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4.3 GENERAL

4.3.1 Introduction

This chapter describes the high mast light towers used as roadway lighting. High mast lighting structures are generally large diameter post structures with typical heights of 100 to 150 feet supporting a movable ring with up to eight luminaires.

A comprehensive system of inventory and uniform inspection program has been implemented for high mast lighting structures. WisDOT currently inspects the high mast light towers at the recommended intervals outlined in Chapter 1 of Part 4. It is recommended that high mast light towers' mechanical and electrical systems be inspected by maintenance personnel during luminaire replacement. In addition to maintenance-related inspections, it is required that routine and detailed inspections be completed by qualified structure inspection Team Leaders in accordance with Figure 4.3.1-1. More frequent inspections may be warranted if the high mast light tower defects are known and it encroaches on the roadway, roadside, overhead power lines, publicly used areas, or private property. During the routine and maintenance-related inspections, all existing systems should be inventoried by element and assessment. During the installation of new high mast lighting structures, the resident engineer on all State roadway projects should complete an inventory of all installed items. Refer to Part 4, Appendix B, for the applicable inspection forms.

Inspection Type	High Mast Light Tower
Maintenance Related Inspection	<ol style="list-style-type: none">1. Interval Based on Maintenance Frequency2. Full Luminaire Ring and Winch Inspection3. Electrical and Mechanical Inspection
Routine Inspection	<ol style="list-style-type: none">1. 48 Month Maximum Interval2. Inventory All Structures3. Foundation Inspection4. NDT Anchor Rods5. Visually Inspect Tower and Luminaire Ring for Defects using High Power Telescope
In-Depth Inspection	<ol style="list-style-type: none">1. When Structural Capacity may be Compromised due to Defect2. NDT of Post/Base Weld3. Close Visual Inspection using Climbing Camera Device, Mounted Camera on Ring, Inspector Access with Specialized Equipment, or Temporary Lowering of Tower with Crane

Figure 4.3.1-1: Types and Levels of Effort Associated with the Inspection.



4.3.2 High Mast Lighting Inspection

The inspector must be familiar with all the available elements within the Highway Structures Information System (HSI) and appropriately capture them within the inspection report for each high mast lighting structure. Evaluating elements provides a more accurate picture of the structure being inspected and alerts the Department of potential future issues including traffic hazards or functionality of the high mast light. The major elements for inspection are the Foundation, Anchor Bolts, Steel Base Plate, and Steel Pole and Splices. In addition to inventorying all applicable elements and evaluating each element with the appropriate defects, the inspector must also report all appropriate assessments on the high mast light. Refer to Section 4.3.4 High Mast Lighting Assessments. Examples of assessments are the structural, electrical, and luminaire ring mechanical components, signs, and drainage.

Element Level Inspection

On the inspection report form, each high mast lighting element is recorded in units of Each. It is important to note that high mast lighting elements do not possess any material defects. Rather, each element condition state definition provides all the defect language within it. Therefore, the inspector is tasked with noting all defects observed during the inspection under the element notes and determining the appropriate element condition state. For an Each unit of measure, the coded Condition State applies to the entire element. In this manner, an Each unit of measure essentially acts as an overall rating for that element. This will quantify the element's state of deterioration and help generate quantity/cost estimates for future remedial work.

4.3.3 High Mast Lighting Elements

High mast light towers are tall, vertical poles that are rigidly anchored to their foundations. The light tower heights can range from 60 feet up to 175 feet, but generally fall between 100 feet and 150 feet. Refer to Figure 4.3.3-1 for an overall view of a high mast light tower. High mast light tower sections can be manufactured to a maximum length of about 55 feet. Splices between sections may either be butt-welded with a back-up bar, or overlap slip joints. Refer to Figure 4.3.3-2 for a close-up view of an overlap slip joint. The towers are typically tapered at a slope of 0.14 inch-per-foot, and are secured to a concrete foundation by anchor bolts with leveling nuts, top nuts, and secondary jam nuts.



Figure 4.3.3-1: Overall View of a Typical High Mast Light Tower.

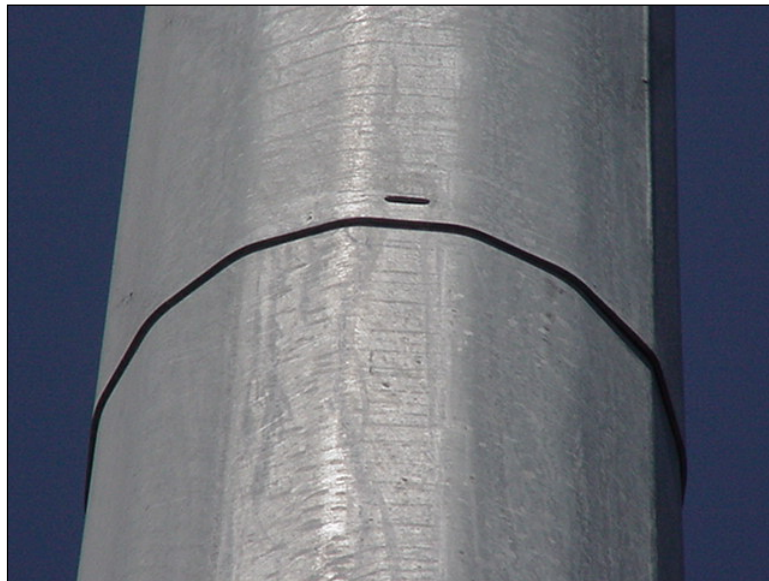


Figure 4.3.3-2: View of a High Mast Light Tower Overlap Slip Joint.

High mast light towers are typically fabricated with galvanized steel or weathering steel. All weathering steel support systems in Wisconsin are currently in the process of being phased out and replaced. Any high mast light towers fabricated of weathering steel should be subjected to more frequent inspections including the removal of handhole plates to examine internal surface corrosion.

Since high mast light towers are slender structures, they possess a low frequency of vibration. These structures are typically very sensitive to the dynamic nature of wind forces, resulting in



vortex shedding related vibrations. High mast light towers are susceptible to vortex shedding due to large bending moments at their base. The bending moments within the structure develop tensile and compressive stresses within the extreme material fibers. The effects of solar heating from the sun can cause additional bending in a tower with the sunlit side exhibiting tensile stress cracks. Since a high mast light tower is a single component structure, it does not possess load path redundancy, and should be considered fracture critical.

High mast light towers support a ring with several luminaires mounted to it which illuminate a large area. The luminaires are typically controlled by use of a photocell mounted on a nearby control panel. Each tower has either an internal or external electric winch that can be used to raise or lower the luminaire ring for routine maintenance.

4.3.3.1 Base / Foundation (Element 8701)

This element includes reinforced concrete foundations used for High Mast Lighting Structures, Overhead Signs, and Signal Monotubes. If a grout pad is present, it is also evaluated in this element. If Anchor Rod(s) were placed eccentrically, record the eccentricity in the notes with measurements for offset. The inspector should verify the eccentricity was reviewed and approved by the owner and that this information is stated within the element notes.

Reinforced concrete bases and foundations are made by placing ready-mix concrete into slip forms steel reinforcing throughout the foundation. The soil adhesion, skin friction, and bearing pressure resist loading from the structure.



Figure 4.3.3-3: View of a Delaminated/Spalled Concrete Foundation – Condition State 3.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the



severity the description represents. Condition states consider material and structural defects of the element, as well as protective systems.

- Condition State 1: The element shows no deterioration.
- Condition State 2: Minor cracks and spalls may be present in the foundation, but only minimal reinforcing steel is exposed. When efflorescence is present, it's minor and no evidence of rust staining. Grout pad (if present) is in good condition. Minor erosion around foundation may be present, but does not affect structural capacity.
- Condition State 3: Many Spalls are present. Corrosion of reinforcement and/or loss of concrete section is evident though not sufficient to warrant structural analysis. Grout Pad (if present) has moderate cracking, spalls, or delaminations. Erosion may be present that reduces the foundation embedment significantly but does not pose a threat to the stability of the structure.
- Condition State 4: The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.



Figure 4.3.3-4: Exposed Foundation Due to Adjacent Construction Work. Condition State 3.

4.3.3.2 Steel Anchor Rods (Element 8702)

This assessment element defines anchor rods, anchor nuts, leveling nuts, and washers connecting the column support to the foundation. Steel anchor rods are embedded within the foundation, and transfer loads from the pole to the foundation. Leveling nuts are placed on the anchor rods and establish a level base for the pole base plate. The base plate is then secured to the anchor rod through tension in the rod supplied by the washer and anchor nut. A jam nut is often found on top of the top nut to prevent top nut from loosening.



Figure 4.3.3-5: View of Loosened Anchor Rods. Note No Jam Nuts Over Anchor Nuts.
Condition State 4 (2 Each).

Element Condition States

Below defines the Condition States specific to each assessment element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element, as well as protective systems.

- Condition State 1: The element shows no deterioration
- Condition State 2: Minor corrosion of the element is present, but the bolts appear to be properly tensioned and the nuts are fully engaged. Anchor rods may be slightly out of plumb (1:40 or less) without need for remediation, or out of plumb between 1:20 and 1:40 with proper beveled washers, and PE Stamped calculations on file to certify the configuration is ok. Anchor rod standoff exceeds current standards, but is within acceptable limits based on calculations.
- Condition State 3: Moderate corrosion of the elements may be present, but not enough to warrant structural analysis. Lock washers may be present. Anchor rod standoff exceeds current standards, and there is no analysis on file and rods appear to be performing adequately.
- Condition State 4: Severe Corrosion is present. Anchor rods are not properly tensioned, nuts may be missing or not fully engaged. Anchor rods are greater than 1:40 out of plumb w/o remediation (Greater than 1:20 requires immediate replacement). Anchor rod standoff exceeds current standards, and rod(s) show signs of bending, movement, buckling, or elongation. The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review

has been completed and it has been found that the defects impact strength or serviceability.

4.3.3.3 Base Plate(s) (Aluminum or Steel) (Element 8703)

This assessment element defines the base plates, flanges, gusset plates, seam welds, and welds at the connection of the column support to the foundation. Base plates are typically welded to the pole, and secured to the anchor rods using high strength nuts and washers. Leveling nuts are used below the base plate to align the structure, and the anchor nuts are utilized to secure the plate to the leveling nuts. The base plate transfers loads from the pole to the anchor rods.



Figure 4.3.3-6: View of Weathering Steel Base Plate.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element, as well as protective systems.

- Condition State 1: The element shows no deterioration.
- Condition State 2: Minor corrosion of the element is present. No cracking of the element is observed. Casting clamp, if used, has no more than one horizontal bolt loose.
- Condition State 3: Moderate corrosion of the element is present. Cracks may be present on the base plate to column support connection weld, but have been arrested or is no longer active and do not affect the capacity of the plate. The base plate may



be distorted (dished). Casting clamp, if used, has no more than two horizontal bolts loose.

- Condition State 4: Severe corrosion is present. Cracks may be present on the base plate to column support connection weld that have not been arrested. Section loss is significant and may affect the ultimate strength or serviceability of the element. Three or more horizontal casting clamp bolts are loose or missing, or cracks exist in the casting clamp assembly. The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.3.3.4 Column Support(s) (Aluminum or Steel) (Element 8704)

This element includes the vertical pole, handhole covers, slip joints and circumferential welds for the column support on the structure. Poles are typically welded to the base plate. Poles greater than 50 feet in length are typically spliced together as separate pieces. Splices can be welded, but are most often slip joints, with an upper section fitting over the top of the section below it. Slip joints depend on gravity to prevent the sections from separating, and are often bolted to prevent rotation and secure the connection. The splice transfers loading between pole sections, and the base plate weld transfers loads to the base plate.

The inspector should pay close attention to the steel and weldments surrounding hand holes, stiffener plates and other connections near the base of the structure. These components are fatigue prone details and may develop cracking due to the cyclic wind loading. The upper pole at a lap splice should also be carefully inspected as the excessive movement at the splice may create failure in the weld of the pole.

Element Condition States

Below defines the Condition States specific to each assessment element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element, as well as protective systems.

- Condition State 1: The element shows no deterioration.
- Condition State 2: Minor corrosion is present. Standing water may be observed inside the post.
- Condition State 3: Moderate damage or corrosion is present, but does not warrant structural review. Cracks may be present on the pole, but have been arrested or is no longer active.
- Condition State 4: Heavy damage or corrosion of elements with section loss. Cracks may be present on the pole that have not been arrested. Elements may be misaligned or have severe impact damage that warrants structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.



Figure 4.3.3-7: View of Minor Scraping Exhibited at the Bottom of the Vertical Pole.
(Condition State 2).

4.3.3.5 Connection(s) - Splices for Columns, Chords, and Mast Arms (Element 8707)

This element defines the splice(s) used to connect members together. This includes the slip joint connections used in many pole applications. The inspector should include the first foot of the vertical pole above the base of the slip joint under this element. Beyond this extent, the pole should be evaluated under Element 8704. This element should not be used to code any defects with the weldments or stiffener plates at the pole/base plate connection. Defects found on these elements should be reported under the appropriate pole/base plate element. Element 8707 shall be used to evaluate the condition of the vertical pole splice connections.

The inspector should pay close attention to rust staining around the base of the slip joint or splice or the buildup of pack rust between the members. This may be evidence of additional distress at the joint. In-depth means of inspection may be warranted in some instances.

Element Condition States

Below defines the Condition States specific to each assessment element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element, as well as protective systems.

- Condition State 1: The element shows no deterioration
- Condition State 2: Minor corrosion is present, but with no discernable section loss. Superficial damage to the element may exist, as may minor misalignments. The connection is solid and is performing the intended function with no loss in capacity. Less than 5% of the connection Bolts/fasteners are loose or missing. Faying surface contact (0.01 in) is >75%.



- Condition State 3: Moderate damage, corrosion or misalignment is present, but does not warrant structural review. Faying surface contact (0.01 in) is between 50~75%. 5~20% of the connection bolts/fasteners may be loose or missing, though the connection is performing the intended function.
- Condition State 4: Heavy damage or corrosion of elements with section loss. Cracks may be present that are active. Faying surface contact (0.01 in) is less than 50%. Greater than 20% of the connection bolts/fasteners are loose or missing. Elements may be misaligned or have severe impact damage that warrants structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.3.4 High Mast Lighting Assessments

Assessments allow for the evaluation of secondary components not necessarily impacting the structural integrity of the structure but those components that are necessary for the proper function of the structure. The inspector must be familiar with all the available assessments within the HSI system that are permitted for each structure type and appropriately capture them within the inspection report for each high mast lighting structure.

Evaluating assessments provides a more accurate picture of the structure being inspected and alerts the Department of potential future issues including traffic hazards or functionality of the lighting structure. The following section describes all the available assessments for high mast lighting that may be reported within HSI.

Assessments are all measured in units of Each, regardless of size. Therefore, it is the inspector's duty to gauge the overall deterioration of the assessment and record the appropriate assessment state.

4.3.4.1 Rodent Screen (9200)

This assessment defines the presence and condition of the screen used to keep rodents from accessing the underside of the baseplate area.



Figure 4.3.4-1: View of Rodent Screen between Base Plate and Foundation.

Refer to the following assessment states:

- Good: Rodent screen is present and is in good condition.
- Fair: Rodent screen is present - it may have some damage or deterioration but it is performing the intended function.
- Poor: Rodent screen is present - it may have some damage or deterioration and is not performing the intended function.
- Severe: Rodent screen is absent on structures where it is required, or incorrectly installed where it does not function properly.

4.3.4.2 Electrical, Luminaire Device and/or Cameras (9201)

This assessment defines the visual condition of luminaries and/or cameras in the system on the structure, as well as the visual condition of the electrical boxes. A separate electrical inspection covers the electrical systems in detail.

Typically the ring will not be operational during a routine inspection by the inspector. Therefore, the inspector must bring the appropriate tools to best evaluate the overall condition of the device. Binoculars or scope are often used for inspection purposes.



Figure 4.3.4-2: View of Luminaire Ring.

Refer to the following assessment states:

- Good: Components appear to be fully functioning.
- Fair: Minor damage or misalignment is noted. Light cover latches are broken.
- Poor: Broken or missing lenses. Bulbs are burnt out or missing. Camera (if present) does not appear to be functioning.
- Severe: Significant damage or deterioration is visible that threatens separation of component from the pole structure.

4.3.4.3 Winch and Cables (9204)

This assessment defines the visual condition of the winch and cable system used to hoist and suspend the luminaire in HML structures. This includes the support brackets, housing anchorage, and cable attachments. A separate electrical inspection covers the motor and mechanical system used to raise and lower the luminaire.

Typically the inspector will not be able to verify the winch system is functioning. However, the inspector should attempt to inspect all attached cable and fasteners for any deterioration or distress. Commonly rodents will build nests on the winch system. This may be an indication the rodent screen is missing or not properly fastened to the base plate.



Figure 4.3.4-3: View of an Internal Winch System. Note Nesting Material Located Between Spools.

Refer to the following assessment states:

- Good: Elements appear to be fully functioning.
- Fair: Bolts may be loose or missing. Elements may be out of alignment.
- Poor: Housing may be bent or cracked. Cable anchorages may be loose, damaged or missing. Cables may be kinked, tangled, fraying, or damaged.
- Severe: The element is damaged or deteriorated to the point that failure is eminent.

4.3.4.4 Handhole Covers and Caps (9205)

This assessment defines handhole covers and caps for columns, chords, and mast-arms.

The inspector shall remove the fasteners and verify the cover or cap is functioning and securely fastened upon completion of the inspection of the interior.



Figure 4.3.4-4: View of a Handhole Cover.

Refer to the following assessment states:

- **Good:** The element(s) are present and show no deterioration.
- **Fair:** The element(s) exist and are performing the intended function. Minor corrosion or damage exists.
- **Poor:** Moderate corrosion or damage exists. The element may be loose and need tightening.
- **Severe:** Element is missing, or is significantly damaged and not performing the intended function.

4.3.4.5 Crash Protection Systems (Guardrail, attenuator, barrier) (9207)

This assessment defines the state of devices used to protect the structure. Evaluate for a distance of no more than 50' from the structure, or as deemed appropriate by the engineer.



Figure 4.3.4-5: View of Barrier Wall Acting as Crash Protection System for Structure.

Refer to the following assessment states:

- **Good:** The element shows no deterioration.
- **Fair:** Minor damage or deterioration is noted. Element is still performing its intended function.
- **Poor:** Minor damage or deterioration is noted. Element is still performing its intended function.
- **Severe:** Significant damage or deterioration is visible. There is sufficient concern to warrant structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.3.4.6 Structure ID Plaque (9208)

This assessment defines the plaque used to identify the structure.

The ID plaque should be installed on the vertical pole at the base and clearly visible.



Figure 4.3.4-6: View of a Structure ID Plaque.

Refer to the following assessment states:

- Good: The element is present and show no deterioration.
- Fair: The element is present, but has minor deterioration.
- Poor: The element is present, though may not be installed in the correct location. The element may have moderate deterioration.
- Severe: The element is missing, illegible, or incorrect.

4.3.4.7 Protective Coating(s) (Galvanization, Paint, etc.) (9209)

This assessment defines the overall condition of the protective system(s) of the metal component of the structure.

Corrosion or other deterioration of the base material should not be considered under this assessment. Assessment 9209 shall only include the effectiveness of the coating itself. Areas of missing coatings are considered fully ineffective or failed. However, it is the inspector's duty to apply an overall evaluation to the assessment not simply rate those few localized areas of failed coating, if present.

Refer to the following assessment states:

- Good: The coating(s) are fully effective.
- Fair: The coating(s) are substantially effective, though small areas of peeling, dulling, bubbling or cracking of the coating may be present.
- Poor: The coating(s) have limited effectiveness and need touch-up work.



- Severe: The coating system has failed, and provides no protection to the underlying metal for a majority of the structure.

4.3.5 Recommended Inspection Procedures

High mast lights are difficult to inspect because they are too high for lift trucks, and most are inaccessible to vehicles because of ditches or railings. The following checklist of items comprises the inspection process for High Mast Lighting.

1. Arrive at site and set-up traffic control (if required).
2. Identify Structure Number (Note location within Structure Specific Notes)
3. Measure and document the distance(s) to the nearest paved roadway, public facility, private property or overhead power lines.
4. Perform Inspection. Provide photographs and/or sketches for Condition State 3 and 4 defects.
 - Verify anchor rod diameter and length, then scan for defects.
 - Examine anchor rods for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
 - Examine anchor rods for any eccentricity. Verify element notes indicate eccentricity was noted and approved by Owner or Owner's representative. Note any noticeable eccentricity measurements within the element notes.
 - Note height of base plate above top of foundation.
 - Examine rodent screen visually for holes, connection, and corrosion.
 - Examine the foundation visually and by sounding with a standard inspection hammer.
 - Inspect ground line for any material washing out around foundation.
 - Examine inside of pole for corrosion, section loss, cracking, water accumulation, and/or pack rust by removing handhole cover. Utilize a light inside cover. Note and remove any nesting debris.
 - Inspect the welds around hatches and handholes and all transverse welds near the base of the high mast pole for potential cracking.
 - Perform ultrasonic testing of anchor rods to note any breaks and verify lengths. Perform ultrasonic testing of base plate/post connection during in-depth inspections. Magnetic particle testing may be used as determined by the inspector.



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- Examine the pole using visual methods. The most common approach would be to use a 25X scope, triangulated from 3 sides, for deterioration of the material, such as cracking, corrosion, and/or pack rust, noting the width, length, depth, and/or orientation of the deterioration. Pay specific attention to splice connections. (Light ring cameras and drones have also been used for pole inspections, and are an acceptable alternative. See Figure 4.3.5-1).
 - Examine light ring (likely by using a 25X scope) for loose hardware, cracked lenses, damaged housing, and levelness of ring.
 - Note previous inspection frequency and recommend inspection frequency.
5. Review of inspection notes to ensure completeness and correctness.
 6. Remove any traffic control.

If severe deterioration is noted or suspected during the maintenance related or routine inspections, a need for an in-depth inspection may be warranted. A detailed inspection will be scheduled on an as-needed basis.



Figure 4.3.5-1: View of a Magnetic Climbing Camera Unit Used During Close Visual Inspection.



Figure 4.3.5-2: View of a Typical Luminaire Ring, Lowered for Maintenance.



Figure 4.3.5-3: View of the Hatch Opening and Internal Winch System with a Portable Motor.



Figure 4.3.5-4: View of a Misaligned Luminaire Ring.

Refer to Figure 4.3.5-5 for a close-up view of the hatch doors on an old and a new high mast light tower. There are differences in the door design on the older structures as shown on the left compared to the new structures as shown on the right. The new door is secured with bolts, a lock in easily accessible areas such as Park and Rides, and no longer has a latch. Note that the electrical circuit plaque has not yet been installed on the new structure.



Figure 4.3.5-5: View of the Hatch Doors for Old and New High Mast Light Towers.



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