APPENDIX B

COMPLEX BRIDGE PROCEDURES

B.01 Purpose

The Federal Highway Administration has determined that the requirements of Metric 19 Inspection Procedures – Complex Bridges were not achieved as a result of the 2014 (PY15) National Bridge Inspection Program Review (NBIP). The evaluation of this metric is in association with the regulations promulgated under 23 CFR Part 650.313(f) of the National Bridge Inspection Standards (NBIS).

The objective is to assure that all complex bridges have specialized inspection procedures which clearly identify the complex features, inspection frequency of those features, unique specific risk factors, and detailed inspection methods and equipment to be employed. Also, to establish recognized criteria and processes for additional inspector training, necessary experience for inspecting complex structures, and monitoring to verify the work is completed according to established policy. Information describing the NBIP review for the metric may be accessed at the following webpage: http://www.fhwa.dot.gov/bridge/nbip/metrics.pdf

B.02 Inspection Procedures and Qualifications

Each complex bridge owner is required to develop bridge specific inspection procedures and qualifications for all movable structures in their inventory. The information must be retained in the bridge file for review prior to subsequent routine and fracture critical inspections. **In addition, all NBI inspections on movable structures completed after November 1, 2015 require the Movable Bridge Inspection Checklist and copy of bridge specific procedures to be submitted electronically to MDOT Bridge Field Services.** The checklist and procedures shall be sent to MDOT-BridgeInspection@michigan.gov within 30 days of completing the inspection.

These changes affect nine distinct agencies statewide, and are required to achieve compliance with Metric 19 for the continuation of federal transportation funding. MDOT owns one lift and eleven bascule structures which are located within 6 of the 7 regions. In addition, eight local agencies also own twelve bridges comprised of bascule or swing span designs.

An example of bridge specific inspection procedures and qualification requirements are provided in section B.03. It is suggested that the bridge owner or consultant review the example provided and reference the checklist while drafting their own procedures. The checklist is available at the Bridge Operations website and may be accessed by selecting the following link: http://w3.michigan.gov/documents/mdot/Complex_Checklist_2015-8-31_498874_7.pdf?20150901164023

B.03 US-31 over Manistee River

Str. No. 6436/B01-51011: US-31 over the Manistee River is a two leaf bascule structure that is owned by MDOT Big Bridge. The bascule bridge is 315.91 feet long by 53.81 feet wide. It consists of two approach spans and a center 132.91 feet long movable span (see Figure B.03.01). The deck supports four lanes of vehicular traffic and the pier protection systems provide 121.39 feet of horizontal clearance for marine vessels. The structure was designed by the Scherzer Rolling Lift Bridge Company and constructed in 1933.

Figure B.03.01 Movable span of Manistee Bascule Bridge

The bridge is controlled by a relay system and contains four drives. Each leaf is opened by a 40 horsepower motor with identically sized auxiliary motors. Span seating and position information are provided by limit switches and transmitters. Data from the switches and transmitters is utilized by the control system and displayed at the bridge operator's control desk. In the event of utility power failure a stand-by backup generator is used to maintain functionality. The motor shafts are connected to an input shaft that connect to the primary reducer, where two output shafts each extend to open gear reducers, which ultimately provide torque to the pinion at the rack. Also included within the system for each leaf are brakes at each motor, emergency brakes at each output shaft from the primary reducer, couplings, and multiple types of bearings. Additional details may be reviewed in the machinery component layout diagram (see Figure B.03.02). Due to the age, there are several inherent unique structural features that exist which require additional effort during inspections.

B.03.01 US-31 over Manistee River Inspector Qualifications

Routine safety and fracture critical inspections shall be conducted by an individual that meets the requirements specified in NBIS section 650.309(b). In addition, the team leader performing the work shall be a licensed engineer in the State of Michigan, having successfully completed NHI# 130078 Fracture Critical Inspection Techniques for Steel Bridges, and has more than four years of experience in bridge construction, maintenance, or design.

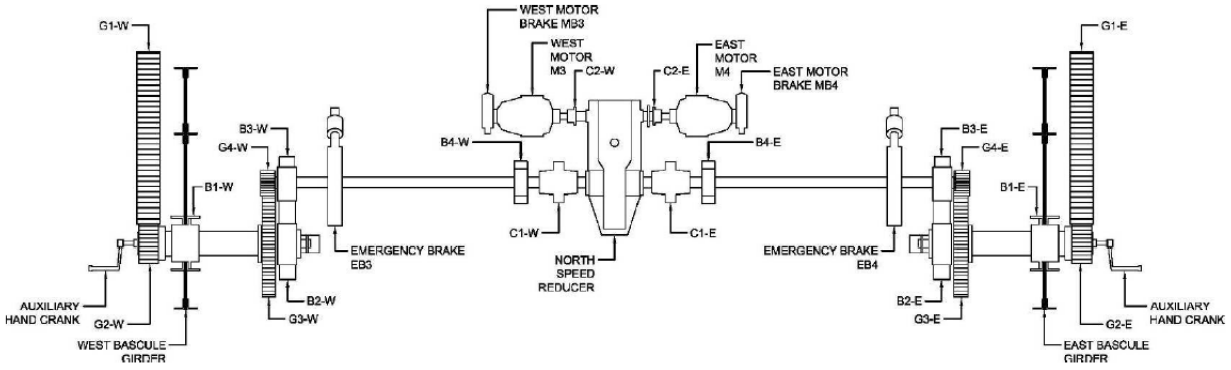

Figure B.03.02 North Span Drive Machinery Diagram (South Span Similar)

Detailed inspections performed internally and special inspections may be conducted by staff that meet the requirements described above, Statewide Bridge Crew welders, Statewide Electrical Crew electricians, region bridge engineers, or other individuals designated by the bridge owner.

Contracted detailed inspections shall be conducted by a team with varying levels of experience based according to discipline and level. The project manager shall serve as the team leader and have five years of recent documented experience in the in-service detailed inspection of movable bridges. The project manager shall also be a licensed engineer in the state of Michigan and have attended the two week Safety Inspection of In-Service Bridges class or the refresher course within the previous five years. Lead inspectors for structural, mechanical, and electrical shall be professionally registered in their area of expertise and have three years of recent documented experience in inspection, design, or construction of movable bridges.

There are no additional requirements, other than those specified by NBIS section 650.309(d), for diving inspectors performing underwater inspections.

B.03.02 US-31 over Manistee River Routine and Fracture Critical Inspection Procedures

Routine and fracture critical inspections are usually performed concurrently and immediately after a pre-inspection cleaning has been performed by the Statewide Reachall Unit. Since the movable span is non-redundant and fracture critical an under-bridge unit must be used to complete the hands-on inspection. The unit must be deployed from each side of the bridge due to the deck width. The inspection must be scheduled approximately four weeks in advance with the North Region Bridge Engineer and Statewide Reachall Unit. Prior to performing field work the complex inspection procedures, previous inspection reports, plans, highlighted drawings of fracture critical elements, and MiBRIDGE for any previous Request for Action Reports shall be reviewed.

The inspection procedures provided in Chapters 5 and 7 of the MiSIM shall be utilized during each inspection. Highlighted drawings of fracture critical bridge elements are retained in the bridge file. In addition, there are several complex, fracture critical, or unusual features that exist. All of these must be inspected visually, at an arms-length distance, and at the frequency noted.

B.03.04 US-31 over Manistee River Complex Inspection Features

Item: Fracture Critical Primary Girders (see Figure B.03.03)
Quantity: Two
Location: Span 2S
Equipment: Reachall and flashlight
Frequency: Every fracture critical inspection
Supplemental Information: Monitor corrosion at built up members

Figure B.03.03 Fracture Critical Primary Girders

Item: Fracture Critical Floorbeams (see Figure B.03.04)
Quantity: Ten
Location: Span 2S
Equipment: Reachall and flashlight
Frequency: Every fracture critical inspection
Supplemental Information: Floorbeams 4S and 6S have numerous flame cut holes in web

Figure B.03.04 Fracture Critical Floorbeams

Item: Fracture Critical Steel Cross/Uplift Girder (see Figure B.03.05)
Quantity: Two
Location: North end of Span 1S and south end of Span 3S over the bascule piers
Equipment: Reachall and flashlight
Frequency: Every fracture critical inspection
Supplemental Information: Monitor corrosion as Beams 2 and 10

Figure B.03.05 Fracture Critical Steel Cross Girder

Item: Live Load Shoe/Uplift Bearings (see Figure B.03.06)
Quantity: Four
Location: Near each end of the cross girders
Equipment: Reachall
Frequency: Every inspection
Supplemental Information: Verify strike plate is in contact with shoe

Figure B.03.06 Live Load Shoe/Uplift Bearings

Item: Rack and Frame Support (see Figure B.03.07)
Quantity: Four Racks and Two Frames
Location: Bascule piers
Equipment: Flashlight
Frequency: Every routine and fracture Critical inspection
Supplemental Information: Inspect portion facing counterweight with flashlight. Monitor frame support corrosion at locations that interface with concrete.

Figure B.03.07 Rack and Frame Support

Item: Tread and Track (see Figure B.03.08)
Quantity: Four Treads and Tracks
Location: Bascule piers
Equipment: Flashlight
Frequency: Every other, special inspection
Supplemental Information: Request operator to open bridge for visual inspection of all surfaces.

Figure B.03.08 Tread and Track

Item: Mechanical System Equipment (see Figure B.03.09)
Quantity: Two
Location: Bascule piers
Equipment: Flashlight
Frequency: Every routine inspection and according to section B.03.03
Supplemental Information: Visually inspect shafts, bearings, pinions, tail locks, and machine anchorages.

Figure B.03.09 Mechanical System Equipment

Item: Electrical System (see Figure B.03.10)
Quantity: NA
Location: Entire Structure
Equipment: Access is restricted to Statewide Electrical Crew and designated individuals
Frequency: As-needed and according to section B.03.03
Supplemental Information: Discuss any operation abnormalities with operator and contact Statewide Electrical Crew supervisor

Figure B.03.10 Electrical System

Item: Pile Cluster Interior (see Figure B.03.11)
Quantity: Four
Location: Adjacent to Bascule piers
Equipment: Confined Space Personal Protection and Flashlight
Frequency: Approximately 6 years during scheduled detailed inspections
Supplemental Information: Requires boat for access

Figure B.03.11 Pile Cluster Interior

Item: Vaulted Abutments (see Figure B.03.12)
Quantity: Two
Location: Abutments
Equipment: Confined Space Personal Protection and Flashlight
Frequency: Approximately 6 years during scheduled detailed inspections
Supplemental Information: Accessible from manholes in sidewalks

Figure B.03.12 Vaulted Abutments

Item: Pier Protection Cell (see Figure B.03.13)
Quantity: Two
Location: Bascule piers
Equipment: Confined Space Personal Protection and Flashlight
Frequency: Approximately every 6 years during scheduled detailed inspections
Supplemental Information: Inspect portion facing counterweight with flashlight. Monitor frame support corrosion at locations that interface with concrete.

Figure B.03.13 Pier Protection Cell

B.03.03 US-31 over Manistee River Detailed Inspection Procedures

The Statewide Bridge and Electrical Crews perform detailed inspections during scheduled preventive and routine maintenance. Both crews are comprised of highly knowledgeable and experienced individuals with many years of movable bridge evaluation and repair experience. In addition to resolving complex bridge issues, they also perform a variety of specialized tasks on other critical transportation assets and infrastructure. During each month from May through November two-person teams perform the following at the bascule bridge:

- Lubricate and inspect racks and pinions
- Lubricate and inspect primary gear housing and reducer gears
- Lubricate and inspect tail locks
- Inspect oil level in gear boxes
- Inspect brakes
- Lubricate and inspect traffic gates

- Inspect shafts, motors, bearings, couplings and machinery anchorage components
- Examine bridge during test openings

Both crews also perform detailed inspections as-needed and respond to unplanned events on a 24 hour basis. Two common examples include traffic gate impact damage and inoperable bridge machinery. When the bridge cannot open or close normally, the operator is responsible for referencing the contact list in the bridge house and calling the following responders:

Scott Long, Statewide Electrical Crew Supervisor, (517) 719-9219

Roger Wiseman, State Bridge Crew Supervisor, (517) 242-3233

Christopher Idusuyi, Statewide Emergency Coordination Engineer, (517) 242-5783

If the element causing the failure cannot be repaired within a reasonable amount of time Christopher Idusuyi is contacted for proper reporting to the US Coast Guard and initiating the critical finding notification process. When the bridge is not open to vehicular traffic for a period of two or more hours an email is provided to MDOT-BridgeInspection@michigan.gov for reporting to FHWA.

Contracted detailed inspections are completed approximately every 6 years in accordance with the recommendation provided in Section 2.1.5.4 of the AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual. The inspection is delineated into three separate disciplines which include structural, mechanical, and electrical.

Structural inspection of members/elements includes investigating for cracks, corrosion, spalls, unusual movement, settlement, changes in alignment, and loose connections. The concrete deck surface is sounded with a hammer or chain drag, and delaminated, spalled, and cracked areas on the deck surface will be marked with chalk or chalk paint to be visible in photographs.

The percent of deck surface and soffit deficiencies is noted in the report. Cracks in steel members are marked in the field for easy location, using dye penetrant. Losses due to corrosion are measured using an ultrasonic thickness gauge to determine the amount of section remaining. Where section loss greater than 20% is discovered, a sketch is provided indicating the location, size, and shape of the steel deficiency. The inspection of fracture critical elements involves identifying locations and providing a description of the elements with sketches. The inspection of the superstructure includes, but is not limited to the following elements:

- Bridge deck systems, such as concrete slab, steel grid and overlay. The steel grid decks are examined for section loss due to corrosion, cracking of the bars, cracking of welds, and loose bolts/rivets
- Structural steel trusses, girders, stringers, floor beams, including connection and supporting members such as stiffeners, diaphragms, cross frame laterals, brackets, pins, bearings, and shear transfer devices.
- Live Load Bearings and Span Locks.
- Bridge railing, sidewalks, safety walks, median barriers and hand rails.

- Expansion joints and other joints
- Supports for the bridge lighting
- Paint or other protective systems
- Drainage inlets, troughs, down spouts, and supports
- Bridge lighting and supports or other protective systems
- Forty feet of approach pavement, sidewalks, and slopes
- Evaluate MIOSHA General Industry Standards for access requirements for maintenance personnel (Fixed Ladders, Gear Guards, Confined Space, etc.)
- Evaluate potential Design Exceptions that may be need for proposed recommendations of repairs (Review MDOT Bridge Design Manual Section 12)

The substructure elements including abutments, piers, fender systems, pile clusters or dolphins are inspected for damage, distortion, delamination, cracks, corrosion, spalls, and movement/settlements. In addition, wood elements are inspected for defects such as checks, splits, and decay. Concrete members are sounded with a hammer to determine any delamination, check for spalling, exposure of reinforcing steel and cracking. These deteriorated areas are marked with chalk to be visible in photographs, and quantities are measured for repair estimates. Steel members are inspected for corrosion, distortion, and section loss. Sketches of cracks measured in linear feet and spalls/delaminations measured in square feet, with the depth of spall given in inches are included in the reporting process.

Every component of the mechanical system is inspected. Components are inspected for leakage, cracks, unusual noise, corrosion and wear. The inspection of the drive system and auxiliary drive system is inspected for, but not limited to, counterweight sheaves, shafts, bearings, counterweight ropes, brakes, gear sets, speed reducers, couplings, mounted bolts, span machinery supports and anchorages. Components are opened, and cleaned by MDOT for inspection as directed by the CONSULTANT to enable the vendor to measure the thickness of the gear teeth, gear set backlash, gear set clearance, bearing clearances (including trunnions), and observe the conditions of the wearing surfaces. The vendor will also note any lubrication needed for the open gear sets.

a. Bridge Operation: The operation of the bridge is observed in all modes to investigate the condition of the drives, the functionality of the traffic signals, bells and gates, interferences between movable and stationary parts of the bridge, controllability of the moving span, the effectiveness of the stabilizing machinery, and the span balance determination. During operation, the machinery is monitored for abnormal noises and vibration.

b. Span Balance Determination: The balance test of the bascule span is part of the inspection. Span balance determination is completed using Strain Gauge balancing techniques. If determined that the structure is out of balance, the vendor also provides technical support during the balancing operation to resolve the imbalances. MDOT supplies forces to add/remove counterweights blocks as needed.

c. Testing: The vendor may determine that other non-destructive testing beyond what is mentioned in the Scope of Work is needed to make a better judgment. However, such testing (ultrasonic, magnetic particle testing, acoustic emission, etc.) is evaluated by MDOT for each individual basis presented. If

the MDOT approves the test, the vendor must is responsible submitting a testing proposal. The testing proposal shows what tests are to be performed, what specific information is gained from testing, and how the information is used.

The mechanical components that stabilize the movable span when it is in motion and at rest are inspected. The components inspected include, but are not limited to, span guides, counterweight guides, counterweights, balancing chains, centering devices, span locks and drives, buffers, bump blocks and live load supports or wedges. In addition, the traffic barriers and gates are also inspected.

The electrical inspection includes the visual inspection and testing of electrical components of the drive, stabilizing, control system, bridge lighting, auxiliary generator, submarine cable and flexible cables, and bridge safety features. The bridge safety features include the navigational lights, horns/bells, traffic lights, gates, and safety interlocks. The electrical equipment inspection will include, but not be limited to the following: a detailed examination for smooth operation, uniform and regular movement, proper mounting, applied tension, vibration, overheating, wear, rust, carbon deposits, loose terminations, noise, lubrication, alignment, clearances, spring tension, arching, insulating fluid levels, insulating fluid contamination, dirt contamination, insulation conditions, system grounding, enclosure grounding, equipment grounding, bonding, current/ voltage/ kilowatt readings, weather tightness, safety, and signs of distress or pending distress. In addition, the inspection also includes insulation tests of all major electrical components and lead current tests on the electrical drives.

For constant voltage drive systems (DC or Sinusoidal AC), the power consumed by the normal drive motors is measured and recorded on a strip chart during the test opening/closing of the movable span. The results of the test are reviewed for any defects or inconsistencies.