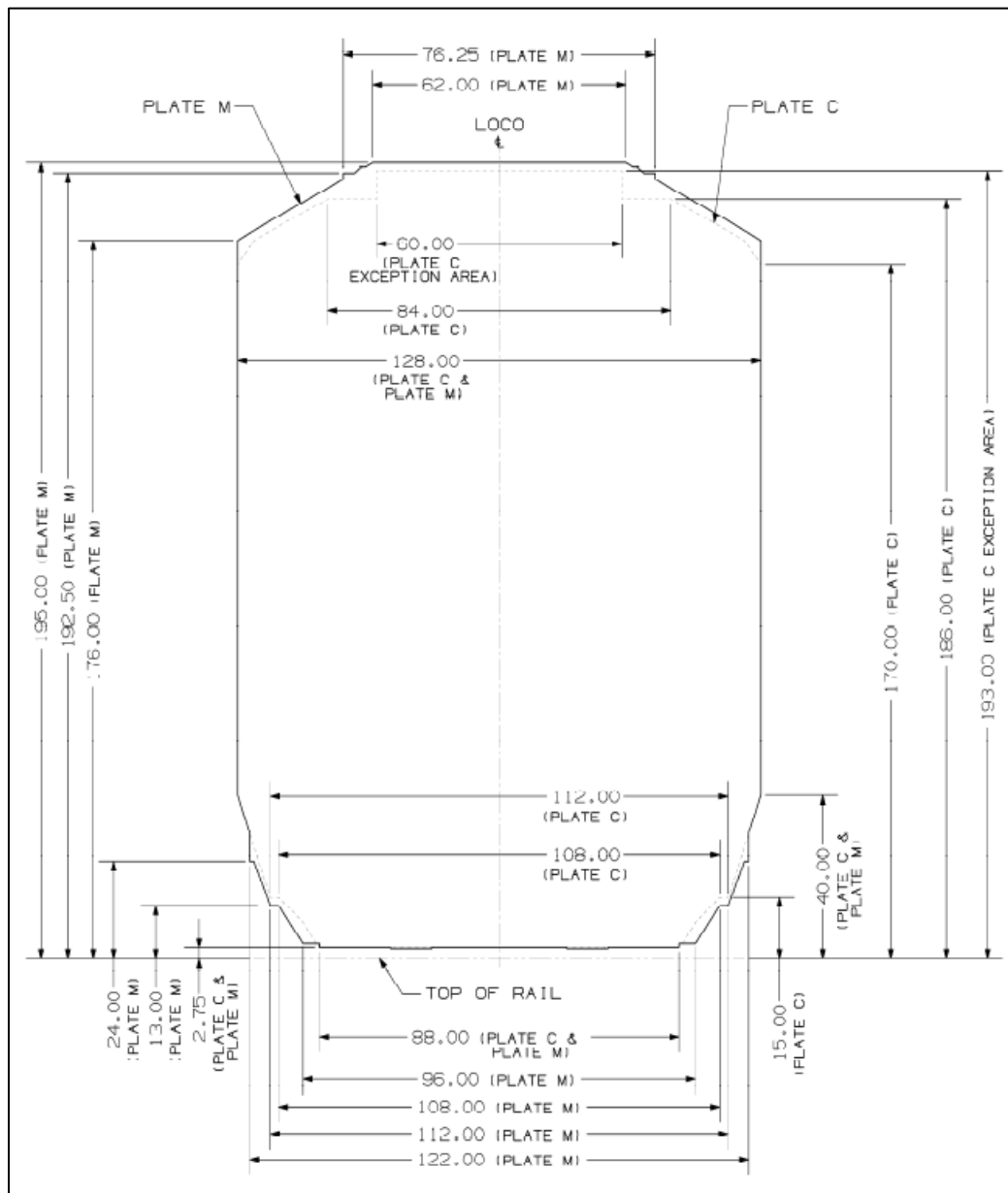


Figure 10-1: Structure Gauge Plate M

11. Rolling Stock Facilities

11.1 Functional Design Criteria for Diesel-Electric Locomotive Depot



11.1.1 The rolling stock maintenance facility will be located at the Milne Port and will be designed to perform all maintenance activities on the diesel-electric locomotives, ore cars and track maintenance rail vehicles that will be used for the mainline operation. The facility shall be of a modular design that will be optimized for maintenance operations, administrative functions and other activities required for the inspection and maintenance of the rolling stock fleet.

11.2 Main Workshop Facility for Diesel-Electric Locomotives



11.2.1 The facility must provide for minor and major repairs which must include for A, B and C shedding that will include but not be limited to the following activities:

- Unscheduled repairs.
- Scheduled repairs.
- Unscheduled maintenance.
- Scheduled servicing/maintenance.
- Component removal and replacement (i.e. blower motors, traction motors, compressors, radiators, turbo charger, alternator, electronic control cards, valves, cables, etc.). Repair of these components will be by the OEM.
- Wheel milling/cutting.
- Minor engine repairs.
- Sanding.
- Addressing Fault Reports.
- Fluid top-up on sub-systems.
- Electronic cards/modules exchange.
- Toilet servicing.

11.2.2 The locomotive maintenance facility shall be fully enclosed in a maintenance building/shed enabling two locomotive to be serviced in the facility at any given time. The servicing line shall be equipped with a pit that will allow maintenance staff to enter underneath the locomotive while stationary on the rail line inside the workshop. Access stairs shall be provided at both ends of the pit and adequate lighting to be provided inside the pits.

11.2.3 Mobile scissor jack platforms shall be provided to allow maintenance staff to obtain access to both sides of the locomotives and perform maintenance activities. The scissor jack platforms shall be able to lift small components (max. 500 kg) that must be installed on the locomotive. Further consideration to fixed working platforms will be given during the final design stage.

11.2.4 Two overhead cranes with a capacity of 75 tonnes each shall be provided to traverse the main repair/servicing area. A 15 tonnes overhead crane shall be provided for the adjacent

- truck/bogie repair area. A forklift with lifting capacity of 15 ton shall be used for all other lifting activities inside the workshop.
- 11.2.5 The locomotive servicing and pit areas will be equipped with 380V and 220V power connections as well as compressed air sockets for electrical and pneumatic maintenance tools being used by the maintenance staff.
- 11.2.6 The pits will be designed to allow for easy inspection and maintenance of the vehicles as well as allow the cleaning of the locomotive's below deck equipment and trucks/bogies during inspection cycles.
- 11.2.7 The floor design will allow for the drainage and collection of effluent from the pit area that will then be treated on site. Adequate light shall be provided inside the pits in order for staff to perform inspections. These lights must be waterproof and adhere to IP65 standards.
- 11.2.8 The rolling stock maintenance facility shall be able to maintain the dedicated locomotive fleet of five (5) mainline diesel-electric locomotives and one shunt mobile.
- 11.2.9 The facility shall have adequate space for storage of locomotive components in the prescribed manner and this facility must form part of the main shed structure.
- 11.2.10 Office provision shall also be made to accommodate the required staff levels at the depot and must link to the main shed structure.
- 11.2.11 The daily servicing and provisioning of locomotives will take place on the departure siding by means of mobile fueling, sanding and maintenance equipment.

11.3 Main Workshop Facility for Iron Ore Cars



- 11.3.1 The inspection and maintenance of the dedicated ore car fleet shall be conducted in the rolling stock maintenance facility at the Milne Port.
- 11.3.2 All scheduled and unscheduled work shall be conducted at this facility.
- 11.3.3 The maintenance of the ore car fleet shall be based on a lifting cycle which will be derived from the annual kilometres travelled and the associated monitored wear on the wheel sets.
- 11.3.4 The following ore car maintenance facility functional design criteria was used in the design of the facility:
- The facility shall be able to handle four (4) ore cars within the enclosed facility.
 - The maintenance facility shall operate 365 working days per year.
 - Wheel set changes shall be required when the ore car wheels reach the specified hollow wear limit.
 - Maintenance on ore car components are based on an remove and replace principle and component repairs are completed by the OEM.

- The ore car maintenance facility must be able to maintain the dedicated ore car fleet of 180 cars.
- The facility shall be designed to handle the 2, 4, 6, 8 year maintenance cycles.
- The depot shall be equipped with overhead cranes that can conduct body and bogie lifts inside the main structure of the facility.
- A separate truck/bogie repair area adjacent to the repair lines shall be provided to conduct all maintenance on truck/bogie frames, wheels, sub-assemblies, brake systems, couplers, draw gear and body repairs.
- Provision shall be provided for the testing of the full braking system after the scheduled maintenance lifts of the ore cars. This shall be conducted by means of a single car brake testing system.
- Provision shall be made in the maintenance facility for a wheel lathe that will be required to cut and profile the wheels of the ore car fleet.
- The facility shall have adequate space for the storage of ore car components in the prescribed manner and the facility must be linked to the main facility structure.
- The facility shall have an office to accommodate the required staffing levels at the facility and office shall be linked to the main facility structure.
- Provision shall be made for the on-site storage of the following items: oil, rubber pipe, cleaning agents, small parts, coupler and draw gear, bearings, brake valves, knuckles, seals, gas bottles, lubricants and filters and must be linked to the main facility structure.

11.3.5 The ore car activities that will be conducted in the rolling stock maintenance facility shall include but not limited to:

- Scheduled repair.
- Unscheduled repair.
- Body repairs.
- Bogie repairs.
- Wheel cutting and re-profiling.
- Bearing replacements.
- Bogie frame repairs and alignment.
- Draw gear replacement.
- Brake system component replacement.
- Body Painting and Stencilling.

11.4 Rolling Stock Maintenance Facility Stores and Offices

- 11.4.1 The rolling stock maintenance workshop is designed as a single building that provides space for the locomotive repair and car repair. Stores and offices have been moved adjacent to the workshop in modular format for the optimizing process.
- 11.4.2 The stores for both locomotive and ore car spares are located on the ground floor of the workshop facility and offices are housed adjacent to the workshop. The stores layout is designed with separate areas for locomotives and cars. Provision must be made for parts received- and dispatch counters with the actual stores located in-between. Space allowance must be made based on the spares requirements of the cars and locomotives.
- 11.4.3 The bigger component store is equipped with wider doors to allow the delivery and collection of heavy parts by means of a forklift directly from the workshop area. An open area store for larger and heavier components is allowed for. The smaller store areas must be equipped with shelving to increase storage space of the smaller components. The store for small parts provides access for individuals only with no need for access for forklifts.
- 11.4.4 Allowance must also be made for a dark and ventilated store room required for all the rubber pipes and seals. Provision must also be made for a locomotive battery store with battery recharging equipment and with suitable ventilation.
- 11.4.5 Provision is made for two compressor rooms that house a compressor for the car brake testing bays and a separate compressor that will supply air to the rest of the car and locomotive workshop areas. A separate gas and cleaning agent store must be provided and these are all situated outside the main building, some 25 m away from the main maintenance building. A run-off water collection treatment facility must be provided for the effluent generated inside the workshop area and must be disposed after treatment.

11.5 Wayside Condition Monitoring

The following wayside condition monitoring installations are to be considered in the detail design and will be further evaluated for suitability for use on the project and where these facilities need to be installed:

- A Lidar Scanning system located after the unloader to validate that the ore-cars are empty and that there is no excessive back-haul of iron ore that has not been unloaded
- A weigh in motion weigh bridge at the mine
- Automated equipment identification at the weigh in motion system at the mine
- Hot box detection systems at various locations
- Dragging equipment detection systems at various locations
- Wheel impact detection and acoustic monitoring system at the port

12. Design Criteria Summary

- 12.1 This Section is a high level tabular summary of the design criteria covered in the preceding Sections of this design rational for the major elements of the optimized track, supporting

infrastructure, operations and rolling stock for the railway between Mary River Mine and Milne Port associated with the Expansion Study – Stage II upgrades.

12.2 The tables also provide cross reference to the section numbers where these criteria are discussed.

Table 12-1: General Design

Item	Element	Design Criteria	Section
1.	Project Language	Canadian English	1.5
2.	Rail Classification	Standard Gauge - heavy Haul Railway	1.6
3.	Design Context	Mainly AREMA based, and all codes specified	1.7
4.	Units of Measure	International System (SI)	1.10

Table 12-2: Site Conditions

Item	Element	Design Criteria	Section
1.	Site Conditions	Defined Table 3.1	3.2
2.	Design Base	Standard Specification (H349000-S003120)	3.2

Table 12-3: Operations

Item	Element	Design Criteria	Section
1.	Ore Traffic	12 Mtpa (12.24 Mtpa – wet (2%moisture))	4.1.3
2.	Locomotive Axle Load	32.7 tonnes	4.2
3.	Car Axle Payload - Initially	30 tonnes	4.2
4.	Maximum Ore Car Axle Load	32.5 tonnes	4.2
5.	Train Design Speed	60 km/h	4.3
6.	Operating Speed	60 km/h	4.3
7.	Locomotives per Train	2	4.4.2
8.	Cars per Train	80	4.4.2
9.	Train Design Length (80)	900 m	4.5
12.	Gross Train Weight Loaded (80)	10770 tonnes	4.5
13.	Gross Train Weight Empty (80)	2189 tonnes	4.5
14.	Net Weight (80)	8581 tonnes	4.5
15.	Trainloads per day (80)	6 Loads/day	4.5

Table 12-4: Alignment

Item	Element	Design Criteria	Section
	Horizontal Alignment		5.2
1.	Minimum off-set from Tote Road	15 m	5.2.1
2.	Curve Radius Target	≥ 1000 m	5.2.2
3.	Curve Radius Minimum Target	500 m	5.2.2
4.	Transition Curves R > 300 m	80 m	5.2.3
5.	Transition Curves R ≤ 300 m	60 m	5.2.3
6.	Tangent Length between Reverse Curves	30.5 m	5.2.4
	Vertical Alignment		5.3
1.	Vertical Curve rate of Change	0.040 m/20 m/20 m; K=100	5.3.1
2.	Ruling Gradient facing Loaded	1.5% (1:67)	5.3.2
3.	Ruling Gradient facing Empty	2.0% (1:50)	5.3.2
4.	Exceptional facing Empty < 775 m	2.5% (1:40)	5.3.2
5.	Allowed Facing Empty > 775m; G>1% to follow	2.2% (1:45)	5.3.2
6.	Grade Compensation for G=1:X in Radius (R)	1: 20/((20/X)-(14/R)).	5.3.3

Item	Element	Design Criteria	Section
7.	Gradients in Passing Track	0 to 0.25%	5.3.2.11
8.	Exceptional facing Empty < 775 m	0 to 0.125%	5.5.2.5
9.	Allowed Facing Empty > 775; G>1% to follow	0 to 0.1%	5.5.2.6

Table 12-5: Earthworks

Item	Element	Design Criteria	Section
	Embankments		6.2
1.	Typical Side Slopes	1V:1.5H	6.2.1
2.	Sub Ballast Layer 150 mm	Type 26 Crushed Rock	6.2.2
4.	2nd Layer 550 mm in Non-Susceptible & Potentially Susceptible to Ice soils, choked with Type 26	Type 12 run of quarry rock fill	6.2.2
5.	2nd Layer 1350mm in Moderately Susceptible & Highly Susceptible to Ice soils, choked with Type 26	Type 12 run of quarry rock fill	6.2.2
6.	Geotextile below 1350 mm layer	542 g/m ² Stiff Woven	6.2.2
	Sub-grade Cuttings		6.2.3
1.	Cut side slopes in rock	1V:8H	6.2.3
2.	Cut side slopes ice rich soils	1V:2H (for pre feasibility)	6.2.3
3.	Layer Work, Geotextiles and Polystyrene Insulation	Section 6.2.2	6.2.2
4.	Grading Layer Works	Table 6-3 to 6-5	6.5
5.	Recovery of cut frozen ground for fills	Cut to spoil for FS	

Table 12-6: Hydrology

Item	Element	Design Criteria	Section
1.	Design Peak Flows	Extrapolated from Tote study	7.2.1
2.	Flood Return Period	200 years	7.2.2
3.	Design Flows	Q100: V = 3m/sec	7.2.3

Table 12-7: Bridges and Culverts

Item	Element	Design Criteria	Section
1.	The design Criteria for Bridges and Culverts are already in concise summarized format and very comprehensive in the Section indicated		8

Table 12-8: Track

Item	Element	Design Criteria	Section
	Track Superstructure – Rail		9.3
1.	Mainline, sidings and yards	136 RE (67.4 kg/m)	9.3.2
2.	Mainline Joints	Welded	9.3.2
3.	Yard & Siding Joints	Jointed and Welded	9.3.2
4.	Mainline Ties	Untreated Hardwood Ties	9.4.1
5.	Yard & Siding Ties	Untreated Hardwood Ties	9.4.1
6.	Mainline Tie Spacing	540 mm	9.4.1
7.	Yard & Siding Tie Spacing	540 mm	9.4.3
8.	Curves R< 400m Tie Spacing	540 mm	9.4.3
9.	Mainline, sidings and yards Fastenings	Pandrol “e”-clips	9.5.1
10.	Mainline Turnouts	AREMA No. 9 & 12	9.7
11.	Yard Turnouts	AREMA No. 9	9.7.4

Baffinland Iron Mines LP:
Mary River Expansion Project
H353004

Design Criteria

Railway Design Criteria and Design Rational

Item	Element	Design Criteria	Section
	Ballast		9.6
1.	Ballast Shoulder General	300 mm	9.6
2.	Ballast Shoulder on outside of Curves < 350m	600 mm if LWR	9.6
3.	Ballast Volume	1600 m ³ /km	9.6
4.	Sub Ballast Depth	150 mm	9.6
5.	Ballast cover between Sub Ballast & Tie	300 mm	9.6
6.	Ballast +Tie Height	478 mm	9.6
7.	Ballast Shoulder Slope	1:2	9.6
8.	Ballast Grading & Properties	Table 9-1 and 9-2	9.6

Table 12-9: Yards and Sidings

Item	Element	Design Criteria	Section
	Milne Tippler Yard		4.7.3
1.	Loading Lines	Part of Mainline km's	4.7.3
2.	Departure Loop	1100 m	4.7.3
3.	Loco Run-around Loop	347 m	4.7.3
4.	Loco Workshop Spur	390 m	4.7.3
5.	Car Workshop Spur	215 m	4.7.3
6.	Bad Order Car Spur	205 m	4.7.3
7.	Good Order Car Spur	160 m	4.7.3
8.	Quarry Spur and Y	400 m	4.7.3
9.	Cross Over	120 m	4.7.3
	Passing Loop (km's 56.017 to 57.490)		4.7.1
1.	Siding	1100 m	4.7.1
2.	Back Track	300 m	4.7.1
	Mary River Mine Yard		4.7.2
1.	Loading Line right through to Stop Block	Part of Mainline km's	4.7.2
2.	Departure Siding	1100 m	4.7.2

Table 12-10: Rolling Stock

Item	Element	Design Criteria	Section
	Locomotives		10.1
1.	Fleet Size	4+1 for exchange	4.4.2
2.	Locomotive Type	Diesel Electric	10.1.1
3.	Traction	AC Traction Motors	10.1.1
4.	Horsepower	3,280 kW	10.1.2
5.	Special Specifications	Extreme Cold Weather	10.1.2
6.	Co-Co	6 axles	10.1.3
7.	Minimum Axle load	32 tonnes/axle	10.1.3
8.	Maximum Axle load	32.7 tonnes/axle	10.1.3
9.	Maximum Length	23 m	10.1.3
10.	Vehicle Gauge	"Plate M" AAR S-2028	10.1.1
11.	Loco Wheel track Gauge	Standard 1,435 mm	10.1.1
	Ore Cars		10.2
1.	Fleet Size	180	4.4.2
2.	Car Tare Weight	23 tonnes	10.2.3
3.	Maximum Payload @ 32.5 t/axle	107 tonnes	10.2.3
4.	Coupler to Coupler Length	10.5 m (10.65m incl. Stretch)	10.2.4
5.	Car Width	3.2 m	10.2.4
6.	Maximum Car Height	7.01 m from top of rail	10.2.4

Table 12-11: Rolling Stock Facilities

Item	Element	Design Criteria	Section
	Locomotive Service (in line servicing in the yards)		11.2
1.	- Re-Fueling - Sanding - Provisioning and Hygiene - Lubrication - Daily Service Tasks - Attend to driver trip report faults - Oil top-up on sub-systems - Electronic cards/modules exchange - Windscreen replacement - Windscreen wipers replacement	Mobile equipment & provisioning done on departure siding.	11.2.10
	Locomotive Maintenance Facility		11.2
2.	- Unscheduled repairs - Scheduled repairs - Unscheduled maintenance - Scheduled maintenance - Component exchange (Blower motors, traction motors, compressors, radiators, turbo charger, alternator etc.). - Wheel cutting - Engine repairs	1 track extended outside workshop;1 locomotive	11.2.1
	Car Maintenance Facility		11.3
3.	- Scheduled repair - Unscheduled repair - Body repairs - Bogie repairs - Wheel cutting and re-profiling - Bearing replacements - Bogie frame repairs - Draw gear replacement - Brake system component replacement - Body Painting and Stencilling.	1 track 2 cars	11.3.6
	Stores and Offices		11.4
4.	- Loco and Car shops under one roof - Stores accommodated inside the building and modular offices outside and linked to workshop	2 track bays, parts exchange and repair and other facilities integrated	1.4.1 to 11.4.5

Annexure A – Delineation of Existing Ground Conditions

Chainage (Jun. 2018)			Borehole Details (First 7m of hole)						Remarks Sub grade (2018)					
From km	To km	Length km	BH Name	From	To	Material	Ice Features	Ice Classification: ND= Not Determined, Poor =Ice Poor, Rich=Ice Rich, Ice Body>=1.0m of ice	NS = Non Susceptible PS = Potentially Susceptible MS = Moderately Susceptible HS = Highly Susceptible	Comments				
0	8.9	8.9	BH16-R003	0	1.5	SAND	Nf	Poor	NS					
				1.5	5.6 (EOH)	SAND and GRAVEL	Nf							
			BH16-Q001	0	0.015	ORGANICS: Frozen organic soil		Poor						
				0.015	1.5	SAND, some GRAVEL, trace COBBLES	Nf							
				1.5	4.6 (EOH)	SAND and GRAVEL trace COBBLES	Nf							
				0	0.762	SAND: Organic								
			BH16-R004	0.8	1.5	SAND with GRAVEL	Nf	Poor						
				1.5	3	SAND, some SILT, trace GRAVEL	Nf							
				3	4.6 (EOH)	SAND and COBBLES, with GRAVEL, some SILT	Nf							
				0	0.9	SAND: Organic	Nf			Poor				
0.9	2.9 (EOH)	SAND and GRAVEL, trace SILT	Nf											
8.9	14.2	5.3	BH16-C006	0	0.6	SAND, some SILT: organic	Nf	Poor	NS					
				0.6	1.5	SILTY SAND, with COBBLES	Nf							
				1.5	2.1 (EOH)	INFERRED BEDROCK: Granitic gneiss								
			BH16-R005	0	1.52	SAND and GRAVEL, some SILT	Nf	Poor						
				1.5	4.6 (EOH)	SAND, some SILT, trace GRAVEL	Nbn/Nf							
			BH17-C001	0	0.6	ORGANICS		Poor						
				0.6	1.5	GRAVELLY SAND, some COBBLES								
				1.5	3	SAND	Nf							
				3	8.2 (EOH)	SAND and SILT, some GRAVEL	Nf							
			BH16-R007	0	1.52	SAND, some GRAVEL, some SILT	Nf	Poor						
				1.52	3.05	SAND, some SILT, trace Gravel	Nbn							
				3.05	3.66	SAND, with GRAVEL	Nf							
				3.66	4.57 (EOH)	GRAVEL	Nf							
			BH16-R008	0	1.5	SAND with GRAVEL	Nf	Poor						
				1.5	3	SAND with GRAVEL, trace COBBLES	Nf							
				3	4.6 (EOH)	SAND and GRAVEL, some COBBLES	Nf							
			14.2	15.2	1	-	-	-		-	-	N/A		
			15.2	16.25	1.05	BH16-B001	0	0.4		SILT: Organic	Vx	Ice Body	HS	
0.4	1.5	ICE LENSE, silt inclusions					ICE							
1.5	6.1	SILTY SAND, trace GRAVEL, trace COBBLES					Vc							
6.1	7.6	BOULDERS: granitic gneiss and mafic gneiss					Nf							
BH16-B002	0	1.5				SAND: some organics	Nf	Poor						
	1.5	3				SANDY GRAVEL, some COBBLES	Nf							
	3	4.6				SAND, some COBBLES, some BOULDERS	Nf							
	4.6	6.1				SILTY SAND, some COBBLES, trace GRAVEL	Nbn							
BH16-B003	6.1	7.2				SAND, some SILT, trace GRAVEL	Nf	Ice Body						
	0	1.5				SILTY SAND, with GRAVEL, trace COBBLES	Vc							
	1.5	3				GRAVEL, with SAND, some COBBLES, trace SILT	Vc							
	3	4				SILTY SAND and GRAVEL	Nbn							
BH16-B004	4	4.6				SAND	Vr	Ice Body						
	4.6	7.6				ICE, silt inclusions	ICE							
	0	1.5				SAND	Nf							
	1.5	4.6				SILTY SAND, some GRAVEL	Nf							
BH16-R009	4.6	5.9				ICE, SILT inclusions	ICE	Poor						
	5.9	6.5				Sand and SILT, trace GRAVEL	Vr							
	6.5	6.9				BOULDERS: Granitic gneiss								
	6.9	7.9				SAND	Nbn							
16.25	20.5	4.25				BH16-R010	0	0.3	SAND: Organics		Poor	NS		
							0.3	1.52	SAND, some GRAVEL	Nf				
						BH16-R011	1.52	3.05	SILTY SANDY GRAVEL, with COBBLES	Nbn	Poor			
							3.05	4.57 (EOH)	SILTY SANDY GRAVEL, some COBBLES	Nf				
20.5	21	0.5				BH16-R012	0	4.6 (EOH)	SAND and GRAVEL	Nf	Poor	NS		
							0	0.3	SAND and PEAT	Nf				
						BH16-R013	0.3	3.6	SAND, some SILT	Nf	Poor			
							3.6	4.6 (EOH)	GRANITE					
			BH16-C007	0	7.6 (EOH)	SILTY SAND, trace GRAVEL, trace COBBLES	Nf	Rich	MS					
				4.6	4.8	Ice lense	ICE							
				6.1	7.6	Rich SILTY SAND	Vx							
				0	0.75	SAND, some GRAVEL, some COBBLES								
			21	27.25	6.25	BH16-R012	0.75	3	SAND, some SILT, trace GRAVEL	Nf	Poor		NS	
							3	4 (EOH)	SAND and GRAVEL	Nbn				
BH16-R013	0	1.5				SAND, trace GRAVEL		Poor						
	1.5	2.5				SAND, with GRAVEL	Nbn							
	2.5	3.45				SAND, some SILT	Nbn							
	3.45	4.6 (EOH)				Possible GRANITE								
BH17-C002	0	0.6				SAND, trace GRAVEL	Nf	Ice Body						
	0.6	1.5				COBBLES and BOULDERS, some SAND, trace GRAVEL	Nf		BH16-C002 located away from rail					
	1.5	2.7				GRAVELLY SAND, some SILT	Nf							
	2.7	10.7 (EOH)				ICE	ICE							
BH16-R014	0	0.45				SILTY SAND	Nf	Poor						
	0.45	1.5				Silty SAND, with GRAVEL, trace COBBLES	Nf		BH16-R014 located away from rail					
	1.5	4				Silty SAND, trace GRAVEL	Nf							
	4	4.5 (EOH)				Sandy GRAVEL, trace COBBLES	Nf							
BH17-C003	0	0.3				SILTY SAND		Poor						
	0.3	3				Inferred BOULDERS, GRAVELLY SAND								
	3	4.6				GRAVELLY SILTY SAND								
	4.6	9.1 (EOH)				SILTY SAND, trace GRAVEL	Nf							
BH16-C008	0	3				GRAVELLY SAND, some COBBLES and SILT	Nf	Ice Body						
	3	13.7 (EOH)				ICE: minor silt inclusions	ICE		BH16-C008 located away from rail					
27.25	30	2.75				BH17-C004	0	3	SAND, some SILT, trace GRAVEL		Poor	PS & NS		
							3	7.6	SILTY SAND	Nf/Vx				
						BH16-R015	0	1.5	GRAVEL with SAND, trace SILT, trace COBBLES	Nf	Poor			
							1.5	3	GRAVEL and SAND	Nf				
			3	4.5 (EOH)	SAND with SILT, trace GRAVEL		Nbn							
			0	0.2	SAND: Organic			Poor	NS					
0.2	2.1	SILTY SAND, trace GRAVEL, trace COBBLES	Nf											
BH16-R017	2.1	4.5 (EOH)	SAND, with GRAVEL, trace SILT	Nbe	Poor									
	0	4.6 (EOH)	SILTY SAND and GRAVEL	Nf										
BH16-R018	0	1.5	SILTY SAND, some Gravel		Poor									
	1.5	3.9	SILTY SAND with GRAVEL	Nf										
	3.9	4.6 (EOH)	SILTY SAND and BOULDERS											
BH16-R019	0	0.9	SILTY SAND, with GRAVEL, trace COBBLES	Nf	Poor									
	0.9	1.5	GRAVEL and SAND	Nf										
	1.5	2.4	SAND,with GRAVEL, with COBBLES	Nf										
	2.4	4.6 (EOH)	SILTY SAND with GRAVEL	Nf										
BH16-R020	0	1.5	SAND and GRAVEL, some SILT, some COBBLES	Nf	Poor									
	1.5	3	SILTY SAND, with GRAVEL, with COBBLES	Nf										
	3	4.6 (EOH)	SILT and SAND	Nbn										
	0	1.7	SILTY SAND, some GRAVEL, trace COBBLES	Nf		Poor								
1.7	3	SILTY SAND, some SILT, some GRAVEL, trace COBBLES	Nf											
3	4.5 (EOH)	SILTY SAND, some GRAVEL	Nf											
BH16-C009	0	4.6	SILTY SAND, trace GRAVEL	Nf	Poor									
	4.6	6.1	SILTY SAND, some GRAVEL	Nbn										
	6.1	7.6	SILTY SAND, with COBBLES, with BOULDERS	Nf										
BH16-R022	0	2.7	SILTY SAND and GRAVEL, trace COBBLES	Nf	Poor									
	2.7	4.5 (EOH)	SILT and SAND, some GRAVEL: TILL	Nbn										
BH16-R023	0	1	SILTY SAND, some GRAVEL: Light brown, fine to medium grained sand, coarse gravel, rounded to subrounded	Nf	Poor									

37.5	38	0.5	BH16-C010	1	4 (EOH)	SAND and SILT: Grey, fine to medium grained	Nbn	Rich	MS						
				0	1.5	SANDY SILT, with GRAVEL, some COBBLES, trace BOULDERS									
				1.5	1.7	ICE LENSE	ICE								
				1.7	2.5	SANDY SILT, some COBBLES, trace GRAVEL									
				2.5	3	Pulvirized ROCK									
				3	4	Pulverized rock mixed with water									
				4	5.5 (EOH)	WEATHERED ROCK: Dolomitic limestone									
38	43	5	BH16-R024	0	4.6 (EOH)	SILTY SAND and GRAVEL	Nf/Nbn	Poor	NS & PS	One borehole categorized as PS out of 4.					
			BH16-R025	0	4.6 (EOH)	SANDY SILT, some GRAVEL, trace COBBLES	Nf/Nbn/Vx	Poor							
			BH16-R026	0	0.45	SAND with GRAVEL, trace SILT: organics	Nf	Poor							
				0.45	4.6 (EOH)	SILTY SAND, wthi GRAVEL	Nf/Nbn								
			BH16-R027	0	1.1	SAND, with SILT, with COBBLES	Nf	Poor							
				1.1	3	SAND and SILT, with GRAVEL	Nf								
			3	4.6 (EOH)	SILTY SAND, with GRAVEL, with COBBLES	Nbn									
43	46.25	3.25	BH16-R028	0	1.05	SAND and SILT, some GRAVEL	Nf	Poor	NS						
				1.05	3	Gravelly Silty SAND	Nf								
				3	3.6 (EOH)	SANDY SILT, with GRAVEL, with COBBLES	Nf								
			BH16-R029	0	1.6	SANDY SILT and GRAVEL, trace COBBLES	Nf	Poor							
				1.6	3 (EOH)	GRAVEL and COBBLES, some SAND	Nf								
			46.25	48	1.75	BH17-C005	0	1.5			SILTY SAND	Nf/Nbn	Rich	HS	
							1.5	3			ICE and SILTY SAND: Rich	Vr			
3	9.1 (EOH)	SILTY SAND, some GRAVEL					Nf/Nbn								
BH16-R030	0	0.6				SAND with SILT, with GRAVEL	Nf	Poor							
	0.6	1.8				SANDY SILT, with GRAVEL, with COBBLES	Nf								
	1.75	3.6 (EOH)				Pulverized rock with fragments of rocks	Nf								
BH16-C011	0	1.1				SANDY GRAVEL, with SILT, trace COBBLES		Ice Body							
	1.1	1.5	Dolomitic Boulder												
	1.5	10.7 (EOH)	ICE: No soil inclusions, sand inclusion below 7.6	ICE											
48	52	4	BH16-R032	0	1.5	SILTY SAND, some GRAVEL, some COBBLES		Poor	NS						
				1.5	2.7 (EOH)	LIMESTONE: Pulverized rock									
			BH16-C012	0	0.8	SAND and GRAVEL: organics	Nf	Poor							
				0.8	1.5	SAND with GRAVEL	Nf								
				1.5	2.6	SANDY SILT and GRAVEL	Vx								
				2.6	3	BOULDERS									
				3	4.6 (EOH)	SANDY SILT, some GRAVEL									
			BH16-R033	0	1.5	GRAVEL, some SILT, some SAND	Nf	Poor							
				1.5	3	SAND and GRAVEL, with SILT, trace COBBLES	Nf								
				3	4.2 (EOH)	COBBLES, with GRAVEL, with SAND, trace SILT	Nf								
52	53	1	BH16-R034	0	1.5	SAND and GRAVEL, trace silt	Nf	Poor	PS						
				1.5	4.6 (EOH)	GRAVELLY SILTY SAND	Vx								
53	53.25	0.25	BH17-C006	0	3	SILTY SAND, inferred BOULDERS		Rich	PS						
				3	6.7	SAND and SILT, some GRAVEL, ICE Inclusions	Vr/Vc/Nbe								
				6.7	7.9	SILT and SAND, inferred BOULDERS									
53.25	59.3	6.05	BH16-R035	0	0.6	SAND, with GRAVEL, with SILT	Nf	Poor	NS & PS	PS boreholes further from rail line					
				0.6	1.15	GRAVEL, with SAND, with COBBLES	Nf								
				1.15	1.5	SAND and GRAVEL, some SILT	Nf								
				1.5	3.6	GRAVELLY SILTY SAND	Nbn								
				3.6	4.6 (EOH)	LIMESTONE									
			BH16-R036	0	1.5	Gravelly SAND, some SILT, trace COBBLES: Organic	Nf	Poor							
				1.5	3	SAND and SILT, with GRAVEL trace COBBLES	Nf								
				3	4.6 (EOH)	SILT and COBBLES, with SAND	Nf								
			BH16-R037	0	4.6 (EOH)	SAND, trace SILT	Nf/Nbn	Poor							
			BH17-C006B	0	0.9	SILTY SAND, some COBBLES	Nf	Poor							
				0.9	6.1 (EOH)	SILTY SAND	Nf/Nbn								
			BH16-R038	0	4.6 (EOH)	SAND, trace SILT, trace GRAVEL	Nf/Vc	Poor							
			BH16-Q7003	0	1.5	SILT and GRAVEL, trace SAND		Rich							
				1.5	5	Visible ice layers, up to 5 mm thick	Vs								
				5	6.1	SAND	Nbn								
				6.1	7.3	Gravelly SILT									
			BH16-Q7004	0	1.52	SILT and GRAVEL		ND							
				1.5	4.6	No recovery									
				4.6	10.6	LIMESTONE									
			BH16-R053	0	6.05 (EOH)	SAND, trace SILT, trace GRAVEL	Nf/Nbn	Poor							
			BH16-R039	0	4.6 (EOH)	SAND, trace SILT, trace GRAVEL	Nf/Nbn	Poor							
			BH16-R040	0	4.6 (EOH)	SAND and SILT, trace GRAVEL	Nf	Poor							
			BH16-R041	0	1.5 (EOH)	SAND		Poor							
			BH16-R042	0	4.5 (EOH)	SAND, trace GRAVEL	Nf/Nbn	Poor							
			BH16-R043	0	9 (EOH)	SAND	Nf/Vc	Poor							
			BH16-Q7001	0	1.5	SILTY GRAVEL		Poor							
				1.5	3.15	SILT, some GRAVEL, trace SAND									
				3.15	3.6 (EOH)	LIMESTONE									
			BH16-Q7002	0	1.5	No recovery		ND							
				1.5	3	Silty GRAVEL, some COBBLES									
				3	4.5	No recovery									
				4.5	5.2	LIMESTONE									
				5.2	6.9 (EOH)	Silty GRAVEL, with COBBLES									
			BH16-R044	0	1.5	SANDY GRAVEL, trace COBBLES		Poor							
				1.5	4.6 (EOH)	SAND, some SILT, some GRAVEL									
			BH16-R045	0	4.6 (EOH)	SAND, some SILT, some GRAVEL, trace COBBLES		Poor							
			BH16-R046	0	1	SAND, some GRAVEL, trace SILT	Nf	Poor							
				1	1.6	SAND and GRAVEL, trace SILT	Nf								
				1.6	3	SILT: Organics, frozen	Nbn								
				3	4.6 (EOH)	SILTY SAND	Nbn								
			59.3	60	0.7	-	-	-			-	-	MS	GPR area	
60	61.2	1.2	-	-	-	-	-	N/A							
61.2	62	0.8	-	-	-	-	-	MS	GPR area						
62	62.5	0.5	-	-	-	-	-	MS	GPR area						
62.5	63.25	0.75	-	-	-	-	-	N/A							
63.25	63.75	0.5	-	-	-	-	-	MS	GPR area						
63.75	65.75	2	-	-	-	-	-	N/A							
65.75	66	0.25	-	-	-	-	-	MS	GPR area						
66	68	2	-	-	-	-	-	N/A							
68	68.25	0.25	-	-	-	-	-	N/A							
68.25	68.5	0.25	-	-	-	-	-	MS	GPR area						
68.5	69.75	1.25	-	-	-	-	-	N/A							
69.75	71	1.25	BH17-C007	0	1.5	ORGANIC SILT, some SAND		Rich	PS						
				1.5	4.6 (EOH)	SILT and SAND, trace GRAVEL	Nbe/Vc/Vr/Vs								
			BH17-B001	0	0.4	SILT: Organic	Vx	Ice Body							
				0.4	1.5	ICE LENSE, silt inclusions	ICE								
				1.5	6.1	SILTY SAND, trace GRAVEL, trace COBBLES	Vc/Nbe/Nbn								
			BH17-B002	6.1	7.6	BOULDERS	Nf	Poor							
				0	1.5	SAND: some organics	Nf								
				1.5	3	SANDY GRAVEL, some COBBLES	Nf								
				3	4.6	SAND, some COBBLES, some BOULDERS	Nf								
				4.6	6.1	SILTY SAND, some COBBLES, trace GRAVEL	Nbn								
71	75.75	4.75	BH17-C010	6.1	7.2	SAND, some SILT, trace GRAVEL	Nf	Poor							
				0	4.6 (EOH)	SAND, trace SILT, trace GRAVEL	Nf/Nbe								
			BH17-C011	0	0.3	SILTY SAND: organic	Nf	Poor							
0.3	4.6 (EOH)	SILTY SAND, trace COBBLES	Nf/Vs/Vr/Nbn												
75.75	77.6	1.85	BH17-C012	0	2.4	SILTY SAND	Nf/Vx	Rich	HS						
				2.4	3	ICE	ICE								
				3	4.6 (EOH)	GRAVELLY SILT and SAND	Nf								
			BH17-C013	0	1.5	SAND and SILT, some GRAVEL	Nf	Ice Body							
				1.5	4.6 (EOH)	ICE and SILTY SAND	ICE + SOIL								
			BH16-R067	0	0.9	PEAT, with SAND, with GRAVEL, trace COBBLES: Organic	Nf	Poor							
				0.9	4.6 (EOH)	SAND, trace GRAVEL, trace COBBLES	Nf								
			BH16-C015	0	1.5	SILTY SAND, some GRAVEL, trace COBBLES	Nf	Rich							
				1.5	3	SILTY SAND, with GRAVEL	Nf								
				3	7.6 (EOH)	SILTY SAND, some GRAVEL	Vx								
				0	1.5	SAND, some SILT	Nbn								

77.6	85.8	8.2	BH16-C016	1.5	3	SANDY SILT, with GRAVEL, trace COBBLES	Vx	Rich	PS		
				3	4.6	SILTY SAND, some GRAVEL	Vc				
				4.6	7.6 (EOH)	SANDY GRAVEL, with SILT	Nbn				
			BH16-R068	0	1.5	GRAVELLY SAND, trace SILT	Vx	Rich			
				1.5	3	SAND	Vx				
				3	4.6 (EOH)	SAND, trace SILT, trace GRAVEL: Organic	Vx				
			BH16-C017	0	3	SAND, some SILT, trace GRAVEL	Vx	Rich			
				3	6.1 (EOH)	SAND and GRAVEL, some SILT	Vx				
			BH16-R069	0	4.6 (EOH)	Sandy SILT, with GRAVEL, with COBBLES		Poor			
BH16-R070	0	0.3	PEAT, GRAVELLY SAND	Nf	Rich						
	0.3	4.6 (EOH)	SAND, trace GRAVEL	Nf/Vx							
85.8	86.9	1.1	BH16-B009	0	17.1	SAND	Nf/Nbn	Poor	NS	One borehole categorized as HS out of 7.	
			BH16-B010	0	7	SAND, trace SILT, trace GRAVEL	Nf/Nbn	Poor			
			BH17-BR86-1	0	0.8	SANDY GRAVEL, trace SILT	unfrozen	Ice Body			
				0.8	5	SAND, trace SILT	Nbn				
				5	6.3	ICE	ICE				
				6.3	35	SAND, trace SILT	Nbn				
			BH17-BR86-2	0	1	SANDY GRAVEL, trace SILT	unfrozen	Poor		BH17-BR86-2 Salinity data: DQ-1, 2, 4, 5, 6, 7, 8 salinity of 1.0 ppt, DQ-11 salinity of 4.0 ppt	
				1	7.6	SAND, trace SILT	Nbn				
			BH17-BR86-3	0	1.5	SAND with GRAVEL, trace SILT	unfrozen	Poor		BH17-BR86-3 Salinity data: DQ-1, 2, 3, 4, 5, 6, 8 salinity of 1.0 ppt	
				1.5	9.1	SAND, trace to some SILT	Nbn				
			BH16-B011	0	10.7 (EOH)	SAND, trace SILT, trace GRAVEL	Nf/Nbn/Nbe	Poor			
			BH16-B012	0	0.8	SAND and GRAVEL	Nf	Poor			
				0.8	2.5	SAND, trace SILT	Nbn				
				2.5	3	SAND and GRAVEL	Nf				
				3	9.1	SITLY SAND, trace GRAVEL	Nbn				
86.9	89.2	2.3	-	-	-	-	-	N/A			
89.2	91.25	2.05	BH16-C018	0	3	SAND, some GRAVEL		Poor	NS & PS		
				3	6.1 (EOH)	INFERRED BEDROCK: Possible Sandstone					
			BH16-C019	0	4.6 (EOH)	SAND, trace GRAVEL	Nf			Poor	
			BH16-C019B	0	1.5	SAND, some GRAVEL	Nf			Poor	
				1.5	6.1 (EOH)	SAND					
BH16-C020	0	9 (EOH)	SAND	Nf/Vr	Rich						
91.25	91.7	0.45	BH16-C021	0	2	SAND	Nf/Nbe	Ice Body	HS		
				2	3	ICE LENSE: sand inclusions	ICE				
				3	9	SAND, some GRAVEL, trace SILT	Nf/Nbn				
91.7	95.1	3.4	BH16-C022	0	0.4	PEAT, with SAND	Nf	Poor	HS	One borhole categorized as PS out of 4.	
				0.4	7.3	SAND, trace SILT	Nbn				
			BH16-C023	0	0.4	PEAT, with SAND	Nf	Ice Body			
				0.4	3	SAND, trace SILT	Nbn				
				3	4.6	SAND, trace GRAVEL	Nf				
				4.6	6.2	SAND and SILT, some GRAVEL					
				6.2	10.7	ICE: minor silt and sand inclusions	ICE				
			BH16-C024	0	10.7 (EOH)	SAND, trace SILT, trace GRAVEL	Nf/Vx/Vr	Rich			
			BH16-C025	0	5.5	GRAVELLY SILTY SAND	Nbn/Nf	Ice Body			
				5.5	7	ICE: sand inclusions	ICE				
95.1	95.5	0.4	-	-	-	-	-	N/A			
95.5	95.75	0.25	BH16-C026	0	0.3	SNOW and ROOTLETS		Rich	MS		
				0.3	3	SILTY SAND, trace GRAVEL	Nf/Nbn				
				3	4.3	SILTY SAND, trace GRAVEL	Nbn				
				4.3	4.6	ICE: Minor silt inclusions	ICE				
				4.6	5.8	SAND and SILT, trace GRAVEL					
				5.8	6.1	INFERRED BOULDERS					
				6.1	10.7 (EOH)	SILTY SAND, trace GRAVEL	Nf				
95.75	96	0.25	BH16-C027	0	0.6	SAND and GRAVEL: Peat	Nf	Rich	HS		
				0.6	1.15	SAND and GRAVEL	Nf				
				1.15	5.65	SILTY SAND, trace GRAVEL	Nf/Nbn				
				5.65	6.1	ICE	ICE				
				6.1	7.4	SILTY SAND, trace GRAVEL	Nf				
96	99.5	3.5	BH16-C028	0	1.5	SAND and GRAVEL, trace COBBLES	Nf	Poor	NS		
				1.5	6.1	SAND, with GRAVEL	Nf				
				6.1	10.7	SAND, trace SILT	Nf				
			BH16-C029	0	6.1	SILTY SAND	Nbn/Nf	Poor			
				6.1	7.6 (EOH)	BOULDERS					
99.5	102.5	3	BH16-C201	0	1.5	SAND, some GRAVEL, trace COBBLES		Poor	NS		
				1.5	2.4 (EOH)	ROCK					
			BH16-C202	0	0.3	TOPSOIL, SILTY SAND, with GRAVEL	Nf	Poor			
				0.3	3	SILTY SAND, with GRAVEL	Nf				
				3	4.6	Crushed COBBLES and BOULDERS					
				4.6	7.6 (EOH)	BOULDERS					
			BH16-C203	0	1.5	SILTY SAND, some COBBLES, trace BOULDERS	Nf	Poor			
				1.5	3	SILTY SAND, some GRAVEL	Nf				
				3	5.8	SILTY SAND	Nbn				
				5.8	6.1	BOULDER					
			BH16-C204	6.1	7.6	WEATHERED ROCK		Poor			
				0	0.2	PEAT, with SAND and GRAVEL	Nf				
				0.2	1.5	SAND and GRAVEL, trace COBBLES, trace BOULDERS	Nf				
				1.5	4.6	SILTY SAND, some GRAVEL, trace COBBLES	Nf				
			BH16-C205	4.6	9.1 (EOH)	INFERRED BEDROCK		Poor			
				0	1.5	SAND, with GRAVEL, some COBBLES, trace BOULDERS					
				1.5	4.6	GRAVELLY SILTY SAND					
				4.6	9.1 (EOH)	INFERRED BEDROCK					
			BH16-C030	0	1.5	SAND, trace GRAVEL	Nf	Ice Body			
				1.5	6.1	SAND, trace SILT, trace GRAVEL	Vc				
				6.1	12.2 (EOH)	ICE and SOIL	ICE				
				0	3	SAND and GRAVEL, some COBBLES	Nf				
			BH16-B013	3	4	SILTY SAND, some GRAVEL	Nf	Poor			
				4	6.1	SAND and SILT: Inferred COBBLES or BOULDERS					
				6.1	10.6 (EOH)	INFERRED SANDSTONE					
				BH16-B014	0	3	SAND and GRAVEL, some COBBLES			Nf	Poor
			3		7	SAND, with GRAVEL, trace COBBLES	Nf				
			BH16-B015	0	10.6	SILTY SAND, with GRAVEL, with COBBLES	Nf/Vx	Rich			
			BH16-B016	0	2.7	GRAVEL and SAND, some SILT, trace COBBLES	Nf	Ice Body			
				2.7	5.8	SAND	Nf				
				2.8	2.9	Ice lense	ICE				
				5.8	6.1	Ice lense	ICE				
				6.1	7.6	SAND, some GRAVEL, some COBBLES	Vx				
102.5	103.3	0.8	BH16-C206	0	1.5	SAND	Nf	Rich	HS		
				1.5	2.4	SILTY SAND, some GRAVEL	Nf				
				2.4	3	ICE, with Sandy SILT inclusions	ICE				
				3	4.6	SAND and GRAVEL	Vc/Vr				
				4.6	5.2	SANDY SILT, trace GRAVEL	Nbn				
				5.2	6.1	BOULDERS					
				6.1	7	SANDY SILT, trace GRAVEL					
103.3	103.75	0.45	BH16-C207	0	1.5	SAND and GRAVEL, some COBBLES	Nf	Rich	PS & NS		
				1.5	6.1	SAND, some GRAVEL, trace COBBLES	Vx				
				6.1	7.3 (EOH)	INFERRED BEDROCK					
			BH16-C031	0	1.5 (EOH)	SAND, trace GRAVEL	Nf	Poor			
103.75	104	0.25	BH16-C032	0	1.5	PEAT, with SAND and GRAVEL	Nf	Rich	HS		
				1.5	3	SILTY SAND, some GRAVEL	Nf				
				3	7	SILTY SAND and GRAVEL, trace COBBLES	Nf/Vc				
104	109.68	5.68	-	-	-	-	-	N/A			

TC 4 ATTACHMENT 1: CN ENGINEERING TRACK STANDARDS



**ENGINEERING
TRACK STANDARDS**

General

The maintenance standards and practices contained herein shall apply to all trackage and rights-of-way owned or operated by the Canadian National Railway and its North American affiliated railways (“the Railway” or “CN”), and are intended as guidelines and not meant to replace or supersede the Federal Railway Administration (FRA) Track Safety Standards or the Transport Canada (TC) Track Safety Rules.

These Standards do not impose any regulatory requirements.

Changes in Railway standards or practices that do not conflict with FRA or TC standards may be implemented on a phased schedule or program, at the Railway’s discretion.

Under the requirements of these Standards, and where appropriate, the Regional Chief Engineer may delegate his authority to a designated individual.

For the purpose of these Standards, the Senior Manager or Manager of Engineering are equivalent positions.

No new or modified material or equipment will be considered for use as a standard without first being subject to a service test, unless otherwise directed by the Chief Engineer Track.

No changes to these Engineering Track Standards, or issuance of Bulletins which modify or circumvent the instructions contained herein, will be allow without approval of the Engineering Standards group.

The most current FRA Track Safety Standards, the TC Track Safety Rules, and the CN Track Standards are located on the CNiNET at [Engineering Standards SharePoint Site](#). (Right click, open Hyperlink)

TABLE 1: CLASSES OF TRACK

Class of Track	Maximum Allowable Operating Speed For Freight Trains is:	Maximum Allowable Operating Speed For Passenger Trains is:
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90 ***

*** In Canada only: 95 MPH Passenger & 100 MPH for LRC Trains

THIS PAGE LEFT BLANK INTENTIONALLY

TABLE OF CONTENTS

<u>SECTION</u>	<u>DESCRIPTION</u>	<u>REVISED</u>
T.S. 1.0	RAIL	SEPT. 12, 2016
T.S. 1.1	ULTRASONIC INSPECTION OF USED RAIL	SEPT. 12, 2016
T.S. 1.2	JOINTS	SEPT. 12, 2016
T.S. 1.3	CONTINUOUS WELDED RAIL	SEPT. 12, 2016
T.S. 1.4	RAIL GRINDING WITH SELF-PROPELLED GRINDING MACHINES	SEPT. 12, 2016
T.S. 1.5	RAIL LUBRICATION AND FRICTION MANAGEMENT	SEPT. 12, 2016
T.S. 1.6	FIELD WELDING	SEPT. 12, 2016
T.S. 1.7	RAIL TESTING AND FREQUENCY	SEPT. 12, 2016
T.S. 1.8	BROKEN RAILS AND MOVEMENT OVER RAIL BREAKS	SEPT. 12, 2016
T.S. 2.0	TIMBER TIE INSTALLATION AND MAINTENANCE	SEPT. 12, 2016
T.S. 2.1	CONCRETE TIE INSTALLATION AND MAINTENANCE	SEPT. 12, 2016
T.S. 3.0	TIE PLATES	SEPT. 12, 2016
T.S.3.1	RAIL ANCHORS	SEPT. 12, 2016
T.S. 3.2	DERAILS	SEPT. 12, 2016
T.S. 3.3	RAIL FASTENINGS	SEPT. 12, 2016
T.S. 4.0	BALLASTING, SURFACING AND LINING	SEPT. 12, 2016
T.S. 5.0	TURNOUTS	SEPT. 12, 2016
T.S. 5.1	RAILWAY CROSSINGS AT GRADE	SEPT. 12, 2016
T.S.6.0	ROADWAY CROSSINGS	SEPT. 12, 2016
T.S. 6.1	INSPECTION & TESTING OF RAILWAY CROSSINGS WARNING DEVICES	SEPT. 12, 2016
T.S. 7.0	TRACK INSPECTION GUIDELINES	SEPT. 12, 2016
T.S. 7.1	TRACK GEOMETRY	SEPT. 12, 2016
T.S. 7.2	VEHICLE TRACK INTERACTION (V/TI) AND WHEEL IMPACTS	SEPT. 12, 2016
T.S. 8.0	MINIMUM TRACK CONSTRUCTION GUIDELINES	SEPT. 12, 2016
T.S. 8.1	TRACK CLEARANCES	SEPT. 12, 2016
T.S. 9.0	GUARD RAILS AND GUARD TIMBERS	SEPT. 12, 2016
T.S. 9.1	ROADBED AND DRAINAGE	SEPT. 12, 2016
T.S. 10.0	S & C COMMUNICATION SYSTEMS and BURIED UTILITIES	SEPT. 12, 2016
T.S. 11.0	FIRE PREVENTION	SEPT. 12, 2016
APPENDIX	SUPERELEVATION and Vmax TABLES	SEPT. 12, 2016

THIS PAGE LEFT BLANK INTENTIONALLY

T.S. 1.0 RAIL

1. Rail Definitions:

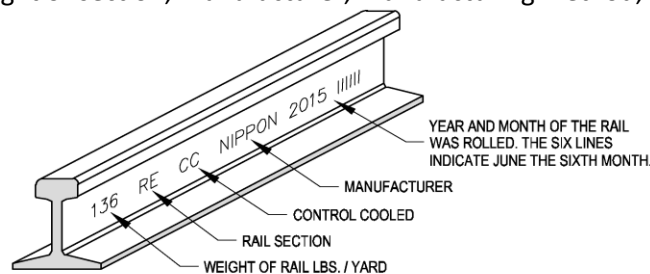
- New Rail: Rail that has not been in service.
- Part Worn (PW) Rail: Rail that has been in service and removed for any reason.
- Scrap Rail: Rail not to be used in any track due to wear, defect, damage or type.
- Gauge Wear: The reduction in rail head width on one side of the rail compared to the nominal rail section, measured 5/8" below the top of the rail head.
- Vertical Wear: The reduction in the total height of the rail compared to the nominal rail section, measured in the center of the head of the rail.

RAIL IDENTIFICATION

2. Rail branding is the raised letters and numbers along the web of the rail. Rail stamping is on the opposite side of the web and has indented letters and numbers.

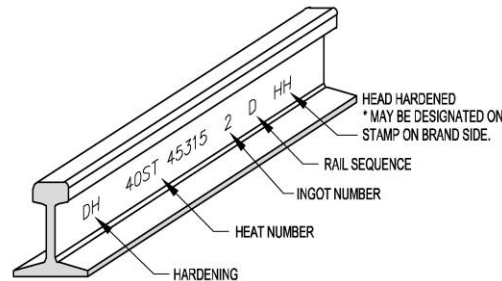
a. Branding identifies:

Rail weight or section, Manufacturer, Manufacturing method, Year and month rolled.



b. Stamping identifies:

Heat, ingot and rail sequence in manufacturing process.



3. The branding code in **TABLE 1** identifies the manufacturing process of rail:

TABLE 1

BRANDING	MANUFACTURING PROCESS
MACKIE, MRC or RC	Control Cooled
CC	Control Cooled
CH	Control cooled and end hardened
BC	Control cooled blooms

BRANDING	MANUFACTURING PROCESS
VT	Vacuum treated - Control Cooled
OP	Other Practices
OH	Open Hearth

4. Rail identified as alloy rail, with branding or stamping as in **TABLE 2**, **MUST NOT** be put back into track:

TABLE 2 ALLOY RAIL

MANUFACTURER BRANDING	STAMPING	CHEMISTRY
ALGOMA	Cr	Chrome
ALGOMA	CrV	Chrome / Vanadium
ALGOMA	CrVMo	Chrome/Vanadium/Molybdenum
CF&I	CROMO	Chrome /Molybdenum
CF&I	HI SI	High Silicon
Hayange (HAY)	SACILOR - CrSiV	Chrome/Silicon/Vanadium
Klockner - AL	Blank	Chrome / Vanadium
Krupp - AL	Blank	Chrome / Vanadium
Sydney (Pre 1976)	HS	High Silicon
Sydney (Post 1976)	CS	High Silicon
Sydney	SYSCO - CrCb	Chrome / Columbium
Sydney	SYSCO - CrMo	Chrome /Molybdenum
Sydney	SYSCO - CrSiV	Chrome/Silicon/Vanadium
Thyssen - AL	Blank	Chrome / Vanadium
Wheeling Pitt	WR	Chrome / Silicon

5. Rail manufactures and brands of non-alloy rails, shown below in **TABLE 3**, **can be reused in track**:

TABLE 3 NON – ALLOY RAIL

MANUFACTURER BRANDING	STAMPING	TYPE	MANUFACTURER BRANDING	STAMPING	TYPE
Algoma	Blank	SS	NIPPON	DH 340	HH
Bethlehem Steel	FT	FHT	NIPPON	DH 370	HH
Bethlehem Steel	HH	HH	NIPPON	HE 370	HH
Bethlehem Steel	MH	SS	NIPPON	HE 400	HH
British Steel	FT	HH	NIPPON	HEX	HH
CF&I	IS	HH	NKK	NHH	HH
CF&I	HH	HH	NKK	SP	HH
CF&I	DH 390	HH	NKK HH	Blank	HH
CF&I	IS	HH	PST (Penn Steel)	Blank	SS
CF&I	SS	SS	PST HH	Blank	HH
TZ (Czech)	IH	SS	RMSM, ERMS,EVRAZ	DH 390	HH
Colorado	Blank	SS	RMSM, ERMS, EVRAZ	SS	SS
Dominion	Blank	SS	RMSM, ERMS, EVRAZ	ISHH	IHHS

TABLE 3 Cont.

MANUFACTURER BRANDING	STAMPING	TYPE
Dosco	Blank	SS
HAY (Hayange)	Blank	HH
ILLINOIS	Blank	SS
INLAND	Blank	SS
ISG (INT'L STEEL)	Blank	SS
ISG HH	Blank	HH
KLOCKNER	Blank	SS
KRUPP	Blank	SS
Lackawanna	Blank	SS
MT (MITTAL USA)	Blank	SS
MT HH	Blank	HH

MANUFACTURER BRANDING	STAMPING	TYPE
RMSM, ERMS, EVRAZ	HCP	HH
RMSM, ERMS, EVRAZ	OCP	HH
RMSM, ERMS, EVRAZ	Blank	SS
SDI (Steel Dynamic)	Blank	SS
SYDNEY	Blank	SS
TATA	Blank	SS
TENNESSEE	Blank	SS
THYSSEN	HH	HH
THYSSEN	Blank	SS
Vilru	Blank	SS
WP (Wheeling Pitt)	MH	SS

6. Rail hardness is identified by branding or stenciling as shown in **TABLE 4**:

TABLE 4

BRANDING	RAIL HARDENING
Blank	Standard Strength
SS	Standard Strength
3HB	Standard Strength
IH	Intermediate Hardness

BRANDING	RAIL HARDENING
IHHS	Int. Hardness High Strength
HH	Head Hardened
FHH	Fully Hardened
DHH	Deep Head Hardened

GRADING PW RAIL:

7. Rail will be graded to determine the suitability for future use. Rail which is planned for removal and cascading to other relays will be graded by the Manager Track Quality. Rail removed for local use will be graded by the Track Supervisors for use in specific tracks. A qualified rail inspector will classify rail at rail yards.

CASCADE OF PW RAIL FOR RELAY:

8. Rail to be cascaded to another rail relay location will be classified into three categories. The rail must meet the wear in **TABLE 5** along with the following conditions:
- Secondary Main, siding or major yard lead – rail to be used on secondary mains and any siding will be free of running surface conditions such as checks, spalls, corrugation, engine burns or other conditions that could render it NTR.
 - Yard and Industry – Restricted to yards, back and industry track may have some running surface conditions.
 - Scrap – Rail beyond the maximum cascade wear of **TABLE 5**, or does not meet the rail surface conditions of the two classifications above. This rail will be considered scrap and marked with “SCRAP”, XXX or painted red.

TABLE 5 MAXIMUM VERTICAL WEAR LIMITS FOR RAIL TO BE CASCADED TO RELAY BY TRACK TYPE (mm)

Cascade Use	136#	132 #	115 / 119 127 / 130	100 RA & RE
Secondary Main, Siding or Major Yd Lead (5-15 MGT)	18	13	8	4
Yard and Industry (< 5 MGT)	20	15	10	7
Local Yard (< 1 MGT)	< 23	< 19	< 16	<10
SCRAP	23	19	16	10

Rail generated from curve relays or is less than 100 RA or RE will not be consider for cascade to relay programs.

PLUG RAIL:

9. The Track Supervisor can save select rail from rail relays for suitable plug rails.
10. Rail used for replacement or plugs in main tracks and controlled sidings will:
 - a. Be a grade equal to, or better than, the parent rail.
 - i. The following rail chemistries must not be reinstalled on any main track or controlled siding unless authorized by the Region Chief Engineer:
 - a. British, Workington, Vilru or Bethlehem FT.
 - b. Any of the alloy rails listed in **TABLE 2**.
 - c. "A" rails (rails with the letter "A" in the heat number)
 - b. Be UTT tested, measured for rail wear and marked per T.S. 1.1 – ULTRASONIC INSPECTION OF USED RAIL – Section 3.
 - i. All PW rail that is saw cut will have the exposed ends tested for longitudinal defects with dye penetrant (DP).
 - a. DP kits include cleaning solvent, Dye Penetrant Spray and Developing Spray.
 - b. Clean saw cut face with solvent if required.
 - c. Apply Dye Penetrant Spray to face of rail and let it stand for approximately 5 minutes, then wipe it off.
 - d. Shake Developer Spray for approximately 1 minute and apply to the rail face. Let dry.
 - e. Red lines or spots showing through the white developer will indicate defects.
 - f. Keep DP kit warm during cold weather for best use.
 - g. The rail will be marked "DP", in 2" white paint marker, on the web at each end tested. Rail installed which has not been dye penetrant tested will be restricted to 10 MPH until dye penetrant testing is complete or the rail is ultrasonically inspected.

- c. Have gauge face and vertical head wear mismatch within maximum allowable limits of **TABLE 6**.
- 11. A plug rail of a different grade may be installed **ONLY** on a **temporary** basis and not welded into track. The temporary plug rail must be **removed within 180 days (6 months) of installation** and replaced with a plug rail meeting the criteria of item 6, above.
- 12. When vertical or gauge mismatch exceeds 3 mm (1/8"):
 - a. Promptly repair by proper taper grinding, welding or replacing the rail.
 - b. Until repairs are made, limit operating speed over rails per **TABLE 6**:

TABLE 6 MAXIMUM ALLOWABLE TOP AND GAUGE MISMATCH

CLASS OF TRACK	MAXIMUM TOP MISMATCH	MAXIMUM GAUGE MISMATCH
1	1/4" (6 mm)	1/4" (6 mm)
2	1/4" (6 mm)	3/16" (4.5 mm)
3	3/16" (4.5 mm)	3/16" (4.5 mm)
4 & 5	1/8" (3 mm)	1/8" (3 mm)

- 13. In the case of emergency, torch cutting of rail is allowable provided:
 - a. The torch cut is relatively smooth.
 - i. Movements over the torch cut rail are limited to 10 mph and supervised by a qualified employee with established communication with the movement.
 - b. That within 30 minutes of torch cutting, the rail is trimmed with a rail saw at least ¼" (6 mm) back from the torch cut and DP tested.
 - c. That if after 30 minutes, or a train has been allowed to pass over the torch cut rail, the rail must be trimmed a minimum of 4 inches back from the torch cut and DP tested.
- 14. When cutting rail, the saw cut must be made:
 - a. With a saw properly secured to the rail.
 - i. Hand held gas or hydraulic abrasive saws use 16 inch cut off wheels.
 - ii. Retro fit kits to convert 14" wheels to 16" wheels are available.
 - b. Square and perpendicular to the rail axis with a variation not to exceed 1/8" (3 mm) and all burrs removed.
 - c. Centered in the crib, if possible, at least 4 inches (102 mm) from the side of the tie.
 - d. No closer than 3 feet (914 mm) to a plant weld or field flash butt weld.
 - e. No closer than 6 feet (1,829 mm) to a thermite weld.
 - f. If a field or flash butt weld is being cut out, make cut at least 3 inches (76 mm) away from the weld to remove the heat affected zone.
- 15. When installing replacement rail, every effort must be made to eliminate existing welds or bolt holes.
- 16. Replacement rails should be planned so as not to have a multitude of field welds clustered together. There should be no more than 4 field welds on the same rail per 39 feet of track.

17. Rail used in main track must not be:
 - a. less than 12 feet (3,658 mm) in tangent track.
 - b. less than 19' 6" (5,944 mm) in curved track.
18. Rail must not be struck with a spike maul, steel hammer or similar tool.
19. Rail should not be transposed in main track with an annual tonnage greater than 10 MGT. In locations where it has been deemed acceptable, the high rail may be transposed to low side. **In no case will the low rail be transposed to the high side of the curve.**
20. Rail with vertical wear as indicated in "Vertical Wear Requiring High Clearance Joint Bars" of **TABLE 7A**, high clearance joint bars must be used on the gauge side of the rail.

TABLE 7 A REQUIREMENTS FOR HIGH CLEARANCE JOINT BARS (mm)

RAIL WEIGHT	140 141	124 136 155	132 152	110 / 112 115/119 130 HF	113	100 115	90 100 HF	85 or less
Vertical Wear Requiring High Clearance Joint Bars	17	14	10	8	7	7	6	5

21. **TABLE 7B** identifies the wear limits when rail should be removed from track. If rail is worn beyond the limits in **TABLE 7B**, and is to be left in track, the Assistant Regional Chief Engineer or designate must be notified. A speed restriction may be placed and additional inspection frequency specified at the discretion of the Regional Chief Engineer. Condition of rail (shells, spalls, corrugation, etc.) must also be taken into consideration.
 - a. If the rail is on a bridge, overpass, turnout, return curves of turnouts, or in a tunnel, the wear limits are only 75% of the wear limits shown in **TABLE 7B**.

TABLE 7 B: MAXIMUM ALLOWABLE RAIL WEAR (mm)

RAIL WEIGHT	140 141	136 CORE See Note	124 136 155	132 152	110 / 112 115/119 130 HF	113	100 105	90 100 HF	85 or less
Maximum Vertical Wear Limits	26	20	23	19	16	13	10	6	5
Maximum Gauge Face Wear Limits	16	16	16	16	16	13	13	11	8
Maximum Combined Wear Limits Vertical + Gage Wear	32	28	28	24	21	17	14	11	8

NOTE: Core Main Track is the primary routes from Vancouver and Prince Rupert to Edmonton and east to Halifax, plus Winnipeg to New Orleans and Chicago to Sarnia to Toronto, also, the Camrose, Three Hills, Missabe, Bluford, Chiles, Beaumont, Baton Rouge and Hammond Subdivisions.

22. Rail on curves at approximately 75% of the wear limits shall be monitored and measured quarterly.
 - a. Measure at least 3 locations throughout the curve.
 - b. The locations should be roughly 400' - 600' apart (shorter spacing for short curves).
 - c. Mark the rail at the measurement points to ensure repeatability.

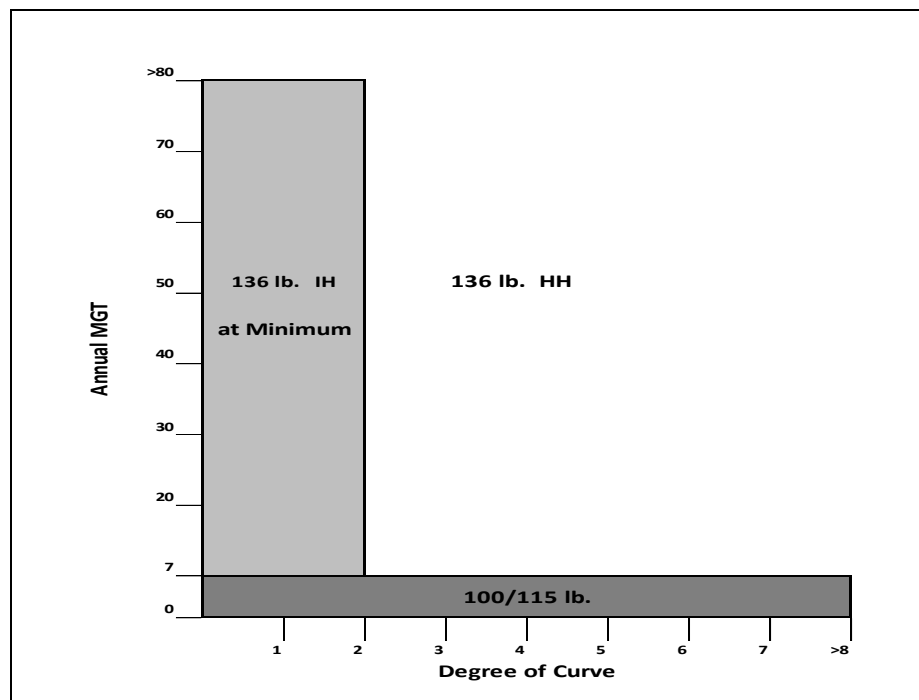
23. **TABLE 8** identifies the maximum allowable vertical rail base offset for welding joints.

TABLE 8			
RAIL WEIGHTS	100 lb. or Less	112 / 115	132 lb or Greater
THERMITE WELDS			
Standard Weld Kit or kit with equal wear	Up to 3 mm	Up to 3 mm	Up to 3 mm
Weld Kit with Sloped Base Plate	Not Allowed	3 - 5 mm	3 - 5 mm
FLASH BUTT WELDS			
Standard Flash Butt Weld	3 mm	3 mm	3 mm
Grind ball to taper over 36"	Not Allowed	2mm ball / 3 mm base	2mm ball / 3 mm base

NOTE: Vertical offsets greater than 5 mm require the use of a transition rail.

24. Rail selection for relay programs will be in accordance with the Rail Usage Guidelines in **TABLE 9**.

TABLE 9: Rail Usage Guidelines



HANDLING RAIL:

25. Rail should be unloaded by a crane with magnets, approved rail grapples or tongs, skids or threaders. Rail must not be dropped. Approved rail grapples are listed on the CN Work Equipment – Safety and Bulletins website.
26. Rail must be center marked to balance the lift. Tag lines will be used when lifting rail with tongs.
27. When rail is unloaded and is a walking hazard it shall be covered by a General Bulletin Order.

28. See T.S. 1.3 CONTINUOUS WELDED RAIL for instructions on unloading CWR.
29. Prior to rail being loaded, either as CWR or jointed, the following detected defects should be removed:

Transverse Fissure, Compound Fissures, Detail Fractures,
Engine Burn Fractures, Bolt Hole Cracks, Vertical Split Head,
Horizontal Split Head, Split Web, Head Web Separation, Piped Rail, Defective
Welds, No-Test Rail (NT)

30. Rail loaded in gondolas with tongs for reuse should be:
- a. Loaded with the rail standing upright and orderly.
 - b. Loaded to the capacity of the car or less. The 70 ton gondola capacity, by rail section, is per the **TABLE 10**:

TABLE 10 RAIL CAPACITY OF 70 TON GONDOLAS

136 #	132 #	115 #	90 #
3,154 LF	3,250 LF	3,680 LF	4,650 LF

31. When loading rail on flat cars for movement only by Engineering equipment (Brandt truck, car mover, etc. and restricted to a maximum 15 MPH.):
- a. Cars must have decks that are suitable, clean and roughly at the same height.
 - b. The maximum length of a rail to be moved is 250 feet.
 - c. The rail shall be loaded standing upright and orderly.
 - d. Place at least 3 hardwood side stakes per side per car;
 - i. extending at least one foot below the stake pocket.
 - ii. tall enough to fully engage the rail.
 - iii. rail must extend at least 3 feet beyond the side stakes at each end of the car.
 - e. Place 1 inch by 3 inch wood strips between the layers of rail.
 - f. Load rail in tapered layers with one less rail per side than the layer below.
 - g. Leave at least 2 feet of buffer from the end of the car to the end of the rail.
 - h. Use tie down straps that are 4 inch wide polyester with ratchet winches.
 - i. Use a minimum of 3 straps per car.

MARKING and STACKING RAIL

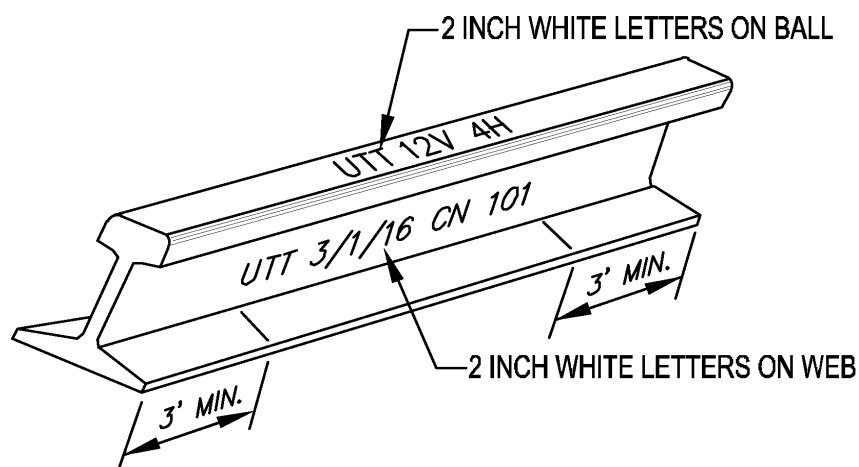
32. Rail placed in storage locations will be marked with 2" high white letters and numbers identifying weight, wear, testing information and scrap status.
33. A white paint crayon, such as a Markal B Paintstik, works well in all conditions providing durable marking. When marking for reference or match marks, a fiber tip paint marker works best. Do not use lumber crayon or chalk.

34. Marking written on rail in track should, when possible, be on the field side web of the rail.
35. See T.S. 1.1 ULTRASONIC TESTING of USED RAIL, Section 3 for marking rail.
36. Scrap rail will be marked with “SCRAP” or multiple “X X X” marked along the rail, or painted red. Some portions of a rail may be reusable, so a cut mark should be placed on the ball of the rail and the unusable portion marked as scrap.
37. Rail to be reused locally will:
 - a. Be center marked for lifting.
 - b. Have the last RFD date and estimated tonnage since the test, if known, written on the web of the rail.
 - c. Have the vertical and gauge wear values written on the ball of the rail.
 - d. Be neatly stacked, by rail section and metallurgy. In material storage yards, clearly identify each rail stand with signs for each. For rail stands along the right of way, ensure the area allows accessibility year round but doesn’t interfere with operations.
 - e. Rail which has not been UTT tested must be segregated from rail which has been tested or is planned to be scrapped. If required, space rail adequately to allow for UTT testing.

THIS PAGE LEFT BLANK INTENTIONALLY

T.S. 1.1 ULTRASONIC INSPECTION OF USED RAIL:

1. Ultrasonic testing, or UTT, will be performed on:
 - a. All rail on main tracks including associated crossovers and sidings.
 - i. Any rail without UTT and a date written on the web of the rail must be considered as having not been tested. If installed, it must be restricted to no more than 10 MPH until tested.
 - b. All used rail purchased from outside parties.
 - c. Rail removed from track prior to reinstallation. See Section 5, below.
2. A qualified person will perform the UTT inspection of rail.
3. Rail to be tested out of track will:
 - a. Be segregated from rail which has already been tested or rail identified as scrap.
 - b. Be placed flat with ample room between rails to allow testing.
 - c. Be brushed to remove rust, scale or dirt if required for testing.
 - d. Be tested with a portable testing unit over the entire rail. Rail ends will be tested with a hand unit.
 - e. Have the following marked on the rail in 2 inch letters using white paint stick or marker:
 - i. UTT / Date of Test / Testing unit number or, if required, either the word SCRAP or "XXX".
 - ii. Vertical and horizontal wear measurements in millimeters.
 - iii. Rail will be marked on both the web and the ball per T.S. 1.0. – RAIL, MARKING and STACKING RAIL.



- f. Have all defects marked for removal and:
 - i. All rail identified as “A” rail will be marked as yard use or scrap.
 - ii. All rail identified as alloy rail per T.S 1.0 RAIL, TABLE 2 will be marked as scrap.
 - iii. Rail worn beyond the allowable limit(s) of T.S. 1.0 RAIL, TABLE 7B will be marked as scrap.
 - iv. All rail with running surface conditions rendering the rail as “No Test” will be marked as scrap.
 - v. All rails with longitudinal defects will marked as scrap.
- 4. Rail which has been removed from track due to a defect that was found by ultrasonic inspection may be reinstalled in track or placed on rail racks for reuse once:
 - a. The defect has been removed from the rail.
 - b. The rail is marked with the UTT identification as outlined in Section 3, above.
- 5. Rail removed from track will:
 - a. When possible, as part of a relay, have the date of the last known UTT inspection written on the rail immediately prior to removal from track.
 - b. Be tested and marked per section 3 above if being sent to an outside party for welding.
 - c. Be allowed to return to track, without speed restriction if:
 - i. Less than 10 MGT has passed over the rail since the last UTT test, and
 - ii. The rail is marked per section 3, above.
 - d. Be considered as having not been UTT tested if there is more than 10 MGT accumulation prior to removal from track since the last test. Such rail will be handled per section 1 and 3, above.
- 6. Rail removed from sidings, crossovers or connections, with unknown accumulated tonnage since the last UTT inspection, but within 90 days of the last UTT inspection may be reinstalled in track. The rail must be marked per section 3 above.
- 7. If a piece of rail was cut from a longer tested piece, ensure all markings per section 3 are written on the remaining rail and / or the piece of rail being used plus the initials of the person transferring the information.
- 8. Used rail purchased from outside parties, will have UTT information or applicable certificates forwarded to the Manager of Rail Testing prior to installation.

T.S. 1.2 JOINTS

1. Joints are considered as either permanent or temporary.
 - a. Permanent joints must be fully drilled and bolted, and in CWR, must have every tie box anchored for a minimum of 200 feet in each direction.
 - i. Where required, 5 ¾" pin brazing head bonds will be applied at non – insulated bolted rail joints.
 - b. Temporary joints are joints which are expected to be removed from track, or are joints intended to be welded. In CWR, drilling for temporary joints will have all holes drilled except the bolt holes nearest to the rail end.
 - i. In the U.S., joints installed during a CWR relay, must within 60 days:
 - a. Be welded, or
 - b. Drill rail and install 6 bolts in the joint, or
 - c. Be box anchor every tie 200 feet in each direction.
 - ii. In Canada it is required that prior to the onset of winter, joints in CWR track that are not welded will have the rail drilled and secured with 6 bolts.
 - iii. Where required, use 16" pin brazing head bonds at rail joints scheduled to be thermite or flash butt welded. Bond will be attached no closer than 7" to the rail end.
2. Joints are defined as supported or suspended:
 - a. A supported joint has the center of the joint located over a tie plate. Supported joints cannot be welded without moving the tie.
 - b. Suspended joints have the center of the joint located between the ties.
3. When jointed rail is installed, stagger of joints should be 12 feet (+/- 2 feet), but will not be evenly staggered when installed as 39 foot lengths.
4. When laying bolted rail or track panels, an expansion gap must be provided by shimming between rail ends per **TABLE 1**. Shims remain until the rail is spiked, anchored and bolts tightened.

TABLE 1

Expansion Gap	33 ft Rail	39 ft Rail	78 ft Rail
	Rail Installation Temperature (°F)		
5/16" (8 mm)	Below 10	Below 6	Below 35
1/4" (6 mm)	10 to 14	6 to 25	35 - 47
3/16" (5 mm)	15 to 34	26 to 45	48 - 60
1/8" (3 mm)	35 to 59	46 to 65	61 - 73
1/16" (2 mm)	60 to 85	66 to 85	74 - 85
None	Above 85	Above 85	Above 85

5. Rail joints should:

- a. Not be installed closer than 20 feet from the edge of a road crossing.
- b. Not be installed closer than 20 feet from the backwall of an open deck bridge on the approach.
- c. Not be installed closer than 4 feet from the backwall of an open deck bridge on the bridge.
- d. Be tightened before the rail is spiked.
- e. Be slotted to prevent flowing or chipping.
- f. Be matched to a different rail size with:
 - i. Compromise rails of the correct sections, or
 - ii. Compromise welds, or
 - iii. Compromise joints of the correct design.
- g. When secured to wood ties with spikes, have spikes driven so spike heads hold the toe of the joint bar. On insulated joints, the spike head should be turned away from the joint bar.
- h. When secured with elastic fasteners, see T.S. 3.3 – RAIL FASTENINGS for the correct clip and insulator for both conventional and insulated joints.

6. Rail ends will:

- a. Have the existing older rail end built up by welding if abutting new rail.
 - i. Joints to be thermite or butt welded will not be built up.
- b. Have excessive flow removed by grinding or end batter repaired by welding, or
- c. Have mismatch in excess of 1/8" on top or gauge side of rail repaired by welding or grinding. Until mismatch is corrected, speed will be reduced per **TABLE 2**.

TABLE 2 MAXIMUM ALLOWABLE TOP AND GAUGE MISMATCH

CLASS OF TRACK	MAXIMUM TOP MISMATCH	MAXIMUM GAUGE MISMATCH
1	1/4" (6 mm)	1/4" (6 mm)
2	1/4" (6 mm)	3/16" (4.5 mm)
3	3/16" (4.5 mm)	3/16" (4.5 mm)
4 & 5	1/8" (3 mm)	1/8" (3 mm)

7. In conventional jointed track, each rail shall have at least two bolts at each joint in track Class 2 through 5. In Class 1 track, each rail will have at least one bolt per joint.
8. CWR, in all track classes, will have each rail end drilled and bolted with at least two bolts.
9. Bolt holes will be located using the correct index bar for the rail section.
 - a. Place the tip of the index bar even with the end of the rail. Do not split the gap between rails with the index bar.
 - b. Bolt holes will not be located using a tape measure.
 - c. Drilling through joint bars is not allowed.
10. Drill bits must be continuously lubricated with water while drilling rail. In cold weather conditions, water may be mixed to prevent freezing. Do not throw snow on bits or holes.
11. Joint bars must be inspected prior to installation for cracks or damage.
12. Only the correct joint bar for the rail section will be used.
13. Joint bars, including compromise bars, must not be field modified from the original design.
14. The joint bar must be installed centered on the gap of the rail joint.
 - a. All rust, dirt, etc will be removed from the joint area before applying joint bars.
15. New track bolts of the correct size will be used to assemble the joint. The bolts nearest the center of the bar will be tightened first and the joint bar will be seated properly into the web of the rail by striking the side of the bar with a sledge hammer. Then tighten the second bolts from the center and the third bolts if required.
16. Tighten bolts using hand or impact wrenches to the following torque values:

TABLE 3

Size of Bolt (In.)	7/8	1	1 1/8
Torque (ft-lb)	375	490	705

17. Rail flow at the bottom of the rail head, especially in curves, may need to be ground off prior to installing joint bars. Joint bars must not be ground.
18. High clearance joint bars may be required due to vertical rail wear. See T.S. 1.0 RAIL TABLE 7A for the wear limits required for these bars.

19. Any joint bar found to be cracked or broken **between the middle two bolt holes**, or any insulated joint found to be defective, must be replaced immediately. Closely inspect the matching joint bar for cracks and replace if needed.
20. In Class 3 track and above:
 - a. Joint bars that are cracked or broken must be replaced as soon as possible.
 - b. Joint bars which are worn or allow vertical movement of the rail after the bolts are tightened must be replaced as soon as possible.
21. When track panels, 39 feet long or less, are installed with three or more square joints, limit speed to Class 3.

COMPROMISE JOINTS, RAILS and WELDS:

22. Compromise joint bars are handed sets and consist of one gauge and one field side bar per set. To determine the size and hand of the joint bar, view the joint, as if standing in the track, facing the center of the joint. The right hand joint will have the heavier rail to the right and the left hand joint will have the heavier section to the left. Each bar will have the rail section stamped on each side along with the hand and gauge / field mark. Ensure the correct joint bar is applied to the corresponding location on the joint.
23. Compromise joints (100/115# or 115/136#) are not permitted on main tracks with speeds higher than Class 2 or where tonnage exceeds 10 MGT annually.
24. Compromise joints, except 132/136#, must not be installed:
 - a. In or within 20 feet of a turnout.
 - b. On or within 20 feet of an open deck bridge.
 - c. In a highway or railroad crossing.
25. Compromise joints are permanent joints that are not intended to be welded, therefore, all bolt holes will be drilled and all bolts installed.
26. Compromise joints will be painted blue annually and inspected monthly.
27. Compromise rails consist of a single piece of rail forged to transition from one section to another. Determination of the hand of a compromise rail is the same as the compromise joint. Ensure the gauge marking of the rail is always toward the centerline of the track.
28. The center of the compromise joints or compromise rails must be centered in a crib to allow full support of a sound tie on either side.
29. Compromise welds are not allowed in tracks:
 - a. Carrying Hazmat/DG or passenger service.
 - b. Handles 10 MGT or more annually.

- c. Class 3 or above.

INSULATED JOINTS:

- 30. Insulated joint types and usages are:
 - a. Bonded plug (glued) – for use in CWR track.
 - b. Encapsulated (coated or poly) – for use in jointed track.
 - c. Fiber – for use in light rail sections. Fiber insulated joint bars in main track or controlled sidings are forbidden.
 - i. Fiber insulated joint bars found in main track, controlled sidings and heavily used switches or leads from the main must be removed and replaced with a different type of insulated joint.
 - ii. Fiber insulated joint bars found to be delaminating must be replaced immediately.
- 31. S & C personnel must advise track personnel of the correct location of insulated joints for proper signal operation. The location must not change or vary from standard without the approval of the Signal Supervisor.
- 32. The proper stagger of insulated joints is 2 cribs (approximately 3' - 4") unless otherwise instructed.
 - a. The end post of the joint must be located at the center of the crib, unless:
 - i. The joint cannot be suspended, then a specifically designed insulated tie plate must be used under the center post, or
 - ii. The joint is specifically designed to be centered on a tie and a special tie plate is installed under the center post.
- 33. When fabricating insulated joints in the field:
 - a. Saw cut rail ends must be perpendicular and be dye penetrant tested.
 - b. Rail drilling per Item 9, above.
 - c. Rough burrs on rail ends and bolt holes will be removed and filed smooth.
 - d. Batter at rail end not to exceed 1/32 inch (0.75 mm).
 - e. Height of adjacent rails shall not differ by more than 1/16 inch (1.5 mm).
 - f. Rust, dirt, scale, etc will be removed from the joint area before applying bar.
 - d. Trim end post even with the running surface to 1/8 inch (3 mm) below the running surface.
- 34. Insulated joints no longer needed in track must be removed.

35. When glued insulated joints have broken the bond and pulled open or have experience broken bolts, the joint should be replaced. Poly coated bars may be installed as a temporary repair , but when installed in Class 3 track and higher, must be replaced with glued joints within 90 days.

WRAP or WELD REPAIR BARS:

36. Wrap or weld repair bars are only to be used to temporarily bolt around a broken rail, or failed or suspect weld. See “T.S. 1.8 – TABLE 1: Supervised Movement over Rail Breaks” for usage instructions.

EXPANSION JOINTS:

37. Sliding or expansion joints will be used as directed by the Chief Engineer Bridges and Structures. See T.S. 3.1 RAIL ANCHORS for details.

INSPECTIONS:

38. Reference T.S. 7.0 TRACK INSPECTION GUIDELINE for joint bar inspection instructions.

T.S. 1.3 CONTINUOUS WELDED RAIL (CWR)

DEFINITIONS

1. The following definitions pertain to CWR:
 - a. “Continuous Welded Rail “(CWR) is rail that is welded into lengths exceeding 400 feet.
 - b. “Rail Laying Temperature” (RLT) is the actual rail temperature at which the CWR is laid.
 - c. “Rail Neutral Temperature” (RNT) is the temperature at which the rail is neither in tension nor compression.
 - d. “Preferred Rail Laying Temperature” (PRLT) is the target installation temperature of welded rail in a particular area per **TABLE 1**.
 - e. “Preferred Rail Laying Temperature Range” (PRLTR) is the PRLT plus 25°F (13° C).
 - f. “Temperature Differential” is the difference between the PRLT and the rail temperature taken at the time of installation.
 - g. “Match Marks” are marks made from the base of the rail, in a straight line, to the top of a tie plate on an unanchored tie.
 - h. “Reference Marks” are a pair of vertical lines, each placed approximately 3 feet away from a joint or planned rail cut, at opposing ends of a rail repair.
 - i. “Procedures for the Installation, Adjustment, Maintenance and Inspection of CWR as required by FRA 49 CFR 213.18. Dated Dec. 16, 2015” is the document filed with the FRA and to be used in the U.S. only

TABLE 1 **PREFERRED RAIL LAYING TEMPERATURE BY REGION**

REGION	PRLT
Eastern and Western Regions (Except for Ashcroft & Yale Subs)	90°F (32°C)
Ashcroft and Yale Subdivisions use:	95°F (35° C)
Southern Region (Except for Track North of Parkland, MP 454 Superior Subdivision)	105° (F)
All Track North of Parkland, MP 454 Superior Subdivision, use:	100° (F)

AMBIENT TEMPERATURE VS. RAIL TEMPERATURE RELATIONSHIP

As a guideline, on a sunny day, the rail temperature can be 30° F, or 17° C, warmer than the ambient temperature. Cloud cover, wind and precipitation can reduce this difference.

HANDLING and UNLOADING.

2. When unloading CWR:
 - a. Place rail as close to the location of installation as possible.
 - i. Coordinate rail support over bridges with B&S Supervisor.
 - b. When practicable, unload rail 6 feet or more from the centerline of track.
 - c. Separate and offset rail ends to allow by-pass if the rail expands.

- d. Minimize the number of cuts in a string.
 - i. Bury rail through road crossings where possible.
 - ii. If unable to unload over bridges, through tunnels or at turnouts, unload rail adjacent to the location for positioning at the time of the relay.
 - e. Secure remaining rail on train prior to moving to a new location.
3. When moving or dragging lengths of CWR:
- a. Maximize the use of rail dollies to prevent damage to rail and track structure.
 - b. If dragging on the track:
 - i. Place blocking to prevent impacting switch components or road crossings.
 - ii. Inspect damage to spikes, anchors or clips behind the movement, especially in curves, cause by the rail.
 - iii. Before dragging rail, see T.S. 11.0 FIRE PREVENTION Section 16 and 17.

INSTALLATION

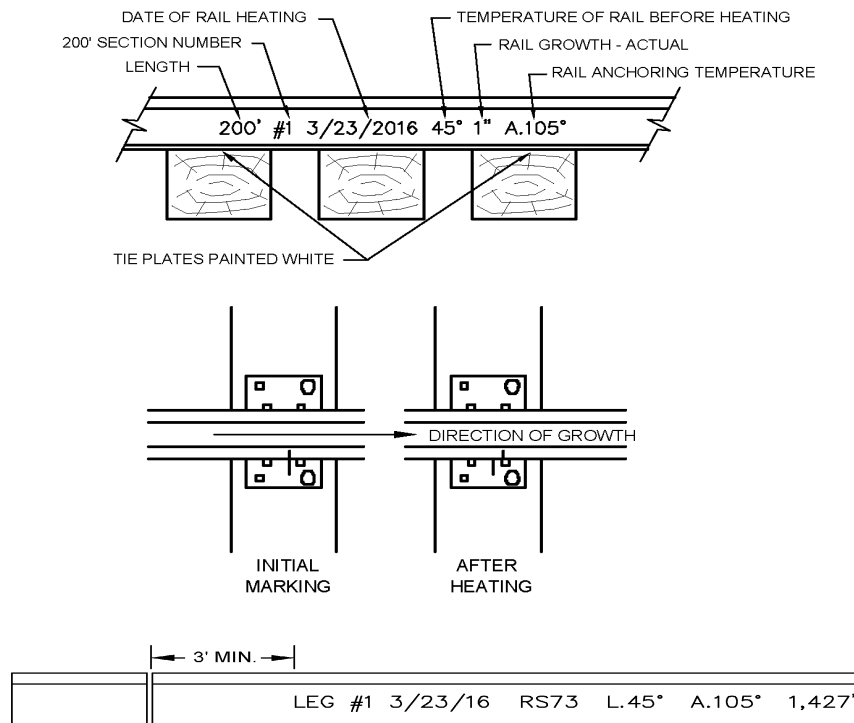
4. The Manager Track Quality will:
- a. Determine the type of rail to be installed per T.S. 1.0-RAIL.
 - b. Determine the tie plates to be used on wood tie track per T.S. 3.0-TIE PLATES.
 - i. Adzing requirements will be determined based on tie plate use and tie condition.
 - c. Determine rail anchor and spike requirements based on T.S. 3.1-RAIL ANCHORS and T.S. 3.3-RAIL FASTENERS, respectively.
5. In preparation for a rail relay, CWR may be left in track between the running rails provided:
- a. The CWR does not sit higher than 1 inch above the top of the running rail.
 - b. Deflectors are placed at each end of the rail.
 - c. Ends of CWR are bypassed and spiked to allow expansion.
 - d. CWR may be left between the running rails only until the next day's work shift.
6. CWR will not end on, or within 200 feet, of an open deck structure.
7. When installing CWR:
- a. Each spike hole of the tie will be plugged, preferably with chemical plugging compound.
 - b. Cribbing will be only to the extent that anchors can be applied.
 - c. Ties will be adzed only to the extent required to produce a flat surface for the tie plate.
 - d. Rail will be heated, or expanded, and anchored within the PRLTR.
 - e. Rail will be gauged and spiked to 56 ½" on all tracks up to 14° curves:

TABLE 2 GAUGE WIDENING FOR CURVES

Degree of Curve	14° - 16°	16° - 18°	Above - 18°
Installation Gauge	56 5/8"	56 3/4"	56 7/8"

8. Monitoring the movement of rail when installing CWR:

- a. Prior to making the first cut, or breaking a joint of a previous day's relay, place a match mark from the base of the rail that will remain in track to an unanchored tie plate.
- b. Measure the rail temperature and length of the rail to be installed.
- c. Determine the total expansion required from the table of **APPENDIX A** based on the difference between the PRLT and the current rail temperature.
 - i. All previous temperature markings on the rail must be painted over.
 - ii. Place match marks at 200 foot intervals
 - iii. Write the distance (usually 200 foot stationing), distance interval, date, pre-heat rail temperature, rail movement at the 200 foot station and rail anchoring temperature at each station.
 - iv. String (leg) number, relay date, gang number, pre-heat rail temperature, anchored temperature, and string length will be written at the end of each string and reported to TIS.



- d. Expansion may be accomplished through heating the rail or the use of rail expanders.
 - i. Use rail vibrators or tap the tie plates to assist rail movement.
 - ii. On concrete tie track, monitor heat to avoid damaging pads or insulators.
 - e. Rail anchors or clips must be installed immediately behind the rail heater at the PRLT.
 - i. Rail anchored within the PRLTR will not require further adjustment.
 - ii. Rail anchored below the PRLT must be adjusted or protected before hot weather.
 - a. If CWR is installed at a temperature more than 40°F (22° C) below the PRLT, track will be speed restricted to 40 MPH prior to the rail temperature reaching the PRLT.
- 9 . CWR will be anchored in accordance with T.S. 3.1-RAIL ANCHORS.
10. Trains may operate over unanchored CWR provided the Foreman instructs the movement:
- a. Limiting operating speed to no more than 10 MPH, and
 - b. With clear instructions to crew to avoid sudden brake applications through or near the work location.
11. CWR will be fastened to ties per T.S. 3.3 – RAIL FASTENINGS.
12. Upon completion of the day's production:
- a. Rail will be anchored or clipped per standard.
 - b. All joints which are not welded that day will be drilled and bolted with at least two bolts per rail end. If joints are permanent joints, then fully drill and bolt joint. Permanent joints must have every tie box anchored a for minimum of 200 feet in each direction.
 - c. Ties will be spiked with a minimum of two rail holding spikes, one field and one gauge, per tie plate. The gang must return to spike to the standard pattern.
 - d. Transitions to existing rail will have vertical and gauge mismatch appropriate for the class of track. Install compromise / transition rails or bars as required.

APPENDIX A**Continuous Welded Rail Thermal Expansion Chart**

Temperature Differential from PRLT ° F	Length of Unrestrained CWR (ft.)							
	200	400	600	800	1000	1200	1400	1482
	CWR Movement (in.)							
5	1/8	1/8	1/4	3/8	3/8	1/2	1/2	5/8
10	1/8	3/8	1/2	5/8	3/4	1	1 1/8	1 1/8
15	1/4	1/2	3/4	1	1 1/4	1 1/2	1 5/8	1 3/4
20	3/8	5/8	1	1 1/4	1 5/8	1 7/8	2 1/4	2 3/8
25	3/8	3/4	1 1/4	1 5/8	2	2 3/8	2 3/4	3
30	1/2	1	1 1/2	1 7/8	2 3/8	2 7/8	3 3/8	3 1/2
35	1/2	1 1/8	1 5/8	2 1/4	2 3/4	3 3/8	3 7/8	4 1/8
40	5/8	1 1/4	1 7/8	2 1/2	3 1/4	3 7/8	4 1/2	4 3/4
45	3/4	1 1/2	2 1/8	2 7/8	3 5/8	4 3/8	5	5 3/8
50	3/4	1 5/8	2 3/8	3 1/4	4	4 3/4	5 5/8	5 7/8
55	7/8	1 3/4	2 5/8	3 1/2	4 3/8	5 1/4	6 1/8	6 1/2
60	1	1 7/8	2 7/8	3 7/8	4 3/4	5 3/4	6 3/4	7 1/8
65	1	2 1/8	3 1/8	4 1/8	5 1/4	6 1/4	7 1/4	7 3/4
70	1 1/8	2 1/4	3 3/8	4 1/2	5 5/8	6 3/4	7 7/8	8 1/4
75	1 1/4	2 3/8	3 5/8	4 3/4	6	7 1/4	8 3/8	8 7/8
80	1 1/4	2 1/2	3 7/8	5 1/8	6 3/8	7 5/8	9	9 1/2
85	1 3/8	2 3/4	4 1/8	5 1/2	6 3/4	8 1/8	9 1/2	10 1/8
90	1 1/2	2 7/8	4 3/8	5 3/4	7 1/4	8 5/8	10 1/8	10 5/8
95	1 1/2	3	4 1/2	6 1/8	7 5/8	9 1/8	10 5/8	11 1/4
100	1 5/8	3 1/4	4 3/4	6 3/8	8	9 5/8	11 1/4	11 7/8
105	1 5/8	3 3/8	5	6 3/4	8 3/8	10 1/8	11 3/4	12 1/2
110	1 3/4	3 1/2	5 1/4	7	8 3/4	10 1/2	12 3/8	13
Movement (in) = Rail Length (ft) X Temp Diff From PRLT (F) X 0.00008								

MAINTENANCE OF CWR:

13. Service failures of CWR include broken rails, pull aparts, rail defects, track buckles and rail damage.
14. When repairing failures in CWR, care must be taken not to add rail to the track.
 - a. Generally, the length of rail installed should not exceed the length of rail removed.
 - b. Rail that has pulled apart, broken, or been cut for defect removal must be readjusted to a minimum of the PRLT -20°F (11°C).
 - c. The Track Supervisor will be responsible for locations and amounts of rail added or removed.
 - d. If rail has not been adjusted to a minimum of the PRLT -20°F (11°C) before rail temperatures exceed the values in **TABLE 2**, then:
 - i. A speed restriction of 25 MPH must be placed, or:
 - ii. A speed restriction of 40 MPH may be placed, but with a required daily inspection made during the heat of the day.

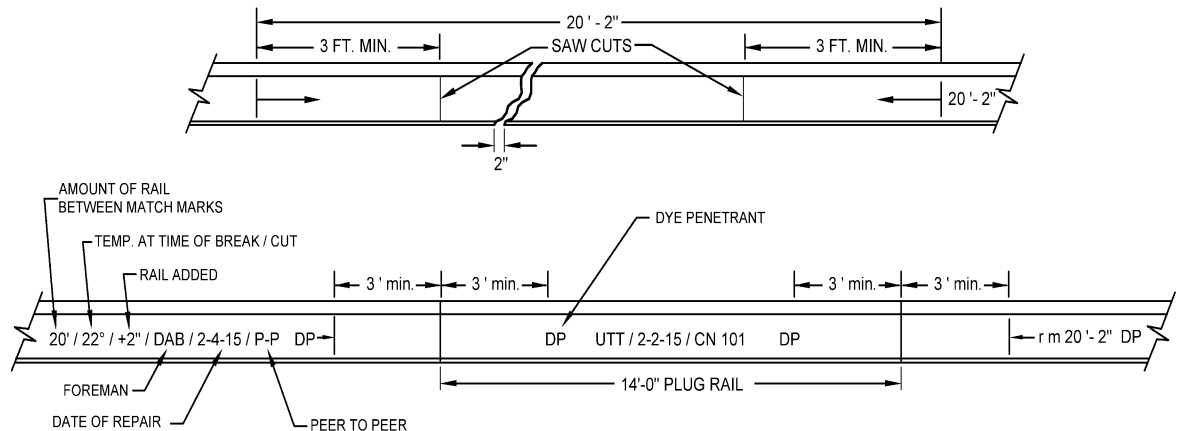
TABLE 2

Rail Temperature at the time of rail break or cut		Temperature at which to readjust rail or apply a temporary slow order	
°F	°C	Canada	US
60	16	63°	135°
50	10	60°	130°
40	4	57°	125°
30	1	54°	120°
20	-7	52°	115°
10	-12	49°	110°
0	-18	46°	105°
-10	-23	43°	100°
-20	-29	41°	95°
-30	-34	38°	90°
-40	-40	35°	85°

15. Where CWR has pulled apart, broken, or is cut for removal of defect or track panel installation, a record of rail pre-cut /break neutral temperature will be maintained when it can be determined. The following information must be used with Recommended Method 1-3-2 to determine pre-break/cut neutral temperature and amount of rail to be adjusted:
- The rail temperature at time of break, pull-apart or rail cut.
 - Gap size.
 - Length of rail installed.
 - Rail base size.
 - Anchor or clip pattern:
 - Every tie anchored or wood track with elastic fasteners(ETA)
 - Every other tie anchored (EOTA)
 - Concrete ties with elastic fasteners (CTEF)
 - Special Conditions:
 - Proximity to fixed locations(switch, turnout, bridge, etc)
 - Proximity to previous cuts or breaks.
 - Ballast status, either frozen or not.
16. All rail repairs in CWR, including panel or turnout installations, will include the use of reference marks. The use of reference marks includes:
- Marking the locations where rail is to be cut. Center this mark in a crib.
 - Place reference marks approximately 3 feet outside the intended saw cut locations.
 - Write the following information on the parent rail immediately beyond the reference marks. **DO NOT WRITE IN THE 3 FEET EITHER SIDE OF THE CUT LOCATION. THIS AREA IS RESERVED FOR THE WELDERS INFORMATION.**
 - The actual distance between the reference marks minus any gap. If the rail grows and must be trimmed, then measure growth and add to the reference mark distance.

- ii. Gap distance.
- iii. Rail temperature at the time of rail cut, pull apart or rail break.
- iv. Length of rail added or removed
- v. Gang identification – Foreman's initials.
- vi. Date.
- vii. Peer-to-peer
- viii. "DP" - indicating dye penetrant testing at each end of each rail.

d. All markings will be legible and written on the field side web using white paint marker.



17. When tight rail is evident or a track buckle occurs:

- a. Following the instructions under "**DESTRESSING CWR**" Section 27, below.
- b. Place the track in the best possible alignment where it will remain without further movement and provides adequate horizontal clearance.
- c. During repairs trains may operate over the track under the direction and supervision of the foreman and not exceeding 10 MPH.
- d. After the track has been repaired and returned to service, it will be treated as disturbed track and protected by speed restrictions as listed in **TABLES 3, 4 or 5**.

MAINTENANCE WORK IN CWR TRACK:

- 18. Prior to surfacing or mechanized tie replacement a main track CWR curve which is more than 3°, and the temperature is more than 50°F (27° C) below the PRLT, or is expected to be in the next 24 hours, the curve must be staked per T.S. 4.0 – BALLASTING, SURFACING and LINING.
- 19. Track maintenance that disturbs track and could possibly cause a buckle must be protected by inspection, monitoring and the appropriate speed restrictions.
 - a. Except in the case of emergencies, no surfacing and lining, rail replacement or tie renewal will be performed if the rail temperature is above the PRLT unless approved by the Assistant Regional Chief Engineer or designate.

20. During the work or before returning the track to service, the supervisor or foreman in charge must ensure that:
- a. Gauge, surface and alignment have been established.
 - b. Crib and shoulder ballast is in place or lateral constraint is otherwise provided.
 - c. The rail is anchored per T.S. 3.1 – RAIL ANCHORS.
21. Speed restrictions for disturbed CWR track will:
- a. Be place with limits at least 1/10th mile, or 500 feet, in advance of the work location.
 - b. Be more restrictive than that shown in the following **TABLES 3,4 or 5** if one or more of the following conditions exist:
 - i. Weak subgrade.
 - ii. Insufficient ballast.
 - iii. Insufficient anchor conditions.
 - iv. Weak tie conditions.
 - c. Prior to removing a speed restriction:
 - i. Track must be inspected.
 - a. Ensuring anchors are applied and tight to the tie.
 - b. Ensuring no signs of tight rail exist.
 - ii. Verify the required tonnage has passed over the track.
 - a. In multiple main track territory, verify route tonnage.
 - b. 12 passenger trains are equivalent to 8,000 tons of traffic.
22. When track work is performed that disturbs the ballast section, a speed restriction that complies with the guidelines of **TABLES 3, 4 and 5 must be applied:**
- a. Spot surfacing is defined as restoring track surface, cross level and alignment through short stretches, not more than 19'6" in length, when a continuous raise is not necessary.
 - b. Spot tie renewal is defined as the installation of 5 ties or less in 39 feet, and installing no more than 3 consecutive ties. Speed restrictions for tie renewal will be treated as either mechanize or spot tie renewal based on the following table:

TIE RENEWAL SPEED RESTRICTIONS

	ALL Track	CORE ONLY	NON-CORE ONLY
SCOPE of WORK	5 or Less Ties per 39' , or 3 or less consecutive ties in a single pass	More Than 5 Ties per 39 feet within 72 hours , or more than 3 consecutive ties in multiple passes within 72 hours .	More Than 5 Ties per 39 feet within 7 days , or more than 3 consecutive ties in multiple passes within 7 days .
ACTIVITY PER TABLES 3,4 & 5	SPOT TIE RENEWAL	MECHANIZED TIE RENEWAL	MECHANIZED TIE RENEWAL

- i. If the temperature is at or expected to be above the PRLT within the next 24 hours, the track must be tamped with a machine work head.
- ii. See T.S. 2.0 TIMBER TIES or T.S. 2.1 CONCRETE TIES for maximum number of consecutive ties to be changed.

23. When the rail temperature exceeds or is expected to exceed the PRLT within the next 24 hours, use **TABLE 3**:

TABLE 3

Activity	Without Dynamic Stabilizer	With Dynamic Stabilizer
Mechanized tie renewal Panelized turnout replacement Out of face surfacing Ballast cleaning / Undercutting Track Surfacing and Lining	1 freight train at 10 MPH, inspect, if OK, then 30 MPH for 100,000 tons, inspect, if ok, then return to track speed. See Note 1c	2 freight trains at 30 MPH, inspect, if OK, then return to track speed. See Note 1c
Spot tie renewal Spot surfacing Shoulder cleaning	1 freight train at 30 MPH, if OK, then return to track speed. See Note 1c	N/A

IMPORTANT - See Notes 1(a), 1(b), 1(c) and 1(d) in Section 26

24. When rail temperature is between the PRLT and 30° F degrees below the PRLT, and is expected to remain in this range for the next 24 hours, use **TABLE 4**:

TABLE 4

Activity	Without Dynamic Stabilizer	With Dynamic Stabilizer
Mechanized tie renewal Panelized turnout replacement Out of face surfacing Ballast cleaning / Undercutting Track Surfacing and Lining	1 freight train at 10 MPH, inspect, if OK, then 30 MPH for 50,000 tons, inspect, if OK, then return to track speed.	N/A
Spot tie renewal Spot surfacing Shoulder cleaning	N/A	N/A

IMPORTANT - See Notes 1(a), 1(b), 1(c) and 1(d) in Section 26

25. When rail temperature is 30 degrees or more below the PRLT and is expected to remain in this range for the next 24 hours, use **TABLE 5**:

TABLE 5

Activity	Without Dynamic Stabilizer	With Dynamic Stabilizer
Mechanized tie renewal Panelized turnout replacement Out of face surfacing Ballast cleaning / Undercutting Track Surfacing and Lining	1 freight train at 30 MPH, inspect, if OK, then return to track speed.	N/A
Spot tie renewal Spot surfacing Shoulder cleaning	N/A	N/A

IMPORTANT - See Notes 1(a), 1(b), 1(c) and 1(d.) in Section 26

26. Note 1(a): Between the hours of 22:00 and 10:00, the 30 MPH restriction may be raised to 40 MPH. If at 10:00 the accumulated tonnage has not been reach, reduce speed back to 30 MPH.
- Note 1(b): If the first two freight trains have not passed over the track before 22:00, then 10 MPH for the first train and 30 MPH for the second train will remain in effect before the speed is increased to 40 MPH.
- Note 1(c): Disturbed track speed restrictions may not be removed between 10:00 and 22:00.
- Note 1(d): A freight train must be at least 8,000 tons. On lines with predominately passenger service, 12 passenger trains is equivalent to 8,000 tons.

DESTRESSING RAIL:

27. Fixed Points require the rail to be destressed in conjunction with tie installation, major track surfacing, undercutting or other operations which disturb the track. Fixed point destressing will be performed:
- If the work is within 400 feet of turnouts, crossings longer than 100 feet, bridges longer than 100 feet, crossing diamonds, areas etc.
 - Prior to the work beginning if practicable, but if destressing is not performed before the rail reaches the PRLT, restrict speed to a maximum of 30 MPH until destressing has occurred. **Note; the rise to this temperature might occur in the following work season.**
 - The Regional Chief or Assistant Chief Engineer may authorize that fixed point destressing is **NOT** required if the following conditions are met:
 - The area is anchored to standard with good anchor condition and no signs of rail running or ballast /tie plowing, or
 - Field verification confirms that the location has been destressed within the last 5 years.

28. When indications of a potential track buckle are evident, the rail must be adjusted by:
- a. Lining the curve out to per T.S. 4.0 – BALLASTING, SURFACING and LINING.
 - b. Cutting the rail to distress using the following process:
 - i. **BEFORE CUTTING**, Place match marks from the base of the rail to the tie plate of an unanchored tie:
 - a. At least 3 feet outside of where the joint will be made, and
 - b. Every 100 feet, in both directions, where anchors will be removed.
 - ii. Place reference marks approximately 3 feet outside the planned cut location, measure the distance between these marks and record on the rail along with the rail temperature.
 - iii. Cut the rail, trimming the rail if required to allow rail growth.
 - iv. Once the rail has stopped growing:
 - a. Remove rail anchors for at least 200 feet each side of the cut.
 - b. Allow additional rail growth by trimming the rail ends and tapping the tie plates within the unanchored area.
 - c. The rail is now at the new Rail Neutral Temperature. If the rail temperature is:
 - i. At or above the PRLT for the location, no further adjustment is required.
 - ii. Below the PRLT, the rail must be adjusted per the amount in table **APPENDIX A** based on Temperature Differential.
 - iii. Remove additional anchors, if needed, to allow for rail expansion.

COLD WEATHER INSPECTIONS

29. Gas welded CWR on core main track will be inspected at additional frequencies:
- a. Between October 1 and March 1 or any time the ambient temperature is expected to be less than 25° F inspections increased.
 - i. To three times per week, with at least 1 calendar day between inspections, and
 - ii. The Track Supervisor must strive to personally perform at least one of the three weekly inspections.
 - b. Additional inspections of non-core tracks will be as directed by the Regional Chief Engineer.
30. Lines are deemed susceptible to cold weather related rail failures if any of the following apply:
- a. Non-signalized territory.
 - b. Jointed or Gas Welded Rail (See Section 23 above).

- c. Rail weight of 115 lb. or less and subject to 286K lb. car loading.
 - d. Rail with a history of rail defects as calculated using a 3 year RSI.
 - e. Lines identified by the Regional Chief Engineer.
31. Daily cold weather inspections will be performed on core lines when the following conditions of **TABLE 6** exist:

TABLE 6 EXTREME COLD WEATHER TRACK INSPECTIONS			
Territory	Track Conditions	Either Condition Met	
		Extreme Low Temperature	Rapid Drop in Temperature
Canadian Lines	Susceptible to Cold	Less than (-) 25 ° C	Greater than 25°C within a 24 hour period
	All Track	Less than (-) 30 ° C	
U.S. Lines North of Chicago	Susceptible to Cold	Less than (-) 15 ° F	Greater than 32 ° F within a 24 hour period
	All Track	Less than (-) 20 ° F	
U.S. Lines Chicago - Bluford	All Track	Less than (-) 10° F	
U.S. Lines South of Bluford	All Track	Less than (-) 5° F	

Additional restrictions may be placed and inspections required for “cold snap” temperature changes, or during intensely cold temperatures.

COLD WEATHER TEMPORARY SPEED RESTRICTIONS:

32. In areas identified as having a history of rail failures, the following temporary speed restrictions will be placed:
- a. Temperatures below -25°C in Canada, or -10°F in the US,
 - i. Reduce freight speed to 40 MPH or track speed, whichever is less.
 - ii. Reduce passenger speed to 60 MPH or track speed, whichever is less.

HOT WEATHER INSPECTIONS

33. When ambient temperature exceed those in **TABLE 7**, or a notification is received indicating a sudden temperature spike, hot weather inspections must be performed between the hours of 11:00 and 22:00.
- a. Hot weather inspections may be suspended if temperatures have stabilized and previous inspections have shown the track is within standard and is stable.

TABLE 7 HOT WEATHER INSPECTION and SPEED RESTRICTION THRESHOLDS	
Territory	Ambient Temperature
All Canadian Regions (Except as below)	More than 30°C (86°F)
Canada - Clearwater Sub west of MP 67.7, Ashcroft Sub. and Yale Sub.	More than 33°C (91°F)
Southern Region North of Centralia, IL.	More than 95° F
Southern Region South of Centralia, IL.	More than 100°F

- b. During hot weather inspections pay particular attention to any of the following conditions:
- i. Lateral or vertical movement of the rail (i.e. “wavy” rail or lifted from the tie plate seat).
 - ii. Alignment deviations.
 - iii. Movement of ties leaving a gap in the ballast or shoving ballast at the end of the tie.
 - iv. Insufficient ballast in cribs or on shoulders.
 - v. Ties plowing ballast longitudinally down the track.
 - vi. Rail moving through anchors or clips.
 - vii. Areas of bunching rail:
 - a. At the bottoms of grades.
 - b. Near areas in advance of PSO’s or other TSO’s.
 - c. In advance of Control Points or heavy brake applications.
 - viii. Areas of recent track work.
 - ix. Areas of track instability.
 - x. Areas of known excess rail or lateral instability concerns.
- c. If a condition is found, a speed restriction of no more than 25 MPH will be placed immediately, or the track will be removed from service until repairs are made.

HOT WEATHER SPEED RESTRICTIONS

34. When temperatures exceed those listed in **TABLE 7**, the following speed restrictions will be placed:

Passenger Trains: Reduce maximum subdivision speeds by 15 MPH, but not less than 60 MPH.

Freight Trains: Reduce maximum subdivision speeds by 10 MPH, but not less than 40 MPH

- a. PSO’s and TSO’s will be reduced by the same amount, but not less than 30 MPH Freight and 40 MPH Passenger.

Note – Subdivisions with maximum speed below 30 MPH Freight or 40 MPH Passenger require specific Hot Weather Speed restrictions if track conditions require operating speeds to be lowered further. Local Operating Bulletins will be utilized to limit operating speeds and/or hours of train operations as agreed upon by the Regional Engineering and Transportation Departments.

THIS PAGE BLANK INTENTIONALLY

T.S. 1.4 RAIL GRINDING WITH SELF-PROPELLED GRINDING MACHINES

1. Planning for grinding programs requires the participation of the Grinding Supervisor, Track Supervisor, Senior Manager Engineering, S & C Supervisor and the B & S Supervisor. These individuals will jointly review:
 - a. Limits of the grinding program.
 - b. If road crossings, both public and private, need to be removed prior to grinding.
 - c. Wayside components such as lubricator wiper bars and collection mats, hot box detectors, wheel sensors, dragging equipment paddles, etc. that need to be removed in advance of grinding.
 - d. Fire hazards along the right of way, such as tie piles, which could ignite during grinding.
 - e. Rail on bridges, and if these locations require rail grinding, rail replacement or deferral.
 - f. Locations where the grinder can take on water or perform maintenance.
2. Rail will be inspected and the appropriate grinding pattern will be determined prior to the arrival of the production grinder. All rail within the limits of the grinding program will be ground and the determination to skip a portion of rail will be made **only** after agreement between the Manager of Rail Grinding, Sr. Manager of Engineering and the Assistant Chief Engineer.
3. Production grinders, when working, will be accompanied by at least two CN employees, with one on the leading end of the grinder responsible for piloting the grinder. The second employee will be on the last fire patrol vehicle of the grinding consist.
4. Production grinders will have adequate lubrication on board and applicators operational, and where required, applying gauge corner lubrication to high rail of a curve and top of rail lubrication to the low rail.
5. The Switch and Crossing Grinder (SCG) will grind road crossings, turnouts, wayside detector locations, etc. If necessary, the SCG may be used to grind tangents, curves or locations of No Test Rail, if economically feasible.
6. When the SCG is grinding a turnout:
 - a. Frogs will not be ground, including jump frogs. The grinding wheels will be raised off the rail, and lowered onto the rail at the welds at the end of the frog.
 - b. Normally switch points will not be ground from the tip of the point to the end of the head side planning, except as in 6.c, below.
 - c. When the difference between the running surface of the switch point and the stock rail, in the riser area, is reduced below 3/16" (4.8 mm), the stock rail and/or switch point may be ground to restore the ¼" – 5/16" (6.4 – 8 mm) dimension.
7. Inspect around insulated joints, turnouts and other locations where metal filings could adversely affect the signal system.

FIRE PREVENTION

8. The B&S Supervisor is responsible for the protection of structures and must prepare a Rail Grinding – Bridge Fire Mitigation Plan (see form at the end of this section) for each structure within the limits of the rail grinding program.
 - a. The Pre Grind Survey portion of the form will be completed for each structure along the grinding program. Information required is:
 - i. The location, by mile post and GPS coordinates, of the structure.
 - ii. The type of structure and deck.
 - iii. The need to have fall protection qualified individuals protecting the structure.
 - iv. Combustible hazards near or under the structure to protect or remove.
 - b. The Grinding Fire Protection Plan portion of the form for each structure will include the following:
 - i. Accessibility of the bridge
 - ii. Water supply at the structure and the need to stage pumps if required.
 - iii. A list of the nearest fire departments.
 - iv. Determination if a fire department should be staged at the structure during grinding.
9. The Track Supervisor, B&S Supervisor and Grinding Supervisor must clearly understand which bridges will be ground.
10. Grinding rail over bridges will be as follows:
 - a. All ballast deck bridges within the limits of the grinding program will be ground.
 - b. Open deck structures constructed with wood ties on steel girders will be ground as required by the program.
 - c. Structures constructed with timber piers, caps, stringers and ties will be ground as part of the program, but only after the risk assessment has been completed and shared with the Grinding Supervisor, and it has been determined that the rail requires grinding.
11. Each day, prior to commencing grinding operations, ensure the following have been covered in the briefing:
 - a. Identify each of the bridges to be ground or skipped.
 - b. A risk assessment and hazard mitigation plan has been completed for each structure to be ground, distributed, reviewed and understood by everyone involved with the work.
 - c. Assignment of individuals and fire fighting equipment, per the hazard mitigation plan, to monitor the structure for a minimum of 30 minutes after the grinding has been completed.
 - d. The grinder has a full water supply, with fire retardant foam additive, and that all pumps and sprayers are operational.

- e. Fire fighting equipment is available, and operational, for each person and at each location. This includes:
 - i. Backpack sprayers, hoses and pumps with fuel.
 - ii. Water supply with fire retardant additive.
 - iii. The condition of on-track equipment to support monitoring and fire fighting operations.
 - iv. Ensure the person assigned to the location understands the operation of the fire fighting equipment.
 - v. Contact information for the nearest fire department.
 - f. The mainline grinder will have at least 30 percent of its maximum water capacity onboard before commencing the grinding of any structure. A Switch and Crossing grinder will have 100% of its maximum water capacity onboard.
 - g. The grinder will not stop, change directions or make sudden movements while on the structure.
 - h. Inform the RTC and Chief Dispatcher of the need to occupy the track for an extended period after grinding to monitor the structures for potential fires.
 - i. Coordinate the follow up inspections to be performed 2 to 4 hours after the grinding has been completed. The inspection includes viewing the structure with thermal imaging devices.
12. Grinding is not to be performed within 200 feet of structures that are not scheduled for grinding unless at least the first 200 feet of the deck are wetted with fire retardant foam / water solution.
13. The structure to be ground must be thoroughly wetted prior to grinding to reduce the risk of fire. This can be performed ahead of the arrival of the grinding train. Where circumstances require additional wetting, the grinding train ditch and tie sprays must be operated continuously during the entire bridge grinding operation.
14. When grinding in the area of any timber structures, a fire inspection must be performed after passing over the structure. This inspection includes viewing the structure with thermal imaging devices.
15. Once grinding is complete, the grinder, with ditch and tie sprays continuously operating, will traverse the entire structure, including 200 feet off each end, at least once to wet any sparks that may have been left by the grinding operation. Grinder movement will be done at a constant speed and without any sudden stops to avoid dislodging slag and swarf from the grinder.
16. The grinder must not leave the structure until either a fire watchman or fire truck is physically in place. A thorough job briefing must be performed with the fire watchman, and they must fully understand their duties. The fire watchman must be equipped with at least three backpack type pump sprayers filled with water and fire retardant foam additive and be familiar with how to operate it. If the hazard mitigation plan identifies that additional fire fighting equipment is required, it will remain with the fire watchman.

RAIL GRINDING - BRIDGE FIRE MITIGATION PLAN

PRE-GRIND SURVEY

SUBDIVISION: _____ MAIN _____ MILE POST _____ DATE OF INSPECTION _____			
GPS COORDINATES _____		NEAREST FIRE DEPARTMENT _____	
<u>BRIDGE TYPE (CHECK ALL THAT APPLY)</u>			
☐ BALLAST DECK	☐ OPEN DECK	☐ TIMBER SPANS	
☐ STEEL SPANS	☐ CONCRETE SPANS	☐ TIMBER CAPS	
☐ STEEL CAPS	☐ CONCRETE CAPS	☐ TIMBER FRAME BENTS	
☐ STEEL FRAMES	☐ CONCRETE PIERS		
DOES THE RAIL REQUIRE GRINDING Y or N		WILL THE RAIL BE GROUND ON THIS CYCLE Y or N	
DOES THE STRUCTURE HAVE WALKWAYS Y or N		IS FALL PROTECTION REQUIRED FOR THIS BRIDGE Y or N	
IS THERE ROAD ACCESS TO STRUCTURE Y or N		IS WATER AVAILABLE AT THE BRIDGE Y or N	
OTHER FIRE DANGERS THAT EXIST (SCRAP TIES, BRUSH, TREES, DRY GRASS, ETC.): 			

GRINDING FIRE PROTECTION PLAN

PERSON ASSIGNED TO MONITOR THE BRIDGE: _____	
OPERABLE RADIO: Y or N	OPERABLE CELL PHONE: Y or N CELL PHONE #: _____
RTC CHANNEL: _____ EMERGENCY DIAL UP TONE: _____ FIRE DEPARTMENT PHONE: _____ SUPERVISOR PHONE: _____ DIRECTIONS TO THE STRUCTURE (IF ROAD ACCESS): _____ _____ _____	
GRINDER HAS FUNCTIONAL PUMPS AND SPRAYERS : Y or N FIRE RETARDANT ADDED TO WATER: Y or N GRINDER WATER SUPPLY AT LEAST 30 % BEFORE STARTING EACH STRUCTURE: Y or N WATER TRUCK HAS FUNCTIONAL PUMPS & SPRAYERS: Y or N FIRE RETARDANT ADDED TO WATER: Y or N WATER TRUCK SUPPLY AT LEAST 30 % BEFORE STARTING EACH STRUCTURE: Y or N	
FIRE FIGHTING EQUIPMENT ASSIGNED TO THE STRUCTURE: _____ _____ _____	
FIRE FIGHTING EQUIPMENT OPERATIONAL: Y or N PERSON ASSIGNED HAS KNOWLEDGE OF EQUIPMENT: Y or N FIRE RETARDANT ADDITIVE: Y or N WATER SUPPLY ADEQUATE: Y or N PUMPS FUELED: Y or N HOSES IN PLACE: Y or N HOSES LONG ENOUGH TO REACH ENTIRE STRUCTURE: Y or N ROUND NOSE SHOVELS: Y or N ADZE: Y or N	
REMAIN AT THE STRUCTURE FOR A MINIMUM OF 30 MINUTES AFTER GRINDING DO NOT LEAVE THE STRUCTURE WITHOUT SUPERVISOR NOTIFICATION RE-INSPECT THE STUCTURE BETWEEN 2 and 4 HOURS AFTER GRINGING	

T.S. 1.5 RAIL LUBRICATION and FRICTION MANAGEMENT

1. Friction management is flange lubrication, top of rail (TOR) lubrication and top of rail traction enhancement. For the items below, the term “applicator” will refer to the dispensing unit any of these in either a fixed location or mobile.
2. It is the Track Supervisors responsibility to ensure wayside and mobile applicators are installed properly and operating correctly.
3. Wayside applicators should be located in accordance with Recommended Method 1-5- 0, and provide coverage to curves of 2 degrees or higher. Applicator installation locations will consider:
 - a. Road and power access to the location. Locations of solar powered installations should have unobstructed exposure to the sun.
 - b. Staying away from open deck bridges, waterways, non-signalized road crossings, turnouts and S & C installations such as hot box, dragging equipment and wheel impact detectors.
 - c. Attempt to keep wayside lubricator installations no closer than ½ mile from a signalized crossing, but not closer than ¼ mile to the crossing.
 - d. Keeping installations at least 100 feet from any insulated joint.
 - e. The carrying properties of the product.
 - f. Traffic patterns of the location to be covered. Locations of starting or stopping points, normal sanding activities, or frost heaves / sink holes must be avoided.
 - g. Other operational conditions requiring coverage.
 - h. The applicator should be located in tangent track.
 - i. Exact location will be determined in the field.
4. At applicator locations, ensure:
 - a. Rail wear is not to the extent to cause damage to the wiper bars by passing wheels.
 - b. Gauge is maintained at 56 ½”.
 - c. Wood ties are sound, free of plate cut and ties are fully spiked in accordance with pattern “D” of T.S. 3.3- RAIL FASTENINGS for at least 50 feet side either of the applicator.
 - d. All pads and insulators on concrete ties are sound.
 - e. All OTM must be in good condition.
 - f. Track will be covered with woven geotechnical fabric:

- i. For a distance of 50 feet from the applicator in each direction of train movement.
 - ii. Fabric to be removed each spring and fall for inspection. Replace fabric if required.
- 5. Applicator types will be approved by the CN Engineering Standards.
- 6. Applicators will be installed in accordance with the manufacturer's instructions.
- 7. Only approved products will be used in applicators.
- 8. Summer and winter grade products will be applied during the appropriate season.
- 9. The applicator reservoir must never be allowed to run dry.
- 10. Applicator actuators, ramps, wiping bars and other parts which might be damaged must be lowered or removed prior to rail grinding operations and must be placed back in service immediately following grinding.
- 11. As lubricants may interfere with proper ultrasonic testing, all applicators should be shut off sufficiently in advance of any Ultrasonic Rail Testing to ensure no lubricant is present. Applicators must be reactivated immediately after testing.
- 12. The Track Supervisor will ensure that wayside applicators are inspected on foot **at least monthly** and reported in TIS.
 - a. Ensure the inspection verifies the lid of the applicator and the control panels are secured with locks.
 - b. Note the level of the lubricant.
 - c. Mechanical pump drive connections must be inspected and lubricated.
 - d. Inspect fluid levels in hydraulically activated applicators and filled in accordance with the manufacturer's instructions.
 - e. Hose connections must be inspected.
 - f. Note any leaking or spillage.
 - g. Ensure the dispensing ports are clear and application bars are operational.
 - h. Note if the applicator is dispensing as intended.
 - i. Ensure coverage on the rail extends to the limits required and that excess product is not present on the rail.
- 13. Each fall and spring remove the fabric from the track to inspect the track, noting:
 - a. Ballast being fouled by grease.

- b. Tie condition
 - i. Saturated with grease or punky
 - ii. Allowing plate or spike movement indicating dynamic gauge widening.
 - c. Excessive or leaking grease.
 - d. Surface condition through and around the lubricator.
14. The area around the applicator must be kept clean. All packaging materials and contaminated grease must be disposed of in an approved manner.
15. On-track applicators will traverse the track at a frequency that will provide adequate lubrication of curves and top of rail coverage. When determining the frequency, consider:
- a. The number of trains daily and traffic pattern.
 - b. The number of curves, including junctions and sidings, and the degree of curves. Higher tonnage and high degree curves require a higher frequency.
 - c. The ability to traverse the territory.
 - d. If On-track application is inadequate, it may require the installation of supplemental wayside applicators.
16. On-track applicator nozzles need to be set to apply a continuous bead of lubricant 1/8 inch wide at a point 5/8" below the top of the rail. Frequent monitoring of the nozzle function and location, along with vehicle speed, needs to be made to ensure proper application.
17. On-track application should stop at the whistle post to each crossing equipped with automatic warning devices. Application should resume once the trailing whistle post is passed.
18. Top of rail lubrication should be applied to both rails simultaneously.

THIS PAGE BLANK INTENTIONALLY

T.S. 1.6 FIELD WELDING

1. Storage of thermite weld kits must be in a dry, protected environment.
2. Shelf life of molds and crucibles is approximately 2 years. Shelf life of weld charges is up to 5 years.
3. Where required, use 16" pin brazing head bonds at rail joints scheduled to be thermite or flash butt welded. Bond will be attached no closer than 7" to the rail end.
4. Rail cut for welding will be dye penetrant tested in accordance with T.S. 1.0-RAIL, Section 10.b.
5. Field welds, both thermite and flash butt, will be made:
 - a. At least 4 inches away from the nearest edge of any hole in the rail or the edge of a tie, and,
 - b. At least 3 feet away from an existing plant or flash butt weld and 6 feet away from a thermite weld.
 - c. Field welds will be made without vibration imparted into the rail by rail traffic, road crossing traffic, work equipment, etc. which can affect the quality of the weld, until 5 minutes after the weld has been poured.
 - d. The use of a rail puller is required on all closure welds if the rail temperature is below the PLRT for that zone.
 - i. A closure weld is the final weld that joins and adjusts two ends of CWR
6. Rail end mismatch of the joint to be welded and type of weld kit to use will be in accordance with T.S. 1.0 – RAIL Section 12 and 19. All welding, including thermite, electric flash butt and track component welding will be in accordance with the CN Track Welder Manual.
7. In no case shall thermite or electric flash butt welds be made when the ambient temperature is below the following:

Thermite Weld	Electric Flash Butt Weld Type	
	Low Consumption	High Consumption
0°F / -18°C	32°F / 0° C	-10° F / -23 C°

- a. Welds must be protected from wind and moisture to prevent rapid cool down.
 - b. Cold weather welding procedures apply at or below 40°F / 4° C. See CN WELDING MANUAL CHAPTER 17 for cold weather welding instructions.
8. Only trained and qualified personnel are allowed to weld.
9. Welders and other employees must move to a safe place, a minimum of 40 feet away, when the thermite charge is ignited and until 1 minute after the pour is completed.
10. Each weld will be labeled on the field side of the rail, in white paint marker, per the diagram below and including the following information:
 - a. Identification of the welder:
 - i. Thermite welder's initials or Flash butt welder number.
 - b. Consecutive weld number/ date of the weld / rail added or removed

- c. Rail temperature when welded / dye penetrant (DP) if the rail was cut and Peer to Peer.

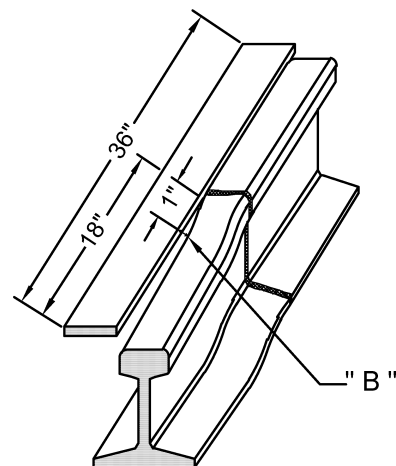
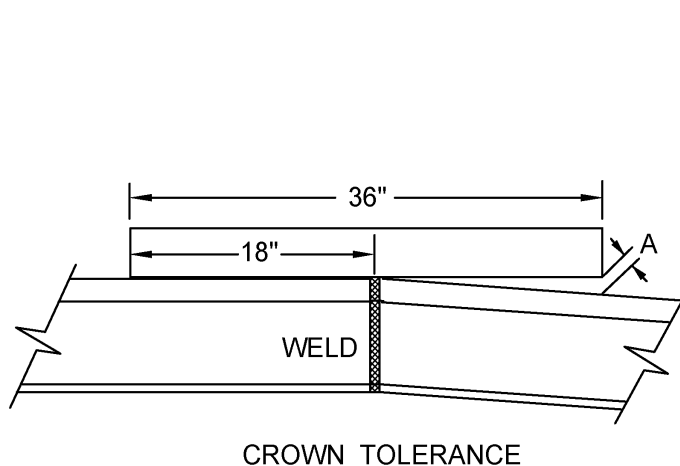


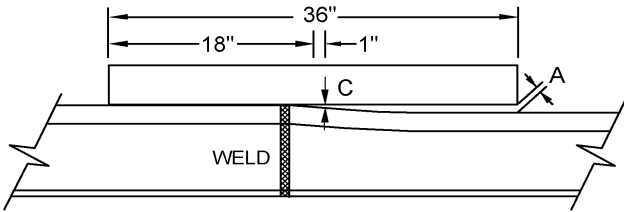
11. All required weld information must be recorded in TIS.

FINISHED WELD QUALITY

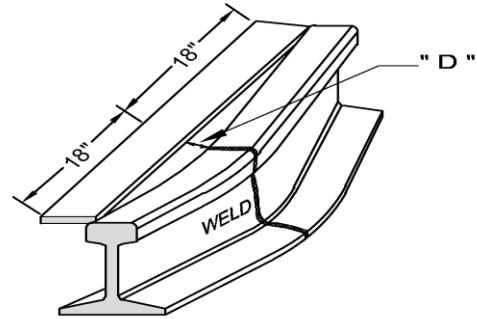
12. Upon completion of the weld:
- Ties under and either side of the welded joint will be firmly tamper under the rail.
 - Ties will have spike holes plugged and spikes driven to the applicable pattern.
 - Anchors will be applied and tightened to the applicable pattern 200 ft. in each direction.
 - Ensure anchors are no closer than 2" to a weld.
 - Cribs will be filled with ballast and dressed to standard.
 - The area around the weld will be cleaned to removed bolts, bars, slag, molds, etc.
13. The weld will be ground to the following tolerances. Welds dimensions outside the tolerances will be re-ground to comply, or the weld will be removed.

MEASUREMENT	DIMENSION	TOLERANCE	
		Field Weld	Flash Butt Weld
Crown: Peak of rail at the weld	A	.030" (0.76 mm)	.060" (1.52 mm)
Horizontal Offset: head difference on side of rail	B	0.015" (0.38 mm)	0.040 (1.01 mm)
Vertical Offset: Addition of crown and vertical height difference	A + C	0.000"	0.060"
Indent - Either dip into gauge side	D	0.030"	0.030"
Indent - Crown inward (peak) toward track center	D	0.030"	0.060"





VERTICAL OFFSET TOLERANCE



LATERAL INDENT TOLERANCE

14. Welds will be ground:
- So the web has no sharp edges protruding from the weld.
 - So that no pin holes are evident on the base.
 - So that that no grind extends into the parent rail.

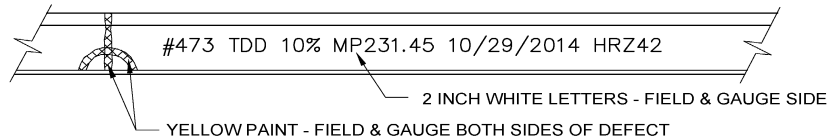
FIRE PREVENTION

15. Rail on a bridge requiring thermite welding or rail end build-up shall be welded off the bridge when possible, and then installed on the bridge after all work on the weld is finished. However, when there is no alternative to doing the welding on a bridge, follow the precautions below:
- Contact the local Welding Supervisor, Track Supervisor and B & S Supervisor to ensure they are aware of the work required to be performed.
 - Before any welding is undertaken, a site inspection must be made to identify any hazards, in particular fire hazards including the structure itself.
 - Review T.S. 11.0 – FIRE PREVENTION to determine the risk level of the situation and the minimum required fire prevention and fire fighting resources to have on hand.
 - Bridge ties must be spread at the joint to be welded.
 - A ¼" thick steel sandbox, partially filled with dry sand, will be placed between the ties in case of thermite weld run through.
 - The wood ties and bridge timbers, plus the area around the structure, must be wetted with a water and fire retarding foam additive to lessen the chance of fire from cutting, grinding or welding.
 - During any cutting, welding and grinding, a designated fire watch person(s) must be assigned. The fire watch must be adequately equipped to fight a fire, if it occurs.
 - Upon completion of the weld, a fire watch, equipped to fight a fire, will remain on site inspecting for any smoldering fires, until the weld has cooled to ambient temperature.
 - Prior to removing the fire watch from the site, contact the individuals listed in 15 a., above, to ensure they are informed.
 - The precautions above are the minimum. Additional precautions can be used.

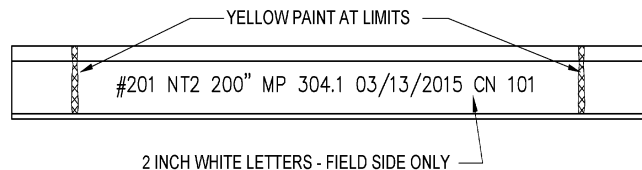
THIS PAGE BLANK INTENTIONALLY

T.S. 1.7 RAIL TESTING AND DEFECTS

1. Rail testing frequencies for all tracks will be certified by the Manager of Rail Testing.
2. Each defective rail must be marked:
 - a. With permanent yellow paint on the web of the field and gauge side of the rail.
 - b. With white paint stick marker, in 2 inch high, right side up letters indicating:
 - i. Defect number / Defect type / Defect size
 - ii. Milepost / Date of test / Unit number



3. Defective rails and In Service Rail Failures must be reported in TIS.
4. Definitions for use with remedial actions for rail conditions:
 - a. Core Main Track is the primary routes from Vancouver and Prince Rupert to Edmonton and east to Halifax, plus Winnipeg to New Orleans and Chicago to Sarnia to Toronto, also, the Camrose, Three Hills, Missabe, Bluford, Chiles, Beaumont, Baton Rouge and Hammond Subdivisions.
 - b. HAZMAT or DG Route is defined as any line with at least 4,000 TIH or 10,000 placarded cars annually.
5. “No Test Rails” (NTR) are rails that the Rail Flaw Detection (RFD) equipment is unable to send and receive an ultrasonic signal through the rail for whatever reason. NTR rail could be:
 - a. Covered with grease, snow or ice, leaves or vegetation, or
 - b. Rail surface damaged to prevent a valid test.
6. NTR’s will be coded in TIS as:
 - a. NT 1 – Rail found to be a “No Test” for the first time.
 - b. NT 2 – Rail found to be a “No Test” for the second consecutive UTT inspection.



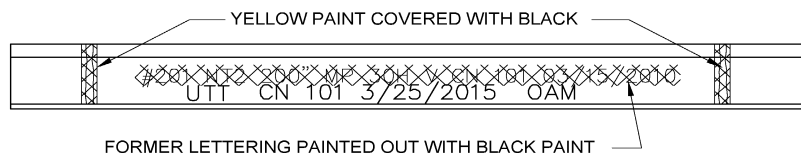
7. TIS information for NTR locations must include:
 - a. GPS coordinates and milepost information for the location of the NTR.
 - b. Length measurement, measured in inches, of the NTR.

8. NTR remedial actions are listed in the **NO TEST RAIL REMEDIAL ACTION TABLE** below:

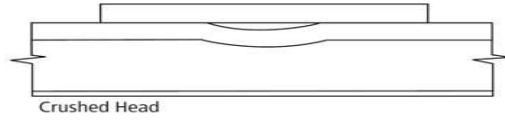
NO TEST RAIL REMEDIAL ACTION TABLE

CLASS OF TRACK AND DESIGNATION	TYPE OF TRACK	NT 1	NT 2
All Class 1 tracks, and Class 2 tracks that do NOT have passenger service or is NOT a HAZMAT / DG route	Yard, Non-Core Main And Other Tracks	Reinspect within 180 days	Repair within 60 days, if not repaired after 60 days, limit track speed to Class 1
Class 2 tracks WITH passenger service or is a HAZMAT / DG route, and all Class 3, 4 and 5 tracks, plus ANY track as identified by the Regional Chief Engineer	Non-Core Main Track	Reinspect within 60 days	Repair within 30 days, if not repaired within 30 days, limit to Class 1 and then repair within 30 days to remain in service
	Core Main Track	Reinspect within 30 days	Reduce speed to Class 2 and repair within 15 days, if not repaired after 15 days, limit to Class 1 and repair within 7 days to remain in service.

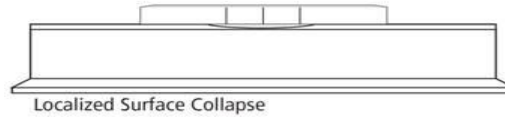
9. No Test Rail, after remedial actions are taken which allow for a successful UTT inspection, will be closed out in TIS, by local forces, and the RFD Test Car Operator will mark the rail with:
- “UTT”, plus RFD Test Car ID, date of successful UTT inspection and operators initials.
 - Black paint will cover over previous yellow paint.



10. Crushed Heads (CH), Localized Surface Collapse (LSC) or Rail End Batter (REB) remedial actions will be according to **TABLE A**; **Exception:** Between November 15 and April 15, on all Class 3 tracks, or greater, north of Stuenkel – MP 31.6, Chicago Subdivision, use **TABLE B**.
- Crushed Heads or Localized Surface Collapse that exceeds 1.5 mm will be marked when found by the RFD equipment and measured by local forces.
 - Center a straight edge over the CH or LSC and measure depth with a taper gauge as shown below.
 - Place the straight edge tip even with the end of the rail with the REB and measure the maximum depth of the crush with a taper gauge as shown below.
 - A record of the inspection location, date and measurement taken must be maintained.
 - Monitoring, measuring and recording of REB, CH or LSC will be by local forces.



Measurement of Crushed Head (CH) Condition



Measurement of Localized Surface Collapse (LSC) Condition



Measurement of Rail End Batter (REB) of Mismatch

TABLE A

CH / LSC (mm)	REB (mm)	REMEDIAL ACTION
3 to 5	----	For Class 3 and higher, measure monthly and schedule for replacement
> 5	> 5	Limit speed to 30 MPH. If not replaced within 7 days, limit speed to 10 MPH
≥ 8	≥ 8	Limit speed to 10 MPH and replace within 48 hours

TABLE B

CH / LSC (mm)	REB (mm)	REMEDIAL ACTION
3 to 4	3 to 4	Measure weekly until replaced
> 4	> 4	Measure weekly and limit speed to 30 MPH until replaced
> 5	> 5	Limit speed to 10 MPH and replace within 48 hours

11. When a rail in track contains any of the defects listed in the **REMEDIAL ACTION for RAIL DEFECTS TABLE** or is damaged, train operation over that rail is not permitted until:
 - a. The rail is replaced, or
 - b. The prescribed remedial action is initiated.
 - i. When joint bars are applied per the remedial actions below, the rail will be drilled for the two outer most bolt holes at each end of the 6 or 8 hole joint bar with bars secured to the rail with four bolts. Where 4 hole bars are used the number of bolts for the class of track will be installed.
 - ii. Speed restrictions to be applied are maximum allowable speeds. Where the class of track is lower than the remedial speed, use the lower speed.

- iii. Visual inspections of defects, visual supervision of movements over defects (when required), and placement of speed restrictions will only be performed by qualified employees.

REMEDIAL ACTION for DEFECTIVE RAILS

		If the defective rail is not replaced immediately take the following remedial action denoted by the Action Code	
Defect Type ²	Percent of Rail Head Cross-sectional area Weakened by defect or size of defect	Class 1 track, Class 2 track, or Any Class 3 track with 20 MGT Or less, and is NOT a HAZMAT/DG route OR carries Passenger Traffic	All Class 3 track carrying HAZMAT / DG or Passenger Traffic or Class 3 track with more than 20 MGT, and all Class 4 and 5 tracks
		REMEDIAL ACTION CODES	REMEDIAL ACTION CODES
Compound Fissure (TDC)	0 – 69%	B & E	10
	70 – 99%	A2	2 or 10
	100%	A	3
Detail Fracture (TDD), Transverse Fissure (TDT), Engine Burn Fracture (EBF) Defective Weld (DWF, DWP, DWC, DWG)	0 - 19%	C ¹	4 ¹
	20 - 59%	D	5
	60 - 99%	US only- A2 or (E then H)	6
	60 - 99%	Canada Only - D	
Vertical Split Head (VSH, VSJ) Horizontal Split Head (HSH, HSJ) Piped Rail (PRO, PRJ) Head Web Separation (HWO, HWJ) Split Web (SWO, SWJ) Defective Weld Longitudinal	100%	A or (B and E)	3
	Up to 1/2"	F*	7
	1/2" to 3"	B & G*	8
	Over 3"	I	9
	Break out in Rail Head	A	3
Bolt Hole Crack (BHO, BHJ)			
	Up to 1/2"	F*	7
	1/2" - 1 1/2"	G*	8
	1 1/2" - 3"	B & G	8
	Over 3"	B & G	9
Broken Rail Base (BBO, BBJ)	Break out in Rail Head	A	3
Broken Rail Base (BBO, BBJ)	0" - 6"	E	10
	Over 6"	A or (E then B)	11
Ordinary Break		A or E	3 or 10
Damaged Rail		D	12
Rail End Batter (REB), Crushed Head (CH), or Localized Surface Collapse (LSC)		See T.S. 1.7 Section 10	See T.S. 1.7 Section 10

Note:

- (1) In the U.S., in Class 3 through 5 track, if the defect was found by ultrasonic inspection, limit operating speed to maximum 50 MPH or the maximum for that class of track, whichever is lower for a period not to exceed 4 days. If joint bars are not applied within this 4 day period, limit operating speed to 30 MPH, until joint bars are applied. After joint bars are applied, limit operating speed to 50 MPH or the maximum allowable for the class of track.
- (2) Defects in special trackwork or highway crossings must be protected as per the above, inspected visually at the minimum frequency by regulation for track inspections and removed within 14 days.

Remedial Actions applicable to **REMEDIAL ACTION for DEFECTIVE RAILS:**

REMEDIAL CODES A - I

- A. Visually supervise each operation over the defective rail.

Follow instructions of T.S 1.8 - IN SERVICE RAIL FAILURES and MOVEMENT OVER RAIL BREAKS pertaining to supervised moves as well as Canadian allowance of unsupervised movements.

- A2. Visual inspection of the defective rail, after which that person may authorize operations to continue over the defective rail, without continuous visual supervision, at a maximum of 10 MPH for up to 24 hours prior to making another visual inspection, a repair or replacement of the rail.

- B. Limit speed over the defective rail to that as authorized by a qualified person to a maximum of 30 MPH.

- C. **In Class 1 and 2 track**, apply joint bars within 10 days after determining to continue the track in use.

In Class 3 track, limit speed to 30 MPH until joint bars are applied. Apply joint bars within 10 days of determining to continue the track in use. After applying joint bars, limit speed to a maximum of 40 MPH. When joint bars have not been applied within 10 days, the speed must be limited to 10 MPH until joint bars are applied.

- D. Limit speed to 30 MPH until joint bars are applied. Apply joint bars within 7 days of determining to continue the track in use. After applying joint bars, limit speed to a maximum of 40 MPH. When joint bars have not been applied within 7 days, the speed must be limited to 10 MPH until joint bars are applied.

- E. Apply joint bars.

- F. *Inspect rail or remove defect within 90 days of detecting the defect.

- G. *Inspect rail or remove defect within 30 days of detecting the defect.

- H. Limit speed to 40 MPH.

- I. Limit speed to 30 MPH and remove defect within 90 days of being detected.

*Note: For RFD defects that are strictly internal and are not visible, perform another inspection with either rail-mounted or handheld RFD equipment. For defects that are visible and measureable, a visual or RFD inspection is acceptable. For defects enclosed within the joint bar area, such as bolt hole defects, when UTT inspection cannot be performed within the re-inspection time frame, the joint bars must be removed and a visual re-inspection must be made.

The re-inspection or replacement must be performed prior to the expiration of the 30 or 90 day interval. If the defective rail remains in track and is not replaced, the cycle starts over with each

re-inspection. If the defect increases in size it may become subject to more restrictive remedial action as described in the **REMEDIAL ACTION for DEFECTIVE RAILS TABLE**.

REMEDIAL CODES 1 - 12

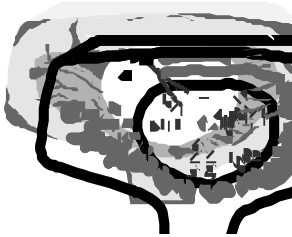
- 1) Intentionally left blank
- 2) Visual inspection of the defective rail, after which that person may authorize operations to continue over the defective rail, without continuous visual supervision, at a maximum of 10 MPH for up to 24 hours prior to making another visual inspection, a repair or replacement of the rail. Remove defect within 72 hours of being detected.
- 3) Visually supervise each operation over the defective rail.

Follow instructions of T.S 1.8 - IN SERVICE RAIL FAILURES and MOVEMENT OVER RAIL BREAKS pertaining to supervised moves as well as Canadian allowance of unsupervised movements.
- 4) Inspect defect. Limit speed to 30 MPH until joint bars are applied. Thereafter limit speed to 50 MPH and remove defect within 7 days of being detected.
- 5) Inspect defect. Limit speed to 30 MPH until joint bars are applied. Then limit speed to 50 MPH. Remove defect within 72 hours of being detected.
- 6) Inspect defect. Limit speed to 10 MPH until joint bars are applied. Then limit speed to 50 MPH. Remove defect within 24 hours of being detected.
- 7) Inspect defect. Limit speed to 50 MPH. Remove defect within 7 days of being detected.
- 8) Inspect defect. Limit speed to 30 MPH. Remove defect within 72 hours.
- 9) Inspect defect. Limit operating speed to 10 MPH. Remove defect within 48 hours of being detected.
- 10) Inspect defect. Apply joint bars. Limit speed to 30 MPH. Remove defect within 72 hours of being detected.
- 11) Inspect defect. Limit speed to 10 MPH. Assign qualified person to visually supervise each movement over defect.
- 12) Inspect defect. Apply joint bars within 10 days. Limit speed to 30 MPH until joint bars are applied. Thereafter limit speed to 50 MPH.

DEFECT TYPES

The illustrations below indicate examples of various defects or failure types. Utilize these examples for determining In Service Rail Failures (ISRF) when completing the Failed Rail Form.

Transverse Fissure



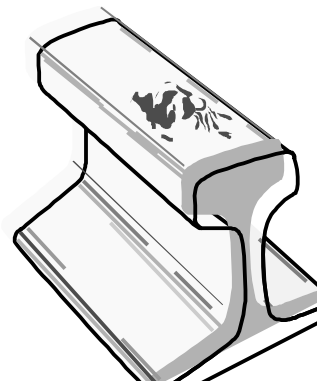
Compound Fissure



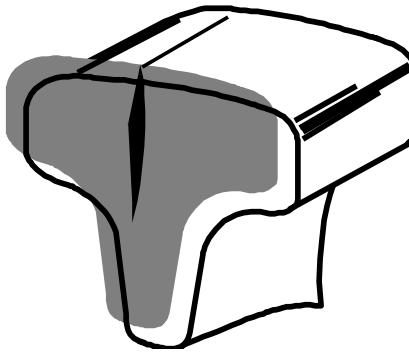
Detailed Fracture



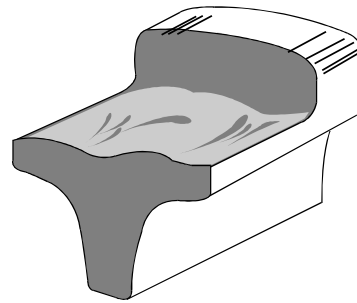
Engine Burn Fracture



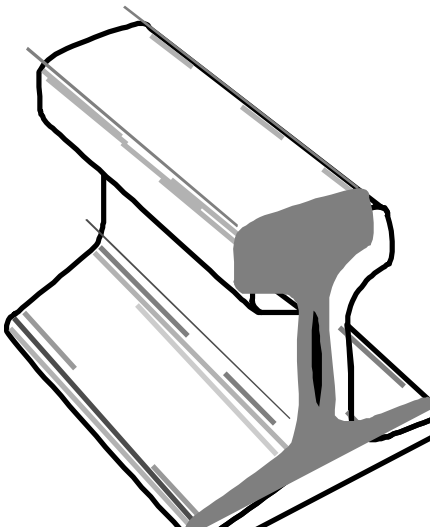
Vertical Split Head



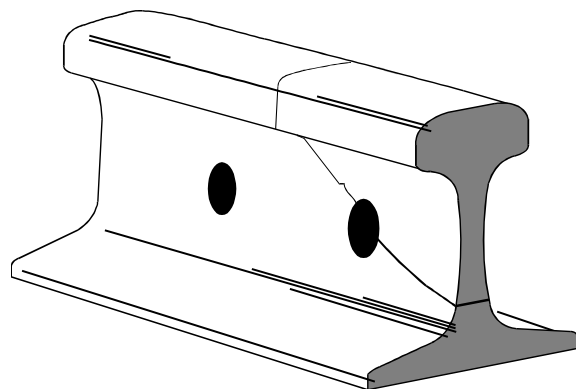
Horizontal Split Head



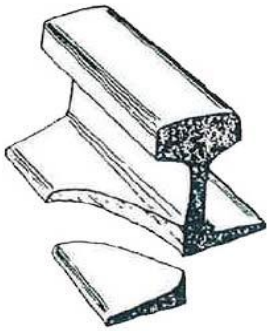
Piped Rail



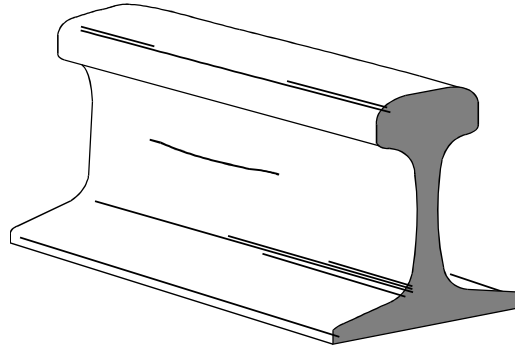
Bolt Hole Crack



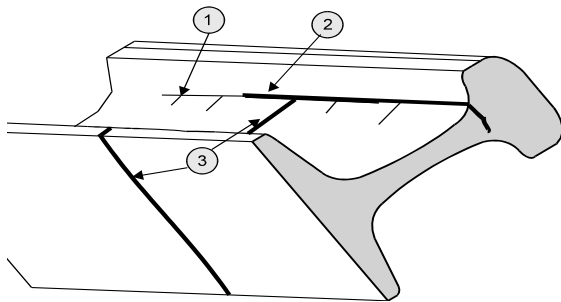
Broken Base



Horizontal Split Web



Head Web Separation

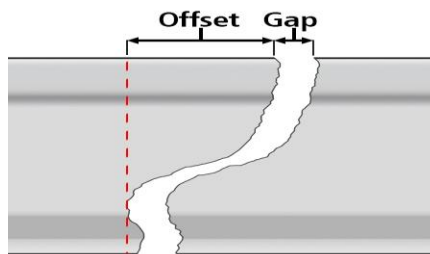


THIS PAGE BLANK INTENTIONALLY

T.S. 1.8 IN SERVICE RAIL FAILURES and MOVEMENT OVER RAIL BREAKS

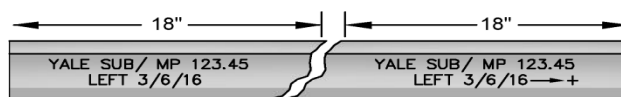
1. The following terms are used to describe rail failures:

- a. In Service Rail Failure (ISRF): An occurrence of any type of rail break or rail weld failure in normal service.
- b. Rail Break: A complete break of the rail.
- c. Offset: The maximum distance the head overhangs the web or base of the rail.
- d. Gap: The distance between the two ends of a rail break or pull apart.



- e. Dutchman: A short piece of rail, with or without a bolt hole, used in conjunction, and within joint bars, in an emergency situation.
 - f. Weld Repair Bars: Temporary use bars, with slotted bolt holes and relief to accommodate welds, for the purpose of aligning rail ends at field welds to allow the passage of trains.
2. All ISRF's will be reported in TIS and on the Broken Rail Response Form at the earliest opportunity. The information that must be recorded is:
- a. Subdivision, track number, milepost, GPS coordinates, tangent or curved track, rail side of break (Left or right when looking at increasing mileposts) and remedial action.
 - b. Rail and ambient temperatures, gap distance, break offset, defect type (if identifiable).
 - c. Rail weight, manufacturer, rolling year, vertical and horizontal wear measurements.
 - d. If a weld, the date of the weld, weld number and welder identification, as well as the rail wear measurements on both sides of the weld.
 - e. Tie type and anchor pattern along with ballast condition.
 - f. Determination of the cause of the rail break can be made using the diagrams in T.S. 1.7 RAIL TESTING AND FREQUENCY.
3. For rail breaks, a clear photo of the rail ends, both side views and bottom, will be taken and forwarded with the Broken Rail Response Form. Photos should be taken in daylight and without flash.
4. ISRF repairs in CWR will be handled according to T.S. 1.3 CONTINUOUS WELDED RAIL – MAINTENANCE OF CWR
5. Broken rails will be retained for 2 weeks in case it is determined to send off for examination.

6. Rail failures that have been directed to be examined in a laboratory will:
 - a. Have the exposed ends sprayed with WD 40, or equivalent, to prevent oxidation.
 - b. Include approximately 18" of rail each side of the failure. Long pieces may be required for longitudinal failures.
 - c. Have the subdivision, milepost, rail side, date and direction written in paint marker on each of the two pieces.
 - d. In a case where the rail breaks into multiple pieces, attempt to reassemble the rail, then place match markings from the pieces to the surrounding rail. Include all pieces with the shipment.



MOVEMENT OVER AN ISRF:

7. A train or engine **MUST NOT** operate over a rail break, (including pull aparts in the U.S.) when **ANY** of the following conditions exist:
 - a. The ISRF:
 - i. Is in a tunnel or on an open deck structure, or
 - a. for supervised moves, the break is within 100 feet of an unanchored open deck bridge.
 - b. for unsupervised moves, (**Canada only**) the break is within 500 feet of an un-anchored open deck bridge.
 - ii. Has ties on either side that are crushed, split or defective.
 - iii. Has cracks that are observed radiating from the broken rail ends.
 - iv. Is in an area of unstable subgrade.
 - v. Has an offset greater than 2 inches.
 - vi. Has a gap more than 3 ½ inches.
 - vii. Extends beyond the limits of the joint bar.
 - viii. Occurs in an area which the Regional Chief Engineer has specified movements over rail breaks are not permitted.

NOTE: See flow charts of **TABLE 1** and **TABLE 2** as a job aide.

8. When **NONE** of the conditions of Item 7 exist, train operations **MAY** continue once:
 - a. The correct size joint bars can be applied to the rail:
 - i. With a bolt through the rail break gap; or,
 - ii. If the break is at a weld location and bolt holes exist, splice bars or weld repair bars can be installed, bolted both sides of the break;

- iii. Trains or engine are allowed to operate at a speed not to exceed 10 MPH, or,
 - b. If the gap (less than 1 1/8 inch) does not allow for a bolt to be installed and bars applied, then limit the speed over the break to 5 MPH. **This is not allowed on a ballast deck bridge.**
9. Where permitted, a Dutchman may be installed to fill the gap. The Dutchman must be:
- a. Marked to indicate the rail weight and length. Have a variety of lengths on hand.
 - b. Used only if there are no evident signs of a longitudinal defect such as a vertical split head, horizontal split head, split web or a head web separation.
 - c. Of similar rail weight and wear. The maximum vertical and gauge mismatch is 3 mm.
 - d. Within the Maximum Gap range as shown below. The offset of a broken rail can be trimmed to allow for installation of a Dutchman.
 - e. Installed so that it is approximately centered within, and secured with joint bars, or a bolt may be installed through the joint bar and between the rail end and the Dutchman with a maximum gap of 3/4" (19 mm) between the opposite end of the Dutchman and the other rail end.
 - f. Constantly monitored during all moments over the location by a qualified employee who has established communication with the train.
 - g. Protected by the speed restrictions as shown in **TABLE A**.
 - h. Inspected and bolts tighten, if required, after each movement is made over the location.
 - i. Removed when permanent repairs are made, but no longer than 24 hours after installation.

Maximum Gap for use of Dutchman rail

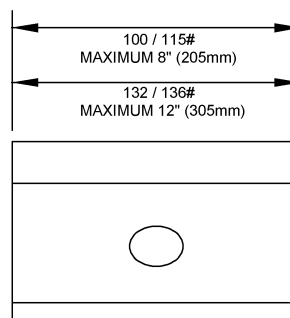


TABLE A Maximum Allowable Speed Over a Dutchman

Maximum Speed	100 / 115 lb	132 / 136 lb
10 MPH	Up to 4" (100 mm) Gap	Up to 6" (152 mm) Gap
5 MPH	4" to 8" (205 mm) Gap or Any Curve	6" to 12" (305 mm) Gap or Any Curve

10. The condition of rail breaks, Dutchman, splice bars, weld repair bars and supporting ties must be observed as movements operate over the break, **EXCEPT**:
- In Canada only:** This requirement may be waived if the rail break is:
- a. a significant distance from a location the employees vehicle can be cleared from the track.
 - b. at a location where there is no other track, grade crossing or road or where access by foot is impeded due to adverse weather provided the following regulatory requirements are met:
 - i. The rail break is either:
 - a. A vertical (ordinary) break.
 - b. A complete break in which there is a sign of a transverse fissure or compound fissure.
 - c. A complete break at a field weld.
 - c. The condition of the rail break, splice bars, weld repair bars and supporting ties are inspected before each movement over the location.
 - d. Repairs are performed not more than 24 hours since the initial inspection of the break.
11. Speed restrictions will be placed in accordance with applicable operating rules:
- a. **In Canada only:** The RTC must be notified, in a clear manner, how the restriction will be applied. One of the following methods must be used:
 - i. place flags per CROR Rule 843; or
 - ii. place approved Rail Break sign; or
 - iii. when flags or approved Rail Break signs are not available, the restriction must be placed between two identifiable locations.
 - b. **In the U.S. only:** The RTC must be notified, in a clear manner, how the restriction will be applied.
12. **In Canada only:** Temporary bond wires, where applicable, may be applied around the rail break provided:
- a. Only Engineering employees trained in the application of bonding or rail repair may install bond wires, and in accordance with T.S. 10.0
 - b. Confirmation of no other rail breaks exist within the block, and
 - c. Confirmation that required speed restrictions have placed, then
 - d. Trains or engines may be authorized through the block on signal indication.

TABLE 1: SUPERVISED MOVEMENTS OVER ISRF

If the condition of the ISRF, joint bars, weld repair bars and the supporting ties can be visually observed as the train or engine operates over the location, and communication has been established with the train crew, use the following flow chart to determine the appropriate action:

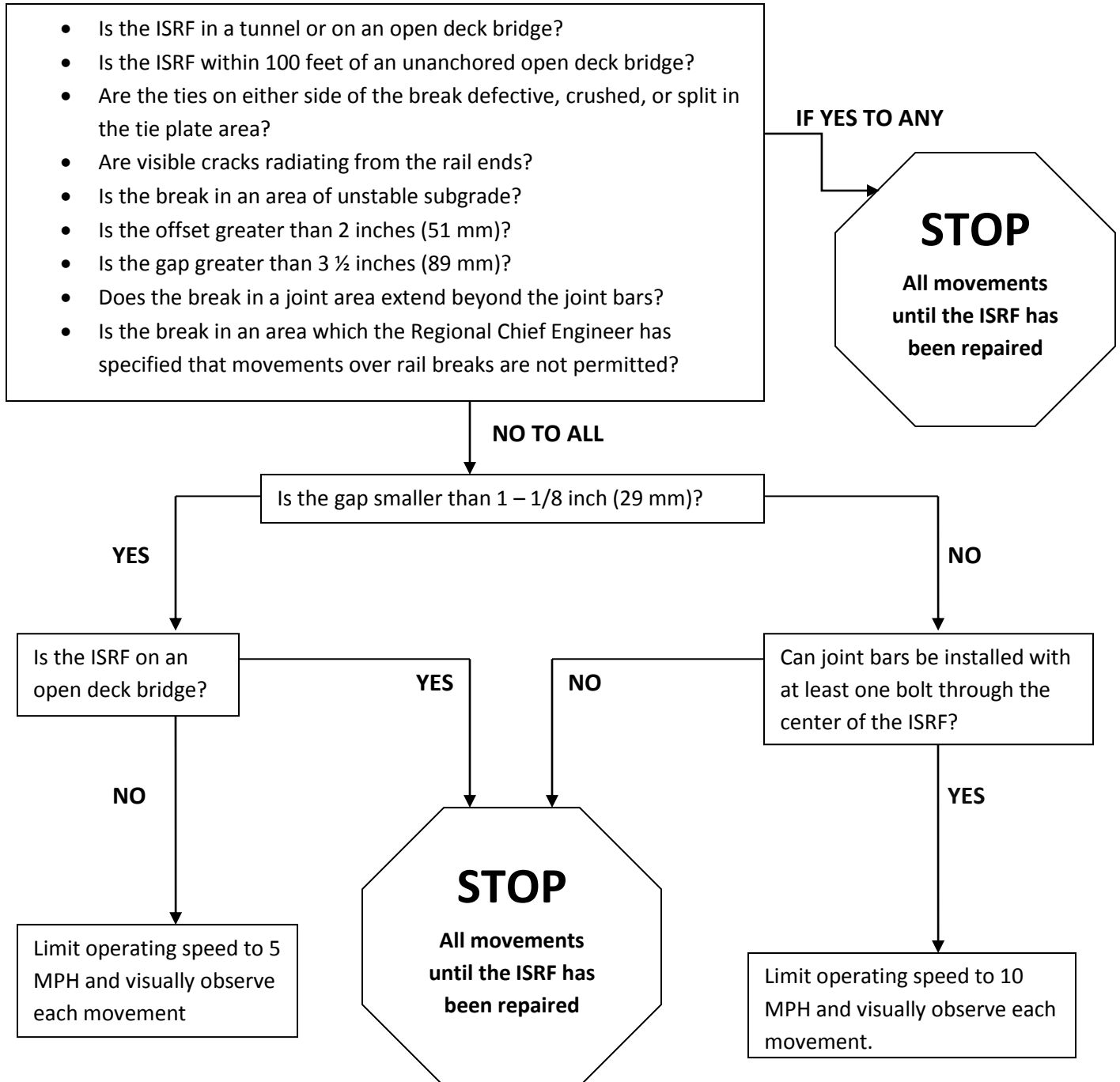
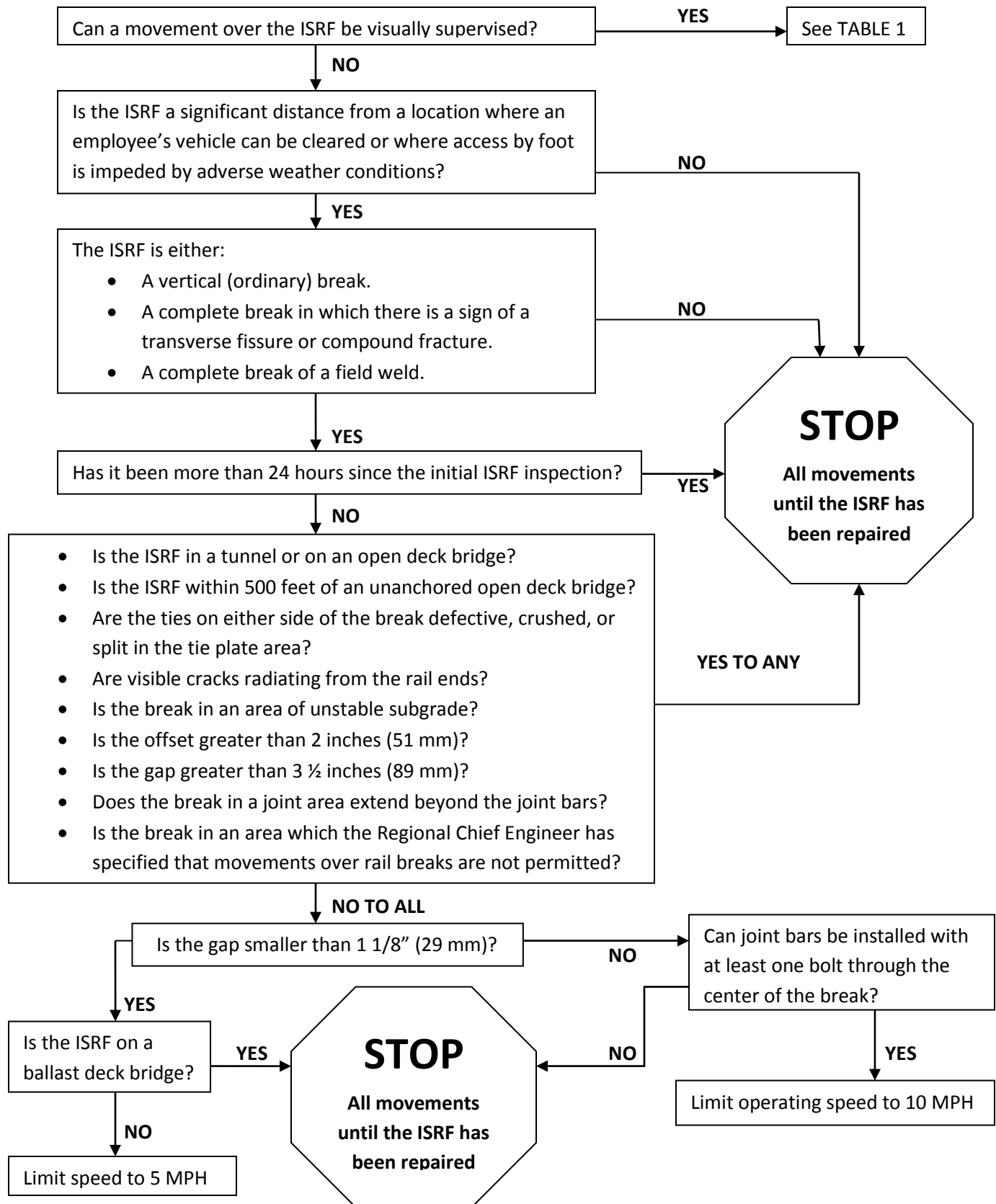


TABLE 2: UNSUPERVISED MOVEMENTS OVER ISRF – CANADA ONLY

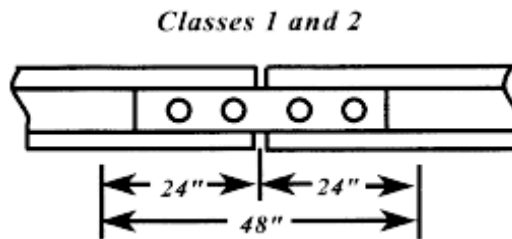


T.S. 2.0 TIMBER TIE INSTALLATION AND MAINTENANCE

1. Wood cross ties will be:
 - a. No. 1 Grade 7"x 9" x 8'-6" treated hardwoods for mains, sidings and secondary tracks.
 - b. No. 2 Grade 6"x 8" x 8'-6" treated hardwoods for spurs, industry and some yard tracks.
 - c. Installed at 20 3/8 inch centers in tracks Class 2 and above
 - d. Installed at 21 ¼ inch centers in Class 1 tracks.
 - e. Installed centered with the track and square with the rail, with the end of the tie approximately 18 ½ inches from the field edge of the rail base.
 - f. Prevented from becoming centerbound.
2. Transition ties will be installed:
 - a. In wood tie track, at the approaches to open deck bridges and trestles.
 - i. Transition ties sets will consist of 3 each 9, 10 and 11 foot hardwood switch ties with the 11 foot ties installed adjacent to the bridge abutment headwall.
 - b. At the transition from wood ties to concrete ties, only at the direction of the Regional Chief Engineer:
 - i. Transition ties sets will consist of 4 each 9, 10 and 11 foot hardwood ties with the 11 foot ties adjacent to the concrete ties.
3. Treated ties must not be handled with any tool having sharp points that will penetrate beyond the depth of the treatment or cause damage to the ties.
 - a. Avoid direct contact of creosote on skin by wearing appropriate PPE.
4. When spikes are removed from a tie, the hole must be filled with approved plugs prior to re-spiking. Chemical plugging compound is preferred.
5. When ties are being installed in turnouts, at insulated joints, within the limits of signalized crossings or wayside equipment scanner locations, the work must be coordinated with the Signal Department.
6. Track shims can be installed on wood ties:
 - a. As the last viable option to correct surface during frozen ballast conditions.
 - b. So that shims are at least the same size as the tie plate and have holes corresponding to the tie plate they are under.
 - c. With the minimum number of shims installed to correct the irregularity.
 - d. So that plates are fastened to the tie with at least 4 inches of spike penetrating the tie.
 - e. With all rail anchors removed through the area of shimming.
 - f. With shims installed per T.S. plan 2206.

- g. With shims removed from track as soon as conditions allow for permanent repairs.
- 7. Gauge rods installed in winter must be removed in the next work season and a sufficient number of ties installed to correct the condition. Gauge rods that have been installed in one winter will be removed prior to the next winter.
- 8. The following definitions of defective ties will be used:
 - a. Broken Tie
 - i. Tie that is broken through the entire depth of the tie.
 - b. Split or End Split Tie:
 - i. Tie that is split end to end, or from the end into a spike hole, or
 - ii. Tie split full depth of the tie allowing ballast to work into the tie resulting in poor surface and gauge.
 - c. Cut Tie
 - i. Tie that is rail or plate cut, or adzed to a depth of 2 inches or more on No. 1 ties, or more than 1 inch on No. 2 ties.
 - d. Crushed Tie
 - i. Tie that has the bearing surface under the rail crushed or splintered 1 inch or more deep to the extent it can not hold surface, line or gauge.
 - e. Spike Killed Tie
 - i. Numerous splits from the tie end,
 - ii. Loose or high spikes.
 - iii. Rail or plate movement of ½ inch or more or wide gauge (including dynamic wide gauge).
 - f. Decayed Tie
 - i. Tie that has rotted, hollowed or deteriorated such that it cannot hold spikes, gauge or surface.
 - g. Damaged Tie
 - i. Tie that has been damaged by derailment, dragging equipment, fire, etc. to the extent that it cannot hold surface, line or gauge.
 - h. Worn Tie
 - i. Worn or rounded on the bottom resulting in poor surface and line or the inability to hold spikes.

9. Each joint will have:



- a. At least one non-defective tie with centerline within the 48 inches shown above.

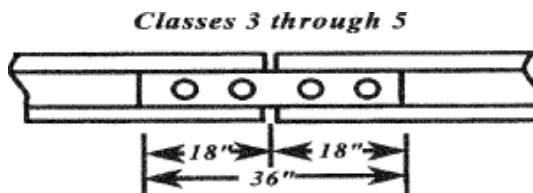


Figure 2

- b. At least one non-defective tie with centerline within the 36 inches shown in FIGURE 2, or ,

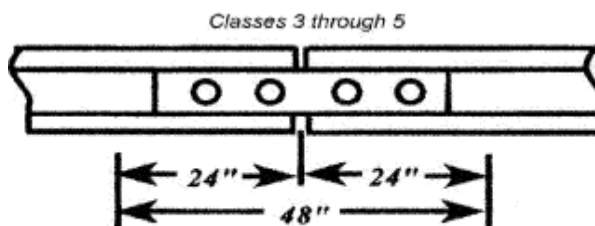


Figure 3

- c. Two non-defective crossties, one on each side of the joint with centerlines within 24 inches of the joint as shown in FIGURE 3.
10. The number of non-defective ties in any 39 foot length of track shall never be less than the **TABLE 1** and distributed to effectively support the entire 39 foot length:

TABLE 1 MINIMUM NUMBER OF NON-DEFECTIVE TIES EVENLY DISTRIBUTED PER 39 FEET OF TRACK

Track Class	Tangent and Curves to 2°	Turnouts, and Curves ≥ 2°
5 and 4	12	14
3	10	10
2	8	9
1	5	6

11. Tie program justification will include:
- a. Track Supervisors must inspect their territories annually for tie quality. When the average defective tie counts reach the level of **TABLE 2**, and a mile-by-mile count will be provided to the Manager Track Quality for future program planning.

TABLE 2 DEFECTIVE TIE COUNTS

Track Class	Percentage of Defective Ties	Defective Tie Count
4 & 5	25 - 30 %	777 - 933
2 & 3	35 - 40 %	1088 - 1244
1	45 - 50%	1341 - 1490

- b. The Track Supervisor, or a person designated by the Regional Chief Engineer, shall be responsible for:
 - i. Inspecting and recording ties for renewal and preparing a list showing the actual number of ties per mile to be replaced.
 - ii. Marking the ties to be replaced with paint on the gauge side of the tie.
 - iii. Place flagging or marker every 25 ties to coordinate unloading.
- 12. Until a major tie program is completed, a spot program should be undertaken when there is a high frequency of:
 - a. Four or more consecutive defective ties;
 - b. Three or more consecutive ties in a curve greater than 2 degrees; or
 - c. Defective ties in the joint area.
- 13. When ties are unloaded using a car topper or grapple:
 - a. Safely place the ties along the right of way to avoid excessive redistribution.
 - b. Avoid distributing ties along the right of way on high fills. Place ties at the nearest high ground or flat spot to avoid loosing ties down the banks or into waterways.
- 14. When renewing ties in either jointed track or CWR, regardless of the installation method:
 - a. Correct the gauge of the track where required.
 - b. Remove no more ballast than is absolutely necessary from the crib or shoulder.
 - c. All ties installed must be spiked, anchored to standard pattern, tamped, including any adjacent ties that may be left hanging, and ballast restored before close of the day.
 - d. When necessary to allow trains to operate through the tie gang area during working hours:
 - i. No more than three consecutive ties on tangent track or two consecutive ties on curved track can be left unspiked.
 - ii. Ties on either side of all joints must be spiked.
 - iii. Limit speed to 10 MPH;
 - e. Apply the appropriate speed restriction based on the type of work and rail temperature per TABLES 3, 4 or 5 of T.S. 1.3 – CONTINUOUS WELDED RAIL, even if the track is jointed.
 - f. In preparation for the following day's tie installation, the spiking pattern may be reduced to a minimum of one gauge and one field rail holding spike per plate on each tie to be removed.

15. In CWR track the maximum number of consecutive track ties that can be renewed in a single pass shall be:

TABLE 3 **NUMBER OF CONSECUTIVE TIES ALLOWED TO BE CHANGED**

Installation Method	Tangent and Curves to 2°	Curves ≥ 2°
With a Junior or Production Tamper	5	4
With Hand Tamping or Hydraulic Tools	3	3

16. When the tie gang is working within 400 feet of a fixed point (turnouts, bridges greater than 100 feet, road crossing greater than 100 feet, diamonds, and areas of non-standard anchor pattern with rail moving more than two inches), see T.S. 1.3 CONTINUOUS WELDED RAIL – DESTRESSING.
17. No ties shall be installed when the rail temperature is 25°F above the PRLT unless directed by the Regional Chief Engineer, who must specify all necessary precautions to be taken such as mandating the use of a stabilizer, increased inspections, more restrictive speed restrictions or limiting work to emergency applications.
18. Prior to surfacing or mechanized tie replacement a main track CWR curve which is more than 3°, and the temperature is more than 50°F (27° C) below the PRLT, or is expected to be in the next 24 hours, the curve must be staked per T.S. 4.0 – BALLASTING, SURFACING and LINING.
19. Cross ties in CWR territory replaced as part of a road crossing rehabilitation may be changed in a single pass provided:
- Crossing surface is replaced immediately following tie renewal;
 - Crossing approaches are restored and are of sound condition;
 - The appropriate speed restriction is applied per T.S. 1.3 CONTINUOUS WELDED RAIL.
21. Transition tie sets in CWR territory may be changed out in a single pass provided:
- The ties are being replaced in conjunction with ballast rehabilitation work.
 - Upon completion of work, the ballast section is fully restored with a 12 inch shoulder.
 - The appropriate speed restriction is applied for mechanized tie renewal.

22. Switch ties installed will:

- a. Be the correct length for the location to be installed in the turnout per the appropriate standard plan. Mark the required tie length on the field side of the rail at the location the tie is to be installed.
- b. Not be cut in order to get shorter lengths.
- c. Be installed so that lacing of standard cross ties does not occur at the end of the long ties.
- d. Be replaced in a single pass provided the location is protected by the appropriated speed restriction for mechanized tie renewal. See T.S. 1.3 CONTINUOUS WELDED RAIL.

23. Ties will be loaded and removed from the right of way as soon as possible following removal from track.

T.S. 2.1 CONCRETE TIE INSTALLATION AND MAINTENANCE

1. Concrete ties shall be installed:
 - a. With tie centers at 24 inches.
 - b. With a minimum 12 inches of clean, well draining ballast under the bottom of the tie.
 - c. With 12 inches of shoulder ballast.
 - d. No closer than 20 feet of an open deck bridge which is more than 50 feet long.
 - i. At the direction of the Assistant Chief Engineer, 12 each 11 foot hardwood ties will be installed as transition ties off the bridge backwall.
2. When the tie gang is working with in 400 feet of a fixed point (turnouts, bridges greater than 100 feet, road crossing greater than 100 feet, diamonds, and areas of non-standard anchor pattern with rail moving more than two inches), see T.S. 1.3.28 CONTINUOUS WELDED RAIL – DESTRESSING.
3. Concrete ties shall have the correct clips, pads and insulators applied at the time of installation. The fastener component guidelines are in **TABLE 1**.

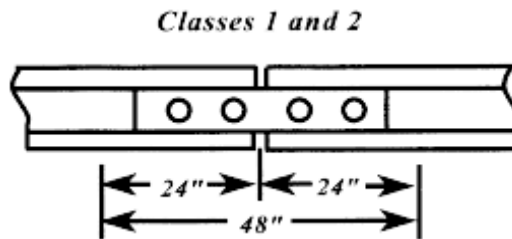
TABLE 1 PREMIUM FASTENERS FOR WOOD OR CONCRETE TIES

Tie Type	Pad Type	Conventional Clip Type	Shoulder Insulator	Joint Clip	Insulated Joint Assy	
					Clip	Insulator
60 A 60 B 60 C 60 E	5 mm Polypad	e-2009L or e-2009 (LH)	HD-6 on both sides, or FP-9 on field side when re-gauging	J273 (136 lb) J267 (115 lb)	e-2063	ECL-2063
55B	10 mm Double Studded		FP-9 on gauge side, HD-6 on field side			
60D	Rubber		HD 10/8			
101 L	Safelok 3 Pad Assy. 38742	Safelok 3 Clip 38643	Safelok 3 Shoulder Insulator 38652	Safelok 38637	Safelok 3 I/J Assy. 38631	Safelok 3 I/J Assy. 38631
WOOD	N/A	e-2055 or e-2056(LH)	N/A	J273 (136 lb) J267 (115 lb)	e-2063	N/A

4. At the transition from wood ties to concrete ties, at the direction of the Regional Chief Engineer, install a transition tie set consisting of 4 each 9, 10 and 11 foot hardwood ties with the 11 foot ties adjacent to the concrete ties.

5. When surfacing is performed on concrete tie track:
 - a. Adjust tamper head limit switches to ensure the correct penetration of the tamping tools below the tie.
 - b. Ballast regulator plow blades must be adjusted to ensure no impact of the fasteners.
 - c. Upon completion of ballast regulating, inspect the fastening system and replace the missing or damaged fasteners.
6. Concrete ties should be inspected for signs of center bound condition. This condition is represented by transverse cracks visible in the middle third of the tie.
7. Concrete tie performance is reduced when:
 - a. The track holds water or is muddy. Drainage of water and replacement of fouled ballast should extend approximately 12 inches below the bottom of tie. See T.S. 9.1.4 – DRAINAGE.
 - b. There are impacts from rail conditions.
 - i. Joints should be welded as soon as possible.
 - ii. Surface irregularities such as corrugated rail, crushed heads, wheel burns, etc. should be removed as soon as possible.
8. Concrete ties are considered defective when:
 - a. The tie is broken transversely under one or both rail seats.
 - b. The tie is broken transversely in the center section of the tie and shows signs of further deterioration such as loss of tension in pre-stressing wires, exposure of the pre-stressing wires or crumbling concrete.
 - c. The tie is broken longitudinally resulting in the loss of ability to hold shoulder(s) in place.
 - d. One or more shoulder is loose or damaged to the extent it cannot properly retain gauge.
 - e. Bottom of the tie is worn to the extent that pre-stressing wires are exposed.
 - f. The rail seat is abraded to the extent repairs are no longer possible. An abraded tie is no longer defective once the repairs have been performed.
9. A cracked tie should not be confused for a broken tie. A concrete tie is not considered broken until the crack extends through the entire tie or runs through the shoulder. Tie end damage caused by handling, ballast regulators or impacts does not make the tie defective.

10. Each joint will have:



- a. At least one non-defective tie with centerline within the 48 inches shown above.

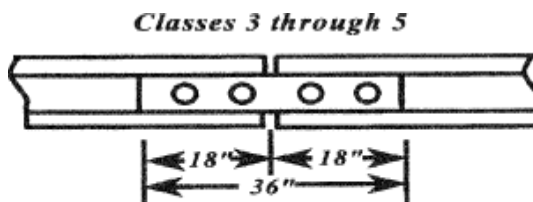


Figure 2

- b. At least one non-defective tie with centerline within the 36 inches shown in FIGURE 2, or ,

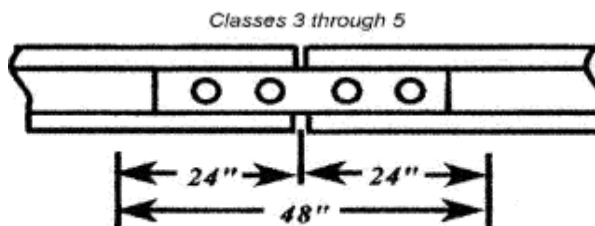


Figure 3

- c. Two non-defective cross-ties, one on each side of the joint with centerlines within 24 inches of the joint as shown in FIGURE 3.
11. The number of ties in any 39 foot length of track shall ;
- a. have the minimum number of non-defective tie as shown in TABLE 2 for the class of track, distributed to effectively support the entire 39 foot length.
- b. Not contain more than 2 defective ties in a row

TABLE 1 MINIMUM NUMBER OF NON-DEFECTIVE TIES EVENLY DISTRIBUTED PER 39 FEET OF TRACK

Track Class	Tangent and Curves to 2°	Turnouts, and Curves $\geq 2^\circ$
5 and 4	12	14
3	10	10
2	8	9
1	5	6

12. Special attention must be paid to the condition of concrete ties in areas of derailment damage. Note the presence and growth of surface cracks or progressive deterioration of the tie.

13. Rail seat abrasion occurs when the concrete in the rail seat area is abraded away by the introduction of moisture. The abrasion erodes the surface of the tie under the rail resulting in loss of restraint by the clip, rail cant and gauge widening.
14. Inspection for signs of rail seat abrasion on concrete ties is critical. Indications of rail seat abrasion are:
 - a. Tie pads curling, squeezing out, or bleeding at the sides or ends of the rail seat.
 - b. Tie pads worn through or indenting into the surface of the rail seat.
 - c. Excessive rail cant.
 - i. Each degree of cant is equal to 1/8 inch (3 mm) of gauge widening.
 - ii. See T.S. 7.1 TRACK GEOMETRY for combination cant defects.
 - d. Signs of rail running through the clips or missing clips.
 - e. Displaced or missing insulators.
 - f. Concrete dust or slurry adjacent to the tie pad.
15. When signs of significant rail seat abrasion appear, inspect the rail seat by unclipping the rail, jacking the rail up, removing the insulators and pads and examining the rail seat. If abrasion is found, notify the Track Supervisor and Regional Chief Engineer to determine corrective actions.
16. When planning for rail relay programs, the MTQ and Assistant Chief Engineer will determine if rail seat abrasion repair will be included in any portion of the program.
17. During rail replacement, tie pads must be removed and the rail seat examined for abrasion.
18. Inspect the fastening system of concrete ties:
 - a. Replace sprung or damaged clips.
 - b. Shoulder insulators should be firmly seated with the post between the cast shoulder and the base of the rail.
 - i. Insulators that are twisted or cracked should be replaced.
 - ii. Shoulder insulators that have a post which is excessively thinned will cause wide gauge and need to be replaced.
 - c. Tie pads should be inspected for signs of tearing, thinning or wear. Correct pad thickness helps maintain required clip loading. Replace worn or defective pads.
19. Shoulder insulators must not be forced or driven in place. Use a rail positioner to provide the suitable gap for installation.
20. Wide post insulators can be installed on the field side shoulder to correct gauge widening.
21. Use care when applying heat to the rail during relays or adjusting a pull apart. Remove the insulator if necessary and reapply after heating. Always inspect both the insulator and pad after heat has been applied to the rail.

T.S. 3.0 TIE PLATES

1. Tie plates will be use on all wood and composite ties. Tie plates will not be installed under inner guard rails.
2. In track Class 3 and higher, tie plates will be under the rail on at least 8 of any 10 consecutive ties.
3. The use of new or pw tie plates shall be as directed by the Regional Chief Engineer, however:
 - a. Broken, damaged or corroded plates must not be reused.
 - b. Tie plates with excessively worn spike holes or shoulders greater than limits shown below should not be reused:
 - i. Square spike holes or round screw spike holes worn more than ¼ inch.
 - ii. Tie plate shoulders worn more than ¼ inch.
4. Tie plates must be installed so that:
 - a. Plates have full, even bearing on the ties.
 - b. The field side shoulder is square against the field side base of rail.
 - c. The plate is centered on the tie.
 - d. The cant of the tie plate is toward the center of the track.
 - e. Each tie plate has the same cant. A cant of 1:40 is standard.
5. Torch cutting of tie plates is not permitted.
6. The Rolled Plate for Pandrol clips should not be reinstalled in main track.
7. Ensure that there are no metal objects that can cause concentrated loading between the rail base and the tie plate in Class 3 and higher track. This includes the tie plate shoulder and spike heads.
8. Victor tie plates will be installed in either an every tie (preferred) or every other tie pattern. Rail will be anchored in accordance with T.S. 3.1 RAIL ANCHORS at these locations.
9. Curve block plate installation requires every third tie to have a curve block plate. Curve block plates can be used on curved closure rails of turnouts and reverse curves behind turnouts to prevent rail cant. Curve block plates are fastened with conventional cut spikes.
10. Tie plates will be used in accordance with the **TABLES 1 and 2**. Larger plates can be used, but avoid using smaller plates than the TABLES indicate.

TABLE 1 **5 1/2" BASE RAIL**

Annual Tonnage (MGT)	Class of Track	11" or 12" Plate	13", 14", Cast or Curve Block Plate
Less than 5	All	0 - 2°	> 2°
5 or more	All	N/A	All Track

TABLE 2

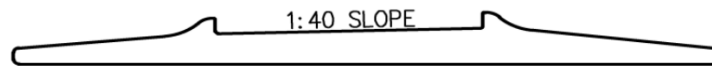
6" BASE RAIL

Annual Tonnage (MGT)	Class of Track	12" Plate	14" Plate	16" Plate	16" Cast, Victor or Curve Block
		DEGREE OF CURVE			
Less than 5	All	0 - 2°	2° - 6°	> 6°	
5 to 20	All	N/A	0° - 4°	4° - 6°	> 6°
20 to 40	1 & 2	N/A	0° - 4°	4° - 6°	> 6°
20 to 40	3,4,& 5	N/A	0 - 2°	2° - 4°	> 4°
> 40	3, 4 & 5	N/A	N/A	0 - 2°	> 2°

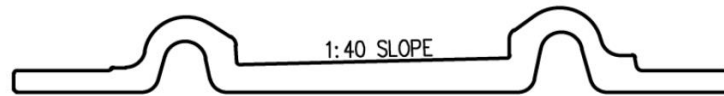
TIE PLATE TYPES

GAUGE SIDE

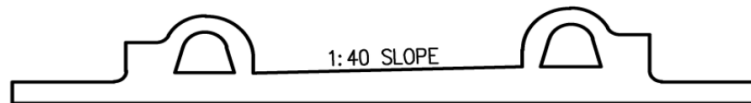
FIELD SIDE



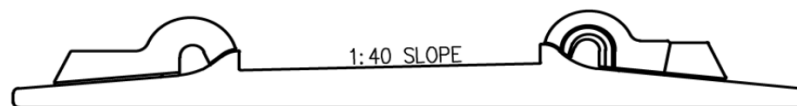
Conventional Rolled Double Shouldered Cut Spike Tie plate



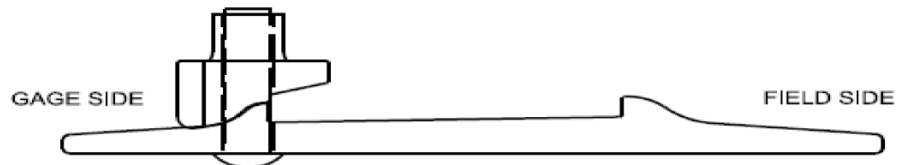
Rolled Plate for Pandrol clips



Cast Tie Plate for Pandrol Clips



Conventional Victor Type Tie Plate for Pandrol Clips



Conventional Rolled Double Shoulder Tie Plate with Curve Block

T.S. 3.1 RAIL ANCHORS

1. Rail anchors should be applied:
 - a. Uniformly along the rail and firmly against the side of the tie.
 - b. Using a sledge hammer, proper wrench tool or properly adjusted anchor machine. Use of spike mauls to apply or remove anchors is forbidden.
 - c. From the gauge side of the rail unless otherwise instructed. Anchors on stock rails are applied, where allowable, from the field side.
 - d. At least 2 inches from a plant or field weld
 - e. Directly opposite each other on the same cross or switch tie. Do not apply anchors across from a rail joint.
 - f. On ties that are square with the rail. Skewed ties must be straightened before anchoring.
 - g. In a location where the application will not interfere with or damage signal wires.
 - h. So the anchor is fully engaged with the base of the rail and so that the base of the rail is just inside the lip of the anchor. Do not overdrive the anchor.
2. Sprung or damaged anchors must discarded.
3. Rail anchors are not required on ties with elastic fastening systems unless additional restraint is required.
4. Anchors can be slid along the rail base only with a mechanical anchor squeeze / spreader.
5. Anchors required to be manually adjusted will be removed and reapplied.
6. Rail anchors will only be removed using an approved maul or removal machine.
7. Rail anchors are not to be installed on shimmed track. Anchors removed during shimming must be replaced when the shims are removed. See T.S. 2.0 TIMBER TIE INSTALLATION AND MAINTENANCE.
8. Rail anchors must be removed from rail prior to removing the rail from track.
9. In jointed rail, the minimum number of evenly distributed anchors per 39 feet of track are:

TABLE 1

Class of Track	Ties to be Box Anchored per 39 feet
1	6
2 and 3	8
4 and 5	10

10. Turnouts must be fully anchored where possible, from 200 feet ahead of the switch point to 200 feet behind the last long ties on all routes. Ensure rail anchors applied to the stock rail do not impede the movement of switch rods or bearing of the switch points on the slide plates.

11. In CWR track, rail anchors will be applied in a box pattern on every other tie , except, every tie for 200 feet will be box anchored:
 - a. Each direction from a permanent joint, except for glued or bonded insulated joints.
 - b. Each direction from where CWR abuts jointed rail.
 - c. Each direction from a crossing diamond or either side of a lift rail assembly.
 - d. Each direction from the abutment of an open deck bridge.
12. CWR on ballast deck bridges will be anchored in a box pattern on at least every other tie.
13. CWR installed on timber spans will only be anchored on ties which are secured with boat spikes to the timber stringers, unless otherwise directed by the Chief Engineer.
14. Moveable span bridges will be anchored as directed by the Chief Engineer.
15. Prior to anchoring CWR on any open deck, the Manager Bridges and Structures will confirm:
 - a. The requirements for bridge traction bracing.
 - b. The proper anchor pattern to use.
 - c. The fixed end of the span is identified.
16. When CWR is installed on a steel span open deck bridge, anchors will be applied only to ties which are secured to the steel stringer with hook bolts, usually every other or every third tie. Anchor per **TABLE 2**, when practicable will be followed:

TABLE 2

Length of Continuous Open Deck Portion	Individual Span Length	Rail Anchor Requirements	Sliding Joint Requirements
100 ft or less	All Spans	No Anchors	None Required
Over 100 ft	100 ft or Less	Box Anchor every 2nd Tie*	None Required
		Or	
		No Anchors	Joint Required
	Over 100 ft	Box anchor every 2nd Tie for 100 ft from the Fixed End of the Span	None Required
		Or	
		No Anchors	Joint Required

* If clips are used, every non-hook bolted tie should have a clip without longitudinal restraint.

17. Sliding joints shall be:
 - a. Of a design and at a location as approved by the Chief Engineer.
 - b. Installed in pairs and opposite each other, or if staggered, the joint will be properly guarded.
 - c. Installed and maintained with sufficient expansion length as per the table below.

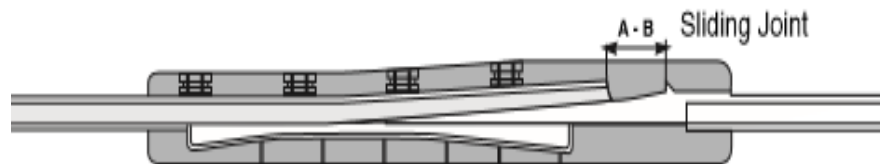
- d. Normally located behind the abutment and in the downgrade approach or expansion end of bridge.
- e. Spaced no more than 1,500 feet apart, which may result in a sliding joint being installed on the deck of longer structures.
- f. The heel gap of the sliding joint will be set according to **TABLE 3**.

TABLE 3

RAIL TEMP (F°)	LENGTH A – B (IN)											
0	16 1/2	16 3/4	17 1/8	17 1/2	17 7/8	18 1/4	18 5/8	19	19 3/8	19 3/4	20 1/8	20 3/8
10	16 1/8	16 3/8	16 3/4	17	17 1/4	17 1/2	17 7/8	18 1/8	18 3/8	18 5/8	19	19 1/8
20	15 3/4	16	16 1/4	16 3/8	16 5/8	16 3/4	17	17 1/4	17 3/8	17 5/8	17 7/8	18
30	15 1/2	15 5/8	15 3/4	15 7/8	16	16	16 1/4	16 3/8	16 1/2	16 5/8	16 3/4	16 3/4
40	15 1/8	15 1/4	15 1/4	15 1/4	15 3/8	15 3/8	15 3/8	15 1/2	15 1/2	15 1/2	15 5/8	15 5/8
50	14 7/8	14 3/4	14 3/4	14 3/4	14 5/8	14 5/8	14 1/2	14 1/2	14 1/2	14 1/2	14 1/2	14 3/8
60	14 1/2	14 3/8	14 1/4	14 1/8	14	13 7/8	13 3/4	13 5/8	13 1/2	13 3/8	13 3/8	13 1/4
70	14 1/4	14	13 3/4	13 5/8	13 3/8	13 1/4	13	12 3/4	12 5/8	12 3/8	12 1/8	12
80	13 7/8	13 5/8	13 3/8	13	12 3/4	12 1/2	12 1/8	11 7/8	11 5/8	11 3/8	11	10 7/8
90	13 1/2	13 1/4	12 7/8	12 1/2	12 1/8	11 3/4	11 3/8	11	10 5/8	10 1/4	9 7/8	9 5/8
100	13 1/4	12 3/4	12 3/8	11 7/8	11 1/2	11	10 5/8	10 1/8	9 3/4	9 1/4	8 3/4	8 1/2

400	500	600	700	800	900	1000	1100	1200	1300	1400	1482

LENGTH OF UNANCHORED CWR (FT)



THIS PAGE BLANK INTENTIONALLY

T.S. 3.2 DERAILS

1. Permanent derails must be installed:
 - a. Where there is any possibility of equipment left standing on tracks, other than main tracks or **designated** sidings, being moved by gravity **or weather** so as to obstruct the main track or siding.
 - b. On tracks used to tie up locomotives on a regular basis. Through tracks so used must be equipped with derails at both ends. Locations used to tie up locomotives will be specified by the Transportation Department.
 - c. At entrances and exits of Main and Running Repair Shops. Derails must be applied to each track not less than 40 feet from the shop doors. Where further safety measures are required, a derail pit may be installed per drawing TS 2212.
 - d. On tracks which an industry will move cars or equipment.
 - e. On mining or other bulk loading / unloading facility tracks where cars are dropped by gravity toward the main or other track that is to be protected.
 - f. Where required to protect track conditions, equipment or on track work where allowed by Operating Rules.
2. Permanent derails shall only be installed or removed as approved and directed by the Regional Chief Engineer or designate.
3. Whenever new tracks are designed or constructed, the Regional Chief Engineer must determine if a derail is required in accordance with Section 1 and approve the type of derail selected is in accordance with Sections 6, 7, 8 and 9, below. The Regional Chief Engineer must ensure that required derails are installed prior to placing the track in service.
4. The Superintendent of Transportation must advise, in writing, the Regional Chief Engineer of all operational changes **which pertain to derail placement**. The Regional Chief Engineer will confirm whether or not the operational changes require the installation of derails and that adequate operating procedures are in place to protect the situation. Whenever operational changes so dictate, the Regional Chief Engineer must ensure that derails are installed in accordance with Section 1, above.
5. Approved derail types include:
 - a. Hinge Type Derail, Hayes Model EB, see Drawing TS 2208 **
 - b. Bi-directional Derail, Western-Cullen-Hayes Models SAEBX and HBXS**
 - c. Sliding Type Derail, Hayes Model HB, see Drawing TS 2209
 - d. Double Switch Point Derail, see Drawing TS 2210
 - e. Portable Derail, Hayes Model LPTS. (Replaces Model TS)
 - f. Older type Hayes cast derails of type A, AP, G, GP and D are not to be used on rail heavier than 85 lb.

** Wheel crowdors can be used in conjunction with the Hinge or Sliding type derails
6. Hinge and sliding derails may be installed where the speed of equipment to be derailed will not exceed 15 mph.

7. On industrial tracks, a wheel crowder will be installed where:
 - a. The derail is located in a curve.
 - b. Equipment to be derailed could exceed 9 mph.
8. At locomotive and car repair facilities, wheel crowders will be installed with Hinge or Sliding type derails.
9. On industrial track the preferred derail is a double switch point derail. This style derail will be installed anywhere:
 - a. The speed of the equipment could exceed 15 mph.
 - b. Cars are moved by the customer or a private locomotive is in use.
10. To determine the proper derail for a specific location based on potential car speed, use **TABLE 1**. Speeds are based on a 263,000 lb. car. Speeds may increase with the use of 286,000 lb cars along with wind direction and velocity.

TABLE 1 DISTANCE REQUIRED FOR A CAR TO REACH SPEED

Gradient (%)	8 mph	9 mph	12 mph	15 mph
0.3	1000	1280	2350	3800
0.5	485	615	1125	1805
0.8	310	395	700	1090
1	225	285	555	785
1.5	155	190	330	510
2	115	140	245	380

11. The location for a derail is governed by local conditions such as grade and length of track, but when practicable, should never be located less than 20 feet behind the fouling point and installed to derail cars away from the track to be protected. Sufficient distance should be allowed so the derailed car cannot continue moving and foul the track being protected.
12. Derails should not be installed on the inside of curves if it can be avoided. If necessary to install a hinge or sliding type derail on the inside of a curve, a wheel crowder must be installed on the outside rail on the same ties.
13. The direction of the movement of a car to be derailed determines the “hand” of the derail required. For example, a right hand derail is installed to derail equipment toward the right.
14. Where insulated joints are involved, derails must be placed far enough behind the insulated joints so that once equipment derails, it stops moving before fouling the track circuit.
15. Guard (Diverting) rails will be installed, per TS 2208, where the derailing point is:
 - a. On a high embankment or sharp curve.
 - b. Near structures that could be struck by derailed equipment.
 - c. Where possible car roll could foul the track to be protected.
16. The Regional Chief Engineer will specify type and location of guard rails to be used. Installations must be in accordance with standard plans.

17. Hinge and sliding derails must be the proper model, size and hand to fit the running rail in order to eliminate the possibility of cars running over them without derailing.
18. The correct size hinge or sliding derail is determined by measuring from the top of the tie to which the derail will be mounted to the top of the ball of the running rail. This distance, in inches, is equal to the size derail required. Derail sizes are:
 - a. Size 5: up to 85 lb rail
 - b. Size 6: 100 lb and 112lb
 - c. Size 7: 115lb to 124lb
 - d. Size 8: 127 lb and larger
19. Plywood or steel shims, of the correct size and with holes punched or drilled for all fasteners, may be placed under the hinge or sliding derail to ensure the block lies flat on the top of the rail. Shimming should be limited to ½ inch before choosing the next size derail.
20. Ties to which derails are mounted will be flat and sound, well tamped, have the top surfaces in the same plane and be perpendicular to the rail. Use hardwood ties.
21. Sliding and hinge derails must be installed at right angles to the rail. In new installations the derail should be fastened to the ties with 1" x 6-1/2" screw spikes. The ties must be drilled with 11/16" (17 mm) pilot holes.
22. Hinge or sliding derails, with any fastener types, will be secured to ties with all holes filled.
23. Hinge derails may have a narrow bead of weld added to the underside of the derail body to keep it from freezing to the ball of the rail.
24. Hinge derails should have handles welded onto the body to make operation easier.
25. In the derailing position the hinge or sliding derail block must:
 - a. Cover the ball of the rail.
 - b. Lie flat on top of the rail throughout the underside of the derailing block surface (except for Section 23, above).
 - c. Have the base plate of the derail bearing flat on the ties.
 - d. Have no excessive motion when locked.
26. If the rail at the hinge or sliding derail is relaid, the derail should be replaced with one of the correct size or shimmed if within acceptable limits.
27. Ensure that when the hinge or sliding derail is in the "off" position, that it is at least lower than the ball of the rail to avoid contacting rolling equipment.
28. Hinge and sliding derails must be clearly visible and painted high visibility yellow.
29. Sliding derails will be operated with Hayes operating stand or a rigid switch stands (31B, 36D, 36 EH or 112E). The throw of the sliding derail is 6 ¼".
30. Switch point derails will be operated with rigid switch stands. The throw of a switch point derail is 5".
31. All derails equipped with operating stands shall have a reflective derail target, in accordance with TS 720, mounted to the mast which is visible when lined in the derailing position. Conventional switch targets and tips are not to be used.

32. Tracks equipped with a derail shall have the handle, or lever, of the switch stand painted yellow.
33. **In Canada only**, derails designated in Special Instructions as Special Derails, shall have a reflective Special Derail target installed on the switch stand. Special Derails must be operated by a switch stand.
34. Power operated and interlocked derails shall be installed and maintained in accordance with plans and instructions provided by the S & C Department.
35. A power or interlocked derail must not be disconnected or adjusted until the Signal Maintainer has been notified.
36. When directed by Special Instructions, derails protected by signals or otherwise marked, will not require derail signs.
37. In Canada, Wisconsin, northern Michigan and Minnesota, all derails not equipped with high operating stands shall have a reflective derail sign, in accordance with the TS plan, mounted to a post and erected adjacent to the derail.
38. All derails must be equipped with an approved switch lock that has been chained, or cabled, to the derail or operating stand.
39. Derails must be inspected by the Track Supervisor, Assistant Track Supervisor, Track Inspector or other qualified inspector monthly noting:
 - a. Proper size, type and fit. See T.S. 3.2- DERAILS.
 - b. Derail is in working conditions or shows signs of damage from impact.
 - c. Ties under derails are sound, fasteners intact and the tie fully supports the derail.
 - d. Lock is present and applied to the derail.
 - e. Derail is painted yellow and clearly visible.
 - f. Derail signs and targets, where required, are in place, retro-reflective and visible.
40. Portable derails will be installed when protecting temporary conditions, workers and equipment, or work activities as prescribed in USOR OTS Rule 500 or CROR 841, and when it is not possible to line and lock, with a private lock, a switch to protect the work location.
41. Portable derails must be correctly installed to ensure proper function. Portable derails will:
 - a. Be sized to fit the rail section on which to be mounted.
 - b. Be of the correct hand to derail equipment away from adjacent track, structures, stored material, equipment, roadways or environmentally sensitive areas if possible.
 - c. Not be installed on the inside of the curve.
 - d. Be placed with the graduated teeth firmly against a sound tie on the gauge side of the rail. Ballast may have to be removed to ensure the proper fit of the derail.
 - e. Have the set screws and the locking screw backed away so the block sits flat on top of the rail. Once fitted, have the set screws tightened, locking screw tightened to the ball of the rail and a private (special) lock applied
 - f. Be disposed of if involved in a derailment.
 - g. Be stored, locked and secured, when not in use to prevent theft or vandalism.

T.S. 3.3 RAIL FASTENINGS

- On wood ties, each rail will be spiked, at a minimum, as per the appropriate pattern below.

NO.	SPIKING PATTERNS		YEARLY MGT	DEGREE OF CURVE			
	F	G		TANGENT UP TO 2°	2° TO 4°	4° TO 6°	DOC > 6°
A			Other Than Main Track	X	X	X	X
			0 - 20	X			
B			0 - 20		X	X	
			Greater than 20	X			
C			0 - 20				X
			Greater than 20		X	X	
D			Greater than 20				X
			ALL TURNOUTS TO BE SPIKED PER PATTERN D				

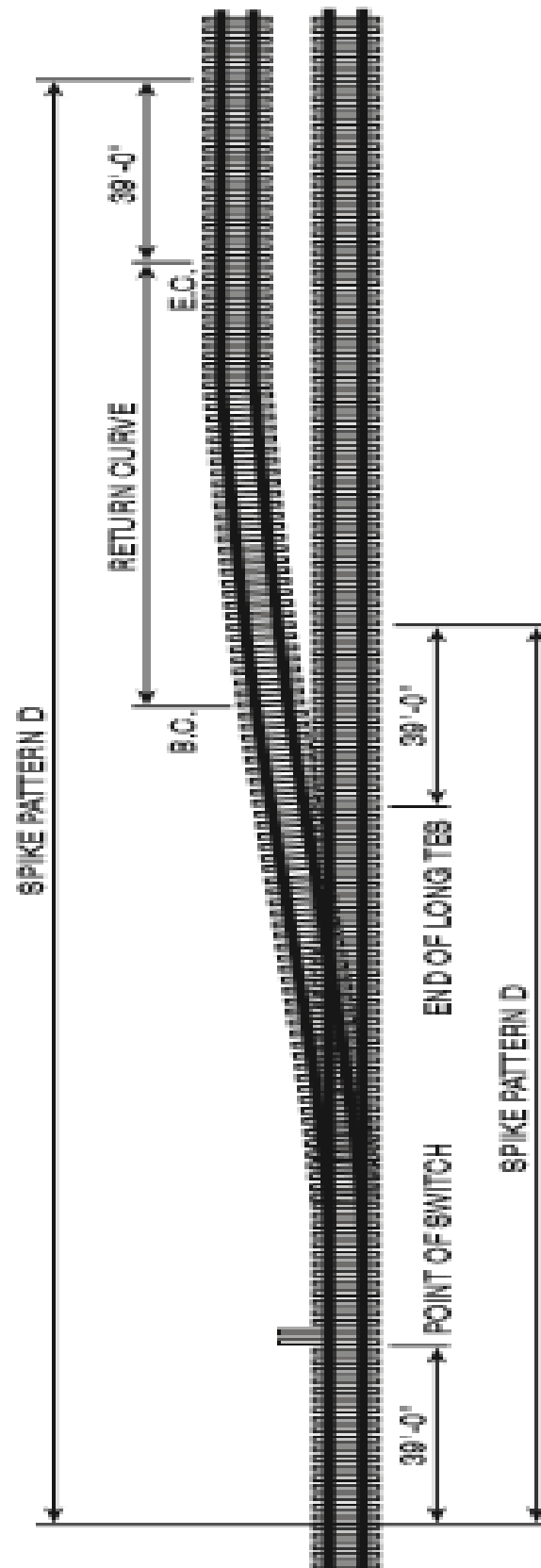
- Plates with square holes will only be secured with cut spikes. Plates with round holes will only be secured with screw spikes or drive screw spikes.
- Plates fastened with either screw spikes or drive screws spikes will have a screw in each hole of the tie plate.
- Ties will be spiked:
 - With the cross tie square to the rail and plates centered on the tie.
 - With rail at uniform standard gauge.
 - With spikes driven vertically with the throat of the spike in contact with the base edge of the rail. Do not drive the spike head onto the rail base causing damage to the rail.
 - Using only standard spike mauls, pneumatic or hydraulic spiking hammers, or with a spiking machine. Do not strike the base of the rail when spiking.
 - With spike heads turned away from the joint bars of insulated joints.
 - At joints with skirted bars so that the spikes are not driven into the spike holes of the joint bar or within 2 inches of the end of the bar.
- When installing screw spikes or drive screw spikes:
 - Drill a plumb 11/16" (17 mm) by 6" pilot hole. Do not drill through the tie.
 - Do not use washers with screw or drive screw spikes on wood ties.
 - Screwspikes must run (turned) into the tie. They must not be driven into the tie.
 - Drive screw spikes can either be driven or turned into the tie.
 - Do not over tighten the screw or twist screw spikes. This can strip the wood fibers in ties.

6. When removing spikes:
 - a. Use a claw bar. If a spike cannot be lifted with a claw bar, use a spike lifter to loosen the spike. Do not strike the heel of the claw bar with a maul or other tools.
 - b. Use a four balled spike puller and claw bar to remove spikes between the running rail and guard rail, or in tight areas.
 - c. Screw spikes will be withdrawn using an impact wrench or other power wrench. Drive screw spikes will be withdrawn using either a claw bar or impact wrench.
7. Plug spike holes with approved plugging material, preferably foam compound, before reinstalling spikes.
8. Spring clips must match the fastening system of the plate or concrete tie. Spring clips must be replaced when the clip is sprung or damaged.

TABLE 1 PREMIUM FASTENERS FOR WOOD OR CONCRETE TIES

Tie Type	Pad Type	Conventional Clip Type	Shoulder Insulator	Joint Clip	Insulated Joint Assy	
					Clip	Insulator
60 A 60 B 60 C 60 E	5 mm Polypad	e-2009L or e-2009 (LH)	HD-6 on both sides, or FP-9 on field side when re-gauging	J273 (136 lb) J267 (115 lb)	e-2063	ECL-2063
55B	10 mm Double Studded		FP-9 on gauge side, HD-6 on field side			
60D	Rubber		HD 10/8			
101 L	Safelok 3 Pad Assy. 38742	Safelok 3 Clip 38643	Safelok 3 Shoulder Insulator 38652	38637	Safelok 3 I/J Assy. 38631	Safelok 3 I/J Assy. 38631
WOOD	N/A	e-2055 or e-2056(LH)	N/A	J273 (136 lb) J267 (115 lb)	e-2063	N/A

9. When fastening rail to concrete ties, ensure base pads, shoulder insulators and clips are installed and in good condition.
10. When installing “e” clips, either by hand or with a machine, drive the clip so that the radius does not contact the shoulder. There should be 3/8” clearance between the bend and the clip housing.
11. Do not attempt to nip or lift a tie using the clip.
12. When removing spring clips:
 - a. Use the removal tool for Safelok clips
 - b. Ensure clips are not allowed to fly freely when released.



THIS PAGE BLANK INTENTIONALLY

T.S. 4.0 BALLASTING, SURFACING AND LINING

BALLASTING:

1. Ballast will only be from a CN approved source and crushed to CN specifications.
2. When unloading ballast:
 - a. Only the amount of ballast planned and required should be unloaded in the correct location minimize distribution required for ballast regulators.
 - b. Unlock and break open doors only when the car is not moving.
 - c. Cars should be unloaded to ensure even weight distribution in the car.
 - d. In superelevated curves, ensure the cars are unloaded evenly to avoid overturning cars to the low side of the curve.
 - e. Ensure ballast does not contact the axles or truck frames of the cars or flows over the ball of the rail, lifting the car causing derailment.
 - f. In the center of the track, a hardwood tie may be placed ahead of the leading axle of a loaded ballast car to plow off ballast.
 - g. Remove ballast from switches and stock rails, cribs with switch rods and flangeways of frogs, crossings or guard rails which could impede passage of flangeways.
 - h. Control ballast flow near road crossings or open deck bridges.
 - i. Cars must be completely empty and doors in the locked position before release.
 - i. Inspect the inside of the car to ensure it is completely empty with no ballast on the hanging on the side slopes.
 - ii. Ballast attached to the sides of the car, or unevenly distributed in the car, requires load leveling or equalization before moving the car.
 - iii. Unevenly loaded cars can result in a possible walk off derailment.
3. Cars with doors that cannot be opened must be bad ordered through Customer Service and not released for loading until repaired.

SURFACING AND LINING:

4. "Spot surfacing" is defined as restoring track surface, cross-level and alignment through short stretches, not more than 19' 6" in length, when a continuous raise is not required.
5. "Out of face surfacing" is defined as the continuous raising of track to restore track surface, cross-level and alignment.
6. When surfacing could affect signal related components or interfere with crossing warning devices, the Signal Department must be notified in order to mark wires, perform needed adjustments, repairs or inspections.
7. When surfacing track:
 - a. Rail temperature must be regularly measured.
 - b. Employees must regularly check the track surface using a track level.

- c. Only the 16 inches either side of each rail will be tamped. The center of the tie must not be tamped except for transition ties and switch ties. Adjust tamper heads for depth and width for concrete ties.
 - d. The line reference rail is:
 - i. For curves, the high rail. Except for reverse curves, use the same rail.
 - ii. For tangent, either rail. Use the same reference rail when lining the same section of tangent track.
 - iii. For turnouts, the straight stock rail side.
 - e. Long stretches of tangent track should be laser lined.
 - i. When laser lining into fixed objects, such as open deck bridges, place the laser on the fixed object
 - ii. Check track centers frequently when laser lining in multiple tracks.
 - f. The reference grade rail for a curve will be the inner (low) rail.
 - g. Through station platforms or tunnels, line and/or top of rail elevations reference points may be required.
8. Surfacing can generate excess rail by:
- a. Raising sags or laser lining track.
 - b. Lining track inwards on curves (See Section 13 below for staking curves).
9. Conditions which should be inspected for when surfacing track to prevent track buckles include:
- a. The bottom of grades near a fixed track location such as a bridge, turnout, road crossing or diamond.
 - b. Areas known for heavy train breaking at or near fixed track locations.
 - c. Areas of insufficient anchors (not per ETS).
 - d. Areas near fixed track locations with directional running traffic.
 - e. Any areas showing signs of high rail compression.
10. When conditions of Section 8 or 9 are found, precautions to be taken include:
- a. Destress the rail. See T.S. 1.3 CONTINUOUS WELDED RAIL – DE-STRESSING RAIL.
 - b. If possible surface away from the fixed location rather than toward it.
 - c. When surfacing curves, follow instructions of Section 13, below
11. Track raises in excess of 6 inches should be avoided. However, if it is necessary, such lifts should be carried out successively so the individual lifts do not exceed 3 inches. Dynamic stabilizers should be used between lifts.
12. Monitor profiles approaching fixed objects such as open deck bridges, road crossings or switches which cannot be surfaced through, ensure the proper runoff is applied. Runoff in 31 feet of track cannot exceed the limits of **TABLE 1** without applying the appropriate TSO.

TABLE 1 MAXIMUM ALLOWABLE RUNOFF

Class of Track	Maximum Allowable Runoff in 62 ft. (in)
1	3 1/2
2	3
3	2
4	1 1/2
5	1

STAKING CURVES

13. Prior to surfacing a main track curve which is more than 3°, and the temperature is more than 50°F (27° C) below the PRLT, or is expected to be in the next 24 hours, the curve must be staked. At least three stakes will be place evenly around the curve with one stake near the middle of the curve. More stakes can be placed if required.

Stakes can be placed outside the reach of track equipment, or can be 1/2"x 24" rebar driven in the middle of the track. The track at the location of the stake should be painted and the measurement, from the stake to the near base of rail, recorded on the web of the rail with paint marker. See T.S. 10 – S&C SYSTEMS AND BURRIED UTILITIES,

14. Inspect for curve movement periodically after the work, especially during periods of large temperature changes. If the curve is found to have shifted inward more than 1 inch, it must be lined out or destressed prior to ambient temperature reaching 85°F US or 21°C Canada. If the curve is not lined out or destressed then a speed restriction must be placed. The effective rail length added to a curve as a result of chording inwards is calculated in **TABLE 2**.

TABLE 2 DISTANCE CURVE HAS CHORDED INWARD (inches)

Degree of Curve	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
EFFECTIVE RAIL ADDED TO THE CURVE PER 1,000 FEET OF CURVE (in.)												
3°	1/4	1/2	3/4	1	1 1/4	1 5/8	1 7/8	2 1/8	2 3/8	2 5/8	2 7/8	3 1/8
3° 30"	1/4	5/8	7/8	1 1/4	1 1/2	1 7/8	2 1/8	2 1/2	2 3/4	3 1/8	3 3/8	3 5/8
4°	3/8	3/4	1	1 3/8	1 3/4	2 1/8	2 1/2	2 3/4	3 1/8	3 1/2	3 7/8	4 1/4
4° 30"	3/8	3/4	1 1/8	1 5/8	2	2 3/8	2 3/4	3 1/8	3 1/2	3 7/8	4 3/8	4 3/4
5°	1/2	7/8	1 1/4	1 3/4	2 1/8	2 5/8	3	3 1/2	4	4 3/8	4 3/4	5 1/2
5° 30"	1/2	1	1 1/2	1 7/8	2 1/2	2 7/8	3 3/8	4	4 3/8	4 7/8	5 1/4	5 3/4
6°	1/2	1	1 5/8	2 1/8	2 3/4	3 1/8	3 5/8	4	4 3/4	5 1/4	5 3/4	6 1/4
6° 30"	1/2	1 1/8	1 3/4	2 1/4	2 3/4	3 3/8	4	4 1/2	5 1/8	5 3/4	6 1/4	6 7/8
7°	1/2	1 1/4	1 7/8	2 1/2	3	3 5/8	4 1/4	5	5 1/2	6 1/8	6 3/4	7 3/8
7° 30"	1/2	1 3/8	2	2 5/8	3 1/4	4	4 5/8	5 1/2	5 7/8	6 5/8	7 1/4	7 7/8
8°	1/2	1 3/8	2 1/8	2 3/4	3 1/2	4 1/4	4 7/8	5 1/2	6 1/4	7	7 3/4	8 3/8
8° 30"	1/2	1 1/2	2 1/4	3	3 3/4	4 1/2	5 1/4	6	6 3/4	7 1/2	8 1/8	8 7/8
9°	1	1 5/8	2 3/8	3 1/8	4	4 3/4	5 1/2	6 1/2	7 1/8	7 7/8	8 5/8	9 1/2
9° 30"	1	1 5/8	2 1/2	3 3/8	4 1/4	5	5 7/8	6 1/2	7 1/2	8 3/8	9 1/8	10
10°	1	1 3/4	2 5/8	3 1/2	4 1/2	5 1/4	6 1/8	7	7 7/8	8 3/4	9 5/8	10 1/2
10° 30"	1	1 7/8	2 3/4	3 5/8	4 1/2	5 1/2	6 3/8	7 1/2	8 1/4	9 1/4	10 1/8	11
11°	1	1 7/8	2 7/8	3 7/8	4 3/4	5 3/4	6 3/4	7 1/2	8 5/8	9 5/8	10 5/8	11 1/2

15. Spirals designed into curves gradually transition the alignment and superelevation from flat, level tangent into the full body of the curve. Superelevation will be added to the spiral in uniform, incremental steps to prevent car body twist
16. Superelevation of main track curves will:
 - a. Be a minimum ½" superelevation for any curve.
 - b. Have a maximum of 5 inches installed unless approved by the Regional Chief Engineer.
 - c. In no case shall superelevation be allowed to exceed 6 inches.
 - d. Be as indicated on the curve list for the subdivision (found on the Engineering SharePoint site).
 - i. Curves on sidings, connections and other non-mainline tracks will have superelevation based on the 2 inch imbalance table in the Appendix.
 - e. See T.S. 7.1-TRACK GEOMETRY for determining superelevation.
17. Turnouts in CWR main track should be anchored before surfacing.
18. When surfacing spring frogs, place track jacks on the rail opposite the wing rail to ensure base plates are not bent by the lifting clamp.
19. When surfacing through a turnout with boltless adjustable rail braces, the switch points and stock rails should be blocked to prevent displacing the stock rail from the switch plate.
20. When surfacing switches at ends of sidings or double track, ensure the diverging route is tamped after surfacing the turnout. Reference drawing TS 007 (or TS 5.0 – Turnouts), for the appropriate return curve alignment. As much as practicable, the top of rail elevation of the diverging route should be held even with that of the normal route through the return curve.
21. When regulating ballast:
 - a. Dress to conform to drawing TS 2205.
 - i. On wood ties, ballast will be broomed so that it is 1" below the top of the tie with no ballast on the tie.
 - ii. On concrete tie track, broom ballast to 1" below the top of the tie ends.
 - iii. Shoulders are 12 "wide off the end of each tie in CWR track, and 6" wide off the end of tie in jointed rail track.
 - iv. The area between two main tracks or main and siding will have a depression in the middle.
 - b. Do not pull dirt, fines or vegetation into the track when dressing shoulders.
22. Ballast at insulated joint locations will be dressed by hand to avoid damage to signal wires and to avoid leaving piles in ballast in the track.
23. Ballast regulator plow blades must be modified when working on track with premium plates or concrete ties to avoid hitting fasteners.
24. After surfacing and regulating in these territories, clips must be visually inspected by the foreman or operator and missing clips replaced.
25. Place appropriate speed restriction for disturbed ballast in accordance with **TABLES 3, 4 or 5**
TS 1.3 – CONTINUOUS WELDED RAIL

T.S. 5.0 TURNOUTS

1. Turnouts will be constructed, installed, inspected and maintained:
 - a. In accordance with the appropriate CN Standard drawings and T.S. 7.0 – INSPECTIONS, sections 20, 21 and 22.
 - b. With correct tie lengths, placement and spacing for the specific turnout.
 - c. To avoid being installed or renewed in main track curves, except in special cases as authorized by the Regional Chief Engineer.
 - d. As Dual Control, Power, DTMF, Spring or Electric Lock switches only at locations approved by the Regional Chief Engineer.
 - e. With location surveyed by CN Design and Construction to ensure accuracy of installation and the correct alignment behind the turnout.
 - f. In the U.S. Only, so that on main track and controlled sidings, turnouts cannot be shifted or relocated without notification made to both CN Design and Construction and the PTC S & C Manager.
2. When turnouts and track panels are delivered as pre-fabricated panels in rail cars, the following precautions will be taken when unloading and transporting:
 - a. Turnout panels must be completely secured to the support racks of the car whenever the car is moved.
 - b. The weight of each panel must be known and compared to the load chart of the machine making the lift prior to attempting a lift.
 - c. Ensure adjacent track protection is in place, if required, for unloading the panel.
 - d. When tag lines are required, secured lines to the ends of the panel while it is still secured to the panel car support rack.
 - e. Each panel in the car will be fully secured to the support rack until it is ready to be lifted from the car. The panel will only be released once the tag and crane lift lines are secured to the panel. Only the panel to be removed on that lift will be released, all other panels will remain secured to the support rack.
 - f. Removal of the panel tie-down chains will be done from behind the panel and support rack.
 - g. No one is allowed in a panel car when the panel is being released or lifted.
 - h. Panels will be placed where they will not affect the safety of railroad operations or the public.
 - i. Ensure the panel car is empty of required turnout components. All tie-down chains must be placed in the car and secured. Release the car back to the panel yard.
3. When assembling and installing turnouts:
 - a. Turnout panels should be laid out flat, straight and level whenever possible, to facilitate welding.
 - b. For turnouts with heater duct ties, excavated deep enough at the duct location to prevent humping the track.

- c. Drive hardwood wedges between the open switch point and the stock rail, at each rod location, to prevent the stock rail from lifting out of the slide plates.
 - i. Place opposing track jacks in the center of the track to push the switch points against the wedges and stock rails.
 - d. Trains should not be permitted to move in either direction over a new turnout until:
 - i. The frog is protected by a properly adjusted guard rail.
 - ii. The switch point is clamped, or lined and locked against the stock rail.
 - e. Place packing material between the open switch point and stock rail to block ballast.
 - f. Cover switch point roller bodies with duct tape to prevent filling with rock.
 - g. Clean ballast from between the switch point and stock rail, from between the switch point and slide plates, and frog and guard rail flangeways before operating trains.
 - h. Clean ballast from cribs to a depth adequate to prevent contact with rods and to facilitate winter switch maintenance and drainage.
- 4. Switch stands, machines, point detectors and locking mechanisms must be installed:
 - a. To conform to TS plans.
 - b. Whenever possible, on the diverging route side of the switch, so the connecting rod is in tension when the switch is in the normal position.
 - c. Plumb and be securely bolted or lagged to the headblock ties. Spring switch stands will be bolted through the head block ties.
 - d. With main line switch stands being of an approved rigid style.
 - e. With yard switch stands being of an approved rigid style. Semi-automatic switch stand installation must be approved only by the Regional Chief Engineer.
 - f. So that low profile switch stands are used where it is to be located between tracks having track centers of 18' 0" or less.
- 5. When installing parallel or ground throw switch stands (112E, 36 EH, 36 E, etc.), the operating lever must point toward the frog for the normal position.
- 6. When installing high switch stands (17D, 31B), the handle should be positioned so that when the switch is in the normal position, the handle faces away from the frog and away from the track. When the switch is lined for the diverging route, the handle should move in the same direction as the switch points.
- 7. The throw is critical on a Racor 22 trailable switch stands. **TABLE 1** indicates the distance from the center of the crank eye bolt to the near face of the crank for the various switch point throws. **TABLE 2** has adjusting recommendations for any crank eye style switch stand.

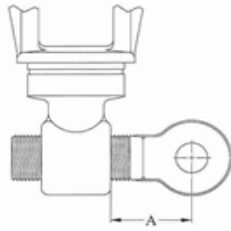


TABLE 1

Switch Point Throw	Crank Eye Length " A"
(+/- 1/32")	(+/- 1/16")
4 1/2"	2 1/16"
4 5/8"	2 3/16"
4 3/4"	2 1/4"
4 7/8"	2 5/16"
5"	2 7/16"

TABLE 2 SWITCH ADJUSTMENT

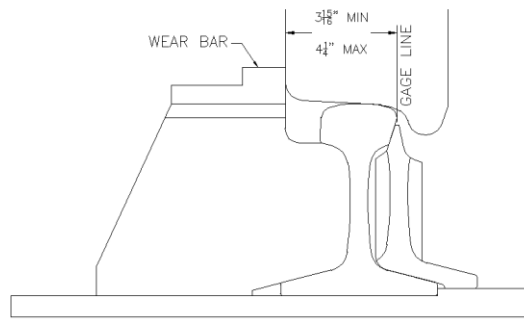
Near Point	Far Point	Crank Eye on Stand	Clevis on Connecting Rod
Fits Properly	Too Tight	Screw In	Screw In
Fits Properly	Too Loose	Screw Out	Screw Out
Too Tight	Fits Properly	Screw In	Screw Out
Too Loose	Fits Properly	Screw Out	Screw In
Too Tight	Too Tight	Screw In	None
Too Loose	Too Loose	Screw Out	None

8. Switch point protectors or switch point guards may be installed to protect switch points on yard, back tracks and industry tracks. The maximum train speed and curvature for the application of the protectors and guards is indicated in **TABLE 3**.

TABLE 3 SWITCH POINT PROTECTOR USAEGE GUIDELINES

Product Name	Maximum Curvature	Maximum Speed	Traffic Volume
Nolan SPP Protectors	All Curves	10 MPH or Less	Less than 25 cars / week
Inside Point Protector Guard Rail	20° or Less	15 MPH or Less	All
Weld on Point Protector	20° or Less	15 MPH or Less	Less than 25 cars / week
Field Side Point Protector	2° or Less	15 MPH or Less	All

9. Ensure the field mounted protector fits properly against the field side web of the rail and that any rail flow on the gauge side of the stock rail is ground off.
10. The limits for adjustable switch point guard bar settings are 3 15/16" minimum to 4 1/4" maximum.



11. Where a switch point, including mainline switches, experiences excessive wear because the switch is located close to, or in a curve, a guard rail may be installed ahead of the switch point, at the approval of the Regional Chief Engineer, to provide protection from facing point moves.
12. Approved switch point foot pedal locks must be installed on all manually operated main track switches (except spring switches) when the following situations exist:
 - a. The switch is seen as facing point from a highway or road crossing at grade, and
 - i. The switch is within 200 feet of the crossing, and
 - ii. Train speed is 30 MPH or more, or
 - b. Any switch where loaded log cars are a significant portion of the rail traffic.
 - c. Switches with foot pedal locks will be identified:
 - i. **In Canada only** – The top of the switch stand casting will be painted white.
 - ii. **In the U.S. only** – A yellow band will be on the switch stand mast.
13. All main track switch stands must be equipped:
 - a. With an approved switch lock in good working order, secured to the switch stand or headblock ties with a cable or chain.
 - b. With high security switch locks for hand operated switches, and switches located within Yard Limits.
 - c. Dual control and power switches, except for self-restoring locally controlled switches (LCS), do not require high security locks.
14. At locations where vandalism is a concern, high security locks may also be installed at the direction of the Regional Chief Engineer on any switch device.
15. Switch stands on non-main track must be equipped with a hook type metal keeper (SRM # 01-29-998) which must be secured to the switch stand or headblock ties with a chain or cable.

16. When switches are removed from service:
 - a. An Engineering or private lock must be secured in the hasp of the switch stand.
 - b. A yellow 3" x 5" plastic tag must be placed on the shackle of the lock.
 - c. A switch point clamp must be tightened and locked to secure the switch point to the stock rail.
 - d. The RTC, Yardmaster or Control Operator must be notified.
17. Adjustable guard bars will be set to ensure guard check for the Class of track. Guard bar adjustment will be accomplished by:
 - a. Measuring the adjustment required to move the guard bar to the appropriate guard check.
 - b. Adjustment of the guard bar will be for the entire length of the guard rail.
 - c. Removing clips or loosening mounting bolts and remove the required thickness of shims from behind the guard bar housing block.
 - d. Inserting the required shims between the guard bar and the guard bar housing block.
 - d. Ensuring all shims have the retaining tabs under the guard bar to prevent them from working out under traffic.
 - e. Ensuring all of the original shims are reinstalled either behind the guard bar or behind the guard bar housing block.
 - f. Reapplying the clips or tighten bolts.
18. The maximum allowable guard bar wear is 5/8" (15 mm). No more than four shims can be used to adjust the guard bar. At point, the guard bar will need to be replaced.
19. Adjustable guard bars used with Jump Frogs should have shims placed under the guard rail base plate through the area of frog ramping. The shims must match the size and hole punching of the guard rail plate.
20. Weld repairs of any type guard rail or guard bar is prohibited.
21. Frog type for a turnout will be determined by traffic patterns:
 - a. Self Guarded Manganese Frogs (SGMF) will not be used in track with speeds higher than 15 MPH.
 - i. SGMF do not require guard rails.
 - ii. The raise guard face of the frog body must not be worn more than 3/8" (10 mm).
 - iii. Restoring the guard face of the frog by welding must be done before rebuilding the frog point.

- b. Jump Frogs (OWLS) will only be used:
 - i. Where diverging traffic volume is light; no unit trains or large cuts of cars per move.
 - ii. With operating speed on the diverging route over frog is limited to 10 mph.
 - iii. With gauge on the main line not in excess of 57 inches.
 - iv. With installation at the approval of the Regional Chief Engineer.
 - c. Spring Rail Frogs (SRF) can be used with the approval of the Regional Chief Engineer.
 - d. Rail Bound Manganese Frogs (RBM) can be used in any situation.
22. Flangeways of all frogs must:
- a. Be at least 1 1/2" (38 mm) wide.
 - b. Not be less than 1 3/8" (35 mm) deep for Class 1, or 1 1/2" (38 mm) deep for Class 2 and above. Note , this does not apply to jump frogs on turnouts or flange bearing frogs on diamond crossings.
23. When surfacing a turnout:
- a. Ensure the headblock ties, ties adjacent to rods where tamper heads cannot reach, and frog ties have ballast firmly packed using hand tampers.
 - b. Avoid bending the base plate of SRF's during tamping. Use track jacks to assist the lift if necessary.
 - i. If SRF base plate bending has occurred, heat the plate and hammer flat. Monitor wing movement to determine if the wing moves freely under traffic.
 - c. When surfacing switches at ends of sidings or double track, ensure the diverging route is tamped after surfacing the turnout. See the drawing at the end of this section for the appropriate return curve alignment and staking measurements.
 - d. As much as practicable, the top of rail elevation of the diverging route should be held even with that of the normal route through the return curve.
24. A Signal Maintainer shall be notified when work is planned which may interfere with the function of the signal apparatus or the adjustment of the switch. This work includes, but is not limited to:
- a. Surfacing the switch.
 - b. Switch tie replacement.
 - c. Switch point welding.
 - d. Switch point and stock rail grinding.
 - e. Switch stand or rod replacement.

25. Switch stands, switch plates, connecting rod bolts and spring rail frogs shall be properly lubricated to provide easy movement and to protect against excessive wear. Turnouts equipped with switch point rollers do not require switch plates to be lubricated.
26. Switch stands, targets, masts, connecting rods and other components must be kept in good operating condition and must have defective parts replaced or repaired immediately.
27. Rigid switch stands that have been run through, must have the weld at the transition from the round spindle to the square mast inspected for cracks or failure.
28. The application of heat or mechanical methods to repair a damaged switch stand mast is prohibited.
29. Insulation in switch rods and gauge plates shall be maintained in good condition at all times.
30. Switch rods and switch connecting clips should have sufficient clearance, so as not to contract the side of ties or slide plates. Tie spacing adjacent to rod locations will be controlled with straps or anchors to maintain proper spacing.
31. All switch connecting clips will be cleaned and painted white at least once annually.
32. Welding of switch rod connecting clips is prohibited.
33. Due to the critical nature of switch point fit to the stock rail, maintain gauge ahead of the switch point.
34. No repair welding of switch points or stock rails is allowed on Class 3 track and above. In case of emergency, welding will be allowed, following proper welding procedures, and limiting the operating speed to Class 2 until the component is replaced.
35. Maintain surface through the switch point so that the switch point bears flat on slide plates when seated against the stock rail.
36. Ensure the switch point does not rest on an adjustable plate roller when the point is closed against the stock rail. Rollers should be adjusted and cleaned to ensure they spin freely and do not cause the switch point to drag or bind.
37. Maintain good tie condition and surface under the heel of the switch point.
38. Maintenance of Spring Rail Frogs includes:
 - a. Good tie condition and surface under the toe of a SRF to keep the horns from impacting the housings.
 - b. Having a 3/8" (10mm) gap between the frog point, (at the 1/2" point) and wing rail. Beyond the tip, the wing rail and frog body should be a tight fit
 - c. Ensuring springs and retarders are fully operational.
 - i. The spring must be able to snap the frog point tight against the frog body.
 - ii. The retarder should hold the wing open for up to a 3 minute closing time.

- d. The clearance between the SRF horn and housing must be 1/8" (3 mm) up to a maximum of 1/4" (6 mm). Ensure frog horns are not dragging on the top or bottom of the housing.
39. Once an RBM frog has been installed, the casting should be ground at:
- a. 0.5 MGT, 1.5 MGT, 4 MGT, then every 12 MGT or as required.
 - i. 0.5 MGT = 3 days of traffic on a 50 MGT/year line.
 - ii. Product warranty requires documentation of work.
40. Bolts for special track work components will be:
- a. Grade 5 for 100 lb. or smaller rail section components. These bolts are identified by three radial lines on the head of the bolt.
 - b. Grade 8 for all components 115 lb. and heavier will be assembled with hardened steel washers. Grade 8 bolts are identified with 6 radial lines on the head
 - c. Of the proper length and diameter for the application.
 - i. Only one lock washer or flat washer should be installed on a bolt.
 - ii. The bolts should have approximately 3/4" of thread extending beyond the nut.
 - iii. Bolts will be tightened using graphite lubricant to the torque values in **TABLE 4**.

TABLE 4

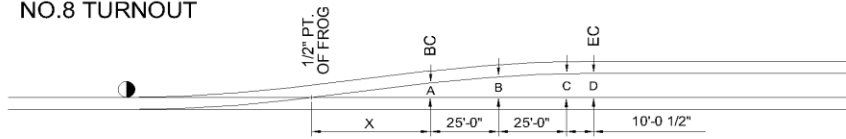
		BOLT TORQUE				
Bolt Diameter	(in.)	1	1 1/16	1 1/8	1 1/4	1 3/8
Grade 5 Bolt	Torque ft-lbs.	670	850	1200	1600	N/A
Grade 8 Bolt	Torque ft-lbs.	840	N/A	N/A	1675	2500

41. The following Turnout Return Curve diagrams are useful in turnout installations for lining the return to the proper alignment for various turnout sizes and track centers.
- a. Measurements along the track start at the 1/2" point of frog and move away from the turnout.
 - b. Offset measurements are from the gauge face of the mainline rail to the gauge face of the near diverging rail.

NO.8 TURNOUT

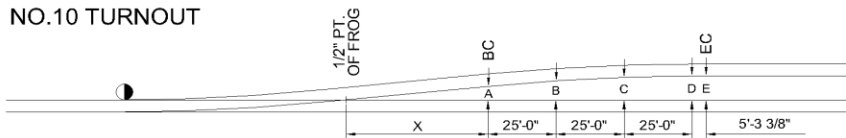
TURNOUT RETURN CURVES

TS-7



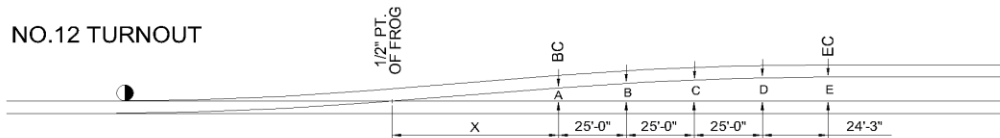
TRACK CENTERS	A	B	C	D	X
13'-0"	4'-6 1/2"	7'-0 1/4"	8'-2 1/4"	8'-3 1/2"	35'-10"
13'-6"	5'-0 1/2"	7'-6 1/4"	8'-8 1/4"	8'-9 1/2"	39'-9 3/4"
14'-0"	5'-6 1/2"	8'-0 1/4"	9'-2 1/4"	9'-3 1/2"	43'-9 5/8"
14'-6"	6'-0 1/2"	8'-6 1/4"	9'-8 1/4"	9'-9 1/2"	47'-9 3/8"
15'-0"	6'-6 1/2"	9'-0 1/4"	10'-2 1/4"	10'-3 1/2"	51'-9 1/4"
16'-0"	7'-6 1/2"	10'-0 1/4"	11'-2 1/4"	11'-3 1/2"	59'-8 7/8"

NO.10 TURNOUT



TRACK CENTERS	A	B	C	D	E	X
13'-0"	4'-3 3/8"	6'-4 3/4"	7'-8 5/8"	8'-3 1/4"	8'-3 1/2"	42'-3 1/8"
13'-6"	4'-9 3/8"	6'-10 3/4"	8'-2 5/8"	8'-9 1/4"	8'-9 1/2"	47'-2 7/8"
14'-0"	5'-3 3/8"	7'-4 3/4"	8'-8 5/8"	9'-3 1/4"	9'-3 1/2"	52'-2 3/4"
14'-6"	5'-9 3/8"	7'-10 3/4"	9'-2 5/8"	9'-9 1/4"	9'-9 1/2"	57'-2 5/8"
15'-0"	6'-3 3/8"	8'-4 3/4"	9'-8 5/8"	10'-3 1/4"	10'-3 1/2"	62'-2 1/2"
16'-0"	7'-3 3/8"	9'-4 3/4"	10'-8 5/8"	11'-3 1/4"	11'-3 1/2"	72'-2 1/8"

NO.12 TURNOUT



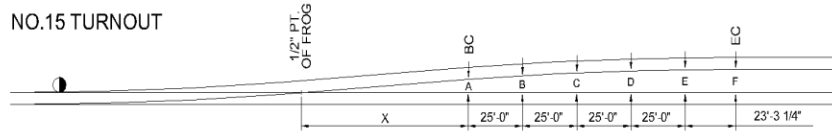
TRACK CENTERS	A	B	C	D	E	X
13'-0"	4'-1 7/8"	5'-11 3/4"	7'-3 1/4"	8'-0 1/2"	8'-3 1/2"	49'-3 3/8"
13'-6"	4'-7 7/8"	6'-5 3/4"	7'-9 1/4"	8'-6 1/2"	8'-9 1/2"	55'-3 1/4"
14'-0"	5'-1 7/8"	6'-11 3/4"	8'-3 1/4"	9'-0 1/2"	9'-3 1/2"	61'-3 1/8"
14'-6"	5'-7 7/8"	7'-5 3/4"	8'-9 1/4"	9'-6 1/2"	9'-9 1/2"	67'-3"
15'-0"	6'-1 7/8"	7'-11 3/4"	9'-3 1/4"	10'-0 1/2"	10'-3 1/2"	73'-2 7/8"
16'-0"	7'-1 7/8"	8'-11 3/4"	10'-3 1/4"	11'-0 1/2"	11'-3 1/2"	85'-2 5/8"

NOTE: MEASUREMENTS ARE FROM GAGE SIDE OF RAIL TO GAGE SIDE OF RAIL

TURNOUT RETURN CURVES

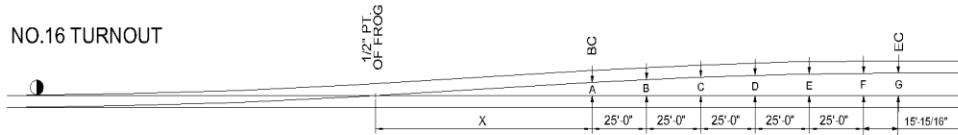
TS-7

NO.15 TURNOUT



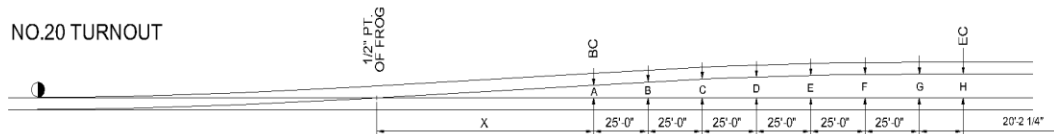
TRACK CENTERS	A	B	C	D	E	F	X
13'-0"	4'-2 1/4"	5'-8 1/8"	6'-10 1/8"	7'-7"	8'-1 3/4"	8'-3 1/2"	62'-0 1/2"
13'-6"	4'-8 3/4"	6'-2 1/8"	7'-4 1/8"	8'-1"	8'-7 3/4"	8'-9 1/2"	69'-6 3/8"
14'-0"	5'-2 1/4"	6'-8"	7'-10 1/8"	8'-7"	9'-1 3/4"	9'-3 1/2"	77'-0 3/8"
14'-6"	5'-8 3/4"	7'-2 1/8"	8'-4 1/8"	9'-1"	9'-7 3/4"	9'-9 1/2"	84'-6 1/4"
15'-0"	6'-2 1/4"	7'-8 1/8"	8'-10 1/8"	9'-7"	10'-1 3/4"	10'-3 1/2"	92'-0 1/8"
16'-0"	7'-2 1/4"	8'-8 1/8"	9'-10 1/8"	10'-7"	11'-1 3/4"	11'-3 1/2"	106'-11 7/8"

NO.16 TURNOUT



TRACK CENTERS	A	B	C	D	E	F	G	X
13'-0"	3'-10 1/2"	5'-3 5/8"	6'-5 1/2"	7'-3"	7'-9 1/8"	8'-2 7/8"	8'-3 1/2"	61'-9 5/8"
13'-6"	4'-4 1/2"	5'-9 5/8"	6'-11 1/2"	7'-9"	8'-3 3/8"	8'-8 7/8"	8'-9 1/2"	69'-9 5/8"
14'-0"	4'-10 1/2"	6'-3 5/8"	7'-5 1/2"	8'-3"	8'-9 1/8"	9'-2 7/8"	9'-3 1/2"	77'-9 5/8"
14'-6"	5'-4 1/2"	6'-9 5/8"	7'-11 1/2"	8'-9"	9'-3 3/8"	9'-8 7/8"	9'-9 1/2"	85'-9 5/8"
15'-0"	5'-10 1/2"	7'-3 5/8"	8'-5 1/2"	9'-3"	9'-9 1/8"	10'-2 7/8"	10'-3 1/2"	93'-9 5/8"
16'-0"	6'-10 1/2"	8'-3 5/8"	9'-5 1/2"	10'-3"	10'-9 1/8"	11'-2 7/8"	11'-3 1/2"	109'-9 5/8"

NO.20 TURNOUT



TRACK CENTERS	A	B	C	D	E	F	G	H	X
13'-0"	4'-0 1/2"	5'-2 3/8"	6'-2"	6'-11 1/2"	7'-6 7/8"	7'-11 7/8"	8'-2 3/4"	8'-3 1/2"	79'-10 1/4"
13'-6"	4'-6 1/2"	5'-8 3/8"	6'-8"	7'-5 1/2"	8'-0 7/8"	8'-5 7/8"	8'-8 3/4"	8'-9 1/2"	89'-10 1/4"
14'-0"	5'-0 1/2"	6'-2 3/8"	7'-2"	7'-11 1/2"	8'-6 7/8"	8'-11 7/8"	9'-2 3/4"	9'-3 1/2"	99'-10 1/8"
14'-6"	5'-6 1/2"	6'-8 3/8"	7'-8"	8'-5 1/2"	9'-0 7/8"	9'-5 7/8"	9'-8 3/4"	9'-9 1/2"	109'-10 1/8"
15'-0"	6'-0 1/2"	7'-2 3/8"	8'-2"	8'-11 1/2"	9'-6 7/8"	9'-11 7/8"	10'-2 3/4"	10'-3 1/2"	119'-10"
16'-0"	7'-0 1/2"	8'-2 3/8"	9'-2"	9'-11 1/2"	10'-6 7/8"	10'-11 7/8"	11'-2 3/4"	11'-3 1/2"	139'-9 7/8"

NOTE: MEASUREMENTS ARE FROM GAGE SIDE OF RAIL TO GAGE SIDE OF RAIL

T.S. 5.1 RAILWAY CROSSINGS AT GRADE

1. When a crossing is to be replaced, it must be surveyed by CN Design and Construction.
2. Determination of the type of crossing to be installed will be based on traffic and speed on each route.
 - i. Flange bearing (OWLS) crossings are limited to 10 MPH for cross traffic with no restriction on the mainline speed.
3. Line deviations on each route should be corrected based on the survey prior to crossing installation.
4. Crossings will be installed according to the plans supplied for each crossing.
5. Subgrade drainage under a crossing diamond must be maintained. When possible ditch away from the crossing in all quadrants.
6. Clean ballast from an approved CN source will be used under the crossing.
7. Avoid damage to crossings when handling and lifting. Jacks and lifting slings should be used under the body of the crossing, not under the legs.
8. Crossings must be fully bolted. All bolts will be provided with spring or hardened steel flat washers as indicated on the plan. Use the correct diameter and length bolt. The correct length bolt will have approximately $\frac{3}{4}$ " of thread extending beyond the nut after tightening. Bolts, with graphite lubricant, will be torqued per **TABLE 1**:

TABLE 1		BOLT		TORQUE		
Bolt Diameter	(in.)	1	1 1/16	1 1/8	1 1/4	1 3/8
Grade 5 Bolt	Torque ft-lbs.	670	850	1200	1600	N/A
Grade 8 Bolt	Torque ft-lbs.	840	N/A	N/A	1675	2500

9. Flange bearing (OWLS) crossings will be maintained so that gouging in the mainline running rail does not exceed 1/2" (13 mm). Gouging in the running rail can not be repaired by welding.
10. Manganese castings will:
 - a. Be ground and slotted, after installation, at the following intervals until the flow subsides:
 - i. 0.5 MGT, 1.5 MGT, 4 MGT, then every 12 MGT or as required.
 - ii. 0.5 MGT = 3 days of traffic on a 50 MGT/year line.
 - iii. Product warranty requires documentation of work.
 - b. Be welded if the tread is worn down 3/8" (10 mm) or more below the original contour.
 - i. 3/8" below the level corners where the raised diamond crossing corner pads have been ground off.
 - ii. If worn more than 3/8" below this level, limit operating speed to 10 MPH.
 - c. If a reversible type, be reversed as needed, to equalize wear.

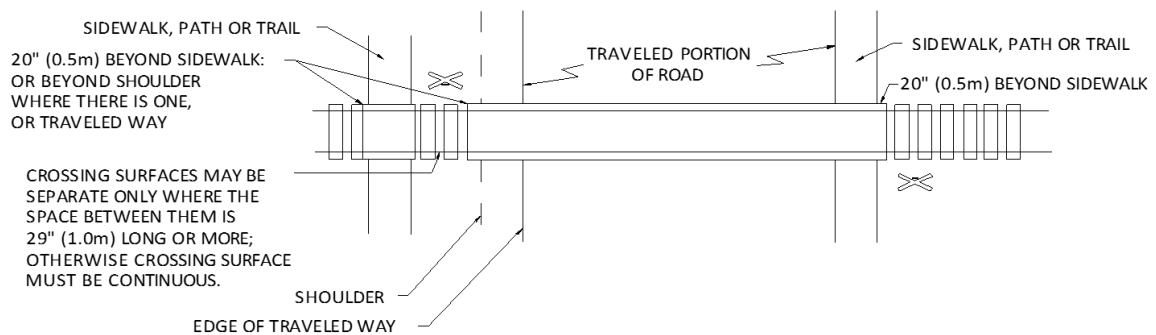
11. Flangeways will be maintained:
 - a. With width no less than 1 1/2" (38 mm).
 - b. With depth no less than 1 3/8" deep in Class 1 and 1 1/2" in Class 2 and above, unless designed specifically as a flange bearing frog.
12. To extend life of the crossing components, maintain good drainage, surface, line, tie condition and bolts.
13. Guard rails may be placed in advance of a crossing at the discretion of the Regional Chief Engineer.
14. Movable point crossings will be adequately lubricated with an approved lubricant.
15. Crossings will be kept free of snow, ice and other debris.
16. All crossings will be ordered with one half of a crossing as a spare to protect continued operation.
17. Track Supervisor is responsible for ensuring the maintenance inventory of crossing material is on hand. Material will be neatly placed and located so as not to be damage in the event of an incident at the crossing.

T.S. 6.0 ROADWAY CROSSINGS

1. Elimination or consolidation of as many road crossings as practical should be a goal in order to reduce exposure to accidents, reduce operational constraints and reduce costs of maintenance. Notify the respective Manager of Public Works (MPW) with candidates or suggestions to obtain approval for closure.
2. Before any maintenance work, by either the Railway or the road authority, can begin at or near an existing crossing or the construction of a new crossing location:
 - a. Information must be shared between the appropriate road authority and the Railway, if required, to ensure protection of the public and Railway operations.
 - b. Work involving excavation of any depth will not begin until all utilities, both Railway and others, have been located and marked. See T.S. 10 – S&C SYSTEMS – PRECAUTIONARY MEASURES.
 - c. If the crossing is protected by automatic crossing warning devices, the responsible S & C employee must be contacted and will protect the crossing accordingly.
 - i. When the crossing is deactivated, the employees, and RTC per applicable operating rules, must have a clear understanding of the means of protection utilized to ensure trains do not operate unprotected over the crossing. In the event that this protection requires manual flagging, this protection shall not be removed until notified by the responsible S&C employee that the crossing has been reactivated or permanently decommissioned.
3. Road crossing definitions;
 - a. Public Crossing is a location where a public highway, road, or street, including sidewalks or pathways, crosses one or more railroad tracks at grade and a public authority maintains the roadway on both sides of the crossing.
 - b. Private Crossing is any location where a roadway crosses one or more tracks at grade, which is not a public crossing.
 - c. Crossing Surface is the timber, concrete, composite of asphalt material placed between and adjacent to the rail to allow vehicle or pedestrian traffic to cross the track.
4. Applications for all crossings should be directed to the MPW who will ensure that all legal, financial and other Company requirements are met before a crossing is approved or constructed. Private crossings must not be converted to public crossings except in accordance with applicable law and not until a formal agreement between the Railway and the Public Authority accepting responsibility for the roadway has been signed and filed with CN Law Department.
5. When an agreement has been signed and filed for the construction of a new crossing, all track components will be renewed within the limits of the crossing in preparation of construction of the crossing. The installation of planking or crossing material is as directed by the MPW.
6. Modification of the length and location of crossings must not be made without the approval of the MPW. In the U.S., CN G.I.S. must be notified if the change could affect PTC.

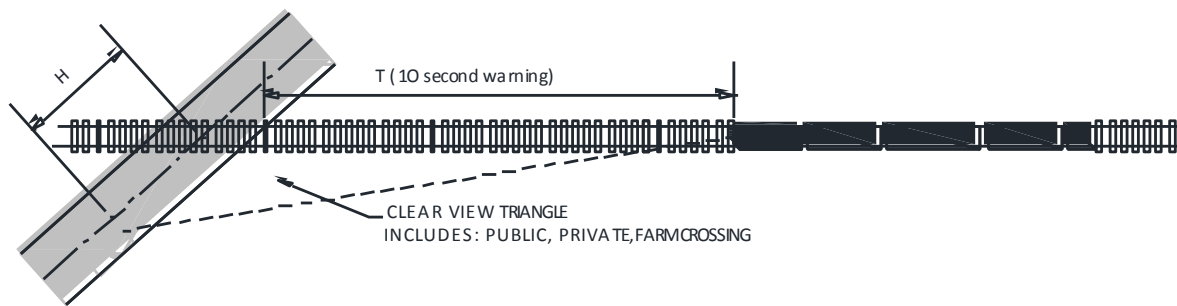
7. Crossings must comply with the safety standards and sight line requirements as outlined by the applicable Regulatory Authority having defined legal status where the crossing exists.
 - a. **In Canada only**, the Regulatory Authority is Transport Canada. (TC Crossing Regulations may be found on the Engineering SharePoint site, under Track Standards/ Miscellaneous Documents).
 - b. **In the U.S. only**, the Regulatory Authority is the individual State and the Federal Railroad Administration.
8. Crossings warning devices will only be as prescribed by the applicable Regulatory Authority and in accordance with the CN Standard Plan for Public crossings. No other forms of crossing protection will be erected. All applicable signage, such as whistle posts, flanger or snow plow signs, and applicable emergency notification signs will be installed by the Railway.
9. Emergency Notification Signs (ENS) will be affixed to all sign posts or signal masts of public crossings. The signs will show:
 - a. **In Canada only**: The subdivision name, mile post location and contact phone number.
 - b. **In the U.S. only**: The DOT number, contact phone number and purpose of sign information are required.
 - i. Two ENS signs will be installed at each public and private crossing.
 - ii. One ENS sign will be installed at each field crossing.
 - iii. One ENS sign is required at the entrance to yard or enclosed industrial facilities.
 - iv. ENS sign must be in place no later than 6 months after the crossing is installed.
10. When a Public Crossing has been granted approval for the elimination of whistling, Prohibited Whistle signs shall be installed in lieu of Whistle Signs in accordance with the Standard Plans. Locations of whistle prohibitions will be listed on the subdivision page of the Timetable.
11. Dirt or gravel crossings are not to be used as permanent crossing.
12. Crossing surfaces will be centered on the crossing and extend a minimum 20" beyond each side of the traveled portion of the roadway and/or sidewalk.
13. Rail joints should be kept 25 feet away from the end of the crossing if possible.
14. At public crossings, the crossing surface should be even with the running rail, but not more than 1 inch (25 mm) higher or lower than the running rail.
15. Crossing flangeways should be kept clear of dirt, sand, ice and other obstructions. The minimum flangeway depth is 1 7/8" (50mm). On newly constructed or reconstructed public crossing, a flange way width of not less than 2 1/2" (65 mm) and not more than 3" (75 mm) shall be provided.
16. Where crossings are deemed to be used by persons with assisted mobility devices, and special considerations for crossing surfaces may be required, contact the MPW.
17. Drainage at road crossings will be maintained. Where possible, cut drainage swales leading away from the edge of the crossing in all quadrants. Culverts under crossings, and especially culverts running under the track at crossings will be kept clear and free flowing.

18. When possible, maintain the roadway approaches to the grade crossing surface level for at least 2 feet to reduce the possibility of vehicles impacting the running rail. When the roadway crosses more than one track, the tracks should be as close to the same elevation, or same plane in curves, as is practicable.
19. The track surface and ties on crossing approaches shall be properly maintained.
20. The Railway is responsible for the physical maintenance of the surface of the traveled roadway between the rails and to the end of the tie, however, costs may be recoverable or shared as per Regulatory Order, formal agreement or license agreement.



NOTES:

1. THE MINIMUM WIDTH OF GRADE CROSSING SURFACE FOR PUBLIC ROADS FOR VEHICLE USE IS 26' (8m) (i.e. MEASURED AT RIGHT ANGLES TO THE CENTERLINE OF ROAD).
2. THE MINIMUM WIDTH OF THE GRADE CROSSING SURFACE FOR A SIDEWALK, PATH, TRAIL OR ANY OTHER ROUTE FOR A PERSON FOR REGULAR USE BY A PERSON USING AN ASSISTIVE DEVICE IS 5' (1.3m) MEASURED AT RIGHT ANGLES TO THE CENTERLINE OF THE SIDEWALK, PATH, TRAIL OR ROUTE.



ROAD TRAFFIC				RAILWAY TRAFFIC			
Maximum Vehicle Speed (km/h)			Minimum * Distance "H" (metres)	Maximum Train Speed (km/h)			Minimum * Distance "T" (metres)
	STOP				STOP		100
1	to	20	50	1	to	10	150
21	to	30	65	11	to	20	300
31	to	40	115	21	to	30	450
41	to	50	165	31	to	40	600
51	to	60	230	41	to	50	750
61	to	70	295	51	to	60	900
71	to	80	395	61	to	70	1050
81	to	90	475	71	to	80	1200
91	to	100	575	81	to	90	1350
				91	to	100	1500

*to be increase as required by Transport Canada Guidelines

T.S. 6.1 INSPECTION AND TESTING OF RAILWAY CROSSING WARNING DEVICES (RCWS)

THIS STANDARD IS APPLICABLE IN CANADA ONLY:

1. RCWS is defined as Railway Crossing Warning Systems maintained by the Railway and consists of:
 - a. Flashing light signals.
 - b. Flashing light signals with bells.
 - c. Flashing light signals, bells and gates.
2. The normal functioning of any RCWS shall not be interfered with in testing or otherwise, without first taking adequate measures to protect the safety of the public or highway traffic which depends upon the normal operation of such systems.
3. RCWS consisting of those devices identified in item 1 shall be:
 - a. Tested at least once in each calendar week with not more than ten (10) days between inspections.
 - b. Tested as directed by the Regional Chief Engineer where track is used less than once per week.
4. The person assigned to perform the test will manually operate the RWCS for one complete cycle, observing the proper functioning of all visible and audible warning devices, such as lights, gates functions and bells. All devices shall be inspected as viewed by approaching vehicle traffic, checking for broken or damaged lenses or other defective parts of the system.
5. If the RCWS fails to operate or does not operate properly:
 - a. Traffic at the crossing must be immediately protected by flagging.
 - i. If the warning device is for more than four tracks, two flagmen shall be used for flagging protection
 - b. Advise the RTC and S & C Maintainer immediately and by any means available.
6. Observation of the "Power On- Off" light mounted on the control box or bungalow by the person making the test is required. If the light is extinguished, flashing or the power is off, the RTC and the S & C Maintainer must be promptly advised and vehicle traffic protected.
7. The person assigned to perform the RCWS test must report the test in TIS, and complete CNR Form 8328, "Highway Crossing Warning System Performance Log Book" at the time the test is completed. The log book must be forwarded to the Signals and Communications Supervisor at the end of each calendar year, or when the book is filled.

THIS PAGE BLANK INTENTIONALLY

T.S. 7.0 TRACK INSPECTION GUIDELINES

1. Track inspections are defined as:
 - a. Regulatory Inspections – Inspections, frequencies and inspector qualifications will be as outlined in the T.C. Track Safety Rules on Canadian lines, and in the FRA Track Safety Standards on U.S. lines.
 - b. Supplemental Inspections – Those inspections as directed by the Railway. These inspections include, but are not limited to:
 - i. Walking Inspections
 - a. Walking curve inspection.
 - b. Walking bridge inspection.
 - ii. Supplemental joint bar inspection.
 - iii. Turnout Inspections.
 - a. Side jaw clip inspections.
 - b. Annual heel block inspections
 - c. Joint turnout inspections.
 - iv. CWR inspections for:
 - a. Disturbed track.
 - b. Hot or Cold weather.
 - c. Curve movement. (See T.S. 1.0 – CONTINUOUS WELDED RAIL)
 - v. Severe weather inspections. (Reference applicable Operating Rules)
2. Regulatory track inspections will be performed only by individuals who are qualified per Section 1.a., above, and are currently qualified under the CN Track Inspection Guidelines (TIG).
3. Track Supervisors are responsible to ensure these individuals meet the qualifications.
4. Track inspectors will, at a minimum, be equipped with the following:
 - a. Level board and Track Gauge
 - b. 62 foot string line and clamps.
 - c. 36 inch straight edge and taper gauge.
 - d. Rail wear gauge.
 - e. Tape measure.
 - f. Spray paint, high visibility ribbon and paint stick marker
 - g. Inspection mirror with telescoping handle.

- h. Counter – clicker type
 - i. Operable GPS unit.
 - j. The most recent track geometry car report, track chart and curve list.
- 5. All inspection reports must be:
 - a. Entered into TIS the same day of the inspection and by the person that performed the inspection.
 - b. Synced with TIS within 24 hours of completing the inspection.
 - c. Amended if changes need to be made to the original inspection.
- 6. Visual track inspections will be made by on-track vehicle and/or by walking. On-track inspection speeds will be sufficient to ensure thorough view of the track.
 - a. Vehicle speed over turnouts, crossings, etc. will not exceed 5 MPH.
 - b. One inspector can visually inspect two tracks provided:
 - i. The two tracks are 30 feet (9.144 m) or less apart.
 - ii. The inspector has an unobstructed view of the adjacent track.
 - iii. Tracks requiring inspections at least once per week are traversed once every two weeks.
 - iv. All sidings are traversed at least monthly.
- 7. Walking inspections may as directed by the Regional Chief Engineer, or be undertaken to monitor priority locations and areas of known problems such as:

RAIL:

 - a. Areas with high numbers of fatigue related defects. See T.S. 1.7. RFD TESTING and FREQUENCY, Section 10 for inspection guidelines.
 - b. Rail defects protected by joint bars.
 - c. Rail damage which has been previously damaged.
 - d. Areas approaching wear limits for rail.
 - e. Locations prone to overstressed rail:
 - i. Areas where repairs have been made (too much / little rail installed)
 - ii. Curves
 - iii. Areas of severe rail corrugation.
 - iv. Areas of heavy brake application.
 - v. Areas of joints abutting welded rail.
 - vi. Areas of steep grades and sags.
 - vii. Areas of insufficient or damaged rail anchors, or significant rail movement.

- viii. Derailment sites or derailment damaged rail.

JOINTS:

- a. High occurrences of cracked or broken bars.
- b. Gauge or top of rail mismatch between rails.
- c. Weak tie condition under or surrounding the joint.
- d. Pumping action of the joint under traffic.
- e. Tie plate movement on top of the tie.

WOOD TIES:

- a. Clusters of defective ties.
- b. Gauge problem areas. > 1/2" (13 mm)
- c. Excessive cant, both positive and negative.
- d. Areas prone to hanging ties – insulated joints, road crossings, bridge approaches, etc.
- e. Cracked, broken or damaged tie plates
- f. Areas of broken / missing spikes and screw spikes.
- g. Areas of high dynamic braking – PSO's, Control Points, etc.

CONCRETE TIES:

- a. Loose, missing or failing clips or insulators.
- b. Rail movement – both longitudinal and lateral.
- c. Loose or damaged cast shoulders.
- d. Ties damaged by derailment or cracks in the rail seat or through the cast shoulders.
- e. Rail seat abrasion – excessive cant or gauge, rail movement, insulators missing.

BALLAST:

- a. Sink holes.
- b. Mud pumping or trapped water / Frost heave or boil locations.
- c. Weak ballast section.
- d. Areas of recent work activity which disturbed the ballast.

ROADBED / SLOPE STABILITY:

- a. Areas historically prone to track geometry problems.
- b. Areas of slope stability (rock slides, slips, mud slides, vegetation, etc.)

DRAINAGE:

- a. Areas prone to ponding water (beaver activity, blocked culverts, etc.)
- b. Areas of increased run off (forestry operations, industrial development, adjacent properties)
- c. Areas of ice build up.

d. Culverts.

TRANSITION AREAS:

- a. Bridge approaches
- b. Transitions from wood to concrete tie track.

DERAILMENT AREAS:

- a. Areas of temporary repairs
- b. Location of square joint associated with panel installation.

8. Walking curve inspections require:

- a. Knowledge of the correct superelevation for the curve,
- b. Review of geometry car reports for locations of gauge, cant or geometry conditions.
- c. Inspection of both the high and low rail, noting:
 - i. Excessive gauge corner wear, measuring rail wear periodically.
 - ii. Excessive flattening of the low rail, measuring rail wear periodically.
 - iii. Adequacy of lubrication on the rail.
 - iv. Proper ballast shoulder on each side.
- d. Line or surface deviations in the track.
- e. Signs of gauge widening from rail wear, plate movement or insulator crushing.

9. Walking curve inspections on wood ties involve:

- a. Observing screwspikes and cut spikes for signs of lift, breakage or rotation.
- b. Tap plates, spikes and screwspikes with a lining bar for signs of loose or broken spikes.
- c. When a broken screw is found, perform a detailed inspection of the surrounding area to determine the extent of broke screwspikes.
- d. Note cracked, broken or damaged tie plates.
- e. Note plate pushing or plate cutting with excessive rail cant – both inward or outward.

10. Walking curve inspections on concrete ties involve:

- a. Inspecting when the ties are not covered with snow or ice.
- b. Walking along the field side noting the condition of clips, pads, insulators, and cast shoulder or outward rail movement or other signs of rail seat abrasion.

11. **In Canada only**, walking inspections must be completed on all jointed tracks, and all tracks with curves 4 degrees or greater per **TABLE 1**.

Note: If electronic or camera inspections of joint bars is performed, walking inspection of tangent track and curves less than 4 degrees in jointed track is not required.

TABLE 1 REQUIRED MINIMUM WALKING INSPECTION FREQUENCY

Class of Track	Annual Tonnage			
	< 5 MGT	5 - 15 MGT	15-35 MGT	> 35 MGT
1	N/A	N/A	N/A	N/A
2	Every 3rd year	Every 3rd year	Every 2nd year	Annually
3	Every 2nd year	Every 2nd year	Annually	Annually
4 & 5	Annually	Annually	Annually	Annually

12. Walking inspections of road crossings will be performed at least annually with not more than 12 months between inspections. Reference T.S. 6.0 ROAD CROSSINGS.
13. Hump leads and pull back tracks should be inspected weekly as directed by the Regional Chief Engineer.
14. Compromise bars will be inspected monthly.
15. All joints bars will be inspected per **TABLE 2**, including:
 - a. Insulated joints in CWR track.
 - b. Jointed rail track less than 200 feet in length between strings of CWR.
 - c. Jointed rail track greater than 200 feet with joints adjoining CWR.
 - d. Conditions may require additional inspections.
 - e. Note, joints within or adjacent to switches, rail crossings and lift or expansion rails are exempt from the periodic joint inspection requirements provided they are inspected in the monthly walking inspection of these devices.

TABLE 2 MINIMUM NUMBER OF INSPECTS PER YEAR

Class of Track	Freight Trains operating over track with annual tonnage of:			Passenger Trains operating over track with annual tonnage of:	
	< 40 MGT	40 - 60 MGT	> 60 MGT	< 20 MGT	> 20 MGT
5 & above	2x	3x*	4x*	3x*	3x*
4	2x	3x*	4x*	2x	3x*
3	1	2x	2x	2x	2x
2	0	0	0	1x	1x
1	0	0	0	0	0
Excepted Track	0	0	0	N/A	N/A

Note: Where a track owner operates both freight and passenger trains over a given segment of track, and there are two different possible inspection interval requirements, the more frequent inspection interval applies.

*- When extreme weather conditions prevent a track owner from conducting an inspection of a particular territory within the required interval, the track owner may extend the interval by up to 30 calendar days from the last day that the extreme weather condition prevent the required inspection.

16. **TABLE 3** shows the periods of the year these inspections will be made.

TABLE 3 JOINT BAR INSPECTION INTERVALS

Inspection Code	Minimum Inspections per Year	Minimum Days Between Inspections	Inspection Periods
4x	4	60	Jan.-Mar. / Apr. - June / July - Sept. / Oct. - Dec.
3x	3	90	Jan. - Apr. / May - Aug. / Sept. - Dec.
2x	2	120	Jan. - Jun / July - Dec.

17. Joints can be Permanently Embedded or Temporarily Buried:
- Permanently embedded joints are locations where the joint is covered within pavement or crossing pads, etc. It is not necessary to disassemble or remove the obstruction to conduct an inspection these joints, however, make every effort, to the extent practicable, to inspect the visible portion of these joints.
 - Temporarily Buried locations are joints where ballast or similar material is in the middle or along the track, rendering the joint unavailable for inspection. Where CWR joints are buried, wait for the completion of track work before conducting the joint bar inspection.
18. In both jointed and CWR main track on bridges, joints will be inspected at least:
- Annually, where yearly tonnage is less than 10MGT; or,
 - Twice annually, where yearly tonnage is greater than 10 MGT.
19. Each joint in CWR track found to require remedial action as outlined in **TABLE 4**, shall be identified in the field with a highly visible marking. Such joint will be uniquely identified by subdivision, milepost, track number and rail (Left or right as viewed in the direction of increasing milepost) for reporting.

TABLE 4

RAIL JOINT CONDITION	ACTION ¹
Visible cracks in joint bar	Replace bar
Loose bolts	Tighten or replace bolts
Bent bolts	Replace bolt(s) or re-inspect per TABLE 1
Missing bolts ²	Replace bolts ²
Tie(s) not effectively supporting the joint	Tamp tie(s), replace tie(s), OR , re-inspect every other week until repaired or replaced.
Broken or missing tie plate(s)	Replace tie plate OR re-inspect every other week until repaired or replaced.

... continued

TABLE 4 continued

RAIL JOINT CONDITION	ACTION¹
Deteriorated insulated joint	Repair / replace joint , OR re-inspect every other week until repaired or removed.
Rail end batter (More than 3/8" in depth and more than 6" in length measured with a 24" straight edge	Repair or protect per T.S. 1.7, Section 10
Rail end mismatch reaches limits specified by FRA 213.115 or TC Part II. D. IV.	Weld, grind or replace
Longitudinal rail movement greater than 2 inches	Add or adjust rail anchors, tight bolts, add/remove rail at the appropriate time, OR, re-inspect every other week until repaired or removed
Wide rail joint gap, greater than 1 1/2inch	Adjust rail gap and secure joint, OR, re-inspect every other week until repaired or removed
Joint vertical movement (profile) that exceeds 75% of the allowable threshold for the designated class of track ³ .	Surface joint, OR, re-inspect every other week until repaired or removed
Fouled ballast ⁴ present in conjunction with joint vertical movement (profile) that exceeds 75% of the allowable threshold for the designated class	Surface joint and provide drainage, OR, re-inspect every other week until repaired or removed
Joint lateral movement (in curve or spiral) that reaches 3/4"	Correct lateral movement, OR, re-inspect every other week until repaired or removed

Note 1: Action may also consist of placing a speed restriction or removing the track from service.

Note 2: A minimum of 2 bolts per rail end must be in place at each joint.

Note 3: Joint lateral and vertical movement is the apparent visible movement measured at the joint.

Note 4: Fouled ballast is defined as ballast that is so contaminated with fines that it is containing standing water within the track structure at joints.

TURNOUTS, DERAILS AND SPECIAL TRACK WORK

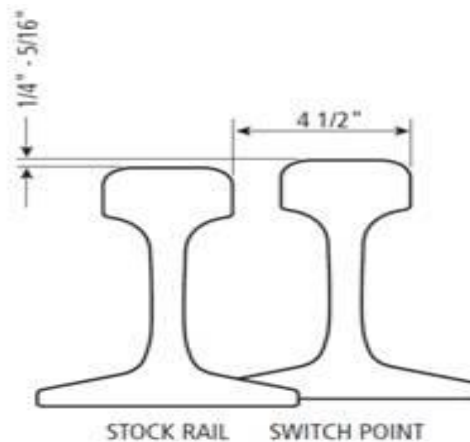
20. Turnouts, rail crossings, and, lift and expansion rail location inspections will be performed by qualified employees at the following minimum frequencies of **TABLE 5**:

TABLE 5	MINIMUM FREQUENCY FOR INSPECTION OF TURNOUTS, CROSSINGS AND SPECIAL TRACKWORK
Routine Inspection	Each time the location is crossed it is visually inspected for defects and noted on the track inspection report
Walking Inspection	Each location shall be inspected on foot at least monthly observing overall conditions, except that in the case that track is used less than monthly each location will be inspected on foot before the track is used. Inspections will be documented and recorded.
Detailed Inspection	A thorough detailed observation of the condition of all components in each location shall be performed annually, documented and recorded.

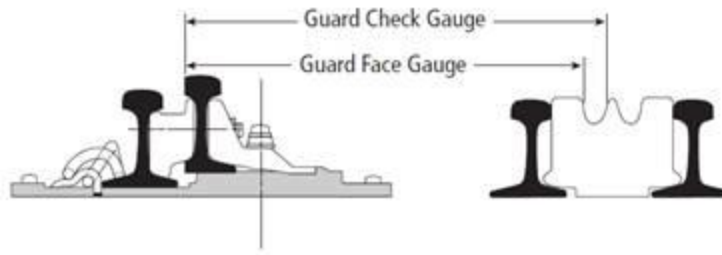
21. All turnouts:
- a. In Class 3 and higher track, switch points must be operated in all positions during one of the inspections performed within a 3 month period.
 - b. In Class 1 and 2 tracks, switch points must be operated in all positions during one inspection every month.
 - c. Which are power or dual control, will be jointly inspected annually by a qualified Track and S&C employee.
22. Turnout inspections will include:
- a. All joints:
 - i. Between and including the insulated joints of the outer most signals of a Control Point or dual control switch.
 - ii. From 50 feet head of the switch points to 50 feet behind the last long tie of the turnout, including the diverging route, of hand operated turnouts.
 - b. Ties:
 - i. Soundness of headblock and switch ties.
 - ii. Spaced correctly through the switch point area and not contacting rods.
 - iii. Square to the normal route of the track.
 - iv. Fully tamped and supporting tie plates.
 - c. Plates and fasteners:
 - i. Braces secured to plates and firmly against the web of the stock rail.
 - ii. Plates not missing, broken, bent, or worn more than 1/8 inch (3mm).
 - iii. Signs of broken or loose spikes or screwspikes,
 - iv. Spikes or screwspikes fully drawn into ties.
 - v. Ties spiked to pattern per T.S. 3.3 – RAIL FASTENERS through the entire turnout and return curve.
 - vi. Rail anchors applied per T.S. 3.1 – RAIL ANCHORS and tight against tie.
 - vii. Elastic fasteners and insulators in place.
 - d. Bolts:
 - i. All heel block and joint bolts, in place, of correct size and, tightened per T.S. 5.0.-TURNOUTS.
 - ii. Cotter pins are in place on all connecting rod and bridle rod bolts.
 - iii. Replace bent, broken or missing bolts and cotter pins.

- iv. Bolts on connecting rods with nuts up.
- e. Switch stands, machines and rods:
 - i. Switch stand and machines are secured firmly to headblock ties with no lost motion.
 - ii. Target visible and firmly attached to mast of the switch stand.
 - iii. Proper locks or keepers in place and attached by chain or cable to the stand.
 - iv. Rods are free moving in cribs.
 - v. Jam nuts are tight on the connecting rod and eye bolts.
 - vi. No rods or clips have been repaired by welding.
 - vii. All side jaw, transit and rocker clips secure and painted white to detect cracks.
-Note bent, broken, welded or corroded clips rods for replacement.
- f. Bolted Heel Block Joints:
 - i. Detailed inspection:
 - a. Twice per year, Spring and Fall, on the normal route of core mainlines switches.
 - b. As directed by the Regional Chief Engineer on the diverging route of core mainline switches, any non-core switches, switching leads and major yards.
 - c. Disassemble joint and inspect bars, bolts, cotter pins and thimbles.
 - i. Note excessive wear, bent or broken components.
 - d. Inspect base plates, tie condition and surface at joint.
- g. Insulation:
 - i. Insulation in rods, gauge plates and heater duct ties in place and not deteriorated.
- h. Rail, stock rails and switch points:
 - i. Where rail wear is 75% of maximum allowable limits, or rail spalls, checking or corrugation are present, perform visual under-head inspection of the rail.
 - ii. Chipping, head flow, crushing, excessive wear or other damage.
 - a. Chipped or broken switch point tips must not have thickness greater than 3/16" (5mm).

- b. Flow of the stock rail or switch point must not exceed $1/16''$ (2 mm) and be corrected before resulting in gapping of point or chipping of the tip or back side of the switch point.
- iii. Stock rail sits $1/4 - 5/16''$ (6-8mm) lower than the switch point at the location where the distance between the gauge face of the switch point to the gauge face of the stock rail measures $4\frac{1}{2}''$ (115 mm).
 - a. Note any location where the outer edge of wheel is contracting the gauge side of the stock rail.
 - b. Replace the both the switch point and stock rail if this dimension is less than $3/16''$ (5 mm).



- iv. Switch points are square to each other and do not overhang the gauge plate by more than one inch.
 - v. Entire planed portion of switch point mates to the gauge face of the stock rail.
 - vi. Switch point tip is not less than $1/2''$ (13 mm) below the top of stock rail.
 - vii. Stock rail is seated in plates, switch point bears flat on slide plates.
 - viii. Switch point rollers, where equipped, are properly adjusted.
- I. Guard Rails:
- i. Guard rails and bars must be replaced when the wear surface is worn more than $5/8$ inch (15 mm).
 - ii. Guard rail bolts must be correct size, in place and tight.
 - iii. Guard bar retaining hooks, shims blocks and clips are secured.
 - iv. Guard rail set to provide correct Guard Check Gauge and Guard Face Gauge.
 - a. Guard Check Gauge is distance from gauge line of frog to the guarding face of the guard rail.



- b. Guard Check Gauge is the distance from the guard line of the frog to the guard face of the guard rail. See **TABLE 6**.

TABLE 6 GUARD CHECK AND GUARD FACE GAUGE MEASUREMENTS

Class of Track	MINIMUM Guard Check Gauge (in.)	MAXIMUM Guard Face Gauge (in.)
1	54 1/8	53 1/4
2	54 1/4	53 1/8
3 & 4	54 3/8	53 1/8
5 & 6	54 1/2*	53

Note*: At the point of heavy point frogs equipped with through gauge plates, use 54 3/8" (1,381 mm).

- j. Frogs:
- i. Bolts are in place and are of proper strength, length and diameter.
 - ii. Plates fit frog body and are firmly attached to sound ties.
 - iii. Flangeway depth, measured from a plane across the wheel bearing (tread) portion of the frog, will not be less than **TABLE 7**:

TABLE 7 MINIMUM FLANGEWAY DEPTH

Class of Track	MINIMUM Flangeway Depth
1	1 3/8" (35 mm)
2 and Above	1 1/2" (38 mm)

- iv. If the tread portion of the frog casting is chipped or worn down more than 3/8 inch (10 mm) below original contour speed will be restricted to 10 MPH.
- v. If the frog point is chipped, broken or worn down more than 5/8" (15mm) and 6 inches back, speed will be restricted to 10 MPH.
- vi. Spring Frogs inspection must include:
 - a. Horns and housing clearance must not be more than 1/4" (6 mm).
 - b. Closing spring will be inspected for adequate compressive force to hold the wing tightly to the frog body.

- i. The frog is designed to have a 3/8 inch (10 mm) gap at the point for 115lb. and heavier frogs. The gap must not exceed 3/4".
 - ii. Retarders will allow the wing to close in 1 to 3 minutes.
 - c. When the wing is fully opened, the flangeway opening is at least 1 3/4" but not more than 1 7/8".
 - d. Frogs must be free of snow, ice, ballast or other debris which effects wing operation.
 - e. Frog base plates must be flat to allow for proper wing movement.
 - f. Tie condition and surface of the toe joint of the frog will be inspected to ensure no pumping of the joint and wing rail.
 - g. Tie condition and fasteners will be sound and frog secured.
 - h. The outer tread portion of the wheel shall not contact the gauge side of the spring wing rail.
 - i. Any SRF with a bolt hole defect or a head web separation shall be replaced.
- vii. Self Guarded Frogs (SGMF) must have the guard face rebuilt if the wear exceeds 3/8" from the nominal guard thickness.
 - a. SGMF guard faces must be rebuilt before repairing the frog point.
- k. Turnout geometry:
 - i. Measure gauge throughout turnout focusing on:
 - a. Gauge from at least 50 feet ahead of, and through the switch points.
 - b. Gauge at 15' -6" intervals in the curved closure rail, and at joints.
 - c. Gauge through frog and guard rail.
 - d. Gauge in return curves.
 - ii. Surface throughout turnout and return curves:
 - a. Line, profile and crosslevel in switch point area.
 - b. Warp behind turnout through the return curve.
 - i. Start wrap measurements with station "0" at the switch point.
 - ii. Each station is 15' -6".
 - iii. Place 4 stations ahead of the switch point and the last station at the end of the return curve.
 - c. Sudden run off behind the turnout on the diverging route.
 - d. See T.S. 5.0-TURNOUTS for correct line of the return curve.

- e. Note ballast in cribs and drainage in and around the turnout.
- I. Operation of switch:
 - i. Free movement of switch stand handle, rods and points.
 - ii. Target is secured and indicates the route correctly.
 - iii. Adequate pressure of the point against the stock rails.
 - iv. Gap of switch point between 1/16 – 1/8" (1.5- 3mm) must be repaired within 24 hours, except, remove the switch from service if any of the following exist;
 - a. Stock rail braces are of rigid spike design.
 - b. Braces, of any design, are moving on the tie.
 - c. Turnout is located in a curve.
 - d. Ties are hanging or pumping.
 - e. The switch stand exhibits any movement.
 - f. Gauge deviations exist ahead of switch points.
 - g. Switch points are chipped.
- 23. Derails and rail crossings at grade will be inspect on foot noting the following:
 - a. Derails will be inspected for:
 - i. Proper size, type and fit. See T.S. 3.2- DERAILS.
 - ii. Derail is in working conditions or shows signs of damage from impact.
 - iii. Ties under derails are sound, fasteners intact and the tie fully supports the derail.
 - iv. Lock is present and applied to the derail.
 - v. Derail is painted yellow and clearly visible.
 - vi. Derail signs and targets, where required, are in place, retro-reflective and visible.
 - b. Rail crossings at grade, inspect:
 - i. All bolts installed and of the correct strength, length and diameter.
 - ii. If the points are chipped, broken or worn more than 5/8" (15mm) down and 6 in. (150 mm) back, then speed will be restricted to 10 MPH.
 - iii. Joints from the outer signals on all routes.
 - iv. Drainage and ballast condition.
 - v. Notify RTC immediately of conditions on the crossing railway which require protection.

COLD WEATHER INSPECTIONS

24. Gas welded CWR on core main track will be inspected at additional frequencies:
- a. Between October 1 and March 1 or any time the ambient temperature is expected to be less than 25° F inspections increased.
 - i. To three times per week, with at least 1 calendar day between inspections, and
 - ii. The Track Supervisor must strive to personally perform at least one of the three weekly inspections.
 - b. Additional inspections of non-core tracks will be as directed by the Regional Chief Engineer.
25. Lines are deemed susceptible to cold weather related rail failures if any of the following apply:
- a. Non-signalized territory.
 - b. Jointed rail or Gas Welded Rail (See Section 23 above).
 - c. Rail weight of 115 lb. or less and subject to 286K lb. car loading.
 - d. Rail with a history of rail defects as calculated using a 3 year RSI.
 - e. Lines identified by the Regional Chief Engineer.
26. Daily cold weather inspections will be performed on core lines when the conditions of **TABLE 8** exist:

TABLE 8 EXTREME COLD WEATHER TRACK INSPECTIONS

Territory	Track Conditions	Either Condition Met	
		Extreme Low Temperature	Rapid Drop in Temperature
Canadian Lines	Susceptible to Cold	Less than (-) 25 ° C	Greater than 25°C within a 24 hour period
	All Track	Less than (-) 30 ° C	
U.S. Lines North of Chicago	Susceptible to Cold	Less than (-) 15 ° F	Greater than 45 ° F within a 24 hour period
	All Track	Less than (-) 20 ° F	
U.S. Lines Chicago - Bluford	All Track	Less than (-) 10° F	
U.S. Lines South of Bluford	All Track	Less than (-) 5° F	

Additional restrictions may be placed and inspections required for “cold snap” temperature changes, or during intensely cold temperatures.

COLD WEATHER TEMPORARY SPEED RESTRICTIONS:

27. In areas identified as having a history of rail failures, the following temporary speed restrictions will be placed:
- a. Temperatures below -25°C in Canada, or -10°F in the US,
 - i. Reduce freight speed to 40 MPH or track speed, whichever is less.
 - ii. Reduce passenger speed to 60 MPH or track speed, whichever is less.

HOT WEATHER INSPECTIONS

28. When ambient temperature exceed those in **TABLE 9**, or a notification is received indicating a sudden temperature spike, hot weather inspections must be performed between the hours of 11:00 and 22:00.
- a. Hot weather inspections may be suspended if temperatures have stabilized and previous inspections have shown the track is within standard and is stable.
 - b. During hot weather inspections pay particular attention to any of the following conditions:
 - i. Lateral or vertical movement of the rail (i.e. “wavy” rail or lifted from the tie plate seat).
 - ii. Alignment deviations.

TABLE 9 HOT WEATHER INSPECTION and SPEED RESTRICTION THRESHOLDS

Territory	Ambient Temperature
All Canadian Regions (Except as below)	More than 30°C (86°F)
Canada - Clearwater Sub west of MP 67.7, Ashcroft Sub. and Yale Sub.	More than 33°C (91°F)
Southern Region North of Centralia, IL.	More than 95° F
Southern Region South of Centralia, IL.	More than 100°F

- iii. Movement of ties leaving a gap in the ballast or shoving ballast at the end of the tie.
 - iv. Insufficient ballast in cribs or on shoulders.
 - v. Ties plowing ballast down the track.
 - vi. Rail moving through anchors or clips.
 - vii. Areas of bunching rail:
 - a. At the bottoms of grades.
 - b. Near areas in advance of PSO's or TSO's.
 - c. In advance of Control Points or heavy brake applications location.
 - viii. Areas of recent track work.
 - ix. Areas of track instability.
 - x. Areas of known excess rail or lateral instability concerns.
- c. If a condition is found, a speed restriction of no more than 25 MPH will be placed immediately, or the track will be removed from service until repairs are made.

HOT WEATHER SPEED RESTRICTIONS

29. When temperatures exceed those listed in **TABLE 9**, the following speed restrictions will be placed:

Passenger Trains: Reduce maximum subdivision speeds by 15 MPH, but not less than 60 MPH.

Freight Trains: Reduce maximum subdivision speeds by 10 MPH, but not less than 40 MPH

- a. PSO's and TSO's will be reduced by the same amount, but not less than 30 MPH Freight and 40 MPH Passenger.

Note – Subdivisions with maximum speed below 30 MPH Freight or 40 MPH Passenger require specific Hot Weather Speed restrictions if track conditions require operating speeds to be lowered further. Local Operating Bulletins will be utilized to limit operating speeds and/or hours of train operations as agreed upon by the Regional Engineering and Transportation Departments.

T.S. 7.1 TRACK GEOMETRY

1. Track Geometry deviations are classified as **URGENT, NEAR URGENT or PRIORITY**.
 - a. **URGENT** defects are deviations which exceed either the TC Track Safety Rules or FRA Track Safety Standards. See **TABLE 2** for deviation thresholds by class of track.
 - b. **NEAR URGENT** deviations are conditions approaching TC Track Safety Rules or FRA Track Safety Standards.
 - c. **PRIORITY** deviations are conditions which exceed CN recommended maintenance tolerances. See **TABLE 1** for deviation thresholds by class of track.
2. When an **URGENT** defect is found, one of the following actions must be immediately take before the operation of the next train over the defect(s):
 - a. Repair defect to bring into compliance with posted class of track.
 - b. If a defect is a speed related type, a TSO must be placed restricting train operations to a maximum speed for which the defect(s) allows.
 - c. Discontinue operation over the defect.
3. When a **NEAR URGENT** deviation is identified by the Geometry Car, the condition must be inspected within 72 hours and remedial action must be taken within 30 days.
4. When a **PRIORITY** deviation is identified:
 - a. The condition must be monitored and repaired prior to becoming an **URGENT** defect:
 - b. Address combination defects (within 100 feet of each other) in the following order:
 - i. Combination defects on curve spirals.
 - ii. Combination defects within the body of the curve.
 - iii. Combination defects near changes in track modulus (bridges, tunnels, crossings, etc.)
 - c. Address all other **PRIORITY** deviations.
5. When unloaded track is measured to determine compliance (static) with requirements of this Track Standard, the amount of movement which occurs while the track is loaded (dynamic) must be added to the measurements of the unloaded track.
6. On Canadian Lines only:
 - a. Where speed related track geometry defects are detected through heavy track geometry car tests, **TABLE 3** and **TABLE 4** may be used to determine the maximum TSO speed to be applied for the 72 hour period immediately following the inspection.
 - b. If the defect has not been repaired after the 72 hour period, the TSO must be revised, restricting trains to a maximum speed that is within the track class allowed by the severity of the defect(s) of **TABLE 2 – URGENT**.

GAUGE

7. Standard gauge is 56 ½" on tangent track and curves up to 14°. For curves over 14°, see E.T.S. 1.3 CONTINUOUS WELDED RAIL Section 7.

8. Minimum gauge for track to remain in service is 56", except:

In Canada only:

- a. Minimum gauge of 55 ¾" is allowed on Class 1 and 2 tracks, and
- b. If gauge is less than 56", per 8.a., and a change in gauge over a distance of 20 feet or less either side of the defect exceeds 1 ½", operating speed must be reduced to Class 1.

9. In Class 1, 2 and 3 track, when wide gauge is found during walking inspections, hi-rail inspections or by Solid Track vehicle (Not by geometry car, Holland Track Star or Pucket Truck), the actions of **TABLE 5** are required:

TABLE 5 WIDE GAUGE CORRECTIVE ACTION TABLE

Gauge Measurement	Action Required
57 1/2" - 57 3/4"	Repair or re-inspect within 30 days ¹
> 57 3/4"	Repair immediately or Remove from Service ²

Note ¹: Gauge conditions with other conditions, as listed, may require repair prior to the 30 day period:

Poor tie condition	High / missing spikes	Single shoulder plates
Heavy Tonnage	Reverse cant	Cross level
Poor Drainage	Poor fasteners or non-standard pattern	

Note ²: Track may remain in service for 24 hours with approval of Assistance Regional Chief Engineer.

10. Loaded gauge, as measured by the CN 1057 Track Geometry Car, Holland TrackStar or Puckett vehicles, apply lateral loads to measure gauge. These values should be the sum of unloaded measurements plus all signs of additional lateral rail movement.
- a. All gauge defects determined by this method must be field verified.
 - b. Delta Gauge – is defined of the difference between unloaded (static) and loaded (dynamic) gauge measurements.
 - c. Gauge Widening Projection (GWP) – is a calculated value that gauge could reach in the event of severe train brake application.
11. Near base to near base measurements for standard gauge for various rail sections is:

TABLE 6 INSIDE BASE TO INSIDE BASE GAUGE DIMENSION

Rail Section	Base Gauge
136 lb.	53 3/4"
132 lb.	53 7/8"
112/115/119 lb.	54"

Note, distance assumes dimension of new rail

12. Gauge variations can be caused by tipped or canted rail. Inward cant results in tight gauge, outward cant results in gauge widening. Rail cant of 1 degree causes a change in gauge of 1/8".
13. Combination Cant Defect, found by the heavy Track Geometry Test Cars, include all 3 components of rail cant, flange wear and rail gauge values. See the Combination Cant URGENT and NEAR URGENT Defect tables for thresholds and remedial actions.
 - a. No individual reading of cant, rail wear or gauge may be in excess of the allowable thresholds.
 - b. Rail cant is of greatest concern and when repairing Combination Cant Defects, correct the cant condition first.

TABLE 7 COMBINATION CANT URGENT DEFECT REMEDIAL ACTION

Combination Cant Defect Threshold			Remedial Action Required	
Flange Wear	Rail Cant	Rail Gauge	Class 1 and 2 Track	Class 3,4 & 5 Track
10 mm	4°	5/8 in.	Repair Immediately, or limit operating speed to 10 MPH until repaired	Repair Immediately, or limit operating speed to 25 MPH until repaired

TABLE 8 COMBINATION CANT NEAR URGENT DEFECT REMEDIAL ACTION

Combination Cant Defect Threshold			Remedial Action Required
Flange Wear	Rail Cant	Rail Gauge	All Tracks Class 1 through 5
9 mm	3.5°	1/2 in.	Inspect within 72 hours and repair within 30 days. If not repaired within 30 days, limit operating speed per the Combination Cant URGENT Defect Table for the applicable Class of track until repaired.

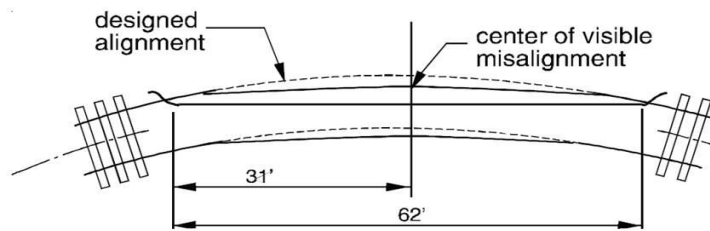
ALIGNMENT

14. The measurement of alignment is the maximum mid ordinate, in inches, (positive or negative) of a 62' or 31' chord, measured from the gauge line to the string line:
 - a. The line rail of a curve is the outer rail,
 - b. The line rail for tangent track can be either rail.
 - c. The line rail for a turnout is the curved closure rail between the switch point and frog.
 - d. Center the midpoint of the chord at the point of misalignment.
 - e. To determine the degree of curve, the measurement from the gauge of the rail to the string line, at the midpoint, is a 1 to 1 ratio for 62 foot chords and a 4 to 1 ratio using a 31 foot chord:

TABLE 9 Examples of Degree of Curve Measurements for 62' and 31' Chords

Midpoint Measurement	1"	1 1/2"	2"	2 1/2"	3"
62 foot Chord Degree of Curve	1°	1°30"	2°	2°30"	3°
31 foot Chord Degree of Curve	4°	6°	8°	10°	12°

- f. To determine the alignment variation in a curve:
 - i. If using a 62' chord, place stationing every 15' 6" for 4 stations either side of the center of the point of misalignment for a total of 9 stations.
 - ii. Average the midpoint measurements at the stations either side of the point of misalignment. This average is the uniformity of the curve.
 - iii. The difference between the midpoint measurement at the point of misalignment and the uniformity is the variation from uniformity.
 - iv. If the 31' chord method is used, place 8 stations either side of the center of the point of misalignment.
 - v. Refer to **TABLE 1** through **TABLE 4** for compliance.



CROSSLEVEL

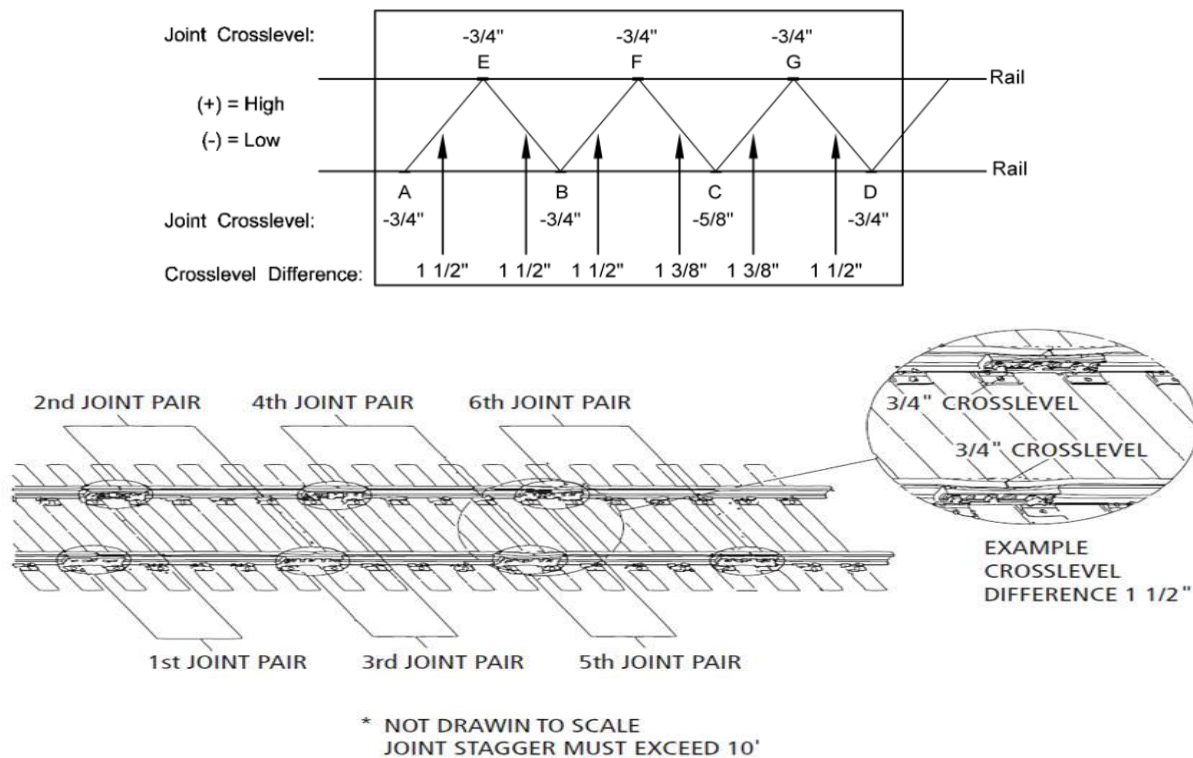
15. Crosslevel is the difference in elevation between the grade rail and the opposite rail measured at right angles with a level board.
16. On tangent track either rail can be designated as the grade or reference rail, however, for measuring purposes, the same rail must be used as the grade rail throughout.
17. The low rail of the curve will be the grade rail.

WARP

18. Warp 31 is defined:
In Canada only: As the difference in crosslevel between any two points less than, or within, 31 feet apart in a spiral.
In the U.S. only: As the difference in crosslevel at two points, 31 feet apart, in a spiral.
19. Warp 62 is the difference in crosslevel between any two points within a 62 foot length of track in tangent, spiral or curved track.
20. Warp 31 and Warp 62 conditions can occur within the same section of track.

HARMONIC ROCK (ROCK and ROLL)

21. Harmonic rock can cause wheel lift derailments. Harmonic rock occurs in jointed rail track in Class 2 through 5. To control this condition, the combined crosslevel shall not exceed 1 - ¼ inches in all 6 consecutive pairs of staggered joints as created by 7 low joints.



22. Jointed track with joint stagger less than 10 feet shall not be considered as having staggered joints.
23. Joints within the 7 low joints outside of the regular joint spacing shall not be considered as joints.

SUPERELEVATION

24. The outside rail of a curve should not be lower than the inside rail, except as allowed by Section 33, below.
25. The low rail of the curve will be the grade rail.
26. Superelevation for each main track curve:
 - a. Will be as indicated on the Curve List or track charts posted on the Engineering SharePoint Site.
 - b. Will be no more than 5 inches installed, unless directed by the Regional Chief Engineer.
 - c. Shall not exceed 6 inches. Curves exceeding 6" of elevation require a plan to reduce elevation.
 - d. Will be a minimum of 1/2" on class 2 or higher track.
 - e. Will be at maximum elevation at the point of full body of the curve.
 - f. Will be run out within the length of the spiral, however, when superelevation must be extended into tangent track, 75% of the elevation must be run out in the spiral.

27. The maximum allowable speed (Vmax) for any curve is calculated using:

$$V_{\max} = \sqrt{\frac{E_a + E_u}{0.0007 * D_c}}$$

Where:

Vmax = Maximum allowable operating speed (miles per hour)

Ea = Actual elevation of the outside rail (inches)

Dc = Degree of curvature (degrees) as measured in Section 14, above

Eu = Maximum allowable unbalanced condition.

The maximum Eu to use is: Freight - 2 inches.

Passenger - 3 inches, except:

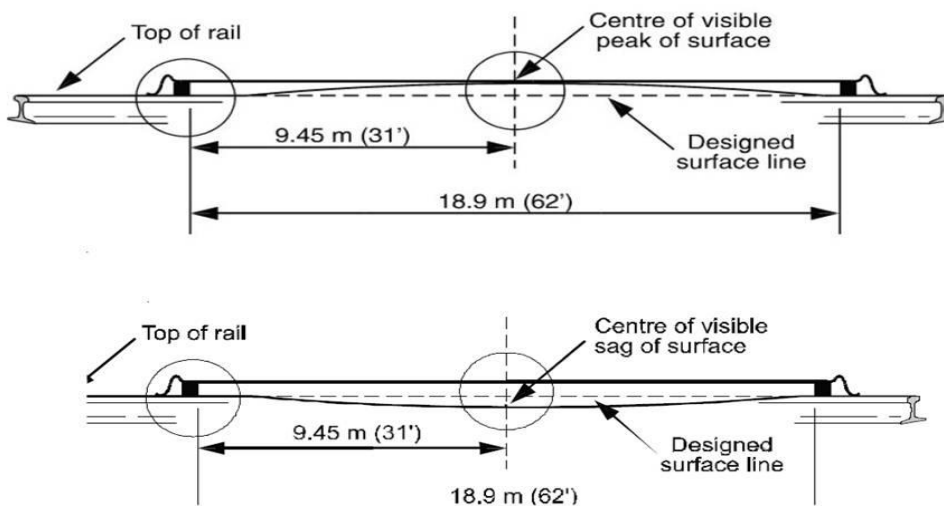
VIA passenger equipment (Canada only) - 4 inches.

LRC (Light Rail Commuter) (Canada only) - 6 inches.

28. When superelevation is less than the amount required, the curve must be checked for Vmax. Vmax tables for 3" and 4" unbalance are found in the APPENDIX at the end of this book.
29. The designated superelevation of a curve is determined by averaging the elevation at 11 stations, 15' 6" apart, along the curve. If a point of superelevation variation exists, the 11 stations will be centered on that point.

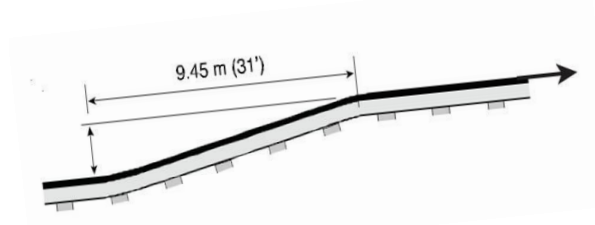
SURFACE

30. Surface is the maximum positive (upward) or negative (downward) measurement, in inches, at the mid-ordinate of a 62 foot chord from the top of the rail surface to the reference line.
- a. Center the 62 foot chord over the point of visible peak or sag and measure the maximum value.



RUNOFF

31. When surfacing track, the run off at the end of a track raise or when surfacing into any fixed object, road crossing, or off the end of a turnout, cannot exceed the URGENT limits for the Class of track.
32. Runoff is measured as the vertical difference of the rail over 31 feet.



33. **TABLES 1 and 2** are to be used to determine the maximum allowable geometry deviation for **PRIORITY** and **URGENT** thresholds for a given Class of track.

TABLE 1 **PRIORITY DEFECTS FOR CANADIAN & U.S. LINES**

CONDITION	DESCRIPTION	CLASS OF TRACK				
		1	2	3	4	5*
Wide Gauge	The distance between the gauge points of the rails 5/8" below the top of the rail may not be more than:	57 5/8"	57 1/4"	57 1/4"	57 1/4"	57 1/4"
Alignment Tangent 62' Chord	The deviation of the mid-offset from a 62' line may not be more than:	3 3/4"	2 1/4"	1 3/8"	1 1/8"	3/8"
Alignment Curved 62' Chord	The deviation of the mid-ordinate from a 62' chord may not be more than:	3 3/4"	2 1/4"	1 3/8"	1 1/8"	1/2"
Alignment Curved 31' Chord	The deviation of the mid-ordinate from a 31' chord may not be more than:	N/A	N/A	7/8"	3/4"	3/8"
Surface	The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than:	2"	1 1/2"	1 1/4"	1"	3/4"
Warp 31 U.S. Only	The difference in crosslevel between any two points 31' apart in spirals may not be more than:	1 7/8"	1 5/8"	1 1/8"	15/16"	5/8"
Warp 31 Canada Only	The difference in crosslevel between any two points less than 31' apart in spirals may not be more than:	1 7/8"	1 5/8"	1 1/8"	15/16"	5/8"
Warp 62 Tangents, Spirals or Curves	The difference in crosslevel between any two points less than 62' apart on tangent, spiral or curves may not be more than:	2 1/4"	1 3/4"	1 1/2"	1 3/8"	1 1/8"
Crosslevel from Design on Tangents, Spirals or Curves	Deviation from zero crosslevel at any point on tangent track, or reverse crosslevel elevation on non-tangent track may not be more than:	1"	1"	1"	1"	11/16"

TABLE 2 URGENT DEFECTS FOR CANADIAN AND U.S. LINES

CONDITION	DESCRIPTION	CLASS OF TRACK				
		1	2	3	4	5*
Wide Gauge	The distance between the gauge points of the rails 5/8" below the top of the rail may not be more than:	58"	57 3/4"	57 3/4"	57 1/2"	57 1/2"
Alignment Tangent 62' Chord	The deviation of the mid-offset from a 62' line may not be more than:	5"	3"	1.3/4"	1 1/2"	3/4"
Alignment Curved 62' Chord	The deviation of the mid-ordinate from a 62' chord may not be more than:	5"	3"	1.3/4"	1 1/2"	5/8"
Alignment Curved 31' Chord	The deviation of the mid-ordinate from a 31' chord may not be more than:	N/A	N/A	1 1/4"	1"	1/2"
Surface	The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than:	3"	2 3/4"	2 1/4"	2"	1 1/4"
Runoff at End of a Raise	The runoff in any 31' at the end of a raise may not be more than:	3 1/2"	3"	2"	1 1/2"	1"
Warp 31 U.S. Only	The difference in crosslevel between any two points 31' apart in spirals may not be more than:	2"	1 3/4"	1 1/4"	1"	3/4"
Warp 31 Canada Only	The difference in crosslevel between any two points less than 31' apart in spirals may not be more than:	2"	1 3/4"	1 1/4"	1"	3/4"
Warp 62 Tangents, Spirals or Curves	The difference in crosslevel between any two points less than 62' apart on tangent, spiral or curves may not be more than:	3"	2 1/4"	2"	1 3/4"	1 1/2"
Crosslevel Tangents, Spirals or Curves	Deviation from zero crosslevel at any point on tangent track, or reverse crosslevel elevation on non-tangent track may not be more than:	3"	2"	1 3/4"	1 1/4"	1"

Note*: In Canada Only, Includes 95 MPH for passenger trains and 100 MPH for LRC trains.

34. **TABLES 3 & 4 are for use IN CANADA only** for where speed related track geometry defects are detected during track geometry (T.E.S.T.) car inspections. The tables may be used to determine the maximum TSO speed to be applied for the seventy two (72) hour period.

TABLE 3 FREIGHT SPEED - ALLOWABLE TEMPORARY SPEED RESTRICTION FOR TEST CAR DEFECTS (Canada)

Freight Speed	Wide Gauge	ALIGNMENT			Surface	WARP		CROSSLEVEL		Runoff
		Tangent 62'	Curve 62'	Curve 31'		31' Spiral	62' Tangents Curves & Spirals	Tangent and Curves	Spiral	
10	58	5	5	N/A	3	2	3	3	1 3/4	3 1/2
15	57 7/8	4 1/4	4 1/4	N/A	2 7/8	1 7/8	2 5/8	2 5/8	1 5/8	3 5/16
20	57 13/16	3 5/8	3 5/8	N/A	2 13/16	1 13/16	2 5/16	2 5/16	1 9/16	3 1/8
25	57 3/4	3	3	N/A	2 3/4	1 3/4	2	2	1 1/2	3
30	57 3/4	2 1/2	2 1/2	1 1/4	2 9/16	1 9/16	1 7/8	1 7/8	1 3/8	2 5/8
35	57 3/4	2 1/8	2 1/8	1 1/4	2 3/8	1 3/8	1 13/16	1 13/16	1 5/16	2 5/16
40	57 3/4	1 3/4	1 3/4	1 1/4	2 1/4	1 1/4	1 3/4	1 3/4	1 1/4	2
45	57 11/16	1 11/16	1 11/16	1 3/16	2 3/16	1 3/16	1 5/8	1 5/8	1 3/16	1 7/8
50	57 5/8	1 5/8	1 5/8	1 1/8	2 1/8	1 1/8	1 1/2	1 1/2	1 1/8	1 3/4
55	57 9/16	1 9/16	1 9/16	1 1/16	2 1/16	1 1/16	1 3/8	1 3/8	1 1/16	1 5/8
60	57 1/2	1 1/2	1 1/2	1	2	1	1 1/4	1 1/4	1	1 1/2

TABLE 4 PASSENGER SPEED - ALLOWABLE TEMPORARY SPEED RESTRICTION FOR TEST CAR DEFECTS (Canada)

Passenger Speed	Wide Gauge	ALIGNMENT			Surface	WARP		CROSSLEVEL		Runoff
		Tangent 62'	Curve 62'	Curve 31'		31' Spiral	62' Tangents Curves & Spirals	Tangent and Curves	Spiral	
15	58	5	5	N/A	3	2	3	3	1 3/4	3 1/2
20	57 7/8	4 1/4	4 1/4	N/A	2 7/8	1 7/8	2 5/8	2 5/8	1 5/8	3 5/16
25	57 13/16	3 5/8	3 5/8	N/A	2 13/16	1 13/16	2 5/16	2 5/16	1 9/16	3 1/8
30	57 3/4	3	3	N/A	2 3/4	1 3/4	2	2	1 1/2	3
45	57 3/4	2 3/8	2 3/8	1 1/4	2 1/2	1 1/2	1 7/8	1 7/8	1 3/8	2 1/2
50	57 3/4	2 1/8	2 1/8	1 1/4	2 3/8	1 3/8	1 13/16	1 13/16	1 5/16	2 5/16
55	57 3/4	1 15/16	1 15/16	1 1/4	2 5/16	1 5/16	1 3/4	1 3/4	1 1/4	2 1/8
60	57 3/4	1 3/4	1 3/4	1 1/4	2 1/4	1 1/4	1 3/4	2	1 1/4	2
65	57 11/16	1 11/16	1 11/16	1 3/16	2 3/16	1 3/16	1 5/8	1 5/8	1 3/8	1 7/8
70	57 5/8	1 5/8	1 5/8	1 1/8	2 1/8	1 1/8	1 1/2	1 1/2	1 1/8	1 3/4
75	57 9/16	1 9/16	1 9/16	1 1/16	2 1/16	1 1/16	1 3/8	1 3/8	1 1/16	1 5/8
80	57 1/2	1 1/2	1 1/2	1	2	1	1 1/4	1 1/4	1	1 1/2
85	57 1/2	1 1/4	1 3/16	13/16	1 3/4	7/8	1 1/8	1 1/8	7/8	1 5/16
90	57 1/2	1	7/8	5/8	1 1/2	13/16	1 1/16	1 1/16	13/16	1 1/8
95	57 1/2	3/4	5/8	1/2	1 1/4	3/4	1	1	3/4	1

THIS PAGE BLANK INTENTIONALLY

T.S. 7.2 VEHICLE TRACK INTERACTION (V/TI) AND WHEEL IMPACTS

1. Vehicle Track Interaction (V/TI) is a locomotive based track measurement system that evaluates how the vehicle interacts with the track. The measurements which are reported are:
 - a. Car Body Vertical (CBV)
 - i. Locations are profile spots and the locomotive is going up or down. Exceptions are typically bridge approaches, road crossings and mud spots.
 - b. Car Body Lateral (CBL)
 - i. Locations of where the locomotive rocks from side to side, generally caused by crosslevel or twist.
 - c.. Truck Lateral (TRL)
 - i. Usually is poor alignment spot or a problem with the locomotive truck.
 - d. Axle Vertical (AXV1 and AXV2)
 - i. An axle vertical exception is measured when the wheel hits a spot in the rail such as:
 - a. Rail Diamonds,
 - b. Crushed heads,
 - c. Joints with broken or cracked joint bars,
 - d. Frogs with heel or point conditions,
 - e. Broken rails,
 - f. Contact with the top of joint bars.
 - e. Mid Chord Offset (MCO1 and MCO2)
 - i. MCO conditions are short profile locations such as missing spikes, missing plates, cracked bars, mud spots, crowned welds, bridge transitions, tie clusters or switch support.
2. Two levels of VTI exceptions require action – **CRITICAL** and **HIGH** priority.
 - a. **CRITICAL PRIORITY:**
 - i. A message is sent to the RTC, then;
 - a. The RTC applies a 25 MPH TSO,
 - b. S & C Call Desk is notified,
 - c. Track Supervisor is notified by S & C Call Desk,
 - d. An immediate inspection of the location, and surrounding area, is performed.

- ii. An Exception Report is e-mailed to the Assistance Chief Engineer, Senior Manager – Engineering, Track Supervisor and Assistant Track Supervisor.
- iii. For Exceptions which are investigated and no apparent defect is found:
 - a. Apply a TSO, not to exceed 40 MPH, until the location is viewed by an Assistant Track Supervisor or above.
 - b. If again nothing is found, instruct the person that initially investigated the exception to close out the condition and remove the TSO.
 - c. The Track Supervisor must then inform the Senior Manager-Engineering of the close out.

b. HIGH PRIORITY

- i. The Exception is emailed directly to the Assistant Chief Engineer, Senior Manager- Engineering, Track Supervisor and Assistant Track Supervisor.
- ii. The Exception report is sent to the S&C Call Desk:
 - a. Between 07:00 and 23:00, the S&C Call Desk notifies the Track Supervisor.
- iii. Inspect within 24 hours.

TABLE 1 VEHICLE TRACK INTERACTION (V/TI) THRESHOLDS

Exception Type	Exception Code	CRITICAL PRIORITY	HIGH PRIORITY
Car Body Vertical	CBV	> 1.8 G	1.3 - 1.8 G
Car Body Lateral	CBL	> 1.2 G	0.8 - 1.2 G
Truck Lateral	TRL	N/A	≥ 0.45 G
Axle Vertical	AVV1 & AXV2	> 180 kips	140 - 180 kips
Mid Chord Offset	MCO1 & MCO2	N/A	≥ 3 inches

WHEEL IMPACTS

- 3. High wheel impact readings, identified at Wheel Impact Detector (Wild) sites, may require track and/or RFD inspections based on severity.
 - a. If a high impact wheel causes multiple broken rails, or if a broken wheel is identified:
 - i. Operating speed will be limited to Class 3 until visually inspected.
 - a. If the Block does not clear behind the train, only one other train is allowed to operate through the Block.
 - ii. An immediate inspection for rail damage will be initiated.
 - iii. The Regional Chief Engineer or designate will contact the Manager of Rail Flaw Detection to determine if RFD inspection is required.

- b. Inspections for rail damage will cover from the location the movement stopped or the train speed was reduced, back, in the direction of the train movement, to where rail damage or marks end.
 - i. Damage or breaks are usually confined to the same rail.
 - ii. Welds, especially field welds, are susceptible to failure from high wheel impacts and should be examined during inspection.
- c. Speed Corrected impacts greater than 200 kips:
 - i. The WILD site will notify the S&C Call Desk.
 - ii. The S&C Call Desk will notify the Track Supervisor.
 - iii. The Track Supervisor will initiate an immediate inspection.
- d. For a speed corrected impact greater than 169 kips, an email alert will be sent to the Assistant Chief Engineer, Senior Manager Engineering and Track Supervisor for the territory.
 - i. Use the Wheel Impact Threshold Action Requirements, Table 2 to determine the actions required based on impact load and temperature.

TABLE 2 WHEEL IMPACT THRESHOLD ACTION REQUIREMENTS

TEMPERATURE	SPEED CORRECTED IMPACT THRESHOLD	ACTION
> 0° C (32° F)	> 169 kips	• Inspect either within normal inspection frequency or 72 hours, whichever is less.
0° C (32° F) to -25° C (-13° F)	> 169 kips	• Inspect either within normal inspection frequency or 48 hours, whichever is less
< -25° C (-13° F)	> 169 kips	• Inspect within 24 hours •• In dark territory, initiate an inspection upon notification.

THIS PAGE BLANK INTENTIONALLY

T.S. 8.0 TRACK CONSTRUCTION GUIDELINES:

1. All requests for the following designs will to be made through the CN Design and Construction group and in compliance with the CN Engineering Specification for Industrial Tracks (ESIT):
 - a. New customer spurs.
 - b. Existing track relocations or extensions.
 - c. Turnout and railroad crossings at grade replacements.
2. Track subgrade and track will be designed and constructed in accordance with drawing TS 2204 and 2205.
3. New designs will limit the maximum curvature to 9 degrees unless specifically authorized by the Regional Chief Engineer. Track designs with curvature in excess of 9 degrees shall have additional requirements that may include, but are not limited to, CWR, premium plates and fasteners, and lubricators, or additional requirements as stipulated in the approval process.
4. Only approved CN track material will be used for construction on CN property.
5. Treated hardwood ties are to be installed unless specifically authorized by the Regional Chief Engineer.
6. Ballast will be from an approved CN source. Estimated quantities for various work is shown in **TABLE 1** based on 12 inches of ballast under the tie.

TABLE 1 ESTIMATED BALLAST QUANTITIES

Main Track and Siding New Construction Cars Required Per Mile		Track Panel Installation Carloads Required	Turnout Installation Requirements Carloads per Turnout			
Concrete	Wood	Per 3 Panels	No. 10	No. 12	No. 15	No. 20
82	80	1	2	2	3	4

7. The minimum weight and grade of rail to be use will be as outlined in T.S. 1.0 – RAIL.
8. Material quantities and requirements for track construction projects are shown in the **TABLE 2**.
9. Local Engineering supervisors will be required to inspect any track being place in service, including industrial track construction which was submitted to CN Design & Construction, prior to approving for CN train operation over that track.
10. Derails must be installed, where required, in accordance to T.S. 3.2 – DERAILS.

TABLE 2		TRACK MATERIAL		
MATERIAL	REFERENCE	CLASS 4 and ABOVE	CLASSES 2 & 3	CLASS 1
Rail	T.S. 1.0	CWR	CWR	CWR or Jointed
Rail Weight (Minimum)	T.S. 1.0	136#	136# Preferred /115#	100RA CA / 115 U.S.
Tie Plates	T.S. 3.0	100 Percent of Ties Plated for All Classes		
Tie Plate Size	T.S. 3.0	16" or 14"	12" or Larger	11" or Larger
Fasteners	T.S. 3.3	Elastic Fasteners, Screwspikes or cut spikes		
Fasteners	T.S. 3.3	Apply Pattern of T.S. 3.3		
Anchors	T.S. 3.1	Apply Pattern of T.S. 3.1		
Tie Spacing - Concrete	T.S. 2.1	24 inch Spacing on All Classes of Track (2,640 / mile)		
Tie Spacing - Wood No. 1 HW	T.S. 2.0	20 3/8" (3,110 /mi)	20 3/8" (3,110 /mi)	21 3/4" (2,980 / mi)
Tie Spacing - Wood No. 2 HW	T.S. 2.0	N/A	N/A	21 3/4" (2,980 / mi)
Switch Ties	T.S. 5.0	Only Treated 7" x 9" Hardwood Ties Are To Be Used		
Sub-ballast Depth	ESIT	12" For All Classes		
Minimum Sub-ballast Width	ESIT	22 feet for All Classes		
Ballast (Crushed Rock)	T.S. 4.0	2 1/2" minus	2 1/2" minus	2" minus / AREMA No. 5
Ballast - Walking	T.S. 4.0	N/A	N/A	AREMA No. 5
Ballast Shoulder Width - CWR	T.S. 4.0	12 " For All Classes of Track		
Ballast Shoulder Width - Jtd	T.S. 4.0	12"	6"	6"
Ballast Depth Under Tie	TS 2204	12"	12"	10" - 12"

T.S. 8.1 TRACK CLEARANCES

1. The clearance requirements of this section apply:
 - a. To all tracks over which the Railway operates, regardless of location or ownership.
 - b. For clearances, both permanent and temporary.
 - c. To include, but not be limited to, vertical and horizontal clearances of overhead structures, side structures, bridges, tunnels, platforms, signals. See B&S drawings K1U 10.1 through 10.4 and Track Standard Plan 3003 for details.
 - d. To overheads wires, which will have a minimum clearance of 27 feet (8.23 m) above top of rail and will increase based on line voltage. Contact CN Design and Construction for details.
2. New tracks shall be designed and constructed with the minimum distance between track centerlines as shown in TABLE 1. The minimum distance between track center lines shall be increased to account for curvature and superelevation as shown in **TABLE 1**.

TABLE 1 MINIMUM TRACK CENTERS and TRACK CENTER WIDENING

TRACK TYPE	CANADA	U.S.
Adjacent Main Tracks - Track Centers	14 ft.	15 ft.
Main Track and Sidings - Track Centers	14 ft.	15 ft.
Yard Tracks - Track Centers	14 ft.	14 ft.
Passenger Station Tracks w/o a Platform Between Tracks - Track Centers	14 ft.	15 ft.
		Widen by
Double track curves with track centers less than 18 feet - widen track centers per degree of curve:		2 in.
Double track curves with track centers less than 18 ft- when outer track superelevation exceeds the superelevation of the inside track, widen track centers per inch of elevation difference:		2 1/2 in.

3. Track centers must not be decreased without the approval of the Regional Chief Engineer. When track centers are found to be less than 13 feet, immediately notify the Regional Chief Engineer.
4. Should it not be possible to construct to the clearance dimensions above, or those of plans of Section 1, advise CN Design and Construction who will ensure the proposed encroachment does not impact railway safety and that the appropriate regulatory agency is notified. Once the notification is completed and the Railway receives approval, the Regional Chief Engineer will advise the appropriate departments and post instructions along with:
 - a. In Canada only: Transport Canada approved Clearance warning signs will be erected.
 - b. In the U.S. only: The appropriate State regulatory agency approved Clearance warning signs will be erected.
5. When surfacing track through passenger platforms, tunnels or under overhead structures, ensure the track is not raised or lined beyond the allowable maximum. Contact CN Design and Construction to set grade and line reference if required.

THIS PAGE BLANK INTENTIONALLY

T.S. 9.0 GUARD RAILS AND GUARD TIMBERS

1. On open deck bridges, interior guard rails and exterior guard timbers shall be treated as equivalent and guard timbers may be used in lieu of guard rails.
2. Guard rails or guard timbers must be installed:
 - a. On all bridges:
 - i. With supporting structure extending above the top of the ties, or have the underside supporting structure protruding beyond the deck of the bridge.
 - ii. Crossing major roadways (two lane paved highway or greater), or commercially navigable waterways.
 - iii. Longer than 100 feet or with curves 2° or greater.
 - b. In tunnels, snow and rock sheds with timber lining, exposed arch ribs, or other lining or construction that is vulnerable to damage. Guard rails are not required on unlined tunnels or tunnels with smooth concrete lining.
 - c. At any location designated by the Regional Chief Engineer or Chief Engineer Structures.
3. On bridges with three or more tracks, the center tracks do not require guard rails.
4. An inside guard rail(s) is required where the piers of overhead structures, without crashwalls, are within 17 feet of the centerline of the track and track speed is greater than 10 MPH.
5. Guard rails and guard timbers shall be installed as per TS Plan 1108:
 - a. Guard rails will be spiked with two spikes per rail on every tie. Unless specifically required, tie plates will not be installed under the guard rail.
 - b. The guard rail ball should be even with, to 2 inches lower, than the ball of the running rail.
6. Guard rails should be electrically isolated from the running rail in order to maintain broken rail protection across the structure. Guard rails, joint bars or spikes must not contract the tie plates of the running rail and must be kept free of debris, particularly shavings and filings.
7. In some locations, guard rails are incorporated into the signal system. Employees must take every precaution to avoid shorting track circuits between the guard rail and the running rail when working around these locations.
8. Existing guard rails which are not required based on the above listed criteria may **NOT** be removed without approval of the Regional Chief Engineer.

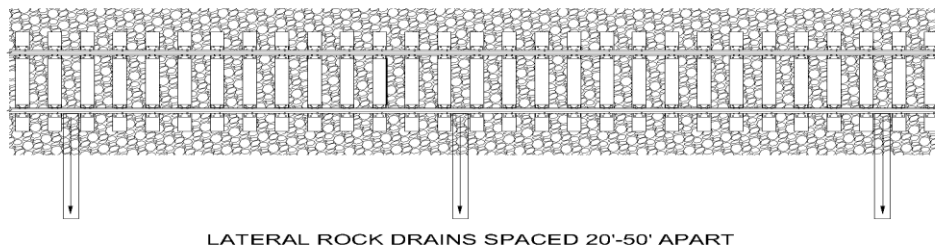
TEMPORARY REMOVAL OF GUARD RAILS

9. Whenever guard rails are temporarily removed to accommodate track or bridge work, a temporary speed restriction of 30 MPH, but not exceeding posted track speed, is required.
10. The Regional Chief Engineer may authorize exceptions to this policy provided each of the following conditions is met:
 - a. The guard rails are removed by a gang to facilitate maintenance work: and
 - b. The gang performing the work does not leave the site unattended for a period greater than 15 days without replacing the guard rails.

THIS PAGE BLANK INTENTIONALLY

T.S. 9.1 ROADBED AND DRAINAGE

1. The roadbed (subgrade) shall be constructed per TS Drawings 2204 and 2205.
2. Roadbed surfaces should slope away from the track to ensure proper drainage.
3. Chronic subgrade soft spots, frost or mud boils and heaves should be improved by:
 - a. Providing ditches which are draining the track structure and flow freely.
 - b. Installing cross (lateral) sub-surface drainage along the track or below the road bed.
 - c. Evaluation by a CN Geotechnical Engineer if required.
4. When installing lateral drains:
 - a. Cut to a depth below the granular layer or water pocket and slope to the toe of subgrade or ditch line.
 - b. Fill the lateral drain with clean coarse ballast wrapped in filter fabric.
 - c. Locate the lateral drains every 20 to 50 feet along the track for the length of the soft track or poorly drained condition.



5. Do not allow rip rap or other fill materials to remain on the top of embankments where it could be hit by on-track equipment or lead to overloading the subgrade.
6. Vegetation along and on the embankment should be maintained so that stability of the track structure is not degraded.
7. Waterways, ditches and drainage must:
 - a. Be maintained to ensure adequate support for safe passage of trains.
 - b. Be regularly inspected to ensure they are operating as designed.
 - c. Be maintained free of vegetation and debris so that drainage is not impeded.
 - d. Not be filled with ballast or with waste from ditching, shoulder cleaning or undercutting.
 - e. Not be altering, adjusted, rerouted or constricted unless approved by a hydrology study and all required regulatory permits have been acquired.
 - f. Be monitored for plugged or frozen conditions which can result high water on one side of the track (differential water level) which can weaken the subgrade and cause rapid failure.
8. Adjacent landowners, buildings and overhead structures are not allowed to drain or modify existing drainage ways to divert water onto Railway property without approval of the CN.

9. Beaver activity can affect drainage causing unstable subgrade, plugged culverts and washouts. Beaver activity outside the right of way may not be visible from the track. Employees must look for rising water along the subgrade, new dams, evidence of tree cuttings and changes of outflow from culverts.
10. Downstream beaver dam failure can result in sudden drawdown of water along the track. This drawdown can result in sudden subgrade failure.
11. Employees should determine the existence of beaver dams or retention ponds located upstream of the track which could pose a significant threat in the event of failure. These can hold large volumes of water which could suddenly discharge toward the track causing washouts.
12. Culverts will be:
 - a. Installed per Recommended Method 9-1-0, with a size determined by hydrologic study.
 - i. If installed by open cutting in CWR the rail must be destressed prior to the rail temperature reaching the PRLT or a 25 MPH TSO must be placed.
 - b. Given a general inspection, along with associated drainage ways, by track inspectors during routine track inspections.
 - c. Inspected annually for general condition, and a detailed inspection and evaluation will be performed on a scheduled basis.

T.S. 10.0 SIGNAL & COMMUNICATIONS SYSTEMS and BURIED UTILITIES:

1. The table below is a guideline of risk of S&C and utility damage associated with various work activities:

WORK ACTIVITY	RISK	WORK ACTIVITY	RISK
Ditching	High	Derailment	High
Undercutting	High	Surfacing and Regulating	Med
Culvert Replacement	High	Mechanized Tie Replacement	Med
Bridge Deck Replacement	High	Rail Relay	Med

LOCATES:

2. All locations of the right of way should be considered as possibly having buried utilities. Inspect the area for witness posts or vent pipes indicating the possible existence of buried utilities.
3. All personnel involved must be vigilant during work on the right of way and near the track for utilities, wires or communication devices that are unmarked.
4. Employees, contractors and equipment operators must take steps to avoid damage to bootlegs, bond wires, S&C wires and other appliances.
 - a. Identify all bond wire connections to rail components prior to lifting the rail out of track.
5. Where communications, signal, power, or fiber lines, or pipelines are known or suspected to exist:
 - a. Stakes, temporary track protection masts or sign posts must not be driven into the ground.
 - b. Use an alternative location or method for erecting such as rail mounted flag staffs.
 - c. In all other locations, avoid driving any stake or temporary sign mast deeper than 12" into the ground unless it is known to be clear.
6. Utility locates must:
 - a. Include both CN and outside party utilities.
 - i. Different departments are responsible for the various Railway utilities across the system.
 - b. Be completed and the area marked before signs posts are driven or excavation begins.
 - c. Be done in a method that will remain visible during the work.
 - d. Be considered as a rough estimate of the location and depth of buried utilities.
7. Cables may run anywhere on the right of way and at varying depths. Be aware that:
 - a. Cables may be shallow in rock cuts and near culverts, underpasses and approaches to bridges.

- b. Cables encased in bridge troughing will be treated in the same manor as buried cables.
 - i. The S&C Supervisor must be notified any time bridge troughing is to be removed.
- c. Cables may be found attached to the sides or bottom of bridges or the sides of tunnel walls.

EXCAVATIONS:

- 8. Prior to starting any excavation on the right of way, even after the location has been staked, **the local S&C Supervisor and utility owner must be given at least 48 hours notification.** Also:
 - a. An S&C employee and/or utility representative may need to be present through the duration of the excavation.
 - b. Under emergency situations, an S&C employee must immediately be notified to be on site.
- 9. Excavating at locations of buried power distribution cables will include:
 - a. De-energizing power distribution lines if required.
 - i. Voltages to 7,200 volts may be encountered.
 - ii. De-energizing will require a power clearance form to be filled out by the department responsible for the line.
 - iii. After confirming the line is de-energized, a briefing will be held before any excavation work begins.
 - iv. Upon completion of excavation, the Department responsible for the line will ensure all employees involved are clear of the area and aware the line will be re-energized.
 - b. Use vacuum excavation near the cables or hand excavation using only tools with wood or similar handles.
 - c. Install temporary supports to ensure exposed cable is never left unsupported for spans greater than 15 feet.
- 10. During the course of work, if abnormal or unusual conditions are found, protect train operations and public road crossings and advise the proper authorities of the condition.
- 11. In the event of an accidental cable strike or other damage of any utility, the Foreman shall report the incident and location as soon as it is known to have occurred.

WORK WITHIN CROSSING CIRCUITS:

- 12. When any work that is planned at a crossing or within the approach circuit to a crossing:
 - a. **The S&C Supervisor requires 48 hour advance notice.**
 - b. If excavation is to occur a utility locate must be requested.
 - c. Care must be taken to ensure the integrity of the crossing is not compromised.

- d. Crossing warning device interference or nuisance ringing must be avoided.
 - i. Crossing warning device interference requires flagging to protect the crossing.
- 13. When track work which involves cutting or removing rail within an approach circuit of a road crossing with a crossing warning device and may cause interference of the normal operation of the protection:
 - a. The S&C Maintainer must be notified before the application of rail bypass cables or temporary bond wires.
 - b. Obtain positive protection prior to applying rail bonds or bypass cable and making track impassable
 - c. Temporary rail bypass cables may be applied around a removed rail. The maximum cable length is 100 feet.
 - d. Temporary rail bond may be applied around any **non-insulated** joint.
 - i. The maximum bond length is 60 inches.
 - ii. The S&C Call Desk must be notified of the installation.
 - iii. The temporary bond wire must be removed and/or replaced with permanent bonds within 72 hours by a qualified S&C employee.
 - e. The use of rail bypass cables and temporary bond wires must not be:
 - i. Installed around insulated joints.
 - ii. Installed within interlocking limits (between opposing signals governing movement across a diamond or over turnouts).
 - iii. Installed across the track from one rail to the other.
 - iv. Installed for the purpose of circumventing normal signal operation.
 - f. In the event the crossing activates with the rail bypass cables applied, perform the following:
 - i. Check both ends of cable for tightness and wait 20 seconds to see if the crossing recovers.
 - ii. If the crossing does not recover, remove and reapply each end of the cables, each time wait 20 seconds.
 - iii. If the crossing does not recover, contact the S&C Maintainer and arrange for manual protection of the crossing until the issue is rectified.
 - g. Once the work is complete, proceed in the following sequence to remove:
 - i. Remove cable and safely store.
 - ii. Cancel the positive protection.
 - iii. Advise the S&C Maintainer that the bypass cables have been removed.

THIS PAGE BLANK INTENTIONALLY

T.S. 11.0 FIRE PREVENTION

1. Prevention of fires on to property and structures must be considered at the beginning of each task when working on the right of way.
2. Fire risk is highest during spring when dry grasses are prevalent. Fire risk can also rise in the summer during extreme hot and dry periods, and anytime work is performed near wooden structures. Local, State or Provincial agency warnings or advisories should be noted when working in these types of conditions. Use the higher of the agency or CN activity rating.
3. HOT WORK is any activity which involves cutting, grinding, welding or open flames.
4. The RIGHT OF WAY AND BRIDGE FIRE RISK ASSESSMENT, MITIGATION AND EMERGENCY RESPONSE form must be completed prior to performing any hot work when fire risk exists.
5. FIRE WATCH is a person assigned to observe a location during and after hot work. The fire watch will:
 - a. Have communications and contact information adequate to request assistance or contact the RTC.
 - b. Be equipped with sufficient firefighting equipment to suppress flare-ups.
 - i. The firefighting equipment will be a minimum of a filled 5 gallon back pack sprayer, and
 - ii. One round nose shovel and adze.
 - c. Be stationed in a safe position to fight fires as work is being performed.
 - d. Remain at the location for a minimum of two hours after the work is completed.
6. Fire prevention, fire awareness training and firefighting preparedness are mandated in Canada by Transport Canada's "Rules for the Control and Prevention of Fires on Railway Rights-of-Way". These rules outline:
 - a. The right's of a fire service inspector to request inspection of the right-of-way to assess fire risk and training.
 - b. The requirements of the Railway to train, staff and provide equipment to prevent or fight fires.
 - c. To provide training records which will include:
 - i. Location and duration of training.
 - ii. Names and titles of trainer(s) and participants.
 - iii. Subject matter of the training course.
 - d. The responsibility of the Railway for fires along, or originating from the right-of-way.
 - e. Limitations on days or time of day that hot work can be performed.
7. These items are also addressed locally by respective Provincial natural resources management governments and some State's Department of Natural Resources (or equivalent). These agencies have standards and guidelines pertaining to fire risk index, fuel values (combustible materials present), required firefighting equipment, fire

prevention and fire fighting training, and minimum fire watch inspection times. Consult these requirements when planning to perform work.

- a. Be aware that environmental management agencies can restrict work activities based on “High” or “Extreme” fire risk rating.
8. Local Supervisors will:
- a. Ensure crews know the agency fire risk rating and work restrictions.
 - b. Ensure crews have firefighting equipment inventory that is required.
 - c. Maintain supplementary firefighting assets where required
 - d. Have an updated fire fighting action plan where required.
 - e. Have a fire plan for critical or strategic structures.
 - f. Arrange for track patrols during periods of extreme fire danger.
 - i. Be aware of on going fires.
 - ii. Be aware of wind speed and direction when active fires are present.
 - iii. Provide constant monitoring of bridges if situations require.
9. Risk factors which need to be considered prior to performing hot work along the right-of-way include:
- a. Dry or dead vegetation.
 - b. Ties or timbers stacked and/or distributed along the right-of-way.
 - c. Weather, such as recent precipitation or lack thereof, wind speed and direction, temperature, humidity and forecasts.
 - d. Structural materials such as timber caps, stringers, piling or posts and ties. When these components are cracked, rotting or decayed the possibility of igniting increases.
 - e. Clothing – greasy or oily clothes can be ignited during cutting or grinding activities.
 - f. Smoking – smoking materials must be rubbed out and buried or disposed of properly.
 - g. Equipment – Steel tracked equipment or cutting heads have the potential to throw sparks into combustible materials.
 - h. Fueling – ensure gas powered machines are fueled on a noncombustible surface, and after the machine has cooled to minimize the possibility of igniting in the event of a fuel spill.
 - i. Vehicles must not be parked in locations where hot exhaust systems could ignite dry vegetation.
10. Work activities addressed in these instructions include, but are not limited to:
- a. Routine work – defined as work performed on the right-of-way such as cutting rail, any welding, hand grinding, applying signal bond wires, etc.
 - b. Work on structures, in timber lined tunnels or snow sheds:
 - i. Rail related work (cutting, welding, hand grinding, applying signal bond wires, etc.).

- ii. Dragging rail along the right-of-way and over bridges.
 - iii. Bridge work involving cutting with saw or torch, welding or grinding.
 - iv. Rail grinding with self propelled machines.
- 11. The minimum briefing for any Hot Work fire must include:
 - a. Completing the RIGHT OF WAY AND BRIDGE FIRE RISK ASSESSMENT, MITIGATION AND EMERGENCY RESPONSE form.
 - b. The nearest fire department or fire service.
 - c. The contact number for fire / emergency services
 - d. Access to the location and directions to the site.
 - e. Any warnings, advisories or work restrictions issued by any agencies concerning fire risk status.
 - f. Fire fighting equipment on hand and ensuring operability of such equipment.
 - i. A minimum of two 5 gallon backpack sprayers with foaming nozzles.
 - ii. A minimum of two round nose shovels.
 - iii. A minimum of two adzes.
 - iv. Fire equipment to be staged no more than 50 feet from the work location.
- 12. For routine work during High or Extreme fire conditions, additional fire protection will include:
 - a. Increasing the quantity of water carried onboard trucks to at least 90 gallons which includes at least 4 filled 5 gallon backpack sprayers with foaming nozzles.
 - b. Foam fire suppressant added to the water supply.
 - c. Centrifugal pumps with at least 100 feet of 1 ½" diameter hose.
 - d. Wetting of the area where sparks may be generated and in the direction of the wind.
 - e. Use of spark screens for all cutting, welding and grinding.
 - f. Wetting of area after work is complete.
 - g. Posting a fire watch for at least two hours after work is completed.
- 13. Any hot work on a structure or in a timber lined structure will include:
 - a. A briefing with the B & S Supervisor and the Track Supervisor detailing the work to be performed.
 - b. A site inspection to identify all hazards, in particular fire hazards including the structure itself.
 - i. Remove piled timbers, dry grasses or brush if necessary.
 - c. Wetting of the immediate area and materials in the direction the wind is blowing prior to commencing hot work:

- i. Foam fire suppressant additive must be mixed with water.
 - i. Protect foam from entering the waterway.
 - ii. Foam will make ties slippery and extreme caution needs to be exercised.
 - d. Fire proof mats or packing sand will be placed to protect timber.
 - e. Spark shields will be used on timber structures in all conditions.
 - i. When possible, direct rail cutting sparks toward the center line of the track.
 - f. Cutting of structural components or rail will be made:
 - i. With a Saws-all or shear for sway brace and hook bolts, drift pins, etc.
 - ii. Using abrasive saws for cutting rail.
 - iii. Using a torch as the last option and only after discussing with the B & S Supervisor and Track Supervisor.
 - iv. Using chain saws to cut wood components.
 - g. Wet the entire area as often as required both during the work and after the work is completed.
 - h. A fire watch will remain with the bridge for a minimum of 2 hours.
14. Long term bridge construction or repair projects, which involve pile driving, significant torch cutting or other fire risk, will have a fire fighting and prevention plan which includes pumps and hoses utilizing either river water or a minimum 300 gallon portable water tank.
15. Rail on a bridge requiring flash butt welding, thermite welding or rail end build-up shall be welded off the bridge, when possible, and then installed on the bridge after all work on the weld is finished. However, if there is no alternative but to perform the welding on a bridge, follow the precautions below:
- a. The briefing will include all items listed in the above sections.
 - b. Bridge ties must be spread at the joint to be welded.
 - c. For thermite welds, a ¼" thick steel sandbox, partially filled with dry sand, will be placed between the ties in case of thermite weld run through.
 - d. If required, position an employee in a safe location under the structure to watch for and fight fires.
 - e. Fire watch will be posted for at least two hours after final work is completed.
16. Dragging rail on track causes heat build up on the rail being dragged and generates sparks which can ignite combustible materials. Track behind any rail dragging operation must be inspected for damage to rail fastenings and for fires or smoldering ties.
17. When dragging rail over an open deck bridge and temperatures are above 20°F (-10°C):
- a. The briefing will include all items listed in the above sections.
 - b. Rail will not be dragged faster than 3 MPH across the bridge.
 - c. Care must be taken to avoid "steel on steel" contact of rail on open deck bridges.

- d. At least one fire watches will remain at each structure for at least 2 hours after the move is completed,
- 18. Rail grinding with self propelled machines fire prevention requirements is covered in E.T.S. 1.4 GRINDING WITH SELF PROPELLED MACHINES.
- 19. In the event of a fire or flare up on or near any part of the structure, a fire watch will remain in place for a minimum of 4 hours after the fire has been extinguished and relieved of duty on after approval of the B&S Supervisor.

RIGHT OF WAY and BRIDGE FIRE RISK ASSESSMENT, MITIGATION and EMERGENCY RESPONSE PLAN

COMPLETE FORM WHEN PERFORMING HOT WORK AND A FIRE RISK EXISTS

WORK ACTIVITY _____

SUBDIVISION _____ MILE POST _____ TRACK _____ ACCESS DIRECTIONS _____

NEAREST FIRE /EMERGENCY SERVICE _____ CONTACT NUMBER _____

FIRE HAZARD RATING (circle one): LOW MEDIUM HIGH EXTREME WILL WORK PRODUCE FIRE RISK? (Circle one) : YES NO

ARE WORK ACTIVITY RESTRICTIONS IN EFFECT BY GOVERNING AGENCIES? **YES NO** IF YES, CONTACT SUPERVISOR CONCERNING RESTRICTIONS, **UP TO AND INCLUDING SHUTDOWN**

FOREMAN _____ PEER TO PEER _____ DATE _____

NO TORCH CUTTING ON A BRIDGE OR IN A TIMBER STRUCTURE WILL BE ALLOWED UNTIL AFTER BRIEFING WITH B&S SUPERVISOR AND TRACK SUPERVISOR.

WORK DESCRIPTION	FIRE HAZARD RATING			
	LOW	MEDIUM	HIGH	EXTREME
			ALL WORK ON BRIDGES WITH TIMBER PILING, CAPS, STRINGERS OR TIMBER TIES ON STEEL, IS CONSIDERED "HIGH" AND "EXTREME" RISK CATEGORY	
ROUTINE TRACK WORK ALONG RIGHT-OF WAY WITH NO CUTTING OR GRINDING (T.S.11.11)	2 ROUND NOSE SHOVELS 2 ADZE 2 BACK PACK SPRAYERS	2 ROUND NOSE SHOVELS 2 ADZE 2 BACK PACK SPRAYERS	2 ROUND NOSE SHOVELS 2 ADZE 2 BACKPACK SPRAYERS	2 ROUND NOSE SHOVELS 2 ADZE 2 BACKPACK SPRAYERS
ROUTINE TRACK WORK ALONG RIGHT OF WAY INVOLVING CUTTING, ANY WELDING AND OR GRINDING (T.S. 11.12)	2 ROUND NOSE SHOVELS 2 ADZE 2 BACK PACK SPRAYERS	2 ROUND NOSE SHOVELS 2 ADZE 2 BACK PACK SPRAYERS	2 ROUND NOSE SHOVELS 2 ADZE 4 BACKPACK SPRAYERS 90 GAL. TOTAL WATER PUMP AND 100' OF HOSE SPARK SCREEN / MATS	2 ROUND NOSE SHOVELS 2 ADZE 4 BACKPACK SPRAYERS 90 GAL. TOTAL WATER PUMP AND 100' OF HOSE SPARK SCREEN / MATS
TRACK WORK ON A BRIDGE, IN A TIMBER LINED TUNNEL OR SNOW SHED. WORK INVOLVES CUTTING, ANY WELDING OR GRINDING. (T.S. 11.13 & 15)	USE HIGH OR EXTREME	USE HIGH OR EXTREME	2 ROUND NOSE SHOVELS 2 ADZE 4 BACKPACK SPRAYERS 90 GAL TOTAL WATER PUMP AND 100' OF HOSE SPARK SCREEN / MATS FIRE WATCH- 2 HR MIN	2 ROUND NOSE SHOVELS 2 ADZE 4 BACKPACK SPRAYERS 90 GAL TOTAL WATER PUMP AND 100' OF HOSE SPARK SCREEN /MATS FIRE WATCH- 2 HR MIN
DRAGGING RAIL (T.S. 11.16 & 17)	2 ROUND NOSE SHOVELS 2 ADZE	2 ROUND NOSE SHOVELS 2 ADZE 2 BACK PACK SPRAYERS BRIDGE FIRE WATCH 2 HR MIN	2 ROUND NOSE SHOVELS 2 ADZE 4 BACKPACK SPRAYERS BRIDGE FIRE WATCH 2 HR MIN	2 ROUND NOSE SHOVELS 2 ADZE 4 BACKPACK SPRAYERS BRIDGE FIRE WATCH 2 HR MIN
BRIDGE WORK INVOLVING ANY CUTTING, GRINDING, WELDING (T.S. 11.11 & 13)	USE HIGH OR EXTREME	USE HIGH OR EXTREME	2 ROUND NOSE SHOVELS 4 BACKPACK SPRAYERS 2 ADZE 90 GAL TOTAL WATER SPARK SCREEN /MATS FIRE WATCH 2 HR MIN	2 ROUND NOSE SHOVELS 4 BACKPACK SPRAYERS 2 ADZE 90 GAL TOTAL WATER SPARK SCREEN / MATS FIRE WATCH 2 HR MIN

APPENDIX I

SUPERELEVATION

SUPERELVATION - BALANCED CONDITION																		
Degree of Curve	SPEED (MPH)																	
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
0°-15"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	1	1	1 1/4	1 1/4	1 1/2	1 1/2
0°-30"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/4	3	3 1/4
0°-45"	1/2	1/2	1/2	1/2	1/2	3/4	1	1	1 1/4	1 1/2	2	2 1/4	2 1/2	3	3 1/4	3 3/4	4 1/4	4 3/4
1°	1/2	1/2	1/2	1/2	3/4	1	1	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4	4 1/2	5		
1°-15"	1/2	1/2	1/2	1/2	3/4	1	1 1/2	1 3/4	2 1/4	2 3/4	3 1/4	3 3/4	4 1/4	5				
1°-30"	1/2	1/2	1/2	3/4	1	1 1/2	1 3/4	2 1/4	2 3/4	3 1/4	3 3/4	4 1/2	5					
2°	1/2	1/2	1/2	1	1 1/4	1 3/4	2 1/4	2 3/4	3 1/2	4 1/4	5							
2°-30"	1/2	1/2	3/4	1	1 1/2	2 1/4	2 3/4	3 1/2	4 1/4									
3°	1/2	1/2	1	1 1/4	2	2 1/2	3 1/4	4 1/4										
3°-30"	1/2	1/2	1	1 1/2	2 1/4	3	4	5										
4°	1/2	3/4	1 1/4	1 3/4	2 1/2	3 1/2	4 1/2											
4°-30"	1/2	3/4	1 1/4	2	3	3 3/4	5											
5°	1/2	3/4	1 1/2	2 1/4	3 1/4	4 1/4												
5°-30"	1/2	1	1 1/2	2 1/2	3 1/2	4 3/4												
6°	1/2	1	1 3/4	2 3/4	3 3/4													
6°-30"	1/2	1	2	3	4													
7°	1/2	1 1/4	2	3	4 1/4													
7°-30"	1/2	1 1/4	2 1/4	3 1/4	4 3/4													
8°	3/4	1 1/4	2 1/4	3 1/2	5													
8°-30"	3/4	1 1/2	2 1/2	3 3/4														
9°	3/4	1 1/2	2 1/2	4														
9°-30"	3/4	1 1/2	2 3/4	4 1/4														
10°	3/4	1 1/2	2 3/4	4 1/4														
10°-30"	3/4	1 3/4	3	4 1/2														
11°	3/4	1 3/4	3	4 3/4														
11°-30"	1	2	3 1/4	5														
12°	1	2	3 1/2															

$$E = S^2 \cdot D \cdot 0.0007$$

S = Speed (MPH)
D = Degree of Curve

SUPERELVATION - 2 INCH IMBALANCED CONDITION																		
Degree of Curve	SPEED (MPH)																	
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
0°-15"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
0°-30"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1 1/8	1 1/2
0°-45"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	5/8	1	1 3/8	1 3/4	2 3/4	3 1/4
1°	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1	1 3/8	2	2 1/2	3	4 3/8	
1°-30"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	5/8	1 1/8	1 3/4	2 3/8	3 1/8	3 7/8	4 3/4			
2°	1/2	1/2	1/2	1/2	1/2	1/2	1/2	7/8	1 1/2	2 1/4	3	3 7/8	4 7/8					
2°-30"	1/2	1/2	1/2	1/2	1/2	1/2	3/4	1 1/2	2 3/8	3 1/4	4 1/4							
3°	1/2	1/2	1/2	1/2	1/2	5/8	1 3/8	2 1/4	3 1/4	4 3/8								
3°-30"	1/2	1/2	1/2	1/2	1/2	1	1 7/8	3	4 1/8									
4°	1/2	1/2	1/2	1/2	1/2	1 3/8	2 1/2	3 5/8										
4°-30"	1/2	1/2	1/2	1/2	7/8	1 7/8	3	4 3/8										
5°	1/2	1/2	1/2	1/2	1 1/8	2 1/4	3 5/8											
5°-30"	1/2	1/2	1/2	1/2	1 1/2	2 3/4	4 1/8											
6°	1/2	1/2	1/2	5/8	1 3/4	3 1/8	4 3/4											
6°-30"	1/2	1/2	1/2	7/8	2 1/8	3 3/8												
7°	1/2	1/2	1/2	1 1/8	2 3/8	4												
7°-30"	1/2	1/2	1/2	1 1/4	2 3/4	4 3/8												
8°	1/2	1/2	1/2	1 1/2	3	4 7/8												
8°-30"	1/2	1/2	1/2	1 3/4	3 3/8													
9°	1/2	1/2	1/2	2	3 5/8													
9°-30"	1/2	1/2	5/8	2 1/8	4													
10°	1/2	1/2	3/4	2 3/8	4 1/4													
10°-30"	1/2	1/2	1	2 5/8	4 5/8													
11°	1/2	1/2	1 1/8	2 7/8	4 7/8													
11°-30"	1/2	1/2	1 1/4	3														
12°	1/2	1/2	1 3/8	3 1/4														

$$E_2 = E - 2''$$

or

$$E_2 = S^2 \cdot D \cdot 0.0007 - 2''$$

APPENDIX II

MAXIMUM CURVE SPEEDS (V_{max}) FOR 3" AND 4" UNDERBALANCE CONDITIONS

Maximum Allowable Speeds (V_{max}) for 3 Inches Underbalance

Elevation	0"	0.5"	1"	1.5"	2"	2.5"	3"	3.5"	4"	4.5"	5"	5.5"	6"
Degree of Curve	Maximum Allowable Operating Speed (MPH)												
0° 30"	93												
1° 00"	65	71	76	80	85	89							
1° 30"	53	58	62	65	69	72	76	79	82	85	87	90	
2° 00"	46	50	53	57	60	63	65	68	71	73	76	78	80
2° 30"	41	45	48	51	53	56	59	61	63	65	68	70	72
3° 00"	38	41	44	46	49	51	53	56	58	60	62	64	65
3° 30"	35	38	40	43	45	47	49	52	53	55	57	59	61
4° 00"	33	35	38	40	42	44	46	48	50	52	53	55	57
4° 30"	31	33	36	38	40	42	44	45	47	49	50	52	53
5° 00"	29	32	34	36	38	40	41	43	45	46	48	49	51
5° 30"	28	30	32	34	36	38	39	41	43	44	46	47	48
6° 00"	27	29	31	33	35	36	38	39	41	42	44	45	46
6° 30"	26	28	30	31	33	35	36	38	39	41	42	43	44
7° 00"	25	27	29	30	32	34	35	36	38	39	40	42	43
8° 00"	23	25	27	28	30	31	33	34	35	37	38	39	40
9° 00"	22	24	25	27	28	30	31	32	33	35	36	37	38
10° 00"	21	22	24	25	27	28	29	30	32	33	34	35	36
11° 00"	20	21	23	24	25	27	28	29	30	31	32	33	34
12° 00"	19	20	22	23	24	26	27	28	29	30	31	32	33

Maximum Allowable Speeds (V_{max}) – CANADA ONLY for 4 Inches Underbalance – APPLIES TO VIA ROUTES

Elevation	0"	0.5"	1"	1.5"	2"	2.5"	3"	3.5"	4"	4.5"	5"	5.5"	6"
Degree of Curve	Maximum Allowable Operating Speed (MPH)												
0° 30"													
1° 00"	76	80	85	89	92								
1° 30"	62	65	69	72	76	79	82	85	87	90			
2° 00"	53	57	60	63	65	68	71	73	76	78	80	82	85
2° 30"	48	51	53	56	59	61	63	65	68	70	72	74	76
3° 00"	44	46	49	51	53	56	58	60	62	64	65	67	69
3° 30"	40	43	45	47	49	52	53	55	57	59	61	62	64
4° 00"	38	40	42	44	46	48	50	52	53	55	57	58	60
4° 30"	36	38	40	42	44	45	47	49	50	52	53	55	56
5° 00"	34	36	38	40	41	43	45	46	48	49	51	52	53
5° 30"	32	34	36	38	39	41	43	44	46	47	48	50	51
6° 00"	31	33	35	36	38	39	41	42	44	45	46	48	49
6° 30"	30	31	33	35	36	38	39	41	42	43	44	46	47
7° 00"	29	30	32	34	35	36	38	39	40	42	43	44	45
8° 00"	27	28	30	31	33	34	35	37	38	39	40	41	42
9° 00"	25	27	28	30	31	32	33	35	36	37	38	39	40
10° 00"	24	25	27	28	29	30	32	33	34	35	36	37	38
11° 00"	23	24	25	27	28	29	30	31	32	33	34	35	36
12° 00"	22	23	24	26	27	28	29	30	31	32	33	34	35

CONVERSION TABLE

CONVERSION TABLE		
Inches		Millimeters
Fraction	Decimal	mm
1/16	0.0625	1.5
1/8	0.125	3
3/16	0.1875	5
1/4	0.25	6
5/16	0.3125	8
3/8	0.375	10
7/16	0.4375	11
1/2	0.5	13
9/16	0.5625	14
5/8	0.625	15
11/16	0.6875	18
3/4	0.75	20
13/16	0.8125	21
7/8	0.875	23
15/16	0.9375	24
1	1	25
1 1/16	1.0625	27
1 1/8	1.125	29
1 3/16	1.1875	30
1 1/4	1.25	32
1 5/16	1.3125	33
1 3/8	1.375	35
1 7/16	1.4375	37
1 1/2	1.5	38
1 9/16	1.5625	40
1 5/8	1.625	41
1 11/16	1.6875	43
1 3/4	1.75	44
1 13/16	1.8125	46
1 7/8	1.875	48
1 15/16	1.9375	50
2	2	51
3	3	76
6	6	152

TC 4 ATTACHMENT 2: CN GENERAL ENGINEERING INSTRUCTIONS FOR CANADIAN LINES

CN GENERAL ENGINEERING INSTRUCTIONS

CANADIAN LINES

The instructions contained within this document are issued for the information and guidance of all employees and contractors engaged in the inspection, maintenance, and construction of track, roadway, signals, bridges, buildings and other structures and must be adhered to.

They apply to the operation of CN Canadian Lines and supersede CN General Engineering Instructions dated October 2006.

Except as provided herein, all Canadian Railway Operating Rules (CROR) and Special Instructions remain in force

Office of the
Vice President System Engineering

November 2013

David Ferryman
Vice President System Engineering

CN GENERAL ENGINEERING INSTRUCTIONS

CANADIAN LINES

Table of Contents

1.0	General	1
2.0	Job Briefing	1
3.0	Personal Protective Equipment (PPE) and Clothing	2
	Forms of Protection	6
	Application of Portable Derails	6
4.0	Lone Worker Protection	6
5.0	Safety Watch.....	11
6.0	Crossing Bridges Using Lone Worker or Safety Watch	13
	Separated Work Groups.....	16
7.0	Clearing Trains	16
8.0	Adjacent Track Instruction.....	17
9.0	Off Track Machinery	17
10.0	Track Unit Procedures	18
	Verifying Limits	19
	Working on or Around Track Units.....	22
11.0	Track Unit Operation	23
	Track Unit Operating Speed	24
12.0	Contractor Employee Qualifications	25
13.0	Handling Switches in OCS Territory.....	30
14.0	Highway/Roadway Crossings and Traversing a Highway/Roadway Crossing	31
	Manual Protection at Highway/Roadway Grade Crossing.....	33
15.0	Scope	33
16.0	General Principles	33
17.0	Definitions	33
18.0	Protection Required	34
19.0	Equipment Required	38
20.0	Flagging Procedures	39

1.0 General

- 1.1 Every employee and/or contractor engaged in the inspection, maintenance, and construction of track, roadway, signals, bridges, buildings and other structures shall be subject to and conversant with these instructions. Except where specifically noted, the rules and regulations herein apply equally to employees and contractors.
- 1.2 When local conditions necessitate, instructions in addition to those contained herein, may be issued providing further specific guidelines.
- 1.3 All Engineering employees required to occupy or foul any track, shall be governed by these instructions. They are also responsible to make themselves familiar with all conditions and special instructions applicable to the territory in which they are working.
- 1.4 Employees governed by these instructions must have a copy accessible while on duty.
- 1.5 An employee is foul of the tracks when the individual or equipment is within 4 feet (1.2 meters) of the nearest rail.
- 1.6 Highway/Roadway Grade Crossing means a location where a public highway, road, street, or unrestricted private roadway and associated sidewalks and any pedestrian or bicycle pathway cross one or more railway tracks at grade.
- 1.7 Track unit means any on track equipment (e.g. hi-rails, welding trucks, Brandt trucks, frog trucks, boom truck, etc.).

2.0 Job Briefing

- 2.1 Prior to commencing any work, the employee in charge of a work group will hold a job briefing session for all persons engaged in the activity.

A supplemental job briefing is required when:

- Method of protection is changed, or
 - Method of protection is extended or about to be released.
 - Job task is changed.
- 2.2 The job briefing session shall cover all relevant issues with respect to the task being performed and necessary safety precautions that must be taken, including, but not limited to the following:
 - Designation of the employee in charge

-
- Method of on-track protection being used and the limits of authority
 - Track(s) that may be fouled
 - Operational control of movements on adjacent tracks, if any
 - Procedure to arrange for protection on adjacent tracks, if necessary
 - Maximum zone speed and minimum sight line requirements when using safety watch protection, or if working adjacent to live tracks
 - Means of providing a warning when Safety Watch is used
 - Designated place of safety where workers will clear for trains or track units
 - Designated work zones around track units
 - Safe working and travelling distances between track units
 - A field level risk assessment specific to the task to be performed

2.3 At the conclusion of the job briefing, all employees shall confirm understanding. Job briefing information shall be kept in writing, in prescribed job briefing books, for ready reference by each employee.

3.0 Personal Protective Equipment (PPE) and Clothing

- 3.1 Employees are required to wear PPE appropriate to the work location and the job being done. The following PPE applies to all employees as a minimum requirement:
- Hard hats
 - Protective eyewear (including side shields)
 - Protective footwear (minimum 6 inches **(152 mm)** high, laced top, defined heel)
 - Reflective apparel

Exceptions to these requirements are as follows:

- When working inside designated office/buildings
- When inside an enclosed vehicle or equipment (car, truck, van, etc.)

- 3.2 Employees are required to wear hearing protection where posted or within 100 feet **(31 meters)** of operating machinery. Hearing protection must be worn within 500 feet **(152 meters)** of a snow jet.

Personal Protective Equipment Charts

-
- 3.3 Table 1 contains craft-specific PPE charts for employees that outline requirements for protective equipment. The PPE chart is designed to work in conjunction with the requirements of Section 3.0.

NOTES: Face shields are more restrictive than goggles and can be substituted for goggles. Shin guards are more restrictive than leggings and can be substituted for leggings.

TABLE 1: ENGINEERING GENERAL PPE REQUIREMENTS

	Hearing Protection	Gloves	Rubber Gloves	Goggles	Face shield	Shin Guards	Respiratory Protection Contact Safety Department	Disposable Overalls	Rubberized Apron	Welder's Jacket or Sleeves	Welder's Leathers	Spats/Leggings	Welding Glasses (Shade #)*	Welding Helmet	Remarks/Special Requirements
Abrasive grinding (frog grinding portable)	R	R			R	R	X								
Abrasive grinding or cutting (stationary: bench grinder, chop saw, ect.)	R	X			R		X								
Adzing machine	R	R			R	R	X								Steel instep protection
Banding materials		R			✓										
Batteries: handling or servicing		R	X	R				X							Remove watch if not covered by gloves
Blowing/cleaning with compressed air, steam or water	R	R	X	R	X		X	X							
Boring, reaming, or drilling	R	X			X										
Boutet or thermite welding	R	R			R	R	X						6-8		
Breaking frozen material (ice, ground, gravel, cinders, ballast, etc.) with hand tools		R			R										
Breaking or cutting concrete, stone, or asphalt	R	R			R		X								
Buffing/polishing with wire wheel	R	X			R										
Cadwell bonding	R	R			R							R			
Carbon-arc cutting and gouging	R	R												R	
Chain saw, brush saw, and weed trimmers	R	R			R							R			Chain Saw & Brush Saw; legging/spats
Chemicals, refrigerants or fuels: handling		R	X				X	X	X						
Chipping or cutting	R	R		R											
Chop saw	R	R			R										
Cleaning agents: spraying/general use		X	X	X	X		X	X							
Climbing equipment		R													
Climbing poles and rail/work equipment		R													
Cut-off disks, saws, or other tools with carbide bits	R	R			R							X			

R= Required equipment

X= May be required based on task and materials

✓= Recommended additional equipment

* Welding Shade Chart is found in CN track welding manual appendix A

TABLE 1: ENGINEERING GENERAL PPE REQUIREMENTS

	Hearing Protection	Gloves	Rubber Gloves	Goggles	Face shield	Shin Guards	Respiratory Protection	Contact Safety Department	Disposable Overalls	Rubberized Apron	Welder's Jacket or Sleeves	Welder's Leathers	Spats/Leggings	Welding Glasses (Shade #)*	Welding Helmet	Remarks/Special Requirements
Cutting rivets, bolts, or cotter keys; spitting nuts; etc. (mechanically)	R	R			R											
Cutting rivets, bolts, or cotter keys; spitting nuts; etc. (mechanically with torch)	R	R		R										6-8		
Dusty conditions							X	X								
Electrical hazard		X														
Electrical welding	R	R					X				✓	✓			R	
Gas welding, cutting, or heating	X	R					X				✓	✓		6-8		
Hammer-punch	R	R														
Hand tools	X	X														
Intermodal facility: outside of offices	R	X														
Lifting and carrying		X														
Machining steel, iron, or other metals	R	X			X											
MIG/TIG welding	R	R					X				✓	✓			R	
Mule: operation of car mover	R	R														
Painting/spray painting	X	X					X	X								
Pneumatic tools	R	R														
Powder-actuated tools	R	R		R												
Rail drill	R	R														
Rail grinder	R	R			R	R										
Rail saw	R	R			R								R			
Sand blasting (abrasive blasting)	R	R					R	X								Sand blast hood
Scaling, scraping, or removing welding flux	X	R			X		X									
Steam cleaning	R	R	R		R		X		X							
Striking or striking with hardened tools/fastenings	X	R														
Washing locomotives, machinery, or vehicles	R	R	X						X							
Woodworking machines	R	R			X											

R= Required equipment

X= May be required based on task and materials

✓= Recommended additional equipment

* Welding Shade Chart is found in CN track welding manual appendix A

Forms of Protection

- 3.4 All engineering employees required to foul* or occupy tracks must be protected by one of the following means:

- Positive protection as per the CROR
- Safety Watch protection
- Lone worker protection

*Excludes when not performing work and solely crossing tracks. Tracks may be crossed without protection only when sightlines permit and there are no Class 5 restrictions in place.

Application of Portable Derails

- 3.5 In conjunction with CROR rule 840.1, portable derails will be used where a special lock cannot be applied to a switch to prevent movement from operating over the portion of the track where work is being performed.
- 3.6 Portable derails are to be installed 100 yards (91 meters) (if possible) on each side of the work location within the limits of the red flag. Portable derails are only to be used on tracks where speeds do not exceed 20 mph (32 km/hr).
- 3.7 Consider the following in selecting the orientation of the derail:
- Materials and Equipment – select the derail orientation (left hand or right hand) and place the derail such that a derailed car moves away from any stored material or equipment.
 - Adjacent Live Track – select the derail orientation (left hand or right hand) and place the derail such that a derailed car moves away from the adjacent live track.
 - Surrounding Terrain – select the derail orientation (left hand or right hand) and place the derail such that a derailed car moves away from any waterways, highways, roadways, non-CN lands and/or sensitive/restricted areas.

4.0 Lone Worker Protection

NOTE: Lone Worker protection is not applicable in multi-track Class 5 territory (i.e. multi-track territory where freight train speeds exceed 60 mph and passenger trains exceed 80 mph).

- 4.1 Employees using lone worker protection must participate in a job briefing with his or her supervisor or other designated employee.

The job briefing must include the lone worker's planned itinerary and the procedures that will be applied to establish protection.

- 4.2 Employees performing the tasks shown in Table 2 using lone worker protection will comply with the following:
- The work must not affect the movement of trains;
 - The lone worker must be able to visually detect the approach of a train at maximum timetable speed and be in a place of safety 15 seconds before the arrival of the train;
 - Power operated tools and track units are not in use within hearing distance;
 - The ability to hear and see approaching trains and track units is not impaired by background noise, lights, precipitation, fog, passing trains or physical conditions;
 - The employee has identified a place of safety prior to occupying or fouling the track.
- 4.3 An employee who uses lone worker protection must first complete the Statement of On Track Safety. The statement must designate the date and time for which it is valid. The statement must also indicate the maximum authorized speed of trains within the limits and the sight distance that provides the required warning of approaching trains. The lone worker using lone worker protection to establish protection shall produce the Statement of On Track Safety when requested by a company officer.
- 4.4 A lone worker must use another form of protection if:
- The requirements of 4.2 cannot be met, or
 - The task to be undertaken is not listed in Table 2.

Determination of Adequate Clear Sightline Distance

- 4.5 There are a number of ways in which clear sightline distances can be determined. Employees should select the method that best suits their situation.
1. Track features such as crossings, bridges, overpasses, turnouts, way side buildings, etc., whose mileage is known can be used as reference points to determine the sight distance from the work location.

-
2. Mileage boards can be used as a reference point to determine the sight distance from the work location.
 3. If railway pole lines are present, these can be counted in either direction to obtain sightline distances.
 4. If work location is one that is frequented often (such as a turnout, road crossing, railway crossing at grade, etc.), a tape measure, measuring wheel or a track unit with a distance counter can be used to measure sight distances for all future visits to that location.
 5. The use of portable hand held optical distance measuring devices may be used to determine clear sightline distances.

NOTE: Employees may be required to demonstrate how the sightline distance was obtained. This information must be recorded in the job briefing book.

Clear Sightline Distance

- 4.6 Lone Worker Protection will NOT be considered as adequate protection where sightlines, train speeds, weather conditions, restricted clearing ability, etc., do not allow sufficient time for the employee being protected to move to and occupy a previously arranged place of safety *not less than 15 seconds before a train moving at a maximum speed for that track, reaches that point*. Should more time be required to clear the track, it must be added to the 15 seconds.

Example: An employee is working under Lone Worker protection on a track where the maximum train speed is 35 mph (56 km/hr). It is determined that it will take the employee 5 seconds to clear himself and his tools from the track and be in a place of safety after being warned of an approaching train. This 5 seconds must be added to the 15 seconds indicated above. Therefore, from the table below, the clear sight lines required are found under the 20 second column for a train speed of 35 mph (56 km/hr), or 1030 feet (314 meters). of clear distance in either direction.

- 4.7 Table 3 indicates the required distance by which time employees and their tools must be completely in the clear and in a safe location for trains traveling at various speeds.

**TABLE 2: WORK PERMITTED UNDER LONE WORKER
OR SAFETY WATCH PROTECTION**

	Description of Work	Permitted Under Lone Worker	Permitted Under Safety Watch
1	Anchoring	yes	yes
2	Bolt tightening or individual replacement	yes	yes
3	Bonding – without drilling	no	yes
4	Bonding – temporary or replacing plug bond	yes	yes
5	Brush cutting – Foul of track hand tools only	yes	yes
6	Brush cutting – Underneath bridge	yes	yes
7	Cotter key replacement	yes	yes
8	Crossing testing	yes	yes
9	Culvert inspections	yes	yes
10	Derail adjustment	yes	yes
11	Digging/shoveling ballast by hand	yes	yes
12	Drifting joints	no	yes
13	Gauge rod removal/installation	no	yes
14	Grinding	no	yes
15	Hand measuring of clearances	yes	yes
16	Inspection of bridges from underneath or beside bridge	yes	yes
17	Inspection of signal apparatus and appliances	yes	yes
18	Inspection of track - on foot	yes	yes
19	Lagging screws - off track tools only	no	yes
20	Lubricating	yes	yes
21	Painting comp joints, switch handles, derails, safety appliances, etc.	yes	yes
22	Pole line work	yes	yes
23	Rail wear/ Track geometry measurements	yes	yes
24	Snow clearing device (SCD) installation, removal and maintenance.	no	yes
25	Shoulder trimming with hand tools	yes	yes
26	Shunting- must have permission from RTC	yes	yes
27	Sign repair and installation-	yes	yes
28	Signal alignment	yes	yes
29	Signal and utility locates	yes	yes
30	Slotting joints	no	yes
31	Snow removal – hand tools only	yes	yes
32	Snow removal – with compressors and backpack blowers** (Not applicable on main track or where speeds are greater than 15 mph)	no	yes
33	Spiking/clip installation	yes	yes
34	Semi automatic spring switch testing (Only applicable on yard tracks where track speed is 15 mph or less)	no	yes
35	Surveying/layout/staking/alignment measurements	yes	yes
36	Switch target replacement/maintenance	yes	yes
37	Tamping by hand (without track jacks)	yes	yes
38	Tie plate replacement (single tie plate without jacks)	yes	yes
39	Tie marking/painting defective ties	yes	yes
40	Welding, points, frogs, and joints	no	yes

1) **When hand tools specified no power tools are permitted.**

2) ****In the application of Item 32 the following conditions apply**
a. applicable where track speed is 15 mph or less
b. when back pack blower is used, must utilize tag line to provide physical warning to clear the tracks.
c. when compressor is used physical warning may be provided by use of tag line, tugging on the air supply hose or shutting off the air supply.
d. Not applicable on main tracks.

TABLE 3: MINIMUM REQUIRED SIGHTLINE DISTANCES

Train Speed (mph)	Required Sightlines (in ft.)			
	15 seconds	20 seconds	25 seconds	30 seconds
10	220	295	370	440
15	330	440	550	660
20	440	590	735	880
25	550	735	920	1100
30	660	880	1100	1320
35	770	1030	1290	1540
40	880	1175	1470	1760
45	990	1320	1655	1980
50	1100	1470	1840	2200
55	1210	1615	2020	2420
60	1320	1760	2205	2640
65	1430	1910	2390	2860
70	1540	2055	2570	3080
75	1650	2200	2755	3300
80	1760	2350	2940	3520
85	1870	2495	3125	3740
90	1980	2640	3310	3960
95	2090	2790	3490	4180
100	2200	2935	3675	4400

5.0 Safety Watch

- 5.1 Work that is performed on or about the track that does not require positive protection as provided by the Canadian Rail Operating Rules (CROR) may be performed using Safety Watch protection.

Exception: In the case of multi-track Class 5 territory, Safety Watch protection may only be used for the sole purpose of undertaking a visual walking inspection. In no case may hand inspection tools such as tape measures, rail wear gauges, track gauges, level boards, etc. be used in such inspections. In addition, all the other provisions of Safety Watch must be adhered to.

A list of work that can be undertaken under Safety Watch is provided in Table 2.

Duties of Safety Watch

- 5.2 The sole duty of the Safety Watch is to protect working personnel by continuously monitoring all approaches to the work site for train and track unit movements or other hazards. The Safety Watch must dedicate their entire attention to this task and never engage in distracting activities, such as talking on a cell phone, text messaging, browsing, etc. In addition, they are never to engage in any other distracting activities, including the work being undertaken.

Safety Watch Job Briefing

- 5.3 Prior to implementing Safety Watch protection, the employee in charge, the Safety Watch and the employee(s) being protected must conduct a thorough job briefing to ensure that at a minimum the following items are covered and there is a clear understanding of:
- Identification of track or tracks to be fouled;
 - The date work is performed;
 - Who is the designated Safety Watch;
 - Where the Safety Watch will be positioned;
 - What work is to be performed;
 - If additional clearing time is required;
 - The maximum speed of trains on that track and required sightline distance;
 - The sightline distance at the work site;

-
- Where the workers will clear on the approach of rail traffic;
 - How the warning is to be given;
 - Where any tools are to be placed when clearing;
 - Who will clear the tools;
 - Other risks at the work site.

This information must be documented (in writing) in the job briefing notes.

Determination of Adequate Clear Sightline Distance

- 5.4 There are a number of ways in which clear sightline distances can be determined. Employees should select the method that best suits their situation.
1. Track features such as crossings, bridges, overpasses, turnouts, way side buildings, etc., whose mileage is known can be used as reference points to determine the sight distance from the work location.
 2. Mileage boards can be used as a reference point to determine the sight distance from the work location.
 3. If railway pole lines are present, these can be counted in either direction to obtain sightline distances.
 4. If work location is one that is frequented often (such as a turnout, road crossing, railway crossing at grade, etc.), a tape measure, measuring wheel or a track unit with a distance counter can be used to measure sight distances for all future visits to that location.
 5. The use of portable hand held optical distance measuring devices may be used to determine clear sight line distances.

NOTE: Employees may be required to demonstrate how the sightline distance was obtained. This information must be recorded in the job briefing book.

Clear Sightline Distance

- 5.5 Safety Watch protection will NOT be considered as adequate protection where sightlines, train speeds, weather conditions, restricted clearing ability, etc., do not allow sufficient time for each worker being protected to move to and occupy a previously arranged place of safety *not less than 15 seconds before a train moving at maximum speed for that track, reaches that point*. Should more time be required to clear the track, it must be added to the 15 seconds.

Example: Employees working under Safety Watch protection on a track where the maximum train speed is 35 mph (56 km/hr). It is determined that it will take the employees 5 seconds to clear themselves and their tools from the track and be in a place of safety after being warned of an approaching train. This 5 seconds must be added to the 15 seconds indicated above. Therefore, from the table below, the clear sight lines required are found under the 20 second column for a train speed of 35 mph (56 km/hr), or 1030 feet (314 meters). of clear distance in either direction.

- 5.6 Table 3 indicates the required distance by which time employees and their tools must be completely in the clear and in a safe location for trains traveling various speeds.

6.0 Crossing Bridges Using Lone Worker or Safety Watch

- 6.1 Employees who need to cross bridges in the performance of their duties using either Lone Worker or Safety Watch protection may do so provided that they adhere to the following criteria:

- The maximum length of track carrying bridge that can be crossed in Class 1 and 2 Track is 300 feet (91 meters).
- The maximum length of track carrying bridge that can be crossed in Class 3 and 4 Track is 200 feet (61 meters).

Bridges in the following category require positive protection in order to cross;

- a) longer than the lengths indicated above, or**
- b) have insufficient sight lines, or**
- c) are located in Class 5 track**

- 6.2 When crossing a bridge and you observe or are made aware of the approach of a movement, clear the bridge in the following manner:

- If you are not yet at the half way point of the bridge, turn around and clear the bridge in the direction from which you came.
- If you are at the half way point of the bridge or beyond, continue and clear the bridge in the direction in which you are proceeding.

Always clear the bridge in the direction of shortest distance.

-
- 6.3 Table 4 should be used as a guide in determining the minimum clear sight line distance required to cross a bridge. These minimum distances are based on timed field measurements for 1 or more people to cross and are based on good weather conditions, good footing conditions and a medium walking pace. **The minimum clear sight line distance to cross a bridge includes the 15 seconds required to be in a place of safety prior to the arrival of a movement. The maximum speed for that track shall be used to determine the minimum sightline distance.**

TABLE 4: MINIMUM SIGHT LINE DISTANCE REQUIRED TO CLEAR BRIDGE

Minimum Sight Line Distance Required to Clear a Bridge (feet)						
Length of Bridge (feet) Maximum Distance to Clear (feet)	50	100	150	200	250	300
	25	50	75	100	125	150
Class 1 Track Freight only	352	469	587	719	836	953
Class 1 Track with Passenger	528	704	880	1078	1254	1430
Class 2 Track Freight only	880	1173	1467	1797	2090	2383
Class 2 Track with Passenger	1056	1408	1760	2156	2508	2860
Class 3 Track Freight only	1408	1877	2347	2875		
Class 3 Track with Passenger	2112	2816	3520	4312		
Class 4 Track Freight only	2112	2816	3520	4312		
Class 4 Track with Passenger	2816	3755	4693	5749		

Note: The above minimum sight line distances are based on the place of safety being at the abutments of the bridge. Should the place of safety be further from the bridge than the abutment location, then additional time and sight line distance will be required and therefore must be assessed at the time the bridge is to be crossed.

If the length of bridge to be crossed is not indicated in the table above, then use the next longest bridge length that is indicated.

Example: You wish to cross a 190 feet (58 meters) long bridge in Class 3 track on which passenger service is run, using Lone Worker Protection. You note that there is a place of safety on either end of the bridge, just off the

abutment. What is the minimum required sightline distance in order to cross this bridge?

Solution: From the table above, select the next longest length bridge. In this case, a 200 feet (61 meters) long bridge with a maximum clearing distance of 100 feet (31 meters). The minimum sight line distance for Class 3 track with passenger is 4312 feet (1314 m).

Separated Work Group

- 6.4 When the nature of the work or size of the work crew is such that the Foreman named in the track authority protection (Protecting Foreman) cannot personally observe, and supervise all persons engaged in the work, he/she shall assign an employee(s) in charge of the separated work groups as per CROR Rule 857 special instructions.

7.0 Clearing Trains

- 7.1 Where track protection authority permits, a train may be authorized by the Protecting Foreman to enter the protection limits and proceed to a location within the limits short of the working point. This location must be a clearly identifiable point such as a mile board, point of switch, public crossing, bridge, etc. and must be identified by mileage. The Protecting Foreman must not permit the train to proceed further until he/she has confirmed that all of the procedures with respect to authorizing trains through protection limits have been met.

NOTE: Not applicable to separated work groups.

- 7.2 Except in the case of emergency, a train or engine authorized into the protection limits may only be stopped once for the purpose of clearing employees.
- 7.3 Workers required to clear for a train must position themselves in a safe location and clear a minimum of 19 feet (6 meters) from the nearest rail on which the train has been cleared. If it is not possible to clear a minimum of 19 feet (6 meters), the train speed must be reduced when passing the workers and not exceed 30 mph (48 km/hr). Under no circumstances may employees stand on live and unprotected track while observing passing trains on adjacent tracks. Where the work area includes difficult terrain or special features such as bridges or tunnels, a safe clearing area must be identified prior to occupying or fouling the track.

-
- 7.4 In single track territory when track units are removed from the track or cleared in a nearby spur, siding or back track, booms, wings, etc. must be retracted and secured clear of the affected track. Small tools and other material must also be cleared and secured to avoid being struck by a passing train.

8.0 Adjacent Track Instruction

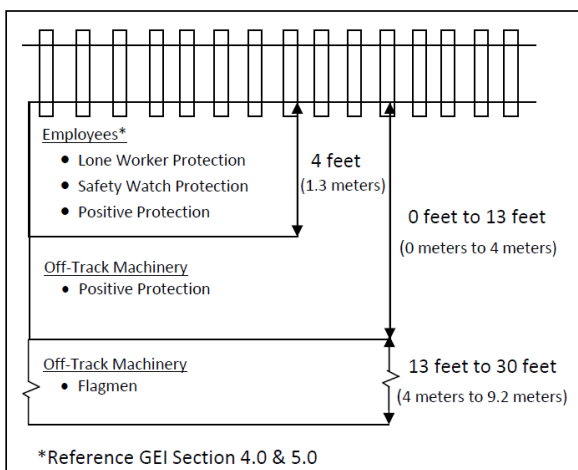
- 8.1 In the application of this instruction, adjacent tracks that are governed by CROR Rule 105 and that are fouled will require protection.
- 8.2 In multi-track territory, positive track protection must include the track or tracks immediately adjacent to the track on which the work is being performed. Tracks shall be considered adjacent when the measured distance between track centers is less than 25 feet (7.6 meters).
- 8.3 Exception: In multi-track territory, where the Protecting Foreman is in immediate contact by radio or in-person with all track units and workers, and the track units being protected and the activity being performed will not foul an adjacent track as per GEI rule 1.5, track protection need not be applied on adjacent tracks. When clearing trains in multi-track territory, workers must avoid crossing over live unprotected track. Only those employees instructed by the Protecting Foreman may cross a live track for the purposes of providing a train inspection. When working on an inside track that is bound by live tracks, workers must position themselves between the rails of the protected track on which they are working when clearing a train.

9.0 Off Track Machinery

- 9.1 Off track machinery such as bulldozers, frontend loaders, excavators, etc. which are working within 13 feet (4 meters) of the nearest rail or such that boom swing or bucket extension will extend within 13 feet (4 meters) of the nearest rail, must be provided with positive protection in accordance with applicable operating rules.
- 9.2 Off track machinery working within 30 feet (10 meters) of the nearest rail, regardless of protection, must stop working on the approach of a train and remain stopped until the train has passed.

- 9.3 Off track machinery working between 13 feet and 30 feet of the nearest rail requires protection by a flagperson.

FIGURE 1: TYPE OF PROTECTION NEEDED



10.0 Track Unit Procedures

- 10.1 Operators of track units, while on rail, must be qualified in the CN General Engineering Instructions (GEI) and Canadian Rail Operating Rules (CROR), must be knowledgeable of the physical characteristics of the unit in which they are operating and must become familiar with and be governed by the operating and maintenance instructions or manuals supplied by the Railway and/or Manufacturer. Operators of high rail vehicles must have a valid motor vehicle license.
- 10.2 Pre-trip inspection of track units is required at the start of every shift.
- 10.3 The operator of a track unit is responsible for completing the required logbook(s), and to inspect and to maintain the track unit at the prescribed frequency.
- 10.4 Unauthorized persons are not permitted to ride on track units. With the exception of Federal, Provincial or Municipal police and Federal Regulatory Officers (with valid identification and in the course of duty), all authorized, non-Company personnel are required to sign a "Release of Liability" form when riding on track units.
- 10.5 Unless specified, track units must not be relied upon to shunt track circuits

Track units with damaged or defective insulation must be repaired immediately.

- 10.6 When a track unit operator or pilot is copying a track authority, writing other information, or using ETOP, the track unit must be stopped.
- 10.7 When a train is operating on an adjacent track, track units must be brought to a stop. If it can be done safely, the passing train should be inspected on both sides.
- 10.8 In the application of CROR 857 special instruction, the following will apply:
- Prior to entering the limits of the confliction(s) as indicated on the foreman's TOP or OCS clearance, the foreman named in the authority must contact all other conflicting foreman. If unable to contact the conflicting foreman named in the authority, the foreman named in the authority may enter the said limit but only to the point to cancel the preceding TOP, OCS clearance, or clear the main track. The foreman may only clear the track after trying to communicate with the conflicting foreman by all means and through the RTC. When clearing, the foreman must:
 1. Be able to visually see the next crossing or siding switch, and
 2. Not exceed 10 mph (16 km/hr).
- 10.9 All occupants riding in a track unit are responsible for its safe operation.
- 10.10 Verifying Limits
- a) Operators of track units being protected must have in their possession, written or electronic confirmation of their authority to occupy the track and the working limits. When working in a group consist (two or more track units), only the lead track unit and the rear track unit are required to have in their possession a written or electronic copy of the protection or authority.
 - b) When working or traveling, the lead track unit must comply with the following requirements:

Prior to passing a controlled signal or identifiable location, the occupants of the track unit must:

- Review the permit or authority to verify the controlled signal (signalled territory)

or identifiable location (non-signalled territory) being approached is included in the current protection, and

- Record the time and the signal number/name (signalled territory) or identifiable location (non-signalled territory) being passed when the permit/authority is verified.
- For the purpose of this instruction identifiable locations are station name signs, siding switches, and/or mileage posts), The identifiable locations that must be verified and recorded are station name signs and siding switches only. However, when the work limits include a mileage, a stop must be made one (1) mile before and at the mileage stated in the authority.

A lone track unit operator must bring the track unit to a complete stop before recording the location being passed as per item 10.6.

- c) When travelling within the same controlled signals or identifiable location multiple times (working), the occupants are required to verify they are authorized to enter the limits upon the initial entry only. They may work within the location moving in both directions an unlimited number of times; however the permit/authority need only be verified once.
- d) The rear track unit need not stop at control points or identifiable locations unless it reverses direction and becomes the lead unit.
- e) The operator of the track unit or another designated occupant in the track unit must make the following broadcast upon departing each signal or identifiable location. The radio broadcast must include the;
 - Identity of the track unit or the identity of the operator, and
 - Present location and direction of travel.

When in a terminal area, no radio broadcast is required.

- f) The instructions of this section (Section 10.10) do not apply to test cars within the working limits when testing.

10.11 The operator must ensure that the track unit is equipped with a proper flagging kit, first aid kit, charged fire extinguisher and a train radio.

-
- 10.12 All tools and materials must be properly secured against movement when the track unit is operating.
 - 10.13 Track units may be coupled only by using an approved coupling device.
 - 10.14 Lights to the front and rear and strobe lights, (when available), must be displayed when the track unit is operating on rail. (Note: Strobe lights must not be operated when traveling on the highway.)
 - 10.15 When it is necessary for individual employees to travel under difficult conditions such as extreme heat or cold, heavy snow or rain, or in remote areas, etc. additional safety precautions such as establishing specific call-back times with another competent employee, shall be taken.
 - 10.16 Unless protected by CROR Rule 105c, when not in immediate use or left unattended, track units must be protected against trains or engines and secured against unauthorized or unintentional movement. Track units may be protected by CROR 840.1 or other methods, ie removing the track from service. Additional clearance must be maintained where the possibility of snow removal machinery or wide load operations exist.
 - 10.17 Track units must not be brought to a stop on the switch points of dual control switch or the point of a moveable point frog.
 - 10.18 Spring switches and semi-automatic switches must be lined by hand for trailing point movements by track units.
 - 10.19 Track units must operate over self-restoring dual control switches and power operated self-restoring derails in accordance with instructions, if issued, for those devices otherwise they must be placed in hand position when being traversed by a track unit.
 - 10.20 Except during the actual working operation, extendible working components of a track unit must be retracted to the travel position and all locking devices put in place before the track unit is moved.
 - 10.21 Operating track units in the vicinity of passenger trains entraining and detraining should be avoided. A track unit must move with extreme care when moving alongside a train carrying passengers which is discharging or receiving traffic. They must not pass between such train and the station

or platform, unless movement is properly protected.

- 10.22 Track inspections and track work should be planned such that track units operate or work in the forward direction whenever possible. When necessary to change direction of travel, if possible and practicable, track units should be turned and operated in the forward direction.
- 10.23 The following safety precautions must be taken when operating track units in reverse:
- Lights on the leading end of the track unit must be illuminated.
 - A back up audible alarm must be operating. If not so equipped or operable, the operator must sound the horn on a regular basis. Three short sounds of the horn will be used before commencing a reverse movement.
 - When visibility in the reverse direction is obscured, another employee must be positioned so as to warn the operator of any obstructions.
 - Employees operating track units designed to work in both directions and working within a gang consist must conduct a job briefing session ensuring that procedures involving the track unit(s) movements and the operation of the gang are covered.

Working on or Around Track Units

- 10.24 The following precautions must be taken when working on or about track units:
- All persons operating or riding in track units must understand the duties that each person will perform.
 - Use handrail if so equipped, when getting on, getting off or riding a track unit.
 - A track unit must be stopped before getting on or off. Exception: Authorized personnel may entrain or detrain a tamper in work mode.
 - Use the 3-point contact method when getting on or off a track unit.
 - When working near or observing track units, communicate with the operator and ensure that the following is understood:
 - Operating procedure,
 - Location of employees working around and observing the track unit,
 - Operators blind spot,

-
- Signal warnings that track unit will move,
 - Where duties require employees to be near working track unit, employees must stay outside the 15 feet (4.5m) safe area,
 - Where duties require the employees to be within the 15feet (4.5m) safe area, the operator and employee must jointly establish a safe location for the employee to occupy.

11.0 Track Unit Operation

- 11.1 Track units will operate under full control prepared to stop at all times. Operators must be increasingly vigilant as they approach any level crossing (public, private, farm or pedestrian), interlockings, animals or people near the track and when passing over bridges.
- 11.2 Initial brake test – Immediately after setting the unit in motion the brakes must be tested to ensure they are operating properly. In all cases, occupants, if any, are to be warned of brake tests by the operator.
- 11.3 Distance to stop test – The operator must conduct a “distance to stop” test when the track unit reaches the operating speed. This will be done by applying full controlled braking without producing a wheel skid situation while bringing the vehicle to a complete stop. Further “distance to stop” tests must be conducted when there are changes in conditions that affect the track unit’s ability to stop, in advance of areas with poor sight lines, road crossings or other work groups.
- 11.4 Immediately after performing a “distance to stop test” and while still stopped, the following information must be recorded:
 - Time the test was performed,
 - Location where the test was performed,
 - Operating speed at the start of the test,
 - Braking distance.

The recorded information must be retained and available for inspection for the duration of the shift.

- 11.5 Track units must maintain a spacing of at least 300 feet (91 meters) between track units, when traveling. Track units must maintain a spacing of at least 500 feet (152m) from a standing train or engine on the same track, or when following a moving

train or engine. These distances may be decreased if there is a clear understanding with the train or engine that it is safe to do so. An increase in spacing is required if stopping distances are increased.

- 11.6 When track units are traveling together, track unit operators must advise each other when planning to stop. If communication with the other track unit operator(s) is not acknowledged, the operator must stop the track unit, exit and use all possible means to flag the following track unit operators to stop.
- 11.7 While working, track units must maintain a minimum 40 feet (13m) spacing between units. If work requires a closer spacing, a clear understanding between all operators and employees must be established.

Track Unit Operating Speed

- 11.8 Track units will operate at a speed not exceeding "Track Unit Speed", unless otherwise directed by Operating Rule or Special Instruction.
- 11.9 Work track units unless specified by special instruction for a particular unit or type of unit must not exceed a maximum of 25 mph (40 km/hr). Work track units are any track unit not included in 11.10.
- 11.10 Light duty hi-rail vehicles assigned for the purpose of conducting inspections must not exceed a maximum of 45 mph (75 km/hr) on tangent track and 30 mph (50 km/hr) on curves. Vehicles operating in this category must have authorization by the Regional Chief Engineer.
- 11.11 Track units must not exceed 5 mph (8 km/hr.) over any switch that has power operation capability, or moveable point frogs.
- 11.12 Track units will operate with extreme caution while traveling through the closed point of a spring frog, self-guarded manganese frogs and all other special track work, ensuring that all wheels are properly on the rails at all times.
- 11.13 Unless otherwise specified by special instruction, the maximum speed, when reversing, will be Track Unit Speed not exceeding 15 mph (25 km/hr).

12.0 Contractor Employee Qualifications

Contractors working for CN must comply with the requirements below. Exemptions may only be granted by the Regional Chief Engineer or his/her representative in the case of emergencies.

Contractor Requirements

- 12.1 The contractor must identify a Safety Officer who will be a point of contact for CN on:
 - Safety related matters such as action plans
 - Employee qualifications
 - Employee training
 - Exchanging documentation on policy and procedure changes, etc.
- 12.2 Provide CN with a list of the employees working on or expecting to work on CN property and their qualifications. This includes the employee's full name, date of birth as well as:
 - Training completion dates
 - Refresher and recertification due dates
 - Proof of training provider (i.e. CN, other railroads, outside college, etc.)
 - CN will only accept CROR qualifications that are provided by a CN Operating Practices approved training supplier.
- 12.3 Employees must carry documented proof of training in their possession while on CN property. Employees who are not in the list per rule 12.2 and who's proof of qualifications are not provided will not be allowed on CN property.
- 12.4 Contractors must ensure that their employees are briefed and are provided current copies of CN's standards and policies including most recent updates.
- 12.5 In order to allow new employees access to a CN work site, the following process must be followed:
 - Contractors must provide their names and qualifications to the office of the Regional Chief Engineer and Supply Management prior to these employees gaining access to CN property.
 - Contractor must receive CN's acceptance of the qualifications prior to new employees entering CN property.
- 12.6 Provide a safety plan to the Regional Chief Engineer including the following but not limited to:

-
- An injury prevention program
 - Safe track unit operation
 - Staying within their track authority limits
 - Specify method of ensuring compliance and an auditing process
 - Field level risk assessment

CN Requirements

- 12.7 CN will provide the track protection for contractors, except in specific cases as authorized by the Vice President of Engineering.
- 12.8 CN will specify the level of training required in the following tables.

JOB SPECIFIC TRAINING REQUIREMENTS

NOTE: The job specific training requirements of Table 5, 6, and 7 do not preclude other training requirements specific to the position: such as crane, welder, machine operation or other trade skills as the job may require.

TABLE 5: TRACK TRAINING REQUIREMENTS

Job Title / Role	Contractor Orientation Training (eRailsafe)	CROR	GEIs	Track Inspection Guidelines	Track Unit Operations
Foreman / Asst Foreman	Yes	Yes	Yes	Yes	Yes
Machine Operator – On Track	Yes	Yes	Yes	n/a	Yes
Machine Operator – Tamper	Yes	Yes	Yes	Yes	Yes
Machine Operator – Off Track	Yes	n/a	n/a	n/a	n/a
Flagman	Yes	Yes	Yes	Yes	Yes
Flagman – other*	Yes	Yes	Yes	n/a	n/a
Trackman / Welder / Labourer	Yes	n/a	Yes	n/a	n/a

* Note: This has limited application. It includes protecting utility companies and work not impacting track infrastructure.

TABLE 6: BRIDGE TRAINING REQUIREMENTS

Job Title / Role	Contractor Orientation Training (eRailsafe)	CROR	GEIs	Track Inspection Guidelines	Track Unit Operations	Fall Protection	Fall Rescue	Confined Space
Bridgetenders	Yes	Yes	Yes	n/a	n/a	n/a	n/a	n/a
Machine Operator On Track	Yes	Yes	Yes	n/a	Yes	As required	As required	n/a
Machine Operator Off Track	Yes	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Workers On Bridges	Yes	n/a	n/a	n/a	n/a	Yes	Yes	n/a
Workers Off Bridges	Yes	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Flagman	Yes	Yes	Yes	Yes	Yes	n/a	n/a	n/a
Culvert Work/Inspection	Yes	n/a	n/a	n/a	n/a	n/a	n/a	As required

TABLE 7: S&C TRAINING REQUIREMENTS

Job Title/Role	Contractor Orientation Training (eRailsafe)	CROR	GEIs	Boom Truck Qualifications	Track Unit Operations	Fall Protection	Signal Apprenticeship Qualifications
Foremen / Coordinator	Yes	Yes – Note 1	Yes	n/a	Yes – Note 1	Yes	n/a
Ground Work only							
Foremen /Coordinator	Yes	Yes – Note 1	Yes	n/a	Yes – Note 1	Yes	Yes
Ground work, Wiring and Hookup							
Machine Operator – on Track	Yes	Yes	Yes	n/a	Yes	Yes – Note 3	n/a
Machine Operator – off Track	Yes	n/a	Yes	n/a	N/A	Yes – Note 3	n/a
Flagman	Yes	Yes	Yes	n/a	Yes	n/a	n/a
Boom Truck Operator- on Track	Yes	Yes	Yes	Yes	Yes	Yes – Note 3	n/a
Boom Truck Operator- off Track	Yes	N/A	Yes	Yes	N/A	Yes – Note 3	n/a
Mechanic/ Maintainer	Yes	Yes – Note 2	Yes	n/a	Yes – Note 2	Yes	Yes
Laborer	Yes	Yes – Note 2	Yes	n/a	Yes – Note 2	Yes	n/a

Note 1 – If job has on track equipment then these qualifications are required.

Note 2 – If these employees operate the vehicles and or equipment on track.

Note 3 – If these employees are used to be climbing signal and communication structures.

13.0 Handling Switches

13.1 In addition to CROR rule 104 (q), employees must record the following information on the back of their TOP or OCS clearance when handling a main track switch:

- Time of day the switch was handled.
- Location of the switch.
- Initials of employees' that handled the switch and initial of the employee that confirmed the position. When the employee confirming the position of the switch is not present (i.e. confirmed via telephone or radio), the full name of the person or RTC initials must be recorded.
- Position the switch was left.

14.0 Highway/Roadway Grade Crossings and Traversing a Highway/Roadway Grade Crossing

14.1 Hi-Rail Vehicles at Highway/Roadway Grade Crossings

When hi-rail vehicles are being removed from or placed on the track, at/or near a grade crossing, employees must warn the traveling public by:

- a) Displaying 360 degree flashing light and four way emergency flasher, (if equipped).
- b) Employees must watch for highway vehicles and provide flagging if conditions require such an action.
- c) When road traffic volume warrants, road traffic must be stopped before attempting to mount or dismount the track with the hi-rail vehicle. This can be accomplished by:
 - i. Stopping traffic in each direction and requesting the motorist to hold his position until the hi-rail is clear of the crossing, or
 - ii. Where equipped, activating the automatic warning system.

14.2 Any track unit or hi-rail must be operated with caution when approaching highway/roadway grade crossings. This includes giving roadway traffic preference and:

- a. Approaching grade crossing under complete control, being prepared to stop if necessary.
- b. A track unit must not obstruct a highway/roadway grade crossing until the way is seen to be clear by the operator of the track unit.
- c. A track unit must be brought to a full stop before proceeding over a highway/roadway grade crossing when the view of the approach is obstructed or when traffic is heavy.
- d. If required due to traffic volumes, sightlines, or other special conditions, the operator of the track unit must only proceed over the highway/roadway grade crossing after stopping under the protection of a flag-person, except a track unit being operated by one person alone may after stopping, proceed with extreme caution.

14.3 At all road crossings, the operator of a track unit must be prepared to stop clear of the

crossing. When a conflict with approaching highway traffic exists the track unit must be brought to a stop and may only proceed when traffic has cleared or stopped and it is safe to do so.

- 14.4 Where the view is obstructed, or road traffic is heavy or travels at high speeds, a track unit must be brought to a full stop, clear of the crossing. Once it is safe, the track unit may then proceed.
- 14.5 Highway traffic must be given the right-of-way unless protection is provided by one of the methods in 14.6, 14.7 or 14.8.
- 14.6 At crossings where a protective device exists that can be operated by a switch or remote control device, the protection may be activated to protect movements through the crossing. The crossing may be occupied once roadway traffic has come to a stop. Once the track unit has cleared the crossing, the protective device must be returned to normal.
- 14.7 At crossings protected by a flag person, the track unit may proceed when given the appropriate signal by the flag person.
- 14.8 When necessary, the occupants of a track unit will protect against roadway traffic. Procedures specified in Section 15 through 20, "Manual Protection at Highway/Roadway Grade Crossings" shall apply.

Manual Protection at Highway/Roadway Grade Crossings

15.0 Scope

- 15.1 These practices are intended to ensure that there are acceptable procedures and instructions in place to permit railway employees to safely perform manual protection at highway/railway grade crossings when:
 - a. The uncontrolled movement of traffic could be hazardous to workers;
 - b. Work is being performed at or near a railway/road grade crossings;
 - c. Automatic warning devices are not working as intended; or
 - d. Signal light, gates, and other protective devices are broken or damaged.
- 15.2 Except as otherwise noted, this circular is intended to apply to manual protection performed by engineering employees, contractors working on behalf of the railways or other authorized and qualified persons. Train and Engine Crews required to manually protect crossings will continue to be governed in accordance with the provisions of the Canadian Railway Operating Rules (CROR) and individual operating instructions.

16.0 General Principles

- 16.1 Manual protection of highway/railway grade crossings should be carried out in a manner that provides roadway users with a message consistent to that which they encounter for other roadway flagging situations.
- 16.2 Clear instructions must be in place between railway and highway flag-persons when both are involved in a manual protection plan.
- 16.3 Vehicles should not be left in a location that could interfere with the view of grade crossing warning systems or flag-persons.
- 16.4 Unnecessary prolonged activation of railway crossing warning systems should be avoided.

17.0 Definitions

- 17.1 **Flag-person** means a responsible employee or contractor qualified by the railway company or the road authority to stop or otherwise direct and control highway traffic through a highway/roadway grade crossing through instruction and a demonstrated knowledge of this circular and all other applicable rules, procedures and instructions.

-
- 17.2 **Foreman** means the designated employee in charge of work at the grade crossing.
- 17.3 **Highway/Roadway Grade Crossing** means a location where a public highway, road, street, or unrestricted private roadway and associated sidewalks and any pedestrian or bicycle pathway cross one or more railway tracks at grade.
- 17.4 **Qualified person** means a person, who, because their knowledge, training and experience is qualified to perform that duty safely and properly.
- 17.5 **Railway Company** means a railway company that owns or operates over the line of railway at the grade crossing.
- 17.6 **Road Authority** means the public agency that has legal authority to open and maintain a road that passes across the line of railway at the grade crossing.
- 17.7 **Traffic** means all road users including drivers cyclists and pedestrians that may use a grade crossing.
- 17.8 **Traffic control** means a method used for warning traffic and protecting track work at or near grade crossings.
- 17.9 **Traffic control plan** means the plans or written procedures detailing the traffic accommodation activities for a grade crossing project. Traffic control plans must be approved by the proper road authority.

18.0 Protection Required

- 18.1 Malfunction of Automatic Warning Systems
- a. When a railway company is aware that an automatic grade crossing warning system malfunction has taken place, a qualified person shall arrange for appropriate means of warning highway traffic and railway employees. This may include but is not limited to:
 - i. Train and engine crews providing manual protection until the train or engine movement fully occupies the crossing;
 - ii. A qualified flag-person providing manual protection in accordance with Section 19, until the on-track equipment has cleared the crossing;
 - iii. A uniformed police officer providing manual protection in accordance with practices

-
- acceptable to their organization until the on-track equipment has cleared the crossing; and
 - iv. In the case of workers at or near the crossing, a lookout to warn workers of approaching traffic.
 - b. A malfunction of a warning system at or near a grade crossing includes:
 - i. An activation failure, a partial activation or a false activation of an automatic warning system or any of its components;
 - ii. When traffic signal pre-emption systems, designed to operate in conjunction with the automatic warning system at or near a grade crossing, will not operate or will not operate properly. In this case, the road authority must be notified immediately.
 - c. Movement of trains where there is known to be a malfunction of an automatic warning system shall be governed in accordance with current company operating instructions and Canadian Rail Operating Rules.

18.2 Traffic Control for Very Short Duration Work

In instances where maintenance work at a grade crossing may be of very short duration and will have a minimal impact on traffic, a qualified person at the location must review the activity and assess the need for traffic control measures. Depending on the work to be performed, control measures could include items such as a lookout to warn workers of approaching traffic, flag persons and/or advance warning signage.

- a. Examples of such activities would include but not be limited to:
 - i. Removal of snow and ice build-up in flange ways;
 - ii. Repair of high spikes;
 - iii. Visual ground inspection of track and signal equipment;
 - iv. Testing the operation of a grade crossing warning system;
 - v. Removal of isolated debris from crossing surface; or

vi. When required, parking a vehicle on the shoulder of the road or the right-of-way in the immediate vicinity of grade crossing.

- b. All workers must wear high-visibility reflective apparel and any work vehicles in the vicinity must employ 360 degree flashing lights and/or 4-way emergency flashers.
- c. In all cases the railway company shall safely restore normal operations of the system as soon as possible.

18.3 Traffic Control for Scheduled Work in the Vicinity of a Grade Crossing

When carrying out scheduled work in the vicinity of a highway/railway grade crossing, except as provided in Sections 18.1 and 18.2 above, a sufficient number of flag-persons or other means of manual or positive protection, must be provided when:

- a. Work is to be carried out on a line of the railway that may cause obstruction of sight-lines at a highway/roadway grade crossing not equipped with an automatic warning system when there is the possibility of the operation of a train.
- b. The crossing warning system which includes either the warning lights with or without gates, advance warning system, or interconnected traffic signals or prepare to stop signs are unable to operate properly due to scheduled maintenance or construction work within the rail approach to the crossing or the road approach to the crossing when there is the possibility of the operation of a train.
- c. Work equipment is close enough to the crossing to obstruct the motorist view of approaching trains or is continuously activating the warning system.
- d. Test of a highway/roadway grade crossing warning system causes the operation of the light units or gate arms at the same time that a train or other railway equipment may enter onto the operating control circuits of the warning system.
- e. Traffic is required to pass a worker, equipment or other obstruction that

may block all or part of the traveled roadway, except as outlined in Section 18.2 above (Very Short Duration Work).

- f. Train movements are anticipated and the presence of track units or work equipment could lead to confusion for highway users.

Should the work affect the highway/roadway grade crossing for an extended period of time or result in roadway lane closures, the road authority must be notified in advance as provided for in Section 18.4.

18.4 Traffic Control for Lane Closures and Long Duration Construction Work

Before undertaking work which will require the regulation of traffic over a grade crossing for an extended period of time or which will require lane closures, the road authority must be notified well in advance and:

- a. A written traffic control plan must be prepared (see Figure 2);
- b. A flag-person or other mutually agreed to means of manual protection in accordance with the traffic control plan must be provided;
- c. The foreman or other person in charge of the work must:
 - i. Be governed by instructions from the road authority ensuring the flagging protection procedures to be followed for such work conforms to the applicable provincial or road authority requirements;
 - ii. Ensure that all protective devices as determined above are in place prior to commencement of work;
 - iii. Determine who will perform the flagging duties, whether the road authority, railway personnel or a contractor;
 - iv. Ensure detailed instructions and job briefings are provided to persons performing traffic control duties; and
 - v. Notify Signals and Communications of work to be done at the crossing and arrange for the Signal Maintainer or other authorized and qualified person to isolate/deactivate/reactivate

automatic warning devices, if applicable.

19.0 Equipment Required

- 19.1 For daytime grade crossing work requiring manual protection, each flag-person shall be provided with:
- a. A traffic control hand held approved STOP/SLOW paddle as shown in Figure 2 is recommended. A red flag may be used when a STOP/SLOW paddle is not available;
 - b. Approved high visibility reflective vest or similar apparel;
 - c. Required personal protective equipment;
 - d. An effective means of communication when flag-persons are not visible to each other.
- 19.2 A flag-person used for scheduled or construction work must have the following clothing and equipment:
- a. A STOP/SLOW sign as shown in Figure 2, mounted on a 4 foot long pole;
 - b. Approved high visibility reflective vest or similar apparel;
 - c. Required personal protective equipment;
 - d. An effective means of communication when flag-persons are not visible to each other;
 - e. The appropriate traffic cones, barricades, signs, lighting and other traffic control devices prescribed by the province in which the work is being performed.

These requirements may be altered or augmented as necessary to meet the requirements prescribed by the province and the traffic control plan.

- 19.3 During the hours of darkness, or in other conditions of poor visibility, in addition to the above equipment requirements, each flag-person is to be provided with a working flashlight which may be fitted with a red signalling baton or a lit red fusee.

20.0 Flagging Procedures

20.1 General Procedures

- a. During traffic control each flag-person must remain on duty at the assigned station until relieved.
- b. Except as provided by section 20.4, a flag-person must not direct traffic for more than one lane at the same time.
- c. A flag-person shall not perform any other work while physically directing vehicular traffic.
- d. A flag-person must stand in a safe position on the side of the lane he/she is flagging with an unobstructed view of approaching traffic.
- e. A flag person must ensure that it is safe for a movement to proceed before signalling for that movement to proceed.
- f. No employee other than the flag-person may give signals to a motorist except in an emergency.
- g. Only one flag-person may give a signal to a motorist at one time.
- h. A flag-person must make all motions and signals for traffic control precisely and deliberately so that the meaning of signals is clearly understood.

20.2 Hand Signals

- (A) When using a STOP/SLOW paddle a flag-person must:
 - i. Use the normal signals shown in Figure 4 when stationed on the driver's right side of the traffic lane under the flag-person's control.
 - ii. The signals shown in Figure 4 will be reversed when the flag-person is stationed on the drivers left side.
 - iii. The flag-persons sign must not be used to wave traffic on and must never be displayed to traffic in other than a static manner.
- (B) When using a red flag, a flag-person must use the following procedures:
 - i. To stop traffic; face traffic and extend the flag staff horizontally across the traffic lane in a

stationary position so that the full area of the flag is visibly hanging below the staff. The free arm shall be held with the palm of the hand above the shoulder level toward approaching traffic.

- ii. To direct traffic to proceed; stand parallel to the traffic movement and with flag and arm lowered from the view of the road users, motion with the free hand for road users to proceed. Flags shall not be used to signal traffic to proceed.
- iii. To alert or slow traffic; face traffic and slowly wave the flag in a sweeping motion of the extended arm from shoulder level to straight down without raising the arm above a horizontal position. The flag-person shall keep the free hand down.

20.3 Emergency Vehicles

Emergency vehicles such as fire trucks, police vehicles, and ambulances pose special problems for flag-persons and emergency procedures to be used should be known prior to commencement of flagging operations.

- a. When the flag-person becomes aware that an emergency vehicle is approaching, he or she should immediately contact the other flag-persons in order to open a path for the emergency vehicle(s).
- b. If there is a hazard that will affect the safety of an emergency vehicle, yourself or others, the emergency vehicles must be stopped, even ever so briefly, in order to relay specific instructions.

20.4 Traffic Control with one Person

Whenever one person is required to flag at crossings where vehicles can move in either direction or more than one lane is involved, the flag-person should:

- a. Speak to the driver of the first vehicle stopped to ensure that he/she remains stopped clear of the crossing while the flag-person stops vehicles arriving from the other direction, or from an adjoining lane.

-
- b. When stopping vehicles at a crossing with more than one track, the flag-person should first stop the vehicle whose line of site is most restricted.

20.5 Traffic Control Signs

- a. When traffic control is scheduled or of long duration, signs advising of a flag-person ahead should be placed in advance of each flag-person's station. (Examples shown in Figure 3).
- b. Signs must be erected as per instructions from the road authority.
- c. Signs must be checked to ensure they are functioning as intended.
- d. Signs must be removed promptly upon completion of work.

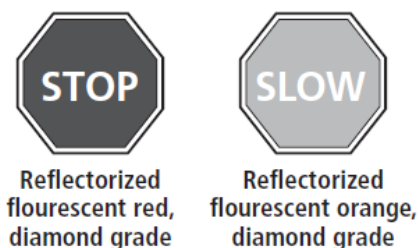
20.6 Scheduled and Construction Work Requiring Traffic Control Plans

- a. A detailed traffic control plan must be written and approved by the road authority.
- b. These plans should include communication procedures, job briefings and situational awareness.
- c. Detailed instructions must be given to the flag-person(s) along with job briefings.
- d. Unless otherwise identified in the traffic control plan, grade crossing protection shall be in conformity with the requirements of the Manual of Uniform Traffic Control Devices for Canada (MUTCD).
- e. Road closures and barriers should be considered whenever work at a grade crossing is being planned. Barricades must only be placed as per the road authority's instructions.

20.7 Notification of the Signal Maintainer or Other Authorized Personnel

Scheduled track work must not be performed within the limits of an automatic warning system at a grade crossing until the signal maintainer or other authorized and qualified person has been notified. Only Signals and Communications personnel may isolate/deactivate/reactivate automatic warning systems at grade crossings.

Figure 2 STOP/SLOW Sign



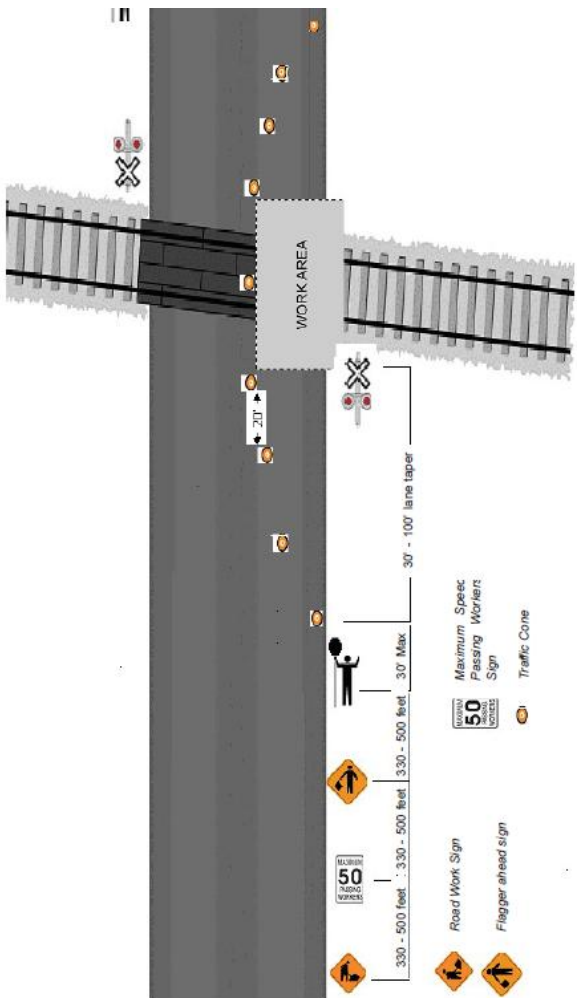
The STOP/SLOW paddle shall have an octagonal shape on a rigid handle. STOP/SLOW paddles shall be at least 450 mm (18 in) wide with letters at least 150 mm (6 in) high. The background of the STOP face shall be red with white letters and border. The background of the SLOW face shall be orange with black letters and border. When used at night the STOP/SLOW paddle shall be reflectorized.

NOTE: All traffic control equipment, including signs and personal protective equipment must be kept clean and in working condition.

Figure 3 Traffic Control Plan

Diagram shows an example of a traffic control plan for protecting work at a grade crossing. (two way traffic, single lane closure)

NOTE: This is an example only. Signs should be placed as per traffic control plan developed with the proper road authority.



Each situation will require individual safety assessment, and consideration must be given to traffic volume, vehicle types, sightlines and distances, sign spacing, duration of work and other factors to ensure traffic control devices are adequate in each case.

1. All signs shall be spaced 330-500 feet (100-150 meters) apart unless otherwise indicated.
2. All signs shall be kept clean and in good condition.
3. Identical signing is required from both directions.
4. The bottom of sign should not be less than 1' (30 cm) above the road surface.
5. All signs must be in accordance with instructions from road authority.
6. Traffic cones are placed at 20 foot (6 meter) maximum intervals when flag-persons are used.

-
7. Lane taper must not exceed 100' (30 meters) or be less than 30' (10 meters) when flag-persons are used.
 8. No vehicles shall be parked on road unless required for actual operations.
 9. Traffic Control plan must document procedures to follow to accommodate emergency vehicles. Flag-persons must discuss and understand these procedures prior to commencement of flagging operations.

Figure 4 Hand Signals when STOP/SLOW paddle is used for traffic control

To Stop Traffic



(A) By day

- Face traffic.
- Display "STOP" paddle in right hand.
- When approaching vehicle has almost stopped, use left arm to indicate stopping point.



(B) By night

- Face traffic.
- Display static reflectorized "STOP" paddle in right hand and flashlight with red signaling baton attached in left hand.
- Move left arm from 3 to 6 o'clock.
- When approaching vehicle has almost stopped, use flashlight/baton to indicate stopping point.

To Slow Traffic



(A) By day

- Face traffic.
- Display static "SLOW" paddle in right hand.
- If traffic slows below desired speed give appropriate "Move Traffic" signal.



(B) By night

- Face traffic.
- Display static reflectorized "SLOW" paddle in right hand and flashlight with red signaling baton attached in left hand.
- Move left arm from 3 to 6 o'clock.
- If traffic slows below desired speed give appropriate "Move Traffic" signal.

To Move Traffic Slowly



(A) Slowly by day

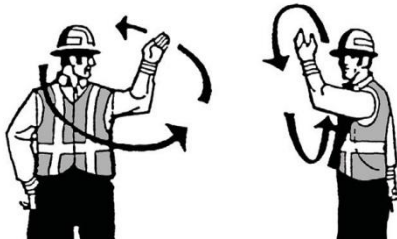
- Face across the approach lane and look across left shoulder at traffic to be moved.
- Display static "SLOW" paddle in right hand.
- Advance traffic by rotating lower left arm in an elliptical manner in the direction the vehicle wheels will rotate.



(B) Slowly by night

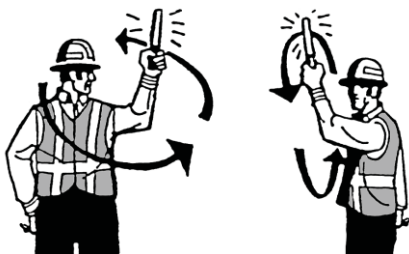
- Face across the approach lane and look across left shoulder at traffic to be moved.
- Display static "SLOW" paddle in right hand and flashlight, with red signaling baton in left hand.
- Advance traffic by rotating lower left arm.

To Move Traffic at posted speed



(A) At posted speed by day

- Face across the approach lane and look across left shoulder at traffic to be moved.
- Lower right arm to conceal paddle and motion traffic on.



(B) At posted speed by night

- Face across the approach lane and look across left shoulder at traffic to be moved.
- Hold flashlight with red signaling baton in left hand.
- Lower right arm to conceal paddle and motion traffic on with left arm at shoulder level.

Standard Specification

Railcars

2018-09-10	4	Approved for Use	A. Aquil	F. van Biljon	F. van Biljon	F. Pittman
2018-07-17	3	Approved for Use	A. Aquil	F. van Biljon	F. van Biljon	F. Pittman
2018-03-13	2	Approved for Use	A. Aquil	F. van Biljon	F. van Biljon	F. Pittman
2017-01-07	1	Approved for Use	J. Lategan	F. van Biljon	N. Mason	M. Weaver
2016-12-12	0	Approved for Bid	J. Lategan	F. van Biljon	N. Mason	M. Weaver
Date	Rev.	Status	Prepared By	Checked By	Approved By	Approved By
HATCH						Employer

*TC 15 ATTACHMENT 1: MARY RIVER PROJECT -
BAFFINLAND & IRON MINES LP, INFORMATION
REQUEST RESPONSE: RAILWAY EQUIPMENT -
BRAKING SYSTEM*

MARY RIVER PROJECT – BAFFINLAND & IRON MINES LP

Information Request Response: Railway Equipment - Braking system

1.0 Introduction

The proposed Rail System alignment for the above-noted project has been analyzed for the maximum descending and ascending grade determination and the maximum air brake retardation force calculation required for safe loaded train operation. The Rail System layout is captured in site plan and horizontal section plan drawings H3530004-30000-224-271-0001-0001, H353004-30000-224-271-0002-0001 and H353004-30000-224-271-0003-0001.

2.0 Assumptions and Plan Limits

The Rail System is measured in metric units and the total distance of train travel one-way is approximately 109 km. The Milne Port is shown on the drawings as km 0.0 and the Mary River Mine as km 109. The trains travel loaded from the mine location to the Milne Port location for unloading. The horizontal curves along the alignment are shallow; the minimum curves shown as $R = 500$ m which is equivalent to $5730/(500 \times 3.3 \text{ feet in 1 meter}) = \text{about } 4 \text{ degrees}$. These curves would actually decelerate the descending movement due to the curve resistance between the wheel flanges and the rail, however, this has not been considered in order to allow another factor of safety on the acceleration and braking effort calculations on the descending grades. Also, the rolling resistance of the wheels are also not considered from the calculations to further add another factor of safety for the braking effort determination. The rolling resistance of wheels on rail is normally assumed as 1.5 to 2 lbs. of retarding force per ton, but as indicated here, this retardation force is omitted from the calculation.

3.0 Loaded Train Weight & Length

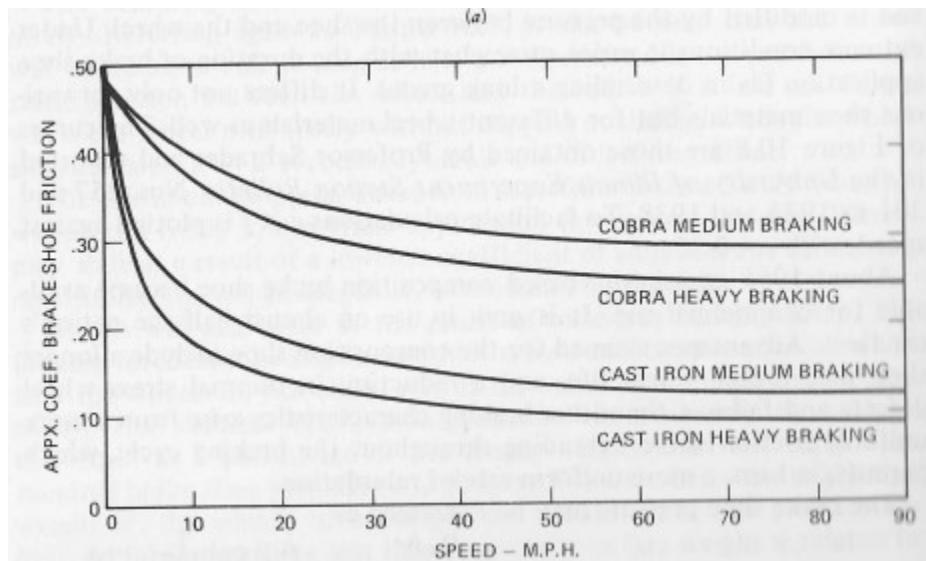
As per BIM/Hatch Railcars Standard Specification H355004-PR002-224-078-0001, the maximum train length would be 85 cars with two locomotives (one on each end of the train). The ore cars are to be loaded to 286,000 lbs gross vehicle load. The GE High-Adhesion EVO locomotives are approximately 74 feet long, weighing on average 420,000 lbs. The ore cars are 31.25 feet in length (as per the Railcars Standard Specification) over pulling face of couplers.

Loaded Train Weight would be $= 85 \times 143 \text{ tons} + (2 \times 210 \text{ tons per locomotive}) = 12,575 \text{ tons}$

Total maximum train length $= 85 \times 31.25 + (2 \times 74 \text{ per locomotive}) = 2,804.25 \text{ feet}$

4.0 Ore Car Brake Shoes

Under section 3.6.8 of the same Railcars Standard Specification, the ore cars will be equipped with a standard high-friction composition brake shoe. Typically, these brake shoes have a coefficient of friction between 0.375 and 0.350 for speeds around 20 mph (32 km/hr) as per the graph below for Medium and Heavy Braking conditions:



Reference: Railroad Engineering, 2nd Edition, William W. Hay, 1982, John Wiley & Sons publication

Brake shoe coefficient of friction is affected by two conditions:

- a) Heavy braking for long periods of time (30 to 45 minutes) will result in a condition known as "Brake Fade". Brake Fade is the reduction in the coefficient of friction of the shoes as the brake application starts heating up the brake shoe and a fade of the effectiveness is seen. To combat against this undesired condition, the AAR has developed a new specification for Tread Conditioning or Fade Resistant Brake Shoes which are less affected by the heat generated by the heavy brake application over extended periods of time. One such brake shoe is designed by Wabtec and is approved by AAR against Specification M-926. Shown below is an illustration of the Tread-Guard brake shoe manufactured by Wabtec.



- b) A built up of snow and ice in the wheel tread and brake shoe interface will also reduce the coefficient of friction of the brake shoes. The same Tread-Guard brake shoe manufactured by Wabtec has an imbedded cast iron insert that will also help "condition"

the tread/shoe interface by better removing snow and ice accumulation and keeping the coefficient of friction steady and unaltered.

Finalization of the rail car braking systems specification is currently underway. Fade Resistance and/or Tread-Conditioning brake shoes similar to the Wabtec - Tread Guard Brake Shoe are being considered as part of the final specification.

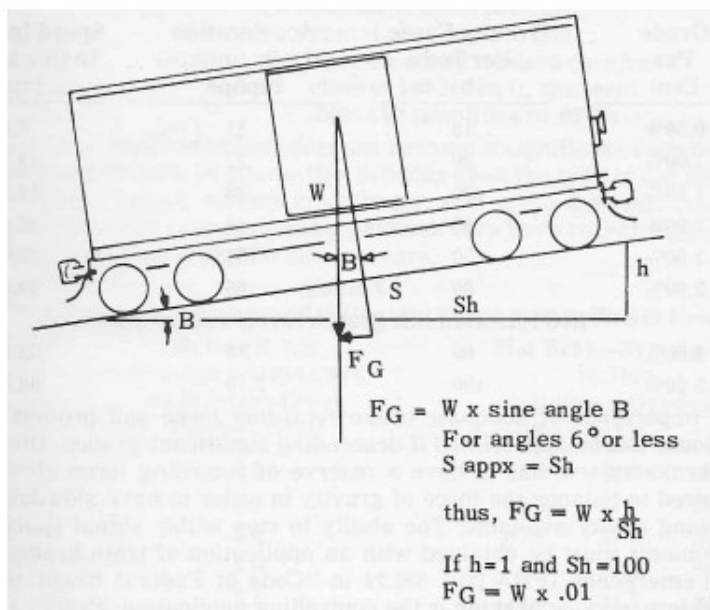
As the ore cars are not currently equipped with the Fade Resistance or Tread-Conditioning brake shoes, **a conservative "average" coefficient of friction of 0.30 was assumed** for the brake force and retardation calculations.

5.0 GE Locomotive Dynamic Brake Considerations

Dynamic Brake is a locomotive braking feature that is highly used by train crews to complement automatic brakes of the train while negotiating a steep descending grade. GE standard High-Adhesion locomotives are normally equipped with 98,000 lbs. of Dynamic Brake retardation force at the highest DB8 setting. To be again conservative in the evaluation of Dynamic Brake capabilities of the two locomotives on the 85 car train and given the reluctance of locomotive engineers to be in DB8 setting all the time while braking (to prevent the DB system from heating up), the 98,000 lbs of DB retardation has been reduced by 25% in the braking effort calculations and only have considered 75% DB of 98,000 = 73,500 lbs. of retardation for each locomotive.

6.0 Descending Grade Gravity Force Calculations and Retardation

A train on a descending grade is exposed to a gravity force that tends to pull the train down the grade and accelerate its movement when not counterbalanced. This simple illustration from a well-known reference book on railway train braking shows the evaluation of such a gravity force:



Reference: Engineering & Design of
 Railway Braking Systems, September
 1984, Air Brake Association

In simple terms, the gravity force of the train on the descending grade is equal to about 20 lbs. per ton of train weight per each percent grade of descending track profile. This gravity force needs to be nullified by the braking force retardation on the train, generated by the automatic brake application of the ore cars and the Dynamic Brake effort of the locomotives. Other retardation forces that are present during the decent include the rolling resistance of the wheels,

on rail as well as the curving resistance of the track. However, as noted in Section 2.0, to be more conservative in the calculations of the required total brake retardation force, these two considerations have been omitted.

For the 12,575 ton loaded train, the retardation force needed per each percent descending grade will be = $12,575 \times 20 \times 1$ (percent) = 251,500 lbs. of automatic brake and Dynamic Brake retardation combined.

7.0 Survey of Steepest Descending Grades on Track Plan

A survey of the entire 109 km track profile of the loaded train from the mine to port revealed the following steepest descending grades:

- a) Between km 97.5 and km 96.3 (1.2 kms) the elevation drops from 187.55 to 169.29, or a descending section of 18.24 meters over 1.2 kms which is equivalent to about a 1.52% descending grade. This grade is not considered long as it is only 1.2 kms long and our train length is about 850 meters, so the train will be on the descending grade in its entirety for a very short amount of time.
- b) Between km 74.0 and km 71.5 (2.5 kms) the elevation drops from 183.54 to 138.38 or a descending section of 45.16 meters over 2.5 kms which is equivalent to a 1.80% descending grade. This seems to be the longest and steepest descending grade on the loaded train run.
- c) Between km 37.0 and km 35.0 (2 kms) the elevation drops from 157.94 to 124.96 or a descending section of 32.98 meters over 2 kms which is equivalent to a 1.65% descending grade. Once again, this 2 km of descending section is not very long considering our train length of 850 meters.
- d) Between km 4.0 and km 2.0 (2 kms) the elevation drops from 77.18 to 56.58 or a descending section of 20.6 meters over 2 kms which is equivalent to a 1.03% descending grade.

Considering all the above descending grade sections, 1.8% will be used as the most severe descending grade in the braking calculations.

8.0 Brake Retardation Calculations and Equivalent Automatic Brake Applications

Using the 1.8% steepest descending grade, in the retardation force calculations and using the established 0.3 for brake shoe coefficient of friction and 75% of full Dynamic Brake effort per locomotive, the following calculation can now be used (based on the formulae established in the Reference document "Engineering Design of Railway Brake Systems" published in September 1984 by the Air Brake Association).

BRAKE EFFORT CALCULATOR				INPUTS	CALCULATED		
CARS/TRAIN	85			GRADE	1.80		
TWR/CAR	286000	LBS		GRADE FORCE FOR TRAIN AT 20 LBS/TON/PERCENT GRADE			
# UNITS	2						
TWR/UNIT	420000	LBS		RETARDING FORCE NEEDED	452700	LBS	
TOTAL TONS	12575	TONS		DYNAMIC BRAKE (DB) / UNIT	98000	LBS	
				TOTAL DB @ 75%	147000	LBS	
TRAIN SPEED	20	MPH					
				RETARDING FORCE NEEDED FROM AIR BRAKES	305700	LBS	
CARS OPERATIVE	85			RETARDING FORCE NEEDED PER CAR	3600	LBS	
TONS/BRAKES	148			BRAKE SHOE COEFF. OF FRICTION	0.3		
				BRAKE FORCE (BF) NEEDED PER CAR	12000	LBS	
				BRAKE FORCE (BF) NEEDED PER WHEEL	1500	LBS	
AIR BRAKE CALCULATIONS PER CAR							
LEVER RATIO(L)	8			BF = P x L x A x N x E			
BC SIZE (DIAM.)	10	INCH					
BC AREA (A)	78.5	SQINCH					
# OF BC (N)	1						
EFFICIENCY(E)	0.75						
BRAKE FORCE	12000	LBS		NEEDED TO CONTROL GRADE			
BC PRESS (P)	25	PSI		NEEDED TO CONTROL GRADE			
BP DROP	10	PSI		TO DEVELOP REQUIRED BC PRESSURE			
BHP / WHEEL	24	BHP		BRAKE HORSEPOWER INPUT PER WHEEL			

The above calculation shows that when all brakes are working on all 85 ore cars of the train, the crew needs a 10-psi brake pipe reduction to generate the required retardation on the 1.8% grade to maintain track speed at 20 mph (32 km/hr). Not knowing the established track speed of this descending grade section, it is recommended not to exceed 32 km/hr in order to have a comfortable and safe brake pipe reduction of 10-psi and have the Brake Horse Power (BHP) at the wheels/shoe interface below 30 BHP, as a recommended maximum by same reference above published by the Air Brake Association.

$$\text{BHP} = \frac{\text{Retarding Force (lbs)} \times \text{Speed (mph)}}{375}$$

(reference: "Management of Train Operation and Train Handling", September 1972, Air Brake Association)

8.1 15% Inoperative Cars and Brake Retardation Evaluation

Transport Canada and the Federal Railroad Administration (FRA) allows a train to continue in service having as many of 85% of the wagon brakes in operating condition. In a 85 car train, this means that a minimum of 73 cars need to have operative brakes for the train to continue in service. Performing the same calculation for 85% effective brakes yields:

BRAKE EFFORT CALCULATOR				INPUTS	CALCULATED		
CARS/TRAIN	85			GRADE	1.80		
TWR/CAR	286000	LBS		GRADE FORCE FOR TRAIN AT 20 LBS/TON/PERCENT GRADE			
# UNITS	2						
TWR/UNIT	420000	LBS		RETARDING FORCE NEEDED	452700	LBS	
TOTAL TONS	12575	TONS		DYNAMIC BRAKE (DB) / UNIT	98000	LBS	
				TOTAL DB @ 75%	147000	LBS	
TRAIN SPEED	20	MPH					
				RETARDING FORCE NEEDED FROM AIR BRAKES	305700	LBS	
CARS OPERATIVE	73			RETARDING FORCE NEEDED PER CAR	4190	LBS	
TONS/BRAKES	172			BRAKE SHOE COEFF. OF FRICTION	0.3		
				BRAKE FORCE (BF) NEEDED PER CAR	13970	LBS	
				BRAKE FORCE (BF) NEEDED PER WHEEL	1750	LBS	
AIR BRAKE CALCULATIONS PER CAR							
LEVER RATIO(L)	8			BF = P x L x A x N x E			
BC SIZE (DIAM.)	10	INCH					
BC AREA (A)	78.5	SQINCH					
# OF BC (N)	1						
EFFICIENCY(E)	0.75						
BRAKE FORCE	13970	LBS		NEEDED TO CONTROL GRADE			
BC PRESS (P)	30	PSI		NEEDED TO CONTROL GRADE			
BP DROP	12	PSI		TO DEVELOP REQUIRED BC PRESSURE			
BHP / WHEEL	28	BHP		BRAKE HORSEPOWER INPUT PER WHEEL			

In this case, the train would require a 12-psi brake pipe reduction (automatic brake application) to maintain track speed at 20 mph (32 km/hr). This will keep the BHP still at 28, below the maximum value of 30 BHP for wheel/rail interface. Full Service Brake application being a 25-psi reduction of the brake pipe from 90-psi (released) to 65-psi brake equalization, the safe margin understood by train crews is not to go below 50% of Full Service Brake reduction or 50% of a 25 total psi reduction (i.e. a 13 psi brake application).

8.2 Dynamic Brake Failure En-Route and Brake Retardation

Dynamic Brakes can fail on locomotives during the trip. Shown below is the same calculation for all brakes on the ore cars being effective but no DB effort present on the locomotives:

BRAKE EFFORT CALCULATOR				INPUTS	CALCULATED		
CARS/TRAIN	85			GRADE	1.80		
TWR/CAR	286000	LBS		GRADE FORCE FOR TRAIN AT 20 LBS/TON/PERCENT GRADE			
# UNITS	2						
TWR/UNIT	420000	LBS		RETARDING FORCE NEEDED	452700	LBS	
TOTAL TONS	12575	TONS		DYNAMIC BRAKE (DB) / UNIT	0	LBS	
				TOTAL DB @ 75%	0	LBS	
TRAIN SPEED	20	MPH					
				RETARDING FORCE NEEDED FROM AIR BRAKES	452700	LBS	
CARS OPERATIVE	85			RETARDING FORCE NEEDED PER CAR	5330	LBS	
TONS/BRAKES	148			BRAKE SHOE COEFF. OF FRICTION	0.3		
				BRAKE FORCE (BF) NEEDED PER CAR	17770	LBS	
				BRAKE FORCE (BF) NEEDED PER WHEEL	2220	LBS	
AIR BRAKE CALCULATIONS PER CAR							
LEVER RATIO(L)	8			BF = P x L x A x N x E			
BC SIZE (DIAM.)	10	INCH					
BC AREA (A)	78.5	SQINCH					
# OF BC (N)	1						
EFFICIENCY(E)	0.75						
BRAKE FORCE	17770	LBS		NEEDED TO CONTROL GRADE			
BC PRESS (P)	38	PSI		NEEDED TO CONTROL GRADE			
BP DROP	15	PSI		TO DEVELOP REQUIRED BC PRESSURE			
BHP / WHEEL	36	BHP		BRAKE HORSEPOWER INPUT PER WHEEL			

This calculation shows that DB is critical for the train operation on this descending grade in order to maintain train speed at 20 mph (32 km/hr). When DB fails on both locomotive units, the crew will need a 15-psi Brake application (beyond 50% of Full Service Brake) and the BHP will increase to 36, surpassing the maximum allowed value. In this case, train speed needs to be reduced to 15 mph (24 km/hr) to maintain the proper BHP below 30 maximum, as shown below:

BRAKE EFFORT CALCULATOR				INPUTS	CALCULATED		
CARS/TRAIN	85			GRADE	1.80		
TWR/CAR	286000	LBS		GRADE FORCE FOR TRAIN AT 20 LBS/TON/PERCENT GRADE			
# UNITS	2						
TWR/UNIT	420000	LBS		RETARDING FORCE NEEDED	452700	LBS	
TOTAL TONS	12575	TONS		DYNAMIC BRAKE (DB) / UNIT	0	LBS	
				TOTAL DB @ 75%	0	LBS	
TRAIN SPEED	15	MPH					
				RETARDING FORCE NEEDED FROM AIR BRAKES	452700	LBS	
CARS OPERATIVE	85			RETARDING FORCE NEEDED PER CAR	5330	LBS	
TONS/BRAKES	148			BRAKE SHOE COEFF. OF FRICTION	0.3		
				BRAKE FORCE (BF) NEEDED PER CAR	17770	LBS	
				BRAKE FORCE (BF) NEEDED PER WHEEL	2220	LBS	
AIR BRAKE CALCULATIONS PER CAR							
LEVER RATIO(L)	8			BF = P x L x A x N x E			
BC SIZE (DIAM.)	10	INCH					
BC AREA (A)	78.5	SQINCH					
# OF BC (N)	1						
EFFICIENCY(E)	0.75						
BRAKE FORCE	17770	LBS		NEEDED TO CONTROL GRADE			
BC PRESS (P)	38	PSI		NEEDED TO CONTROL GRADE			
BP DROP	15	PSI		TO DEVELOP REQUIRED BC PRESSURE			
BHP / WHEEL	27	BHP		BRAKE HORSEPOWER INPUT PER WHEEL			

8.3 One Locomotive DB Failure & 85% Effective Brakes

BRAKE EFFORT CALCULATOR			INPUTS	CALCULATED		
CARS/TRAIN	85		GRADE	1.80		
TWR/CAR	286000	LBS	GRADE FORCE FOR TRAIN AT 20 LBS/TON/PERCENT GRADE			
# UNITS	2					
TWR/UNIT	420000	LBS	RETARDING FORCE NEEDED	452700	LBS	
TOTAL TONS	12575	TONS	DYNAMIC BRAKE (DB) / UNIT	49000	LBS	
			TOTAL DB @ 75%	73500	LBS	
TRAIN SPEED	15	MPH				
			RETARDING FORCE NEEDED FROM AIR BRAKES	379200	LBS	
CARS OPERATIVE	73		RETARDING FORCE NEEDED PER CAR	5190	LBS	
TONS/BRAKES	172		BRAKE SHOE COEFF. OF FRICTION	0.3		
			BRAKE FORCE (BF) NEEDED PER CAR	17300	LBS	
			BRAKE FORCE (BF) NEEDED PER WHEEL	2160	LBS	
AIR BRAKE CALCULATIONS PER CAR						
LEVER RATIO(L)	8		BF = P x L x A x N x E			
BC SIZE (DIAM.)	10	INCH				
BC AREA (A)	78.5	SQINCH				
# OF BC (N)	1					
EFFICIENCY(E)	0.75					
BRAKE FORCE	17300	LBS	NEEDED TO CONTROL GRADE			
BC PRESS (P)	37	PSI	NEEDED TO CONTROL GRADE			
BP DROP	15	PSI	TO DEVELOP REQUIRED BC PRESSURE			
BHP / WHEEL	26	BHP	BRAKE HORSEPOWER INPUT PER WHEEL			

The calculation above shows that with one locomotive DB failure and only 85% of ore car brakes effective, the train crew will need to reduce speed to 15 mph (24 km/hr) in order to keep their BHP below the maximum 30 value.

9.0 Train Length & Brake Signal Propagation

The brake pipe reduction or increase to apply and release the brakes respectively takes place at a speed of approximately 600 feet/second. This means that for a train of 2,800 feet long, it takes less than 5 seconds for all the cars to start responding to the brake application and release signal. In addition, the 85 car train will run in Distributed Power Mode (DPM), with one Lead locomotive on the head-end and one Remote locomotive on the tail-end of the train. One of the features of DPM is that the signal to apply and release the brakes is sent from the Lead to the Remote via radio frequency. As a result, the Remote will reduce brake pipe application at the same instant as the Lead. Having two sources of brake application and release signal propagation, reduces the total application time by half, resulting in the brakes applying and releasing in less than 3 seconds on all the ore cars. This has distinct advantages over a regular train with lengths approaching 7,000 to 8,000 feet and powered by head-end locomotives only with a single point of air brake signal propagation.

10.0 Locomotive Main Reservoir Charging, Air Dryers and Drain Valves

The Distributed Power Mode (DPM) will also help in charging the brake pipe because it will do it from two separate sources (head-end and tail-end of the train) thereby accelerating the total charge time of the train. The locomotives will also be equipped with main reservoir drain valves and air dryers which will remove the condensate and moisture from the brake pipe air. Having an air dryer will not allow freezing of moisture in the brake pipe; which normally in cold temperatures will interfere with the brake signal propagation. There will be strict maintenance procedures in place to ensure that drain valves and air dryers are inspected prior to every trip to ensure proper operation.

11.0 Total Flow Limits for Distributed Power Trains

In Canada or U.S.A., the total flow limit allowed for a train in operation is 60-cfm. Above this total leakage limit, the train is required to stop and find the source(s) of the leakage and reduce ore cars (if necessary) in order to bring the flow below this limit. As of November 2011 and based on extensive testing done by Canadian Class I railways, Transport Canada has agreed to extend the 60-cfm limit to 90-cfm for Distributed Power trains. This considers that multiple sources of air brake application and release coming from Remote locomotives can accommodate the extra leakage in the trainline without affecting normal brake operations. Leakage will increase in train operations during extreme cold temperatures, as the rubber in the control valves and brake cylinders starts to shrink. However, this extended limit of leakage for DPM operation will help operate during the few days where temperatures approach -45C.

12.0 Automated Train Brake Effectiveness Testing (ATBE) Proposal

ATBE is a relatively simple process where Hot Wheel Detectors (located on the wayside of the track at the bottom of descending grades adjacent to Hot Bearing Detectors) will scan the wheel temperatures of the ore cars while brakes are applied on the descending grade. The braking train, as it clears the descending grade, will still have a certain specific higher wheel temperature as a result of negotiating the descending grade with automatic brakes applied. Colder wheels within the braking train will be then identified as rail cars with non-operating air brakes. This system was designed and implemented at Canadian Pacific (CP) back in 2007. After extensive testing, Transport Canada agreed to give CP a waiver to exempt their entire coal train operation from manual and stationary air brake testing in the yard prior to departure; (a test that is known at the NO.1 Brake Test). Since then, CP has operated thousands of coal trains through ATBE without the need of manual and stationary testing in the yards. The advantages of ATBE is that the brakes are tested during the train operation for the amount of brake effort that is required to maintain track speed. The test is done without human interference with the results broadcast directly to the crew or Rail Traffic Control. Immediate action can be taken at the next descending grade by reducing track speed and setting a deeper brake application to compensate for the inoperative rail cars brakes. Attached to this report are a couple of papers that were presented at the ASME and ABA associations relative to this new process.

The final configuration of the wayside monitoring equipment and supporting processes are currently in the design stage. Wheel temperature detectors at the bottom of the four (4) descending grade locations (highlighted above in Section 7.0) and the establishment an ATBE process which will improve the brake inspection and reduce cycle time of the trains (by eliminating the stationary tests in the yards) are both being considered as part of the final design.

13.0 Ore Wagon Brake Design for Extreme Cold Climate

The ore cars will be designed and built with a body-mounted brake system, where the brake cylinder and slack adjuster are mounted high at the end platform level of the wagon. Contrary to truck-mounted air brake system setups, this will protect against the potential packing of snow and ice around the air brake system in addition, guarantees have been received from the Brake System supplier that their equipment is tested and certified to operate even at -45C temperatures. A review of the Environment of Canada website for weather conditions affecting the Baffin Island area of operation, the 4-year data indicates that temperatures drop below -40C only 1% of the time, below -35C only 8% of the time and at no time temperatures have reached below -45C.

These conditions, even though being severe in the Arctic North, are very similar to cold temperatures under which most Canadian Railways operate throughout severe parts of our winter season.

14.0 Emergency Brake Application on Mountain Grades

The U.S. Federal Railroad Administration (FAA) has implemented a Rule where a train that surpasses a maximum speed by 5 mph on a Mountain Grade must resort to an immediate Emergency Brake application as it is considered an “uncontrolled movement”. Mountain Grade is considered descending grade at and exceeding 1.8% grade. A similar Operating Practice is being considered for the Baffinland trains over the 4 descending grades identified, which would require an Emergency Brake application when the speed of train surpasses the maximum track speed by 5 km/hr. These measures will be an extra precaution for train handling in the rare case where they could be needed.

15.0 Locomotive Tractive Effort Calculations for Ascending Grades

According to the site plan, the loaded train will have the most severe ascending grade to climb around km 70.5 where the grade continues about 7 km up to km 63.5 and the elevation varies from 129.0 to 183.393, or 53.39 meters over a distance of 7000 meters, resulting into a calculated ascending grade of 0.76%. The same Gravity force that was calculated in km 6.0 will now need to be overtaken to maintain track speed of the train on this ascending grade.

The Gravity or Grade Resistance is calculated to be:

$$GR = 0.76 \times 20 \times 12,750 \text{ tons} = 193,800 \text{ lbs}$$

Adding to it, the rolling resistance of 1.5 lbs per ton for the wagon wheels, we get:

$$RR = 12,750 \times 1.5 = 19,125 \text{ lbs.}$$

$$\text{Total Resistance} = GR + RR = 193,800 + 19,125 = 212,925 \text{ lbs or } 213,000 \text{ lbs.}$$

GE AC locomotives can produce up to 30% adhesion in all-weather conditions and that will amount to a Tractive Effort = 420,000 (weight of unit) x 0.30 (adhesion) = 126,000 lbs and a total of 252,000 lbs for the two locomotives combined. This is more than sufficient to overcome the Total Train Resistance of 213,000 lbs. The train would be able to get up this grade at a speed approaching 20 mph (30 km/hr) with the 85 loaded ore cars.

On the empty run, the train will need to negotiate the 1.8% ascending grade between km 71.5 and km 74.0. The empty cars would have a tare weight of 23 tons each and the total empty train would weigh:

$$\text{Empty Train Weight} = 85 \times 23 \text{ tons} + (2 \times 210 \text{ tons/loco}) = 2,375 \text{ tons}$$

$$\text{Grade Resistance on the 1.8\% ascending grade would be} = 2,375 \times 1.8 \times 20 = 85,500 \text{ lbs.}$$

$$\text{Rolling Resistance for the empty train would be} = 2 \times 2,375 = 4,750 \text{ lbs}$$

$$\text{Total Train Resistance of the Empty Train} = \text{GR} + \text{RR} = 85,500 + 4,750 = 90,250 \text{ lbs.}$$

As shown above, the two locomotives can generate above 250,000 lbs. of tractive effort, which is more than sufficient to take the empty train at the desired track speed up the 1.8% ascending grade.

Abe Aronian, P.Eng
January 17, 2019
Calgary, AB

*TC 15 ATTACHMENT 2: AUTOMATED TRAIN
BRAKE EFFECTIVENESS (ATBE) TEST PROCESS AT
CANADIAN PACIFIC*

JRC2012-74035

AUTOMATED TRAIN BRAKE EFFECTIVENESS (ATBE) TEST PROCESS AT CANADIAN PACIFIC

Abe Aronian, P.Eng
 Canadian Pacific
 Calgary, Alberta, Canada

Michelle Jamieson, P.Eng
 Canadian Pacific
 Calgary, Alberta, Canada

Kim Wachs
 Canadian Pacific
 Calgary, Alberta, Canada

ABSTRACT

In 2011, Canadian Pacific (CP) implemented a new Automated Train Brake Effectiveness (ATBE) process for coal trains which replaces the visual Class 1 (No.1) Air Brake test required under Canada's Department of Transport (Transport Canada – TC) regulations. The ATBE process relies on Wayside Detector technology to assess the operation of brakes on each railcar under dynamic conditions.

CP began analyzing wayside detector information in 2008 as the basis for evaluating the braking performance of coal trains in Canadian Export service, specifically targeting existing Hot Box / Hot Wheel Detectors strategically situated alongside the track. Using the wayside detector output, the new ATBE process improves upon the visual No.1 Brake Test by evaluating brake *effectiveness*. The wayside detector information is automatically transmitted to a central Equipment Health Monitoring System after each train passing, where train brake effectiveness is evaluated and results published to mechanical maintenance facilities and train crews. The published results constitute the completed ATBE Test for the train.

Given the substantial number of mechanical components requiring visual inspection each day by railway train inspectors, and taking into account the considerable investment CP has made into Wayside Detection technology, focus has moved towards Technology Driven Train Inspections (TDTI), preferring predictive, proactive maintenance practices and condition-based maintenance policies instead of the traditional reactive maintenance approach.

INTRODUCTION

On a daily basis hundreds of railcar inspectors in dozens of mechanical inspection locations visually inspect hundreds of thousands of railcar components across Canadian Pacific's (CP) network. In addition to component inspections, each time a train is assembled, and at specified distance intervals in the United States, manual testing of the train braking system is required under Canadian and United States regulations.

Out on the mainline, CP's network contains a range of wayside detection systems including approximately 400 Hot Box Detectors (HBD), many combined with Hot Wheel Detectors (HWD) and Dragging Equipment Detectors. While each detector has its primary function in terms of highlighting specific potential defects on railcar components, there is a host of opportunities to garner from this detector information indications of other railcar and component defects.

Building on an integrated system of wayside detector information and condition-based maintenance policies, there is a migration away from subjective manual inspections towards Technology Driven Train Inspections (TDTI). "Brake systems, which can have a direct influence on wheelset life through overheating of wheels and wheel sliding, account for ... 20 percent of repair and maintenance costs" on freight cars, based on 2008 repair costs captured by the Association of American Railroad's Car Repair Billing (CRB) database. Wheelset replacement accounts for 51% of all freight car maintenance costs in 2008 [1]. By using technology to identify effective brake performance defects, it not only creates a safer operation, but also introduces a more predictive and preventative approach to managing railcar health.

The immediate benefits are improved safety through the reliability of TDTI, improved railcar and infrastructure health through predictive and preventative maintenance practices, and operational efficiency by taking the inspections online during actual train operations.

To start down the TDTI path, CP began investigating and validating the use of HWD information to highlight railcar brake system performance. The following outlines the development of the Automated Train Brake Effectiveness (ATBE) Test process at CP, and reaching the goal of replacing the manual brake testing currently regulated in Canada by the Department of Transport (Transport Canada – TC). The process applies specifically to CP's captive Canadian coal fleet which runs in a closed loop in British Columbia (BC), Canada, referred to as the BC Coal Loop.

NOMENCLATURE

AAR	– Association of American Railroads
AEI	– Automatic Equipment Identification
ATBE	– Automated Train Brake Effectiveness
B/O	– Bad Order
CP	– Canadian Pacific
CRB	– Car Repair Billing
EHMS	– Equipment Health Monitoring System
FRA	– Federal Railroad Administration
HBD	– Hot Box Detector
HWD	– Hot Wheel Detector
RTC	– Rail Traffic Controller
TC	– Transport Canada
TDTI	– Technology Driven Train Inspection
TTCI	– Transportation Technology Center, Inc.

CANADIAN REGULATIONS FOR TRAIN BRAKE INSPECTION AND TESTING

Canadian Department of Transport

To understand CP's ATBE process requires knowledge of the existing train brake inspection and testing requirements. Train brake standards are regulated in Canada by the Department of Transport's Railway Freight and Passenger Train Brake Inspection and Safety Rules – in short, the Train Brake Rules. The Train Brake Rules, Section 11, require that where a train is made up at a Safety Inspection Location designated by the railway company, train brakes must be inspected and tested by a certified car inspector [2]. The brake testing, referred to as a No.1 Brake Test, requires verification of:

- the integrity and continuity of the train brake pipe;
- the condition of the brake rigging on each car;
- the application and release of the brakes on each car;
- the piston travel on each car within specified limits [2].

The results of the No.1 Brake Test must be communicated to the train crew, and recorded in the company's train brake status system.

CP Application – Captive Coal Fleet on the BC Coal Loop

The BC Coal Loop on CP's network is a loop of nearly 1,500 miles (2,400 km) traveled by a captive fleet of coal trains from the coal mines in southeast BC to export terminals on the Pacific coast. Figure 1 highlights the BC Coal Loop on a portion of CP's track network.

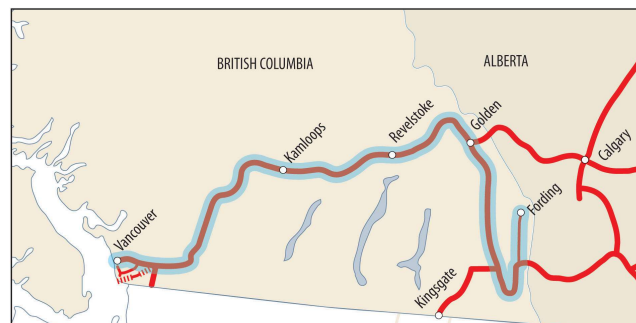


Figure 1: BC Coal Loop in Southern BC

The mechanical facility in Golden, BC is the *designated safety inspection location* for the BC coal fleet. The coal loop cycle begins when an empty train arrives in Golden and receives a Safety & Maintenance inspection, removal and replacement of any bad order (B/O) cars, and a No.1 Brake Test. Brake rigging is visually inspected during the Safety & Maintenance inspection. When the train is ready for the No.1 Brake Test, the locomotives supply air to the train and the integrity and continuity of the brake pipe are verified. A brake application, then brake release, are initiated, each followed by a visual inspection of the piston and brakes on each car of the train. The brake test typically takes 60-90 minutes. The results of the brake test, and any cars which did not pass, are communicated to the train crew. The train crew will note the results on paperwork which remains with the train throughout its cycle, and will verify compliance with the Train Brake Rules for quantity and distribution of cars with operative brakes:

- the train must have at least 95% of brakes operative when departing the *safety inspection location*;
- no more than two consecutive cars may have inoperative brakes;
- and the tail-end three cars must have operative brakes [2].

The train departs Golden and travels south to the coal mines near Sparwood, BC, and once loaded returns North through Golden where it joins the mainline West to the Pacific coast. Once the train is emptied at the coal terminal, it returns East on the mainline to Golden to complete the cycle.

USING TECHNOLOGY TO FIND INEFFECTIVE BRAKES

While piston travel and observation of a brake shoe next to the wheel tread during brake application can indicate that the air brakes on a railcar are responding, these rarely indicate the force with which the brake is applied – the brake *effectiveness*. CP began to examine using wheel temperatures as an indication of brake effectiveness in 2008. The focus was on using existing wayside detector technology to evaluate brakes during real-time operation as a train passes over the detector site.

Given a scenario where train brakes should be applied for a lengthy duration, for example to control speed on a long descending grade, wheel temperatures measured by a HWD that are substantially cooler than the train average wheel temperature would indicate a brake not properly applying. Conversely, in a situation where train braking typically should not occur, wheel temperatures substantially higher than the train average wheel temperature would indicate a brake not properly released.

CP's Wayside Detector Network

HBD sites on CP's mainline network are situated approximately every 25 miles (40 km), with a number of these sites combined with HWD systems. All 41 sites on the BC Coal Loop are combined HBD/HWD systems. Each site is equipped with a Serial Device Manager (SDM) which automatically downloads the train report from the HBD/HWD after each train passing and transmits it to a central office system for processing and reporting.

Cold Wheel Detection

The BC Coal Loop runs through CP's most rigorous territory, crossing three mountain ranges with steep grades of up to 2.4% in both eastward and westward directions. While this offers some hearty railroading experiences, it also provides an excellent scenario to test for cold wheels on a train.

After a loaded coal train passes through Golden, BC to join the mainline on the Mountain Subdivision, it travels west over the Purcell Mountain range to descend a 20-mile long (32 km) grade. The sustained descending grade averages approximately 2.2%, with a speed limit of 20 mph (32 km/h). An 18,000 ton loaded coal train will use a combination of air brakes and dynamic brakes to maintain authorized track speed on the grade.

All wheels on the train should increase in temperature over the course of the descent due to brake shoe friction on the wheel tread. Located on and in close proximity to the Mountain Subdivision grade, a portion of which is shown in Figure 2, are two HBD/HWD sites – one situated approximately one-third of the way down at Mile 95.1, and the other situated two miles beyond the end of the grade at Mile 111.7. These sites are marked for Cold Wheel detection.

Hot Wheel Detection

On tangent, level sections of track where it is expected that a train is not applying brakes, all wheels on the train should have relatively low rolling temperatures only. Two such locations on the BC Coal Loop containing a HWD site are marked for Hot Wheel detection. The empty coal train, departing Golden Southbound, immediately passes the first site on the Windermere Subdivision at Mile 123.3; this allows for immediate identification of possible handbrakes left on, or potential sticking brakes. After the train is loaded and traveling Westward on the mainline, it passes the second hot wheel site on the Mountain Subdivision at Mile 54.5, prior to reaching the Cold Wheel sites.

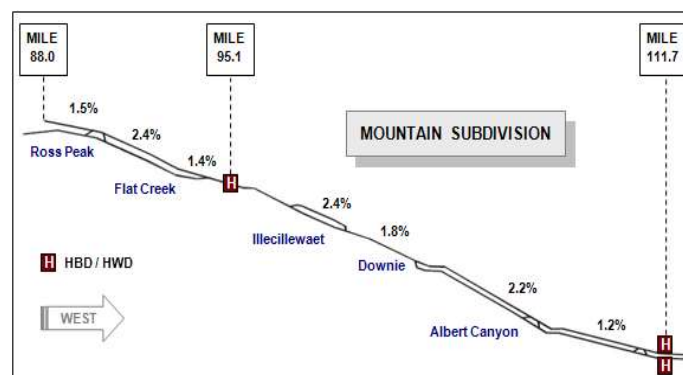


Figure 2: Westward 20-mile long descending grade, Mountain Subdivision

Highlighting the Outliers

Research conducted by Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR) to which all major North American Class I railroads belong, revealed that “a relative indication of wheel temperature is sufficient to identify abnormally hot or cold wheels (and thereby detect and diagnose brake problems) and take action accordingly” [3]. The standard HWD on the CP network measures wheel temperatures using bolometer or pyrometer technology, relative to ambient temperature.

Some HWD sites use a single hot wheel scanner set outside the rails aimed such that it captures wheel readings from both the near and far rail. Other HWD sites consist of one independent hot wheel scanner for each rail. To provide a more accurate indication of relative wheel temperatures, the individual wheel temperatures on each rail are normalized using a rail-based compensation factor, calculated for each rail as shown in Eq.1:

Eq.1: Compensation Factors

$$\begin{aligned} CF1 &= (1 + AVG2 / AVG1) / 2 \\ CF2 &= (1 + AVG1 / AVG2) / 2 \end{aligned}$$

where CF1 = Compensation Factor for Rail1
 CF2 = Compensation Factor for Rail2
 AVG1 = Average Wheel Temperature for Rail1 *
 AVG2 = Average Wheel Temperature for Rail2 *

* Rail Averages do not include wheel temperatures from locomotives or unidentified equipment

Each measured wheel temperature is then compensated using the appropriate rail compensation factor, as shown in Eq.2:

Eq.2: Compensated Wheel Temperatures

$$\text{WHL1\_COMP} = \text{CF1} * \text{WHL1}$$

$$\text{WHL2\_COMP} = \text{CF2} * \text{WHL2}$$

where WHL1_COMP = Compensated Wheel Temperature on Rail1
 WHL2_COMP = Compensated Wheel Temperature on Rail2
 WHL1 = Wheel Temperature on Rail1
 WHL2 = Wheel Temperature on Rail2

When plotting the wheel temperature distribution for a given coal train recorded at a given HBD, the wheel temperatures tend to align in a Normal Distribution. The empirical rule for normal distributions finds 99.7% of values lying within plus or minus three standard deviations from the population mean, or, within 3.0 sigma levels from the mean. Applying the empirical rule to the wheel temperature distribution for a given train provides a means of seeking the outliers: these are the wheels that are not receiving the expected brake application or release relative to the rest of the train.

For the brakes to be considered ineffective, the wheel temperature must not only be an outlier, but must also exceed an absolute threshold. Setting an absolute threshold considers the variability in distribution spread, avoiding alarms on wheels which may be a statistical outlier on a very narrow distribution, but still hold a temperature indicating acceptable brake reaction. The Cold Wheel threshold takes into account the presence of regular wheel rolling heat, approximately 50°F, when identifying wheels that are “cold”. Various cold wheel thresholds above 50°F were examined by identifying cars meeting the Sigma and absolute threshold levels, and validating subsequent, if any, brake defects found. Similarly, different Hot Wheel thresholds were evaluated, taking into account heat generated by hand brakes left on. Analysis of the population of wheels affected resulted in setting the absolute thresholds for coal trains as follows:

- Cold Wheel: $\leq 70^\circ\text{F}$
- Hot Wheel: $\geq 200^\circ\text{F}$

Figure 3 shows the wheel temperature distribution for a train passing the HWD at Mile 111.7 on the Mountain Subdivision. The train contained a car which had all four

wheels on the south rail highlighted as Cold Wheels, and the four wheels on the north rail very close to being cold wheels.

In addition to the sigma level and absolute threshold for identifying cold wheels, the Cold Wheel test must also ensure that the train is in a condition of long duration braking for wheels to heat up to a valid level in order to truly find cold wheel outliers. It is possible that a train could be stopped on the descending grade for a meet or otherwise, giving enough time for the wheel temperatures to cool down. In order for the cold wheel test to be valid for coal trains, the train average wheel temperature must be $\geq 200^\circ\text{F}$.

The Hot Wheel test does not use a train average check. As indicated before, the un-braked rolling temperature of wheels lies around 40-50 degrees F above ambient. Because designated hot wheel sites are chosen at locations where brakes are typically not applied, it is unlikely that even if brakes were applied for a short period of time, it would result in a considerable wheel temperature increase nearing the hot wheel threshold of 200°F.

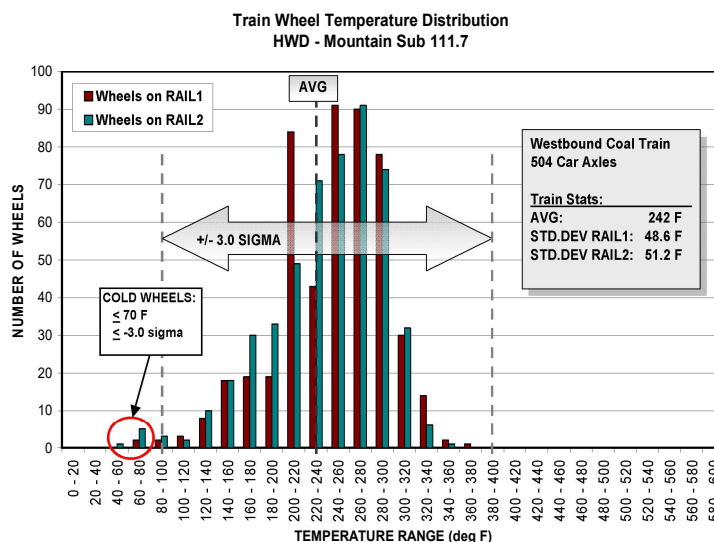


Figure 3: Train Wheel Temperature Distribution (excluding Locomotives)

In summary, the rules for identifying ineffective brakes on coal trains in the BC Coal Loop are:

Hot Wheels: Wheel Temperature $\geq 200^\circ\text{F}$
 Sigma Level ≥ 3.0

Cold Wheels: Wheel Temperature $\leq 70^\circ\text{F}$
 Sigma Level ≤ -3.0
 Train Average Wheel Temperature $\geq 200^\circ\text{F}$

Central Office Equipment Health Monitoring System

CP began developing its own internal Equipment Health Monitoring System (EHMS) in 2004. EHMS consists of a component for receiving wayside detector data transmissions – by land line telephone communication, cellular communication, and File Transfer Protocol (FTP); a Business Rules Management System, or Rules Engine, for processing the detector information and highlighting alarms; a central database for storing the detector information and alarms; and a component for publishing alarm information to various third parties and other systems.

The wayside detector data communication is automated, with transmission immediately following the train passing. Most HBD/HWDs on the CP network do not contain a vehicle identification module, and only supply data relative to the axle position within the train. The EHMS process enhances the received detector information with vehicle identification information from Automatic Equipment Identification (AEI) sites in the vicinity through an intricate train and equipment matching algorithm.

EHMS publishes equipment alarms via email, pop-up notifications on Rail Traffic Controller (RTC) consoles, an online interactive reporting application, and to a separate car bad order information system used by mechanical shop staff.

Identifying and publishing the alarms is dependent on all systems – from the HWD to the components of EHMS – being continuously alive. EHMS is supported 24 hours a day, 7 days a week. In addition to performing rules analysis and highlighting alarms, it also performs wayside detector heartbeat monitoring. Appropriate parties will be notified when a detector does not report an expected train report.

AUTOMATING THE TRAIN BRAKE EFFECTIVENESS TEST ON THE BC COAL LOOP

Once the theory and rules for the ATBE test were developed, CP spent the next year and a half (Oct.2008 – Apr.2010) validating the process with the mechanical facility in Golden. Golden received automated notification via email from EHMS listing any cars on a given train identified with cold wheels. The B/O cars were removed from the train at the end of its cycle and brought into the repair shop for inspection, testing and repair. Testing included undergoing a mandatory single car air brake test (SCABT) as prescribed by AAR Standard S-486. The results through the validation period showed very good correlation between highlighted cold wheels and brake-related defects, with over 80% of B/O cars undergoing brake-related repairs.

To apply to TC for an exemption from specific elements of the Train Brake Rules, specifically those referencing the requirement for a manual brake test at the Golden safety inspection location, CP needed to demonstrate an end-to-end process that followed the car from initial defect identification through to repair. The process must also demonstrate compliance with other key requirements within the Train Brake

Rules outside of the exemption request. In particular, the process must continue to communicate train brake defect information to the train crew and to Golden mechanical facility, and train brake status information must continue to be documented and retained for a specified period of time.

Additionally, as the foundation for the ATBE test, the designated hot and cold wheel detectors must be shown to be in good working order and performing as intended. HBD/HWDs are maintained, inspected and calibrated at a minimum according to manufacturer specifications, captured in CP's Red Book of Signals & Communications Requirements. Each HBD/HWD train report undergoes a series of validation checks during EHMS processing, mainly focusing on confidence that the HBD/HWD successfully reported all axles and correctly related bearing and wheel temperature readings to the correct axle. If the train report does not pass the validation checks, it is marked as invalid and may not be used in the compilation of the final ATBE status.

Besides the obvious ways in which the ATBE Test differs from the No.1 Brake Test in terms of identifying brake effectiveness, it also differs in that the brakes are not tested at just one location. There are two hot wheel and two cold wheel inspection sites situated at different parts of the cycle. Figure 4 maps the process at the key points on the BC Coal Loop, with the "H" indicating an HBD/HWD site:

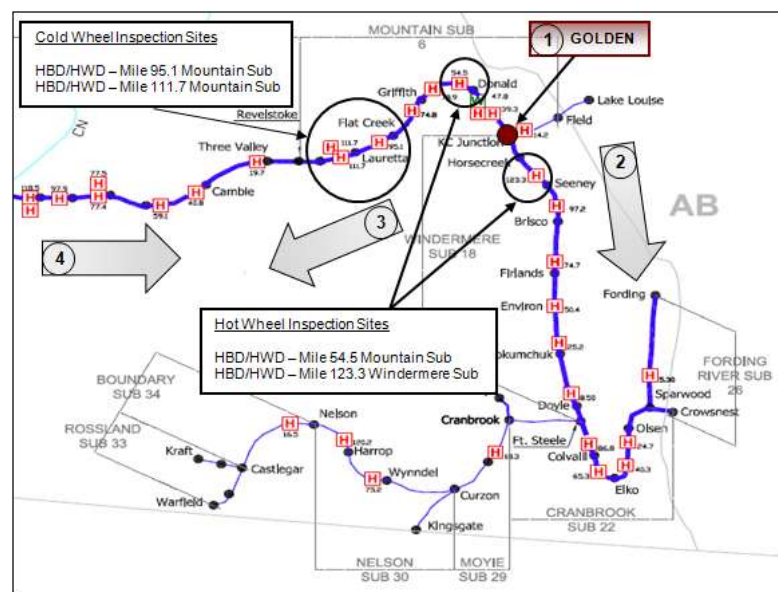


Figure 4: ATBE Test Process on BC Coal Loop

1. Cycle Start: Empty Train at Golden Mechanical Facility
 - Train undergoes Safety & Maintenance Inspection
 - Removal of any B/O cars from train; replacement with pre-brake-tested spare cars

2. Empty Train travels South to Coal Mines

- Train passes Hot Wheel Inspection Site – Mile 123.3 Windermere Sub
- EHMS publishes any hot wheel alarms, which are transmitted to the train crew via RTC (train dispatch)
- If the train crew is notified of hot wheel alarms, they will stop the train to inspect for sticking brakes, or a left-on hand brake
- If the problem cannot be rectified, the train crew will have air brakes cut out on the problem car for remainder of cycle; the train crew will update brake status paperwork, and ensure compliance with Train Brake Rules regarding distribution and quantity of inoperative brakes within the train
- In the event the train is no longer in compliance with the Train Brake Rules regarding operative brakes, the train crew will set off or remarshal cars in order to be in compliance
- EHMS sets “B/O” status on any alarmed cars in the bad order information system for mechanical staff

3. Loaded Train travels West to Pacific Coast

- Train passes Hot Wheel Inspection Site – Mile 54.5 Mountain Sub
- Same process followed as described for hot wheels in section 2.
- Train passes Cold Wheel Inspection Sites – Mile 95.1 and Mile 111.7 Mountain Sub
- EHMS publishes any cold wheel alarms, which are transmitted to the train crew via RTC
- If the train crew is notified of cold wheel alarms, they will note the cars on the brake status paper work, and ensure compliance with Train Brake Rules regarding distribution and quantity of inoperative brakes within the train
- In the event the train is no longer in compliance with the Train Brake Rules regarding operative brakes, the train crew will set off or remarshal cars in order to be in compliance
- EHMS sets “B/O” status on any alarmed cars in the bad order information system for mechanical staff

4. Empty Train travels East to Golden Mechanical Facility

- Prior to the empty train arrival at Golden Mechanical Facility, a TDTI report will be compiled by EHMS and published with either:
 - i. A list of all cars on the train identified with hot and/or cold wheel alarms, or
 - ii. A message indicating no alarms found on the train, or
 - iii. A message indicating EHMS could not retrieve at least once successful hot wheel test and one successful cold wheel test from the database, and a No.1 Brake Test is therefore required in Golden

- In the event a train arriving empty into Golden has not been preceded by a TDTI report, Golden will perform the full No.1 Brake Test on the train

Once the empty train arrives in Golden, any cars with hot and/or cold wheel alarms must be removed from the train and brought to the shop for testing and repairs. The “B/O” status in the bad order information system will prevent the cars from being added to train consist documentation. Alarm details such as the type of alarm (hot, cold) and the wheel location of the alarm are provided and help the Carmen in testing and repairing any defects. All repairs are recorded in the bad order information system before the car is released.

WAIVER FROM TRANSPORT CANADA FOR EXEMPTION FROM PERFORMING THE NO.1 BRAKE TEST ON COAL TRAINS OPERATING IN THE BC COAL LOOP

Internal Risk Assessment

A formal risk assessment was conducted in Golden in April 2010 which included Union representation from both mechanical services and train crew unions, and management representation from both local operations and head office. The purpose was to review the safety implications of replacing the No.1 Brake Test with the ATBE Test, as well as ensure that all elements outlined in the Train Brake Rules would continue to be met or exceeded by the ATBE process. The final outcome found that no risks associated with the ATBE Test required mitigating measures. CP nevertheless developed mitigating measures for the lower risk items identified, such as employee education and process auditing.

Exemption Application

On 30 June, 2010, CP filed an application with TC requesting an exemption from sections of the Train Brake Rules, specifically those items mandating performance of the No.1 Brake Test. The exemption request targets coal trains in the BC Coal Loop, where the brakes will be evaluated by the ATBE test. There followed a one year review during which TC and CP were engaged in ongoing question and answer sessions, and a further request from TC that CP run both the regulated No.1 Brake Test and ATBE test in parallel for a number of months, tracking all results.

Parallel Process

The parallel process tracking was conducted for four months, from October 2010 to January 2011. Figure 5 summarizes the results for the cars made B/O by each process. The first set of columns of the month (shown in blue) represent the cars identified by the ATBE process, while the second set of columns (shown in green) represent those identified by the Carmen during the No.1 Brake Test:

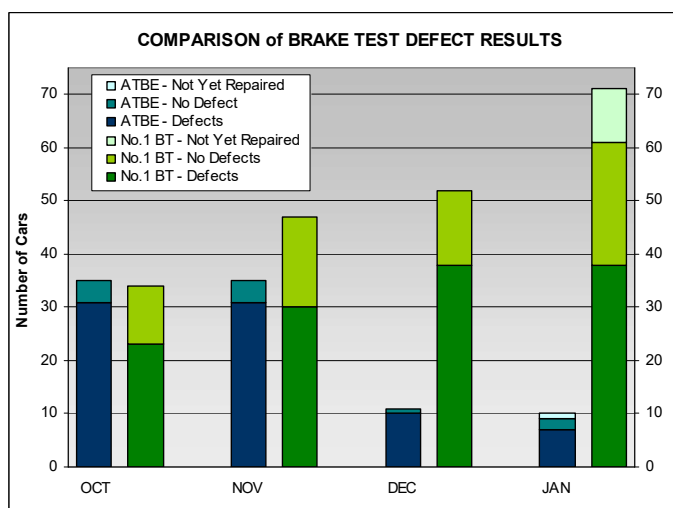


Figure 5: ATBE and No.1 BT Defect Results

Each column also shows the portion of B/O cars from each process that were found to have brake-related defects (the darker portion: "... – Defects"), and those that were found to have no brake-related defects (the lighter portion: "... – No Defects"). At the end of the month of January when results were compiled for TC, a number of the B/O cars had not yet been inspected and repaired, and are shown as "... – Not Yet Repaired". December 2010 and January 2011 brought large amounts of snow, resulting in lower successful reporting from the HBD/HWDs for the ATBE test, and therefore lower defective cars identified by the process.

The defect rate, shown in Figure 6, was considerably higher for the cars identified by the ATBE test, compared to that of the cars identified by the Carmen (values for January disregard cars not yet tested and repaired):

	ATBE	NO. 1 BT
OCT	89 %	68 %
NOV	89 %	64 %
DEC	91 %	73 %
JAN	79 %	62 %

Figure 6: ATBE and No.1 BT Defect Rates

The actual cars identified by the Carmen during the No.1 Brake Test and those identified by the ATBE process were for the most part different. To further understand the cars identified by the Carmen that were not identified by the ATBE test, the HWD wheel temperature data from the previous trip was examined to see if there was any indication the wheels might be trending towards ATBE alarm levels. Figure 7 shows a trending breakdown of the B/O cars identified by the Carmen:

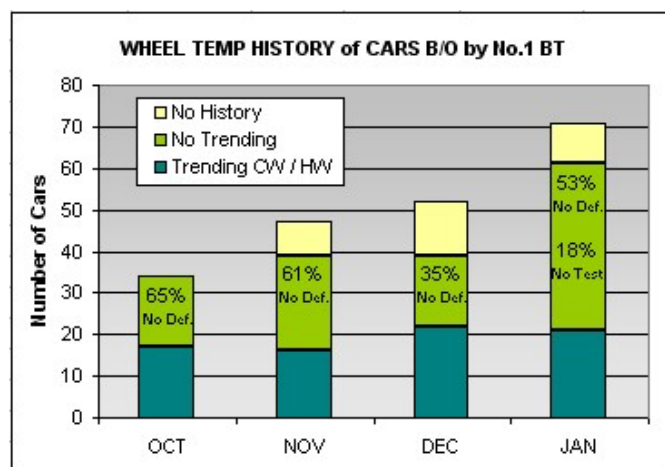


Figure 7: Breakdown of Cars found B/O during No.1 BT trending towards Hot / Cold Wheel Alarm Levels

The breakdown indicates that a portion of the cars identified by the Carmen were trending towards the hot or cold wheel alarm levels (shown in blue: "Trending CW / HW"):

- OCT: 50% of B/O cars trending cold / hot
- NOV: 34% of B/O cars trending cold / hot
- DEC: 42% of B/O cars trending cold / hot
- JAN: 30% of B/O cars trending cold / hot

These cars would have been subsequently identified as alarms by the ATBE process during their next trips.

The cars that did not appear to be trending (shown in green: "No Trending") contained a high rate of cars with no brake-related defects found, even after receiving an Automated Single Car Air Brake Test. This count is indicated by the percentages shown in Figure 7. A portion of the cars did not have recent prior history (shown in yellow: "No History") – they may have been parked, or newly introduced into the BC Coal Loop.

The cars that did not appear to be trending, but were found with defects by the Carmen during the Brake Tests, showed the following brake-related issues:

- Leaking brake pipe and combined reservoir piping
- Bad order slack adjusters
- Broken Empty/Load sensor arms

These leaking pipes and the broken components should have been found during train's Safety & Maintenance inspections. As to the slack adjusters, these are mechanical devices that could fail without prior notice and at any time. They would not "trend" toward a defective condition or state.

The vast majority of the cars identified by the ATBE process, found with defects, were cars that were not identified by the Carmen. Most of these cars required replacement to their Service or Emergency brake valve portions. A small number of cars identified by the Carmen during the No.1 Brake Test were left in the train with the control valves cut out. These cars subsequently received a Cold wheel alarm from the ATBE test, proving once again that the ATBE Process was working properly. Figure 8 shows the percentage of cars identified uniquely by each process. Values for the ATBE test are based on total cars with defects found; values for the No.1 Brake Test are based on “No Trending” amounts as displayed in Figure 7, and disregards those cars with no defects found.

	ATBE	NO. 1 BT
OCT	94 %	35 %
NOV	87 %	39 %
DEC	90 %	65 %
JAN	63 %	48 %

Figure 8: Percentage of cars found uniquely by each the ATBE test and the No.1 BT

The parallel process demonstrated that the ATBE process found air brake defects that were almost impossible to find during a stationary visual brake inspection. These brake malfunctions would only be apparent during the actual braking of a train. The defects found by Carmen were mainly minor leakage conditions that would not be extremely detrimental to the proper brake effectiveness of a train. As a conclusion, we did determine that the ATBE test is more accurate in evaluating brake dynamic performance, or brake *effectiveness*.

Waiver Granted by Transport Canada

On 18 June, 2011, nearly a year after the initial exemption application was filed, CP obtained a Waiver from TC allowing the replacement of the manual No.1 Brake Test by the HWD-based ATBE test on coal trains running in the BC Coal Loop. The Waiver came with a set of 20 requirements and conditions outlining:

- the specifics of the ATBE test supplied by CP (designated HWD site locations, rules, thresholds),
- conditions covering wayside detector health,
- requirements for supplying detailed processes and training to the Mechanical shop staff, Train Crews and RTCs with respect to their roles, and
- specifications for monthly reporting back to TC on successful ATBE tests and defect results.

TC has set a time limit of 18 months for improving the successful ATBE rate, at which point CP expects the requirements for monthly reporting may be re-evaluated. The remaining requirements and conditions will remain in effect for the duration of the exemption.

Brake rigging and brake shoes continue to be inspected during the regulated Safety & Maintenance inspection, while train line flow and leakage requirements remain the responsibility of the Train Crews.

Full Process Implementation

CP launched the full ATBE test process on 27 September, 2011. Each coal train running in the BC Coal Loop received its last No.1 Brake Test and officially entered into the ATBE process. CP continues to monitor the inspection and repair results of cars identified by the ATBE test, and report these results on a monthly basis to TC. From results to date, the ATBE process continues to find a high rate of defective cars by both the Cold and Hot wheel alarm thresholds. The Hot Wheel alarm process is also identifying a number of cars en-route with handbrakes left on. These cars are now inspected immediately by the train crews and the hand brakes released, causing no further damage to the wheels. These cars are however still removed from the train for inspection and repair at the end of the train cycle, for a more detailed testing and inspection.

The most challenging part of the process is achieving a successful match of the HBD/HWD data to a coal train symbol and consist during the EHMS portion of the process. If data cannot be matched to a coal train symbol, that train misses a potential brake effectiveness evaluation. Missing evaluations from both cold or both hot wheel HBD/HWD sites results in the train defaulting back to a No.1 Brake Test upon end of the cycle at the Golden mechanical facility. Tracking successful ATBE test results show a 75% positive test rate. CP continues to actively pursue improvements to the EHMS train matching algorithm.

CONCLUSIONS

The ATBE test process at CP is a change from a subjective manual and visual inspection of railcar air brakes to an automated technology-based inspection. The ATBE approach to evaluating brake performance is not only equivalent to the existing Train Brake Rules No.1 Brake Test, but exceeds it in its ability to evaluate beyond brake responsiveness and tests for brake *effectiveness*.

TDIT is not just a local phenomenon – railroads across North America are developing ideas to evaluate railcar and component health using wayside detectors, and working with the AAR to test, validate and advance these ideas. Similar to CP's No.1 Brake Test exemption, American Railroads are investigating relief from the FRA regulated 1,000-mile inspection, the Class 1A brake test [4].

The benefits are improvements to safety, to equipment and infrastructure health, and to operational efficiency through proactive maintenance and online inspections during regular train operations.

ACKNOWLEDGMENTS

The authors would like to acknowledge the CP employees at the Golden, BC Mechanical Facility for their contributions and continued efforts in support of the ATBE process.

REFERENCES

- [1] S. Cummings, C. Pinney, Analysis of Wheelset Removals, Transportation Technology Center Inc., Technology Digest TD-10-003, March 2010
- [2] Transport Canada, Railway Freight and Passenger Train Brake Inspection and Safety Rules, TC O 0-95, October 1, 2008
- [3] S. Cummings, H. Tournay, Kari Gonzales, Wayside Wheel Temperature Detector Test, Transportation Technology Center Inc., Technology Digest TD-08-013, March 2008
- [4] J. A. Robeda, Automating the Class 1A Brake Test – 1,000-mile Inspection, Transportation Technology Center Inc., Technology Digest LD/TD-10-001, March 2010

TC 15 ATTACHMENT 3: UPDATE ON TECHNOLOGY DRIVEN TRAIN INSPECTIONS AT CANADIAN PACIFIC

Update on Technology Driven Train Inspections at Canadian Pacific

Michelle Jamieson, P.Eng, Abe Aronian, P.Eng
Canadian Pacific, Calgary, Canada

Whether you are a supplier or a customer, in the railroad industry or the oil industry, at a desk or in the field, we are all facing increased focus on using technology to improve what we do – to make tasks more efficient, safer and more reliable. It is not only about using existing technology to implement new ideas, or implementing new technology to improve existing ideas. To use technology effectively, we need the technology, we need to understand the technology, and we need a solid process that considers the full task from beginning to end, building on our own human experience.

Since the end of September, 2011, Canadian Pacific (CP) has been applying these principles in the ongoing application of its Automated Train Brake Effectiveness (ATBE) process. The ATBE process uses existing wayside detector technology to evaluate the brake status of each car on a train as it travels over the detector site at track speed. The automated gathering, processing and publishing of this information has allowed CP to obtain an exemption from performing the Transport Canada (TC) regulated No.1 Brake Test on its BC coal train fleet, providing the train receives a valid and success ATBE test.

Abbreviations

ATBE	Automated Train Brake Effectiveness
BC	British Columbia
CP	Canadian Pacific
EHMS	Equipment Health Monitoring System
HBD	Hot Box Detector
SCABT	Single Car Air Brake Test
TC	Transport Canada
TTCI	Transportation Technology Center, Inc.
WTD	Wheel Temperature Detector

Background

CP has a network of over 400 combined Hot Box Detector / Wheel Temperature Detector (HBD-WTD) sites situated approximately every 25 miles on the primary traffic lines of its 14,400 mile network. The HBD-WTD uses infrared technology to measure the temperature of each wheel and each bearing relative to ambient temperature as the train passes over the detector site. The railroad industry has seen both technical publications and individual railroad initiatives which support the use of wheel temperatures as an indication of railcar brake effectiveness. For example, research conducted by the Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR), concluded that “a relative indication of wheel temperature is sufficient to identify abnormally cold or hot wheels (and thereby detect and diagnose brake problems) and take action accordingly” [1].

Identifying Cold / Hot Wheels

The BC coal trains are a captive of unit trains which cycle between the coal mines in southeast British Columbia (BC) and export terminals on BC's west coast. They run through some of CP's most rigorous terrain in a 1,500-mile cycle, crossing three mountain ranges with steep grades of up to 2.4% in both eastward and westward directions. During each cycle, the empty coal train passes through the designated Mechanical Safety Inspection location, where railcars are inspected and bad order cars are removed. Figure 1 shows CP's track network, with the BC Coal route highlighted in blue.



Figure 1: CP Track Network – BC Coal Route highlighted in blue

The mountain grades provide plenty of opportunity for a lengthy brake application as the 22,000 ton loaded coal trains travel west to the coast. On a long descending grade, where it is expected that wheels will heat up due to brake shoe friction on the wheel, a wheel temperature measured by a WTD that is substantially lower than the train average wheel temperature would indicate that brakes are not effectively applied. Conversely, on flat tangent track, where it is expected that brakes are typically not applied, a wheel which is substantially hotter relative to the train average wheel temperature would indicate sticking or non-releasing brakes. The ATBE process focuses on identifying these “outliers” – wheels which are behaving noticeably different than expected, relative to the other wheels on a train.

CP designated two individual “Cold Wheel” and two individual “Hot Wheel” WTD sites on the BC coal route. WTD reports from these designated sites are passed through statistical evaluation within CP's central office Equipment Health Monitoring System (EHMS). The statistical evaluation assumes a normal wheel temperature distribution, with expected wheel temperature stabilization at both the Cold and Hot Wheel site locations.

Cold Wheel outliers are identified by meeting the following criteria:

- Wheel temperature is below a given temperature threshold
- Wheel temperature is at least three standard deviations below the train mean wheel temperature

- Train mean wheel temperature is above a given temperature threshold in order to confirm train is in state of brake application

Hot wheel outliers are identified by meeting the following criteria:

- Wheel temperature is above a given temperature threshold
- Wheel temperature is at least three standard deviations above the train mean wheel temperature

ATBE Process Overview

Identification of potentially ineffective brakes by cold and hot wheel analysis is only one step. The process which turns this information into a *technology-based inspection* must:

- Validate the data being used,
- Publish the processed information,
- Maintain an auditable log of process events, and
- Provide traceable reporting which meets regulatory requirements.

To meet the criteria above, CP's ATBE process follows the following steps during a train cycle:

1. Train departs the designated Mechanical Safety Inspection Location with 100% operative brakes.
2. Train passes designated Hot Wheel and Cold Wheel WTD sites, shown in Figure 2:
 - a. First designated hot wheel site located immediately after initial departure from Mechanical Safety Inspection Location, in order to catch hand brakes left on;
 - b. The train crew must stop and inspect all hot wheel alarms, checking for hand brakes and sticking brakes – if the issue cannot be resolved, car brakes must be cut out;
 - c. Remaining hot and cold wheel sites located on mainline as loaded train travels to coast.
3. WTD train reports are automatically transmitted real-time to EHMS:
 - a. EHMS validates the data integrity of each report;
 - b. If EHMS identifies any outliers in a valid report, wheel-based alarms are published to mechanical staff, Train Crews (via Rail Traffic Controller), and CP's car maintenance system;
 - c. EHMS logs processing events: train report received from WTD, processing complete, valid/invalid report, any alarms published to 3rd party applications;
 - d. Train Crews add published alarm information to their Train Brake Information forms, ensuring operational brake requirements continue to be met, or taking action if not.
4. Final ATBE Report is published to designated Mechanical Safety Inspection Location prior to train return at end of cycle:
 - a. If any hot/cold wheel alarms exist for cars on train, alarmed car(s) and wheel(s) are listed;
 - b. If no hot and/or cold wheel alarms exist for cars on train, "no alarms" is indicated for each the hot and/or cold wheel case;
 - c. If status of a given car cannot be verified, individual cars requiring a No.1 Brake Test are listed;
 - d. If train did not receive at least one valid hot wheel and one valid cold wheel test, requirement for No.1 Brake Test is indicated.
5. Upon train arrival of the empty train back at the designated Mechanical Safety Inspection Location, any alarmed cars are removed from the train and sent to the repair shop:
 - a. All alarmed cars must receive an Single Car Air Brake Test (SCABT) using an automated device prior to being returned to active service;

- b. If the car passes the SCABT with no defect found, it will undergo an Extended Brake Cylinder Leakage Test using the automated Single Car Test Device.
6. Brake tested cars are added a train which has had cars removed, ensuring the train departs with 100% brake status.

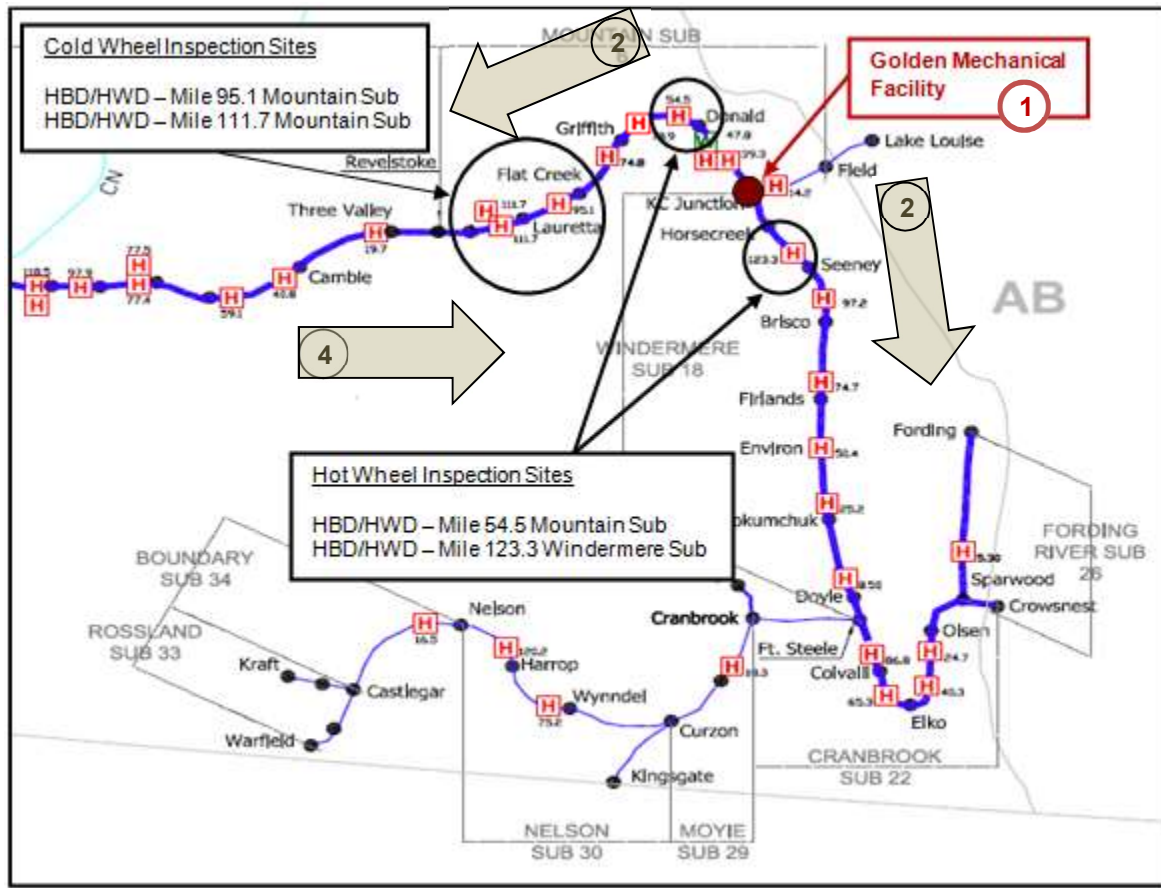


Figure 2: Detailed view of BC Coal Train Route

The EHMS application stores all train report information, alarms published, and processed report log events. In addition, shop personnel can access the HBD-WTD data from a user interface, including the ATBE reports.

In the event a successful ATBE report is not received at the designated Mechanical Safety Inspection Location prior to train arrival, the default remains to perform the manual No.1 Brake Test.

ATBE Outcome to Date

CP was granted an exemption from performing the regulated manual No. 1 Brake Test by TC in 2011. The exemption came with twenty conditions covering designated cold and hot WTD sites, WTD maintenance, cold and hot wheel alarm thresholds, required actions for alarms and failed tests, and a concentrated effort to improve the number of successful tests.

In the nearly three years since implementation, CP has run over 4,400 coal trains through the ATBE process, from October 2011 to July 2014 inclusive. 2014 introduced some interesting challenges, which will be discussed further, so is excluded from the summarized outcome below:

- 3,500 coal trains passed through the ATBE process (2011-2013)
- 96% received a valid ATBE Test
- 147 trains (4%) required a manual No.1 Brake Test
- Over 485,000 car passings have received an air brake inspection by the ATBE process.

Of the individual cars that underwent a successful ATBE test:

- 1,313 cars received at least one or more cold wheel alarms
 - this results in a car alarm rate of 0.09%
 - 69% of alarmed cars received brake related repairs
 - some cars with no defect found did alarm again after leaving the shop, resulting in the Carmen digging deeper to locate the root cause
- 449 cars received at least one or more hot wheel alarms
 - this results in a car alarm rate of 0.27%
 - 14% of alarmed cars were due to hand brakes left on with departure from Golden
 - 66% of alarmed cars received brake related repairs (including releasing hand brakes!).

On a train level:

- 15% of valid trains received at least one or more cold wheel alarms
- 8% of valid trains received at least one or more hot wheel alarms.

Note that some cars will have both hot and cold wheel alarms, in the event the brakes were cut out after a hot wheel alarm.

The time taken to perform the manual No.1 Brake Test while with the train stationary in the yard was approximately 30-90 minutes, depending on the season, outdoor temperature and yard congestion. That time is saved from the train total cycle time under the ATBE process, with the train undergoing a more efficient brake evaluation while in service, at track speed.

An evaluation of brake related repairs during the first year of ATBE process operation showed an evident increase in brake-related parts consumption and repairs at Golden shop, which can be translated into an increase in the overall health and safety of the coal fleet cars.

Following is a review of some of the findings and improvements to the ATBE process based on what has been learned in the three years since implementation. The mechanical staff in Golden trust the ATBE evaluations and have found some interesting defects that are very unlikely to be visible to a manual inspection. By learning and improving, the process continues to become more reliable.

Learnings and Improvements

Every process begins with an idea and a “happy path”, and over time is refined and improved as experience uncovers the many variations to and deviations from the happy path. This same experience also contributes concrete support to the premises of the initial idea.

The following planned and learned items have led to further understanding and improvements to the ATBE process:

1. Using WTDs with integrated Tag Readers
2. Does one single cold or hot wheel indicate potential brake-related issues on a car?
3. What is a wheel temperature of zero degrees Fahrenheit (degrees F)?
4. Monitoring train report validation failures
5. WTD scanner technology and effects on output
6. Adaption from train-based to car-based data processing

Integrated Tag Reader

In 2012, CP initiated a three-year replacement and upgrade for its 400+ HBD-WTD sites. The new model incorporated an integrated automated communication module allowing for real-time train data transmission to CP's central office system, EHMS, and the option of an integrated tag reader. The tag reader would produce HBD-WTD reports not just with bearing and wheel temperature readings, but with the readings associated to each equipment initial and number (equipment ID) read by the tag reader.

Train reports from detectors without integrated tag readers depend on a "virtual AEI" matching algorithm in EHMS which matches the reported detector information with train consist information, associating the railcar component readings from the detector to the appropriate equipment IDs. Successfully identifying a railcar's equipment ID allows ongoing tracking of the railcar status through publication of alarms to train crews and the car management system. Matching to the train consist information also provides the train symbol, allowing EHMS to identify the coal trains for the ATBE process.

While the EHMS virtual AEI algorithm was on average 90% successful at identifying the train and equipment details for the ATBE WTD sites with the old model non-tag-reader WTDs, supplying each upgraded ATBE site with an integrated tag reader boosted the successful identification of the coal trains to 94%, thus decreasing the risk of a coal train not receiving the ATBE evaluation. Without a successful ATBE evaluation at at least one Cold Wheel and Hot Wheel site, the train must receive the manual No.1 Brake Test back in Golden.

Potentially achieving 100% match rate is affected by a number of factors, such as the availability of updated consist information from external systems, train consist modification due to unplanned car set-offs and lifts, trains slowing/stopping while passing over an HBD-WTD site resulting in truncated reports, and work trains and road switchers which may not have available consist information.

How Many Cold or Hot Wheels Indicate a Bad Order Car?

Does one cold or one hot wheel on a given car constitute a car with potentially inoperative brakes? For the sake of the TC exemption it does. However, experience has also shown the validity of this assumption. Reviewing cars in 2014 with at least one or more cold wheel alarms, the distribution of wheel alarms, displayed in Figure X, shows that 51% of cars had only one wheel reaching alarm limits.

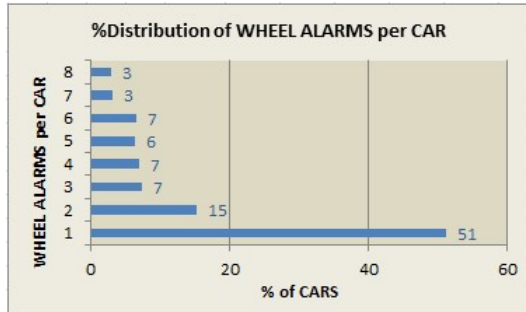


Figure X: Distribution of Wheel Alarms per Car

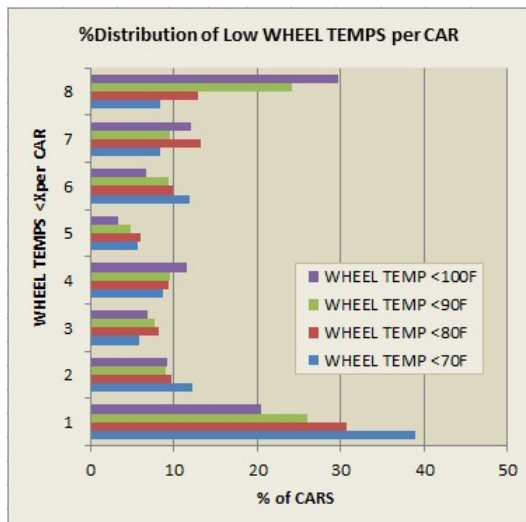


Figure Y: Distribution of Wheel Temps Less than a Given Temperature per Car

Looking at the actual wheel temperatures of these alarmed cars, however, shows that while all wheels on a car or truck may not have alarmed, many were still showing comparatively colder temperatures than the minimum required train average wheel temperature. Figure Y shows the distribution of the number of wheels on an alarmed car that are below a given temperature. Nearly 30% of cars had all eight wheels with temperatures below 100F, even if only 3% of cars, from Figure X, had all eight wheels alarmed.

The actual wheel location of the alarm acts as an indicator to the Carman repairing the car. Per the “10 Commandments of ATBE” for proper brake inspection prepared in the initial days of the ATBE process, when a bad order railcar comes into the shop with a cold or hot wheel alarm, the first thing a Carman checks is the wheel alarm location(s) [2]. This helps focus the inspection for brake related issues. In addition, a Carman will often check the other reported wheel temperatures on the car at the time of alarm as further information to help narrow the investigation for potential defects.

Brake related problems are not always truck-based or car-based defects, nor are they only air-related (valves, piping, brake cylinders or empty/load devices). One railcar of note had been through the shop more than once within a short span of time with a repeating cold

wheel alarm on the R2 wheel. Each time, the railcar passed the automated SCABT, sustained no leakage during an extended leakage test, and did not have alarms on any other wheel. A visual check of brake rigging and brake beams found no visible issues. It was noted that during the extended leakage test, the R2 wheel experienced less braking force compared to the other wheels. The truck was eventually removed, where it was discovered that the brake beam guide had noticeable wear and a burr at the R2 wheel location. This was likely impeding the brake beam from applying adequate brake force to the wheel.

In another case, a railcar came into the shop with a cold wheel alarm on the R4 wheel. Verification of the other wheel temperatures on the railcar at the time the alarm was raised showed normal temperatures relative to the train average. The shop foreman went into the car management system to make a note to the Carmen to investigate closely at the R4 wheel location, and found that the car already had a logged defect for a worn brake beam head at the R4 wheel location. The cold wheel alarm confirmed the effect of the defect on brake effectiveness at the R4 location.

Other mechanical issues that have been identified and repaired from the cold and hot wheel alarms include:

- excessive piston travel
- defective slack adjuster – both body- and truck-mounted
- impeded brake beam guides – shown in Figure X
- broken and/or bent brake beam – shown in Figure Y and Z
- shifted brake beam strut
- binding brake rigging
- worn brake levers
- missing pins on brake rods, levers and slack adjusters
- worn brake shoes



Figure X: Impeded brake beam guide



Figure Y: Worn brake beam



Figure Z: Worn brake beam - removed

Some of these defects – such as worn brake beam guides or binding brake rigging – would not be visible during the manual No.1 Brake Test or inspection.

Wheel Temperature Readings of Zero degrees F Above Ambient Temperature

It is expected that a rolling wheel will retain some degree of heat above ambient temperature. When alarm publications began to appear during the first winter of the ATBE process with cold wheels showing zero degrees F, it raised questions despite the cold weather. When one train report resulted in 14 cars with cold wheels, 13 of them registering wheel temperatures of zero degrees F, a deeper investigation followed. Working with the Signals & Communications technicians, it was found that heavy snow can affect the scanner such that the shutter can stick and wheel heat cannot be measured, or accumulated or blowing snow can affect the scanner read. While the HBD-WTD sites are equipped with blowers to keep the site clear of snow, the blower itself acts as one more component contributing to the success or failure of the ATBE test. If the blower does not function as intended, the WTD output becomes comprised.

To address the wheel temperature readings of zero degrees F, readings are filtered from alarm publication if not greater than zero. Furthermore, if a train has more than 5% of cars with at least one wheel temperature reading of zero, the train report is rendered invalid as the WTD could not give a reliable indication of train brake status. If the train report meets all other validations other than this one, a non-zero cold wheel alarm can still be identified and published, so that the car is removed at the end of the cycle for air brake defect investigation and repair. There is the risk that the alarm could be a false positive, however it was determined that this was the better approach versus disregarding potentially valid cold wheels

Train Report Validation

The purpose of the ATBE process is to maintain railcar brake reliability. Naturally, the reliability of the technology used to assess the brake reliability is as important. Since inception, each train report

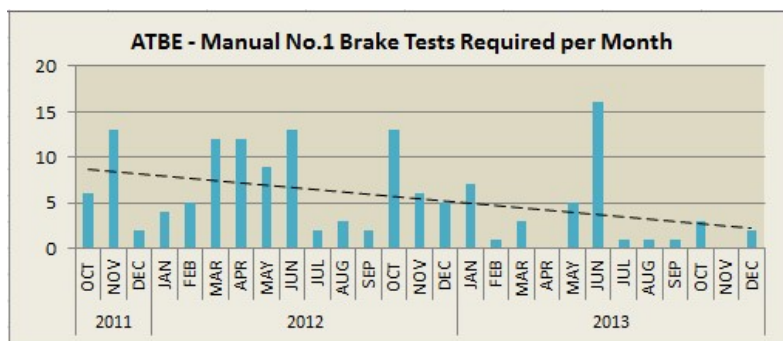


Figure X:

the number of manual No. 1 Brake tests required as a result of invalid (or missing) trains reports has decreased. Figure X shows the number of manual No.1 Brake Tests required each month from 2011 to 2013 along with the decreasing trend, addressing the TC exemption condition related to improving successful ATBE test rates.

Figure X shows the successful validation rates at each Cold and Hot Wheel WTD location, along with the degree of each validation failure during the first month of ATBE implementation (October 2011). During this month, the WTD at Mountain 95.1 had the lowest pass rate at just below 80%. The primary cause of validation failure (shown as pink in Figure X) was the difference in reported transducer counts from each of the detector's four transducers, which contribute to determining the total axle count. The second noticeable cause of validation failure was attributed to failing the minimum train

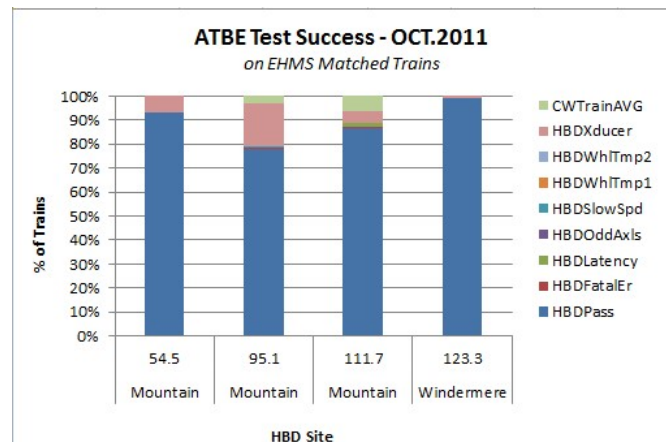


Figure X:

average wheel temperature requirement to ensure the train is braking at cold wheel WTD sites (light green in Figure X). This can also be seen as an issue at the Mountain 111.7 location.

When, in January 2014, the new HBD-WTD models were brought into the ATBE process, the expectation was a general increase in successful tests with the integrated AEI. Instead, we saw a dismal success rate at the cold wheel sites of only 20-30%. Figure Y shows the vast majority of failures being due to the minimum Train Average Wheel Temperature requirement not being met (light green).

Prior to the implementation of the new detector model, both models had been co-located at one of the cold wheel sites in order to evaluate the performance of the new model relative to the old. While the initial evaluation found some differences in the individual model output, it had been determined that it was not drastic enough to merit changes to the ATBE threshold limits. Based on the January 2014 validation output, this was going to require a more in-depth review.

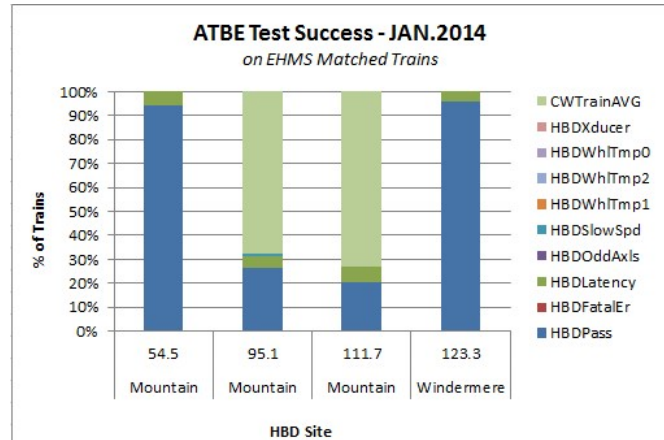


Figure Y:

Scanner Technology

The old HBD-WTD model scanners use bolometer technology to measure the bearing and wheel heat. The new HBD-WTD model scanners use pyrometer technology. While both technologies essentially measure changes in infrared radiation, the manner in which the scanner measures and the HBD-WTD processor processes the input results in differences in the output.

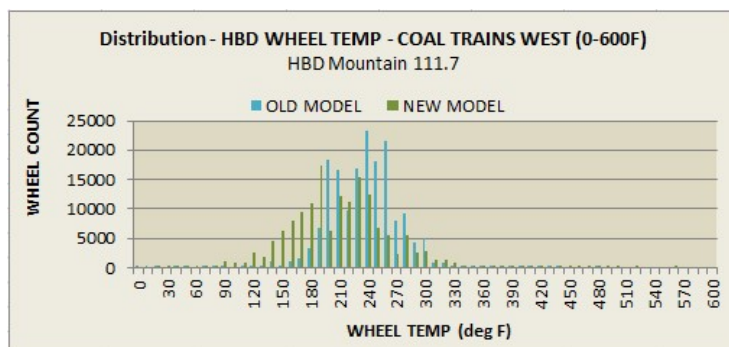


Figure X:

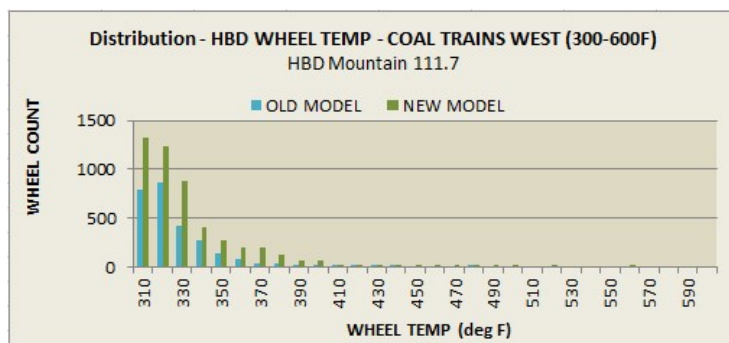


Figure Y:

The high-level review of the co-located HBD-WTD sites showed that:

- at lower temperatures: the new model tended to report lower readings;
- at higher temperatures: the new model tended to report higher readings.

Reviewing a month of wheel temperatures from westbound coal trains at a cold wheel site – August 2013 for the old model HBD, August 2014 for the new model HBD – Figure X shows that the old model distribution generally centres around higher wheel temperatures (in blue) relative to the new model. Taking a lens to the upper temperature range (300-600F), Figure Y shows that while the new model tends to centre around lower temperatures, at the high end it reports more high temperature readings.

While this does not impede the use of the applied statistical model for identifying the cold and hot wheel outliers, it was determined that the specific thresholds applied needed re-examination. Using historical data from the new WTD, multiple alarm projections were made with varying both the minimum Train Average Wheel Temperature requirement as well as the minimum Wheel Temperature requirement. Figure X shows three different combinations of the Train Average Wheel Temperature threshold and Wheel Temperature thresholds (shown as different colours within each bar), and the number of alarmed cars the combinations would have produced.

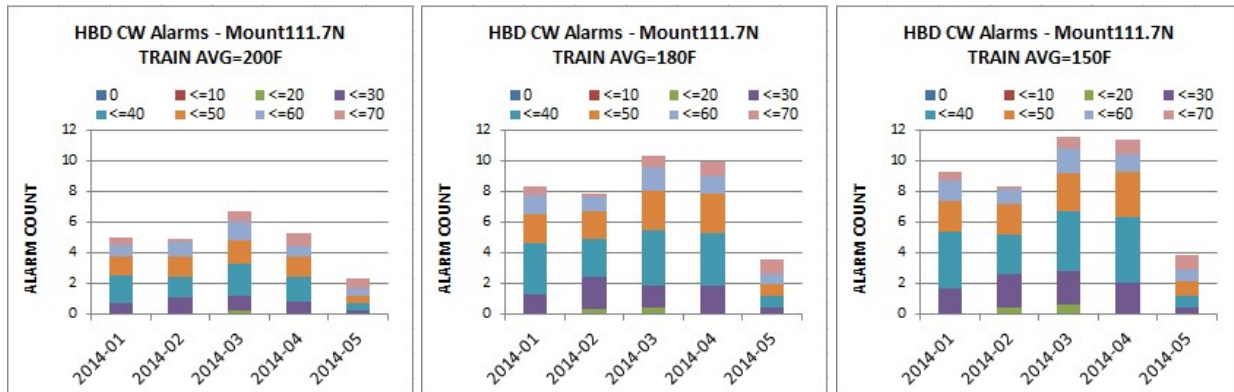


Figure X: Three examples of combination of Train Average Wheel Temperature threshold and Wheel Temperature thresholds

It was found that while the decrease in Train Average Wheel Temperature threshold from 200F to 180F resulted in a noticeably greater number of cars alarmed per day on average, due to the greater number of valid tests, the change when decreasing from 180F through to 150F was less significant. There was no apparent or obvious reason to change the Wheel Temperature threshold.

After reviewing the proposed change with TC, the Train Average Wheel Temperature threshold was lowered from 200F to 180F in July 2014. Figure X shows the steady climb in ATBE test success at the cold wheel sites (in blue).

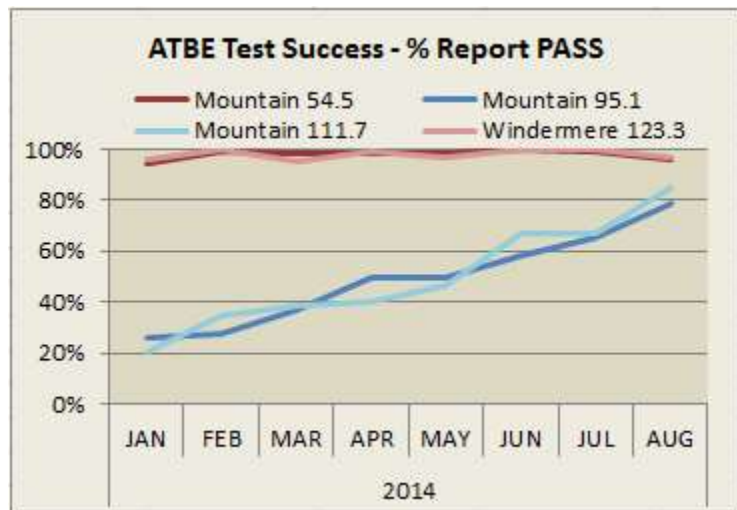


Figure X: % of Train Reports with Valid ATBE Test at each ATBE WTD Location

Transition from Train-based to Car-based Process

The ATBE process was initially designed and implemented for coal trains on a train level basis. That is to say, the progress through a cycle was tracked through the Train ID, and cars associated to that Train ID. This worked well for a captive fleet of unit trains, as long as the consist and conventions for applying the Train ID remained consistent. Prior to the empty coal train arriving back at Golden Shop at the end its cycle, the final brake status report was easily compiled by fetching any alarms and/or no-alarms status for each of the Cold and Hot Wheel WTD train reports related to the connected Train IDs. The bad

orders were removed in Golden, tested cars added, and the train departed with 100% operative brakes. The train remained relatively whole from departure to shipper to port back to mechanical facility.

But what if the train travels as a unit train, is separated into blocks for numerous shippers, with different blocks then reassembled into a new train? This would require the process to track individual car status rather than cars associated to an individual train. In 2014, the ATBE process for the coal trains in BC was overhauled and turned into a car-based process. In doing so, the process was made configurable to allow for additional trains and routes without the dependency on them remaining as unit trains.

To track an individual car's status, a car is given a 'cycle start' timestamp in EHMS as soon as it leaves the designated Mechanical Safety Inspection location. When the train reaches the end of its cycle, prior to arriving at its designated Mechanical Safety Inspection location, the EHMS application will gather any alarms for each car on the arriving train which occurred after the cycle start timestamp, and list them in the final ATBE status report for the arriving train, so that any bad orders can be removed, repaired and tested. Similar to the train-based process, EHMS verifies the train had a valid test at at least one hot wheel and one cold wheel HBD location. Any individual cars which cannot be verified are listed for No.1 Brake Test on those cars only.

Conclusion

The ATBE test has served CP well with over 3,500 trains passing through the process from 2011-2013, and approximately 96% of those receiving a valid ATBE test. The purpose of using technology to perform inspections is to have more efficient, safe and reliable inspections – CP has seen positive results on all fronts. It must be stressed that it is not only applying technology that provides the gains, but the combination of technology, an understanding of the technology, and a solid process using the technology output. The process is never complete – we continue to learn from it, implement those learnings, and as a result see better efficiency, safety and reliability.

Acknowledgements:

The authors would like to acknowledge the contributions of the staff at the Golden Mechanical Facility in BC for their ongoing feedback, photos, support and efforts in making the ATBE process a success.

REFERENCES

- [1] S. Cummings, H. Tournay, Kari Gonzales, Wayside Wheel Temperature Detector Test, Transportation Technology Center Inc., Technology Digest TD-08-013, March 2008
- [2] Golden Mechanical Facility, 10 Commandments for Proper Air Brake Inspection Process, 2011

TC 16 ATTACHMENT 1: RAILWAY FREIGHT CAR INSPECTION AND SAFETY RULES GE

***Railway Freight Car
Inspection and Safety Rules***

December 9, 2014

PART I – GENERAL	3
1. SHORT TITLE	3
2. SCOPE	3
3. DEFINITIONS.....	3
4. SAFETY INSPECTIONS.....	5
5. PRE-DEPARTURE INSPECTION	6
6. CERTIFICATION AND QUALIFICATION OF EMPLOYEES	7
7. ADDITIONAL REQUIREMENTS FOR DANGEROUS GOODS CARS	7
8. CORRECTIVE ACTION REPORTING	8
PART II – SAFETY DEFECTS	9
9. WHEELS	9
10. AXLES	9
11. ROLLER BEARINGS and ADAPTORS	10
12. PLAIN BEARINGS	10
13. TRUCKS	11
14. CAR BODIES	12
15. COUPLERS and DRAWBARS	13
16. DRAFT ARRANGEMENTS	14
PART III – OTHER REQUIREMENTS.....	15
17. DESIGN	15
18. TECHNOLOGY.....	15
19. FILING REQUIREMENTS	15
20. EXCLUSIONS	16
21. EXCEPTIONS	16
APPENDIX 1	17
PRE-DEPARTURE INSPECTION	17

PART I – GENERAL

1. SHORT TITLE

- 1.1 For ease of references, these Rules may be referred to as the “Freight Car Safety Rules”.

2. SCOPE

- 2.1 These Rules prescribe the minimum safety standards for freight cars operated by railway companies subject to the jurisdiction of Transport Canada pursuant to the *Railway Safety Act*.

3. DEFINITIONS

In these Rules,

- 3.1 “bad order” means a freight car that has been identified with a defect;
- 3.2 “bad order card” or “home shop card” means a railway company form that may be affixed to a freight car to indicate maintenance requirements and/or a defect identified during a safety inspection;
- 3.3 “bad order information system” means any method a railway company records, controls and protects the movement of a freight car with a defect;
- 3.4 “block of cars” means one (1) or more cars that have received a safety inspection or a pre-departure inspection as a solid coupled block for which an inspection record is available;
- 3.5 “break” or “broken” means a fracture resulting in complete separation into parts;
- 3.6 “captive service” means an operation where freight cars are assigned exclusively to transportation between specified points;
- 3.7 “certified car inspector” means a person who is trained, qualified and certified to perform safety inspections of freight cars in accordance with subsection 4.1 of these Rules;
- 3.8 “cracked” means fractured without complete separation into parts;
- 3.9 “defect” means any item that is defective on a freight car as indicated by “safety defect” of these Rules and *Railway Freight and Passenger Train Brake Inspection and Safety Rules*;

3. DEFINITIONS (cont'd)

- 3.10 “Department” means the Department of Transport (commonly referred to as Transport Canada);
- 3.11 “freight car” means a car designed to carry freight on rail and includes a caboose and a service equipment car;
- 3.12 “in service” means all freight cars except those that are:
- (a) in “bad order” status;
 - (b) in “home shop for repair” status as outlined in subsection 4.8 of these Rules;
 - (c) in a repair shop or on a repair track; or
 - (d) on a storage track and are empty;
- 3.13 “interchange” means the transfer of freight cars between railway companies;
- 3.14 “person in charge” means a person trained, qualified and certified in accordance with subsection 6.1 of these Rules and appointed by a railway company to ensure the safe conduct of an operation or of the work of employees;
- 3.15 “qualified person” means a person who because of his/her knowledge, training and experience is qualified to perform a pre-departure inspection in accordance with subsection 5.1 of these Rules;
- 3.16 “railway company” means a railway or railway company subject to the *Railway Safety Act*;
- 3.17 “railway safety inspector” means a Department of Transport inspector designated pursuant to section 27 of the *Railway Safety Act*;
- 3.18 “railway schedule” means an electronic or paper record that indicates the type of inspection, brake test and operational activity performed by a railway and the location where the activity is performed;
- 3.19 “safety defect” means any item that is defective on a freight car as prescribed by Part II of these Rules and General Order No. 0-10, “*Regulations Respecting Railway Safety Appliance Standards*”, or the latest edition of AAR Safety Standard S-2044 “Safety Appliance Requirements for Freight Cars” of the Manual of Standards and Recommended Practices;
- 3.20 “safety inspection” means an examination of:
- (a) a stationary freight car by a certified car inspector; or
 - (b) a stationary or moving freight car, by other technology, as adopted under subsection 18.2; or
 - (c) a combination of both

to verify that it may be moved safely in a train and to identify those safety defects

3. DEFINITIONS (cont'd)

prescribed in Part II of these Rules and General Order No. 0-10, "*Regulations Respecting Railway Safety Appliance Standards*", or the latest edition of AAR Safety Standard S-2044 "Safety Appliance Requirements for Freight Cars" of the Manual of Standards and Recommended Practices;

- 3.21 "safety inspection location" means a location designated by a railway company where safety inspections are performed;
- 3.22 "safety inspection record" means a record which attests that a safety inspection was performed;
- 3.23 "service equipment car" means rolling stock used to house employees at work sites, a material car used for transporting railway maintenance-of-way equipment or for railway company purposes other than revenue service.

4. SAFETY INSPECTIONS

- 4.1 Subject to sections 20 and 21, of these Rules, a railway company shall ensure the freight cars it places or continues in service are free from all safety defects described in Part II of these Rules, and that such cars comply with General Order No. 0-10, "*Regulations Respecting Railway Safety Appliance Standards*", or the latest edition of AAR Safety Standard S-2044 "Safety Appliance Requirements for Freight Cars" of the Manual of Standards and Recommended Practices.
- 4.2 Safety inspections shall be performed by certified car inspector(s) at safety inspection locations
 - (a) where trains are made up;
 - (b) on cars added to trains;
 - (c) where cars are interchanged.

Such inspections may occur before or after a car is placed in a train at that location.

- 4.3 All freight cars that have previously received an inspection under subsection 5.1 of these Rules shall receive a safety inspection by a certified car inspector at the safety inspection location designated for that train by the railway company in the direction of travel.
- 4.4 A safety inspection is not required on blocks of cars that have previously received a safety inspection, in the direction of travel, for which the inspection status information is available.
- 4.5 A safety inspection is not required at an interchange point and/or when entering Canada provided there are records that indicate that a Safety Inspection, as per these Rules or an inspection by qualified mechanical personnel in the United States, was performed.

4. SAFETY INSPECTIONS (cont'd)

- 4.6 A freight car identified with a safety defect at other than a safety inspection location may be moved to another location for repair, in accordance with company procedures, including placing a loaded car for unloading when authorized by a person in charge, who shall ensure that:
- (a) the car is safe to move;
 - (b) a means to protect the car's safe movement is implemented, including identifying for the employees involved the nature of the defect(s) and the movement restrictions, if any;
 - (c) an empty car shall not be loaded until repaired; and
 - (d) the appropriate records will be retained for a period of ninety (90) days.
- 4.7 A car may also be moved from a safety inspection location to another location when authorized by a person in charge provided the conditions of item 4.6 (a), (b), (c), (d) are adhered to.
- 4.8 A freight car with defects shall be controlled and protected by the use of a bad order information system, and/or by the use of a bad order or home shop card.
- 4.9 A railway company shall maintain a safety inspection record for the cars it places in service at each safety inspection location. This information shall be retained for ninety (90) days and will be made available to a Railway Safety Inspector upon request.

5. PRE-DEPARTURE INSPECTION

- 5.1 At locations where a certified car inspector is not on duty for purposes of inspecting freight cars, a pre-departure inspection of the train or the cars added shall be performed by a qualified person, as a minimum, for those conditions listed in Appendix 1 of these Rules.
- 5.2 Pre-departure inspections shall be performed on both sides of equipment by:
- (a) a standing inspection on both sides; or
 - (b) a standing inspection on one side and a roll by inspection, not exceeding 8.2 km. (5MPH) on the other side.
- 5.3 A pre-departure inspection under 5.1 is not required on blocks of cars:
- (a) lifted enroute that have previously received a safety inspection in the direction of travel for which the inspection status information is received (maximum two blocks); or
 - (b) that have previously received a pre-departure inspection at that location for which inspection information is received.

5. PRE-DEPARTURE INSPECTION (cont'd)

- 5.4 The results of the pre-departure inspection performed by other than the lifting train crew shall be retained for a period of thirty (30) days.
- 5.5 All noted hazardous conditions shall be reported for correction in accordance with company procedures.

6. CERTIFICATION AND QUALIFICATION OF EMPLOYEES

- 6.1 A railway company shall ensure that its certified car inspectors are trained, and qualified to perform safety inspections of freight cars in compliance with these Rules. Certified car inspectors must demonstrate to a railway company, by means of oral or written examinations and on-the-job performance, a knowledge and ability to perform safety inspections of railway freight cars.
- 6.2 A railway company shall ensure that its qualified persons are trained and qualified to perform pre-departure inspections of freight cars in compliance with these Rules.
- 6.3 A railway company shall file with the Department a full description of the training program, criteria and all amendments used for:
 - (a) certifying those employees performing safety inspections in accordance with subsection 4.1 of these Rules; and
 - (b) qualifying those employees performing inspections in accordance with subsection 5.1 of these Rules.
- 6.4 A railway company shall maintain a record of all their certified car inspectors. This record shall be made available to a Railway Safety Inspector upon request.
- 6.5 Certified car inspectors shall be re-certified if they have not been performing the duties prescribed in these Rules within the past three (3) years.

7. ADDITIONAL REQUIREMENTS FOR DANGEROUS GOODS CARS

- 7.1 Additional inspections of cars carrying goods subject to the *Transportation of Dangerous Goods Act*, latest revision, are required as follows:
 - (a) tank cars destined for loading with a dangerous good or other cars destined for loading of explosives shall be given a safety inspection at the nearest safety inspection location in the direction of travel prior to being placed for loading;
 - (b) freight cars loaded with a dangerous good shall be given an inspection by employees of the receiving railway, at the point of loading, for those conditions listed in Appendix 1 of these Rules.

8. CORRECTIVE ACTION REPORTING

- 8.1 Every railway company shall respond in writing or by acceptable electronic means, within fourteen (14) days, to the Department's Regional Office concerned, on the corrective action taken to correct non-compliance reported by a Railway Safety Inspector. The railway company's response shall include the corrective action taken, the location and date, and where applicable, the car reporting mark and car number.

PART II – SAFETY DEFECTS

Part II contains those safety defects which, when present, prohibit a railway company from placing or continuing a freight car in service.

9. WHEELS

9.1 A railway company shall not place or continue a car in service if:

- (a) a wheel rim, flange, plate or hub area has a crack or break. Heat checks or chips in a wheel rim are not considered to be cracks or breaks;
- (b) a wheel has a chip or gouge in the flange more than 1 ½ inches (38.10 mm) in length and ½ inch (12.70 mm) in width;
- (c) a wheel has a shelled spot that is more than 1 ¼ inch (31.75 mm) in width and 1 ½ inches (38.10 mm) in length;
- (d) a wheel has a slid flat spot that is more than 2 ½ inches (63.50 mm) in length or two adjoining flat spots each of which is more than 2 inches (50.80 mm);
- (e) a wheel shows evidence of being loose;
- (f) a wheel flange is worn to a thickness of 7/8 inches (22.22 mm) or less at a point 3/8 inches (9.52 mm) above the tread of the wheel;
- (g) the height of a wheel flange from the tread to the top of the flange is more than 1 ½ inches (38.10 mm);
- (h) the thickness of a wheel rim is 11/16 inches (17.4 mm) or less;
- (i) a straight plate wheel has:
 - i. a blue or reddish brown discoloration on the front and back face of the plate that extends more than four inches (101.60 mm) into the plate;
 - ii. a combination of heat discoloration on the rim and plate with a rim thickness of 1 ¼ inches (31.75 mm) or less;
 - iii. any visible tread defects with a rim thickness of 1 ¼ inches (31.75 mm) or less; or
 - iv. 1 inch (25.40 mm) or less of rim thickness); or
- (j) a wheel is the wrong size.

10. AXLES

10.1 A railway company shall not place or continue a car in service if:

- (a) an axle has a crack or is bent or broken;
- (b) a journal shows evidence of overheating;
- (c) a plain bearing axle has:
 - i. a cracked or broken end collar; or
 - ii. a groove, pitting, rusting or etching on the surface of the journal; or
- (d) an axle is the wrong size.

11. ROLLER BEARINGS AND ADAPTORS

- 11.1 A railway company shall not place or continue a car in service if:
- (a) a roller bearing shows signs of having been overheated;
 - (b) a roller bearing has damaged external parts that are visibly cracked, broken or bent;
 - (c) a freight car involved in a derailment has not had its bearings inspected according to the procedures outlined in the latest edition of the Field Manual of the AAR Interchange Rules;
 - (d) a roller bearing has:
 - i. missing or loose cap screw;
 - ii. a broken, missing or improperly applied locking plate; or
 - iii. a backing ring that is loose or damaged when car is on a repair track;
 - (e) a roller bearing is the wrong size; or
 - (f) a roller bearing is losing grease to the extent that fresh grease is spread across the truck side frame and the seal is loose, cocked or damaged.
- 11.2 A railway company shall not place or continue a car in service if a roller bearing adapter is missing, cracked, broken, out of place or the wrong size.

12. PLAIN BEARINGS

- 12.1 A railway company shall not place or continue a car in service if:
- (a) a journal bearing lubrication system has any of the following conditions:
 - i. a journal bearing box has no visible free oil;
 - ii. a journal bearing box contains foreign matter that can damage the bearing or affect the lubrication of the journal and the bearing;
 - iii. a journal bearing box lid is missing;
 - iv. a lubricating pad is missing, not in contact with the journal or the wrong size;
 - v. a lubricating pad is scorched, burnt or glazed;
 - vi. a lubricating pad contains fabric in such a condition that it impairs proper lubrication of the pad; or
 - vii. A lubricating pad has metal parts contacting the journal;
 - (b) a journal bearing:
 - i. is missing, broken, out of place or wrong size;
 - ii. has a crack in the back or lug portion;
 - iii. on which the lining is loose, has a piece broken off; or
 - iv. is overheated, as evidenced by melted lining; or
 - (c) a journal wedge is missing, broken, out of place, or the wrong size.

13. TRUCKS

13.1 A railway company shall not place or continue a car in service if:

- (a) a side frame or bolster:
 - i. is broken;
 - ii. has a crack of $\frac{1}{4}$ inch (6.3 mm) or more in the transverse direction of a tension member, except that shrinkage cracks or hot tears that do not significantly reduce the strength of the bolster or side frame shall not be considered cracked;
- (b) a truck is equipped with an ineffective damping mechanism as indicated by:
 - i. a side frame column wear plate missing (except by design), or broken to the extent that it no longer performs its design function;
 - ii. a broken or missing activating side spring;
 - iii. truck springs that show evidence of not maintaining travel or load;
 - iv. hydraulic snubbers with an accumulation of wet fluid and fluid is not visible in the sight glass if so equipped;
 - v. truck springs compressed solid;
 - vi. truck springs on which more than one of the outer springs in any spring cluster are broken, out of place or missing; or
 - vii. a friction wedge is missing, broken to the extent that it becomes non functional or worn beyond the wear indicator.
- (c) the truck side bearings:
 - i. have part of the assembly missing, out of place or broken;
 - ii. are in contact with the body side bearing on both sides at one end of the car, unless intended by design;
 - iii. while on level track, are in contact with the body side bearings at diagonally opposite sides of the car, unless intended by design;
 - iv. at one end of the car have a total clearance from the body side bearing of more than $\frac{3}{4}$ inches (19.05 mm); or
 - v. at diagonally opposite sides of the car, have a total clearance from the body side bearing of more than $\frac{3}{4}$ inches (19.05 mm); or
 - vi. when more than one constant contact side bearing is not making contact.
- (d) there is interference between the truck bolster and the centre plate, or the body bolster and the truck side frame, which prevents proper truck rotation;
- (e) a brake beam support is worn to the extent that it does not support the brake beam; or
- (f) a truck is designed with a spring plank, but the spring plank is missing, broken, bent to the extent that it no longer performs its design function or incorrectly installed.

14. CAR BODIES

14.1 A railway company shall not place or continue a car in service if:

- (a) any portion of the freight car body, truck or their appurtenances (except wheels) has less than 2 ½ inches (63.50 mm) clearance from the top of the rail;
- (b) the car centre sill or stub sill is:
 - i. broken;
 - ii. cracked more than 6 inches (152.40 mm); or
 - iii. permanently bent or buckled more than 2 ½ inches (63.50 mm) in any 6 foot (1.83 m) length;
- (c) the car has a stub sill attachment with a crack greater than 6 inches;
- (d) the tank car stub sill:
 - i. is broken
 - ii. has any crack in the parent metal;
 - iii. has a transverse weld that is cracked more than 3 inches (76.2 mm) or is missing;
 - iv. has a longitudinal weld that is cracked more than 6 inches (152.40 mm) or is missing; or
 - v. has a weld that is cracked or missing, where the total length cannot be measured;
 - vi. is bulged; more than 1 1/2 inch in any 3 foot length.
- (e) the car has a side sill cracked more than 6 inches (152.40 mm) when the car is not equipped with a full centre sill;
- (f) the car has a broken cross bearer or body bolster;
- (g) the car has a coupler carrier that is:
 - i. broken;
 - ii. missing; or
 - iii. non-resilient, and the coupler has a type F head;
- (h) the car body has been improperly positioned on the truck;
- (i) it has a centre plate that:
 - i. is improperly secured, with more than 25% of the fasteners missing and/or the centre plate observed to have moved;
 - ii. is broken; or
 - iii. has two or more cracks through its cross section thickness at the edge of the plate extending into the portion of the plate that is obstructed from view while the truck is in place;
- (j) it is a box car which has:
 - i. more than one door stop missing or broken per door;
 - ii. safety hangers missing or inoperative on sliding or plug doors so equipped;
 - iii. a sliding or plug type doors off the rails;
 - iv. a plug type door not closed;

14. CAR BODIES (Cont'd)

- v. a plug type door with not less than 60% of the locks fully engaged; or
 - vi. door rail supports cracked or broken to the extent that they do not perform their design function;
- (k) it is a hopper car which has a bottom gate off the track or unsecured such that it could fall off;
- (l) it is a loaded car with lading restraining devices worn or damaged to the extent that those devices will not restrain the load;
- (m) an object extends from the side of a car body except by design;
- (n) a car is not loaded in accordance with the prevailing “AAR General Rules Governing the Loading of Commodities on Open Top Cars”, or a circular of the Railway Association of Canada; or
- (o) the car has any object which is not secured and could fall off.

15. COUPLERS AND DRAWBARS

- 15.1 A railway company shall not place or continue a car in service if:
- (a) the car is equipped with a coupler shank that is bent out of alignment to the extent that the coupler will not couple automatically;
 - (b) the car has a coupler knuckle that is broken or cracked on the inside pulling face of the knuckle, except that shrinkage cracks or hot tears that do not significantly reduce the strength of the knuckle shall not be considered cracked;
 - (c) the car has a knuckle pin that is missing or broken;
 - (d) the car has a thrower that is inoperative;
 - (e) the car has a coupler retaining pin lock that is missing or broken;
 - (f) the car has a coupler with an inoperative lock lift or a coupler assembly that does not have anti-creep protection to prevent unintentional unlocking of the coupler lock;
 - (g) the coupler lock is missing, inoperative, bent, cracked or broken;
 - (h) the car has a coupler that has a crack as identified in the latest edition of the Field Manual of AAR Interchange Rules , except that shrinkage cracks or hot tears that do not significantly reduce the strength of the coupler shall not be considered cracked;
 - (i) the coupler heights between two adjacent freight cars vary in excess of 4 inches (101.6 mm);
 - (j) it is equipped with a solid drawbar:
 - i. that is cracked more than 2 inches or;
 - ii. that has a missing pocket casting support or;
 - iii. that has a missing or broken primary pin.
 - (k) it is equipped with an articulated car connector:
 - i. attachment weld cracked greater than 4”;
 - ii. casting crack greater than 2”;
 - iii. primary pin tipped, broken or not properly seated;
 - iv. retaining pin broken, missing or not engaging primary pin;
 - v. retaining pin securement missing; or
 - vi. wedge retaining bolts broken or missing.

16. DRAFT ARRANGEMENTS

- 16.1 A railway company shall not place or continue a car in service if:
- (a) the car has a draft gear that is inoperative;
 - (b) the car has a broken yoke;
 - (c) a vertical coupler pin retainer plate:
 - i. is missing (unless intended by design); or
 - ii. has more than 25% of the fasteners either loose or missing;
 - (d) the car has a draft key or draft key retainer that is:
 - i. inoperative;
 - ii. missing; or
 - iii. broken;
 - (e) the car has a follower plate missing or broken to the extent that it no longer performs its design function;
 - (f) the draft gear carrier plate is missing or has more than 25% of the fasteners loose or missing;
 - (g) a draft stop is missing or broken to the extent that it no longer performs its design function; or
 - (h) a car cushioning unit is broken, inoperative, or missing a part, except where its sliding parts have been effectively immobilized.

PART III – OTHER REQUIREMENTS

17. DESIGN

- 17.1 Every new freight car shall be designed and constructed in accordance with the “Association of American Railroads Manual of Standards and Recommended Practices”, or to an equivalent standard to provide for safe operation.
- 17.2 Every new freight car built after January 1, 2015 shall be designed and constructed with safety appliances in compliance with the latest edition of AAR Safety Standard S-2044 “Safety Appliance Requirements for Freight Cars” of the Manual of Standards and Recommended Practices. Cars built prior to January 1, 2015 shall be designed and constructed with safety appliances in compliance with General Order No. 0-10, “*Regulations Respecting Railway Safety Appliance Standards*”.

18. TECHNOLOGY

- 18.1 A railway company may operate freight cars with advanced technological improvements provided that the testing and operating procedures have been filed with the Department, sixty (60) days, prior to testing or placing in service and the results of the railways risk assessment is provided with the submission.
- 18.2 If a railway company wishes to use alternate methods in place of specific requirements in this rule, to perform all or part of safety inspection and or a pre-departure inspection, it shall engage in early consultation with Transport Canada to review the new methods being contemplated. The railway company will file an alternative practice with the department. Such filing must demonstrate that it meets or exceeds the equivalent level of safety to the rule and include a risk assessment as well as evidence of consultation with relevant associations or organizations. Filings must be made at least 60 days prior to implementation.

19. FILING REQUIREMENTS

- 19.1 A railway company shall file with the Department:
- (a) training procedures and amendments as outlined in subsection 6.3 of these Rules;
 - (b) safety inspection locations as outlined in subsection 4.2 of these Rules. The railway company shall file any changes to the list of safety inspection locations to the Department sixty (60) days prior to implementing such changes;
 - (c) railway schedules to comply with the requirements of subsection 4.2 and 5.1, of these Rules. Any changes to the railway schedules shall be filed by the railway company with the Department within thirty (30) days of implementation;
 - (d) advanced technological improvements as outlined in section 18, of these Rules;
 - (e) captive service operations as outlined in subsection 21.2(b) of these Rules.

20. EXCLUSIONS

20.1 These Rules do not apply to the following:

- (a) freight cars operated solely on a track inside an industrial or other non-railway installation;
- (b) cars that are destined for:
 - i. export to another country; or
 - ii. use inside an industrial or other non-railway installation; provided that the railway ensures safe movement of the cars.

21. EXCEPTIONS

21.1 Except for Part II of these Rules and General Order No. 0-10, "*Regulations Respecting Railway Safety Appliance Standards*", or the latest edition of AAR Safety Standard S-2044 "Safety Appliance Requirements for Freight Cars" of the Manual of Standards and Recommended Practices, these Rules do not apply to railway company service equipment cars, including those that are self-propelled, where not moving as part of a revenue train, provided "RSE" (railway service equipment) is stenciled or otherwise displayed on each side of each car in clearly legible letters.

21.2 Subsection 4.2 of these Rules does not apply to freight cars used exclusively in captive service if a railway company:

- (a) establishes appropriate safety inspection criteria and restrictions for freight cars used exclusively in captive service; and
- (b) files railway schedules with the Department that specify the locations of captive service, the round trip mileage, the type of equipment operated, along with the applicable inspection criteria and any restrictions imposed on operation of such equipment, 60 days prior to operation.

APPENDIX 1

PRE-DEPARTURE INSPECTION

Freight cars shall, as a minimum, be inspected for these hazardous conditions:

1. car body related hazards:
 - (a) car body leaning or listing to the side;
 - (b) car body sagging downward;
 - (c) car body positioned improperly on the truck;
 - (d) object dragging below the car body;
 - (e) object extending from the side of the car body;
 - (f) door insecurely attached;
 - (g) broken or missing safety appliance; and
 - (h) lading leaking from a placarded dangerous goods car;
2. overheated wheel;
3. broken or cracked wheel;
4. hand brake that failed to release; and
5. any other apparent safety hazard likely to cause an accident or casualty before the train arrives at its destination.

*TC 16 ATTACHMENT 2: TRANSPORTATION
SCHEDULED MAINTENANCE, 12-CYLINDER AC TIER 4
EVOLUTION SERIES LOCOMOTIVE*

GE Transportation

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Document No. GEK-115064, Rev. G



imagination at work

© 2018 General Electric Company. All rights reserved. The information contained in this publication is the property of General Electric Company and is disclosed in confidence. This publication is intended for use by GE customers solely for purposes of operating and performing routine maintenance of purchased or licensed GE products, and it shall not be reproduced, redistributed, retransmitted, translated, abridged, adapted, condensed, revised or otherwise modified, in any form, in whole or in part, or used for any other purpose, or disclosed to third parties, without the express written consent of GE. However, if a GE customer ("Customer") requires additional copies of this publication or portions thereof for internal use, GE hereby grants to Customer a limited right to reproduce this publication, in whole or in part, and Customer agrees to use such authorized copies ("Copies") solely for its intended purposes. Any Copies made under this limited reproduction right shall contain this notice and any other legal notices appearing in this publication. The Customer shall be responsible for complying with U.S. export control laws with respect to distribution of all Copies.

GE and Customer agree that the information contained herein does not purport to cover all details or variations in GE products or to provide for every possible contingency with installation, operation or maintenance. Should further information be desired or should particular problems arise that are not covered sufficiently for the user's purposes, the matter should be referred to General Electric Company. Any applicable Federal, State or local regulations or company safety or operating rules must take precedence over any information or instructions given in the Technical Documentation. GE has no obligation to keep the material up to date after the original publication.

GENERAL ELECTRIC COMPANY EXPLICITLY DISCLAIMS ALL WARRANTIES OF ACCURACY, MERCHANTABILITY OR FITNESS FOR ANY PURPOSE IN CONNECTION WITH THIS PUBLICATION AND USE THEREOF.

If you are not an authorized recipient of this publication, you are hereby notified that any perusal, use, distribution, copying or disclosure is strictly prohibited. If you have received this publication in error, please immediately return to GE at the following address: GE Transportation, Technical Publications Department, Building 14, 2901 East Lake Rd., Erie, PA 16531.

Revision History

Rev	Date	By	Description
NEW	Apr-2013	GEM	Initial release of publication.
	May-2013	GEM	Items updated include NOx Sensor and Hot box heater cartridges, as well as changed engine oil filters and nozzles interval as per Workflow 90893354 .
	Sep-2013	GEM	Revise Diesel Engine Exhaust Manifold and Bellows by adding "while engine is idling". Add Water Separator Element to Diesel Engine Water Separator.
A	Apr-2014	GEM	Revise to include most current comments and markups for Cab Equipment, Air Brake System, Compressed Air, Cooling System, Display Panel, Diesel Engine, Traction Motor Combo and Truck.
B	Jun-2014	GEM	Revise to include most current comments including Air Brake Equipment, Cooling System, Display Panel and, Diesel Engine.
C	Jul-2014	GEM	Revise GE Spec. from D6A2C5 to D6A2C10 for Bearings.
D	Nov-2014	GEM	Revise Table 1 to include references to GEK-115176 , <i>GEVO LOW EMISSIONS LOCOMOTIVES SPECIAL MAINTENANCE INSTRUCTIONS</i> .
E	Jan-2016	GEM	Add replacement of the EGR Valve Auxiliary Oil Line Filter as per Workflow: 145995340 . Revise Traction Motor Support bearings to 3 Years and When Renewing Wheels as per Workflow: 130810967 .

Revision History

Rev	Date	By	Description
F	Oct-2016	RKS	Added Section 1.1, EXCLUSION ZONE WARNING Revised Table 1 as per the Workflow: 156348951 .
G	Sep-2018	RKS	Updated Table 1 to add Platform - Tank / Sill interval as per Main Workflow: 173062193 and Writer's Workflow: 174123322 .

GEK-115064G

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

TABLE OF CONTENTS

Section	Page
1. GENERAL INFORMATION	1
1.1. EXCLUSION ZONE WARNING	2
2. CONTROLS AND INDICATORS.....	2
3. FUNCTIONAL DESCRIPTION	2
4. SCHEDULED MAINTENANCE	3
5. REMOVAL AND REPLACEMENT PROCEDURES	15
6. SUMMARY DATA.....	15

1. GENERAL INFORMATION

This publication defines the scheduled maintenance intervals for 12-Cylinder AC Tier 4 Evolution Series locomotive. The 12-Cylinder AC Tier 4 Evolution Series locomotive complies with the Environmental Protection Agency Tier 4 emissions regulations for railway locomotives.

NOTE: Refer to COMPONENT OVERHAUL SCHEDULE, 12-CYLINDER TIER 4 EVOLUTION SERIES LOCOMOTIVE, for additional information concerning the various components listed in this publication. Refer to GEK-115176, GEVO LOW EMISSIONS SPECIAL MAINTENANCE INSTRUCTIONS, for additional information concerning emission critical parts.

For successful locomotive operation, the railroad must:

1. Provide knowledgeable workers and supervision.
2. Provide adequate maintenance facilities, tools, shop supplies, and renewal parts.
3. Provide fuel, lubricating oil, and water treatment equal to or better than that specified.
4. Perform inspection and maintenance according to planned schedule and keep adequate records.

When servicing the locomotive:

1. Never mix lubricants of different brands or grades, with the exception of engine lubricating oils in the same class.
2. Too much lubrication can be as harmful as too little. Never overfill.
3. Always clean the grease fittings before adding grease, and clean the equipment covers if they are removed during service.
4. Use only clean containers when handling lubricants and fuel.

The following equipment have sealed bearings and require no periodic lubrication until the device is overhauled:

1. Braking Grid Blower Motors.
2. Prelube Pump.

Revisions are indicated by margin bars.

1.1. EXCLUSION ZONE WARNING

The exclusion zone is an area around the engine cab where personnel may be injured in the event of catastrophic failure of an engine component. This zone is the area outboard of the engine cab and extends for 28 unobstructed feet away from the locomotive (see Figure 1). Personnel must be aware of this area when working around a locomotive that is operating at or above idle.

To ensure the safety of personnel working around locomotives running at or above IDLE, the following exclusion zone rules must be observed:

- Personnel may pass through the Exclusion Zone but shall not stop in the zone
- Personnel may not be present on locomotive running boards when unit is above IDLE except for specified N4 Air Intake Manifold tests
- Operation above Idle should not occur when occupied structures are within the Exclusion Zone

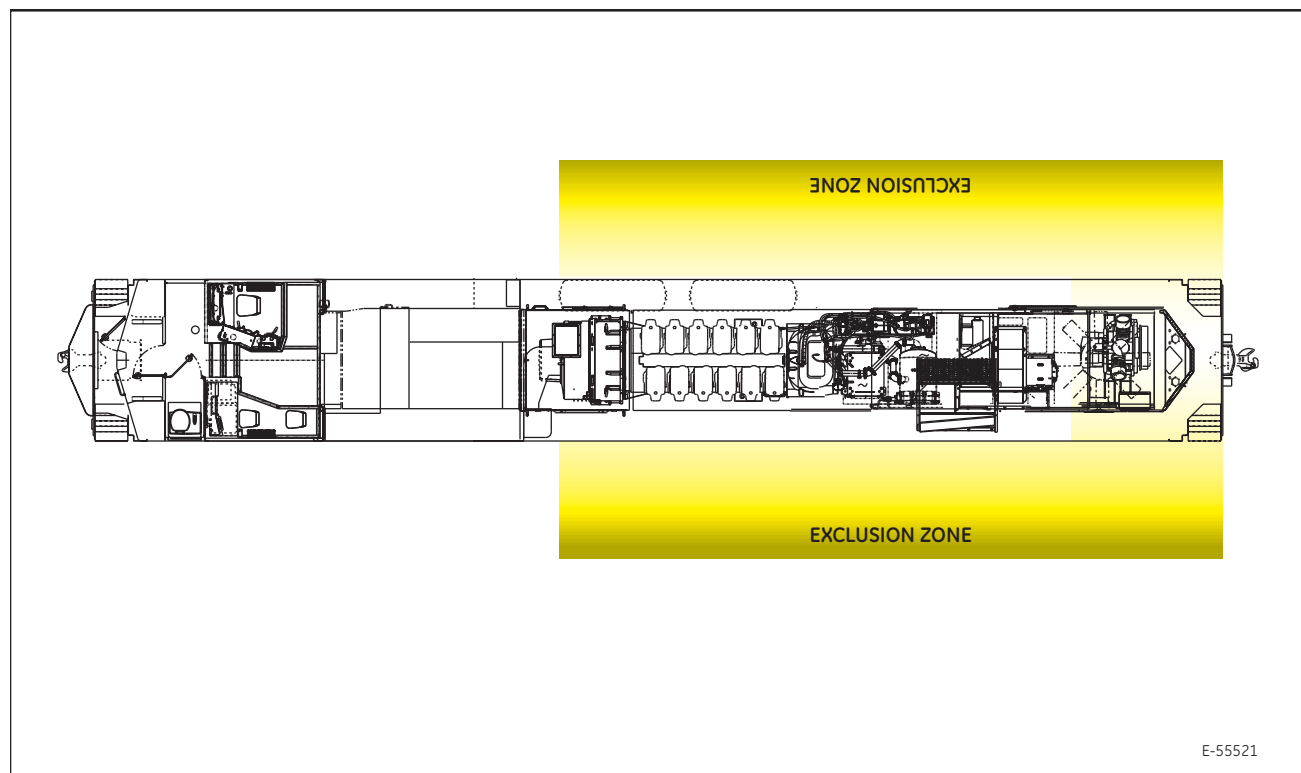


Figure 1. Exclusion Zone

2. CONTROLS AND INDICATORS

Not Applicable

3. FUNCTIONAL DESCRIPTION

Not Applicable

4. SCHEDULED MAINTENANCE

Table 1. Scheduled Maintenance

Running Maintenance

Major Component/System	Task Description	Frequency
Air Brake Equipment		-
Air Brake Equipment Electronic Air Brake (EAB) System	Perform an EAB System Functional Test.	92 Days
Air Brake Equipment EAB System Filters and Dirt Collectors	Replace	1 Year
Air Compressor		-
Air Compressor Air Compressor	Check oil level at engine IDLE, add oil as required.	Daily/Trip
Air Compressor Air Compressor	Check operation of compressor load/unload system.	184 Days
Air Compressor Air Compressor	Clean exterior of air coolers and inspect for leakage.	1 Year
Air Compressor Air Compressor	Drain oil and replace with new.	1 Year
Air Compressor Oil Strainer	Replace	1 Year
Air Compressor Air Inlet Filter	Replace	1 Year
Air Compressor Air Compressor	Replace all internal components in crankcase breather.	3 Years
Alternator		-
Alternator Main and Auxiliary	Inspect surface conditions of collector rings. Check brushes for brush length and surface condition.	184 Days
Bearings		-
Bearings Air-To-Air Fans (if equipped)	Lubricate bearings using GE Spec. D6A2C10	1 Year

Running Maintenance

Major Component/System	Task Description	Frequency
Bearings Alternator Blower	Lubricate bearings, GE Spec. D6A2C10	1 Year
Bearings Equipment Blowers	Lubricate bearings, GE Spec. D6A2C10	1 Year
Bearings Exhauster Blowers	Lubricate bearings, GE Spec. D6A2C10	1 Year
Bearings Main Alternator	Lubricate bearings using GE Spec. D6A2C10	1 Year
Bearings Radiator Fan	Lubricate bearings using GE Spec. D6A2C10	1 Year
Bearings U-Tube	Clean grease fittings and apply 43 oz (1200 g) of D50E28 (Mobilith SHC460) U-tube bearing grease to PE bearing and 26 oz. (750 g) to CE bearing while rotating axle. Excess grease will exit the seals and may be wiped off. If the U-tube is removed, it must be requalified with proper bearing end play and vibration testing.	When renewing Wheels
Bearings GEB30, GEB13 and GEB32 AC Traction Motor Connection End	Carefully clean off bearing cap and remove. Visually examine bearing for broken rivets, huck bolts, cage or other signs of damage. Clean old grease out of bearing cap; clean and dry cap. Apply 6 oz. (170 g) of D6A2C17 (Unirex N3) grease to bearing and apply 2 oz. (60 g) of same grease to bearing cap cavity and reinstall carefully. Note: If bearing is removed, it must be replaced with a new bearing as pulling it off damages the cage.	When renewing Wheels
Bearings Journal	Inspect and lubricate	When renewing Wheels
Bearings Traction Motor Support	Renew Support Bearing grease using GE Spec. D50E28	3 Years and When renewing Wheels

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Running Maintenance

Major Component/System	Task Description	Frequency
Bearings Traction Motors (all models)	Visual inspect. Run motor with no load to check armature bearings for unusual noises and binding. Check for vibration. Check commutator smoothness. Resurface commutator if necessary using jig grinding device. Clean insulators. Blowout debris with compressed air. Repair covers as required.	When renewing Wheels
Cab		-
Cab Lights	Check operation of all interior and exterior lights for proper operation.	Daily/Trip
Cab Locomotive	Inspect for loose bolts, nuts, and pipe joints. Tighten as appropriate	Daily/Trip
Display Panel Locomotive Systems	Run Manual Self-Test using the DID/IFD/VID/SDIS Panel.	184 Days
Cab Exit Signs (Photo-Luminescent - if equipped)	Inspect all four photo-luminescent exit signs for damage. If damaged or missing, replace.	184 Days
Cab Equipment		-
Cab Equipment Alerter	Test for proper operation.	Daily/Trip
Cab Equipment Ventilation System	Check flexible motor air ducts for leaks.	Daily/Trip
Cab Equipment Battery	Inspect and water as required for flooded batteries	92 Days
Cab Equipment Battery	Wash exterior of trays.	92 Days
Cab Equipment Low Voltage System	Check for damaged insulation, short circuits, and grounds.	92 Days
Cab Equipment Window Wipers	Check operation. Replace wiper blades as necessary.	92 Days

Running Maintenance

Major Component/System	Task Description	Frequency
Cab Equipment Winterization Doors (Manual- if equipped)	Check position: OPEN: October through March, CLOSE: April through September. Note: In areas where the ambient temperature does not fall below 40 F (5 C) doors may be closed all year.	92 Days
Cab Equipment Winterization Doors (Pneumatically Actuated)	Run Self-Test on each door or set of doors to insure proper operation. (If so equipped).	92 Days
Cab Equipment Battery	Charge and Load test.	184 Days
Cab Equipment AUX. Filters (if so equipped)	Replace	184 Days
Cab Equipment Dynamic Brake Blower Motors	Check commutator surface, brush condition and length. Minimum brush length 1.4 inches. Inspect according to GEK publication. For single blower packages with a double-ended GY19 blower, only inspect the two sets of brushes which are accessible from the A side walkway. If any of those fail inspection, replace all 4 sets.	184 Days
Cab Equipment Electrical Equipment	Inspect for burned contact tips, burned wiring, and loose or overheated electrical connections.	184 Days
Cab Equipment Engine Air (Baggy) Filters	Replace	184 Days
Cab Equipment HVAC Air Filters	Replace	184 Days
Cab Equipment Control Equipment, compressor control panel and Compartments	Check contactors, relays, and position sensors for proper operation.	1 Year
Cab Equipment Snubber Panel & RC filters (Applicable for Locomotives VSPD)	Inspect snubber pannel and auxiliary blower motor filters (RFF, TBF, A2AF, CMF, ABF and EBF)	1 Year
Cab Equipment Temperature Switches	Check operation.	1 Year
Cab Equipment Temperature Sensor	Check Operation of HVAC and Strip Heater Switches	1 Year

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Running Maintenance

Major Component/System	Task Description	Frequency
Cab Equipment Inertial Air/Spin Filters	Clean and inspect	4 Years
Compressed Air System		-
Compressed Air System Compressed Air System	Test operation of horn, bell, and wipers. Ensure proper operation of air dryers (if equipped). Ensure main reservoir condensate drain valves are in automatic position and operating properly.	Daily/Trip
Compressed Air System Sand Box	Check sand box for level of sand and refill as necessary	Daily/Trip
Compressed Air System Compressed Air System	MR2 Check valve test	92 Days
Compressed Air System Compressed Air System	Brake Pipe Leakage Test	92 Days
Compressed Air System Compressor Control Panel	Check MR1 sensor for proper operation	92 Days
Compressed Air System Snowblaster Magnet Valves (if equipped)	Check operation.	184 Days
Compressed Air System Snowblaster (If equipped)	Inspect snowblaster high-pressure hoses.	184 Days
Compressed Air System Snowblaster (If equipped)	Inspect snowblaster nozzles for proper alignment.	184 Days
Compressed Air System Snowblaster (If equipped)	Remove, clean, and reinstall snowblaster nozzles.	184 Days
Compressed Air System Auxiliary and MR2 Final Filters	Replace	1 Year
Compressed Air System Compressed Air System	Verify settings of the Pressure Relief Valve	1 Year
Compressed Air System Compressed Air System	Inspect platform to trucks and end connection hoses, sand hoses and traps. Replace if damaged.	1 Year
Compressed Air System Air Filter Dryer/Coalescer Filter Element (If Equipped)	Replace	1 Year

Running Maintenance

Major Component/System	Task Description	Frequency
Compressed Air System Direct Inline Filter Element (If Equipped)	Replace	1 Year
Compressed Air System Magnet Valves	Renew ASMV, RSMV, H MV, H MV2 , IPMV, CMV Magnet valves	1 Year
Compressed Air System Magnet Valves	Renew Split Cooling System Water Flow Magnet Valves.	3 Year
Compressed Air System Magnet Valves	Renew Horn Magnet Valves (If equipped).	5 Year
Cooling System		-
Cooling System Cooling Water	Check water level and water treat- ment concentration. Add treated water or clean water and compatible water treatment compound as needed.	Daily/Trip
Cooling System Pipe Connections and Hoses (Oil and Water)	Inspect metal hose and pipe connec- tions, between the engine cab and radiator cab for leaks. Inspect cou- pling connections for cracks. Replace damaged couplings as necessary. Report any findings.	92 Days
Cooling System Air-To-Air Fans (if equipped)	Inspect charged air system duct work and heat exchangers for charged air leaks and dirt or debris build up . Clean the system as necessary. Check all the heat exchangers (Radiators, Intercooler and Aftercooler) for tube seperation and cracks	184 Days
Cooling System Air-To-Air Fans (if equipped)	Run Self-Test to verify proper opera- tion.	184 Days
Cooling System Auto Drain valve (If equipped)	Test functionality	184 Days
Cooling System Radiator	Clean as necessary. Run fans back- wards to clean debris from screens.	184 Days
Cooling System Shutters (if equipped)	Inspect shutter mechanisms for looseness, jamming, and wear. Run Self-Test to verify proper operation.	184 Days
Cooling System Turbo Ducts	Inspect Turbo Ducts for broken clamps. Replace if necessary.	184 Days

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Running Maintenance

Major Component/System	Task Description	Frequency
Cooling System Water Based Intercooler (if equipped)	Inspect for water leakage.	184 Days
Cooling System Cooling System	Inspect for oil and corrosion. Clean as necessary.	1 Year
Cooling System Magnum Series GURU Valve Cartridge (if equipped)	Replace	18 Months
Cooling System Radiator Fan	Perform visual and functional inspection of fan. Ensure the fan spins freely without rubbing or interfering with other components. Visually inspect the blades and hub for marks indicating burns, cracks or dents. Check that the fan hub does not have worn edges.	2 Years
Display Panel		-
Display Panel Display Panel	Check DID/IFD/VID/CFD for any SUMMARY messages. If any message other than "READY" or "READY-Work Report Stored" is displayed, investigate the cause. Run locomotive Self-Test if needed	Daily/Trip
Display Panel Display Panel	Download and store fault log and engine statistics. Run manual self tests.	184 Days
Display Panel Smart Displays (SFD) Panels	Check illumination bulb, replace if necessary	184 Days
Diesel Engine		-
Diesel Engine Engine Oil	Check oil level at engine IDLE.	Daily/Trip
Diesel Engine Diesel Engine	Listen while engine is idling for any unusual sounds. Make visual inspection with all doors open at this time. Look for water, lubrication and fuel leaks and make corrections as necessary.	Daily/Trip
Diesel Engine Exhaust Manifold and Bellows	Check for leaks, cracks and broken welds while Engine is idling	Daily/Trip

Running Maintenance

Major Component/System	Task Description	Frequency
Diesel Engine Fuel Lines	Inspect fuel lines for damage, leaks and excessive vibration due to loose clamps. Replace if necessary.	Daily/Trip
Diesel Engine Fuel Hoses	Visually inspect fuel hoses to/from the fuel priming pump in the radiator cab. Replace any damaged hoses.	Daily/Trip
Diesel Engine Engine Oil	Collect an oil sample. Make a complete laboratory analysis to determine if oil is suitable for continued use. If acceptable, fill to FULL mark with an approved lubricating oil. If not acceptable, change oil using GEK_76679.	7 to 10 Days
Diesel Engine Water Separator	Ensure that the water separator drain tank is serviced. Drain tank when indicator illuminates.	As Required
Diesel Engine Engine Data Download	Download all Maintenance Cycle Data	92 Days
Diesel Engine Pop Test	Perform the Pop test. Investigate any engine cylinders that do not pop properly.	92 Days
Diesel Engine Crankcase	Clean the eductor tube(s).	184 Days
Diesel Engine EGR System Auxiliary oil line filter (If Equipped)	Replace	184 Days
Diesel Engine Engine Lubricating-Oil Filters and Oil Change	Clean lubricating-oil filter housing, change oil, and install new filters. NOTE: Locomotives must use Generation 4 Long Life engine oil to be approved for the 184 day interval for oil changes. Check GEK_76679 publication for change out frequency.	184 Days
Diesel Engine Fuel Oil Strainer (if equipped)	Replace (Note: Confirm part number in the latest revision of the PARTS CATALOG before ordering.)	184 Days
Diesel Engine Fuel Filter Element	Replace (Note: Confirm part number in the latest revision of the PARTS CATALOG before ordering.)	184 Days

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Running Maintenance

Major Component/System	Task Description	Frequency
Diesel Engine Hoses	Visually inspect the coalescer hoses for tears or holes in the silicone layer. Replace if any damage is found.	184 Days
Diesel Engine Oil Pipe	Inspect pipe connections between Engine and Rad Cab for oil leaks. Inspect victaulic connections for cracks. Replace as necessary	184 Days
Diesel Engine NOx Sensor	Replace	See GEK-115176 , GEVO LOW EMISSIONS LOCOMOTIVES SPECIAL MAINTENANCE INSTRUCTIONS
Diesel Engine Hot Box Heater Cartridges	Replace	184 Days
Diesel Engine Engine Crankcase	Visually inspect all crankcase components.	1 Year
Diesel Engine Engine Valves	Check valve lash and adjust as necessary	1 Year
Diesel Engine Water Separator	Replace (Note: Confirm part number in the latest revision of the PARTS CATALOG before ordering.)	1 Year
Diesel Engine Fuel Heater (if equipped)	Visually inspect for any leaks, corrosion, or damaged gaskets	2 Years
Diesel Engine Fuel Injection Nozzles	Replace (For T4 Only)	See GEK-115176 , GEVO LOW EMISSIONS LOCOMOTIVES SPECIAL MAINTENANCE INSTRUCTIONS
Diesel Engine High Pressure Fuel Pumps	Replace	See GEK-115176 , GEVO LOW EMISSIONS LOCOMOTIVES SPECIAL MAINTENANCE INSTRUCTIONS
Platform		-
Platform Retention Tank/Sump	Check level, drain if necessary (In accordance with applicable laws and regulations.)	7 to 10 Days
Platform Fuel Tank Sump	Drain any trapped water. Frequency can be changed based on operating conditions	92 Days

Running Maintenance

Major Component/System	Task Description	Frequency
Platform Coupler	Inspect coupler and coupler levers for defects.	92 Days
Platform Fuel Tank	Inspect fuel tank and hoses for cracks.	92 Days
Platform - Tank / Sill	Inspect the main sill, bottom plate and fuel tank transition for visible crack from all 4 corners.	368 Days
Platform MU Cables	Inspect trainline MU receptacles (pins, cover, spring, etc.) and cables for damage.	92 Days
Platform Retention Tank	Inspect drain troughs along the walkways to ensure drain holes are not plugged	92 Days
Traction Motor		-
Traction Motor Power Leads	Check power leads for abrasion damage and rubbing against other cables or truck parts. Verify connections are tight.	92 Days
Traction Motor Traction Motor	Visually inspect. Check for vibration.	When renewing Wheels
Traction Motor Combo		-
Traction Motor Combo Gear Case	Inspect for mechanical damage.	92 Days
Traction Motor Combo Gear Case	Check oil level. Fill to bottom of filler opening. If oil loss is greater than limits, remove combo and inspect (Refer to GEK_114829 for oil to be used & oil loss limits)	92 Days
Traction Motor Combo Gear Case	Check for damaged or missing, fill or drain plugs. Clean metal particles from drain plug if removed	92 Days
Traction Motor Combo Gear Case	Inspect entire combo for excessive oil leakage (traction motor seals, motor shaft/axle gearcase seal interface areas, for streaks on gear case flank, seepage or leaks at split joint).	92 Days

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Running Maintenance

Major Component/System	Task Description	Frequency
Traction Motor Combo Gear Case	Inspect gear case mounting bolts for tightness by hand or wrench. Visually check for any gap in the joint, perform a hammer test or use a 0.005 inch feeler gauge to see if it will fit under the bolt head or washer. If loose, broken, or missing, replace with new parts. Tighten bolts to torque values specified in GEK_114829. Note: (1) Load washer assemblies, if used must be replaced. (2) New bolts (lightly lubricated) shall be of the same Grade as removed [Grade 5 bolts = 3 marks on the bolt head, Grade 8 bolts = 6 marks on the bolt head] OR as specified in latest BOM	92 Days
Traction Motor Combo Gear Case	Check accessible gear case split line bolts for looseness by hand or wrench or use an 8 oz hammer test. Tapping with a light hammer or metal rod should sound different for loose or broken bolts. If loose, broken, or missing, replace with new parts. Tighten bolts to torque values specified in GEK_114829. Note: New bolts (lightly lubricated) shall be of the same Design or Grade as removed or as specified in latest BOM	92 Days
Traction Motor Combo Gear Case	Inspect U-Tube to Traction Motor mounting bolts for tightness by hand or wrench. Visually check for any gap in the joint, perform a hammer test or use a 0.005 inch feeler gauge to see if it will fit under the bolt head or washer. If loose, broken, or missing, replace with new parts. Tighten bolts to torque values specified in GEK_114829. Note: (1) Load washer assemblies, if used must be replaced. (2) New bolts (lightly lubricated) shall be of the same Grade as removed [Grade 5 bolts = 3 marks on the bolt head, Grade 8 bolts = 6 marks on the bolt head] OR as specified in latest BOM	1 Year

Running Maintenance		
Major Component/System	Task Description	Frequency
Traction Motor Combo Gear Case	Drain and refill.	1 Year
Traction Motor Combo Gear Case	Renew gearcase seals. Drain and refill the gear case	When renewing Wheels
Traction Motor Combo Pinion and Axle Gear	Clean and inspect	When renewing Wheels
Traction Motor Combo Gear Case	If the U-tube is removed, it must be requalified with proper bearing end play and vibration testing.	When renewing Wheels
Truck		-
Truck Trucks	Inspect for any loose or dragging equipment. Repair as needed.	Daily/Trip
Truck Trucks	Ensure sand pipes are aligned properly and sanders operate correctly.	Daily/Trip
Truck Brake Rigging and Shoes	Inspect for excessive wear. Replace shoes as needed.	Daily/Trip
Truck Slack Adjuster	Adjust slack adjuster as needed for proper piston travel.	Daily/Trip
Truck Hydraulic shocks/dampers	Check for leaks or cracks.	92 Days
Truck Traction Motor Suspension Link	Visually inspect the suspension link mounting bolts are still in place (bolt heads showing). Verify Huck pin and collar are present or Camcar Bolt is tight.	92 Days
Truck Wear Plates: Pedestal Liners	Check for presence of plate, cracked welds and excessive wear. Replace as necessary.	92 Days
Truck Wear Plates: Lateral Liners	Inspect and replace as necessary (applicable to locomotives with steerable trucks)	184 Days
Truck Hand Brake	Visually inspect hand brake for defects and lubricate internal components.	184 Days
Truck Electronic Parking Brake (If equipped)	Inspect	1 Year

Scheduled Maintenance, 12-Cylinder AC Tier 4 Evolution Series Locomotive

Running Maintenance

Major Component/System	Task Description	Frequency
Truck DWM Lift Mechanism Pins and Chain (Only on C4 truck type)	Replace	5 Years
Truck Trucks	Check truck clearances and renew or shim load bearings as required.	When renewing Wheels
Wheels		-
Truck Wheels	Visually inspect the wheel rim versus the witness groove for wheel wear. Check for cracks, shelled treads or flat spots. Make corrections as required.	Daily/Trip

5. REMOVAL AND REPLACEMENT PROCEDURES

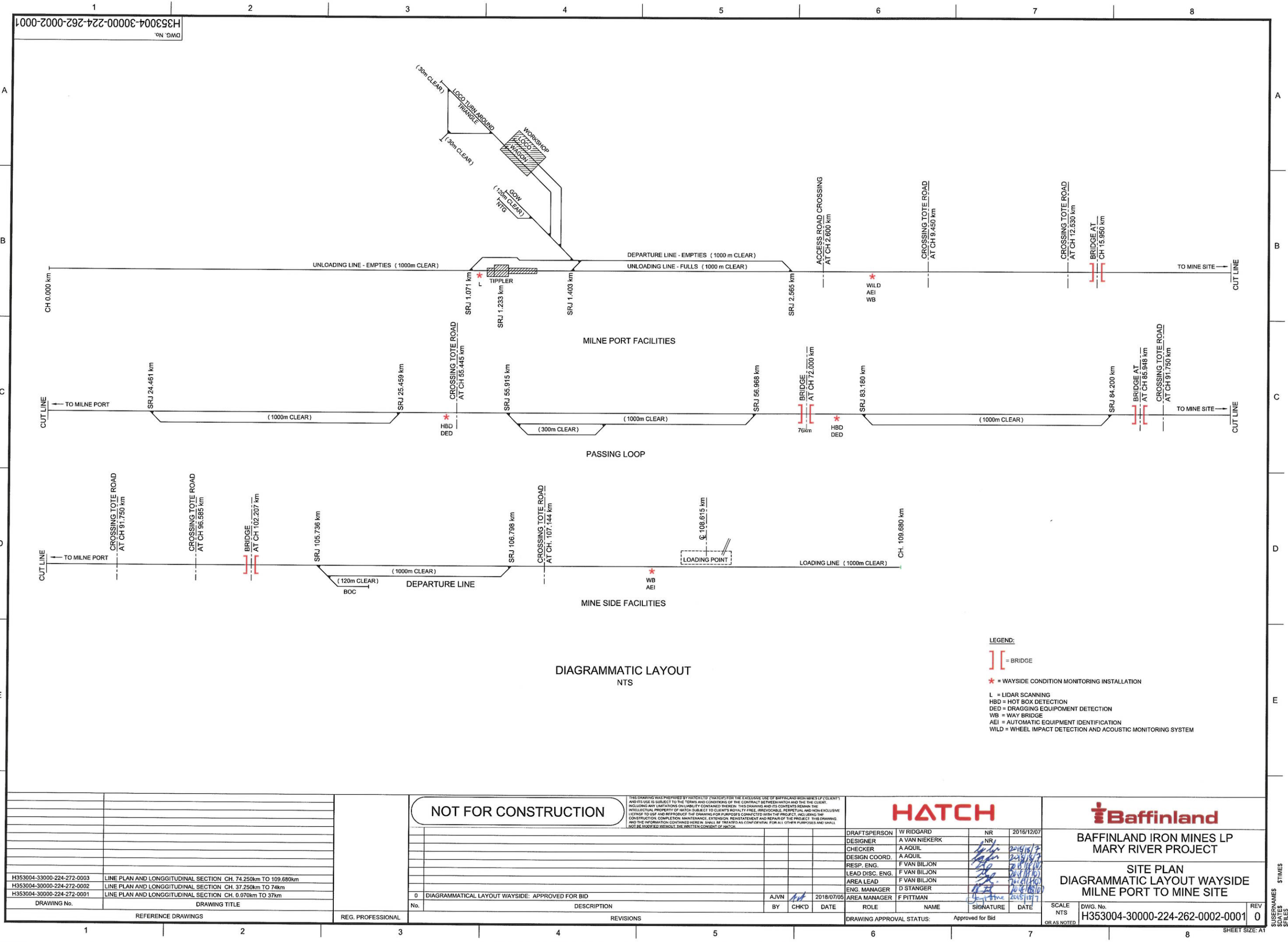
Not Applicable

6. SUMMARY DATA

Not Applicable

This page intentionally left blank.

*TC 17 ATTACHMENT 1: DRAWING NO. H353004-
30000-224-262-0002-0001*



TC 18 ATTACHMENT 1: TABLE 1

List of derailment equipment	Number	Location	
		Mine	Port
Crane 300t	1	X	
CAT type 998 Front End Loaders (or equivalent)	2	X	
CAT Type 992 Front End Loaders (or equivalent)	2	X	
CAT Type 994 Front End Loader	1	X	
Tamper	1	X	
Ballast regulator	1	X	
Ballast cars	5		X
Flat cars	2		X
F350 Hi Rail	2		X
F350 Hi Rail	2	X	
Fuel truck	1		X
Hydraulic and other rerailling equipment	1		X
Geometry car	1		X
CAT D6 dozers (or equivalent)	4	X	
CAT D9 dozer	3	X	
CAT D10 dozer	2	X	

Track material will be located at the port or at other designated stockpile locations along the rail alignment

Not all equipment will always be at the locations indicated since some might be at work along the rail alignment when a derailment occurs, these pieces of equipment will be dispatched to the derailment site as required

Pipelaying machines are not currently part of the derailment equipment list but the list is not final and further consideration is being given to the over all equipment compliment as the project progresses

During construction accommodation camps will be erected at two locations along the alignment to support construction, however to support the derailment recovery effort considerations is currently being given to retain one of these camps when in operations to support derailment recovery, this these camps can provide sleeping facilities, food and sanitary facilities.

APPENDIX 7

COMMITMENT REGISTER

TO:	Nunavut Impact Review Board	From:	Baffinland Iron Mines Corporation
File:	Phase 2 Proposal Updates to Environmental Management and Monitoring Plans and Commitment Registry	Date:	January 30, 2018

**REFERENCE: PHASE 2 PROPOSAL – COMMITMENT REGISTRY WITH UPDATES FROM ADVANCE
TECHNICAL RESPONSES**

Introduction

Baffinland Iron Mines Corporation (Baffinland) developed environmental management, mitigation and monitoring documents to support the Final Environmental Impact Statement (FEIS) and Early Revenue Phase and has continued to create and update its plans throughout operations. As an operational mine, it is important to recognize that all management plans are living documents, where regular updates are tracked through a formal versioning process. It is recognized that the Phase 2 Proposal requires a consolidated update to many of Baffinland's management plans and that some of these management plans will require further update(s) once Phase 2 is approved by the Nunavut Impact Review Board (NIRB) and Nunavut Water Board (NWB), and, revisions to the Project Certificate No. 005 and Type A Water License No. 2AM-MRY1325, respectively, are granted.

As part of the regulatory review and consultation process, including the technical review period, new mitigation, monitoring and commitments are being identified. The attached Commitment Register has been updated based on the current round of Advance Technical Responses to provide a tool to easily identify changes.

Management, Mitigation and Monitoring Plan Update Schedule

Required changes to plans will be tracked, and the Commitment Register will be updated for circulation at various milestones through the regulatory process, including but not necessarily limited to the following: with submission of information request responses; with submission of technical question responses; immediately following the technical meetings; and in advance of any formalized engagement activities as necessary. It is anticipated that the final draft plans reflecting all changes identified will be distributed after the technical meetings and before final written submissions are due, with some reasonable exceptions. These exceptions include plans that are specific to a separate approval or permitting process and include, but are not limited to the following:

- Ore Dock Construction Management Plan: to be developed during the permitting phase
- Interim Closure and Reclamation Plan: to be developed in accordance with regulatory timelines as established for the ICRP
- Interim Waste Rock Management Plans: do not apply to Phase 2 Proposal
- Phase 1 Waste Rock Management Plan: to be submitted December 31, 2019 as part of ongoing process to address existing operational issues
- Oil Pollution Emergency Plan – Milne Inlet: to be developed in accordance with regulatory timelines associated with the OPEP
- Landfill Maintenance and Operations Manual: to be developed when appropriate detailed engineering information is available (after the closure of Quarry 1)

Baffinland Phase 2 Commitment Register

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
1	TSD 28	EPP	2.2	Operation of North Railway	The construction and operation of the railway will require updates related to local land use
2	TSD 28	EPP	2.3	Operation of North Railway	The construction and operation of the railway will require updates related to land disturbance.
3	TSD 28	EPP	2.12	Operation of North Railway	The construction and operation of the railway will require updates related to caribou protection measures.
4	TSD 28	EPP	2.19	Operation of North Railway	The construction and operation of the railway will require updates related to lo traffic management.
5	TSD 28	EPP	2.20	Operation of North Railway	The construction and operation of the railway will require updates related to local land use, and drilling, blasting, and crushing.
6	TSD 28	EPP	2.3	Land Disturbance Mitigation	Mitigation to be added: Slopes will be flattened as necessary when being constructed in ice-rich or thaw sensitive materials, and will be protected with thermal and erosion protection material, if required. Excavations will be minimized, especially in areas of known ice-rich permafrost. Prior to embankment construction, ground disturbance will be minimized and vegetative or organic cover left in place to provide the maximum protection of the thermal regime. In areas where excavation is required, the foundations will be over excavated and backfilled with 0.8 m of non-freeze/thaw susceptible fill to minimize frost heaving and settlement. Slopes will be flattened as necessary when being constructed in ice-rich or thaw sensitive materials, and will be protected with erosion protection material, if required. This will include a geotextile layer as well as an engineered backfill. For high embankment fills on ice-rich materials, the side slopes may be flattened significantly or stabilization berms constructed to reduce the creep deformation potential. For construction during the summer, woven geotextile may be required over unstable ground.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					Proper runoff collection and diversions drainage systems will be used to control runoff and erosion from affecting the modified thermal regime. As part of basic design, thermal modeling will be conducted for each typical embankment condition and configuration to identify the actual permafrost protection measures required and to predict the nature of the active layer and the effect that construction will have on the thermal regime over the life of the Project. The thermal modeling will incorporate potential warming trends resulting from climate change based on world-recognized global warming scenarios. Thaw settlements and surface sloughing of cut slopes is expected, particularly during the thaw seasons immediately following construction. The behaviour of both cut slopes and embankment fills will be monitored throughout these thaw seasons and remedial measures will be implemented as necessary. For example, it is expected that many of the cut slopes will need to be monitored as thaw settlements occur. Silt fences and other erosion protection measures will be installed as necessary to prevent siltation of adjacent drainage courses and water bodies.
7	TSD 28	EPP	2.9	Drainage Patterns	Add measures to minimize changes to the hydrologic drainage patterns.
8	TSD 28	EPP	2.17	Drainage Patterns	Add measures to minimize changes to the hydrologic drainage patterns.
9	TSD 28	EPP	2.25	Drainage Patterns	Add measures to minimize changes to the hydrologic drainage patterns.
10	TSD 28	EPP	2.27	Drainage Patterns	Add measures to minimize changes to the hydrologic drainage patterns.
11	TSD 28	EPP	2.29	Drainage Patterns	Add measures to minimize changes to the hydrologic drainage patterns.
12	TSD 28	EPP	2.18	Culvert Design	Add the following design considerations for culvert installation/replacement: •Install culverts at the same slope as the existing stream, where feasible. •Minimize culvert lengths. •Culverts with lengths that exceed 50 m may be considered barriers to fish passage due to darkness. Examine and consider methods to provide light

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					inside culverts, where applicable. • Compare culvert velocities to the velocity in the existing watercourse to determine fish passage potential. This information can be used to reassess design velocities under proposed conditions with the culvert installed. With the channelization of flows and conveyance in culverts, the velocity of the flows may increase. This may be mitigated by placing rocks and boulders inside the culverts (stream replication) to provide greater friction, thereby reducing velocities and increasing the flow depth and to provide resting locations for fish. Boulders may be bolted into place. - In culverts on steep slopes, high velocities may result in the movement of rocks inside the culvert. At these locations, install baffles, baffle inserts or weirs to: • assist in keeping rocks inside the culvert; • maintain and increase roughness in order to reduce velocities; and • provide additional resting locations for fish as they move through the culvert.
13	TSD 28	EPP	2.2	Railway and Road Safety Features	The following safety features will increase the visibility of the crossings and increase safe use of the road: • Early warning signs will warn road users of an approaching railway crossing and stop sign ahead. • A combined stop and railway crossing sign will be located on either side of the crossings. • Crossing timbers will ease vehicle, ATV, and snowmobile crossing. • Instructional bulletins regarding the rail crossings will be posted in English and Inuktitut at each end of the Tote Road.
14	TSD 28	EPP	2.3	Thaw Settlements from Construction	Thaw settlements and surface sloughing of cut slopes is expected, particularly during the thaw seasons immediately following construction. The behaviour of both cut slopes and embankment fills will be monitored throughout these thaw seasons and remedial measures will be implemented as necessary. For example, it is expected that many of the cut slopes will need to be monitored as thaw settlements occur. Silt fences and other erosion protection measures will be installed as necessary to prevent siltation of adjacent drainage courses and water bodies.
15	TSD 28	EPP	2.3	Permafrost Protection	Excavations will be reduced, especially in areas of known ice-rich permafrost.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
16	TSD 28	EPP	2.3	Embankment Construction	In areas where excavation is required, the foundations will be over excavated and backfilled with 1.5 m of non-freeze/thaw susceptible fill to reduce frost heaving and settlement. For high embankment fills on ice-rich materials, the side slopes may be flattened substantially or stabilization berms constructed to reduce the creep deformation potential. To reduce the rate of creep settlement, embankments thicker than three metres should be constructed with side slopes no steeper than 5H:1V or with toe buttresses. For construction during the summer, woven geotextile may be required over unstable ground.
17	TSD 28	EPP	2.3	Thermal Regime	Proper runoff collection and diversion drainage systems will be used to control runoff and erosion from affecting the modified thermal regime.
18	TSD 28	EPP	New Section 'Ore Dock Construction'	Ore Dock Construction	An Ore Dock Construction Environmental Plan will be prepared to meet Fisheries Act Authorization requirements and implemented during construction of marine facilities in Milne Inlet. Silt curtains will be installed around localized construction areas during the ice break-up period and around the full perimeter of construction including removed sediment disposal area during the open-water season. Silt curtains will be installed prior to any in-water work in order to encapsulate the entire construction footprint and to reduce disturbance to the marine environment in the surrounding area. Construction of concrete components of the dock will consist of installation of prefabricated concrete elements whenever possible. If in-situ concrete production is required, works will be conducted in the way to avoid contact of cement and uncured concrete with surrounding water. The majority of construction work, particularly in shallow water (e.g., access causeway), will take place in winter as land-fast ice is formed. It is expected that, as construction gradually moves offshore, ice will thicken and become grounded. Therefore, ice surrounding construction areas will act as a barrier limiting particulate deposition and spills in surrounding water. To reduce disturbance to the marine environment, the ore dock components will be constructed sequentially, moving from onshore to offshore; the causeway will be constructed in small sections, placing protective layers and armoring immediately after core material is placed to minimize erosion. Backfilling of the berth will only occur after a sufficient length of quay is installed so the fill remains within the structure footprint and no material is dispersed. Machine

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					operation in water will be reduced, e.g., piling and filling equipment will operate on the constructed sections of the ore dock and will not enter the water. Use of a suction pump for localized removal of soft sediment layer will reduce dispersal of re-suspended sediment in water. Disposal of removed sediment will be conducted in accordance in a way to minimize effects on water and sediment quality. The material will be removed using a suction pump, which will reduce dispersal of re-suspended sediment in water. Most acoustically sensitive fish will avoid the immediate impact area once impact pile driving is underway. Operators are encouraged to take advantage of this behaviour by adopting a ramp-up / soft-start procedure when operating the impact hammer, when this is technically feasible. A ramp-up procedure consists of initial activation of the equipment using the lowest energy source / pulse and gradually increasing the intensity of the sound until it reaches the required intensity, thus allowing time and incentive for acoustically sensitive fish to leave the area prior to operating the impact driver at full power.
19	TSD 28	EPP	New Section 'Ore Dock Construction'	Ore Dock Construction	Concurrent impact pile driving activities will be minimized when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned, they will be sequenced where possible to minimize acoustic impacts. Underwater noise generated during impact pile driving will not exceed 207 dB re 1µPa ² -s (SPLPk) at a distance of 200 m from the source. If the sound level exceeds 30 kPa at a distance of 10 m from the source, measures will be undertaken to reduce either the intensity of the sound generated or the level of sound propagation through the water column. The appropriate measure will be chosen based on practicality and effectiveness and may include: The placement of bubble curtains around the wetted pile during impact driving. Bubble curtains are proven to be an effective mitigation measure for dampening underwater noise generated by pile driving, and are reported to reduce peak pressures by up to 30 dB (Buehler et al. 2015). The use of a vibratory hammer in place of an impact hammer for pile driving. Impact pile driving activities will be temporarily suspended if aggregations of fish are spotted within the immediate work area or if any fish spawn is observed attached to equipment or structures in the water. Impact pile driving will be scheduled when practical to avoid sensitive fish periods such as fish spawning and migratory periods. During in water construction, a silt curtain will be installed in order to isolate the footprint of

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					the proposed ore dock. The curtain will be designed and procured in sections which relate to the water depth in order to remain buoyant and extend to the ocean floor with sufficient slack. Prior to construction work within the silt curtain area, efforts will be made to salvage fish and release them alive outside of the work area. The silt curtain will also serve as a deterrent to fish re-entering the isolated work area. Construction activities will be managed through development of the Environmental Protection and Monitoring Plan, outlining specific procedures to avoid or reduce effects on the marine environment. Proposed mitigation measures during construction will include the installation of silt curtains around in-water works to minimize disturbance to the surrounding marine environment, turbidity monitoring and underwater noise monitoring during pile installation and dredging, and environmental monitoring with regular inspection audits to verify effectiveness of mitigation measures and compliance of Project activities with existing permits and authorizations. Proposed mitigation measures included the use of a bubble curtain to reduce peak sound pressure levels emitted from the pile (during pile driving).
20	TSD 28	EPP	New Section 'Ore Dock Construction'	Ore Dock Construction	The proposed ore dock will be constructed in succession to limit disturbance to the natural marine environment, with a focus on in-water activities and producing an effective structure for long term, low maintenance operation. The dock face will be oriented parallel to the existing seabed contours to minimize dredging activities. The proposed ore dock will be constructed during the ice-covered season, when ringed seal would be the only marine mammal species present in Southern Milne Inlet. A ramp-up procedure consists of initial activation of the equipment using the lowest energy source / pulse and gradually increasing the intensity of the sound until it reaches the required intensity, thus allowing time and incentive for marine mammals to leave the immediate zone of potential injury before the pile driver is operating at full power. Installation of a bubble curtain around the wetted pile to dampen sound transmission through water during active pile driving. During all pile driving activities, marine mammal monitoring will be undertaken by a qualified and experienced Marine Mammal Observer (MMO), with all sightings communicated to the piling contractor. Implementation of a 1-km Marine Mammal Exclusion Zone – defined as the zone within which MM may be potentially exposed to sound levels above the injury threshold criteria (180 dB

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					re 1 μ Pa SPLrms for cetaceans and 190 dB re 1 μ Pa SPLrms for pinnipeds). The occurrence of a marine mammal within the exclusion zone will trigger specific mitigation actions (e.g., shut-downs) such to avoid potential for physical injury to animals from pile driving noise. Shut-down procedures –pile driving will be temporarily suspended when a marine mammal enters within the exclusion zone until which time it moves outside the safety zone. Implementation of a 30 minute pre-operational (pre-ops) search for marine mammals prior to start-up of pile driving. This would consist of a visual scan of the water by the MMO to determine that no marine mammals are present within the exclusion zone. If an animal is spotted within the exclusion zone during the pre-ops search, the ramp-up procedure will be delayed 20 minutes from the time the marine mammal has left the exclusion zone, or was last sighted in this zone. The MMO will periodically verify underwater sound levels in the field using a hydrophone and a real-time sound monitor to confirm that sound levels at the modeled exclusion zone radius are below the established injury thresholds for marine mammals. If sound levels are shown to exceed the injury thresholds at the exclusion zone radius, the exclusion zone boundary will be adjusted accordingly. Vessels will reduce speeds to a maximum of 9 knots when transiting along the established shipping corridor, and 5 knots when operating in Milne Port, thus reducing the overall noise output generated by ship propulsion and the potential for ship strikes.
21	TSD 28	Borrow Pit and Quarry Management Plan	Appendix E	Identify New Quarry Sites	Update tables and figures with new quarry site information.
22	TSD 28	Interim Closure and Reclamation Plan	3.2	Project Description	Update to include new Project components and infrastructure.
23	TSD 28	Interim Closure and Reclamation Plan	6	Closure and Objectives	Update to include North Rail, consistent with the Closure Objectives and Criteria for the South Rail already considered.
24	TSD 28	Interim Closure and Reclamation Plan	13.3.2	Post-closure Monitoring	Update to include new Project components and infrastructure.
25	TSD 28	Interim Closure and Reclamation Plan	13.3.7	Post-closure Monitoring	Update to include new Project components and infrastructure.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
26	TSD 28	Interim Closure and Reclamation Plan	14	Annual Security Requirements	Baffinland will submit a revised version of the ICRP within 60 days following approval of the requested water licence amendment, in accordance to Part J, Item 2 of the Licence. In accordance to Part C of the Licence, Baffinland will update the security requirements for the Project annually, with necessary adjustments accounted for in the results of the Annual Security Review process.
27	TSD 28	Interim Closure and Reclamation Plan	Appendix A	Mine Closure and Reclamation Plan Drawings	Update to include new Project components and infrastructure.
28	TSD 28	Explosives Management Plan	2.1	Project Timelines	Update to incorporate the project timelines and applicable activities from the Phase 2 Proposal.
29	TSD 28	Explosives Management Plan	2.3	Quantity of Ammonium Nitrate	Update to incorporate the new quantity of ammonium nitrate required for Phase 2.
30	TSD 28	Explosives Management Plan	2.4	Quantity of Ammonium Nitrate	Update to incorporate the new quantity of ammonium nitrate required for Phase 2.
31	TSD 28	Explosives Management Plan	2.4	Expansion of Explosives Area	Update to incorporate the expansion of the explosives area to accommodate increases in volume of ammonium nitrate and storage of pre-packaged explosives required for Phase 2
32	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	4.3	Water Supply for Temporary Camps	Describe water supply to temporary camps.
33	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	5.4	Sewage Disposal for Temporary Camps	Describe sewage disposal plans for temporary camps.
34	TSD 28	Fresh Water Supply, Sewage and	Table 4-2	Additional Water Sources	Add the additional dust suppression water sources within the Northern Transportation Corridor.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
		Wastewater Management Plan		for Dust Suppression	
35	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	4.2	Additional Water Supply Mitigation	Add that monthly cumulative withdrawals from lakes represent less than 10% of the monthly outflow, unless site-specific conditions indicate that a greater water withdrawal will not be significant in the context of fish habitat (i.e., Camp Lake).
36	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	4.2	Additional Water Supply Mitigation	Add that stream water take stations are selected to be sufficiently large such that the instantaneous water withdrawal rate does not exceed 20% of the 10-year monthly low flow condition if a stream is fish-bearing, or 40% of the 10-year monthly low flow condition if the stream is not fish-bearing.
37	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	4.2	Additional Water Supply Mitigation	Add mitigation that at select streams where the water take exceeds than the applicable threshold under mean flow conditions but not under the 10-year low flow, water withdrawals are permitted only during the months of June and July.
38	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	7	Address Water Management Changes with New Ore Stockpiles	Update to reflect the changes in water management associated with ore and product stockpiles, including the use of the temporary ore transfer stormwater pond as a water source for dust suppression.
39	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	8	Update to Include New Water Monitoring Locations for Milne Landfill	Update to include the addition of the Milne Port Landfill and associated water quality monitoring locations.
40	TSD 28	Fresh Water Supply, Sewage and Wastewater Management Plan	Appendix B	Updates to Figures and Block Diagrams	Update to reflect new infrastructure and water quality monitoring locations.
41	TSD 28	Fresh Water Supply, Sewage and	Appendix C	Updates to Figures and	Update to reflect new infrastructure and water quality monitoring locations.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
		Wastewater Management Plan		Block Diagrams	
42	TSD 28	Snow Management Plan	4.3	Snow Stockpile Locations	Revise snow stockpile locations based on site layout changes arising from the Phase 2 Proposal.
43	TSD 28	Snow Management Plan	Attachment A	Project Camp Sites Snow Management Guidelines	Update to reflect camp infrastructure.
44	TSD 28	Snow Management Plan	Attachment B	Milne Port Ore Stockpile Snow Management Guidelines	Update to reflect revised ore stockpile infrastructure.
45	TSD 28	Snow Management Plan	Attachment D	Tote Road Snow Management Guidelines	Expand scope of section to include North Railway Snow Management Guidelines.
46	TSD 28	Waste Management Plan	3.7	Milne Port Landfill	Update to include new landfill facility at Milne Port
47	TSD 28	Hazardous Materials and Hazardous Waste Management Plan	Appendix B	Hazardous Waste Storage Facilities Locations	Provide updated site layout figures identifying hazardous waste storage facilities.
48	TSD 28	Hazardous Materials and Hazardous Waste Management Plan	3.1.2	Explosives Quantities	Update to reflect new quantities of ammonium nitrate and explosives.
49	TSD 28	Hazardous Materials and	5	Roles and Responsibilities	Update roles and responsibilities for Project departments and personnel related to Phase 2.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
		Hazardous Waste Management Plan			
50	TSD 28	Hazardous Materials and Hazardous Waste Management Plan	Appendix A	Concordance Tables for Relevant Terms and Conditions	Update to reflect terms and conditions in amended Type 'A' Water Licence and Project Certificate.
51	TSD 28	Hazardous Materials and Hazardous Waste Management Plan	Appendix B	Site Layouts	Update to reflect new Project facilities and infrastructure.
52	TSD 28	Life of Mine Waste Rock Management Plan	3	Waste Rock Production Schedule	Quantities of waste rock generated over the mine life and the phasing of waste rock deposition over time will be updated to reflect the higher production rate associated with the Phase 2 Proposal.
53	TSD 28	Life of Mine Waste Rock Management Plan	4	Waste Rock Production Schedule	Quantities of waste rock generated over the mine life and the phasing of waste rock deposition over time will be updated to reflect the higher production rate associated with the Phase 2 Proposal.
54	TSD 28	Landfill Maintenance and Operations Manual	Throughout	New Non-hazardous Waste Landfill at Milne Port	Update to include reference to the new non-hazardous waste landfill at Milne Port.
55	TSD 28	Health and Safety Management Plan	2.4	Consistency with Emergency Response Plan	Update section to ensure it is consistent with the detailed information provided in the Emergency Response Plan.
56	TSD 28	Health and Safety Management Plan	8	References	Change reference to reporting and documentation requirements so it is not referencing Appendices of the FEIS.
57	TSD 28	Health and Safety Management Plan	9	References	Change reference to reporting and documentation requirements so it is not referencing Appendices of the FEIS.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
58	TSD 28	Health and Safety Management Plan	11	References	Change reference to reporting and documentation requirements so it is not referencing Appendices of the FEIS.
59	TSD 28	Health and Safety Management Plan	12	References	Provide Canadian reference for indicators (Recordable incident rate, lost time injury rate) rather than OSHA (United States).
60	TSD 28	Health and Safety Management Plan	Annex 1	Update Out-of-date Annex 1 Document	Provide updated Annex or reference to other more recent safety plans.
61	TSD 28	Emergency Response Plan	Appendix B	New Risks due to Updated Site Layouts (Part of Water Licence Amendment Application)	New risks to be considered including: collisions along road/rail, stranding due to rail accident.
62	TSD 28	Emergency Response Plan	Foreword	Railway Emergency Plan	Remove 'Future revisions to the Emergency Response Plan will include references to the Railway Emergency Plan' and add reference to the Railway Emergency Plan.
63	TSD 28	Emergency Response Plan	2.2	Reference to Railway Emergency Response Plan	Add Railway Emergency Response Plan to Baffinland Emergency Response figure. Add Section 2.2.6 which will describe Railway Emergency Response Plan.
64	TSD 28	Emergency Response Plan	4.2	Add Probable Emergencies Related to Rail	Add sections on probable emergencies that may occur with the railway (e.g., derailments).
65	TSD 28	Emergency Response Plan	8.1	Emergency Response Equipment for Railway Incidents	Add additional emergency response equipment that will be available for incidents on the railway.
66	TSD 28	Emergency Response Plan	9	Reporting Requirements	Add information on how railway occurrences must be reported as per Transportation Safety Board Regulations Section 5(1).

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
				for Railway Occurrences	
67	TSD 28	Emergency Response Plan	Appendix A.1	New Project Certificate Conditions	Add any new Project Certificate conditions applicable to Emergency Response that have been added to the amended Project Certificate.
68	TSD 28	Emergency Response Plan	Appendix A.2	Reference Regulatory Documents Related to railway	Add reference to regulatory documents related to railway.
69	TSD 28	Spill Contingency Plan	7	New Fuel Storage and Handling Facilities	Update to include the location and details of new fuel storage and new spill response equipment.
70	TSD 28	Spill Contingency Plan	Appendix A	Site Layouts	Update to reflect new Project facilities and infrastructure.
71	TSD 28	Spill Contingency Plan	6.4	Rail-based Emergency Response Vehicles	Update to include rail-based emergency response.
72	TSD 28	Spill Contingency Plan	Table 7-1	Fuel Storage Capacity	Update to include updated fuel storage capacities.
73	TSD 28	Spill Contingency Plan	Table 7-2	Explosives Storage Quantities	Update to include current explosives storage quantities.
74	TSD 28	Spill Contingency Plan	7.4.1	Potential Spill Scenario	Add detail on potential scenario: Railway Lubricants/Oil Spill.
75	TSD 28	Spill Contingency Plan	8	Reporting Requirements	Update reporting requirements to include Transportation Safety Board reporting requirements.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
76	TSD 28	Spill Contingency Plan	Appendix B	Inventory	Add rail-based emergency response vehicles and spill kit supplies to inventory.
77	TSD 28	Spill Contingency Plan	Appendix C	Railway Specific Chemicals to MSDS Inventory Appendix	Add any additional chemicals that will be used for railway operations to the MSDS inventory.
78	TSD 28	Oil Pollution Emergency Plan – Milne Inlet	4.1	Bulk Oil Transfer, Ship to Shore	Update section to reflect increased volumes of fuel to be transferred (110ML+) and relocation of fuel transfer manifold.
79	TSD 28	Oil Pollution Emergency Plan – Milne Inlet	Appendix A	Site Layout	Update to reflect new Project facilities and infrastructure.
80	TSD 28	Spill at Sea Response Plan	General Overview	Project Description	Update description of project to change mode of ore transport to railway, increase tonnage from 3.5 to 12 Mtpa.
81	TSD 28	Spill at Sea Response Plan	General Overview	Shipping Route	Change shipping route description/figure to indicate final destination is not necessarily Rotterdam.
82	TSD 28	Spill at Sea Response Plan	Figure 1-1	Shipping Route	Change shipping route description/figure to indicate final destination is not necessarily Rotterdam.
83	TSD 28	Spill at Sea Response Plan	Context for the SSRP	Number of Tugs in Use	Increase number of tugs from 2, to 6-10.
84	TSD 28	Spill at Sea Response Plan	Context for the SSRP	List of Vessel Types	Remove reference to Rotterdam, add capsize vessels to list of vessels.
85	TSD 28	Spill at Sea Response Plan	Context for the SSRP	Number of Fuel Tanker Deliveries	Increase number of fuel tanker deliveries per year.
86	TSD 28	Spill at Sea Response Plan	Section 11	Fuel Volume due to	Confirm maximum volume of fuel on capsize vessels and update Table 11-1 Fuel Inventory if greater than 3000 m ³ .

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
				Capesize Vessels	
87	TSD 28	Spill at Sea Response Plan	Table 15	Update to Fuel Volumes in Risk Register due to Capesize Vessels	Update table with increased spill volume due to increased fuel volume on capesize vessels.
88	TSD 28	MMER Emergency Response Plan	Appendix A	Site Plans	Update to reflect the new water management infrastructure at the primary crusher pad (Mine Site) and secondary crusher pad (Milne Port).
89	TSD 28	MMER Emergency Response Plan	Appendix B	Drainage Plan	Update to describe the Phase 2 components and activities that interact with surface water.
90	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	1.4	Incorporate Scope of Phase 2 Proposal	Update to describe the Phase 2 Proposal components and activities that interact with surface water quantity and water quality including mitigation measures to address the effects on streams receiving diverted flows, and mitigation measures to address fish passage at select culvert crossings along the railway.
91	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	4	Mitigation Measures for Surface Water	Update mitigation measures for exposed soils, sedimentation, erosion, dust suppression, stream crossings, flow diversions, and fish habitat based on activities and components in the Phase 2 Proposal. Mitigation measures to be updated/added include: •In-stream work will not be conducted during the restricted activity window, September 1 through June 30, where applicable (i.e., where spawning habitat is present or at sites where fall spawning movements are occurring such as at the bridge crossing sites CV-15-5, CV-70-3, and CV-85-3) to avoid effects on Arctic Char spawning and egg incubation. •Work in watercourses will be conducted in isolation of surface waters, if flow is present. •If dewatering is required, salvage fish prior to dewatering and release to adjacent surface waters; if water is pumped from within a cofferdam prior to fish salvage, screens meeting criteria set out by DFO will be used. •Preserve low vegetative cover within 100 metres (m) of the crossing unless effective erosion and sediment control are in place to protect water quality. •Implement measures as soon as possible to stabilize banks disturbed by construction to avoid erosion or sediment releases to the water.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					Re-vegetation with natural vegetation is the preferred approach. •Implement measures for managing water flowing onto the site, as well as water being pumped/diverted from the site, such that sediment is filtered out prior to the water entering the waterbody (e.g., by discharging water to a vegetated area). •Deposit all dredged material in a manner to prevent its re-entry into the watercourse. •Stabilize slopes with rocks, geotextiles, and/or hydraulic seed and mulch.
92	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	4	Mitigation Measures for Surface Water	Update mitigation measures for exposed soils, sedimentation, erosion, dust suppression, stream crossings, flow diversions, and fish habitat based on activities and components in the Phase 2 Proposal. Mitigation measures to be updated/added include •Fill material placed below the high water level within the waterbody's flood plain will be either erosion resistant or protected from erosion and only clean fill will be used. •No waste material resulting from work activities will be left in a manner such that it can enter the water (e.g., by being left on the ice). •Machinery will be washed, refueled and serviced, and fuel and other materials will be stored in such a way as to prevent any deleterious substances from entering the water. Such activities typically occur at least 50 m from the high water mark. -machinery will arrive at site in a clean condition and be maintained free of fluid leaks, invasive species and noxious weeds. •Limit fording of the watercourse by machinery to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, a temporary crossing structure will be constructed. -design mitigation for potential effects of increased flows on fish habitat include channel widening; regrading, construction of habitat features (in fish bearing streams); and channel stabilization. •Install culverts at the same slope as the existing stream, where feasible. •Minimize culvert lengths. •Culverts with lengths that exceed 50 m may be considered barriers to fish passage due to darkness. Examine and consider methods to provide light inside culverts, where applicable. •Compare culvert velocities to the velocity in the existing watercourse to determine fish passage potential. This information can be used to reassess design velocities under proposed conditions with the culvert installed. With the channelization of flows and conveyance in culverts, the velocity of the flows may increase. This may be mitigated by placing rocks and boulders inside the culverts (stream replication) to provide greater friction, thereby reducing velocities and

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					increasing the flow depth and to provide resting locations for fish. Boulders may be bolted into place.
93	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	5.3	Description of Hydrology	Update regional hydrology and peak flow estimates.
94	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	6.1	Water Management Plans for Milne Port, Tote Road, and Mine Site	Update water management plans for site drainage, laydowns, soil stockpiles, rock cuts, quarries, mine effluent, and dust suppression. Key issues include management of contact water from construction and operations.
95	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	6.2	Water Management Plans for Milne Port, Tote Road, and Mine Site	Update water management plans for site drainage, laydowns, soil stockpiles, rock cuts, quarries, mine effluent, and dust suppression. Key issues include management of contact water from construction and operations.
96	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	6.3	Water Management Plans for Milne Port, Tote Road, and Mine Site	Update water management plans for site drainage, laydowns, soil stockpiles, rock cuts, quarries, mine effluent, and dust suppression. Key issues include management of contact water from construction and operations.
97	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	7	Water Management Plans for Milne Port, Tote Road, and Mine Site	Update water management plans for site drainage, laydowns, soil stockpiles, rock cuts, quarries, mine effluent, and dust suppression. Key issues include management of contact water from construction and operations.
98	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	New Section	Water Management	Add water management plans for laydowns, soil stockpiles, soil disposal areas, rock cuts, quarries, flow diversions, watercourse crossings, and water takes for dust suppression. Key issues include maintaining minimum flows for fish, fish

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
				Plan for North Railway	passage at culverts, and management of contact water and dust from construction and operations. Includes mitigation measures to address the effects on streams receiving diverted flows, and mitigation measures to address fish passage at select culvert crossings along the railway.
99	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	9	Monitoring Plan for Fish Passage Along North Railway	Add monitoring during construction and operation of the North Railway, and where applicable, at new or relocated stream crossings along the Tote Road, to assess fish passage at fish-bearing stream crossings.
100	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	New Section	Pre-Construction Survey Request	A survey of the Camp Lake outflow and at water withdrawal site BG32 is recommended in the first year following Project approval in late summer/fall when water withdrawals occur and during a low flow event to ensure there is no stranding of Arctic Char. In the event that stranding is observed, a fish salvage would be undertaken to relocate stranded fish to a local waterbody.
101	TSD 28	Surface Water and Aquatic Ecosystems Management Plan	9	Monitoring Plan for Flow Diversions	Update monitoring plan to include post-construction monitoring for low risk flow diversions.
102	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	Table 1-1	Commitments relevant to Phase 2 Proposal	Update, post approval, to include commitments made (if any) relevant to monitoring Phase 2 Project impacts.
103	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	Table 1-2	Terms and Conditions relevant to Phase 2	Update, post-approval, to include new or revised Project Terms and Conditions relevant to monitoring Phase 2 Project impacts.
104	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	1.5	Relationship to Other Management Plans	Update management plan references and describe the relevance of those management plans to the mitigations identified in the TEMMP.
105	TSD 28	Terrestrial Environment	2	Key Indicators for Follow-up Monitoring	Post-approval text editing to cross-reference to Phase 2 impact assessment and updated status report.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
		Mitigation and Monitoring Plan			
106	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	3	Mitigation Measures	Post-approval updates to include any mitigations that may be agreed to during technical review and Project Terms and Conditions requirements. Update all cross-references to any updated or new Terms and Conditions. This will include mitigation measures for-wind turbine operations, should wind turbines be approved as part of the Phase 2 Proposal. Specific mitigation measures to be added include: •seasonal avoidance of construction near nests during the breeding season; and •temporarily making raptor nest sites potentially affected by construction inaccessible during the nesting seasons and hazing nesting pairs to discourage nesting at an affected nest site.
107	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	4.3	Vegetation Monitoring	Programs identified in Tables 4-3 (Vegetation Monitoring: Vegetation Health) and 4-4 (Vegetation Monitoring: Dust) may be adjusted pending comments and direction received during the technical review and Project Terms and Commitments post project approval.
108	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	4.5.1	Caribou Monitoring	May be updated to address any MoUs that Baffinland may have in place with the Government of Nunavut or other parties to support broader regional research/monitoring to better understand north Baffin Island population recovery and ecology.
109	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	4.5.2	Caribou Monitoring	May be updated to address any MoUs that Baffinland may have in place with the Government of Nunavut or other parties to support broader regional research/monitoring to better understand north Baffin Island population recovery and ecology.
110	TSD 28	Terrestrial Environment Mitigation and Monitoring Plan	Appendix B	Monitoring Details and Methods	As part of ongoing “living” document, the methods are updated regularly as part of annual report and review/critique by the TEWG and the Nunavut Impact Review Board (NIRB). Portions of these methods may be updated to identify changes in spatial scope of plots, frequency of sampling, or analytical methods pending technical review and final project terms and conditions, post project approval.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
111	TSD 28	Shipping and Marine Wildlife Management Plan	All	New Shipping Scenario	Update to reflect new shipping scenario included in the Phase 2 Proposal.
112	TSD 28	Shipping and Marine Wildlife Management Plan	1.3	Commitments Relevant to Phase 2	Update (post-approval) to include commitments made (if any) relevant to monitoring Phase 2 Project impacts.
113	TSD 28	Shipping and Marine Wildlife Management Plan	1.3	Terms and Conditions Relevant to Phase 2	Update (post-approval) to include new or revised Project Terms and Conditions relevant to monitoring Phase 2 Project impacts, including revisions to the Table of Concordance in Appendix G.
114	TSD 28	Shipping and Marine Wildlife Management Plan	Appendix G	Terms and Conditions Relevant to Phase 2	Update (post-approval) to include new or revised Project Terms and Conditions relevant to monitoring Phase 2 Project impacts, including revisions to the Table of Concordance in Appendix G.
115	TSD 28	Shipping and Marine Wildlife Management Plan	1.5	Relationship to Other Management Plans	Update references in document and describe the relevance of those management plans to the mitigations identified in the SMWMP.
116	TSD 28	Shipping and Marine Wildlife Management Plan	3	Updated Project Description for Shipping relevant to Phase 2 shipping operations	Update to reflect current Project Description for shipping operations, including vessel specifications, schedule, ship loading and unloading, safety, navigation, insurance and compensation.
117	TSD 28	Shipping and Marine Wildlife Management Plan	5	Environmental Management Practices Relevant to Phase 2	Document will be updated to include additional mitigation measures to minimize impacts on marine mammals and fish and fish habitat due to increased frequency of shipping, extended shipping season, and updated berth design relevant to Phase 2 operations. Mitigation to be added to Section 5.3 include: •When marine mammals appear to be trapped or disturbed by vessel movements, the vessel will implement appropriate measures to mitigate

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
				Shipping Operations	disturbance, including stoppage of movement until wildlife move away from the immediate area. •Project vessels shall not approach within 300 m of a walrus or polar bear observed on sea ice. •All Project vessels will not be operated in such a way as to separate an individual member(s) of a group of marine mammals from other members of the group.
118	TSD 28	Shipping and Marine Wildlife Management Plan	5.5.1	Detailed Ballast Water Management Plan	A stand-alone ballast water management plan will be developed (to be included as a separate Appendix in the SMWMP) to address the increased risk from invasive species and D-2 requirements of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, to prescribe ballast water monitoring and reporting requirements specific to the Project, and to identify management procedures in the event of any non-compliance events.
119	TSD 28	Shipping and Marine Wildlife Management Plan	6	Environmental Monitoring Relevant to Phase 2 shipping Operations	Update to reflect environmental monitoring and Environmental Effects Monitoring (EEM) commitments relevant to Phase 2 shipping operations.
120	TSD 28	Shipping and Marine Wildlife Management Plan	7	Roles and Responsibilities Relevant to Phase 2 Shipping Operations	Update to identify Project-specific roles and responsibilities related to environmental issues for Phase 2 shipping operations.
121	TSD 28	Shipping and Marine Wildlife Management Plan	8	Environmental Reporting	Update to reflect environmental reporting requirements relevant to Phase 2 shipping operations.
122	TSD 28	Marine Environmental Effects Monitoring Plan	1	Commitments Relevant to Phase 2	Update (post-approval) to include commitments made (if any) relevant to monitoring Phase 2 Project effects.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
123	TSD 28	Marine Environmental Effects Monitoring Plan	1	Terms and Conditions Relevant to Phase 2	Update (post-approval) to include new or revised Project Terms and Conditions relevant to monitoring Phase 2 Project impacts.
124	TSD 28	Marine Environmental Effects Monitoring Plan	New subsection of Section 1	Relationship to Other Management Plans	Add new sub-section in Section 1.0 identifying relationship of MEEMP to other management plans. Update management plan references and describe the relevance of those management plans to the mitigations identified in the MEEMP.
125	TSD 28	Marine Environmental Effects Monitoring Plan	Table 1.1	Effect Pathway Linkages Relevant to Phase 2	Update to include impact predictions made in the FEIS Addendum for the Phase 2 Proposal.
126	TSD 28	Marine Environmental Effects Monitoring Plan	3	Study Design for EEM Program - Marine Ecosystem Relevant to Phase 2	Update to identify EEM study design changes required to monitor for Project effects on Marine Ecosystem related to Phase 2 construction (new ore dock) and operations (e.g., increased shipping, expansion of ore stockpiles, fugitive dust emissions, increase in wastewater discharge). Revised study design will be based on results from EEM studies conducted to date and Phase 2 modelling.
127	TSD 28	Marine Environmental Effects Monitoring Plan	3.4.7	Update Study Design for Aquatic Invasive Species Monitoring Program Relevant to Phase 2	Update to identify study design changes required to monitor for potential aquatic invasive species introduction related to increases in the overall ballast water discharge volume and new discharge locations. Revised study design will be based on results from aquatic invasive species monitoring study conducted to date and Phase 2 modelling.
128	TSD 28	Marine Environmental	6	Update Study Design for EEM Program - Marine	Update to identify EEM study design changes required to monitor for Project effects on Marine Mammals related to Phase 2 construction (e.g., new ore dock) and operations (e.g., increased shipping, extended shipping season).

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
		Effects Monitoring Plan		Mammals relevant to Phase 2	Revised study design will be based on results from EEM studies conducted to date,
129	TSD 28	Air Quality and Noise Abatement Management Plan	2.3	Wind Power	Update for potential addition of wind power as an offset to diesel power generation.
130	TSD 28	Air Quality and Noise Abatement Management Plan	3.4	Noise Modelling	Add noise modelling results from TSD 07.
131	TSD 28	Air Quality and Noise Abatement Management Plan	3	Dustfall Mitigation	Update mitigation measures to reduce dustfall, including additional water takes and applications, as well as the continued examination of viable alternatives.
132	TSD 28	Air Quality and Noise Abatement Management Plan	3	Dustfall Monitoring	Update dustfall monitoring program to account for new and modified emission sources during construction and operations.
133	TSD 28	Air Quality and Noise Abatement Management Plan	3.4.1	Noise Mitigation	Add mitigation to use acoustical screening from existing on-site buildings to shield dwellings from construction equipment noise.
134	TSD 28	Air Quality and Noise Abatement Management Plan	3.4.1	Noise Mitigation	Add mitigation that local topography will be taken advantage of to screen noise emissions, where possible.
135	TSD 28	Air Quality and Noise Abatement Management Plan	3.4.1	Noise Mitigation	Add mitigation that discussions with the HTO will determine if it would be preferred to move the existing HTO cabin to an area outside of the area of disturbance for noise.
136	TSD 28	Air Quality and Noise Abatement Management Plan	5.3	New Mitigation and Monitoring Measures for Underwater Noise	Add mitigation and monitoring measures for marine underwater noise, including bubble curtains and marine mammal monitoring.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
137	TSD 28	Air Quality and Noise Abatement Management Plan	4	Roles and Responsibilities	Update roles and responsibilities for Project departments and personnel.
138	TSD 28	Air Quality and Noise Abatement Management Plan	Attachment 2	Concordance Tables for Relevant Terms and Conditions	Update to reflect terms and conditions in amended Project Certificate.
139	TSD 28	Cultural Heritage Resource Protection Plan	1.1.1	Incorporate the scope of the Phase 2 Proposal	Update to remove reference to the FEIS and 2012 Archaeology Mitigation Plan, as that plan has already been implemented.
140	TSD 28	Cultural Heritage Resource Protection Plan	3.2	Annual Reporting Requirements	Section 3.2 incorrectly discusses annual reporting to NIRB on archaeology. Update this section to reflect Baffinland's commitment to provide the Government of Nunavut with an annual archaeology status report by February 28, in addition to the requirement for any licensed archaeologists on the project to provide an archaeology permit report by March 31.
141	TSD 28	Cultural Heritage Resource Protection Plan	4	Annual Reporting Requirements	Commitment #11 in Section 4 incorrectly discusses annual reporting to NIRB on archaeology. Update this section to reflect Baffinland's commitment to providing the Government of Nunavut with an annual archaeology status report by February 28, in addition to the requirement for any licensed archaeologists on the project to provide an archaeology permit report by March 31.
142	TSD 28	Roads Management Plan	4	Operational Mitigation Measures	Update operational measures to mitigate erosion, sedimentation, and fish passage at culvert crossings associated with the Phase 2 Proposal.
143	GN 75	Human Resource Management Plan	5.3	Education and Training Partnerships	Baffinland will include both the GN Department of Family Services and the GN Department of Education in Section 5.3 of a revised future version of the Human Resource Management Plan.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
144	CIRNAC 11	Snow Management Plan	4.3	Snow Stockpile Locations	Details on the physical delineation of 31 m boundary from water body.
145	ECCC 21	Metal Mining Effluent Regulations Emergency Response Plan	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
146	ECCC 21	Aquatic Effects Monitoring Plan.	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
147	ECCC 21	Life of Mine Waste Rock Management Plan	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
148	ECCC 21	Interim Waste Rock Management Plan	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
149	ECCC 21	Interim Closure and Reclamation Plan	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
150	ECCC 21	Marine Environmental Effects Monitoring Plan	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
151	ECCC 21	Phase 1 Waste Rock Management Plan	Throughout	References to MMER	References to the Metal Mining Effluent Regulations (MMER) under the <i>Fisheries Act</i> will be updated to refer to the current Metal and Diamond Mining Effluent Regulations (MDMER)
152	NRCAN-IR4	Explosives Management Plan	1.2	Explosives Storage Areas	Add information related to four new explosives storage areas for the storage of pre-packaged explosives (for use in rail construction) that are planned along the Northern Transportation Corridor (as shown on Figure B.2 and in Figure B.2 sheets in Appendix B of TSD 02 [Project Description]).

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
153	GN 01	Other Commitment	N/A	N/A	Specific design parameters for the Wind Energy Project will be developed at the preliminary engineering phase. Specific locations and lengths of collector lines, number of poles, and placement above and/or below ground will depend on site-specific factors and will also be assessed during preliminary design work, but fully determined at detailed design in consultation with turbine vendor.
154	GN 06	Other Commitment	N/A	N/A	Dedicated crossing locations of the railway for land users will be determined through consultation with local community members and elders.
155	Various	Other Commitment	N/A	N/A	New mitigation and monitoring that arises during the technical review will be added to the applicable management plans if required.
156	GN67, GN 72, WWF IR-01, DFO 3.2.4	Other Commitment	N/A	N/A	Baffinland will undertake an additional stand-alone assessment of icebreaking effects that addresses icebreaking effects during the shoulder season which will include underwater noise modelling of icebreaker transits along the Northern Shipping Route. The acoustic modelling will be based on a conservative scenario for icebreaking noise based on thickest seasonal ice conditions in the RSA and maximum acoustic propagation potential. The stand-alone acoustic modelling report and icebreaking assessment will be submitted to the NIRB in 2019 once reporting is completed.
157	GN 79	Other Commitment	N/A	N/A	Baffinland plans to engage "Operation Lifesaver" (Operation Lifesaver Canada 2017). Baffinland believes that this organization has the experience and knowledge that can help the company ensure Nunavummiut are educated about rail safety through rail safety presentations to schools, and community groups such as Hunter and Trapper Organizations.
158	CIRNAC 9	Other Commitment	N/A	N/A	An update to the water quality predictions for the Waste Rock Facility that incorporates data collected will be provided in 2019.
159	CIRNAC 17	Other Commitment	N/A	N/A	Results from the 2018 Geochemical Evaluation will be provided in 2019.
160	DFO 3.1.1	Other Commitment	N/A	N/A	Baffinland is currently reviewing the required water crossings to identify a short-list of crossings that are better suited to alternatives to CSP culverts and will be prepared to discuss this with DFO.
161	ECCC 01, QIA 05	Other Commitment	N/A	N/A	Upon selection of the specific site(s) for wind turbine(s), Baffinland will conduct a risk assessment including any surveys required for informing site

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
					sensitivity, consistent with Environment and Climate Change Canada's Environmental Assessment Guidance Document on Wind Turbines and Birds.
162	ECCC 01	Other Commitment	N/A	N/A	Baffinland will conduct the required pre-construction phase surveys for migratory birds and species at risk surveys, consistent with ECCC guidance prior to construction of the wind energy project .
163	ECCC 01, QIA 05	Other Commitment	N/A	N/A	Baffinland will identify mitigation and monitoring requirements from the pre-construction phase surveys and incorporate them into the wind energy project design, consistent with Environment and Climate Change Canada's Guidance Document on Recommended Protocols for Monitoring Impacts of Wind Turbines and Birds
164	ECCC WL 01	Other Commitment	N/A	N/A	Prior to use for dust suppression, water quality monitoring of contact water will be completed to ensure that the water meets the appropriate effluent discharge limits. Monitoring will be undertaken through sampling of water prior to discharge.
165	QIA 10	Other Commitment	N/A	N/A	Reclamation research plans are expected to be developed in consultation with IQ. Where practical, IQ will be incorporated into research plans for revegetation.
166	QIA 23	Other Commitment	N/A	N/A	Before final siting of the wind turbines is confirmed, Baffinland will carry out specific engagements with local land users to identify optimal and/or preferable locations.
167	QIA 52	Other Commitment	N/A	N/A	Exact coordinates for the Proposed additional SNP stations to address the Phase 2 Proposal will be provided to the NWB for approval prior to the commissioning of the associated Phase 2 infrastructure.
168	QIA 55	Other Commitment	N/A	N/A	Roads used in operation will be constructed to appropriate design criteria, as presented in TSD 02.
169	ECCC 10	Air Quality and Noise Abatement Management Plan	Attachment 7	Dust Monitoring Locations	The Dustfall Monitoring Program will be expanded to include additional monitoring locations as required for the Northern Transportation Corridor.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
170	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	5.3.1	Surface Water Runoff Estimation	Provide mean flows for streamflow record (not just 2015 flows)
171	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	6	Stormwater Management	Update stormwater management to reflect Phase 2 and the addition of the, North Railway
172	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	9.1	Rpi	Add routine inspections for railway.
173	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	9.2.1	Water Monitoring	Add new water monitoring stations.
174	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	Appendix B	2016 Work Plan	Remove 2016 work plan details.
175	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	Appendix C	Water Balance	Update with water balance PFDs.
176	ECCC WL 02	Surface Water and Aquatic Ecosystems Management Plan	Appendix D	Site Layouts	Update site layouts showing SNP stations.
177	CIRNAC 6	Other Commitment	N/A	N/A	Follow-up and Adaptive Management Plans will be updated to indicate the criteria and thresholds to trigger mitigation measures.
178	CIRNAC 6	Other Commitment	N/A	N/A	Quality Assurance and Quality Control measures to be applied to each monitoring program will be included in relevant plans, where warranted.
179	QIA 69	Other Commitment	N/A	N/A	A detailed fish salvage plan will be developed and included in an Environmental Management Plan (EMP), which will form part of the application for the Fisheries Act Authorization (FAA).
180	CIRNAC 15	Phase 1 Waste Rock Management Plan	Throughout	Closure strategies,	Submit updated Phase 1 Waste Rock Management Plan for review by December 31, 2019

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
				thermal modeling	
181	CIRNAC 17	Other Commitment	N/A	N/A	Results from the 2018 Geochemical Evaluation to be provided in 2019
182	ECCC 16, ECCC 17	Aquatic Effects Monitoring Plan		Ammonium nitrate, Project effects	Revised version of AEMP to be provided as part of the Amendment to the Type 'A' Water License process
183	ECCC 19	Freshwater, Sewage and Wastewater Management Plan	Section 6	Wastewater volumnes, treatment capacity	Provide end of March, 2019
184	ECCC 23	EPP	2.19, 2.25, 2.26, 2.28, 2.30	Dustfall Mitigation, Ore Dock Construction	Updates for dust management/suppression during construction and operation of North Railway, and water quality monitoring during construction of the ore dock
185	PCA 6; QIA 83	Other Commitment	N/A	N/A	Stand-alone acoustic modeling report and icebreaking assessment will be submitted to NIRB in 2019 once reporting is complete. Include consideration of ice management activities and vessel noise in the presence of ice
186	QIA 60	Other Commitment	N/A	N/A	Community consultations to be carried out in 2019 regarding Baffinland's DFO Authorization Application
187	QIA 74	Ballast Water Management Plan	N/A	N/A	Create Ballast Water Management Plan
188	DFO 3.2.3	Other Commitment	N/A	N/A	The 2018 Marine Mammal Observer (MMO) monitoring report will be provided in the Q1 of 2019.
189	QIA 06; QIA 19; QIA 95	Other Commitment	N/A	N/A	Three IQ sessions are planned between January and March of 2019 in support of the Phase 2 Proposal. The status and results of these workshops will be reported to the NIRB and Interveners during the review process as they become available.
190	QIA 13	Other Commitment	N/A	N/A	Baffinland is committed to working with QIA on future IQ studies and welcomes their feedback on alternative data collection methods that may be employed.

Commitment ID#	Commitment Source	Management Plan	Section to be Updated	Required Update	Description of Update/ Commitment
191	QIA 33	Other Commitment	N/A	N/A	Detail maintenance and safe operating procedures plans for culverts will be prepared as part of the Transport Canada Railway operating permit application. The development of these detail plans will commence later in 2019.
192	QIA 74	Other Commitment	N/A	N/A	To verify vessels' compliance with the Regulations and BWM Convention, Baffinland will conduct regular inspections of ships arriving at Milne Port to determine their compliance with federal ballast water regulations and the BWM Convention standards. The inspection would include a review of the following on-board documentation
193	QIA 83	Other Commitment	N/A	N/A	A supplemental acoustic modelling report is forthcoming that will include consideration of ice management activities and vessel noise in the presence of ice.
Note: highlighting indicates new commitment since last circulation					