Tunnel Inspection Manual

Montana Department of Transportation

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MONTANA
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Table of Contents

Chapter 1 – Program Organization 1-1
1.1 Background 1-1
1.2 Purpose 1-1
1.3 Overview 1-1
1.4 Inspection Program Functions 1-1
1.5 Emergency Response Plans 1-2

Chapter 2 – Tunnel Inspection 2-1
2.2 Types of Inspection 2-1
2.3 Inspection Quality Control and Quality Assurance 2-3
2.4 Critical Findings Procedures 2-4
2.5 Load Rating 2-4
2.6 Complex Tunnels 2-4
2.7 Additional Information 2-4

Appendix A – Inspection Checklists
A.1.1 Required Photographs Checklist
A.1.2 Condition State Data
A.1.3 Confined Space Checklist
A.1.4 Damage Inspection Documentation
A.1.5 Special Inspection Documentation

Chapter 1 – Program Organization

1.1 Background

In January 1999, a portion of the lining of the Sunset Tunnel in Oregon collapsed, killing an Oregon DOT employee. The lining was being inspected after heavy rains and a report from a concerned traveler when it collapsed. Previous inspections of the tunnel had not documented the extent of deterioration in the lining. In July 2006, a portion of the suspended ceiling in the Central Artery Tunnel in Boston collapsed, killing a motorist. After investigating the failure, the National Transportation Safety Board (NTSB) suggested that the Federal Highway Administration (FHWA) seek legislative authority to establish a mandatory tunnel inspection program similar to the National Bridge Inspection Standards (NBIS).[1]

On July 6, 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law. MAP-21 contained a number of tunnel inventory and inspection provisions to establish the national minimum standards for tunnel inspection, evaluation and inventory. On July 14, 2015, FHWA published the final rule of the National Tunnel Inspection Standards (NTIS) for tunnel inspections, which became effective on August 13, 2015.

1.2 Purpose

This manual is written to comply with the requirements of the National Tunnel Inspection Standards (NTIS) and the National Tunnel Inspection Program (NTI). It is not intended to override requirements already established in 23 CFR Part 650 Subpart E – National Tunnel Inspection Standards, the Specifications for the National Tunnel Inventory (SNTI), and the Tunnel Operations, Maintenance, Inspection, and Evaluation Manual (TOMIE). This manual provides supplemental information specific to the Montana Department of Transportation (MDT). At the time this manual is written, MDT only has one tunnel.

1.3 Overview

The MDT Tunnel Inspection Program is administered by the Bridge Management Section of the Bridge Bureau and operates under the auspices of FHWA in accordance with the NTIS. The five primary responsibilities of the Tunnel Inspection Program are:

1. Maintain Public Safety and Confidence
2. Protect Public Investment
3. Maintain a Desired Level of Service
4. Provide Accurate Tunnel Records
5. Fulfill Legal Responsibilities to comply with Federal Regulations

MDT is responsible for the inspection of both on and off system tunnels within the state. At the time this manual was written, only one tunnel is inspected by MDT. This tunnel is the Orange Street Tunnel in Missoula.

1.4 Inspection Program Functions

Tunnel inspection strictly refers to condition inspection of tunnels. The NTIS requires all states to collect inspection data and maintain and inventory of all public tunnels. Each state must have a tunnel inspection organization capable of performing the required inspections, completing

required reports, and maintaining inventory records. In Montana, this function is handled by the Bridge Management Section located in Helena.

1.4.1 Bridge Management Section

The Bridge Management Section is responsible for the overall tunnel inspection program and is a part of the Bridge Bureau in Helena. The section consists of a number of engineers and technicians that provide direction and support to the program. The primary functions and responsibilities are listed in figure 1.3.1.

Bridge Management Section Functions and Responsibilities	
Bridge and Tunnel Program Management	Technical Support for the Districts
Bridge and Tunnel Database Management	Inspection QA/QC
Consultant Inspection Contract Management	Bridge and Tunnel Load Rating
Bridge and Tunnel Maintenance	Overweight Load Permitting
Bridge and Tunnel Program Quality Assurance	Local Agency Coordination
Inspector Coordination, Training, and Certification	Research and Implementation of New Methods and Techniques
Inspection QA/QC	Ensuring FHWA Metrics are met

Figure 1.3.1

1.4.2 Program Manager Qualifications

MDT's Tunnel Inspection Program Manager must maintain an active Professional Engineer license in the state of Montana and have successfully completed FHWA approved comprehensive tunnel inspection training. The program manager must also successfully complete FHWA approved tunnel inspection refresher training every 5 years. Successful completion of training courses includes a passing score of 70% or greater on the end-of-course assessment.

1.4.3 Inspection Personnel

- Team Leader – A Team Leader is required for initial, routine, and in-depth inspections and is the person responsible for each inspection. See Code of Federal Regulations (CFR) §650.509(b) for Team Leader qualifications. Team leaders are also required to maintain their status as a nationally certified tunnel inspector by completing a cumulative total of 18 hours of FHWA approved tunnel inspection refresher training over each 60

month period. It is the responsibility of the Team Leader to maintain documentation supporting their status as a nationally certified tunnel inspector.

- Inspector – additional qualified Team Leaders and tunnel inspection trainees who help the Team Leader with inspection activities.
- Discipline Specialist – specially qualified personnel for inspecting specific aspects of the tunnel, such as a geotechnical engineer, electrical inspector, ventilation system inspector, etc. Qualifications for discipline specialists will be outlined in Tunnel-Specific Inspection Procedures.
- Maintenance Personnel – county or MDT Maintenance personnel who maintain the tunnel. They can assist with access to tunnel components and inform the Team Leader of any known issues with the tunnel structural components or its systems.

1.4.4 Tunnel Load Rater Qualifications

A tunnel load rater must be a licensed Professional Engineer in the state of Montana and have at least 2 years of experience load rating bridges or tunnels.

1.5 Emergency Response Plans

For tunnels that require an emergency response plan (ERP), the plan will be documented in the tunnel file. All new tunnels added to the inventory will be reviewed by the Program Manager to determine whether they require an ERP. See sections 2.4 and 2.5 of the TOMIE and National Fire Protection Association (NFPA) 502 for more information on emergency response.

The following resources are to be used when developing Emergency Response Plans for tunnels:

MDT Emergency Operations and Disaster Plan, specifically Appendix C – Bridge and Structure Specific Activities:
https://mdtinfo.mdt.mt.gov/maint/docs/des_manual/mdt_emergency_disaster_plan.pdf

Chapter 2 – Tunnel Inspection

2.1 – Tunnel Files

Official files for Montana Department of Transportation (MDT) tunnels are electronic and are currently on a share drive: \\state\mdt\prd\Helena\Bridge\BMS_Public\Tunnels

Element and Inventory data is also stored in the Montana Structure Management System (SMS), which is powered by AASHTOWare BrM software. Because BrM is not capable of handling multimedia for tunnels at the time this manual was written, it is not the official location of the tunnel files.

Each tunnel file will include the following information:

- Tunnel inventory documents such as plans, shop drawings, and/or measurements.
- Tunnel inventory data (available in the inspection reports)
- All inspection reports
- Tunnel-specific inspection procedures
- Reports on any Maintenance activities completed on the structure
- All inspection photos
- Load rating documentation
- Load posting documentation (if applicable)
- Any memoranda of understanding that exist concerning the Tunnel
- All logs of functional system testing

2.2 – Types of Inspection

All inspection intervals will be documented in the tunnel-specific inspection procedures and updated as necessary.

2.2.1 – Initial Inspection

An Initial / Inventory Inspection is the first inspection of tunnels that are not already in MDT's tunnel inventory and the first inspection of new tunnels or rehabilitated tunnels that were fully closed to traffic during rehabilitation work.

When a new tunnel is added to the inventory, a tunnel is replaced by a new structure, or a tunnel is fully closed to traffic during rehabilitation work, the Inventory Inspection will be completed and fully documented in the tunnel file within 90 days of the tunnel opening to traffic.

An Initial / Inventory Inspection consists of up to 3 steps, depending on the tunnel being inspected as noted in the following subsections:

2.2.1.1 Determination of the Structure Location

For tunnels that are new to the inventory, the structure location is determined using a GPS device and aerial photos in google or SMS. The tunnel ID will be assigned as a five-digit number starting with T (ex: T1002)

See SNTI items I.12, I.13, and I.14 for information on what part of the tunnels is to be recorded for the latitude and longitude.

2.2.1.2 Collection of Inventory Data

When available, the inspector will use the tunnel construction plans to determine the measurements, design type, material, and other pertinent inventory information. The inspector is responsible for obtaining tunnel construction plans and shop drawings from local agencies and forwarding these plans on to the Bridge Management Section in Helena. When plans are not available for the tunnel, the inspector will determine the inventory information during a site visit. This includes measuring and sketching tunnel dimensions and structural components as needed.

2.2.1.3 Condition Inspection

The inspector will visit the tunnel site to complete the initial condition inspection for the tunnel, then fully document all condition inspection findings.

2.2.2 Routine Inspections

In accordance with the SNTI, a routine inspection is "a regularly scheduled comprehensive inspection encompassing all tunnel structural elements and functional systems and consisting of observations and measurements needed to determine the physical and functional condition of the tunnel, to identify any changes from initial or previously recorded conditions, and to ensure that tunnel components continue to satisfy present service requirements."

Routine inspections must be performed by a qualified Tunnel Inspection Team Leader. Routine inspections will be conducted at regular intervals. The interval will not exceed 24 months unless a written justification is approved by FHWA to extend the interval up to 48 months.

See TOMIE section 4.6.2 for more information on what is required during routine inspections.

If multiple structural elements are in poor condition, the routine inspection interval will be reduced to 12 months or less. The frequency will be based on the program manager's judgement. If only one structural element is in poor condition, or in the case of functional systems in poor condition, the Program Manager may elect to use Special Inspections instead of reducing the Routine Inspection frequency.

For an existing tunnel that is open to public traffic during rehabilitation work, regularly scheduled Routine NTI inspections will be performed. If an inspection cannot be conducted on or before its due date because of reasonable circumstances such as a hazardous project site or conditions unfavorable to complete an inspection, then those circumstances will be documented and sent to the Tunnel Program Manager and the inspection will be rescheduled at the earliest date possible – this date will be no later than 2 months past the original due date for the inspection.

2.2.3 In-Depth Inspections

In accordance with SNTI Section 1.5 Definitions, an in-depth inspection is "a close-up inspection of one, several, or all tunnel structural elements or functional systems to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations.

In-depth inspections may occur more or less frequently than routine inspections, as outlined in the tunnel-specific inspection procedures. In-depth inspections must be performed by a qualified Tunnel Inspection Team Leader.

In-depth inspections may include taking measurements, such as current draw of sump pumps during operation, which are not normally taken during a routine inspection. Representative in-

depth inspections may include: inspecting sump areas, including the submersible pump using permit-required confined space entry; hands-on inspection of lighting fixtures, including taking apart components; and disassembly of electrical distribution equipment to identify deficiencies.

In-depth inspections will be conducted on an as-needed basis, so do not have a regular frequency. The program manager will determine when an in-depth inspection is needed based on inspection results and inspector recommendations.

2.2.4 Damage Inspections

A damage inspection is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions, such as earthquakes or vehicular collisions. The scope of the inspection depends on the extent of the damage. A qualified tunnel inspection Team Leader is not required to oversee Damage inspections.

Damage inspections are typically used in the decision-making process for implementing emergency load restrictions and closure. They are also be used in the decision-making process to lift emergency restrictions that were put in place by Maintenance personnel until a Damage Inspection could be completed and the structure assessed for strength and structural stability.

A Damage inspection will be completed as soon as is reasonably possible after the event that caused damage. Ensure that it is safe for inspection personnel to be on or inside the tunnel before performing a Damage inspection.

2.2.5 Special Inspections

Special inspections are performed on tunnels with one or more defects that require more frequent inspection than a routine inspection. A special inspection can be set at any interval less than 24 months. Typical intervals are 1 year, 6 months and 3 months. Special inspection frequencies are determined by the Program Manager based on the condition of the elements and the significance of the defect. A Special inspection does not always require a qualified tunnel inspection Team Leader.

2.3 – Inspection Quality Control and Quality Assurance

Inspection quality control (QC) will be conducted according to the consultant's QC plan. The QC plan will include a full item by item review of all inspection items completed by a qualified tunnel inspection Team Leader who was not on site during the inspection. It is anticipated that the one tunnel in MDT's inventory will be inspected by consultants for the foreseeable future. No additional tunnels are expected to be added to the inventory in the near future, but if an additional tunnel is constructed or otherwise added to the inventory, then it is expected it will be inspected by consultants as well.

MDT will perform Quality Assurance (QA) reviews. QA reviews consist of a review of elements, photos, and descriptions to ensure everything is adequately documented, the inspection was thorough, and all required items are documented. Quality Assurance will be performed by the tunnel inspection Program Manager or designated staff under the supervision of the Program Manager. QA reviews consist of data quality checks in the office and in the field. Field reviews will be performed after every three routine inspections or more frequently if the Program Manager sees a need for more frequent field reviews. Office reviews will be conducted after every 2 inspections.

2.4 – Critical Findings Procedures

Critical findings consist of any defect that requires immediate action to ensure the safety of the traveling public. This includes structural issues that could cause a partial or full collapse of the tunnel and functional system issues that could endanger the public (such as a ventilation system that is not working properly).

If a possible critical finding is noted during inspection, the inspection Team Leader will call the MDT tunnel inspection Program Manager immediately to discuss the issue. A critical finding determination will be made within 24 hours of receiving notice from the inspectors. Most critical findings will be determined within a few hours, but 24 hours is available to allow the Program Manager or designee to travel to the tunnel and inspect the issues themselves.

FHWA, the tunnel owner, MDT district maintenance and any other affected parties as noted in the Tunnel Specific Inspection Procedures will be notified of any critical findings within 24 hours of the time the issue was determined to be a critical finding.

2.5 – Load Rating

Refer to the most current version of the *MDT Load Rating Manual* and any additional information on the MDT Load Rating website for load rating MDT's tunnel. MDT Load Rating Website: https://www.mdt.mt.gov/business/contracting/bridge/loadrating/default.aspx

2.6 – Complex Tunnels

Complex tunnels are defined in the CFR as "a tunnel characterized by advanced or unique structural elements or functional systems." MDT's tunnel inspection Program Manager will be responsible for determining whether a tunnel is complex or not. Advanced or unique structural characteristics are widely variable, so they will be evaluated on a case by case basis. Advanced or unique functional systems consist of the following:

- Extensive electrical systems that power more than two tunnel functional systems (ventilation systems, fire suppression, emergency egress, etc.)
- Extensive fire suppression systems that include sprinklers and heat and smoke sensors
- Control rooms with computer control systems

Complex tunnel files will include documentation noting that they are considered complex and why they are considered complex. Tunnel inspection procedures for complex tunnels will include information on how to access complex components for inspection, what type of personnel are required to inspect complex features, the frequency of inspection for each complex feature (if different from the regular tunnel inspection frequency) and any detailed plans available showing the layout of the complex features.

2.7 – Additional Information

- *Tunnel Operations, Maintenance, Inspection, and Evaluation Manual* (TOMIE), FHWA publication number FHWA-HIF-15-005 for more detailed inspection information.
- *Specifications for the National Tunnel Inventory* (SNTI), FHWA publication number FHWA-HIF-15-006 for information on the required coding of National Tunnel Inventory Items and Elements.
- *23 CFR Part 650 Subpart E, "National Tunnel Inspection Standards (NTIS)"*

Appendix A

Inspection Checklists

Required Photographs Checklist		
Required Photograph	Photo #	Notes
Begin Approach looking ahead-station at near tunnel bore		
Begin Approach looking ahead-station at far tunnel bore		
End Approach looking back-station at far tunnel bore		
End Approach looking back-station at near tunnel bore		
Typical bore Cross Section – Looking ahead station		
Typical bore Cross Section – Looking back station		
Additional photo(s) of bore (specify details in Notes column)		
Curb inlet with metal grating		
Curb inlet catch basin		
Curb typical condition		
Curb typical condition		
Additional photo(s) of roadway drainage components (specify details in Notes column)		
Bore general lighting condition		
Bore general lighting condition		
Additional photo(s) of roadway lighting components (specify details in Notes column)		
Structural inspection access methods (specify details in Notes column)		
Civil inspection access methods (specify details in Notes column)		

Required Photographs Checklist		
Required Photograph	Photo #	Notes
Mechanical inspection access methods (specify details in Notes column)		
Signage inspection access methods (specify details in Notes column)		
Electrical inspection access methods (specify details in Notes column)		
Lighting inspection access methods (specify details in Notes column)		
Representative photos detailing prevalent conditions (specify details in Notes column)		
All deficiencies coded in CS3 or CS4 (specify details in Notes column)		
Any safety-related deficiencies (specify details in Notes column)		
Load Posting Signs (a picture is required for all load posting signs or locations of missing signs for each roadway that crosses the tunnel)		
Crossing Roadway Approach (a picture is required of the approach roadway in each direction for all roadways that cross the tunnel)		

Condition State Data

Date:		Structure No:	
Temperature:		Structure Name:	
Inspected by:		Structure Type:	
Weather:		Location:	
Facility Carried:		ADT/Year:	
Latitude:		Longitude:	

Structural Elements

Element Number	Description	Unit	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4
10000	Steel Tunnel Liner	SF					
10001	Cast-in-Place Concrete Tunnel Liner	SF					
10009	Other Tunnel Liner	SF					
10010	Steel Tunnel Roof Girders	SF					
10011	Concrete Tunnel Roof Girders	SF					
10041	Concrete Interior Walls	SF					
10151	Concrete Portal	SF					
10111	Concrete Slab-on-Grade	SF					
10139	Other Joint	LF					

Notes/comments:

Civil Elements

Element Number	Description	Unit	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4
10158	Asphalt Wearing Surface	SF					
10169	Other Traffic Barrier	LF					
10170	Steel Pedestrian Railing	LF					

Notes/comments:

Condition State Data

Mechanical Elements

Element Number	Description	Unit	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4
10300	Drainage and Pumping System	EA					
10301	Pumps	EA					

Notes/comments:

Electrical Elements

Element Number	Description	Unit	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4
10500	Electrical Distribution System	EA					

Notes/comments:

Lighting Elements

Element Number	Description	Unit	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4
10600	Tunnel Lighting Systems	EA					
10601	Tunnel Lighting Fixtures	EA					

Notes/comments:

Condition State Data

Signage Elements

Element Number	Description	Unit	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4
10850	Traffic Sign	EA					
10910	Lane Signal	EA					
10911	Lane Signal Fixture	EA					

Notes/comments:

Additional notes/comments

Notes/comments:

Confined Space Checklist

Evaluation Details
Evaluation Date:
Location and Description of Space:
Entry Purpose:
Entry Supervisor/Person Performing Evaluation Name (Printed):
Entry Supervisor/Person Performing Evaluation Signature:

Confined Space Identification		
Assessment	Yes	No
Is the space large enough and so configured that an employee could bodily enter?		
Does the space have limited or restricted means for entry or exit?		
Is the space not designed for continuous human occupancy?		
If the answer is yes to ALL of the above, it is a confined space. Proceed to Permit-Required Confined Space Identification below. If the answer is no to ANY of the above, it is not a confined space. No further action needed.		
Evaluation Notes:		

Permit-Required Confined Space Identification		
Assessment	Yes	No
Does the space contain or potentially contain a hazardous atmosphere?		
Does the space contain any chemicals or chemical residues?		
Does the space contain any flammable combustible substances?		
Does the space contain or potentially contain any decomposing organic matter?		
Does the space have any pipes which bring chemicals into it?		
Does the space contain rusted surfaces?		
Is vision obscured by dust at 5 feet or less?		
Does the space have poor natural ventilation which could allow an atmospheric hazard?		
Are there any corrosives which could irritate the eyes in the space?		
Are cleaning solvents or paints going to be used in the space?		
Is welding, cutting, brazing, scraping, or sanding going to be performed in the space?		
Are residues going to be scraped off the surface of the space?		

Confined Space Checklist

Permit-Required Confined Space Identification

Assessment	Yes	No
Does the space have any materials that can potentially trap, engulf, or drown an entrant?		
Does the space have converging walls, sloped floors or tapered floor to smaller cross-sections which could trap or asphyxiate an entrant?		
Does the space restrict mobility to the extent it could trap an entrant?		
Does the space contain any mechanical equipment servicing the space?		
Does the space contain thermal hazards (e.g.; extreme hot or cold)?		
Does the space contain excessive noise levels which could interfere with communication?		
Does the space present any slip, trip, or fall hazards?		
Are there any operations conducted near the space opening which could present a hazard?		
Are there any hazards from falling objects?		
Are there lines under pressure servicing the space?		
Is electrical equipment located in or required to be used in the space?		
Is there exposure to uninsulated primary electrical voltages?		
Are there any conditions which could prevent any entrants' self-rescue from the space?		
Does the space present a hazard other than those noted above which would make it a permit-required space?		

If the answer is no to ALL of the above, it is a non-permit confined space. The space does not contain and could not reasonably be expected to contain or develop any hazards. The space can be entered following non-permit confined space entry procedures.

If the answer is yes to ANY of the above, it is a permit-required confined space. Proceed to Permit-Required Confined Space Classification below.

Evaluation Notes:

Permit-Required Confined Space Classification

Check one of the following classification categories based on the assessment of the space:

	Reclassification - If all hazards identified in Permit-Required Confined Space Identification can be completely eliminated without entry, the space can be entered following PRCS temporary reclassification procedures.
	Alternate Entry - If the only hazard in the space is an atmospheric hazard that can be controlled with ventilation, the space can be entered following PRCS alternate entry procedures.
	Full Permit. If hazards cannot be eliminated without entering the space, full permit entry procedures must be followed.

Evaluation Notes:

Damage Inspection Documentation			
Date:		Structure No:	
Temperature:		Structure Name:	
Inspected by:		Structure Type:	
Weather:		Location:	
Facility Carried:		ADT/Year:	
Latitude:		Longitude:	
Description of Damage Event:			

	Y / N	Comment
Does damage require full closure?		
Does damage require partial closure or other restriction to access?		
Are repairs required to allow full access?		

Recommended Repair Information

Repair Priority	Repair Required to Open Tunnel? (Y / N)	Repair Description	Impacted Element Number(s)	Timeline
1.				
2.				
3.				
4.				
5.				

Damage Inspection Documentation

Damaged Elements Condition State

Instructions:
Only enter elements below that have been damaged during the event.
Enter the appropriate damaged quantities in the "Element – Damaged Condition State" section.
Using the prior inspection data as a starting point, update the "Element – Total Tunnel Condition State" based upon the damage noted

Element Number	Description	Unit	Element – Damaged Condition State				Element – Total Tunnel Condition State				
			Damage Quantity	Damage CS2	Damage CS3	Damage CS4	Total Quantity	Good CS1	Fair CS2	Poor CS3	Severe CS4

Notes/comments:

Special Inspection Documentation			
Date:		Structure No:	
Temperature:		Structure Name:	
Inspected by:		Structure Type:	
Weather:		Location:	
Facility Carried:		ADT/Year:	
Latitude:		Longitude:	
Description of Issue:			

	Y / N	Comment
Does issue require full closure?		
Does issue require partial closure or other restriction to access?		

Recommended Monitoring Information

Item Monitored	Any Repair Required (Y / N)	Monitoring Description	Impacted Element Number(s)	Timeline
1.				
2.				
3.				
4.				
5.				