Tunnel Inspection Policies and Procedures Statewide

State Project No. H.011006.5

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Contents

1 Introduction

This document is Louisiana's Department of Transportation and Development (LADOTD) Policies and Procedures Manual for the State's Tunnel Inspection Program. This manual is applicable to tunnel inspection on all highway tunnels located on public roads that are fully or partially located within the State's boundaries, except for tribal or federally tunnel owned facilities.

1.1 Purpose

The purpose of this document is to formally establish responsibility and standards for periodic safety inspection and load rating evaluation of all tunnels on public roads in Louisiana. This Policies and Procedures document has been developed in accordance with the Federal Highway Administration: Tunnel Operations, Maintenance, Inspection, and Evaluation Manual, (FHWA TOMIE). It defines the inspection program, applicable inspection standards, frequencies, team personnel qualifications and roles, inventory and element identification procedures, lists required equipment for tunnel inspection, and identifies access points and general or specific procedures for the inspection of tunnels in the State of Louisiana.

1.2 Scope

This manual covers the general policies and procedures of the LADOTD regarding periodic safety inspection and evaluation of tunnels on public roads in Louisiana. The scope details of implementation set forth in this document are intended to reinforce and augment the requirements established by the National Tunnel Inspection Standards (NTIS), National Tunnel Inspection Program (NTIP) Compliance Review Manual, Specifications for the National Tunnel Inventory (SNTI) and by the Federal (FHWA) Tunnel Operations, Maintenance, Inspection, and Evaluation (TOMIE) Manual.

2 Policy

2.1 National Tunnel Inspection Standards (NTIS)

The National Tunnel Inspection Standards (NTIS), as set forth in the Code of Federal Regulations, Title 23 (Highways), Part 650 (Bridges, Structures and Hydraulics), Subpart E (National Tunnel Inspection Standards), shall hereby apply to all structures defined as highway tunnels that are located on all public roads fully or partially within the boundaries of the State of Louisiana.

- NTIS definition of "tunnel":

"tunnel - means an enclosed roadway for motor vehicle traffic with vehicle access limited to portals, regardless of type of structure or method of construction, that requires, based on the owner's determination, special design considerations that may include lighting, ventilation, fire protection systems, and emergency egress capacity. The term "tunnel" does not include bridges or culverts…"

2.2 Federal Highway Administration: Tunnel Operations, Maintenance, Inspection, and Evaluation Manual, (FHWA TOMIE)

The FHWA TOMIE Manual is referenced by the NTIS for details concerning tunnel operation, maintenance, inspection and evaluation. Accordingly, all provisions of the FHWA TOMIE Manual apply to all tunnels in the state of Louisiana that are governed by the NTIS.

2.3 Federal Highway Administration: Specifications for the National Tunnel Inventory, (FHWA SNTI)

The FHWA SNTI is referenced by the NTIS for details concerning tunnel inventory. Accordingly, all provisions of the FHWA SNTI apply to all tunnels in the state of Louisiana that are governed by the NTIS.

2.4 National Tunnel Inspection Program (NTIP) Compliance Review Manual

The National Tunnel Inspection Program (NTIP) Compliance Review Manual, developed by FHWA, provides the guidance and direction on performing annual compliance reviews of the State's tunnel safety inspection programs. The NTIP is, in most aspects and by design, very similar to the National Bridge Inspection Program (NBIP). The NTIP Compliance Review Manual does not repeat the majority of the guidance given in the NBIP, but rather it highlights some of the key differences and points to be emphasized in the NTIP reviews. Therefore, refer to the NBIP document for guidance if not found in the NTIP Compliance Review Manual.

2.5 Exceptions

This document is limited to tunnels located on public roads that are fully or partially within the State's boundary, except for tunnels owned by tribal or a federal agency, those are the responsibility of other entities.

3 Terminology

3.1 NTIS and 23 CFR 650

In this document, the term *23 CFR 650* shall be the abbreviation for the Code of Federal Regulations, Title 23 (Highways), Part 650 (Bridges, Structures and Hydraulics), Subpart E (National Tunnel Inspection Standards).

Since the National Tunnel Inspection Standards (NTIS) are contained within 23 CFR 650, the NTIS and 23 CFR 650 are in effect synonymous. Terms such as 23 CFR 650.505 refer to a subsection within the NTIS.

3.2 Definitions

Definitions of terms used in this document can be found in 23 CFR 650.505 of the NTIS.

4 General

The details of implementation set forth in this document are intended to reinforce and augment the requirements established by the NTIS, NTIP, and by the FHWA TOMIE Manual.

4.1 Establishment of LADOTD Tunnel Inspection Program

As required by 23 CFR 650.507 of the NTIS and under the authority of Louisiana Revised Statute 48:35, LADOTD shall have a tunnel inspection organization which shall be responsible for:

- Establishing written policies and procedures;
- Maintaining tunnel inventory and inspection data;
- Regularly reporting National Tunnel Inventory (NTI) data to the FHWA;
- Maintaining a state's registry of personnel qualification records, experience, and training including national inspector certifications; and
- Establishing an effective quality control and quality assurance program.

This document hereby establishes the LADOTD Tunnel Inspection Program as the organization charged with implementing the responsibilities listed above. The functions necessary to carry out any of these responsibilities may be delegated, but any work contracted or delegated outside of LADOTD shall be completed in accordance with this document.

4.2 Nationally Certified Tunnel Inspector

LADOTD shall maintain documentation of certification of National Certified Tunnel Inspectors in their AssetWise inspection software.

A nationally certified tunnel inspector shall;

- Complete an FHWA approved comprehensive tunnel training course (score 70% or greater on an end-of-course assessment, and;
- Complete a cumulative minimum total of 18 hours of FHWA approved tunnel inspection refresher training over each 60-month period, and;
- Maintained documentation supporting completion of FHWA approved comprehensive tunnel inspection and/or tunnel inspection refresher training and provided documentation upon request along with current contact information.

4.2.1 Refresher Training

All individuals (Program Manager, individuals with PM delegated duties, and Team Leaders) engaged in tunnel inspection are required to be nationally certified tunnel inspectors and shall be required to meet the minimum refresher training requirements stipulated in the NTIS. These individuals must complete a cumulative total of 18-hours of FHWA-approved tunnel inspection refresher training over each 60-month period. A copy of the certified training document of the refresher training status and current contact information shall be provided to the Program Manager of the tunnel inspection program. The Program Manager will input any updated contact information and refresher training documentation into the State's registry of Nationally Certified Tunnel Inspectors.

4.3 Qualifications and Roles – Tunnel Inspection Team Members

All tunnel Inspection Team Members will be vetted prior to the start of inspections. Their qualifications will be checked to determine if they meet the minimum requirements. For positions that require a registered professional engineer, verification of their licensure will be checked from the state board. The LADOTD Database of Verification will be used to confirm the licensure of Inspection Team Members. Resumes and background checks will be conducted to determine the Team Member's years of inspection experience and that they meet the National Tunnel Inspection Standards requirements. Team Members requiring nationally certified tunnel inspection training shall submit completion of training certification documentation.

All engineering service Inspection Team Members must meet the qualifications prior to being authorized to proceed or participate with the inspection.

Supporting qualification, experience, and training documentation shall be provided to the LADOTD Program Manager.

Each inspection report shall clearly indicate the Lead Team Leader, Team Leader, and Inspectors.

4.3.1 Program Manager

The program manager (PM) is the individual in charge of the tunnel inspection program for a State, Federal Land, or Tribal government that has one or more tunnels within their jurisdiction. This person must lead the tunnel inspection organization and ensure the requirements of the National Tunnel Inspection Standards (NTIS) are fulfilled. The program manager provides overall leadership and guidance to inspection Team Leaders and Load Raters. The program manager may delegate duties or functions to qualified delegates who manage a particular subset of tunnels; however, the program manager remains responsible for ensuring compliance.

On behalf of the tunnel inspection organization, the program manager:

- maintains the tunnel inventory;
- reports inventory updates;
- submits the tunnel inventory;
- develops written program procedures and policies;
- schedules and set inspection dates;
- assures inspections are performed timely and properly documented;
- assures timely inventory data entry;
- determines if and when an in-depth inspection is required;
- determines when a registered professional engineer is required in an inspection;
- verifies and monitors inspection program member qualification, experience, and training;
- requests needed training, approves allowable experience;
- maintains a list (registry) of nationally certified tunnel inspectors, as outlined in Section 4.2;
- establishes procedures for a systematic quality control (QC) and quality assurance(QA) process;
- monitors and reports critical findings;
- provides FHWA with annual critical findings report;
- oversees load rating, restriction, and posting aspects;
- procures specialized inspection and safety equipment;
- monitors and procures any engineering service tunnel inspection related work;
- coordinates with tunnel facility staff;
- and advises the team leader, as necessary.

Ideally, the program manager shall have a general understanding of all aspects of tunnel engineering including design, construction, operation, maintenance, inspection, evaluation, load rating, and rehabilitation. Good judgment is essential for this position in order to respond appropriately to safety and structural concerns within the tunnel.

The program manager has delegated to the LADOTD Assistant District Administrator of Operations and/or the District Bridge Engineer of each regional district office, through the inspection program, the following duties and functions:

- schedule inspections
- assure inspections are properly coded
- perform and properly document timely inspections within the tolerance threshold,
- assure timely inventory data entry, coordinated with PM when an in-depth inspection might be needed
- monitor inspection program Team Leaders and inspectors (field or with specialty) training
- establish procedures for a systematic quality control (QC) district office process
- report critical findings status
- procure general inspection and safety equipment
- coordinate with tunnel facility staff
- manage program team leaders and inspection staff
- oversee any field engineering service inspection work.

Minimum qualifications for the Program Manager are specified in 23 CFR 650.509 of the NTIS. The program manager (or qualified delegate individuals with PM duties) qualifications for the State of Louisiana are:

- A registered professional engineer; or
- have at least 10 years of tunnel or bridge inspection experience; and
- Individual must also be a nationally certified tunnel inspector,

Per this document, the Program Manager of the LADOTD Tunnel Inspection Program shall be the LADOTD Section 51 Structures and Facilities Maintenance Engineer.

4.3.2 Lead Team Leader

The Lead Team Leader is the person on-site who responsible for the entire inspection team of initial, routine, or in-depth inspections. This person should not be associated with the operation or maintenance of the tunnel. This person is responsible for inspection planning, preparing, performing, and reporting. The Lead Team Leader is responsible for evaluating the deficiencies, quality checking inspection data, and ensuring the inspection reports are complete, accurate, and legible. The Lead Team Leader shall also conduct safety briefings, as needed. The Lead Team Leader shall evaluate the recommendations for the repair of defective items and must initiate appropriate actions when critical findings are discovered, as outlined in Section 4.10. An inspection team may have several team leaders but there should only be one designated **Lead** Team Leader.

The Lead Team Leader must meet all of the qualification, training, and experience requirements of a Team Leader as defined in the NTIS 23CFR 650.509(b). These qualification are listed in 4.3.3. A Lead Team Leader must also be a nationally certified tunnel inspector.

4.3.3 Team Leader

The team leader is the person on-site who is responsible for the discipline-specific inspection team of initial, routine, or in-depth inspections. This person should not be associated with the operation or maintenance of the tunnel. This person is responsible for inspection planning, preparation, performance, and reporting; including coordination of field work. The team leader is responsible for evaluating the deficiencies, reporting inspection data, and ensuring inspection reports are complete, accurate, and legible. The team leader shall provide recommendations for the repair of defective items and communicate to the lead team leader when critical findings are discovered.

Each Inspection Team Leader shall meet the minimum qualifications, experience, and training specified in 23 CFR § 650.509. **Team Leaders must** be a nationally certified tunnel inspector **and m**eet at least **one** of the four qualifications listed below:

- Be a registered professional engineer and have six months of tunnel or bridge inspection experience.
- Have 5 years of tunnel or bridge inspection experience.
- Have all of the following:

  - A bachelor's degree in engineering or engineering technology from a college or university accredited or determined as substantially equivalent by the Accreditation Board for Engineering and Technology.
  - Successfully passed the National Council of Examiners for Engineering and Surveying Fundamentals of Engineering examination.
  - Two (2) years of tunnel or bridge inspection experience.
- Have all of the following:
  - An associate's degree in engineering or engineering technology from a college or university accredited or determined as substantially equivalent by the Accreditation Board for Engineering and Technology.
  - Four years of tunnel or bridge inspection experience.

The mechanical and electrical systems of all LADOTD Tunnels are complex systems, therefore the mechanical and electrical Team Leaders must also be Discipline Specific Specialist.

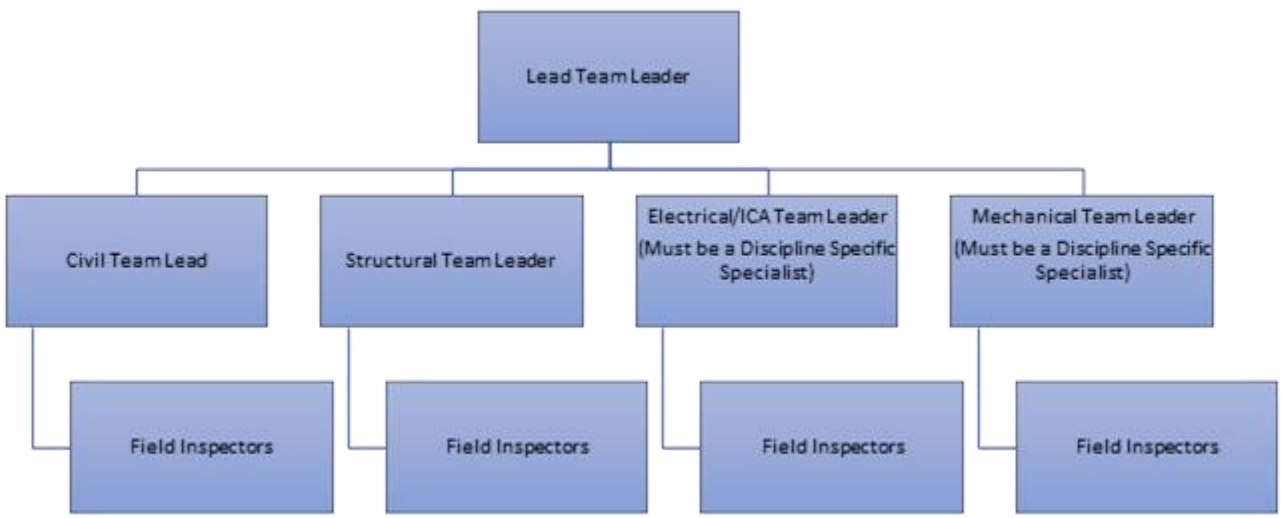

Figure 4-1 Inspection Team Org. Chart

4.3.4 Inspectors

The inspection team should consist of a minimum of two individuals to carry out the field work in a balanced and efficient manner. Discipline Specific Specialists and trained tunnel Field Inspectors involved in initial, routine, or in-depth inspections should assist the Team Leaders with the inspections, as necessary. The Inspectors should not be associated with the operation or maintenance of the tunnel or functional systems (See 23 CFR 50.513). All individuals on the inspection team should:

- Be knowledgeable of tunnel components and understand their function;
- Be able to climb and/or use equipment to access various areas of the tunnel;
- Be able to use equipment and apply appropriate test methods;
- Be able to print legibly and draw accurate sketches;
- Be able to read and interpret drawings; and
- Be able to use appropriate technology as required for data collection.

4.3.4.1 Discipline Specific Specialists

Discipline specific specialists are to be used when complex civil/structural, mechanical, or electrical systems need to be inspected, the lead team leader should assign discipline specific specialists with suitable training and experience to help conduct these inspections. These specialist individuals should be registered professional engineers or at least Engineer Interns (Certified through LAPELS). These specialists should have the education, training and experience put forth in the FHWA TOMIE Manual. Specialists include civil/structural specific inspectors, mechanical specific inspectors, and electrical specific inspectors.

Supporting documentation shall be provided to the LADOTD Tunnel Inspection Program Manager.

Civil/Structural Specialist

Civil/Structural inspectors shall have the following education, training, and experience:

- Be a nationally certified tunnel inspector;
- Specialist individuals should be registered professional engineers:
- Have one (1) year tunnel or bridge inspection experience with the ability to identify and evaluate defects that diminish the integrity of a structural member;
- Have design experience and be familiar with the type of civil/structural systems installed in the tunnel. Examples of these systems include, but are not limited to:
  - Liner
  - Roof girders, ceiling girders, and invert girders
  - Columns/piles
  - Cross passageways
  - Interior walls
  - Portals
  - Ceiling slabs, invert slabs, and slabs on grade
  - Hangers and anchorages
  - Ceiling panels
  - Joints
  - Wearing surfaces
  - Traffic barriers
  - Pedestrian railings
- Be able to assess the degree of deterioration for concrete, steel, masonry, and timber materials; and
- Be aware of the applicable codes and guidelines for structural systems.

Mechanical Specialist

Mechanical inspectors shall have the following education, training, and experience:

- Be a nationally certified tunnel inspector;
- Specialist individuals should be registered professional engineers;
- Have one (1) year tunnel or bridge inspection experience with the ability to evaluate physical and operational conditions of mechanical systems and equipment;
- Be aware of applicable codes and guidelines for mechanical features; and
- Have design experience or be familiar with the type of mechanical systems in tunnels. Examples of these systems include, but are not limited to:
  - Tunnel ventilation
  - Air conditioning
  - Heating

  - Control units
  - Plumbing
  - Tunnel drainage and pumping systems
  - Emergency generators
  - Fire Protection
  - Wells/Septic
  - Flood gates

Electrical Specialist

Electrical inspectors shall ideally have the following education, training, and experience:

- Be a nationally certified tunnel inspector;
- Specialist individuals should be registered professional engineers;
- Have one (1) year tunnel or bridge inspection experience with the ability to evaluate the physical condition, as well as the operational condition of the electrical systems and equipment;
- Have design experience or be familiar with the type of electrical systems installed in tunnels. Examples of these systems include, but are not limited to:
  - Power distribution
  - Emergency power
  - Lighting
  - Emergency lighting
  - Fire detection
  - Air-quality monitoring
  - Cameras and safety systems
  - Communications
- Be aware of applicable codes and guidelines for electrical systems to include:
  - NETA MTS-2011 – InterNational Electrical Testing Association (NETA), Maintenance Testing Specifications—developed for those responsible for the continued operation of existing electrical systems and equipment to guide them in specifying and performing the necessary tests to ensure that these systems and apparatus perform satisfactorily, minimizing downtime and maximizing life expectancy.
  - NFPA 70 – National Fire Protection Association 70 – covers installations of electric conductors and equipment within or on public and private buildings or other structures, installations of conductors and equipment that connect to the supply of electricity, installations of other outside conductors and equipment on the premises, and installations of optical fiber cables and raceways.
  - NFPA 70B – National Fire Protection Association 70B – recommended practice for electrical equipment maintenance for industrial-type electrical systems and equipment but is not intended to duplicate or supersede instructions that electrical manufacturers normally provide.
  - NFPA 70E – National Fire Protection Association 70E – addresses those electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees.
  - NFPA 72 – National Fire Protection Association 72 – national fire alarm code that covers the application, installation, location, performance, and maintenance of fire alarm systems and their components.
  - NFPA 502 – National Fire Protection Association 502 – covers fire protection and fire and life safety requirements for limited access highways, road tunnels, bridges, elevated highways, depressed highways, and roadways that are located beneath air-right structures.
  - ITA Guidelines for Structural Fire Resistance for Road Tunnels – International Tunneling Association (May 2004) – covers guidelines for resistance to fire for road tunnel structures.

- IES LM-50 – Illuminating Engineering Society, Lighting Measurements–50 – provides a uniform test procedure for determining, measuring, and reporting the luminance characteristics of roadway lighting installations.
- IES RP-22 – Illuminating Engineering Society, Recommended Practices–22 – provides information to assist engineers and designers in determining lighting needs, recommending solutions, and evaluating resulting visibility at vehicular tunnel approaches and interiors.

4.3.4.2 Field Inspectors

Field inspectors, associated with initial, routine, or in-depth type of inspections, assist the Team Leader and Discipline Specific Specialists carry out the inspection work. The Field Inspector shall have knowledge of LADOTD's inspection and reporting procedures. Some duties of the inspector include carrying inspection equipment, filling out inspection forms, taking photographs, and making sketches. The NTIS does not mandate specific qualifications for field inspectors; however, the following qualifications are recommended for field inspectors assigned to civil/structural, mechanical, and electrical inspection work. Ideally, the field inspectors would have an engineering background with education, training, and experience within their respective fields of practice.

Supporting documentation shall be provided to the LADOTD Tunnel Inspection Program Manager.

- Civil/structural field inspectors shall:
  - Be trained in general civil/structural inspection requirements;
  - Have tunnel or bridge inspection experience with concrete, steel, timber, and masonry structures; and
  - Design and maintenance experience is also useful.
- Mechanical field inspectors shall:
  - Be trained in general mechanical inspection requirements;
  - Have inspection experience with mechanical and plumbing systems; and
  - Design and maintenance experience is also useful.
- Electrical field inspectors shall:
  - Be trained in general electrical and electronic inspection requirements;
  - Have inspection experience with electrical systems; and
  - Design and maintenance experience is also useful.

4.3.5 Inspector for Damage, Cursory, and Special Inspections

A tunnel inspector is a person allowed to conduct tunnel damage, cursory, and special inspections. This person could be associated with the operation or maintenance of the tunnel. A tunnel inspector should meet the minimum qualifications and experience of a Team Leader with the exception that the Inspector for Damage, Cursory, and Special Inspections does not have to meet the minimum nationally certified tunnel inspector requirements. Criteria for this type of inspection is discussed in Section 4.4.4.

It is LADOTD's recommendation that whenever possible for damage or special type of inspections a Team Leader with nationally certified tunnel inspector credentials be used.

4.3.6 Specialty Inspection Assistance

The Program Manager with input from the District's ADA of Operations or District Bridge Engineer will determine when tunnel distinctive features or functions warrant specialty inspection assistance. Specialty contractors are beneficial when the regular inspection staff lacks the specialized skills and experience necessary to inspect sophisticated equipment or complex systems such as power distribution systems, fire protection and detection systems, security systems, structural integrity, and Supervisory Control and Data Acquisition (SCADA) systems. It is advisable to use qualified specialty contractors when inspecting complex units that pose elevated risks to safety such as boiler units, electrical systems, or energized equipment like transformers. This may help to minimize health and safety risks to the inspection crew and prevent damage to very expensive equipment. Each type of specialty inspection work shall be led by a registered Professional Engineer with at least six months of tunnel or bridge inspection experience.

The Program Manager shall consider the following to determine if specialty inspection assistance is required: type of tunnel construction, functional systems, system performance history, and physical and operational conditions. In most cases, this process will be used to determine when an in-depth inspection is needed or when rehabilitation or upgrading a function system should be considered. The following are examples of some specialty work:

- Electrical and Electronic Inspections – To inspect elements with advanced electronic circuitry, the staff furnished by the specialty contractors shall have the following education, training and experience:
  - Certification by an organization meeting the requirements of the InterNational Electrical Testing Association (NETA); or
  - All the following qualifications:
    - Be nationally recognized as an electrical testing laboratory;
    - Be regularly engaged in the testing of electrical systems and equipment for the past five years;
    - Have at least one professional engineer with at least six months of tunnel or bridge inspection experience on staff that is licensed in the State of Louisiana; and
    - Have in house or lease sufficient calibrated equipment to do the testing required.
- Boiler Inspection – To inspect boilers, boiler room, and pressure vessel located within the tunnel facility, the staff furnished by the specialty contractors shall be:
  - Listed as an authorized inspection agency by the National Board of Boiler and Pressure Vessel Inspectors;
  - Have at least one professional engineer with at least six months of tunnel or bridge inspection experience on staff that is licensed in the State of Louisiana; and
  - Certified for boiler and pressure vessel work by an organization meeting the requirements of the American Society of Mechanical Engineers (ASME).

4.4 Inspection Type and Frequencies

Frequency requirements for each inspection type are established by the NTIS in 23 CFR § 650.511, supplemented by this document, and applied by this document to all tunnel inspections in the State of Louisiana. The frequency requirements are described below.

The frequencies for inspections shall be determined by such factors as environment, construction material, state of maintenance and known deficiencies.

Criteria and frequencies for inspections can be found in the TOMIE manual in accordance with 23 CFR 650.511 – Inspection Interval.

4.4.1 Initial Inspections

The original or first inspection of a newly constructed tunnel has no other definable frequency. The first inspection of a tunnel is to gather all inventory, perform an appraisal, and other data necessary to determine the baseline condition of the structural elements and functional systems. Initial inspection shall be conducted after all construction is completed and prior to opening to traffic. Initial inspections may be performed at either the Routine level or the In-depth level; however, an In-depth level inspection is preferred.

4.4.2 Routine Inspection

The “normal” or default frequency for Routine tunnel inspections is 24 months. However, more-frequent inspections may be necessary for some tunnels following LADOTD’s established criteria and less-frequent inspections may be allowable on other tunnels with FHWA coordination. Each tunnel has a designated routine inspection date as a month, date, and year format which should only be modified by the Program Manager for rare circumstances. An acceptable inspection interval tolerance of within 2-months before or after the established routine inspection date is allowed. These inspections are intended to be comprehensive, covering the structural, civil, mechanical, electrical and lighting, fire and life safety, security, signs, and protective systems.

Inspection intervals greater than 24 months for Routine inspections require written FHWA approval in accordance with 23 CFR 650.511(b)(4).

4.4.3 In-Depth Inspection

These inspections shall be conducted in accordance with the TOMIE Manual and/or on an as- needed basis as determined by the Assistant District Administrator (ADA) of Operations, District Tunnel Engineer, Program Manager, and/or Bridge Inspection Engineer. In-depth inspections are close-up, hand-on inspections conducted on one, several, or all of the elements or functional systems. Frequency of inspection is discussed in the below tables.

4.4.4 Special, Cursory, and Damage Inspections

A special inspection is typically performed after an initial, routine, damage or in-depth inspection finds significant deficiencies that need to be monitored. A special inspection could be scheduled at the discretion of the tunnel owner or LADOTD District Bridge Engineer, as needed, to monitor a specific known or suspected deficiency. Special inspections are scheduled based on the needs of the tunnel facility, inspection findings, and established written procedures. Special inspections can be scheduled using a six-month or twelve-month interval.

Qualifications for these personnel are discussed in Section 4.3.5 in accordance with 23CFR650.509(d).

An established special inspection criterion has been developed based on a risk analysis approach that considers such factors as tunnel age, traffic characteristics, geotechnical conditions, and known deficiencies. In general, if any related functional system; ventilation system, pumps, power distribution, emergency power generation, or lighting is 25% or less operational (i.e. if a cumulative 75% or more place in CS3 and 4) the facility will be placed on a six-month special inspection cycle.

Cursory inspection is not a scheduled inspection. It is only used to verify aspects or quantities included in an earlier inspection and as a method to document the verification findings, if needed. This type of inspection is seldom used by LADOTD.

Damage inspection is not a scheduled inspection, this occurs as a direct or indirect result of environmental or human actions to assess the tunnel structural elements or survey any systems for damage.

Structural

The Structural Special, Damage or In-Depth Inspection will be conducted for the following reasons:

Inspection Type	Description
In-Depth Inspection	A Structural In-Depth Inspection will be conducted after all routine inspections are performed. The purpose of the structural In-depth Inspection is to identify and document structural defected areas and within the tunnel walls, crown and portals. This identification will help LADOTD to monitor the structural integrity of the tunnels over time. Non-destructive devices will be used throughout the entirety of the tunnels to identify hollow areas. The frequency of the In-depth Inspection will be every 24 months, as this follows the Routine Inspections.
Damage Inspection	A Structural Damage Inspection will be conducted in response to natural disasters or human activities that have caused unexpected damage to the tunnel structural elements. Damages can be caused by motor vehicle impact, fire, flood, earthquake, or explosions. If any structural elements, such as the tunnel walls, crown,

	walkways, safety railings, vent shafts, or portal areas have experienced damages due to unforeseen events, a structural damage inspection will be warranted. If any of these events occur within or adjacent to the tunnel, a structural damage inspection will be warranted. This applies to all tunnels under LADOTD's responsibilities. As such, a Damage Inspection will be conducted as needed regardless the frequency of Routine Inspections.
Special Inspection	A Structural Special Inspection will be conducted after initial, routine, damage or in-depth inspection when significant structural deficiencies have been discovered and need to be monitored. Structural deficiencies that warrant a special inspection can include, but are not limited to: 1. Cracks with large displacements, where these displacements need to be monitored 2. Extensive leaks 3. Unravelling tiles The frequency of the special inspection will be based on the type of deficiency to be monitored and determined by an agreement between the Assistant District Administrator (ADA) of Operations, District Tunnel Engineer, Program Manager, and/or Bridge Inspection Engineer.

Mechanical

The Mechanical Special, Damage or In-Depth Inspection will be conducted for the following reasons:

Inspection Type	Description
In-Depth Inspection	A mechanical In-Depth Inspection will be conducted after all routine inspections are performed. The purpose of the mechanical In-depth Inspection is to identify and document functional system deficiencies not readily detectable during the initial, routine, or damage inspections. This identification will help LADOTD to verify that mechanical systems are performing as expected. The frequency of the In-depth Inspection will be every 24 months, as this follows the Routine Inspections.
Damage Inspection	A Mechanical Damage Inspection will be conducted in response to natural disasters or human activities that have caused unexpected damage to the tunnel mechanical elements. Damages can be caused by motor vehicle impact, fire, flood, earthquake, or explosions. If any mechanical elements, such as the drainage ventilation or safety systems have experienced damages due to unforeseen events a mechanical damage inspection will be warranted. If any of these events occur within or adjacent to the tunnel, a mechanical damage inspection will be warranted. This applies to all tunnels under LADOTD's responsibilities.

	As such, a Damage Inspection will be conducted as needed regardless the frequency of Routine Inspections.
Special Inspection	A Mechanical Special Inspection will be conducted after initial, routine, damage or in-depth inspection when significant mechanical deficiencies have been discovered and need to be monitored. Mechanical deficiencies that warrant a special inspection can include, but are not limited to: 4. Abnormal noise or vibration in equipment 5. System performance degradation (system pressure loss, reduction in airflow The frequency of the special inspection will be based on the type of deficiency to be monitored and determined by an agreement between the Assistant District Administrator (ADA) of Operations, District Tunnel Engineer, Program Manager, and/or Bridge Inspection Engineer.

4.5 Inspection Procedures

4.5.1 FHWA TOMIE

Each tunnel shall be inspected in accordance with the inspection procedures set forth in the FHWA TOMIE Manual.

4.5.2 Tunnel Specific Procedures

The three tunnels that LADOTD are required to maintain are the Harvey Tunnel, Belle Chasse Tunnel, and Houma Tunnel. **All LADOTD tunnels are complex tunnels,** therefore Specific Inspection Procedures have been developed within section 4.5, which describe how inspections will be performed for each tunnel.

4.5.3 Tunnel Closure

In general, all tunnel closures will be coordinated with LADOTD facility personnel. Submit closure request to LADOTD 30 days before requested closure, unless an emergency inspection is warranted. The closure procedures that will be coordinated with LADOTD include closure duration, time of closure and specific lane closure for these tunnels. Coordination with LADOTD is imperative to provide safety to the traveling public. In advanced of the tunnel inspections, news of the pending tunnel closure will be broadcasted to the public. This will give the public an opportunity to plan alternate routes.

Closures will include utilizing cones and truck mounted attenuators with directional signs to block off public vehicle entry into the tunnels according to LADOTD Standard Specifications for Temporary Traffic Control. Detour signs will be in place to provide direction for the public. Normally, catwalks are open to the public. These catwalks will be closed to the public during inspections. Cones, caution tapes, and signs will be placed at the entrances to the catwalk.

- Harvey Tunnel

LADOTD facility personnel will close entry roads to the tunnels. The roads to be closed are the tunnel entrance roads that connect the Westbank Expressway to the east and west tunnel portals. The catwalk entrances are above the portal and adjacent to Destrehan Avenue and Peters Road. These entrances will be closed off to the public.

- Houma Tunnel

The road to be closed is Tunnel Boulevard. The Houma Tunnel is bi-directional, therefore, full road closure at both ends of the tunnel will be necessary. Closures will be placed to provide detours for the traveling public. The catwalk entrances will also be closed at the tunnel portals on Tunnel Boulevard.

- Belle Chasse Tunnel

Route 23 South will be closed on both sides of the Tunnel to provide full tunnel closure. Traffic will be redirected to Route 23 North over Belle Chasse bridge to provide bi-directional traffic. Catwalk entrances to on North Tunnel Road and R Street will be closed to the public.

4.5.4 Confined Space Procedures

Confined spaces for the LADOTD tunnels include the tunnel air ducts. Harvey Tunnel air duct is not a permit confined space. Both Houma and Belle Chasse Tunnel air ducts are permit confined spaces. It is imperative that gas monitors, permit confined space forms, and entry attendants will be used to provide safe entry for the inspection crew. Prior to entry into these spaces, the air quality will be checked with the gas monitors. If air quality is safe, entry can begin. An entry attendant shall remain at the entrance at all times and have constant radio communication with the inspection crew. The inspection crew shall have gas monitors at all times and report the air quality at 15-minute intervals to the entry attendant. Should the air quality decrease and the gas monitor alarm, the inspection crew will exit the confined space immediately. Re-entry into the permit confined space can only be achieved if air quality improves.

4.5.5 Lock Out/Tag-Out (LOTO) Requirement

If a disconnecting means is required to be lockable open elsewhere in the Code, it shall be capable of being locked in the open position. The provisions shall remain in place with or without the lock installed. Any equipment installed, updated, replaced and/or modified should accept a lock in the open (off) position. A LOTO mechanism should be permanently fixed on the protective device. The LOTO mechanism cannot be an accessory that is readily removable. These requirements exclude the use of portable LOTO devices intended to be temporary.

LOTO requirements will consist of the following:

1. LOTO program including written procedures of the electrical systems
2. Provide the necessary equipment for LOTO procedures (locks, tags, diagrams, etc.)
   a. Any lock shall have only 1 key. Proper identification of this individual includes name, face, department, phone number, etc.
   b. Tags shall display. “Do not use, Do not operate, etc.” Use tagout only when conditions are provided where it is not possible to apply a lock. Two isolation means are required for this method.
3. Provide LOTO training to all qualified personnel
4. Perform annual audits to ensure compliance with the LOTO program

LOTO procedures and programs should be prepared for any person or party exposed to electrical energy. A written LOTO procedure should be developed for each system or piece of electrical equipment. LOTO is applied to only power sources and not associated controls. Procedures include locating sources of energy, providing up-to-date single line diagrams, and identify key locations where LOTO is required as well as the proper PPE required at these locations.

A proper LOTO program consists of the following:

1. The shutdown procedure and qualified person responsible
2. Removal of stored energy from the system
3. Means of disconnecting verification
4. Identify key personnel with the LOTO training
5. Verification that equipment cannot be energized
6. Test LOTO equipment including verifying test equipment and measuring energy
   a. Check for zero energy on phase to phase
   b. Check for zero energy on phase to ground
   c. Re-verify test equipment

7. Analyze grounding requirements of the system. Dangerous back feed or equipment rated over 600V shall implement personnel safety grounding.

4.5.5.1 Restoring Equipment

When restoring equipment to service after a LOTO, the following steps should include:

1. Inspect the equipment and work area to ensure that nonessential items and material have been removed. This includes tools, parts, spare parts, accessories, and damaged components. All equipment safety covers/guards should be reset.
2. Confirm that all personnel have been safely positioned or removed from the work area.
3. Verify that equipment controls are set to the default working state, if applicable.
4. Remove the LOTO device and re-energize the equipment.
5. Notify working staff that service/maintenance is completed, and the equipment is ready for use.

Only trained and authorized workers can perform the restoration of equipment following a LOTO.

Refer to Section 4.14.1 for specific Lock-Out/Tag-Out Procedures.

4.5.6 Team Leader

Initial, Routine, and In-depth inspection shall have the presence of at least one lead Team Leader who meets the requirements set forth in this manual. The lead Team Leader shall be at the tunnel at all times during the inspection.

Cursory inspections do not require a team leader.

Damage inspections and Special inspections do not require the presence of a team leader, however the presence of one is recommended.

4.5.7 Tunnel Load Rating

Load ratings shall be performed by, or under the direct supervision of, a registered professional engineer. Load rating evaluation will be performed in accordance with the latest 23 CFR 650.517 approved reference edition of the AASHTO Manual for Bridge Evaluation.

Load restriction or closure status shall be entered onto the inventory within 3-months after the change in status. Post or restrict the roadways in or over the tunnel, when required. Posting shall be made as soon as possible but not later than 30 days after a valid load rating. Only load restriction or closure status will be reported in the inventory for roadways in the tunnel, not for roadways over the tunnel.

At-grade roadways in tunnels do not require load rating. However, roadways on elevated slabs or any highways over the tunnel will require to be load rated. The type of tunnel construction for the LADOTD tunnels with at-grade roadways do not require vehicular load-carrying capacity analysis; however, any roadway over the tunnels will be evaluated. Load rating documentation and calculations shall be maintained as part of the tunnel record.

4.5.8 Complex Tunnels

Tunnels that require specialized inspection procedures and/or additional inspector training or experience shall be identified as complex tunnels. Each complex tunnel shall have its own specialized inspection procedures and shall be inspected according to those procedures, (See 23 CFR 650.513). In a complex tunnel situation, regulations require that an agreed process be in place that would at minimum consider the type of construction, functional systems, history of performance, and physical and operational conditions of the tunnel (See 23 CFR 650.507). Refer to Section 4.3.6 Specialty Inspection Assistance of this document for aspects on the process.

4.6 Tunnel Inspection Records

The findings and results of tunnel inspections shall be recorded and stored on AssetWise. AssetWise will be used in the field to collect data and sync to the web server for approving reports, inspection management, performance management and maintenance needs management. The tunnel inspection records shall become part of the tunnel file. See Section 4.11 of this document.

The inspection report approval process and data entry into the inventory database shall be completed within 3-months after the completion of the inspection.

The data required to complete the forms, as well as guidance with the functions that must be performed in order to compile the data, can be found in the current editions of the following manuals/documents:

- FHWA TOMIE Manual;
- FHWA SNTI; and
- LADOTD Recording and Coding Guide

4.7 Tunnel Inventory Development

The SNTI (Specifications for the National Tunnel Inventory) is used to collect the tunnel inventory items such as tunnel identification, age and level of service, classification, geometric data, inspection, navigation, and structure type. The SNTI inventory items require the following information: the item name, specification, commentary, examples, format, and the alpha-numeric identification. The specification contains descriptions of each inventory item and it provides a series of explanations in the commentary section. Example items are also provided to demonstrate "how to" code information for various situations.

The SNTI contains the requirements for coding and reporting inventory and inspection data to be submitted to the FHWA as part of the National Tunnel Inventory (NTI). This data will allow tunnel owners, the FHWA, and the general public to attain information on the condition of highway tunnels in the United States.

The inventory data contains items that are used for tunnel identification such as age, service classification, geometric data, navigational clearances, and structural type. This data can be obtained from existing records and field verified as needed. The data must be collected and submitted in accordance with the NTIS.

LADOTD shall prepare and maintain an inventory of all tunnel structures subject to the NTIS.

4.7.1 Collection and Retention of Data for Tunnel Inventory

Inventory data shall be collected on AssetWise and will be submitted annually to the FHWA as support for LADOTD' s infrastructure needs. The Collector Module of AssetWise allows users to schedule, create, edit, and review inspection reports, create and review maintenance items during the inspection process, view the inspection schedule to ensure all inspections are completed on time, and more.

The tunnel inventory data shall become part of the tunnel file. See Section 4.11 of this document. Guidance for the collection and retention of tunnel inventory data can be found in the following documents:

- LADOTD Recording and Coding Guide;
-
- FHWA TOMIE Manual, and
- FHWA SNTI

4.7.2 Time Limits for Data Entry into Tunnel Inventory

The NTIS establishes time limits for entering data into a state's tunnel inventory. Per this document, the time limit that shall apply to all tunnels in the State of Louisiana that are governed by the NTIS is 3-months for both data on state-owned tunnels and data on tunnels owned by other entities.

- For data from all inspections the time limits shall be measured from the date of inspection.

- For data on new tunnels and from modifications to existing tunnel that alter previously recorded data, the time limits shall be measured from the date that physical completion of the work has progressed to a point that safe collection of the required data is possible.

4.8 Inspection Element Identification

The SNTI is used with the Tunnel Operations, Maintenance, Inspection, and Evaluation Manual (TOMIE) to collect comprehensive tunnel inspection data on the structural, civil, and functional systems within the tunnel. Functional systems include mechanical systems, electrical systems, lighting systems, fire life safety and security systems, signs and protective systems. There are two main tables that provide element level coding instructions. The first table has five parts: the element name, unit of measure, element number, specification, and commentary. The second table lists the four condition states, which are discussed in Section 4.9.

The SNTI includes instructions for recording the condition states of tunnel structural, civil, and functional systems. Structural elements include liners, roof girders, columns, piles, cross passageways, interior walls, portals, ceiling slabs, ceiling girders, hangers and anchorages, ceiling panels, invert slabs, slabs on grade, invert girders, joints and gaskets. Civil elements include wearing surfaces, traffic barriers, and pedestrian railings. Functional systems include the mechanical, electrical, lighting, fire and life safety systems, security equipment, signs, and protective finishes.

The Element Number is the unique number assigned to represent that element. Element numbers were derived based on their section, subsection and element. The Specification and Commentary sections provide the detailed description of each element, how to calculate the quantity of the element and some explanation or additional clarification to consider for coding each element.

In addition to the elements defined herein, a State, Federal Agency, or Tribal Government may define sub-elements that are consistent with the SNTI, which can provide additional information for its internal asset management needs. An example would be developing a sub-element for fan motors which can impact the effectiveness of the ventilation system.

Alternatively, a State, Federal Agency, or Tribal Government can develop agency defined elements, which are not linked to an element defined within the SNTI to avoid confusion or inconsistency.

4.9 Condition State Ratings

The TOMIE Manual defines condition state ratings for tunnel inspections and is based on an element level inspection approach. The condition states defined in the TOMIE manual are:

- CS1 Good Condition
- CS2 Fair Condition
- CS3 Poor Condition
- CS4 Severe Condition

The condition state of each tunnel element is evaluated using the criteria provided in the TOMIE Manual. The abbreviated nomenclature (e.g., CS1) is used to describe the condition of individual defects in the inspection logs, while the written nomenclature (e.g., good condition) is used to describe the general conditions of the tunnel components within the tunnel inspection findings report. The element level inspection approach is further defined in the FHWA's SNTI. The SNTI provides criteria for each tunnel element to allow classification according to the four TOMIE condition states. The element level criteria for structural components shall be modified to better suit the specific details of construction for the tunnel.

The Condition State Definition table lists defects and condition state language that are specific to that element. Only those defects which are appropriate for a specific element are listed. Each defect is then associated with four condition states and descriptive language based on the material type. This is done to recognize that the defect is dependent on the material and its severity. For instance, cracking can occur in steel, concrete and timber, but the type of cracking will differ, and the element condition state language reflects these differences.

The severity of a defect can vary within an element and is described and quantified using the four different condition states.

The limits of Conditions States 1 through 3 are typically well defined for each defect. Condition State 4 is reserved for instances when the defect's conditions are beyond the limits of those defined in Conditions State 1 through 3 and a structural review is recommended or has been performed and reduced strength or serviceability exists.

For an element, the total quantity is divided among the 4 condition states based on the condition state descriptions.

4.10 Critical Findings

Inspection procedures are needed for discovery of critical structural or safety related deficiencies found during the inspection of the tunnel. The procedures should incorporate the following steps, as deemed appropriate:

- Immediate critical deficiency reporting steps.
- Emergency notification to the police and the public.
- Rapid evaluation of the deficiencies found.
- Rapid implementation of the corrective or protective actions.
- A tracking system to ensure adequate follow-up actions

Critical findings are defined in the NTIS, as a structural or safety related deficiency that requires immediate follow-up or action. LADOTD is required to establish a procedure to ensure that critical findings are addressed in a timely manner and actions have been taken, are underway, or are planned to resolve the issue. The critical findings encountered during an inspection are to be reported through e-mail or formal correspondence to the FHWA within 24 hours of finding awareness. The FHWA should be updated every six months as to the status of each critical finding until the issue is resolved, except of tunnel full closure updates will be provided monthly until the issue is resolved and the closure restriction removed. FHWA is to be provided with an annual written summary report in the month of December of the current status of each critical finding identified within the past year and each unresolved finding from a previous year.

LADOTD considers a tunnel element or portion of that element with a severe element level condition state (i.e. Condition State=4) or full closure of the tunnel highway from public access due to structural or safety deficiencies to be viewed as a critical finding.

Refer to tables in Appendices A-F for the Critical Findings Criteria by element.

The tunnel inspection Lead Team Leader, in consultation with LADOTD Program Manager, should establish written procedures for dealing with critical findings prior to the inspection. It is imperative that the inspection team have communication protocols in place to ensure that immediate action can be taken to respond a critical finding. Critical findings normally require one or more of the following actions to be taken in a timely manner:

- Close the tunnel until the severe defect is removed or repaired, if the defect may impact users or user safety.
- Restrict the area from public access until the defect can be removed or repaired.
- Repair the structural member or address the functional or safety issue.

The tunnel inspection organization, in consultation with LADOTD, should also agree to and establish a procedure for proper communication of Critical Findings to FHWA. The specific program procedures for critical findings, shall include but are not limited to the following:

- Define and properly document the critical finding with photos, detailed descriptions, detailed location and measurements.
- Lead Team Leader shall immediately report the critical finding to the LADOTD Structures and Facilities Maintenance Engineer, along with the Program Manager. The Lead Team leader will provide a memorandum with detailed description, location and photographs of the critical finding to the Program Manager who will then report and submit the memorandum of the critical finding to LADOTD Structures and Facilities Maintenance Engineer. The LADOTD Structures and Facilities Maintenance Engineer is specifically in charge

to notify the FHWA contact (via email and phone-call) within 24-hours of identification of critical findings. The LADOTD Structures and Facilities Maintenance Engineer can forward the critical findings memo produced by the Team Leader as he/she deems necessary.

The critical finding memorandum shall include:

- detailed description
- detailed location
- measurements
- photographs
- current status
- activities taken
- activities underway
- monitoring of critical finding
- resolution

LADOTD Structures and Facilities Maintenance Engineer will communicate to the Program Manager within 24-hours of identification of critical finding the measure that they will proceed with to either repair/address critical finding or to restrict critical finding area from public access via e.g. full tunnel closure or partial tunnel closure.

The Lead Team leader shall compile/update an electronic log of all the critical findings that are identified during the cycle year inspection and update any existing, unrepaired critical findings from previous inspections that were submitted to FHWA. This log will be provided by the LADOTD Structures and Facilities Maintenance Engineer to the Lead Team Leader at the beginning of the cycle year inspection. The Lead Team leader will provide LADOTD Structures and Facilities Maintenance Engineer with an updated log of critical findings at the end of the cycle year inspection.

The Lead Team Leader and shall perform a special inspection of a repair that was completed at a critical finding and will ensure the proper documentation, location and confirm the repaired condition of the critical finding. Results from the special inspection will be used to update the electronic log of critical findings.

Detailed descriptions and photographs should be provided that describe the safety or structural concern, identify appropriate actions or follow-up inspections, and maintain a record of the actions taken to resolve or monitor the critical finding. For example, with a large concrete spall that is on the verge of falling into the roadway, the inspection team or tunnel operations personnel can block off the traffic. Then, the maintenance personnel or a specialty contractor can take down and remove the spalled concrete.

Critical Findings Criteria Tables are found in the Appendices of this document.

4.11 Tunnel Files

A tunnel file shall be prepared and maintained for all tunnels subject to the NTIS. The file shall retain pertinent information for the life of the tunnel. Data and documents in the tunnel file shall be consistent with the FHWA TOMIE Manual. Items typically include, but not limited to, the following:

- Inspection reports, structural inventory and appraisals;
- Construction plans, specifications, shop drawings, and as-built plans;
- Records pertaining to maintenance, material tests, load tests, accidents, floods, postings and load permits; and
- Correspondence and photographs that pertain to any of the above records.

4.12 Quality control/quality assurance (QC/QA)

The NTIS requires that quality control and quality assurance (QC/QA) procedures shall exist within a state's tunnel inspection organization in order to maintain a high degree of accuracy and consistency in the inspections

(23 CFR 650.513). Section 13 of this manual has the systematic QC/QA Procedures for Louisiana's Tunnel Inspection Program.

The aforementioned 23 CFR 650.513 section of the NTIS directs that the QC/QA procedures shall include:

- Periodic review of inspection teams
  - Intent is for qualification and/or training to be checked for all inspection team members; team leaders, discipline specific specialists—electrical, mechanical, and civil/structural inspectors, field inspectors for electrical, mechanical, and civil/structural, and for any specialty inspection assistance personnel that might have participated in an inspection.
  - Periodic refresher training review of any inspection program personnel required to be a nationally certified tunnel inspector like the program manager, personnel with delegated program manager duties, discipline specific specialists, specialty inspection assistance personnel, and team leaders
- Data quality checks
  - Intent is to review inventory and element coding for accuracy.
- Independent review of inspection reports and computations.
  - Intent is to maintain a high accuracy degree and consistency.

LADOTD QC/QA Section 51 staff will document the QC/QA efforts performed/accomplished each calendar year. The annual QC/QA accomplishments will be provided to FHWA.

This documentation will affirm that the LADOTD Tunnel Inspection Program has complied with these requirements by the creation of a QC/QA Program within the Tunnel Inspection Program.

The QC/QA Program shall be managed by a Civil Engineer licensed in the State of Louisiana from LADOTD Section 51. Refer to Section 13 of this manual for additional specific QC/QA Procedures.

4.13 Work Hours for Inspection and Tunnel Maintenance Schedule

Work hours for a tunnel inspection are coordinated with Program Manager, LADOTD QC/QA Section 51 Staff, and LADOTD District staff. Working hours are typically Monday through Friday, 7am – 3pm. If available by LADOTD, weekends can be utilized for additional inspections days.

4.14 Inspection Access Points

Access points for each tunnel and discipline are described further in Section 12. Access points need to be coordinated with LADOTD Personnel to gain access to the entire tunnel facility for a complete and thorough inspection, as well as provide safe working conditions for inspectors.

4.14.1 Lock-Out/Tag-Out Procedures

Lock-out/Tag-out (LOTO) procedures shall be incorporated with access points to provide for a safe working environment.

Lock-out/tag-out procedures shall be developed during inspection planning. Prior to inspecting any electrical equipment with the potential to cause injury or damage, the lock-out/tag-out procedures shall be implemented in coordination with the appropriate tunnel facility personnel. The inspection shall not be allowed to proceed until the system is properly de-energized or isolated, locked-out, and tagged-out.

Unexpected energized circuits, the startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities can sometimes occur after lock-out/tag-out. Therefore, it is important to create a checklist to ensure that safety is maintained. The procedure in Section 4.14.1.1 can be used as a guide to help develop a lock-out/tag-out procedure for machinery and equipment.

Machines or equipment shall be stopped, isolated from all energy sources, and locked out. Employees shall not be allowed to congregate near the equipment being removed from service in case of unexpected energizing or the accidental start-up of the machine.

4.14.1.1 Sequence of Lockout

1. The shutdown shall be coordinated with the appropriate personnel at the tunnel facility. Even if the equipment isn't running at the moment, it may be possible to turn on the equipment at the flick of a switch in another room or by some algorithm written into a computer program. Always use established procedures and qualified personnel for the shutdown.
2. The person conducting the shutdown shall follow the appropriate procedures. The type and magnitude of energy running to the equipment shall be identified. The person initiating the shutdown shall be competent and appropriately qualified for servicing the particular equipment. The qualifications of this individual shall be listed in the written procedures. This person needs to understand how to isolate and control the energy running to the equipment.
3. Notify all persons (e.g., employees, maintenance staff, on-site contractors) working in the vicinity of the equipment being shut down, as appropriate and in accordance with established procedures. Inform these people that servicing has been scheduled for the equipment and that the machine will be removed from service.
4. De-activate all sources of energy to the machine and isolate the equipment from all energy sources.
5. Lockout the energy using isolating devices and provide locks assigned to individuals that prevent these isolating devices from being removed. Use appropriate blocking and shields as necessary to secure the equipment. Add tag designations to the equipment. The locks and tags shall contain the appropriate identification and contact information of the person responsible for the shutdown.
6. Stored or residual energy—from capacitors, springs, elevated machine members, rotating flywheels, hydraulic systems, and air, gas, steam or water pressure—shall be dissipated or restrained by appropriate methods such as grounding, repositioning, blocking, or bleeding down. These techniques shall be covered in the written procedures.
7. Perform checks as necessary to ensure that the equipment is properly isolated. One method of checking is to attempt to switch on the equipment. When attempting to turn back on the equipment, clear everyone to a safe distance, clean up tools and loose parts, and ensure that feeder lines are properly secured. If the lock-out/tag-out procedure was inadequate for any reason, it's possible that the equipment will reenergize and endanger the occupants in the room. By using the normal operating controls, the feeder lines can be tested for energy and the machine can be observed for signs of power. If the machine turns-on, lights-up, or has moving gauges, then power is likely getting to the equipment and the cause shall be further investigated. Successful implementation of this check shall increase the level of confidence in the lock-out procedure; and it serves to validate the process. Once this check has been completed, the operating controls shall be switched back to the neutral or "off" position.
8. The equipment shall now be effectively locked-out.

4.14.1.2 Restoring the Equipment to Service

When reenergizing equipment or machines after a shutdown, it is important to follow a carefully controlled process to prevent injury or equipment damage. When the servicing is complete and the machine is ready to be returned to service, the following steps shall be considered when instructions are not already available:

1. Check the equipment and the immediate area to ensure that nonessential items have been removed from the area and that the machine components are operationally intact.
2. Check the work area to ensure that all employees have been safely positioned or removed from the area.
3. Verify that the controls are in neutral or "off".
4. Remove the lockout devices and tags.
5. Provide any visual or audible safety warnings deemed necessary prior to re-energizing the equipment
   - Note: the removal of some forms of blocking may be necessary prior to re-energizing the machine.
6. Notify affected employees that the servicing, maintenance, or inspection has been completed and that the machine or equipment has been placed back into service.

4.14.2 Confined Space Entry Procedures

Tunnel inspections often include team members entering areas of confined space. A confined space is distinguished by the need to obtain a permit for entry, which is regulated by Occupational Safety and Health Administration (OSHA). A confined space is large enough for human entry with limited means of egress and not designed for continuous occupancy. A permit-required confined space usually poses a hazard or danger to the occupants. When planning inspection in a confined space, it is advisable to consult with an appropriately qualified health and safety specialist, who is knowledgeable of applicable laws and regulations.

There are five major concerns when performing inspections within a confined space:

1. Lack of oxygen – oxygen content shall be maintained within certain limits to ensure the health of the inspectors and to lessen the chance for any explosions.
2. Presence of Toxic gases – produced by tasks such as painting, burning, welding or operation of internal combustion engines.
3. Presence of Explosive gases – natural gas, methane, or gasoline vapors may be present.
4. Lack of light – many confined spaces are nearly totally dark. Inspectors need to be able to spot potential hazards and dangerous conditions. Adequate light is also necessary to perform the inspection
5. Limited means of access – many confined spaces have limited points of access and therefore limited locations for emergency egress.

Proper ventilation, additional lighting, and effective communication procedures can help mitigate many of the hazards of confined space; however, some areas of confined space also require permits to enter along with specialized training to meet OSHA requirements.

4.14.2.1 Safety Procedures for Confined Space

OSHA publishes regulations that govern confined space entry, and these requirements must be followed. When operating in a confined space, the proper training, equipment, and permitting are necessary. Equipment such as respirators, tie-off ropes, safety harnesses, two-way radios, and monitors to measure the gas levels may be required. It is important to monitor gas levels in areas of known ground contamination or where potentially dangerous materials are encountered.

The following safety procedures shall be considered when inspecting areas that are characterized as a confined space.

Pre-entry air tests:

a. Test for oxygen with an approved oxygen testing device.
b. Test for other gases, such as carbon monoxide, hydrogen sulfide, methane, natural gas, and combustible vapors.

Mechanical ventilation:

a. Pre-entry – Oxygen and gas levels shall be acceptable for a minimum prescribed time prior to entry.
b. During occupancy – Ventilation shall be continuous regardless of activities. Test for oxygen and other gases at prescribed intervals during occupancy.

Basic safety procedures:

a. Avoid the use of flammable liquids in the confined area.
b. Position inspection vehicles away from the entrance areas and avoid creating carbon monoxide fumes.
c. Position generators "down-wind" of operations. Operations that involve the production of harmful gases or dust shall be performed "down-wind" of personnel.
d. Carry an approved rescue air-breathing apparatus as appropriate.
e. Use adequate lighting with an appropriate backup system. Lifelines shall be considered when entering areas that could become dangerous when dark.

f. Inspection shall be performed in teams, with a person remaining outside the area of confined space. This person shall be able to communicate with others if any serious problems develop.
g. Use communication devices such as two-way radios or cell phones for general and emergency contact; however, make sure that any devices used are reliable in the areas where the work is being performed. Cellular phones may not work in all parts of the tunnel.
h. Be familiar with the confined space entry plan and emergency or rescue procedures.
i. A Confined Space Program shall be prepared and submitted to LADOTD for review prior to the inspection team entering confined spaces. The Confined Space Program shall include the procedures the inspection team will follow regarding the items listed above. In addition, the emergency response group, local hospital and travel route information should be included along with the procedure to follow in case of an emergency.
j. The following emergency response groups have been provided as a suggestion. The inspection team shall verify the capabilities of each group prior to entering a confined space and coordinate with facility personnel to notify the emergency response group that might be contacted (responding) in case of emergency.

- Belle Chasse Tunnel
  - Local Emergency Response: 911
  - Local Confined Space Response Team: To be provided/coordinated by the inspection team
  - Local Hospital: Ochsner Medical Center – West Bank: 2500 West Bank Hwy, Gretna, LA 70056
- Houma Tunnel
  - Local Emergency Response: 911
  - Local Confined Space Response Team: Terrebonne Parish Fire Department (985-873-6391)
  - Local Hospital: Terrebonne General Medical Center - 8166 W Main St, Houma, LA 7036
- Harvey Tunnel
  - Local Emergency Response: 911
  - Local Confined Space Response Team: To be provided/coordinated by the inspection team
  - Local Hospital: West Jefferson Medical Center - 1101 Medical Center Blvd, Marrero, LA 70072

4.14.2.2 Safety Procedures for Permit-Required Confirmed Space

In addition to the above safety procedure.. the following areas are identified as Permit-Required Confined Spaces

- Houma Tunnel – Air Duct
- Belle Chasse - Air Duct

Entry to these spaces required Confined Space Training and Entry Log.

4.15 Required Inspection Equipment

4.15.1 Inspection Tools

Inspection tools are an important component of the inspection program. Equipment and tools that are commonly used for tunnel inspections are listed below:

- Aerial Bucket Truck or High Lift - Used to lift the inspector to areas inaccessible by foot or ladders and to provide close-up inspections.
- Awl/Boring Tool - Used to determine extent of deterioration in timber. Calipers - Used to measure steel plate thicknesses.
- Camera (35mm or digital) with Flash - Used to take photographs for documentation of the inspection.
- Chalk, Kiel, or Markers - Used to make reference marks on tunnel surfaces.
- Chipping Hammer and pricking wheel (See Section 6.2). - Used to sound concrete or tile liner
- Clipboard - Used to take notes and fill out paper forms during the inspection.

- Crack Comparator Gauge - Used to measure crack widths in fractions of an inch or millimeters.
- Dye Penetrant or Magnetic Particle Test Kits – Used to detect surface cracks in steel.
- D–Meter - Used to measure the thickness of steel.
- Extension Cord - Used to get electricity to inspection area. Surge protectors are advised.
- Field Forms - Used to document the findings, take notes, and draw sketches for the various structures.
- Flashlights - Used in dark areas to help illuminate objects during inspection.
- Portable Generator - Used when necessary to provide electricity for the inspection (lighting).
- Ladders - Used in lieu of a lifting system to access overhead areas not visible from the ground and to perform close-up inspections.
- Handheld infrared thermometer.
- Light Meter - Used to measure the brightness in the tunnel.
- Portable Lights - Used where tunnel lighting is inadequate during inspection.
- Pencil – Used to take notes and complete field forms.
- Plumb Bob - Used to check verticality of columns and wall faces.
- Pocket Knife - Used to examine loose material and other items.
- Sample Bottles - Used to obtain liquid samples.
- Scraper - Used to determine extent of corrosion and concrete deterioration.
- Screwdriver - Used to probe weep holes to check for clogs.
- Wire Brush, Paint Brush or Brooms - Used to clean debris from surfaces to be inspected.
- Tablet Personal Computer - Used to take notes or draw sketches in lieu of paper forms.
- Tape measures:
  - Pocket Tapes and Folding Rules - Used to measure dimensions of defects.
  - 100 ft. (30 m) Tape (Non Metallic) - Used to measure anything beyond the reach of pocket tapes and folding rules.

4.15.2 Safety Equipment

Safety equipment that meets appropriate industry standards shall be furnished for the inspection team as follows:

- Appropriate devices for traffic control;
- First aid kit;
- Flashlights;
- Hardhats;
- Leather work gloves;
- Safety vests;
- Protective eyewear;
- Knee pads;
- Safety belts or harnesses;
- Work boots;
- Two-way radios appropriate for use in the tunnel. Cellular phones may be used as appropriate; however, these devices may not work in all areas of the tunnel. Only use devices that are fully functional in all areas to be inspected.
- Protective breathing masks if soot and dirt buildup is prevalent on the tunnel surfaces; and
- Air quality monitoring equipment.

4.15.3 Access Equipment

Access equipment includes man-lifts, bucket trucks, ladders, and/or removable scaffolding. This equipment is generally needed for close-up visual inspection of overhead items. This equipment allows the inspector to view the overhead structural elements and components of functional systems in a close-up, hands-on manner. In rare instances, binoculars may be used to locate surface defects on distant items, but this technique has many drawbacks and shall be used on a limited basis.

4.15.4 Testing Methods

Non-destructive testing (NDT) methods may be used in areas that are difficult to access or in areas that require in-depth evaluations. NDT technology can also be used to characterize the extent of deficiencies in structural elements, and baseline readings from NDT technologies can be used to monitor defects over time. NDT methods are considered effective for evaluating:

- Water leakage;
- Delamination's and spalling of concrete liners due to reinforcing steel corrosion;
- Voids behind and within tunnel linings;
- Concrete permeability;
- Tiles separating from the tunnel liner;
- Detecting integrity of steel liners underneath concrete linings; and
- Problems with integrity of ceiling systems and connections to the tunnel lining.

The techniques produce reasonable results when the surface area of the defects is at least 1 square foot and located at depths less than 4 inches below the surface. In some instances, these techniques are effective at deeper depths. NDT technologies are known to provide useful information; however, the limitations shall be considered prior to use. Some common NDT technologies are:

- Air-coupled GPR;
- Infrared thermography
- Scanners;
- Ground-coupled GPR;
- Ultrasonic tomography;
- Ultrasonic echo
- Ultrasonic surface waves; and
- Impact echo.

More information on NDT technology can be found at: http://www.ndtoolbox.org/content/tunnels

There are various imaging techniques that can be used to verify the tunnel geometry and identify changes that occur with the tunnel surface over time. Also, infrared imagery is useful for identifying water leaks in the liner and component wear in motors or equipment. Water is relatively cool whereas worn parts on motors are usually hot, and infrared imagery can detect these temperature differences.

Each of these methods requires specialized and often proprietary equipment. Additional specialty equipment may be needed for in-depth tunnel inspections and for conducting mechanical and electrical equipment checks.

5 Reviewing Existing Tunnel Records

The available records at each tunnel facility need to be thoroughly reviewed and evaluated prior to conducting an inspection. Important records that are normally part of the tunnel file include the construction plans, shop drawings, working drawings, as-built drawings, specifications, cost- estimates, correspondence, photographs, material certifications, material test data, and load test data. The history of the operating, inventory, maintenance, inspection, and repair records shall also be reviewed. Check for accident records, posting, and permit loads. The goals shall be to identify problem areas, formulate appropriate inspection procedures, check assumptions, verify schedules, and develop inspection documents including forms, survey control, and sketches.

The review process might involve sorting through a large number of documents, determining which records are relevant, searching multiple locations or facilities, and resolving conflicts including different formats, measuring units, or stationing. Processes shall be developed to preserve the integrity of the existing file records, which can be difficult or impossible to replace. For complex tunnels considerable time and effort may be needed to prepare sketches, electrical, mechanical, or hydraulic schematics, or other pertinent details for the inspection.

Communicate with the staff at the tunnel facility to learn if there are any unresolved or lingering problems. If possible, the inspection team shall speak with the staff about recent repairs, maintenance schedules, unusual noises, problems, or impact damage.

6 Structural

6.1 Structural Elements Defined in TOMIE

Structural Elements are inspected in accordance with FHWA Specifications for the National Tunnel Inventory (SNTI). Tunnel components inspected for structural defects include the crown, center wall, liner walls, walkway floors and railings, air ducts, walkway walls, ledges and curbs. Construction and expansion joints are considered as separate elements due to their unique features, characteristic pattern of defects, and their structural relevance within the tunnel. The visual inspection includes noting cracks, damage, leaks, mineralization, staining, efflorescence, spalls or corrosion on the different components. To document the location of the defects during the inspection, the interior of each tube shall be divided using clock positions. Established Station markers for each tunnel will be utilized when applicable. The location and nature of the defects are recorded on the inspection logs and photographs of the defects are taken to supplement the inspection logs. The tunnel inspection logs record the station, clock position, element, defect description, rating, and photograph numbers.

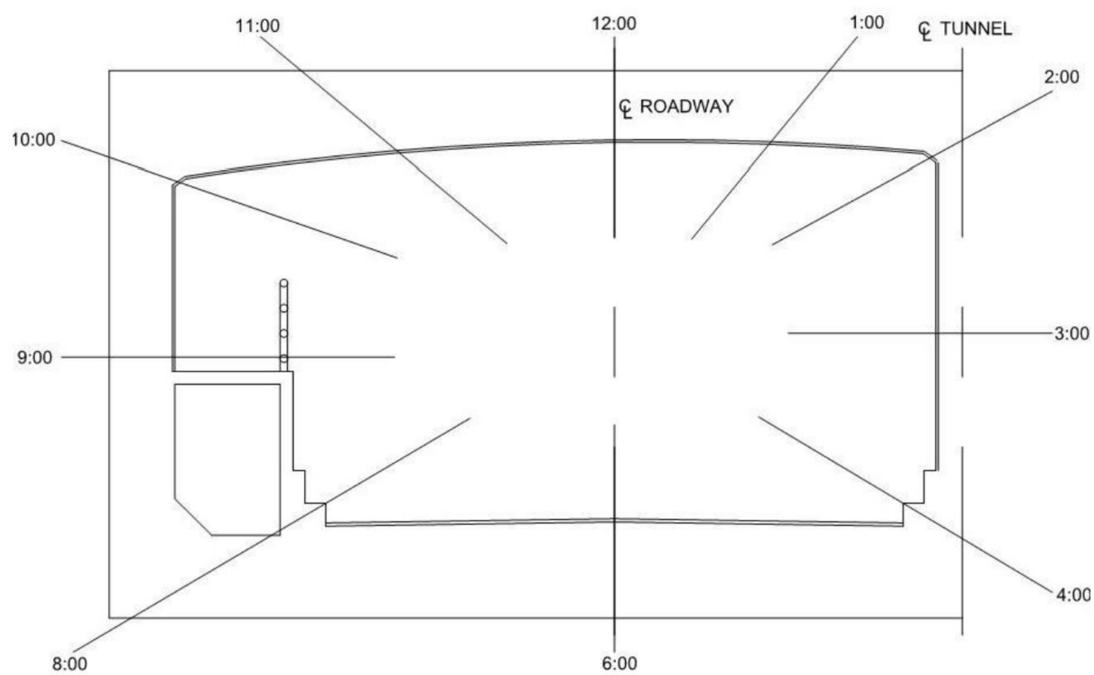

Figure 1 – Sample Clock Positions in a Tunnel Tube

Table 1 below, taken from the SNTI, defines tunnel structural elements and the methodology for determining total element quantities and condition state quantities.

Structural Section

Element Type	Element #	Element Name	Unit of Measure
Liners	10000	Steel Tunnel Liner	area, ft^2
	10001	Cast-in-Place Concrete Tunnel Liner	area, ft^2
	10002	Precast Concrete Tunnel Liner	area, ft^2
	10003	Shotcrete Tunnel Liner	area, ft^2
	10004	Timber Tunnel Liner	area, ft^2
	10005	Masonry Tunnel Liner	area, ft^2
	10006	Unlined Rock Tunnel	area, ft^2
	10007	Rock Bolt/Dowel	each
	10009	Other Tunnel Liner	area, ft^2
Tunnel Roof Girders	10010	Steel Tunnel Roof Girders	length, ft
	10011	Concrete Tunnel Roof Girders	length, ft
	10012	Prestressed Concrete Tunnel Roof Girders	length, ft
	10019	Other Tunnel Roof Girders	length, ft
Columns/ Piles	10020	Steel Columns/Piles	each
	10021	Concrete Columns/Piles	each
	10029	Other Columns/Piles	each
Cross Passageway	10030	Steel Cross Passageway	length, ft
	10031	Concrete Cross Passageway	length, ft
	10033	Shotcrete Cross Passageway	length, ft
	10034	Timber Cross Passageway	length, ft
	10035	Masonry Cross Passageway	length, ft
	10036	Unlined Rock Cross Passageway	length, ft
	10039	Other Cross Passageway	length, ft
Interior Walls	10041	Concrete Interior Walls	area, ft^2
	10049	Other Interior Walls	area, ft^2
Portal	10051	Concrete Portal	area, ft^2
	10055	Masonry Portal	area, ft^2
	10059	Other Portal	area, ft^2
Ceiling Slab	10061	Concrete Ceiling Slab	area, ft^2
	10069	Other Ceiling Slab	area, ft^2
Ceiling Girder	10070	Steel Ceiling Girder	length, ft
	10071	Concrete Ceiling Girder	length, ft
	10072	Prestressed Concrete Ceiling Girder	length, ft
	10079	Other Ceiling Girder	length, ft

Element Type	Element #	Element Name	Unit of Measure
Hangers and Anchorages	10080	Steel Hangers and Anchorages	each
	10089	Other Hangers and Anchorages	each
Ceiling Panels	10090	Steel Ceiling Panels	area, ft^2
	10091	Concrete Ceiling Panels	area, ft^2
	10099	Other Ceiling Panels	area, ft^2
Invert Slab	10101	Concrete Invert Slab	area, ft^2
	10109	Other Invert Slab	area, ft^2
Slab-on-Grade	10111	Concrete Slab-on-Grade	area, ft^2
	10119	Other Slab-on-Grade	area, ft^2
Invert Girder	10120	Steel Invert Girder	length, ft
	10121	Concrete Invert Girder	length, ft
	10122	Prestressed Concrete Invert Girder	length, ft
	10129	Other Invert Girder	length, ft
Joints	10130	Strip Seal Expansion Joint	length, ft
	10131	Pourable Joint Seal	length, ft
	10132	Compression Joint Seal	length, ft
	10133	Assembly Joint With Seal	length, ft
	10134	Open Expansion Joint	length, ft
	10135	Assembly Joint Without Seal	length, ft
	10139	Other Joint	length, ft
Gaskets	10140	Gaskets	length, ft

Table 1 – Typical SNTI Structural Elements

6.2 Sounding of Concrete Lining and Roadway Walls

Available information on a Tunnel shall be reviewed prior to performing the inspection. This information includes as-built drawings, design drawings, shop drawings, inspection reports, documentation of previous inspections or repairs performed within the tunnel, among others. Based on this review, inspection procedures are established including visual and non-destructive methods for determining the structural integrity of the tunnel components.

After performing a visual inspection, the tiled sections of the tunnel are non-destructively inspected for any loose or hollow sounding areas by using mallets or delamination detection tools (pricking wheel). Delamination detection tools are composed of 2 wheels attached to the body of the delamination detection tool (DDT) made of solid aluminum extrusion, threaded to accept a standard painters extension pole or broom handle. There is also a slot (with a set screw) for a marking crayon. The wheels are hardened steel, mounted on precision shoulder bolt axles, spring loaded for smooth turning and maximum auditory feedback.

7 Mechanical

Mechanical systems consist of the tunnel ventilation system, drainage system, emergency generator system, and flood gates. A visual inspection of all mechanical system components shall be performed including tunnel ventilation; carbon monoxide detection; plumbing and sewage ejection; HVAC; drainage; compressed air supply; and the flood gate. Each of the system components shall be reviewed with their condition recorded, photographed and logged. In-depth rigorous testing of the systems shall be completed with prior approval from the LADOTD. The LADOTD operations personnel shall be interviewed and asked to provide the inspection team with copies of any maintenance records or logs. Prior to performing the tunnel inspection, the available drawings, reports and maintenance records provided by LADOTD shall be thoroughly reviewed.

Tunnel ventilation systems incorporate several mechanical components such as fan motors, louvers, motor-operated dampers, and various drive trains. The fans can be centrifugal or axial. The inspection of the ventilation system shall include the review of the maintenance records for each piece of equipment and note any special or frequent previous maintenance problems. The tunnel ventilation system components shall be visually inspected for corrosion, condition and operation. Noise levels and paint conditions shall also be noted. All hardware shall be inspected to check for any loose or missing bolts. The fan and motor shafts shall be tested for vibration using specialized motor vibration testing equipment. When fans are operating, temperature readings on the motor housing shall be taken using a temperature measuring device such as an infrared thermometer gun. The dampers and actuators position and condition shall be recorded. Damper actuators shall be inspected for any signs of leakage. Dampers shall be operated to a fully open and fully closed position. The inspection shall entail checking tunnel ventilation supply and exhaust air ducts for obstructions or accumulation of debris, fan motor accumulation of grease, fan drive conditions, and condition of local disconnects. Fan motor control panels shall be visually inspected for signs of deterioration or broken components. The carbon monoxide detection system shall be visually inspected to verify existing condition and operation. The system shall be tested upon request from the LADOTD. The entire tunnel ventilation system shall be tested in all operational modes for both normal and emergency conditions to verify that all equipment respond as designed.

The tunnel drainage system shall be inspected for pipe leaks, grease accumulation on the motors, paint condition and corrosion. The team shall record the condition of the tunnel drainage system as inspected, as well as, any local disconnects, the number of hours each pump has been in service and the condition of the controls. Pumps shall be turned on manually at the pump control panel. The float system shall be checked for condition and verify that contact points initiate pump activation. For dry pit pumps, the pump and motor shafts shall be tested for vibration using specialized motor vibration testing equipment. Flow and pressure shall be recorded when pumps are operating. Valves shall be operated into a fully open and fully closed position. All pipe supports shall be inspected for signs of deterioration and missing hardware.

Emergency Generator system includes components of the emergency generator such as fuel delivery pumps, fuel storage, engine components, engine cooling system, and exhaust components. The following subcomponents may also be included: main fuel storage tank, day fuel tanks, circulating fuel pumps, fuel tank ventilation, fuel tank sensors, cooling systems, exhaust manifold, insulation exhaust air louver and damper actuator, supply air louver and damper actuator, generator, generator control equipment, control panels, and associated conduit. A visual inspection of the listed components shall be performed to check for condition. Generator testing shall be performed to verify equipment operates as designed. Equipment shall be inspected for any signs of leakage. Temperature and power output shall be recorded at the time of testing.

Flood gates include seals, mechanical components, hydraulic systems, and power supply equipment. A visual inspection of these components shall be performed to check for condition. The flood gate shall be operated into its fully upright position and its fully closed position.

7.1 Mechanical Systems and Elements Defined in TOMIE

Mechanical Systems Section

Element Type	Element #	Element Name	Unit of Measure
Ventilation System	10200	Ventilation System	each
	10201	Fans	each
Drainage System	10300	Drainage and Pumping System	each
	10301	Pumps	each
Emergency Generator System	10400	Emergency Generator System	each
Flood Gate	10475	Flood Gate	each

Table 2 – Typical SNTI Mechanical Elements

8 Electrical

Prior to performing the inspection, a review of previous tunnel renovations and maintenance procedures shall be studied to provide the most productive evaluation of the electrical systems. The electrical inspection shall include a visual evaluation of all systems and their components including but not limited to: tunnel lighting; pump and fan motors and their control panels; switchboards; panels; ventilation building power and lighting; UPS and batteries; and generators. Conduits and cables, where exposed, shall be examined to determine types and condition. Lighting fixtures shall be investigated using a manlift. Illumination levels in the tunnel threshold and transition zones and on the pedestrian walkway shall be recorded using a light meter device. The visual evaluation shall focus on signs of equipment corrosion and deterioration, conditions of internal parts, verification of the equipment functionality to determine the condition of the system as a whole, as well as each of the individual components. Once a system is entirely inspected, the condition state is provided to support future tunnel rehabilitation plans to correct the deficiencies and serve as a guideline for recommendations. Inspection protocols, prepared in advance, shall be followed on a system by system basis. These include checking for proper labels, incoming and outgoing connections, and determining if the immediate area around the equipment and other support spaces provide a safe working area. Cross-referencing the existing systems to one-line diagrams and previous drawings shall be performed to ensure accurate operations and system functionality. The equipment shall be compared with the Department of Energy Condition Assessment Survey (DOE CAS) Manual for Standard System Design Life, which provides lists of design lives for different system components, based on industry standards and manufacturer data. All systems showing minor to severe deficiencies shall be photographed and their condition evaluated and recorded. All inspection notes including system ratings, sketches and any defects documented during the inspection shall be provided to the LADOTD.

8.1 Special Inspection Requirements for High Voltage

Inspect defined electrical elements in accordance with FHWA Specifications for the National Tunnel Inventory

8.2 Electrical Elements Defined in TOMIE

As described below, the TOMIE Manual defines condition state ratings for tunnel inspections and is based on an

Electrical Systems Section

Element Type	Element #	Element Name	Unit of Measure
Electrical Distribution	10500	Electrical Distribution System	each
Emergency Distribution	10550	Emergency Distribution System	each
Tunnel Lighting	10600	Tunnel Lighting Systems	each
	10601	Tunnel Lighting Fixtures	each
Emergency Lighting	10620	Emergency Lighting Systems	each
	10621	Emergency Lighting Fixtures	each

element level inspection approach. These condition states apply to the Electrical Elements. Table 3 shows the typical Electrical Elements as per the SNTI manual

Table 3 – Typical SNTI Electrical Elements

8.3 Functional Systems Testing

The following systems shall be field tested for verification the system is working properly.

1. Emergency power system including transfer switches and onsite generators
2. Lighting control system for tunnel and ancillary spaces

3. Tunnel lighting light level measurements via handheld light meters
4. Communications systems if applicable
5. Tunnel operations and security systems including CCTV, traffic control, etc.

LADOTD maintenance logs will be reviewed for the electrical distribution equipment and annual testing of the tunnel systems for accuracy and overall completeness.

9 Fire/Life Safety

Fire/Life Safety system components consist of Fire Detection, Fire Protection, Emergency Communications, and Operations and Security as defined by the FHWA. Prior to performing the tunnel inspection, the available drawings, reports and maintenance records provided by LADOTD shall be thoroughly reviewed. The Fire/Life Safety inspection shall include a complete visual inspection of each system. When inspecting the Fire Detection system, it will include elements that detect and initiate the response to a fire such as fire alarms, manual fire alarm pull-boxes, heat detectors, smoke detectors, CCTV, and all the detectors, signals, and wiring in the fire alarm control panel. Additional components of the fire detection system include control panels, power supplies, detection devices, and notification devices such as alarms. The fire detection system shall meet or exceed the design requirements. The existing testing records for the system shall be inspected for compliance with NFPA 72. A planned fire drill shall be conducted to ensure all annunciators and notification appliances operate.

The fire protection system shall be fully inspected including all fire extinguishers, pumping systems, piping, piping supports, valves, hose reels, storage tanks, alarms, and level switches. Fire extinguisher cabinets and other designated fire extinguisher locations shall be checked that fire extinguishers are in place. The expiration date, pressure level, and seal shall be checked. Water-based fire protection systems shall be inspected in accordance with NFPA 25. Fire hose valves on the standpipe system shall be visually inspected for condition and each valve’s operability shall be verified by opening the valve to check that there is water flow and sufficient pressure. The hose threads on the valves shall be inspected for any damage. For each valve, a hose cap shall be present and secured to the valve threads. Isolation valves in the standpipe system shall be fully cycled open/close to verify the valves are operational. All valves shall be checked for any signs of water leakage. Piping insulation and heat tracing shall be inspected for condition and operability. Pipe supports shall be visually inspected for any signs of defects including rust, missing hardware, and material loss. The inspection findings shall be recorded and include the condition of the niches and associated doors.

The emergency communication system includes cameras, camera systems (CCTV), intercoms, cellphones, receivers, wiring, and other technology. Simulated emergency conditions’ testing shall be performed. A visual inspection of all emergency communication system components shall be performed. The emergency communication devices such as cameras, intercoms, and all other devices shall be verified for proper operation.

Tunnel Operations and Security system include surveillance, control, and communication equipment such as CCTV cameras, telephones, radios, incident response and detection devices, air quality monitors, the control center and systems, and the Supervisory Control and Data Acquisition (SCADA) system. A visual inspection of CCTV cameras, telephones, radios, and other communication devices shall be performed. Traffic signals and signaling systems shall be inspected for proper operation.

9.1 Fire/Life Safety Elements Defined in TOMIE

Inspect defined fire and life safety elements in accordance with FHWA Specifications for the National Tunnel Inventory.

Fire/Life Safety/Security Systems Section

Element Type	Element #	Element Name	Unit of Measure
Fire Detection	10650	Fire Detection System	each
Fire Protection	10700	Fire Protection System	each
Emergency Communications	10750	Emergency Communications System	each
Operations and Security	10800	Tunnel Operations and Security System	each

Table 4 - Typical SNTI Fire/Life Safety/Security Systems Elements

10 Civil

The civil elements of the system consist of a wearing surface, traffic barriers and curbs, and pedestrian railings. Tunnel wearing surfaces shall be inspected for skid resistance, grooving or rutting, potholes, cracks, scaling or delamination and overall wear. Concrete traffic barriers and curbs shall be inspected for structural deficiencies, such as leaking, staining, cracking, scaling, and rebar exposure. The inspection of the steel traffic barriers and pedestrian railings shall include the rails, posts and anchorages. These elements shall be inspected for impact damage, plumb, missing sections, paint condition, corrosion, anchorage sufficiency and overall integrity.

10.1 Civil Elements Defined in TOMIE

Civil Section

Element Type	Element #	Element Name	Unit of Measure
Wearing Surface	10151	Concrete Wearing Surface	area, ft^2
	10158	Asphalt Wearing Surface	area, ft^2
	10159	Other Wearing Surface	area, ft^2
Traffic Barrier	10160	Steel Traffic Barrier	length, ft
	10161	Concrete Traffic Barrier	length, ft
	10169	Other Traffic Barrier	length, ft
Pedestrian Railing	10170	Steel Pedestrian Railing	length, ft
	10171	Concrete Pedestrian Railing	length, ft
	10179	Other Pedestrian Railing	length, ft

Table 5- Typical SNTI Civil Elements

11 Finishes

The LADOTD tunnel finishes consist of ceramic tiles on the ceiling, tunnel walls, walkway walls and bench/traffic barriers. The tiles serve the purpose of reflecting light, improving visibility and being fire resistant. In order to maintain their functionality, the tiles shall be regularly cleaned. Any delaminated tiles shall be removed for traffic safety. Missing tiles shall be replaced periodically.

12 Access and General Tunnel Insp. Procedures

The tunnels in the inventory currently has very similar construction type with some minor applicable different that are noted within the section. For tunnel systems and other inspection items follow the general procedures noted for: structural elements in Chapter 6, mechanical system elements in Chapter 7, electrical system elements in Chapter 8, fire/life safety elements in Chapter 9, civil elements in Chapter 10, and finishes in Chapter 11.

For tunnel access prior to inspection, the Inspection Team needs to coordinate with the tunnel facility operation personnel to gain safe access to all rooms, buildings and elements. To provide a safe working environment for all inspectors, roadway access needs to be closed off from all public motorists when roadway or duct inspection is performed. All mechanical equipment needs to follow lock-out tag-out procedures when the ventilation system is being inspected.

Inspection of structural elements, such as tunnel walls and ceiling are performed by accessing the tunnel roadway through the two portals. Access to the tunnel ventilation duct, walkway and adjacent tunnel wall is individually described below as it varies for each tunnel. With access to these main points of the tunnel, structural elements can be visually inspected, and non-destructive tools can be used to perform structural tests.

The tunnels have a ventilation, carbon monoxide detection, plumbing and sewage ejection, HVAC and space heating (not applicable to Houma tunnel), drainage, fire protection, compressed air systems (not applicable to Houma tunnel) and flood gates (only applicable to Belle Chasse). The electrical systems are as follows: power distribution, emergency power, lighting, fire life safety, communication and traffic control system. All systems are either accessed through the main roadway, ventilation duct, ventilation buildings, portal pump rooms or mid-channel sump/pump room. Access to each space is individually described for each tunnel.

12.1 Harvey Tunnel (Recall No. 000260)

The Harvey tunnel ventilation ducts span the full length of the tunnel and can be accessed from the roadway via four hatches, two hatches centered around each ventilation building. The walkway, which is located on top of the ventilation duct, is only accessible via a west portal staircase located on Destrehan Ave and an east portal staircase located on Peters Road; it is not accessible via the tunnel roadway. Both ventilation buildings can be accessed via the two staircases or via the at-grade roads mentioned above. The portal pump rooms are located inside the tunnel, in close vicinity to the portals and are accessed via the walkway.

12.2 Belle Chasse Tunnel (Recall No. 002510)

The Belle Chasse tunnel ventilation duct spans the full length of the tunnel and is accessed from the roadway by removing the back panel of any of the mechanical niches. Many of the panels are missing. There are staircases on either end of the tunnel, located just inside the portals that provide pedestrian access from the at-grade N. Tunnel Road and S. Tunnel Road to the walkway, which sits on top of the ventilation duct. The bottom of the staircases lead to the portal pump rooms which are at curb level. This makes the walkway accessible from the roadway. The mid- channel sump is accessed via a hatch under the walkway. The ventilation buildings can be accessed via the at-grade roads mentioned above.

12.3 Houma Tunnel (Recall No. 003280)

The Houma tunnel ventilation duct spans approximately half of the tunnel length is located above the walkway. The walkway is approximately at roadway level and it spans the full length of the tunnel and tunnel approaches on East and West Tunnel Blvd. It is also accessible via east and west portal staircases from Saadi St. and Dunn St., respectively. The east and west portal pump stations, which are located just outside of the portals, and the mid-channel pump room are all accessed through doors from the walkway. The Houma tunnel has only one ventilation building which is located on the west side of the tunnel and is accessible either via the west portal staircases or via the at-grade Dunn St.

13 QC/QA Procedures

Maintaining accuracy, thoroughness, and completeness of tunnel safety inspections is essential for evaluating a structure's safety and for decisions associated with planning, budgeting, tunnel preservation, and future rehabilitation requirements.

13.1 Definitions

Quality Control (QC) is defined as procedures intended to maintain the quality of a tunnel inspection, per 23 CFR 650, Subpart E. QC is performed within a work group.

Quality Assurance (QA) is defined as the use of sampling and other measures to assure the adequacy of QC procedures in order to verify or measure the quality level of the entire tunnel inspection program. QA is performed outside of a work group.

The following outlines the minimum acceptable standards for QC/QA for the LADOTD Tunnel Inspection Program.

13.2 Quality Program

It is the responsibility of LADOTD to maintain an inventory of all tunnels, whether they perform the inspections or not. The quality control is performed by the District Bridge Engineer and staff in each district. Every tunnel inspection report is reviewed for accuracy and compliance in the AssetWise workflow feature. The QC report review consists of:

- Consistent NTIS ratings
- Consistent with previous inspection reports
- Sufficient documentation and photographs

The quality assurance is performed annually alternating by the LADOTD Headquarters Bridge Inspection Office (Section 51) or contracted out to qualified engineering services. The QA review consists of:

- Office review of tunnel files
- Verification of current qualifications and training of inspection personnel
- Verify that inspection personnel are operating in the positions they are qualified for
- Check for implementation of correctional measures and follow-up procedures
- Field review of selected portions of each tunnel

There are seven major topics to address in an effective QC/QA program:

- Independent Reviews
- Objective and quantitative measures of quality
- Quality program documentation
- Comprehensive coverage of the inspection program
- Established procedures for corrective actions
- Established schedule for evaluations
- Documented review procedures

13.2.1 Quality Control

The QC program is used to maintain a high degree of accuracy and consistency within the Tunnel Inspection Program. It is also used to evaluate and communicate directly with staff about any assessment made of their work. The QC program consists of the following elements:

- Systematic documentation review of team leader(s) and inspector(s) qualifications
- Documented organization of tunnel inspection program
- Required training and retraining programs for inspectors
- Maintenance of high quality tunnel inspection manual
- Maintenance of comprehensive tunnel files in accordance with the Tunnel Operations Maintenance Inspection and Evaluation (TOMIE) Manual.

13.2.1.1 Tunnel File Maintenance

The maintenance of comprehensive tunnel files is a QC procedure that helps ensure the quality of the inspection results. The Bridge Maintenance Engineer (Section 51) will maintain a current list of certifications, qualifications, and experience of all tunnel inspection personnel in AssetWise to meet the minimum requirements of 23 CFR 650.

13.2.1.2 Peer Rotation for Quality Control

The rotation of NTIS qualified inspection team leaders is a statewide DOTD policy for all tunnels that are in the National Tunnel Inventory. Every routine inspection should have a different team leader than the previous inspection.

13.2.1.3 QC Review Procedures

The purpose of the office review is to ensure the quality of the process is maintained by confirming that there is a relationship between the field documentation and the ratings in the report. The reviewer is to ensure completeness and adherence to State and FHWA requirements regarding procedures, guidelines and training.

QC functions for each tunnel inspection report are delegated to the Districts or the Engineering service who conducted the inspection and typically include (this will be performed the year the inspection was conducted):

- Completeness and accuracy of data captured, and data entered
- Completeness and accuracy of condition ratings and element ratings
- Adherence of practices to procedures
- Guidelines and training (assure training needs are forward to the Program Manager)
- Qualifications of personnel

13.2.1.4 Corrective actions for QC

To maintain the validity and integrity of the tunnel inspection report, all changes that occur after the original inspection is complete should be thoroughly documented and the record maintained. All changes should be made by either the team leader or by the Quality Control Officer with LADOTD Section 51.

13.2.1.5 Inspector Qualifications

Verifying inspector qualifications is a key element to maintaining compliance with the NTIS. A centralized reporting system within LADOTD Section 51 is used to maintain individual records.

13.2.2 Quality Assurance

The QA program is operated from the Headquarters Bridge Inspection Office (Section 51) and is designed to assure the adequacy of QC procedures in order to measure the quality level of the entire tunnel inspection program. To maintain the validity and integrity of the tunnel inspection report, all changes that occur after the original inspection is complete should be thoroughly documented and the record maintained. All changes should be made by either the team leader or by the Quality Control Officer with LADOTD Section 51.

The QA program consists of the following three elements:

13.2.2.1 Office review of inspection reports

All initial, routine, and in-depth inspection reports are reviewed by an NTIS qualified nationally certified team leader with LADOTD Section 51 the year the inspection is conducted. Additionally, all damage and special inspection reports performed each year are reviewed by an NTIS qualified team leader each year.

13.2.2.2 Field review

One tunnel inspection report is randomly selected from all final report submittals in any given year for re-inspection. This field review is used to evaluate the quality and consistency of the data produced from the inspection.

Furthermore, one tunnel is randomly selected each year for a joint inspection with DOTD District teams to evaluate their documentation processes in the field.

13.2.2.3 Review of tunnel files

A centralized reporting system called AssetWise is used to maintain all tunnel files and individual records. Inventory and routine error reports are run monthly to flag conflicts in the database. Inspector's qualifications and training are verified annually for all tunnel team leaders and inspectors in accordance with this manual requirement and NTIS standards.

It will be reviewed annually that all tunnels have been load rated and properly restricted/posted, if needed, and that documentation is on file.

Annually all QC/QA related work accomplished will be documented by LADOTD Section 51. The annual QC/QA accomplishments will be provided to FHWA. This documented documentation will affirm that the LADOTD Tunnel Inspection Program has complied with these requirements by the creation of a QC/QA Program within the Tunnel Inspection Program.

14 Responsibility

The LADOTD Section 51 Structures and Facilities Maintenance Engineer (acting as the official Program Manager for the Louisiana Tunnel Inspection Program) shall be responsible for implementing this directive and shall issue specific directives, as necessary, to ensure that Louisiana is in compliance with the NTIS and NTIP.

Any LADOTD Tunnel Policies and Procedures Manual observed conflicts, aspects that need clarification, or inclusion needed to be incorporated advise the Program Manager.

14.1 Other Issuances Affected

All directives memoranda or instructions heretofore in conflict with this directive are hereby rescinded.

14.2 Effective Date

This Directive shall become effective immediately upon receipt.

15 Appendices

A. Structural Critical Findings Criteria Tables

Element Number	Element Name
1001-1	**CROWN**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched/delaminated area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Cracking	Width greater than 0.012 in. above spring line or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should not be considered a critical finding but warrants structural review.
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak greater than 1/2 gal/min, should be considered a critical finding.
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Tile Damage	Concentrated area of damages/loose tiles that are visibly loose/unaligned and that can become loose that cannot be removed by LADOTD facility on an immediate basis.

Element Number	Element Name
1001-2	**TUNNEL WALL**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched/deliminated area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Cracking	Width greater than 0.10 in. below spring line or greater than 0.012 in. above spring line or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. – 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should be considered a critical finding.
	A wide (> 0.25 in.) crack or several wide (0.125 in. – 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak of at least greater than ½ gal/min, should be considered a critical finding.
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Tile Damage	Concentrated area of damages/loose tiles that are visibly loose/unaligned and that can become loose that cannot be removed by LADOTD facility on an immediate basis if the defect is located above the tunnel springline.

Element Number	Element Name
1001-3	**LINER WALL INSIDE AIR DUCT**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Cracking	Width greater than 0.10 in. or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should be considered a critical finding.
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak of at least greater than 1/2 gal/min, should be considered a critical finding.
Leakage	Gushing water inflow from one location greater than 5 gal/min.

Element Number	Element Name
1001-4	**INVERT LINER INSIDE AIR DUCT**
Defect	**Critical Finding Criteria**
Cracking	Width greater than 0.10 in. below spring line or greater than 0.012 in. above spring line or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should be considered a critical finding.
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak of at least greater than 1/2 gal/min, should be considered a critical finding.
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Efflorescence / Rust Staining	N/A
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Exposed Rebar	N/A

Element Number	Element Name
1200-1	**CENTER WALL**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Exposed Rebar	Present with measurable section loss, and does warrant structural review.
Efflorescence / Rust Staining	N/A
Cracking	Width greater than 0.10 in. below spring line or greater than 0.012 in. above spring line or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should be considered a critical finding.
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak of at least greater than 1/2 gal/min, should be considered a critical finding.
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Tile Damage	Concentrated area of damages/loose tiles that are visibly loose/unaligned and that can become loose that cannot be removed by LADOTD facility on an immediate basis if the defect is located above the tunnel springline.

Element Number	Element Name
1201-1	**WALKWAY WALL ROADWAY SIDE**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Exposed Rebar	Present with measurable section loss, and does warrant structural review.
Efflorescence / Rust Staining	N/A
Cracking	Width greater than 0.10 in. below spring line or greater than 0.012 in. above spring line or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should be considered a critical finding.
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak of at least greater than 1/2 gal/min, should be considered a critical finding.
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Tile Damage	Concentrated area of damages/loose tiles that are visibly loose/unaligned and that can become loose that cannot be removed by LADOTD facility on an immediate basis if the defect is located above the tunnel springline.

Element Number	Element Name
1202-1	**WALKWAY FLOOR**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Any delaminated or spalled area that cannot be removed and/or repaired by LADOTD facility and may cause a safety concern for pedestrians should be considered a critical finding.
Exposed Rebar	N/A
Cracking	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection that may cause a safety concern for pedestrians. This type of cracking accompanied with or without any degree of leakage that cannot be mitigated by LADOTD facility to eliminate the safety concern should be considered a critical finding.

Element Number	Element Name
1202-2	**WALKWAY FLOOR INSIDE AIR DUCT**
Defect	**Critical Finding Criteria**
Cracking	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection that may cause a safety concern. This type of cracking accompanied with or without any degree of leakage that cannot be mitigated by LADOTD facility to eliminate the safety concern should be considered a critical finding.
Delaminations / Spalls / Patched Areas	Any delaminated or spalled area that cannot be removed and/or repaired by LADOTD facility and may cause a safety concern should be considered a critical finding.
Exposed Rebar	N/A

Element Number	Element Name
1250-1	**TUNNEL PORTAL**
Defect	**Critical Finding Criteria**
Delaminations / Spalls / Patched Areas	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress that cannot be removed by the LADOTD facility on an immediate basis. Does warrant structural review.
Exposed Rebar	Present with measurable section loss, and does warrant structural review.
Efflorescence / Rust Staining	N/A
Cracking (Liners)	Width greater than 0.10 in. below spring line or greater than 0.012 in. above spring line or spacing of less than 1 ft warrants structural review
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks with signs of recent propagation and measurable lining deflection are present. This type of cracking accompanied with or without any degree of leakage should be considered a critical finding.
	A wide (> 0.25 in.) crack or several wide (0.125 in. - 0.25 in.) longitudinal cracks without signs of recent propagation. This type of cracking accompanied with a flowing leak of at least greater than 1/2 gal/min, should be considered a critical finding.
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Settlement	Exceeds tolerable limits and does warrant structural review due to determination on the effect on strength or serviceability of the element or tunnel.

Element Number	Element Name
1603-1	**EXPANSION JOINT**
Defect	**Critical Finding Criteria**
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Waterstop	N/A
Adjacent liner/wall	Spall, delamination, unsound patched area or loose joint anchor that prevents the joint from functioning as intended.
Metal deterioration	Metal cracking, section loss, damage or connection failure that prevents the joint from functioning as intended.
Joint Filler	N/A

Element Number	Element Name
1606	**CONSTRUCTION JOINTS**
Defect	**Critical Finding Criteria**
Leakage	Gushing water inflow from one location greater than 5 gal/min.
Drainage channel	N/A
Adjacent Liner/Wall	Spall, delamination, unsound patched area or loose joint anchor that prevents the joint from functioning as intended.

B. Mechanical Critical Findings Criteria Tables

Element Number	Element Name
10200	**VENTILATION SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a component of the ventilation system including ventilation fans, fan motors, fan controller, airways, sound attenuators, dampers, damper controller, Air Quality Monitoring Equipment (CO), control panels and conduits that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10201	**FANS**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a component of the fan including fan motor, fan controller, belt, chain, bearing, and support that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10300	**DRAINAGE AND PUMPING SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a component of the drainage and pumping system including the pump, sump pump, pump motor, pump controller, piping, drain, and water treatment equipment that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10301	**PUMPS**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a component of the pump including subcomponents such as the sump pump, pump motor, pump controller, pump control panel, bearing, and support that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10400	**EMERGENCY GENERATOR SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a component of the emergency generator system including fuel tanks, fuel pumps, sensors, venting, dampers, generator, controls and raceways that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10475	**FLOOD GATE**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a component of the flood gate including panels, supports, and hydraulic equipment that warrant further evaluation determining the serviceability of the element or tunnel.

C. Electrical Critical Findings Criteria Tables

Element Number	Element Name
10500	**ELECTRICAL DISTRIBUTION SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a subcomponent of the electrical distribution system including switchgears, switchboards, transformers, motor control centers, panelboards, transfer switches and receptacles that warrant further evaluation determining the serviceability of the element or tunnel.
Components	Failure to a component of the electrical distribution system including electrical equipment, wiring, conduit and cable that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10550	**EMERGENCY DISTRIBUTION SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	
Components	Failure to a component of the emergency distribution system including generators, uninterruptible power supplies, transfer switches and other equipment supply emergency power that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10600	**TUNNEL LIGHTING SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a subcomponent of the tunnel lighting system including photocontrols and remote ballasts that warrant further evaluation determining the serviceability of the element or tunnel.
Components	Failure to a component of the tunnel lighting system including luminaires, supports, and raceways that warrant further evaluation determining the serviceability of the element or tunnel.
Anchorage and Supports	Luminaire housing or associated mounting equipment with expected failure above or within immediate vicinity of vehicular traffic. Any immediate threat posing a life safety issue.
System Output	Operation capacity reduced to levels causing concern for tunnel users.

Element Number	Element Name
10601	**TUNNEL LIGHTING FIXTURE**
Defect	**Critical Finding Criteria**
Components	Failure to a component of the tunnel lighting fixture including tunnel luminaires and their connections that warrant further evaluation determining the serviceability of the element or tunnel.
Anchorage and Supports	Luminaire housing or associated connections with expected failure above or within immediate vicinity of vehicular traffic. Any immediate threat posing a life safety issue.

Element Number	Element Name
10620	**EMERGENCY LIGHTING SYSTEM**
Defect	**Critical Finding Criteria**
Subcomponents	Failure to a subcomponent of the emergency lighting system including exit signs, batteries, and remote drivers that warrant further evaluation determining the serviceability of the element or tunnel.
Components	Failure to a component of the emergency lighting system including luminaires, supports, junction boxes, wiring, conduit and controllers that warrant further evaluation determining the serviceability of the element or tunnel.
Anchorage and Supports	Luminaire housing or associated mounting equipment with expected failure above or within immediate vicinity of vehicular traffic. Any immediate threat posing a life safety issue.
System Output	Operation capacity reduced to levels causing concern for tunnel users.

Element Number	Element Name
10621	**EMERGENCY LIGHTING FIXTURE**
Defect	**Critical Finding Criteria**
Components	Failure to a component of the emergency lighting fixture including tunnel luminaires and their connections that warrant further evaluation determining the serviceability of the element or tunnel.
Anchorage and Supports	Luminaire housing or associated connections with expected failure above or within immediate vicinity of vehicular traffic. Any immediate threat posing a life safety issue.

D. Fire/Life Safety/Security Systems Critical Findings Criteria Tables

Element Number	Element Name
10650	**FIRE DETECTION SYSTEM**
Defect	**Critical Finding Criteria**
Components	Failure to a component of the fire detection system including control panels, initiating devices, notification appliances, wiring and conduit that warrant further evaluation determining the serviceability of the element or tunnel.
System Output	Detection sensors or control equipment are not operational in multiple zones

Element Number	Element Name
10700	**FIRE PROTECTION SYSTEM**
Defect	**Critical Finding Criteria**
Components	Failure to a component of the fire protection system including the main fire pump, pressure maintenance/jockey pump, dry pipe valve, valves and tamper switches, storage tanks, tunnel stand pipe, pressure relief and air release valves, backflow prevention, hose stations, hose reels, building sprinklers, fire department connections and fire hydrants that warrant further evaluation determining the serviceability of the element or tunnel.

Element Number	Element Name
10750	**EMERGENCY COMMUNCATION SYSTEM**
Defect	**Critical Finding Criteria**
Components	Failure to a component of the emergency communication system including the communication device itself that warrant further evaluation determining the serviceability of the element or tunnel.
System Output	Emergency communications are not operational.

Element Number	Element Name
10800	**TUNNEL OPERATIONS AND SECURITY SYSTEM**
Defect	**Critical Finding Criteria**
Components	Failure to a component of the tunnel operations and security system including CCTV, telephones, radios, door access and controllers that warrant further evaluation determining the serviceability of the element or tunnel.

E. Signs Critical Findings Criteria Tables

Element Number	Element Name
10850	**Traffic Signs**
Defect	**Critical Finding Criteria**
Anchorage and Supports	Failed anchorage or component connection hardware which results in an unstable situation. Any immediate threat posing a life safety issue.

Element Number	Element Name
10870	**Egress Signs**
Defect	**Critical Finding Criteria**
Anchorage and Supports	Failed anchorage or component connection hardware which results in an unstable situation. Any immediate threat posing a life safety issue.

Element Number	Element Name
10890	**Variable Message Board**
Defect	**Critical Finding Criteria**
Anchorage and Supports	Failed anchorage or component connection hardware which results in an unstable situation.

Element Number	Element Name
10910	**Lane Signal**
Defect	**Critical Finding Criteria**
Anchorage and Supports	Failed anchorage or component connection hardware which results in an unstable situation. Any immediate threat posing a life safety issue.

Element Number	Element Name
10911	**Lane Signal Fixture**
Defect	**Critical Finding Criteria**
Anchorage and Supports	Failed anchorage or component connection hardware which results in an unstable situation. Any immediate threat posing a life safety issue.
Corrosion	Defects impact strength and serviceability of the element or tunnel.

F. Civil

Element Number	Element Name
10160	**STEEL TRAFFIC BARRIER**
Defect	**Critical Finding Criteria**
Components	Failure of a steel traffic barrier that causes a component to protrude into or near the travel lane causing an immediate life safety threat to the public.

Element Number	Element Name
10169	**OTHER TRAFFIC BARRIER**
Defect	**Critical Finding Criteria**
Components	Failure of a traffic barrier that causes a component to protrude into or near the travel lane causing an immediate safety life threat to the public.

Element Number	Element Name
10170	**STEEL PEDESTRIAN RAILING**
Defect	**Critical Finding Criteria**
Components	Failure of a steel pedestrian railing that causes a component to protrude into or near the walkway or travel lane causing an immediate life safety threat to the public.
Components	Failure of a component of a steel pedestrian railing that effects the operations causing an immediate life safety threat to the public.