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Hardesty & Hanover, LLP
for WSP-Sells

H&H Verification Inspection
04/07/2013

MECHANICAL/ELECTRICAL INSPECTION REPORT

METRO-NORTH RAILROAD, DEVON BRIDGE OVER HOUSATONIC RIVER - STRATFORD, CT CONNDOT BRIDGE NO. 08080R MAIN LINE MP 60.42

INSPECTION COMPLETED ON:
MARCH 25, 2012

PREPARED BY: HARDESTY & HANOVER, LLP
FOR: WSP-SELLS

Inspection Personnel:
Robert Plocica, PE (Mechanical)
Ledio Mustaqi (Mechanical)
Robyn Eisensmith, PE (Electrical)
Ray Lopez (Electrical)

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MECHANICAL INSPECTION REPORT

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I. EXECUTIVE SUMMARY

A Type I field inspection of the mechanical systems on Devon Bridge was conducted on March 25th, 2012 by Hardesty & Hanover for the Connecticut Department of Transportation (CONNDOT). The mechanical systems on Devon are split into three categories: span drive machinery, span lock machinery, and span support systems. The existing conditions of the mechanical system were evaluated by hands-on inspection as well as a comparison to the previous inspection report.

The following are the rating descriptions used in this report for each component:

- Good – Exhibiting insignificant wear and/or deterioration. Performs intended function with high degree of reliability and effectiveness.
- Fair – Exhibiting early measurable wear and/or deterioration. Performs with little reduction in reliability and/or effectiveness.
- Poor – Exhibiting severe wear and/or deterioration. Performance is poor and/or unreliable
- Critical – Operation of movable span is prohibited pending replacement or repair.

The general condition of the machinery on both leaves varies from poor to good. Some maintenance items noted in the previous report are still present. However, some new deficiencies were noted and are presented in this report. The major recommendations include:

1.0 GENERAL

- Many components need to be cleaned, painted and/or lubricated where applicable.

1.1 SPAN DRIVE MACHINERY

- Re-align motor coupling key at the north leaf, south motor coupling.
- Adjust span drive brake torques to 368 ft-lb.

1.2 SPAN LOCK MACHINERY

- No major deficiencies.

1.3 SPAN SUPPORT SYSTEMS

- Air buffers should be refurbished and placed back into service.

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II. REPAIR RECOMMENDATIONS

Recommendations for repair of existing deficiencies are prioritized to immediate, 1 week, 2 months, 6 months, and 2 years.

IMMEDIATE (Priority A) – no recommendations
1 WEEK (Priority B) – no recommendations

2 MONTHS (Priority C)

1. Re-align motor coupling key at the north leaf, south motor coupling.
2. Replace span drive bearing shims with new stainless steel shims with holes for mounting fasteners.
3. Outboard flange mounted unused bearing bolt holes (2 per bearing) should be plugged/sealed.
4. North leaf inboard lubrication fitting for bearing B12 should be secured and isolated away from any moving or rotating machinery.
5. Span drive brake pad self-adjusting bolts should be tightened.
6. All span drive brake torques should be adjusted to 368 ft-lb.
7. Gaps at north leaf coupling C3 and span lock instrumentation coupling should be eliminated by disassembling, realigning, and reassembling these couplings.
8. Span drive open gearing covers should be secured and seals installed to keep water from mixing with the lubrication.
9. Hygroscopic breathers should be installed at span drive enclosed gearing.
10. Span lock enclosed gear reducers should have an oil level gauge installed.
11. Air buffers should be refurbished and placed back into service.
12. Replace protruding grease fitting from span drive couplings with recessed fittings.

6 MONTHS (Priority D)

1. The following should be cleaned, painted and/or lubricated where applicable:
    a. Span drive – motors, bearings, brakes, couplings, rack bolts, open gearing, shafts, enclosed gearing and machinery supports.
    b. Span Lock – gear motors, brakes, bearings, couplings, open gearing, shafts, cranks, connecting rods, hooks, receivers, enclosed gearing and machinery supports.
    c. Span support – curved treads and tracks, live load supports and centering devices.

2 YEARS (Priority E)

1. Monitor span drive and span lock bearing clearances.

13. Secure all lubrication tubing in the vicinity of the open gears to avoid getting tubing caught in gearing during bridge operations. See Photo M-V38. 1

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III. INTRODUCTION AND GENERAL DESCRIPTION

INTRODUCTION

The Devon Bridge consists of two (2) adjacent, single leaf Scherzer rolling lift bascule spans. The bridge carries four tracks of the Metro-North railway across the Housatonic River in Stratford, Connecticut. The Devon Bridge runs east and west, while the leaves are identified as north leaf and south leaf. The bridge operator's control room is located at the southwest corner of the bridge, (See Figure M-1: Plan View, Appendix A). The north leaf carries tracks 1 and 3, while the south leaf carries tracks 2 and 4. The leaves are operated independently, whereas, either leaf can be raised individually while the other remains closed.

GENERAL DESCRIPTION OF MECHANICAL SYSTEMS

3.1 SPAN DRIVE MACHINERY

Both leaves consist of one set of identical span drive machinery. Both sets of machinery are located above the track (at the catenary level), west of the movable span, and rotate with the movable structure. All span drive machinery is labeled as indicated, (See Figure M-2: Existing Span Drive Machinery, Appendix A). Bearings are designated with “B” for bearing. Couplings are designated with “C” for coupling. Shafts are designated with “S” for shaft.

The span drive machinery for each bascule span consists of two (2) 75 horsepower at 870 rpm A.C. electric motors. The motors are located on either side of the main reducer. Each of the two motors is coupled to the ends of the input shaft of the main reducer. Each output shaft of the main reducer is coupled to a cross shaft (S3) that drives Pinion E and the first of three symmetrical open gear sets. Each cross shaft is supported by two (2) floor mounted pillow block bearings. Pinion E meshes with Gear D which in turn rotates pinion C, located at the opposite end of common shaft S2. Shaft S2 is also supported by two (2) floor mounted pillow block bearings. Pinion C then meshes with gear B, the second gear set. Gear B is mounted on to shaft S1, the main pinion shaft, and is supported by two (2) flange mounted bearings. At the outboard end of shaft S1, the main pinion and rack form the third and final open gearing set. The stationary rack is located below the main pinion, at the center of the arc of the segmental track girders, which support the movable span.

To operate the bascule leaves, the high speed/low torque 75 horsepower motors transmit power through the main reducer which is converted to low speed/high torque power, and in-turn rotates the main pinions in order to travel along the fixed horizontal racks, exerting a force at the center of the segmental girder arc.

In addition, the span drive machinery for each bascule span is equipped with four (4) shoe type, thruster released, spring set brakes used to stop and hold the movable span. The brake shoes release when power is applied to the thruster and set when power is removed. This type of brake is considered to be "fail safe" in that if power is interrupted,

the brakes are applied and bring the moving leaf to a stop. The motor brake assemblies are located behind each motor while the machinery brakes are located between each motor and the main reducer.

3.2 SPAN LOCK MACHINERY

Each movable span is fitted with one (1) set of identical span lock machinery. All span lock machinery is labeled as indicated, (See Figure M-3: Existing Span Lock Machinery, Appendix A). Bearings are designated with "LB" for lock bearing. Couplings are designated with "LC" for lock coupling. Shafts are designated with "LS" for lock shaft. Gears are designated with "LG" for lock gear. Pinions are designated with "LP" for lock pinion. As per AREMA, section 6.5.35.3 "Locking Devices", the span locks are intended to force and hold down the toe end of the movable span to its seats. The locks firmly seat the span and double as a fail-safe, preventing the span from opening in the event of a machinery failure or an unintended counterweight heavy imbalance condition.

Each span lock assembly is driven independently by machinery located at the toe end of each truss. The span lock machinery consists of a gear motor, open gear set, linkages, shafts, cranks, bearings, couplings, connecting rods, and hooks. Each span lock assembly is powered by a 1 horsepower gear motor that drives an open gear set. The span lock assembly utilizes three (3) linkages to transmit power from the one (1) horsepower gear motor to the span lock hooks. The span locks consist of two large hook castings located at the toe end of each truss.

The first linkage consists of crank 1, crank 2 and connecting rod LCR-1. During opening, the gear motor and open gear set transmit power to the LS-1 cross shafts through this first linkage. Rotation of the gear motor carries through the open gearing, crank 1, LCR-1 and crank 2 (which is mounted in between the two LS-1 cross shafts) in order to rotate both LS-1 shafts. The second and third linkages consist of crank 3, crank 4 and connecting rod LCR-2. The identical linkage assemblies are mounted on each end of the cross shafts LS-1. The aforementioned rotation of the cross shafts transmits power to the hooks through the second and third linkages. Rotation of the cross shafts carries through crank 3, LCR-2, crank 4 and the eccentric pin in order to rotate and swing the hook clear of the clevis so that the span can be opened. During closing, with the eccentric in its highest position, the hook casting engages and exerts an upward force on the clevis casting mounted on the east approach span pier at the front of the leaf. In this position, the front lock firmly seats the bridge and acts as a fail-safe, preventing the span from opening.

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3.3 SPAN SUPPORT SYSTEMS

Each movable span is fitted with four (4) span support systems. These systems are comprised of curved treads and tracks, live load supports, centering devices and air buffers.

Each movable span consists of two (2) segmental girders, which are curved in profile, allowing the leaf to “roll” along the pier during operation. Pockets in the bottom flange of the girders roll along a horizontal track and mate with castings mounted to the pier. This enables the leaf to maintain alignment as it rolls.

The entire dead load of the span is supported by the segmental girders with the exception of a very small span seated imbalance which is supported by the live load supports when the movable span is seated. Each span is equipped with two (2) live load shoe assemblies that come in contact with strike plates located below the track level on the rest pier, east of the movable span. The live load bearings are intended to transmit imbalance loads, as well as live loads, from the movable span to the rest pier support structure.

Centering devices are provided to position the span in the transverse direction to allow for proper alignment of the railroad tracks. Each of the bascule spans is equipped with two (2) centering device assemblies. The centering device consists of male and female members with the female portion mounted to the rest pier and the male portion attached to floor beam at the toe end of the bascule span. When the leaves approach the full closed position, the mating members engage and align the toe end of the leaves to the adjacent approach spans.

Each span is equipped with one (1) air buffer and a strike plate located in the center of each span, at the toe end. As the bridge approaches the nearly seated position, air buffers serve to dissipate the momentum of the span over a longer distance. This, in turn, allows the span to seat in a controlled fashion. Air buffers are also intended to help prevent damage to the span in the event the span approaches the live load supports at excessive speeds.

IV. SCOPE OF INSPECTION

PURPOSE AND SCOPE OF INSPECTION

The purpose of this inspection was to perform an on-site visual and aural examination, including selected measurements and operational testing of the Devon Bridge mechanical systems. The mechanical systems consist of three main categories, span drive machinery, span lock machinery, and span support systems. The inspection was performed in accordance with The American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual, BIM Sec. 6.2.11 and the AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual.

INSPECTION METHODOLOGY

A Type I field inspection of the mechanical systems on Devon Bridge was conducted on March 25th, 2012 by Hardesty & Hanover for the Connecticut Department of Transportation (CONNDOT). The mechanical field inspection was performed by Matt Gagliano, P.E. and Mark Soryal, E.I.T. The inspection was aided by the efforts of Metro-North maintenance crew and bridge operators. Their efforts included sharing valuable insight of the bridge's history, bridge openings, and maintenance.

The field inspection consisted of visual/aural observations and operational testing of the bridge and its mechanical systems to establish their condition. At accessible locations, component measurements were taken and compared to previous measurements to determine wear. The conditions of the inspected components are then labeled as one of the following; good, fair, poor, and critical. Recommendations were then presented, depending on priority, to be completed immediately or within 1 week, 2 months, 6 months or 2 years.

Motors, bearings, brakes, couplings, open gearing, shafting, enclosed gearing, machinery supports, span locks, track and treads, live load supports, centering devices and air buffers were inspected. Measurements of bearing clearances at all span drive bearing locations were taken to determine wear. Measurements of brake pad thicknesses, clearances, and torque readings at the span drive brake locations were also taken to determine wear. Measurements of bearing clearances at all span lock bearing locations were also taken to determine wear. Centering device clearance measurements were also taken to determine wear and leaf alignment. All measurements were then tabulated and can be found in Appendix A. Open gear sets at the span drive locations were inspected to evaluate alignment as well as condition. In addition, measurements of main pinion backlash and tip clearance were taken to determine wear. Lug wear at the tracks and treads was also inspected to evaluate alignment as well as condition.

V. EXISTING CONDITIONS

5.1 SPAN DRIVE MACHINERY

5.1.1 SPAN DRIVE MOTORS

Each set of span drive machinery is equipped with two (2) electric motors. Motor enclosures, fasteners, shafts and keys were visually inspected for signs of damage or distress. All motor enclosures and fasteners exhibited minor paint failure and corrosion, (See Photo M-01, Appendix B). At all locations, motor enclosures and fasteners should be cleaned and the paint touched-up, as necessary. The north leaf, south motor shaft key is not fully seated in the shaft keyway, (See Photo M-02, Appendix B). This motor coupling should be disassembled so as to allow access to re-align the key properly into the motor shaft. During multiple operations of the bridge, all span drive motors operated smoothly with no vibration, heat build-up or noise. Overall, the span drive motor assemblies were found to be in good condition.

5.1.2 SPAN DRIVE BEARINGS

Each set of span drive machinery is equipped with eight (8) floor mounted pillow bearings, four (4) flange mounted pinion bearings and one (1) instrumentation bearing. All bearing components, such as caps, bases, bushings, grease fittings and mounting fasteners were visually inspected for signs of damage or distress. All bearings were found to exhibit scattered areas of paint failure and surface corrosion on the outer housings and fasteners. Bearings should be cleaned and the paint touched-up, as necessary. In addition, all span drive bearings exhibit adequate yet contaminated lubrication and should be lubricated properly, (See Photo M-03, Appendix B). Some bearings are aligned using slotted, U-shaped shims, as well as single nuts on their respective fasteners, (See Photo M-04, Appendix B). This shim type is prone to backing out during operations and, in permanent machinery installations such as this, is commonly avoided. It is recommended that these shims be replaced with new stainless steel shims with holes for mounting fasteners. At all outboard flange mounted bearing locations (B12 and B18), two (2) mounting bolt holes are not being used, possibly not since installation, (See Photo M-05, Appendix B). These bolt holes should be plugged or sealed to minimize corrosion. In addition, at the north leaf, the inboard lubrication fitting for bearing B12 is loose and is resting on an open gearing cover, (See Photo M-06, Appendix B). This lubrication fitting should be secured and isolated away from any moving or rotating machinery. No deficiencies were found on instrumentation bearings. During multiple operations of the bridge, all bearings operated smoothly with no vibration, heat build-up or noise. Overall, the span drive bearings were found to be in good condition.

At all accessible locations, bearing clearances, the clearance between the shaft and bushing sleeve were measured, (See Table M-1, Span Drive Machinery – Bearing Clearance Measurements, Appendix B). Of the 22 bearings measured, 11 were found to have clearances above ANSI RC6 limits. An RC9 maximum fit is a general limit on bearing clearance at which point rehabilitation should be considered. The AASHTO

Inspection manual recommends a RC6 fit or a general rule of thumb for maximum clearance limit as 0.002" times the shaft diameter for bearing clearance. Additionally, the manual also notes that shafts and bearings with greater clearances can continue to operate safely in cases that do not have frequent or hard load reversals. Due to the current operational performance, the relatively slow speed of the shafts and the non-frequent reversal of load, it is only recommended to monitor the clearances at this time. It is anticipated that rehabilitation to reduce the clearance of the machinery bearings will need to be performed within the next 7 years.

5.1.3 SPAN DRIVE BRAKES

Each set of span drive machinery is equipped with four (4) shoe type, thruster released, spring set brake assemblies. Brake assembly enclosures were removed for inspection purposes and replaced after the inspection. All components, such as hand release levers, brake wheels, torque springs, brake pads, thrustor rods and thrusters were visually inspected for signs of damage or distress. Brake assembly linkages and thrusters exhibited adequate paint coverage yet some fasteners and rods remain un-painted, (See Photo M-07, Appendix B). Affected locations should be cleaned and the paint touched-up, as necessary. Brake wheel surfaces exhibited varying degrees of corrosion, from very minor to moderate. Minor pitting and scoring was present at all locations, (See Photos M-08 & M-09, Appendix B). All hand release levers were found to be in good condition and operated smoothly. At some locations, brake pad self-adjusting bolts were found to be loose. These bolts should be tightened to allow the brake pads to self-adjust their position as they wear. During multiple operations of the bridge, all brake assemblies operated smoothly with no vibration, heat build-up or noise. Overall, the span drive brake assemblies were found to be in fair condition.

At all locations, torque settings, pad thicknesses and brake pad clearances were measured and tabulated, (See Table M-2, Span Drive Machinery - Brake Measurements, Appendix A). The previous inspection report claims that the design torque setting for these brakes should be 368 ft-lb. All torque readings were found to be below this design setting and should be adjusted to fulfill the design requirements.

5.1.4 SPAN DRIVE COUPLINGS

Each set of span drive machinery is equipped with two (2) motor couplings, two (2) cross shaft gear couplings and two (2) instrument drive jaw type couplings. All coupling components, such as hubs, keys, keyways and lubrication holes were visually inspected for signs of damage or distress such as relative movement between halves, cracks on keys/keyways, and twists/deformations. All couplings have scattered areas of paint failure with light corrosion and grease build-up on their covers and fasteners, (See Photos M-10 & M-11, Appendix B). Affected couplings should be cleaned and the paint touched-up, as necessary. In addition, grease fittings were found to be un-painted, indicating proper access to lubricate. Protruding grease fittings from a coupling is a safety hazard. Fittings should be used only to add grease, then removed and replaced with a recessed plug after maintenance. At the north leaf, instrumentation coupling C3 exhibited sizeable gaps between the coupling inserts and

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hubs, (See Photo M-12, Appendix B). This coupling and instrumentation unit should be disassembled, realigned, and reassembled. During multiple operations of the bridge, all coupling assemblies operated smoothly with no vibration, heat build-up or noise. Overall, the span drive coupling assemblies were found to be in good condition.

5.1.5 SPAN DRIVE OPEN GEARING

Lubrication tubing was found to be loose in the vicinity of the open gearing. See Photo M-V38. 1

Each set of span drive machinery is equipped with three (3) symmetrical sets of open gearing as well as one (1) set of instrumentation open gearing. All span drive open gearing was visually inspected for signs of wear, damage or distress and/or cracks on keys/keyways. All main pinion and rack gear sets are exposed to the environment and therefore found to be poorly lubricated and exhibiting moderate pitting, wear, plastic flow and surface corrosion, (See Photos M-13 to M-15, Appendix B). Rack bolts and fasteners were also found to be moderately corroded yet showing no signs of section loss, (See Photo M-16, Appendix B). Affected areas should be cleaned and the paint touched-up, as necessary. The intermediate gear sets are protected with metal covers that were found to be inadequately attached and could be easily dislodged by hand. In addition, standing water was found at all locations, (See Photos M-17 & M-18, Appendix B). These covers should be secured, so as not to affect operation of the open gearing, and utilize seals to keep water off the open gearing. Intermediate open gearing sets were free of abrasive contaminants and adequately lubricated. At the contact areas, varying degrees of pitting, plastic flow, scoring and surface rust was noted. Instrumentation open gearing was found to be well lubricated and exhibiting no deficiencies. During multiple operations of the bridge, grease patterns on all open gearing teeth were observed. The patterns indicated that all open gearing sets meshed well with good contact across the teeth. Overall, the span drive open gearing sets were found to be in fair condition.

At all main pinion/rack locations, backlash (the gap between mating teeth) and tip clearance measurements were taken and tabulated. The measurements for backlash ranged from ½" – ¾". The measurements for tip clearance ranged from $^{3}/_{8}$" – ½". At two (2) locations, noticeable misalignment of gear sets was measured. At the south leaf, south rack/main pinion, an axial misalignment of $^{5}/_{8}$" (to the north) was measured. At the south leaf, Pinion C_N/Gear B_N, an axial misalignment of $^{3}/_{8}$" (to the south) was measured. Axial misalignment of the pinion to the rack reduced at the south rack of the south leaf to almost zero misalignment. This seems to agree with the tread/ track direction of wear. During operation, these misalignments did not appear to be adversely affecting the operation or the condition of the gear teeth.

5.1.6 SPAN DRIVE SHAFTING

Each set of span drive machinery is equipped with two (2) cross shafts and one (1) instrumentation shaft. All shafts were visually inspected for signs of damage or distress such as cracks on keys/keyways and twists/deformations. All shafts have scattered areas of paint failure with light corrosion, (See Photo M-19, Appendix B). Affected shafts should be cleaned and the paint touched-up, as necessary. During multiple operations of the bridge, all shaft assemblies operated smoothly with no

vibration or noise. Overall, the span drive shaft assemblies were found to be in good condition.

5.1.7 SPAN DRIVE ENCLOSED GEARING

Each set of span drive machinery is equipped with one (1) main reducer and one (1) instrument drive reducer. Reducer enclosures, fasteners, housing split lines, fitting, shaft seals, shafts and keys were visually inspected for signs of damage or distress. Both main reducers were found to exhibit very minor corrosion surrounding the inspection hatch, (See Photo M-20, Appendix B). Affected areas should be cleaned and the paint touched-up, as necessary. Main reducer sight glasses were found to be cloudy, making it difficult to determine oil levels, (See Photo M-21, Appendix B). Also, neither reducer is equipped with a desiccant type breather. A hygroscopic breather should be installed on both enclosed gear reducers to minimize the moisture inside the gear box. See section 5.4, Operational Testing, for more existing conditions relating to the span drive enclosed gearing. Instrumentation drive reducers were found to exhibit light to moderate paint failure and corrosion, (See Photo M-22, Appendix B). Affected areas should be cleaned and the paint touched-up, as necessary. During multiple operations of the bridge, all span drive enclosed gearing operated smoothly with no vibration, heat build-up or abnormal noise. Overall, the span drive enclosed gearing assemblies were found to be in good condition.

5.1.8 SPAN DRIVE MACHINERY SUPPORTS

Each span drive machinery motor, brake, reducer and bearing is supported by a machinery support. All supports were visually inspected for signs of damage or distress. At all locations, machinery supports exhibited no cracks, section loss, or missing fasteners. However, all machinery supports exhibited minor paint failure and surface corrosion, (See Photo M-23, Appendix B). Affected areas should be cleaned and the paint touched-up, as necessary, to prevent deterioration. Overall, the span drive machinery supports were found to be in good condition.

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5.2 SPAN LOCK MACHINERY

5.2.1 SPAN LOCK GEAR MOTORS

Each set of span lock machinery is equipped with one (1) electric motor. Motor enclosures, fasteners and shafts were visually inspected for signs of damage or distress. Due to the exposure of these components to the environment, all span lock gear motor enclosures and fasteners exhibited minor paint failure and corrosion, (See Photo M-24, Appendix B). At all locations, motor enclosures and fasteners should be cleaned and the paint touched-up. During multiple operations of the bridge, all span lock motors operated smoothly with no vibration, heat build-up or noise. Overall, the span lock motors were found to be in good condition.

5.2.2 SPAN LOCK BEARINGS

Each set of span lock machinery is equipped with twelve (12) plain type bearings. All bearing components, such as caps, bases, bushings, grease fittings and mounting fasteners were visually inspected for signs of damage or distress. All bearings were found to exhibit major paint failure and light surface corrosion on the outer housings and fasteners, (See Photo M-25, Appendix B). Bearings should be cleaned and the paint touched-up, as necessary. Lubrication of the bearings was found to be adequate. During multiple operations of the bridge, all span lock bearings operated smoothly with no vibration, heat build-up or noise. Overall, the span lock bearings were found to be in good condition.

Bearing clearances, the clearance between the shaft and bushing sleeve were measured at all accessible bearings, (See Table M-3, Span Lock Machinery – Bearing Clearance Measurements, Appendix B). Of the 8 bearings measured, 2 were found to have clearances above ANSI RC6 limits. It is only recommended to monitor the clearances at this time. See span drive bearing inspection findings for more information.

5.2.3 SPAN LOCK BRAKES

Each span lock motor is equipped with an internal single solenoid type disc brake on the back of the span lock motor. Brake assembly enclosures were not removed for this inspection; however, the exterior was visually inspected for signs of damage or distress. Due to the exposure of these components to the environment, all span lock brake enclosures and fasteners exhibited minor paint failure and corrosion. Affected areas should be cleaned and the paint touched-up, as necessary. During multiple operations of the bridge, all span lock brake assemblies operated smoothly with no vibration, heat build-up or noise. Overall, the span lock brake assemblies were found to be in good condition.

5.2.4 SPAN LOCK COUPLINGS

Each set of span lock machinery is equipped with one (1) cross shaft coupling and one (1) instrument drive jaw type coupling. All coupling components, such as hubs, keys, keyways and lubrication holes were visually inspected for signs of damage or distress such as relative movement between halves, cracks on keys/keyways, and twists/deformations. All couplings have scattered areas of paint failure with light corrosion build-up on their covers and fasteners. Affected couplings should be cleaned and the paint touched-up, as necessary. In addition, at the north leaf span lock instrumentation coupling, a 0.052" gap between the coupling inserts and hubs was measured, (See Photo M-26, Appendix B). This coupling should be disassembled, realigned, and reassembled. During multiple operations of the bridge, all span lock coupling assemblies operated smoothly with no vibration, heat build-up or noise. Overall, the span lock coupling assemblies were found to be in good condition.

5.2.5 SPAN LOCK OPEN GEARING

Each span lock assembly consists of one (1) open gearing set compromised of pinion LP1, located on the output shaft of the gear motor, and gear LG 1. Both span lock open gearing sets were visually inspected for signs of wear, damage or distress and/or cracks. At both locations, open gearing sets exhibited abrasive contaminants and were inadequately lubricated, (See Photos M-27 & M-28, Appendix B). Span lock open gearing should be cleaned and lubricated properly. In addition, pinion and gear teeth were found to exhibit minor pitting and corrosion. During multiple operations of the bridge, grease patterns on all open gearing teeth were observed. The patterns indicated that all open gearing sets meshed well with good contact across the teeth. Overall, the span lock open gearing sets were found to be in good condition.

5.2.6 SPAN LOCK SHAFTING, CRANKS AND CONNECTING RODS

Each set of span lock machinery is equipped with two (2) shafts, six (6) cranks and three (3) connecting rods all located on the movable span. All shafts, cranks and connecting rods were visually inspected for signs of damage or distress such as cracks and twists/deformations. All of the crank shaft/connecting rod assemblies exhibit major paint failure and light surface corrosion. Lubrication of these components was found to be inadequate at the time of inspection. Affected areas should be cleaned, the paint touched-up, as necessary, and lubricated properly. At both locations, connecting rod LCR-1 was found to be bent yet not affecting operation, (See Photo M-29, Appendix B). During multiple operations of the bridge, all span lock shafts cranks and connecting rods operated smoothly with no vibration or noise. Overall, the span lock shafts, cranks and connecting rods were found to be in good condition.

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5.2.7 SPAN LOCK HOOKS AND RECIEVERS

Each set of span lock machinery is equipped with two (2) hooks and two (2) receivers. The span lock hooks are part of the movable span while the receivers are mounted to the fixed pier. All hooks and receivers were visually inspected for signs of damage or distress such as cracks and twists/deformations. Both hooks and receivers exhibit major paint failure, light surface corrosion, and hardened grease, (See Photo M-30, Appendix B). Affected areas should be cleaned, the paint touched-up, as necessary, and lubricated properly. During multiple operations of the bridge, all hooks and receivers operated smoothly with no vibration or noise. Overall, the span lock hooks and receivers were found to be in good condition.

5.1.7 SPAN LOCK ENCLOSED GEARING

Each set of span lock machinery is equipped with one (1) enclosed gear reducer mounted to the gear motor. The enclosed gear reducer does not have an inspection hatch for internal inspection; however, the exterior was visually inspected for signs of damage or distress. The gear enclosures exhibited minor paint loss and corrosion. Affected areas should be cleaned and the paint touched-up, as necessary. In addition, neither reducer is equipped with a desiccant type breather. No sight glass is installed on these reducers so the oil level could not be determined. An oil level gauge should be installed for inspection purposes. During multiple operations of the bridge, all span lock enclosed gearing operated smoothly with no vibration, heat build-up or noise. Overall, the span lock enclosed gearing assemblies were found to be in good condition.

5.2.8 SPAN LOCK MACHINERY SUPPORTS

Each span lock machinery motor and bearing is supported by a machinery support. All supports were visually inspected for signs of damage or distress. At all locations, the span lock machinery supports exhibited no cracks, section loss, or missing fasteners. However, supports were found to exhibit major paint failure and surface corrosion. Affected areas should be cleaned and the paint touched-up, as necessary, to allow for a clean surface which may be helpful in diagnosing future leaks. Overall, the span lock machinery supports were found to be in good condition.

5.2.9 SPAN LOCK AUXILIARY DRIVE

The auxiliary drive for each span lock assembly is a hand crank system located on the back side of the motor brake. The hand cranks were not available at the time of inspection, and the auxiliary drive was not tested.

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5.3 SPAN SUPPORT SYSTEMS

5.3.1 CURVED TREADS AND TRACKS

Each span is equipped with two (2) curved tread and track assemblies. All track and tread components such as tracks, lugs and pockets were visually inspected for signs of damage or distress. At all locations, track assemblies exhibited major paint loss and surface corrosion. The north leaf tread assemblies were found to be painted while the south leaf tread assemblies were not painted and exhibited minor surface corrosion, (See Photo M-31, Appendix B). All curved treads and tracks should be cleaned, as necessary. During multiple operations of the bridge, all track and tread assemblies operated smoothly with no misalignment, vibration, or noise. Overall, the track and tread assemblies were found to be in good condition.

At all locations, lug wear was present on one or more of the four outer faces, (See Photo M-32, Appendix B). For each lug, the faces exhibiting wear was noted and illustrated, (See Figure M-4, Lug Wear, Appendix A). In addition, sample lug thicknesses were measured and found to be between 2” to 2-1/16” thick.

5.3.2 LIVE LOAD SUPPORTS

Each span is equipped with two (2) live load support assemblies. The live load shoes are located at the toe of each movable leaf while the mating strike plates are attached to the fixed pier. All live load support components, such as shoes, strike plates and plate anchors were visually inspected for signs of damage or distress. All live load shoes and strike plates exhibit moderate paint loss and corrosion. In addition, a slight impression on the face was made by the bearing shoes, (See Photos M-33 & M-34, Appendix B). Affected areas should be cleaned and the paint touched-up, except at the bearing surface. During multiple operations of the bridge, all live load supports functioned correctly and remained securely in place. Overall, the live load supports were found to be in good condition.

5.3.3 CENTERING DEVICES

Each span is equipped with two (2) centering devices mounted at the toe of the leaf. All centering devices were visually inspected for signs of damage or distress. Assemblies were found to exhibit moderate to severe rust, (See Photo M-35, Appendix B). Affected areas should be cleaned and the paint touched-up, as necessary. During multiple operations of the bridge, all centering devices operated smoothly with acceptable misalignment and no unusual noise. Overall, the centering devices were found to be in good condition.

At all locations, clearances between the centering devices were measured, (See Photo M-36, Appendix B). The measurements were then tabulated, (See Table M-4, Span Support Machinery – Centering Device Clearance Measurements, Appendix B). Centering device clearance measurements were found to be slightly larger than previous measurements but acceptable.

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5.3.4 AIR BUFFERS

Each span is equipped with one (1) air buffer and strike plate assembly located at the center of the movable span, near the span lock machinery. The air buffers have been inoperable for some time and were not inspected at the time of this inspection. Air buffer rods did not reach the strike plate and the strike plate fasteners seemed to be bent and unsecure, (See Photo M-37, Appendix B). Air buffers should be refurbished and placed back into service as soon as possible. Overall, the air buffers were found to be in poor condition.

5.4 OPERATIONAL TESTING

During each operation, visual and audible observations for unusual noise, vibration and movement were made for all mechanical components. During operation, both leaves were visually noted to gradually shift toward the north and back to the south as they opened, and would oscillate in its angular position particularly when brought to a stop. In addition, intermediate gear sets were found to be out of sync, rotating at varying speeds and intervals while alternating back and forth between the north and south gear sets. The out of sync operation is not a deficiency but is due to the primary reducer differential allowing the leaf to reposition itself during seating. The excessive measured backlash at all main pinion and rack locations are most likely the reason for both of these observations. Furthermore, during operation, an audible rattling/grinding noise from the south leaf was heard. The previous inspection report had mentioned that this noise was originating from the south leaf intermediate open gearing sets.

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MECHANICAL APPENDIX A

MECHANICAL FIGURES AND TABLES

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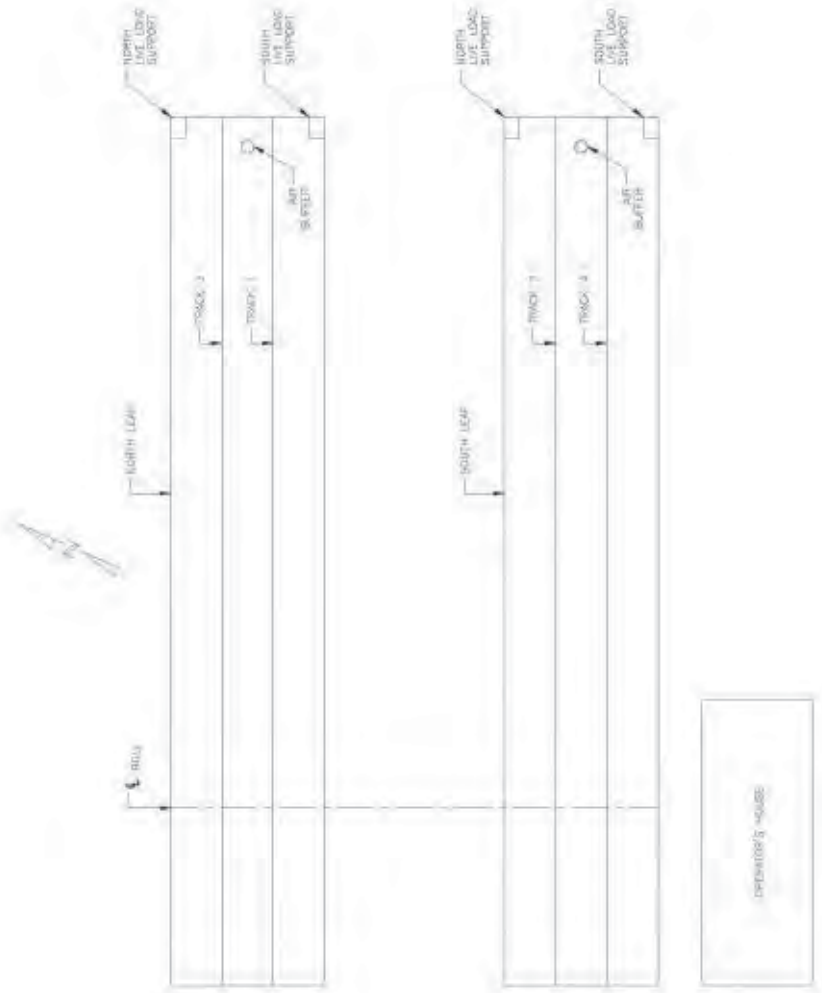

FIGURE M-1: PLAN VIEW
N.T.S.

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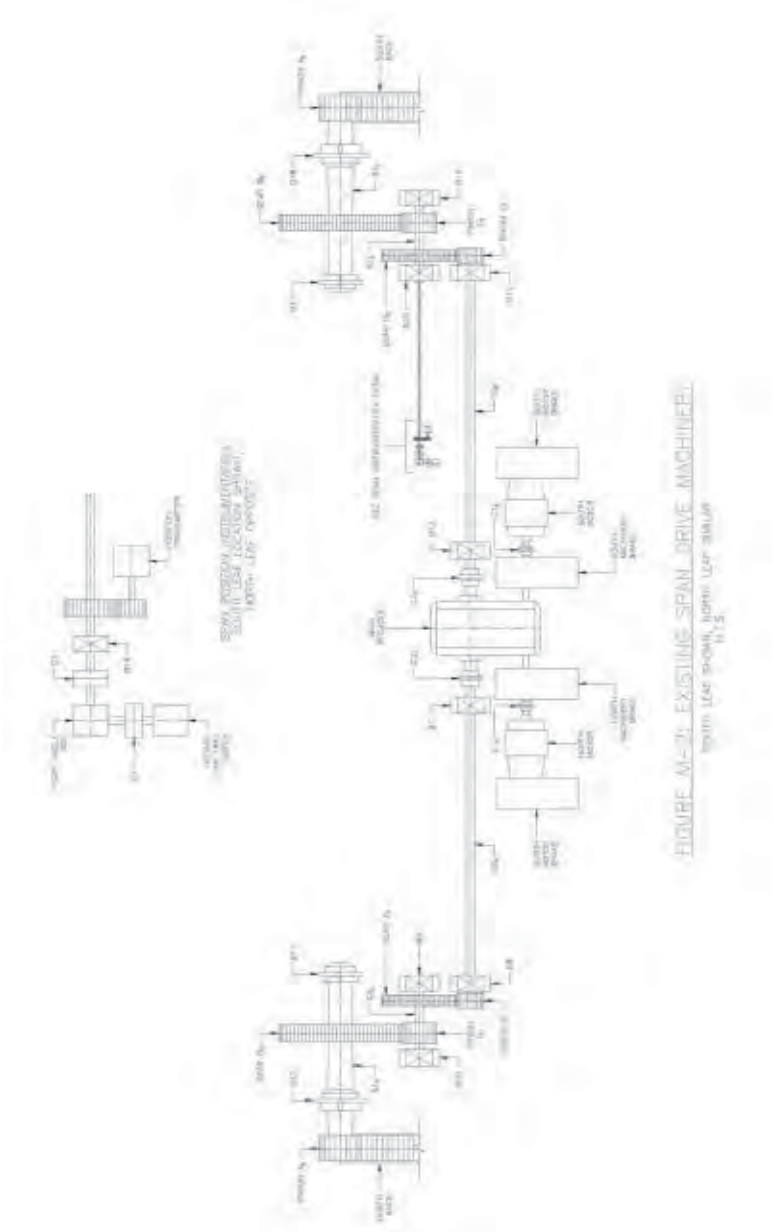

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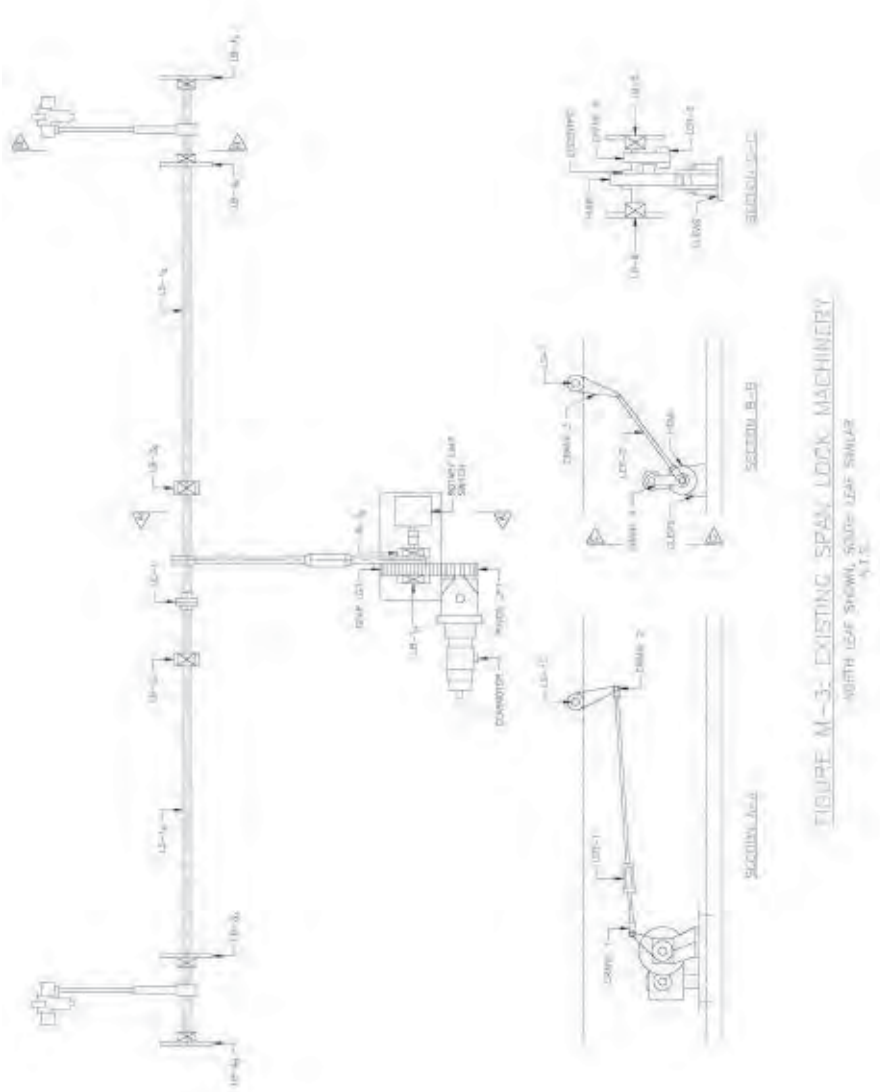

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NO REVISIONS

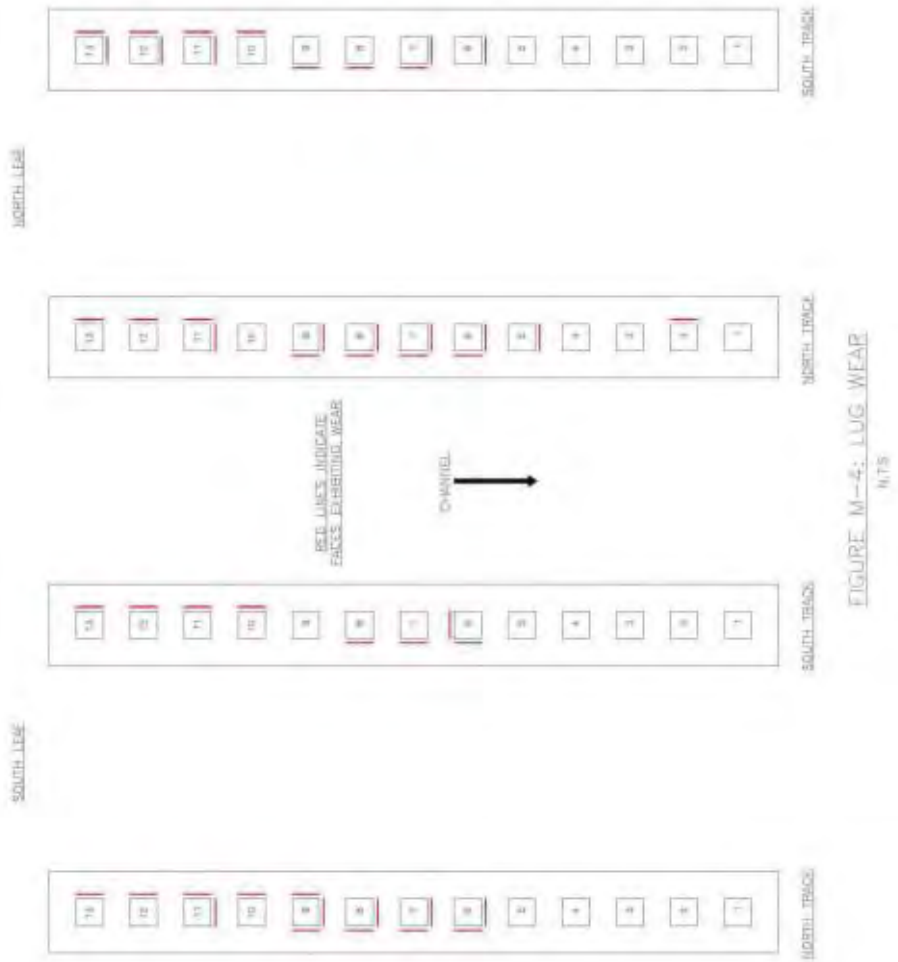

FIGURE M-4: LUG WEAR
N.T.S.

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TABLE M-1 NO REVISIONS

SPAN DRIVE MACHINERY - BEARING CLEARANCE MEASUREMENTS

NORTH LEAF

Mark	Nominal Size Range (in.)	*Bushing Clearance (in.)			Apparent Wear (in.)	Above RC6 Limit
		Previous	RC6 Max	Current		
B7	3.15-4.73	0.008	0.008	0.005	-0.003	N/A
B8	3.15-4.73	0.007	0.008	0.005	-0.002	N/A
B9	3.15-4.73	0.018	0.008	0.016	-0.002	0.008
B10	4.73-7.09	0.010	0.010	0.007	-0.003	N/A
B11	9.85-12.41	N/A	0.013	N/A	N/A	N/A
B12	12.41-15.75	0.028	0.015	0.035	0.007	0.020
B13	3.15-4.73	0.005	0.008	0.005	0.000	N/A
B14	3.15-4.73	0.015	0.008	0.016	0.001	0.008
B15	3.15-4.73	0.022	0.008	0.030	0.008	0.022
B16	4.73-7.09	0.006	0.010	0.005	-0.001	N/A
B17	9.85-12.41	N/A	0.013	N/A	N/A	N/A
B18	12.41-15.75	0.027	0.015	0.022	-0.005	0.007

* Measurement locations are at the 12:00 position or at the top of the bearing.

Note : In the column labeled "Apparent Wear", a positive value translates to an increase while a negative value translates to a decrease.

Note: Bearing Clearances above the RC6 limit are acceptable but are now considered to be class RC9.

SOUTH LEAF

Mark	Nominal Size Range (in.)	*Bushing Clearance (in.)			Apparent Wear (in.)	Above RC6 Limit
		Previous	RC6 Max	Current		
B7	3.15-4.73	0.010	0.008	0.003	-0.007	N/A
B8	3.15-4.73	0.009	0.008	0.009	0.000	0.001
B9	3.15-4.73	0.021	0.008	0.009	-0.012	0.001
B10	4.73-7.09	0.025	0.010	0.019	-0.006	0.009
B11	9.85-12.41	N/A	0.013	N/A	N/A	N/A
B12	12.41-15.75	0.018	0.015	0.026	0.008	0.011
B13	3.15-4.73	0.005	0.008	0.003	-0.002	N/A
B14	3.15-4.73	0.008	0.008	0.011	0.003	0.003
B15	3.15-4.73	0.018	0.008	0.009	-0.009	0.001
B16	4.73-7.09	0.006	0.010	0.008	0.002	N/A
B17	9.85-12.41	N/A	0.013	N/A	N/A	N/A
B18	12.41-15.75	0.013	0.015	0.012	-0.001	N/A

* Measurement locations are at the 12:00 position or at the top of the bearing.

Note : In the column labeled "Apparent Wear", a positive value translates to an increase while a negative value translates to a decrease.

Note: Bearing Clearances above the RC6 limit are acceptable but are now considered to be class RC9.

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TABLE M-2
SPAN DRIVE MACHINERY - BRAKE MEASUREMENTS

NORTH LEAF

Brake Location	Torque Reading (ft-lb)		Pad Thickness (in.)			Pad Contact When Set	Pad Clearance When Released
	Previous	Current	Previous	Current	Acceptable		
North Motor Brake	430	285	0.375	0.375	0.197	Tight	No Clearance
North Machinery Brake	400	285	0.375	0.375	0.197	Tight	No Clearance
South Machinery Brake	430	315	0.375	0.375	0.197	Tight	Slight Clearance
South Motor Brake	430	315	0.375	0.375	0.197	Tight	No Clearance

SOUTH LEAF

Brake Location	Torque Reading (ft-lb)		Pad Thickness (in.)			Pad Contact When Set	Pad Clearance When Released
	Previous	Current	Previous	Current	Acceptable		
North Motor Brake	430	295	0.375	0.375	0.197	Slight Clearance	Slight Clearance
North Machinery Brake	400	295	0.375	0.375	0.197	Slight Clearance	OK
South Machinery Brake	430	295	0.375	0.375	0.197	Slight Clearance	OK
South Motor Brake	430	295	0.375	0.375	0.197	Tight	OK

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TABLE M-3
SPAN LOCK MACHINERY - BEARING CLEARANCE MEASUREMENTS

NORTH LEAF

Mark	Nominal Size Range (in.)	*Bushing Clearance (in.)			Apparent Wear (in.)	Above RC6 Limit
		Previous	RC6 Max	Current		
LB-1N	1.97-3.15	0.015	0.007	0.005	-0.010	N/A
LB-1S	1.97-3.16	N/A	0.007	0.005	N/A	N/A
LB-2N	1.97-3.17	0.007	0.007	0.005	-0.002	N/A
LB-2S	1.97-3.18	0.007	0.007	0.004	-0.003	N/A
LB-3N	1.97-3.19	0.006	0.007	N/A	N/A	N/A
LB-3S	1.97-3.20	0.005	0.007	N/A	N/A	N/A
LB-4N	1.97-3.21	0.006	0.007	N/A	N/A	N/A
LB-4S	1.97-3.22	0.005	0.007	N/A	N/A	N/A

* Measurement locations are at the 12:00 position or at the top of the bearing.

Note : In the column labeled "Apparent Wear", a positive value translates to an increase while a negative value translates to a decrease.

SOUTH LEAF

Mark	Nominal Size Range (in.)	*Bushing Clearance (in.)			Apparent Wear (in.)	Above RC6 Limit
		Previous	RC6 Max	Current		
LB-1N	1.97-3.15	0.008	0.007	0.007	-0.001	N/A
LB-1S	1.97-3.16	N/A	0.007	0.010	N/A	0.003
LB-2N	1.97-3.17	0.012	0.007	0.005	-0.007	N/A
LB-2S	1.97-3.18	0.005	0.007	0.035	0.030	0.028
LB-3N	1.97-3.19	0.005	0.007	N/A	N/A	N/A
LB-3S	1.97-3.20	N/A	0.007	N/A	N/A	N/A
LB-4N	1.97-3.21	0.005	0.007	N/A	N/A	N/A
LB-4S	1.97-3.22	N/A	0.007	N/A	N/A	N/A

* Measurement locations are at the 12:00 position or at the top of the bearing.

Note : In the column labeled "Apparent Wear", a positive value translates to an increase while a negative value translates to a decrease.

Note: Trunnion Bearing Clearances above the RC6 limit are acceptable.

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TABLE M-4

SPAN SUPPORT MACHINERY - CENTERING DEVICE CLEARANCE MEASUREMENTS

NORTH LEAF

Location	Clearance (in.)		Apparent Wear (in.)
	Previous	Current	
North	1.000	1.200	0.200
South	0.250	Tight	--

Note : In the column labeled "Apparent Wear", a positive value translates to an increase in clearance.

SOUTH LEAF

Location	Clearance (in.)		Apparent Wear (in.)
	Previous	Current	
North	1.500	1.625	0.125
South	0.125	Tight	--

Note : In the column labeled "Apparent Wear", a positive value translates to an increase in clearance.

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MECHANICAL APPENDIX B

MECHANICAL PHOTOS

Photo M-01. North Leaf, North Motor.

Photo M-02. North Leaf, South Motor Coupling.

Photo M-03. North Leaf, Bearing B15.

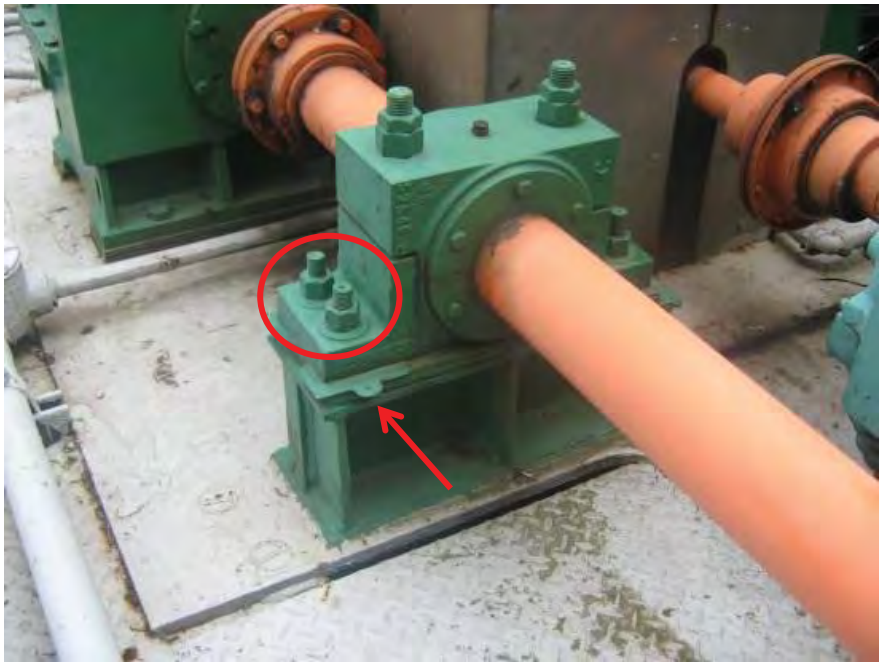

Photo M-04. South Leaf, Bearing B7.

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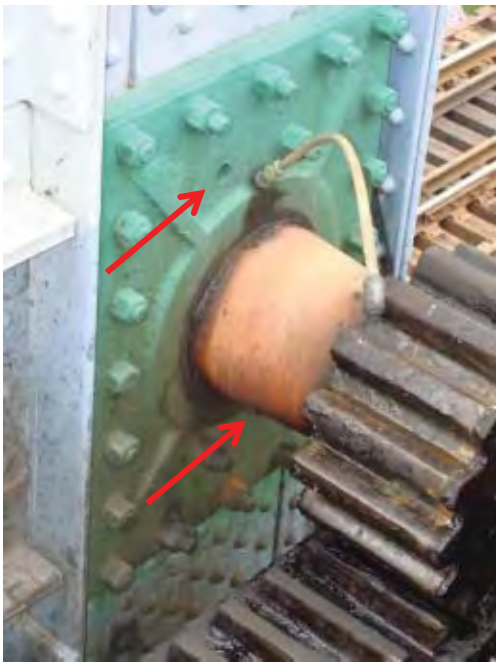

North 1

Photo M-05. ~~South~~ Leaf, Bearing B12.

Photo M-06. North Leaf, Bearing B12 Lubrication Fitting.

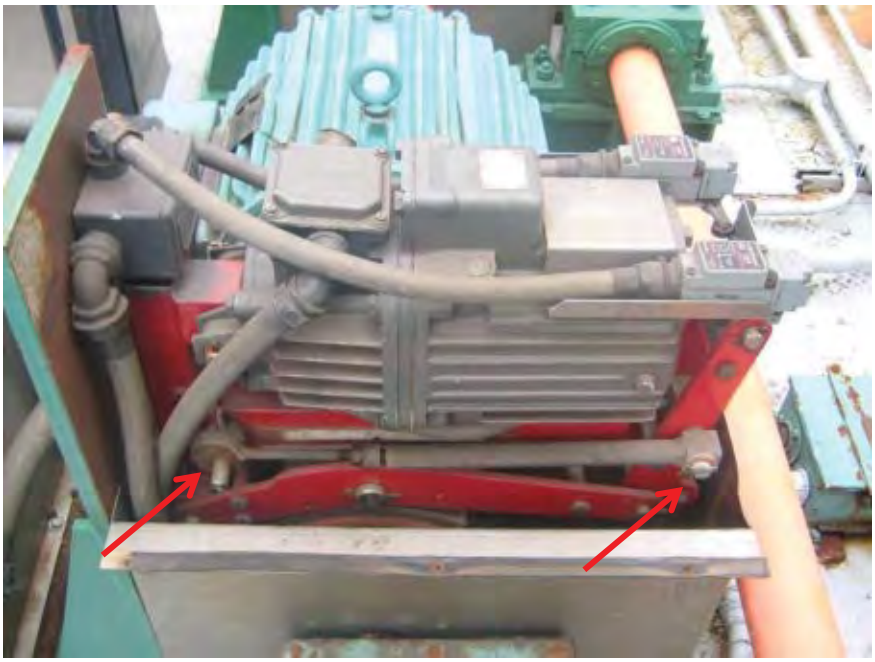

Photo M-07. South Leaf, South Motor Brake.

Photo M-08. North Leaf Brake Wheel. (Minor corrosion)

Photo M-09. South Leaf Brake Wheel. (Moderate corrosion)

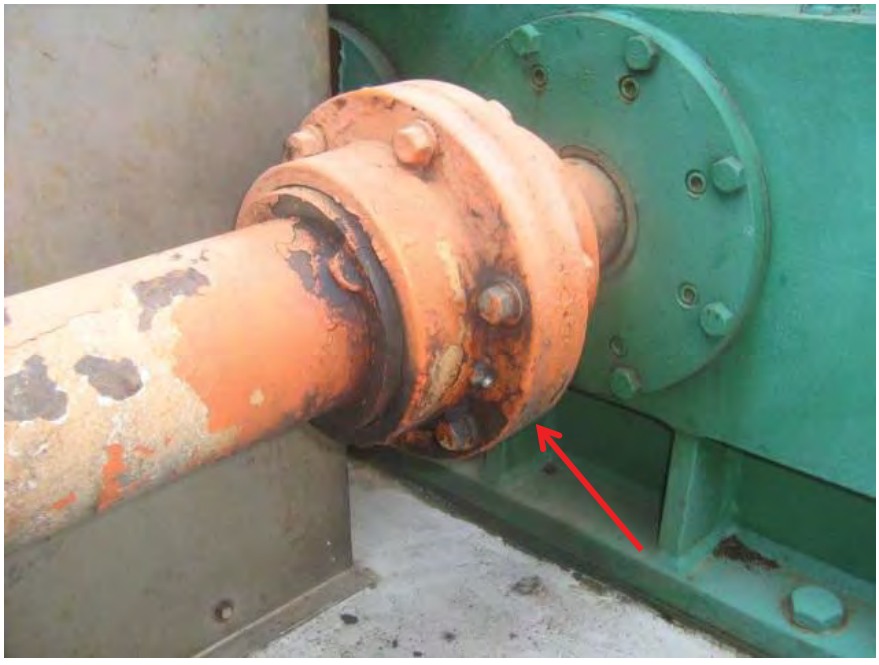

Photo M-10. South Leaf, Coupling $C2_S$.

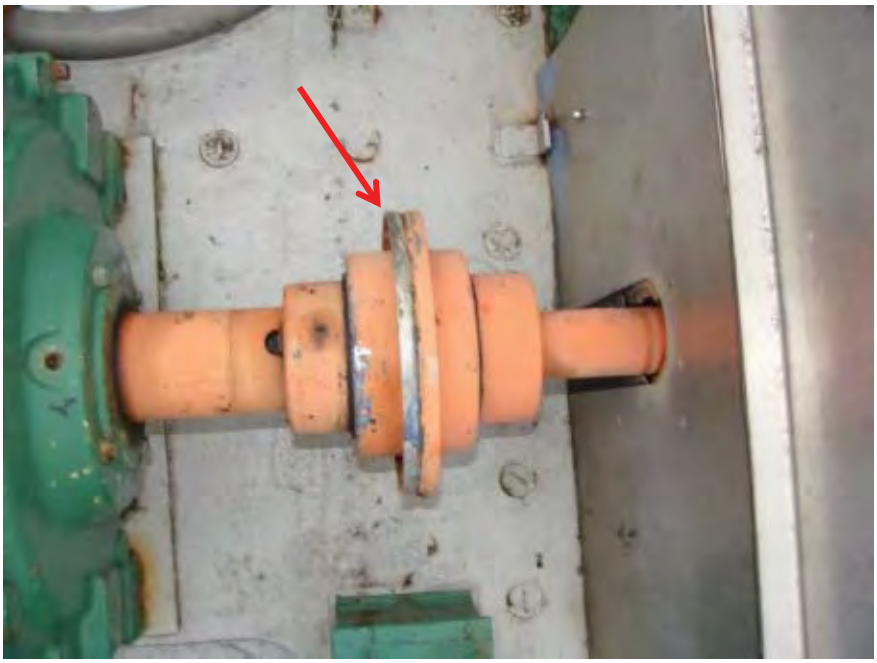

Photo M-11. North Leaf, Coupling $C1_S$.

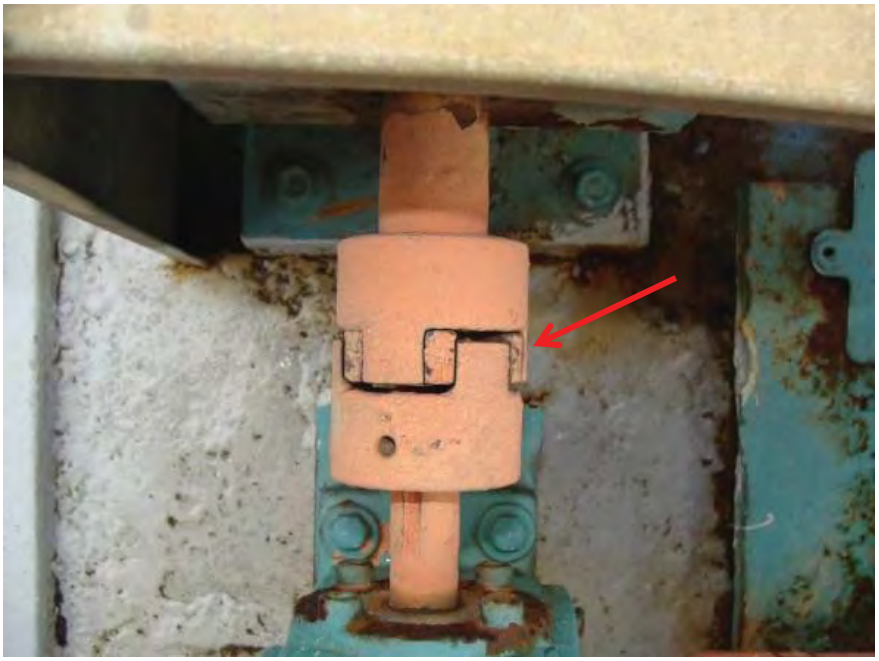

Photo M-12. North Leaf, Coupling C3.

Photo M-13. North Leaf, North Rack and Pinion AN.

Photo M-14. North Leaf Pinion As/South Leaf Pinion AN.

Photo M-15. South Leaf, North Rack and Pinion As.

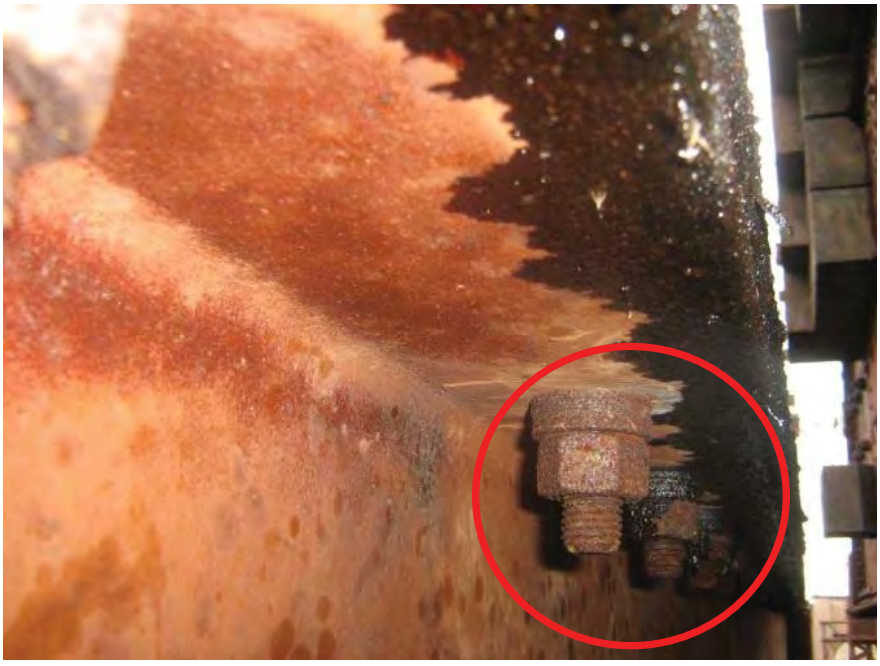

Photo M-16. South Leaf, South Rack (Note corrosion on fasteners).

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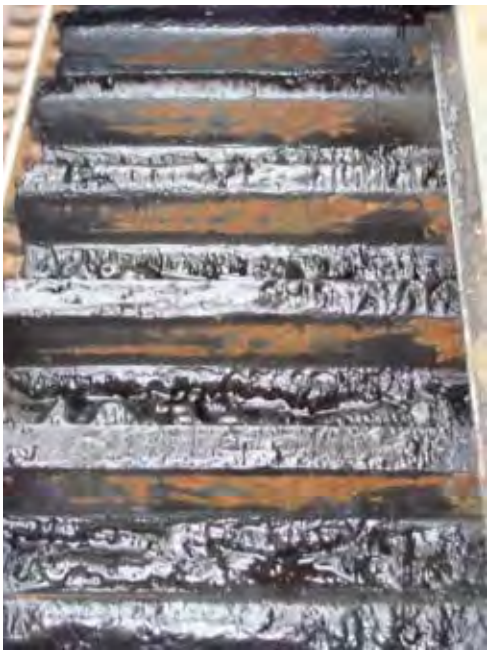

Standing water not found. Most likely dried up.

Photo M-17. South Leaf, Gear Bs ~~(Note standing water on open gearing)~~. 1

Standing water not found. Most likely dried up.

Photo M-18. North Leaf, Pinion C_N ~~(Note standing water on open gearing)~~. 1

Photo M-19. North Leaf, Shaft S3s (Note paint failure and surface rust).

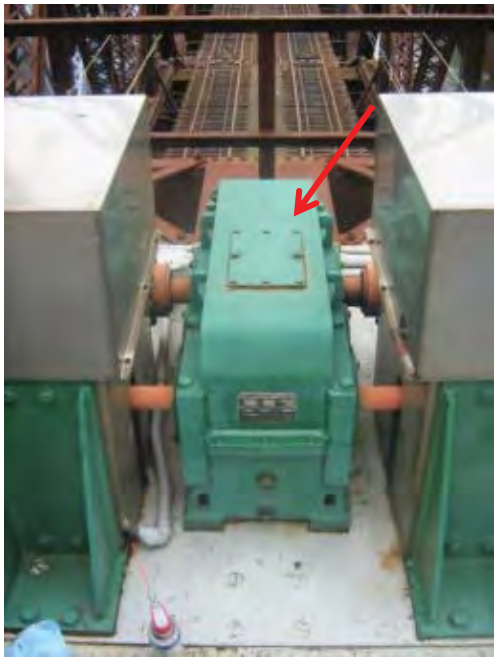

Photo M-20. South Leaf, Main Reducer (Note minor corrosion).

Photo M-21. South Leaf, Main Reducer Sight Glass.

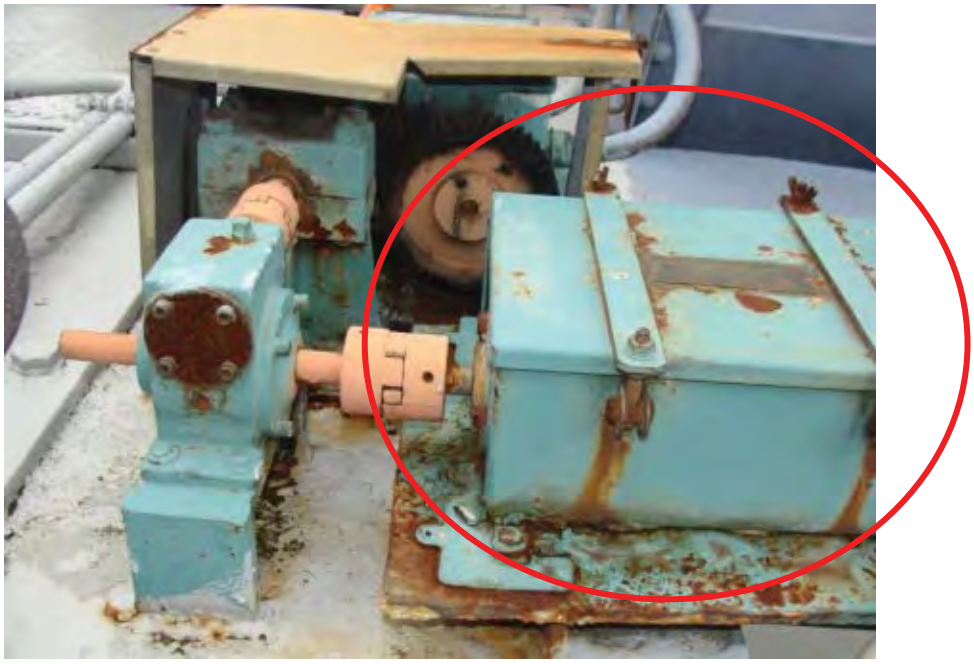

Photo M-22. North Leaf, Instrumentation.

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Tachometer 1

Photo M-23. North Leaf, North Motor ~~Brake~~ Support.

Photo M-24. North Leaf, Span Lock Motor.

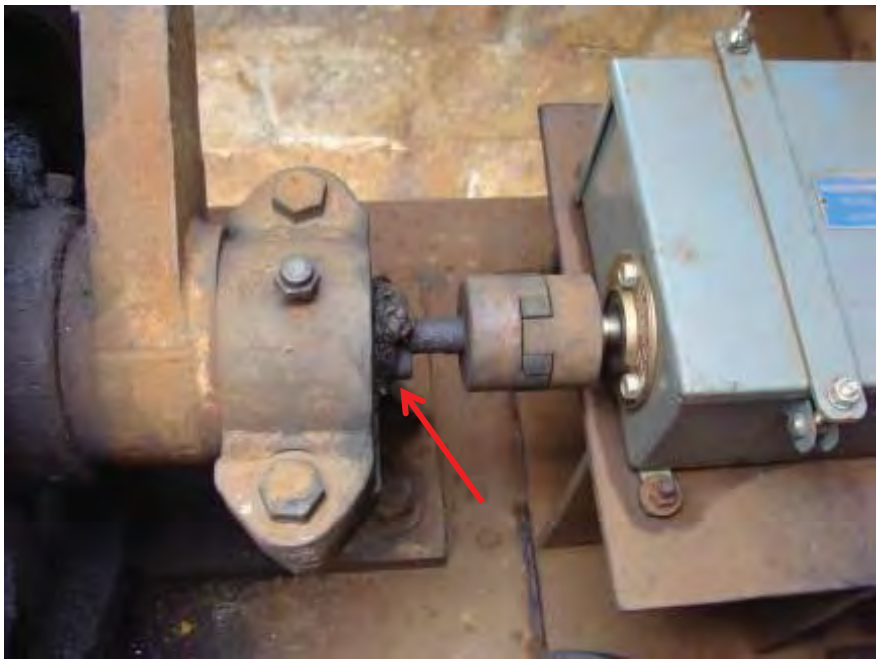

Photo M-25. North Leaf, Span Lock Bearing LB-1s.

Photo M-26. North Leaf, Span Lock Instrumentation Coupling.

Photo M-27. North Leaf, Span Lock Pinion LP1.

Photo M-28. North Leaf, Span Lock Gear LG1.

Photo M-29. North Leaf, Connecting Rod LCR-1.

Photo M-30. South Leaf, North Span Lock Hook.

Photo M-31. North (painted) and South (unpainted) Leaf Tread Assemblies.

Photo M-32. Lug Wear.

Photo M-33. South Leaf, North Strike Plate.

Photo M-34. South Leaf, North Live Load Shoe.

Photo M-35. North Leaf, South Centering Guide.

Photo M-36. North Leaf, North Centering Guide Clearance.

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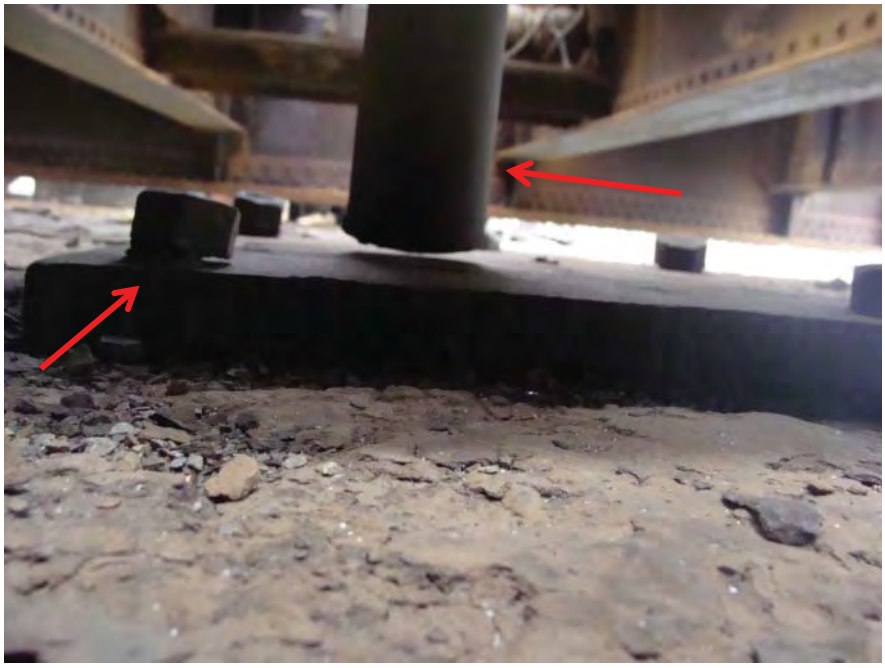

Photo M-37. South Leaf, Air Buffer Strike Plate.

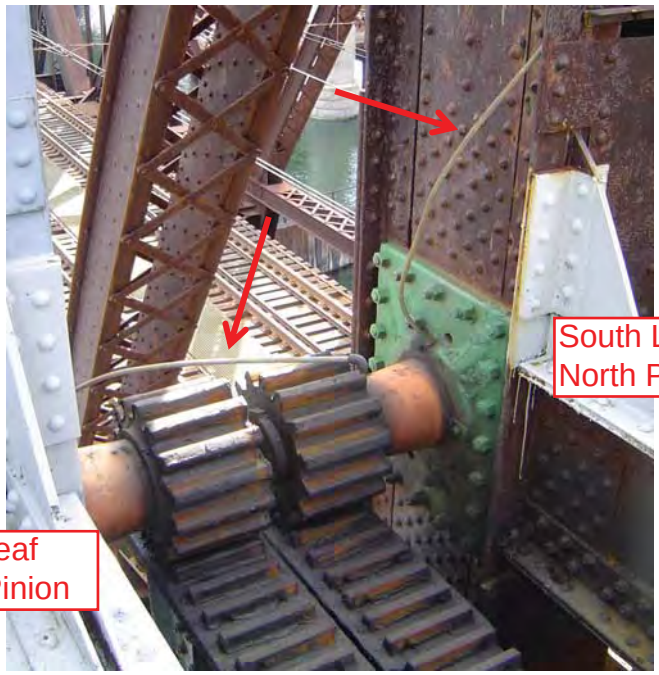

Photo Added
1

Photo M-V38. Pinion Bearing Grease Tubing is loose, over North Leaf (South Pinion) and South Leaf (North Pinion)

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04/07/2013

MECHANICAL APPENDIX C

TIME AT SITE SHEET

H&H Verification Inspection
04/07/2013

1

TIME AT SITE	Project No.	300-097	MNRR Main Line:
	Bridge No.	08080R	Over Housatonic

Date: 3/25/2012	Crew: Matthew Gagliano (PE), Alec Noble (PE), Mark Soryal, Samih Bisharaa	
	Equipment Used: N/A	
Time: 8:00am - 3:00pm	Police (Name/Time): N/A	Flagman (Name/Time): Scott Forbes, 8:00am - 3:00pm
Work Done: Mechanical and electrical visual inspection including field measurements. Both spans were fully operated and span locks were operated with no opening. Inspection completed on this day.		

TIME AT SITE	Project No.	300-097	MNRR Main Line:
	Bridge No.	08080R	Over Housatonic

Date: 4/07/2013	Crew: Robert Plocica (PE), Robyn Eisensmith (PE), Ledio Mustaqi, Raymond Lopez	
	Equipment Used: N/A	
Time: 7:00am - 1:00pm	Police (Name/Time): N/A	Flagman (Name/Time): Kevin Bohan, 7:00am - 1:00pm
Work Done: Mechanical and electrical verification inspection. Both spans were fully operated and span locks were operated with no opening. Inspection completed on this day.		

1

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04/07/2013

MECHANICAL APPENDIX D

MECHANICAL FIELD NOTES

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04/07/2013
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ENGINEERING

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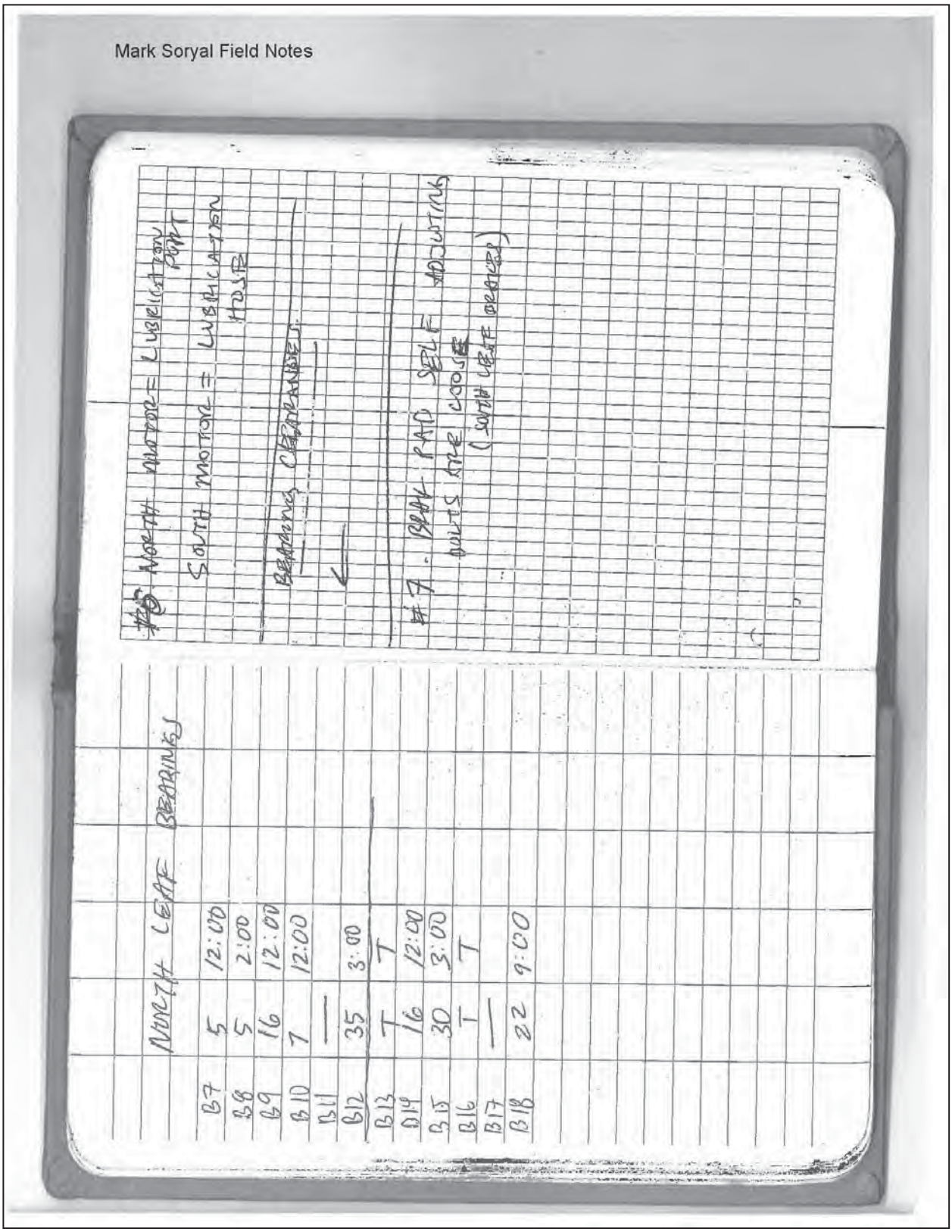
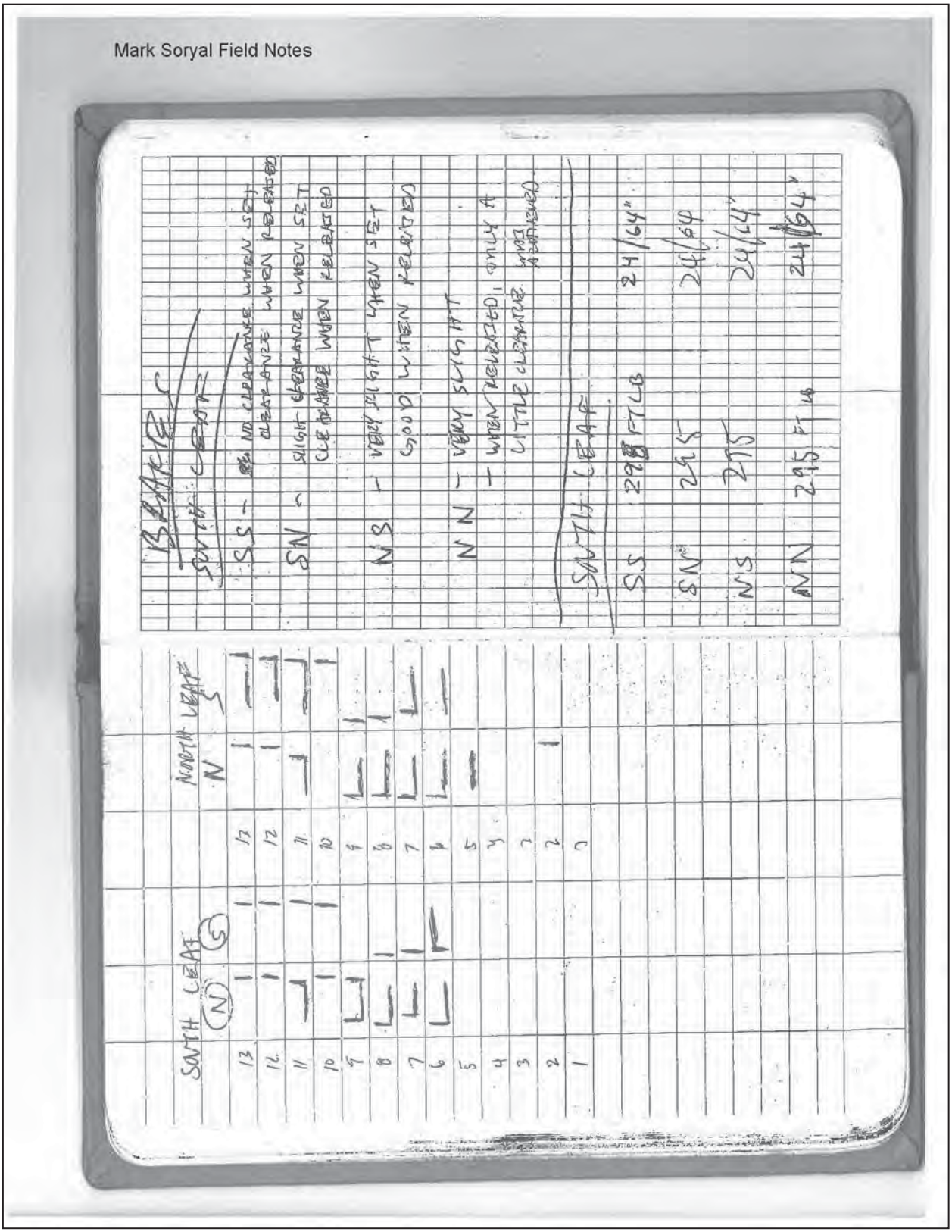
04/07/2013
NO REVISIONS



H&H Verification Inspection
04/07/2013
NO REVISIONS

Mark Soryal Field Notes



HARDESTY & HANOVER, LLP
ENGINEERING

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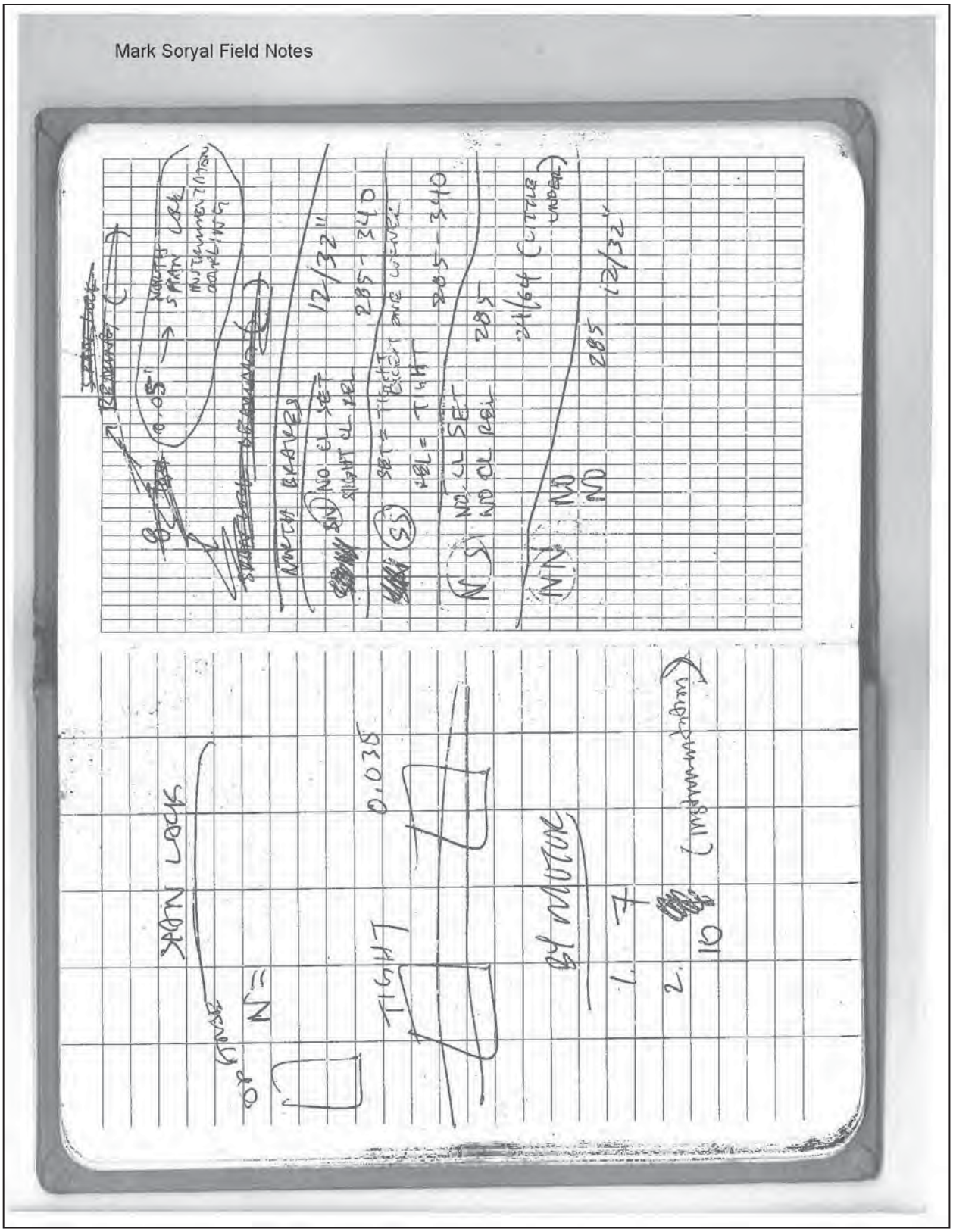
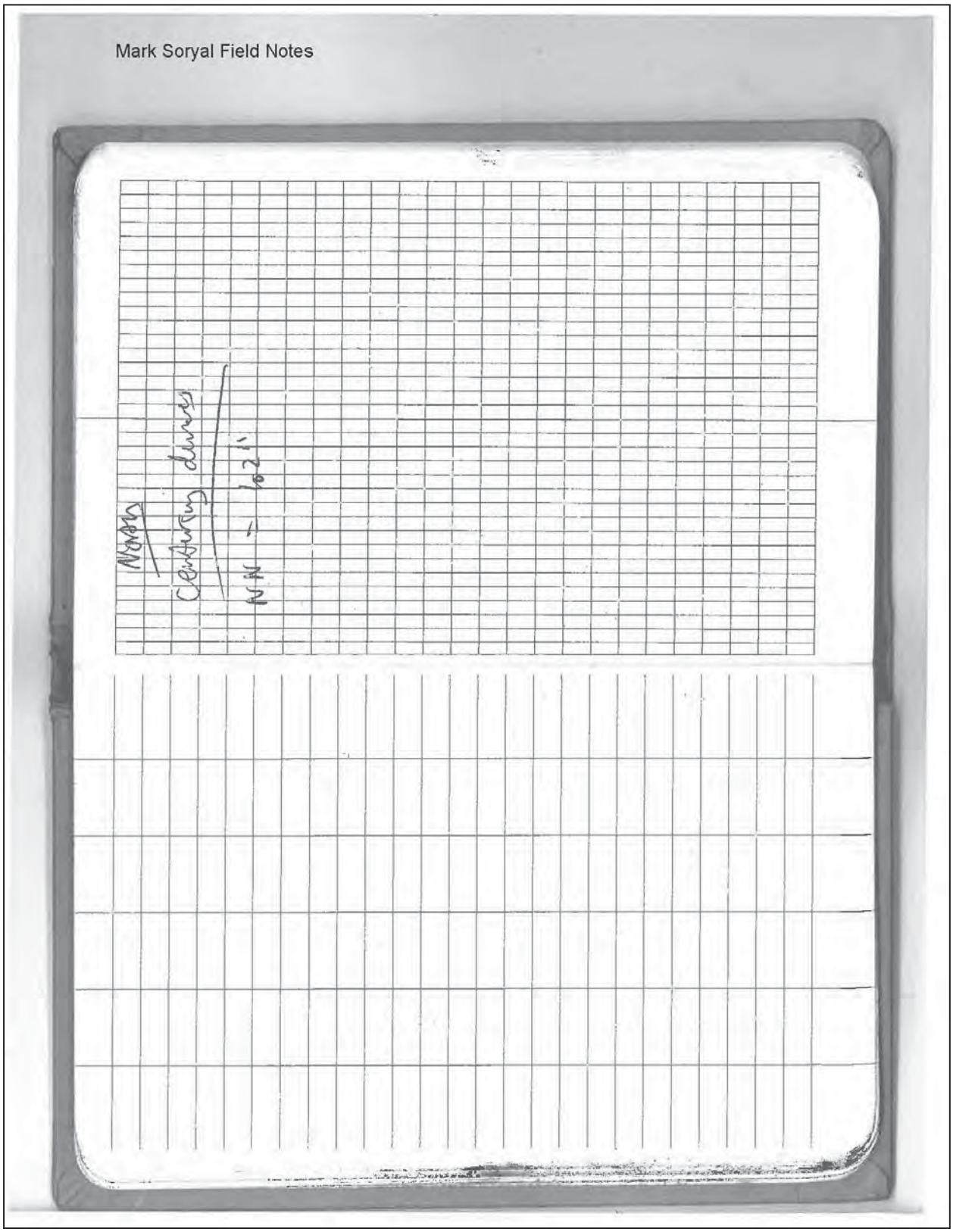
04/07/2013
NO REVISIONS



H&H Verification Inspection
04/07/2013

NO REVISIONS



H&H Verification Inspection
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NO REVISIONS

Mark Soryal Field Notes

During the operation of the North leaf, it was noted that the intermediate gear sets on the North and South sides of the leaf were turning at different intervals, alternating back and forth between the North and South sides. This cycling is indicative of the fact that the backlash for the North and South sides are not uniformly set. Therefore, the driving of the leaf occurs back and forth between the North and South gearing, instead of being uniformly driven by both sides at the same time. Tooth face contact measurements taken on the rack and pinion gears for the North leaf suggest that the leaf is counterweight heavy.

During the operation of the South leaf, there was an audible rattling/grinding noise coming from the South intermediate gear sets during both the raising and lowering of the leaf. The inspection team was unable to further identify which components in this assembly were causing the noise. Tooth face contact measurements taken on the rack and pinion gears for the South leaf suggest that the leaf is span heavy.

Open Gearing → GEAR COVERS ARE NOT SEVERELY SHIFTED OR MISSING

The overall condition of the open gear sets is adequate and the racks and rack pinions on both leaves are considered to be in poor condition

→ RACK & PINIONS ONLY

The backlash for all open gear sets was measured using feeler gauges. In general the back lash for the open gears sets was found to be excessive with the exception of the North D/E gear set on the South leaf. All backlash measurements can be found in Appendix M-II.

As part of the gear geometry inspection, gear tooth thickness and tip clearance measurements were taken on individual teeth for all gear sets. Gear tooth span measurements were also taken to supplement the gear tooth thickness measurements for the pinion A gears only. Due to the condition of the gear teeth on all of the open gear sets, measurements of the gear tooth thickness varied significantly, by more than 10% in some case, from their expected design values. No abnormal values were noted for any of the gear tooth thickness or gear tooth span measurements. A table of tooth thickness measurements can be found in Appendix M II. It should be noted the extensive gear tooth tip clearance measurements performed in the previous inspections have not been rechecked during this inspection. Instead, gear tooth face contact was measured for the rack and pinion A gears.

Gear tooth contact was measured for all four pinion A and rack gear sets using gear bluing and a tape measure. The bluing was applied to the rack gear (see photo M-1) and face contact was measured as a percentage of the dye transferred from the rack to the pinion across the face of the tooth Face contact measurements were taken for both raising and lowering operations, in a series of three gear teeth in each set. Acceptable gear tooth contact is approximately 80% or better, according to industry good practice. Gear tooth contact measurements were attempted on the intermediate gears sets as well, but the

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Mark Soryal Field Notes

bridge controls did not allow for an accurate single rotation of the intermediate gears. This resulted in the gears making multiple revolutions and fouling the contact measurements taken with the existing machinery grease.

All gear tooth contact measurements were found to be less than the acceptable 80% value. In one case, on the North leaf pinion raise faces, the gear tooth contact skipped individual teeth in the series of three teeth (see photo M-2). The skipping of contact is consistent with the alternating between the North and South gears set observed during operation. In general the North leaf racks and pinions showed evidence that the leaf is counterweight heavy, with contact occurring on the lower drive face of the pinions (see photo M- 3). The South leaf rack and pinion face contact suggests that the leaf is span heavy, as evidenced by contact only on the raise drive face of the pinions (see photo M-4). See Appendix M II for the measurements taken for the gear tooth face contact.

All gear sets exhibit pitting and scorings in varying degrees of severity. In general the worst of these deficiencies are found in the rack and pinion gearing and the B/C intermediate gear sets (see photos M-5 and M-6). Most teeth also exhibit light corrosion on sides and face of the gear teeth (see photo M-7). In addition to the surface deficiencies most of the gear sets have plastic flow of the tooth material to varying degrees. The rack and Pinion A gears on both leafs exhibit the worst cases of plastic flow (see photo M-8). These gear teeth have such significant plastic flow in the addendum, deddendum, and tip that most gears no longer have an involute shape. The lubrication of all opens gears is good. Any areas which were cleaned off for measurement purposes were re-lubricated by the maintenance staff at the time of inspection.

Alignment of all open gear sets were checked visually at the time of inspection. Center distance alignment could not be determined on any of the gear sets due to the lack of a scribed pitch diameter. It was verified that the North B/C and D/E gear sets on the South leaf were axially offset to one side by as much as approximately ½" (see photo M-9). Despite the offset, both gear sets still have the ability to make full contact across the entire face of the mating gears. Gear tooth contact measurements were not performed on these gear sets and proper contact cannot be confirmed.

Machinery Supports

The overall condition of the machinery supports is good. All supports have scattered areas of paint failure with light corrosion (see photo M-10). No other deficiencies were noted with the machinery supports.

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LOCKS

On the North leaf the pin between crank 1 and the clevis of LCR-1 shows signs of corrosion and wear of the pin (see photo M-33). On both the North and South leaf LCR-1 is bent adjacent to Crank 1. In the previous inspection it has been reported that, on the South leaf, the South span lock crank 4 comes in contact with the eccentric assembly of the hook. This particular deficiency could not be confirmed or reproduced at the time of the current inspection. No other particular deficiencies were noted regarding the shafts, cranks and links of the span lock machinery.

NORTH INSTRUMENTATION COUPLING = Typ = 0.05"

Couplings

The overall condition of the couplings is fair. Each leaf's span lock machinery contains one coupling each. The coupling is used to connect the two cross shafts which drive the individual span locks underneath the lower chords of the leaf from the central gearmotor. Both couplings have light corrosion throughout their covers and fasteners (see photo M-34). Coupling LC-1, for the North leaf, visibly has excessive misalignment of the two cross shafts (see photo M-34). No other specific defects were noted for any of the couplings. Recent lubrication of the couplings could not be confirmed. All keys and keyways are in an acceptable condition with no deficiencies noted.

A table of individual coupling conditions can be found in Appendix II.

Auxiliary Drive

The auxiliary drives are in good condition. The auxiliary drive for each span lock is a hand crank system located on the back side of the motor brake. The hand cranks were not operated at the time of inspection, and the auxiliary drive was not tested. All shaft covers were intact and no defects were noted. The interlocks for the hand crank covers were present and functional with no deficiencies noted.

Enclosed Gearing

The condition of the span lock reducers is good. Each span lock system has a single enclosed gear reducer used to drive both of the span lock assemblies for the leaf. At the time of inspection the reducers were not inspected internally since the particular model did not include an inspection hatch. The oil level of the reducers could not be determined with removal of the fill plug installed on the reducers. No sight glasses were present on the reducers to determine the lubricant level inside. Both of the span lock reducers also lack a desiccant style breather. Both of the reducer housings and mounting fasteners have light corrosion throughout (see photo M-35).

Bearings

The overall condition of the cross shaft bearings is fair. All of the bearings in the span lock system for each leaf are plain type bearings, which are used to support

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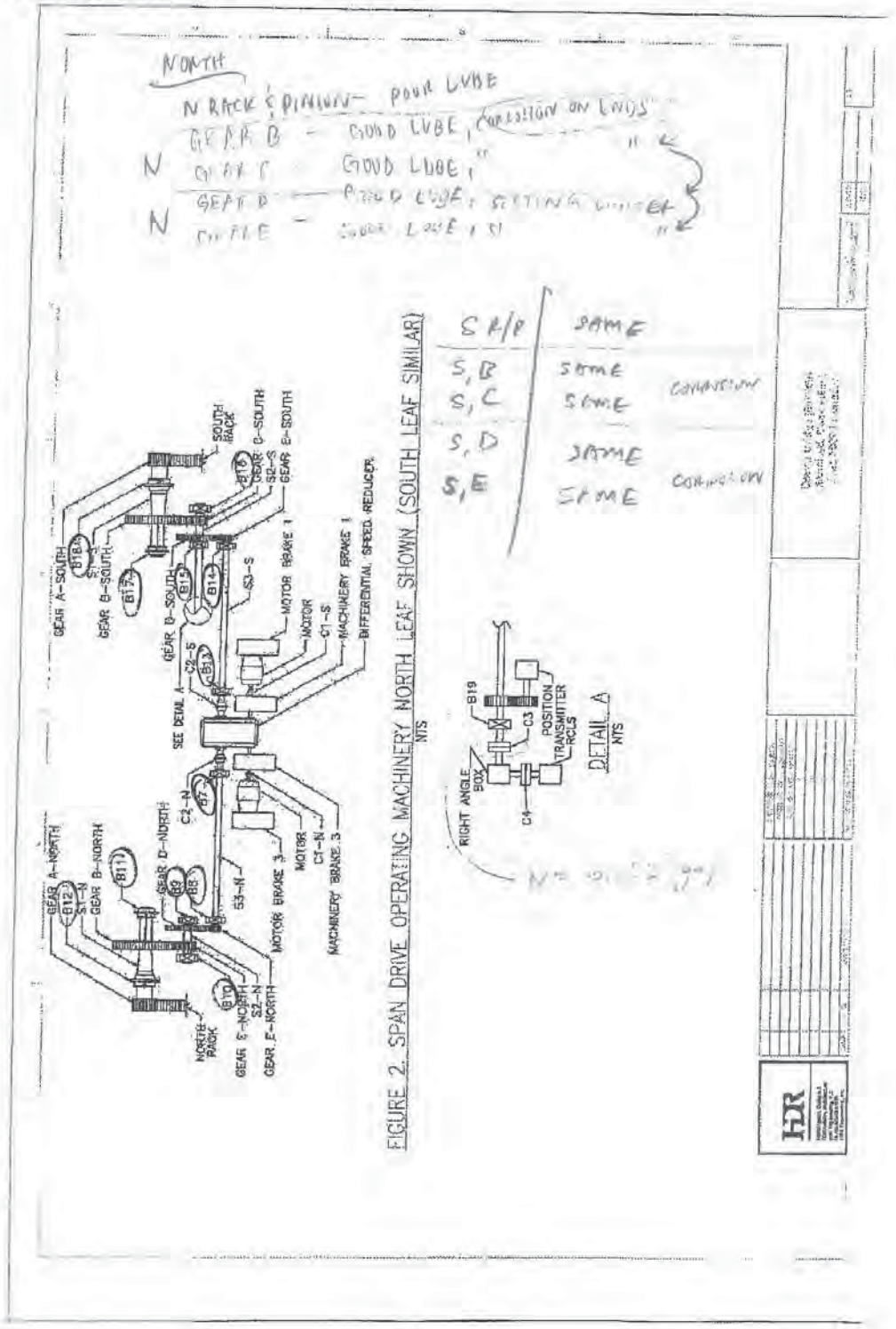

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SPAN LOCK MACHINERY

Span Drive Couplings:

North Leaf Span Lock Couplings		
Coupling Mark	**Lubrication**	**Condition of Cover and Bolts**
LC-1	Poor	Minor surface corrosion
South Leaf Span Lock Couplings		
Coupling Mark	**Lubrication**	**Condition of Cover and Bolts**
LC-1	Poor	Minor surface corrosion

Span Drive Bearings:

Bearing Mark	North Leaf Measured Clearance	South Leaf Measured Clearance	N MEAS	S MEAS
LB-1N	0.015"	0.008"	5	
LB-1S	N/A	N/A	5	
LB-2N	0.007"	0.012"	5	
LB-2S	0.007"	tight	4	
LB-3N	0.006"	tight	—	—
LB-3S	tight	NM	—	—
LB-4N	0.006"	tight	—	—
LB-4S	tight	NM	—	—

* The Original Fit Clearance for all Bearings is 0.0025-0.0073".

SPAN SUPPORT MACHINERY

Centering Device Clearance Measurements		
Location	Clearance	
	Current	Previous
North Leaf, North Side	1"	N/A
North Leaf, South Side	1/4"	N/A
South Leaf, South Side	1/8"	N/A
South Leaf, North Side	1 1/2"	N/A

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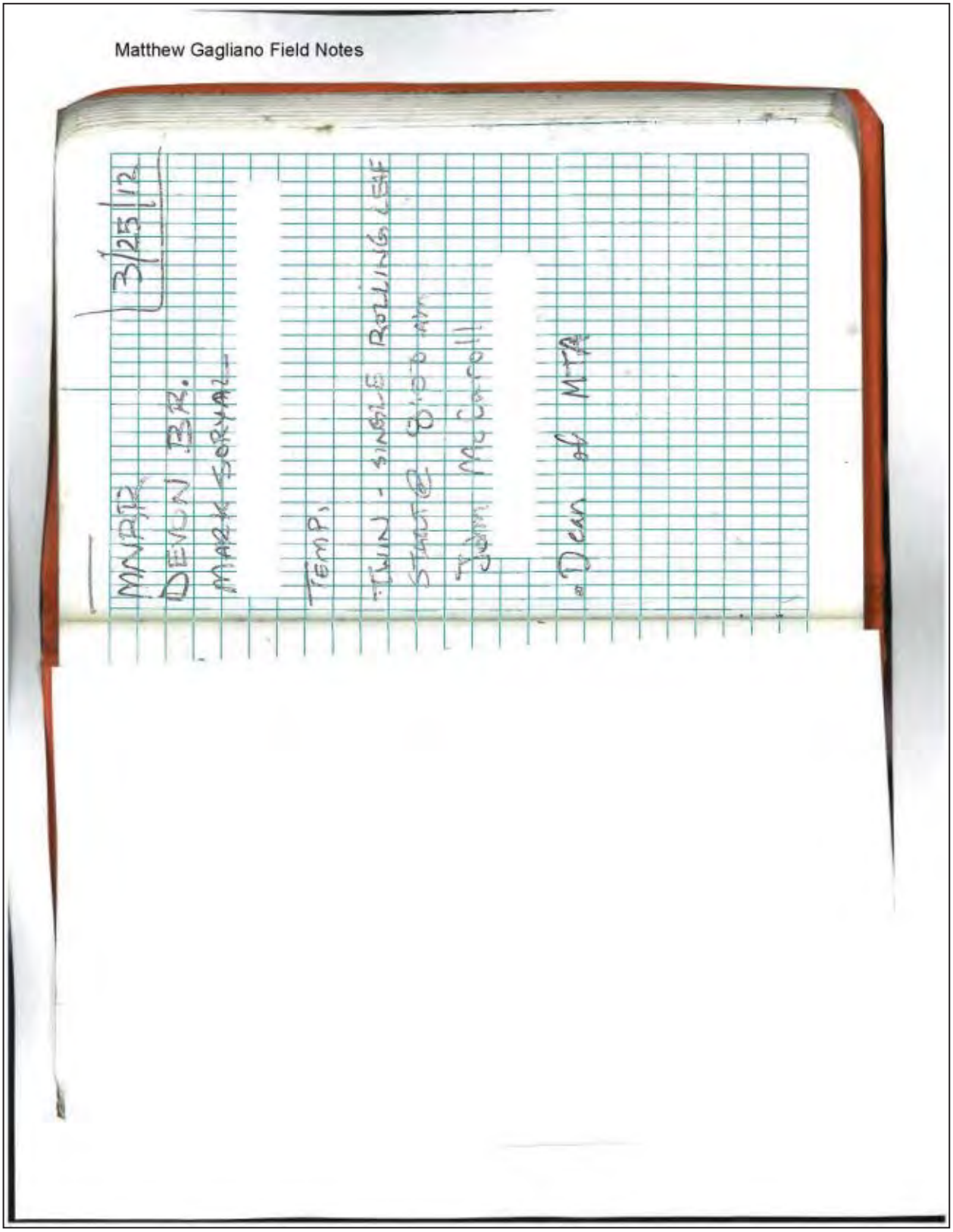

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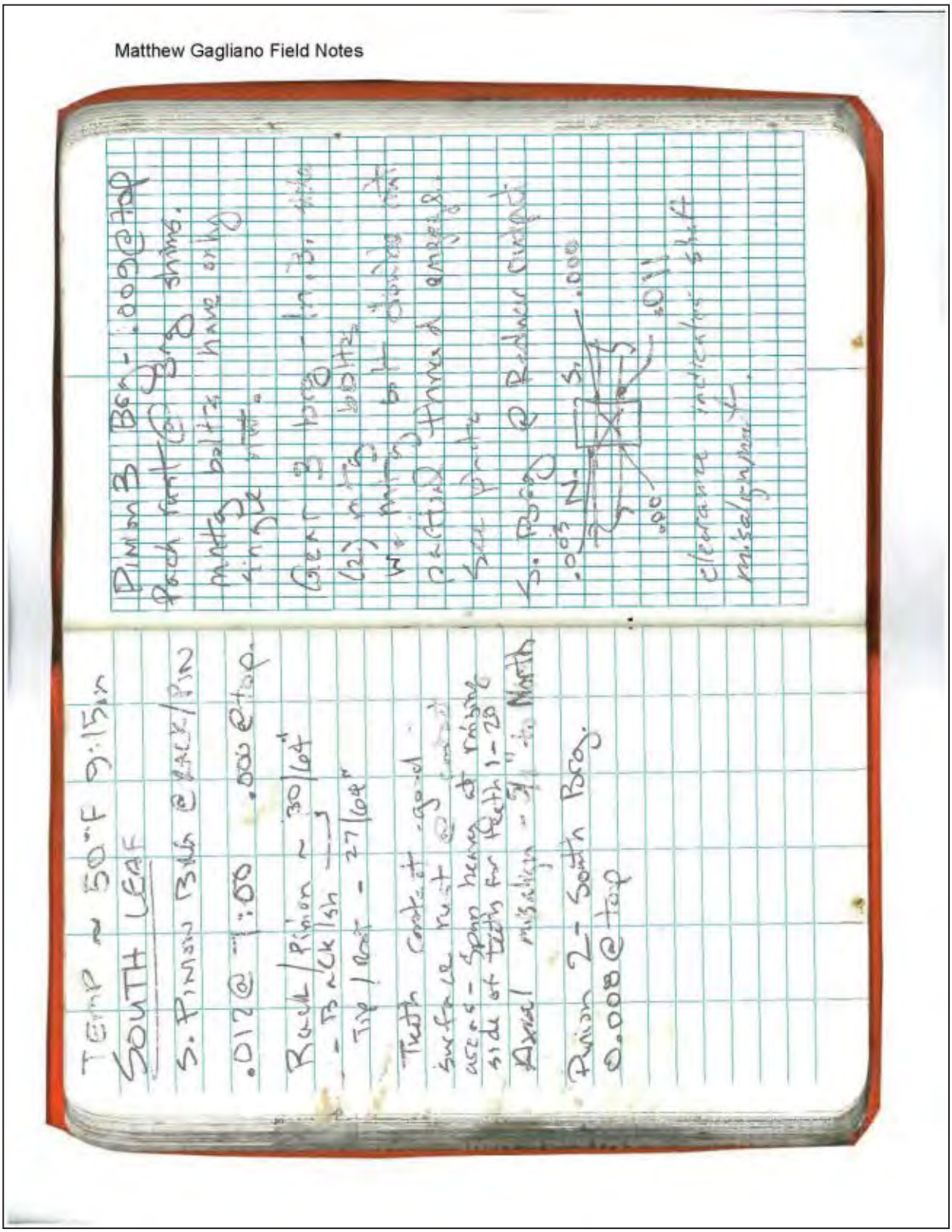

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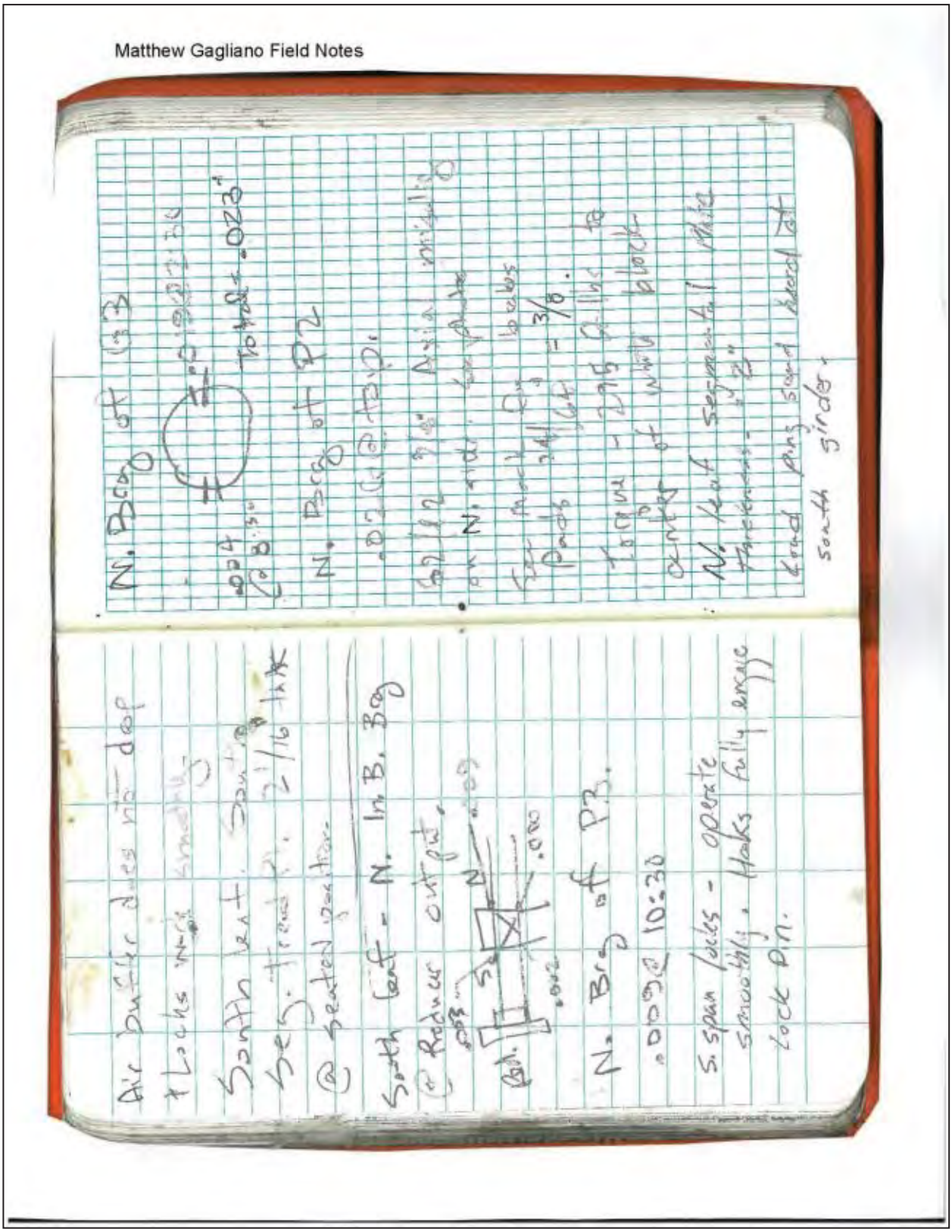

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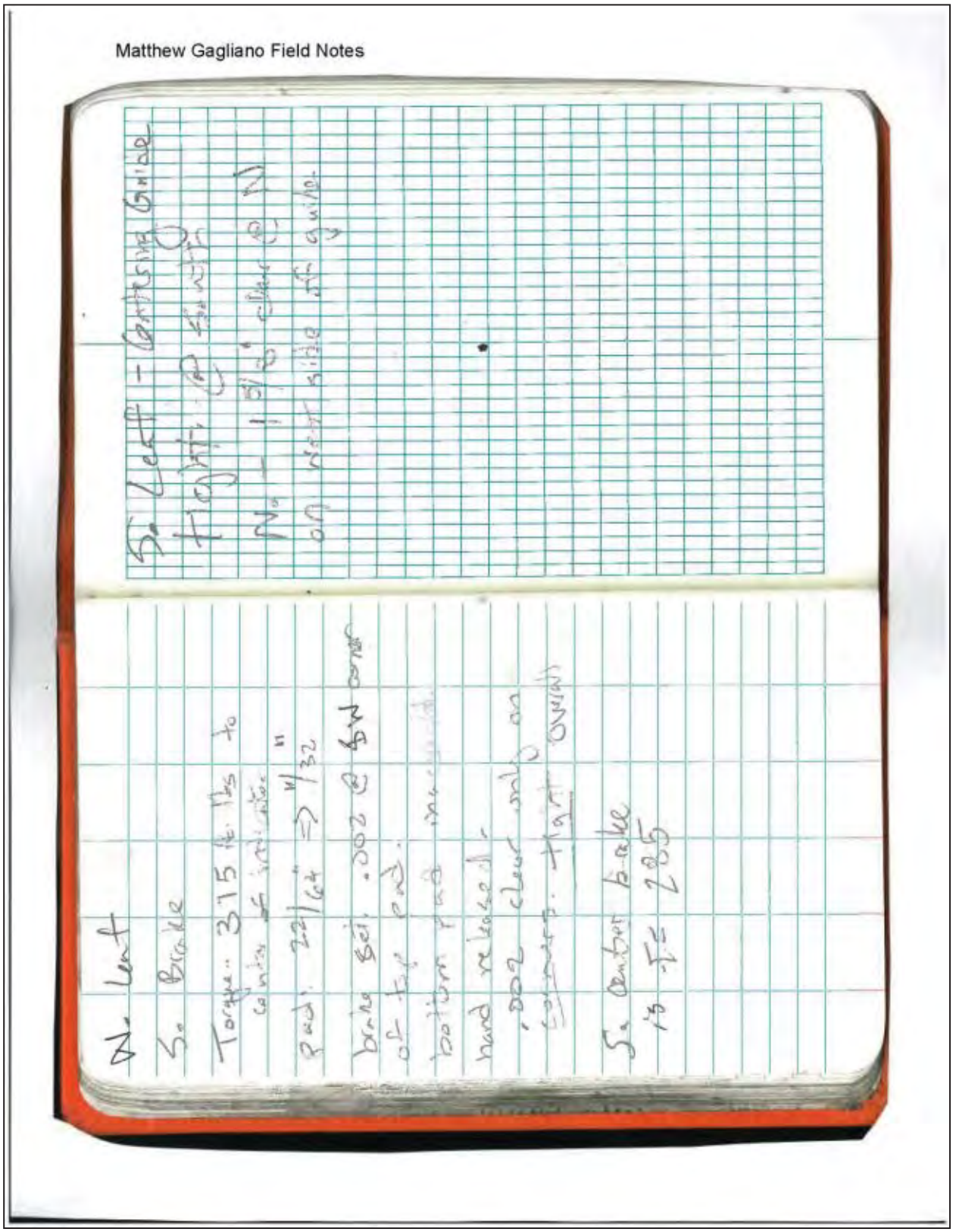

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MECHANICAL APPENDIX E

MECHANICAL PHOTO LOG/CONTACT SHEETS

PHOTO LOG		Project	300-097	MNRR Main Line:
		Bridge	08080R	Over Housatonic
PHOTO NUMBER	**LOCATION**	**PHOTO DESCRIPTION**		
Devon Mech 1		South Rack and Pinion As		
Devon Mech 2		Pinion As and Bearing B12		
Devon Mech 3		Pinion As and Bearing B12		
Devon Mech 4		South Rack and Pinion As		
Devon Mech 5		Pinion As		
Devon Mech 6		South Rack		
Devon Mech 7		South Rack Bolts		
Devon Mech 8		South Rack Bolts		
Devon Mech 9		South Rack Bolts		
Devon Mech 10		South Rack Bolts		
Devon Mech 11		South Rack Bolts		
Devon Mech 12		South Rack Bolts		
Devon Mech 13		South Rack Bolts		
Devon Mech 14		Shaft S1s		
Devon Mech 15		Gear Bs		
Devon Mech 16		Gear Bs		
Devon Mech 17		Pinion Cs		
Devon Mech 18		Pinion Cs		
Devon Mech 19		B16		
Devon Mech 20	South Leaf	Gear Bs		
Devon Mech 21		B17		
Devon Mech 22		B17		
Devon Mech 23		B16		
Devon Mech 24		Gear Ds		
Devon Mech 25		Gear Ds		
Devon Mech 26		Pinion Es		
Devon Mech 27		Pinion Es		
Devon Mech 28		S3s		
Devon Mech 29		B14		
Devon Mech 30		B15		
Devon Mech 31		B15		
Devon Mech 32		B13		
Devon Mech 33		B13		
Devon Mech 34		C2s		
Devon Mech 35		C2s		
Devon Mech 36		Main Reducer		
Devon Mech 37		B16		
Devon Mech 38		B16		
Devon Mech 39		North Rack Bolts		
Devon Mech 40		North Leaf South Rack/South Leaf North Rack		
Devon Mech 41		North Leaf South Rack/South Leaf North Rack		
Devon Mech 42		North Leaf Pinion As/South Leaf Pinion An		
Devon Mech 43	--	Counterweights		
Devon Mech 44		Counterweights		
Devon Mech 45		Counterweights		
Devon Mech 46		Counterweights		

Devon Mech	47	--	Curved Treads and Tracks
Devon Mech	48	South Leaf	South Rack
Devon Mech	49		South Rack
Devon Mech	50		North Tread and Track
Devon Mech	51		Pinion As
Devon Mech	52		North Tread and Track
Devon Mech	53		Pinion As
Devon Mech	54		Gear Bs
Devon Mech	55		General View
Devon Mech	56		North Tread and Track
Devon Mech	57		General View
Devon Mech	58		South Rack
Devon Mech	59		Pinion As
Devon Mech	60		Pinion As
Devon Mech	61		Pinion As
Devon Mech	62		Gerneral View
Devon Mech	63		South Live Load Support
Devon Mech	64		General View
Devon Mech	65		South Live Load Support
Devon Mech	66		South Live Load Shoe
Devon Mech	67		South Live Load Support
Devon Mech	68		North Live Load Support
Devon Mech	69		General View
Devon Mech	70		South Live Load Support
Devon Mech	71		North Live Load Shoe
Devon Mech	72		North Span Lock Hook
Devon Mech	73		North Span Lock LCR-2, Crank 3, and LS-1N
Devon Mech	74		North Span Lock Hook
Devon Mech	75	--	Span Mounting Hardware
Devon Mech	76	South Leaf	Main Reducer Name Plate
Devon Mech	77		Main Reducer Name Plate
Devon Mech	78		Main Reducer Name Plate
Devon Mech	79		Main Reducer Name Plate
Devon Mech	80		Main Reducer Oil Level Sight Guage
Devon Mech	81		Main Reducer
Devon Mech	82		C1s
Devon Mech	83		C1N
Devon Mech	84		C2N
Devon Mech	85		B7
Devon Mech	86		B7
Devon Mech	87		B8 and B9
Devon Mech	88		Pinion EN and Gear DN
Devon Mech	89		Gear DN
Devon Mech	90		Gear DN
Devon Mech	91		Pinion CN
Devon Mech	92		Gear BN
Devon Mech	93		Gear BN
Devon Mech	94		B11
Devon Mech	95		Gear BN

Devon Mech 96	South Leaf	Pinion AN/B12
Devon Mech 97		Position Transmitter Machinery
Devon Mech 98		Position Transmitter Machinery
Devon Mech 99		South Motor Brake Wheel
Devon Mech 100		South Motor Brake Assembly
Devon Mech 101		South Machinery Brake Wheel
Devon Mech 102		South Machinery Brake Assembly
Devon Mech 103	North Leaf	Pinion AN
Devon Mech 104		North Rack
DSC0 6879		Pinion AN
DSC0 6880		Gear BN
DSC0 6881		Pinion CN and Gear BN
DSC0 6882		Gear DN
DSC0 6883		Pinion EN
DSC0 6884		B8/B9
DSC0 6885		B10
DSC0 6886		North Motor Brake
DSC0 6887		B8
DSC0 6888		Brake Assembly Machinery Support
DSC0 6889		B15
DSC0 6890		B14
DSC0 6891		General View
DSC0 6892		South Motor
DSC0 6893		C1s
DSC0 6894		C2s
DSC0 6895		C2N
DSC0 6896		C1N
DSC0 6897		Position Transmitter Machinery
DSC0 6898		C2N
DSC0 6899		C1N
DSC0 6900		Position Transmitter Machinery
DSC0 6901		Position Transmitter Machinery
DSC0 6902		Position Transmitter Machinery
DSC0 6903		Position Transmitter Machinery
DSC0 6904		Main Reducer
DSC0 6905		Main Reducer Name Plate
DSC0 6906		Main Reducer Name Plate
DSC0 6907		Main Reducer Name Plate
DSC0 6908		Main Reducer Oil Level Sight Guage
DSC0 6909		Main Reducer Oil Level Sight Guage
DSC0 6910		B8
DSC0 6911		B9
DSC0 6912		B10
DSC0 6913		B14
DSC0 6914		South Rack
DSC0 6915		B18
DSC0 6916		B16
DSC0 6917		Gear Bs
DSC0 6918		Gear Bs

DSC0	6919		Gear Bs
DSC0	6920		Motor Name Plate
DSC0	6921		North Motor
DSC0	6922		North Motor
DSC0	6923		Main Reducer
DSC0	6924		Main Reducer
DSC0	6925		B14/B15
DSC0	6926		North Leaf South Rack/South Leaf North Rack
DSC0	6927		General View
DSC0	6928		Pinion Es
DSC0	6929		Gear Ds
DSC0	6930		Gear Bs
DSC0	6931		S2s
DSC0	6932		Gear Bs
DSC0	6933	North Leaf	South Rack
DSC0	6934		North Leaf South Rack/South Leaf North Rack
DSC0	6935		North Leaf Pinion As/South Leaf Pinion AN
DSC0	6936		Pinion As
DSC0	6937		B18
DSC0	6938		B16
DSC0	6939		General View
DSC0	6940		Pinion As
DSC0	6941		B16
DSC0	6942		Gear Ds
DSC0	6943		Pinion Cs
DSC0	6944		General View
DSC0	6945		C1s
DSC0	6946		C1s
DSC0	6947		Position Transmitter Machinery
DSC0	6948	--	N/A
DSC0	6949		Pinion AN Lubrication Fitting
DSC0	6950	North Leaf	North Motor Lubrication Fitting
DSC0	6951		South Motor Lubrication Hose
DSC0	6952		General View
DSC0	6953		General View
DSC0	6954		General View
DSC0	6955		General View
DSC0	6956		General View
DSC0	6957		General View
DSC0	6958		General View
DSC0	6959		Pinion AN
DSC0	6960	South Leaf	North Rack
DSC0	6961		North Rack
DSC0	6962		General View
DSC0	6963		General View
DSC0	6964		General View
DSC0	6965		Pinion AN
DSC0	6966		South Track
DSC0	6967		South Track

DSC0	6968	South Leaf	South Track
DSC0	6969		South Track
DSC0	6970		N/A
DSC0	6971		N/A
DSC0	6972		General View
DSC0	6973		General View
DSC0	6974	--	South Leaf Pinion AN/North Leaf Pinion As
DSC0	6975		South Leaf Pinion AN
DSC0	6976	North Leaf	South Rack
DSC0	6977		General View
DSC0	6978		South Rack
DSC0	6979		South Rack
DSC0	6980		South Rack
DSC0	6981		South Rack
DSC0	6982		South Rack
DSC0	6983		North Track
DSC0	6984		Gear Bs
DSC0	6985	--	N/A
DSC0	6986	North Leaf	General View
DSC0	6987		Span Lock Motor
DSC0	6988		Span Lock Pinion LP1/Gear LG1
DSC0	6989		Span Lock Gear LG1
DSC0	6990		Span Lock Bearing LB-1s
DSC0	6991		Span Lock Gear LG1
DSC0	6992		Air Buffer
DSC0	6993		Air Buffer
DSC0	6994		Span Lock Gear LG1
DSC0	6995		Span Lock Pinion LP1
DSC0	6996		Span Lock Auxiliary Coupling
DSC0	6997		South Motor Brake
DSC0	6998		South Motor Brake
DSC0	6999		South Motor Brake
DSC0	7000		South Motor Brake
DSC0	7001		South Machinery Brake
DSC0	7002		South Machinery Brake
DSC0	7003		South Machinery Brake
DSC0	7004		South Machinery Brake
DSC0	7005		North Machinery Brake
DSC0	7006		North Machinery Brake
DSC0	7007		North Machinery Brake
DSC0	7008		North Machinery Brake
DSC0	7009		North Motor Brake
DSC0	7010		North Motor Brake
DSC0	7011		North Motor Brake
DSC0	7012		North Centering Device
DSC0	7013		Air Buffer Rod
DSC0	7014		North Centering Device

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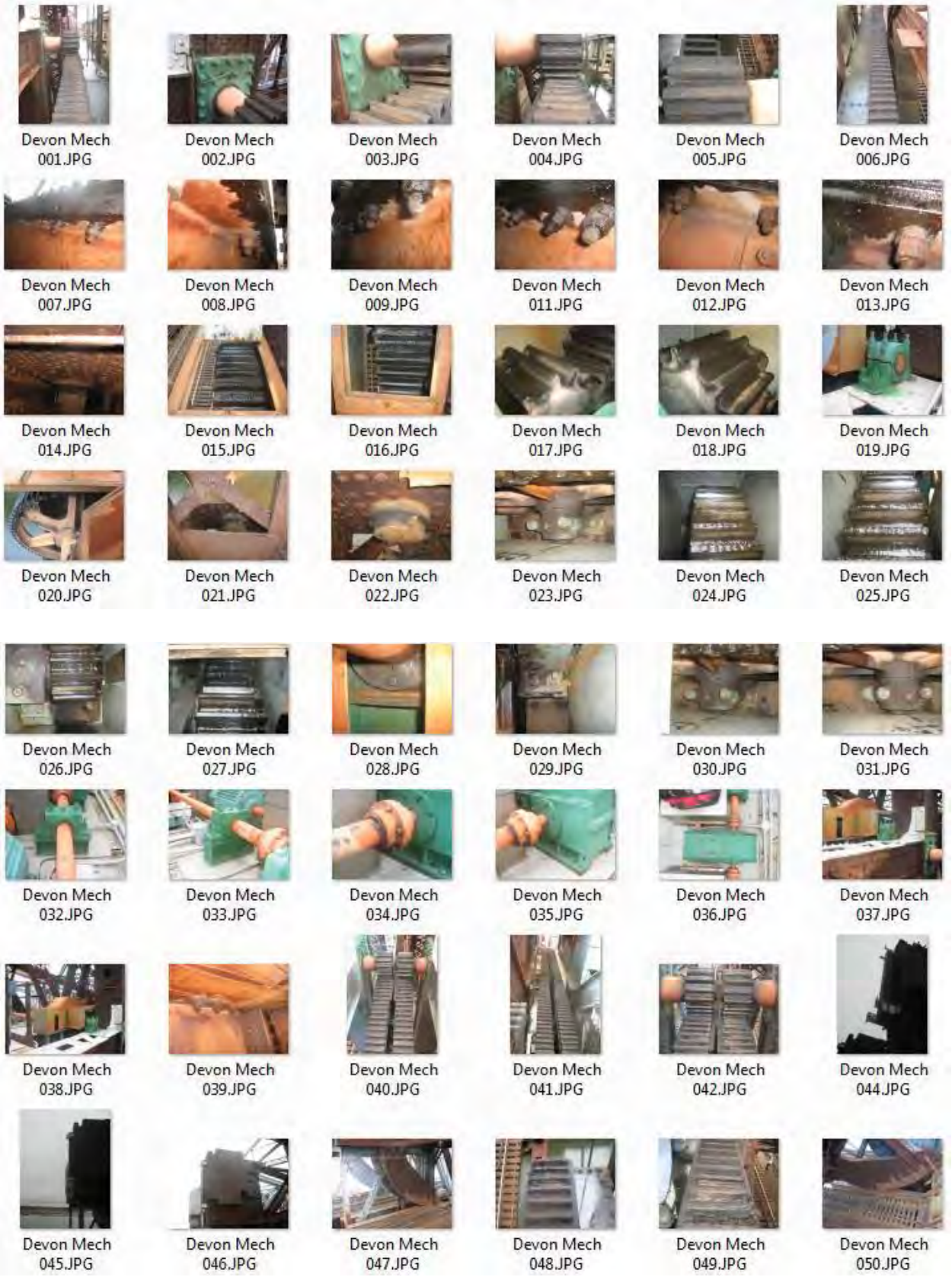

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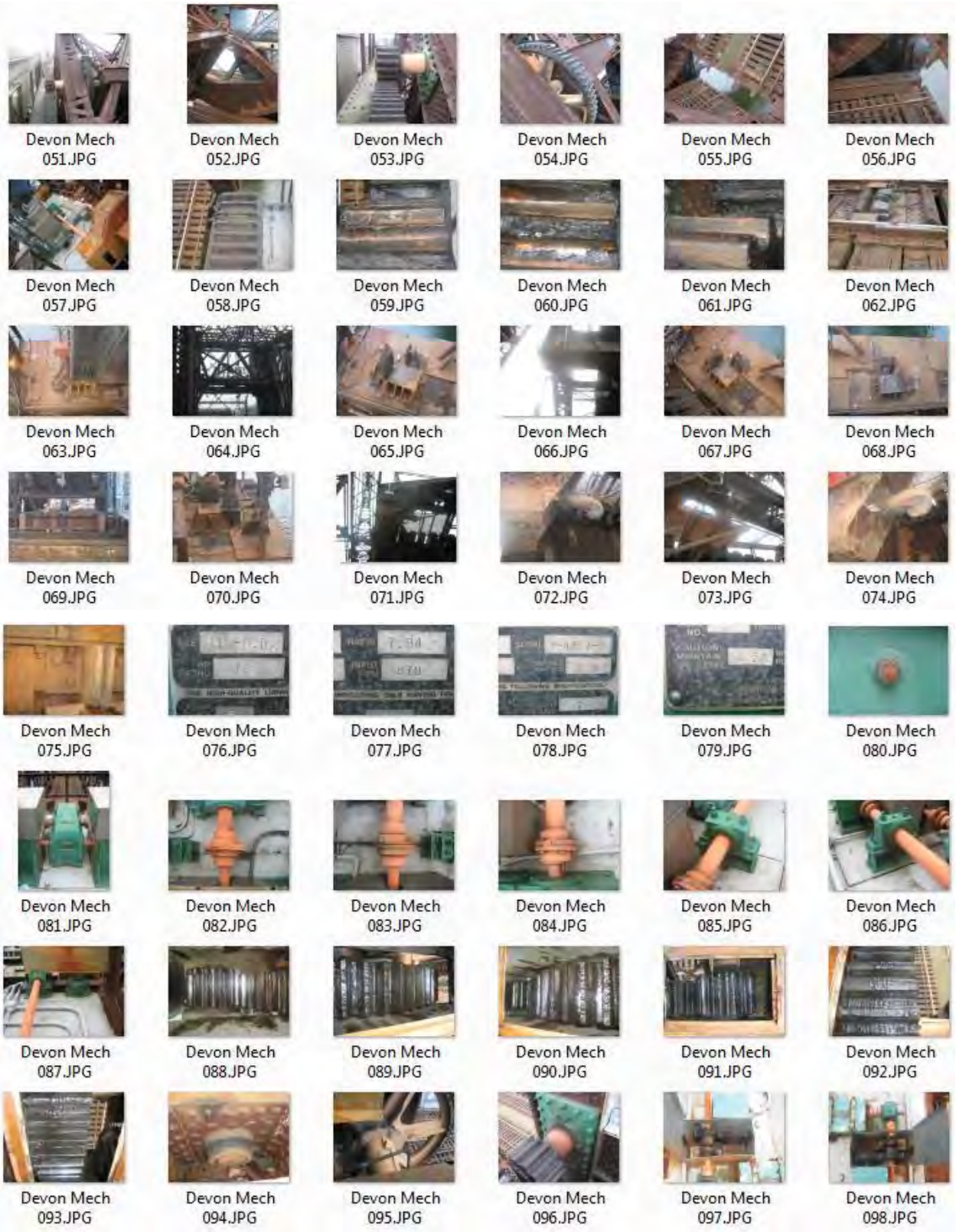

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Devon Mech 099.JPG


Devon Mech 100.JPG


Devon Mech 101.JPG


Devon Mech 102.JPG


Devon Mech 103.JPG


Devon Mech 104.JPG


Devon Mech 105.JPG


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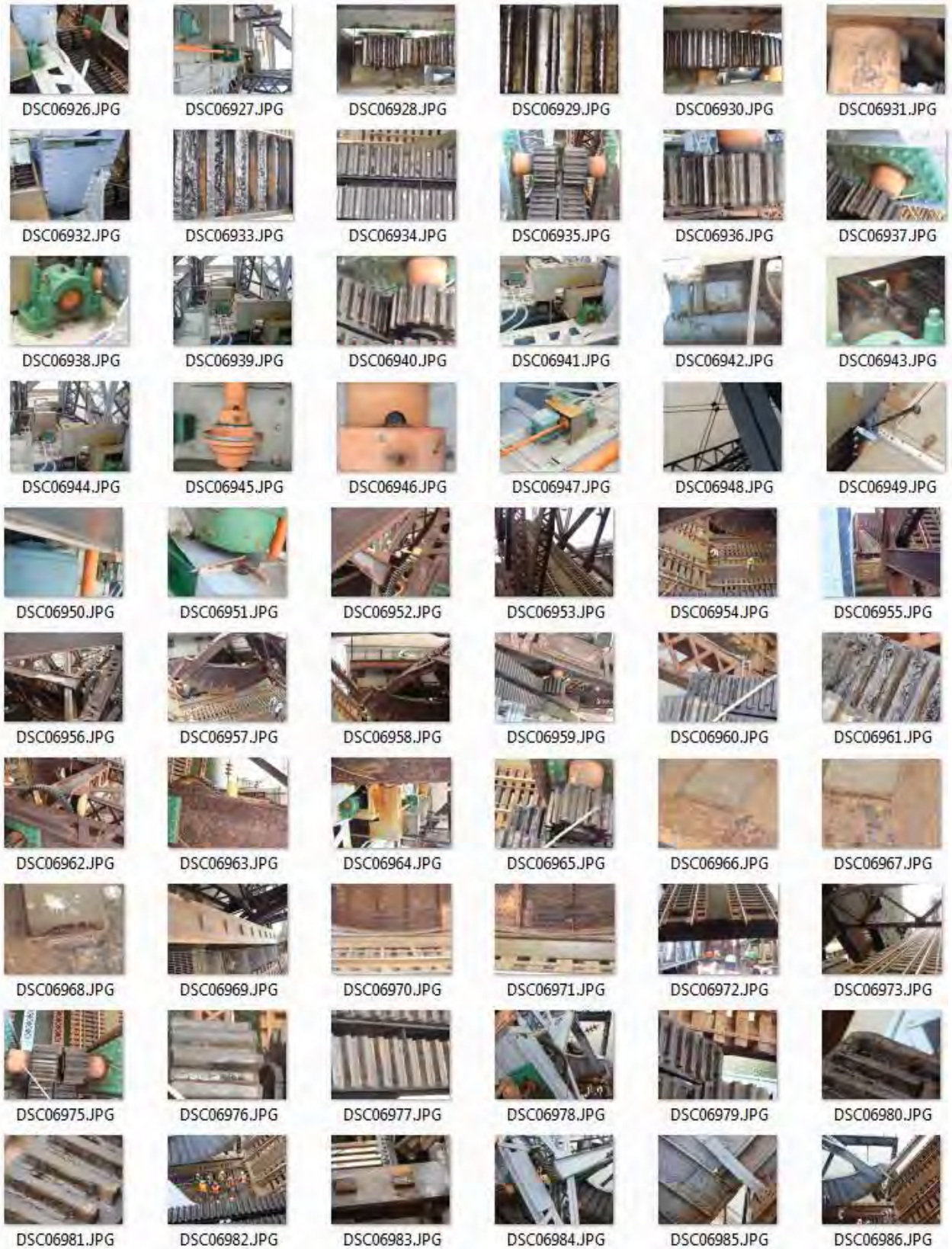

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MECHANICAL APPENDIX F

MOVABLE SPAN NUMERICAL CONDITION INSEPECTION REPORT: MECHANICAL COMPONENTS

H&H Verification Inspection

04/07/2013

MOVABLE SPAN NUMERICAL CONDITION INSPECTION REPORT: MECHANICAL COMPONENTS

COMMON COMPONENTS		BASCULE SPANS		LIFT SPANS	
COMPONENT TITLE	NCR*	COMPONENT TITLE	NCR*	COMPONENT TITLE	NCR*
OPEN GEARING	7	RACK & PINION	7		
REDUCERS	9	TRUNNION ASSEMBLIES	N/A		
SHAFTS	9	SPAN LOCKS	7		
BEARINGS	6	TAIL LOCKS	N/A		
COUPLINGS	9	CURED TREAD PLATES	7		
FASTENERS	7	STRAIGHT TREAD PLATES	7		
MACHINERY SUPPORTS	9	**SWING SPANS**		**MISC. COMPONENTS**	
CENTERING DEVICES	7				
BUFFER CYLINDERS	2				
BUMPER BLOCKS	N/A				
EMERGENCY DRIVES	N/A				
LIVE LOADS	7				
BRAKES	8				

MECHANICAL CONDITION RATING: 7

INSPECTION DATE: 03/25/2012

*NCR = NUMERICAL CONDITION RATAING; SEE BELOW:

NUMERICAL CONDITION RATING (NCR) INFORMATION

9	**NEW**	Displays no wear and/or deterioration: excellent functional performance.
8	**EXCELLENT**	Displays insignificant wear and/or deterioration: performs Intended function with high degree of reliability and effectiveness.
7	**GOOD**	Very early wear/deterioration: performs with high degree of reliability and/or effectiveness.
6	**FAIR**	Early measurable wear/deterioration: performs with little reduction in reliability and/or effectiveness
5	**ADEQUATE**	Moderate wear/deterioration: performs with moderate reduction in reliability and/or effectiveness
4	**MARGINAL**	Advanced wear/deterioration: performance marginal: corrective actions required within one year.
3	**POOR**	Severe wear/deterioration: performance poor and/or unreliable: corrective actions required within six month.
2	**URGENT**	Movable span operational highly unreliable or dangerous and should be restricted: corrective action required as soon as possible.
1	**CRITICAL**	Movable span operation prohibited pending replacement or repair.
0	**FAILURE**	Movable spans will not operate without replacement or repair.
N/A	--	Not Applicable

ELECTRICAL INSPECTION REPORT

H&H Verification Inspection
04/07/2013

I. EXECUTIVE SUMMARY

A Type I field inspection of the electrical systems on Devon Bridge was conducted on March 25th, 2012 by Hardesty & Hanover for the Connecticut Department of Transportation (CONNDOT). The existing conditions of the electrical system were evaluated by hands-on inspection as well as a comparison to the previous inspection report.

The following are the rating descriptions used in this report for each component:

- Good – Exhibiting insignificant wear and/or deterioration. Performs intended function with high degree of reliability and effectiveness.
- Fair – Exhibiting early measurable wear and/or deterioration. Performs with little reduction in reliability and/or effectiveness.
- Poor – Exhibiting severe wear and/or deterioration. Performance is poor and/or unreliable
- Critical – Operation of movable span is prohibited pending replacement or repair.

The general condition of the bridge's electrical system was found to be in good condition and suitable for continued use with proper maintenance. The overall condition rating of the bridge electrical system was found to be a 7-8. Some of the maintenance items noted in the previous report are still present. However, some new deficiencies were noted and are presented in this report. No major deficiencies were found in the bridge.

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1

II. REPAIR RECOMMENDATIONS

Recommendations for repair of existing deficiencies are prioritized to immediate, 1 week, 2 months, 6 months, and 2 years. Recommendations that were listed in the previous inspection report are labeled in parenthesis with the previous priority.

IMMEDIATE (Priority A) – no recommendations

1 WEEK (Priority B) – no recommendations

2 MONTHS (Priority C)

1. Re-lamp green south leaf, south navigation light and the south leaf, north in-board red lamp.
2. ~~Replace broken flexible conduit attached to north span position indicator.~~
3. Repair/replace south span seated switch #2 seated limit switch bent plunger.
4. Repair/replace the operating handles for the circuit breakers located in the individual motor buckets in the MCC that cause nuisance trips.
5. Replace the fasteners for the protective enclosure around the rotor resistors located on the machinery platform of the bridge for the four main drive motors.
6. ~~Realign and tighten several conduit clamps on the elevated machinery platform above the tracks that have become disengaged from the support.~~

1

Unable to open both spans to illuminate green to check navigation light.

Taped.

1

Clamps added.

1

6 MONTHS (Priority D)

1. The interlock for the door on the South Span Motor No. 4 Motor Disconnect is defective and does not interlock properly to assure the door is closed prior to closing the disconnect switch. Repair or replace the switch. Some of the dual rated lugs used for the grounded conductors mounted on the bottom of the disconnect switches exhibit evidence of corrosion and should be replaced.
2. Repair operational enclosure heaters for ~~all motors and brakes~~.
3. The hand release limit switches for the brakes on the South Leaf Span Drive Motors have been adjusted by rotating the nonadjustable limit switches on one of the mounting screws. The switch should be reset to so that at least two screws are used to hold it in place to assure that the switch performs its function in a reliable manner.

1

1 motor brake heater.

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2 YEARS (Priority E)

1. Provide closed circuit television systems (CCTV)
2. Provide standby generator.
3. Fix/replace Allen-Bradley panel view on the PLC cabinet.
4. The marine signaling horns which are located at the ends of the fender system were not fastened in-place; however this was resolved during the course of the inspection. Nevertheless, the connection of the interconnecting cable at the conduit terminal on the south horn is degraded and the horn motor body joints have been taped to prevent the entrance of moisture. This horn should be replaced.
5. The fender light conduits have become disengaged from many of the one-hole clamps as it runs along the top of the fenders. The one-hole clamps should be replaced with corrosion resistant two-hole clamps.
6. The digital span position indicators mounted on the span motor drive door enclosures are not operational. The existing position indicator models are obsolete and not available. A replacement position indicator compatible with the existing selsyn field devices is recommended.

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III. INTRODUCTION AND GENERAL DESCRIPTION

INTRODUCTION

The Devon Bridge consists of two (2) adjacent, single leaf rolling lift bascule spans. The bridge operator's control room is located at the southwest corner of the bridge. The north leaf carries tracks 1 and 3, while the south leaf carries tracks 2 and 4. The leaves are operated independently, whereas, either leaf can be raised individually while the other remains closed.

The bridge is provided with 480-volt three-phase commercial utility power. The commercial electrical power enters an automatic transfer switch in the electrical room. There is no emergency back-up power source.

The leaf(s) are operated from a common control console connected to the span control PLC. Each leaf is provided with its own set of interlocks, drive motors, brakes, and span locks.

GENERAL DESCRIPTION OF ELECTRICAL SYSTEMS

The electrical equipment of each leaf consists of:

1. Two main span wound rotor drive motors with associated primary thyristor drives. Each motor/drive combination is capable of operating its leaf independently and is either selected by the operator or placed into an alternating cycle. The motors are provided with secondary resistors in order to shape their speed torque curves for proper operation with the primary thyristor leaf motor drives.

2. Two thruster type motor brakes connected to each leaf drive motor opposite drive end shaft and two thruster type machinery brakes connected between the output shaft of the motors and the input shafts on the primary reducer.

3. Two span lock brake-motor with additional solenoid actuated brakes.

4. In-sight local disconnect switches for all motors and brakes.

5. Rotary cam limit switches used to provide control, interlocking and indication for leaf position and lock position.

6. Two leaf seated plunger switches.

7. A selsyn type leaf position transmitter used to drive a selsyn type leaf position indicator to show the operator the real time position of each leaf.

IV. SCOPE OF INSPECTION

PURPOSE AND SCOPE OF INSPECTION

The purpose of this inspection was to perform an on-site visual and aural examination, including selected measurements and operational testing of the Devon Bridge electrical systems. The inspection was performed in accordance with The American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual, BIM Sec. 6.2.11 and the AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual.

INSPECTION METHODOLOGY

A Type I field inspection of the electrical systems on Devon Bridge was conducted on March 25th, 2012 by Hardesty & Hanover for the Connecticut Department of Transportation (CONNDOT). The electrical field inspection was performed by Alec Noble, P.E. and Samih Bisharaa. The inspection was aided by the efforts of CONNDOT engineering officials and Metro-North maintenance crew and bridge operators. Their efforts included sharing valuable insight of the bridge's history and bridge openings.

The field inspection consisted of visual/aural observations and operational testing of the bridge and its electrical systems to better establish their condition. At accessible locations, electrical readings were taken and compared to previous measurements. The conditions of the inspected components are then labeled as one of the following; good, fair, poor, and critical. Recommendations were then presented, depending on priority, to be completed immediately or within 1 week, 2 months, 6 months or 2 years.

Utility Service Source, Incoming Service Equipment, Motor Control Center, Span Motor Drives, Programmable Logic Controller (PLC) Controls, Uninterruptable Power Supply (UPS), Control Desk, Leaf Drive Motors, Brakes, Disconnect Switches, Rotary Cam Limit Switch, Leaf Seated Limit Switch, Navigation Lighting, General Lighting, Conduit and Raceway, Junction Boxes, Wire and Cable, Enclosures, Telephone, Radios, and Closed Circuit Television System were inspected. Measurements of output current were taken; all measurements were graphed and can be found in Appendix A.

V. EXISTING CONDITIONS

5.1 UTILITY SERVICE SOURCE

The incoming service is a three phase four wire 480/277 volt provided by the local utility. The bridge electrical distribution equipment is fed from a remote service utilizing messenger supported aerial cables. The feeder cable is well supported and appears to be in good condition.

5.2 INCOMING SERVICE EQUIPMENT

The incoming feeder is terminated within a fused disconnect switch in the electrical room. The load side of the disconnect switch feeds an automatic transfer switch (ATS) located adjacent to it. The ATS feeds the main breaker of the motor control center (MCC) to provide power for span operation, as well as a transformer and lighting panel for auxiliary systems. The service equipment is in generally good condition

5.3 EMERGENCY GENERATOR

No emergency generator or any other alternate source of incoming power was present on the bridge. It is recommended that a standby generator be installed as backup power.

An ASCO Automatic transfer switch is provided for the bridge. Only the main incoming feeder is connected to the switch since there is no backup power supply. The switch appears to be in good condition.

5.4 MOTOR CONTROL CENTER

Power distribution to the motors, drives and auxiliaries is by means of a modular motor control center (MCC). The north and south spans are provided with separate power buses that are energized through a line contactor under the control of the signal system to allow for safe span operation. The MCC is a Culter Hammer Unitrol motor control center with the following name plate information:

Model No. 6AF1359975-A

VOLTAGE	480V	FREQUENCY	60HZ
AMPERS	800A	PHASE	3PH

The MCC is located in the bridge electrical room and contains line contactors and circuit breakers to isolate/select the north and south leaves, starters for the toe locks and brakes, control power breaker and transformer, a circuit breaker for the lighting transformer, unit heaters #1 for operator's room unit heater #2 for hallway and unit heater #3 for power room (See Photo E-01 and photo E-02).

The motor starters and circuit breakers were visually inspected and found to be in good condition. Some circuit breakers were actuated on and off and were operated without

any issues. The interior of the MCC looked mostly clean and neatly arranged and the wire terminations appeared to be tight. There was some evidence of rodent droppings in some of the MCC buckets. There was, no more than anticipated, minor wear on the contact assemblies (See Photo E-03). It was noted that the size 5 isolation contactors are provided with DC coils and rectifiers and that the north contactor rectifier had failed and had been replaced – there is scorching and soot present surrounding the contact areas. In addition, many of the circuit breaker handles are provided with screws to keep them in the on position. As per maintenance staff, without the screws the handles will shut the breakers off due to vibration.

5.5 SPAN MOTOR DRIVES

The bridge is provided with four drive cabinets located in the operator's house. The leaf drive motor controllers are Westinghouse primary thyristor types (See Photo E-04 and Photo E-05). Each drive is provided with a primary resistor bank located on top of the associated drive cabinet (See Photo E-06). Each drive can control either of the two motors for that span through a manual transfer H bridge; although under normal operation drive 1 operates motor 1. This is controlled by heavy duty power transfer switches on the door of the drive cabinets. The control system can automatically alternate operation between the systems for each leaf, or the operator can select the drive to be used for a leaf. The south leaf is controlled by drives No. 2 and No. 4 and the north leaf is controlled by drives No. 1 and No. 3, named for the tracks above each drive motor. The drives are in good condition, inside the cabinets all electrical components appeared clean and all cable terminations appeared to be tight with cables neatly bundled together. There were no signs of excessive heat buildup or corrosion. The digital span position indicators mounted on the span motor drive door enclosures are not operational. The existing position indicator models are obsolete and not available. A replacement position indicator compatible with the existing selsyn field devices is recommended. The previous inspection noted that some of the resistor covers were missing or failed – this has since been repaired although some of the covers are bent. Each drive receives speed feedback from a tachometer/overspeed assembly coupled to each motor. The previous inspection report noted one had failed – this was not noted.

5.6 PROGRAMMABLE LOGIC CONTROLLER (PLC) CONTROLS

The bridge is provided with an Allen Bradley PLC Programmable Logic Controller (PLC) system located in the bridge house electrical room. The PLC system is provided with dual processors, one operational and the other on standby in case of normal processor failure. There is an HMI screen mounted on the door of the PLC cabinet, this screen is out of service. There was one jumper on the PLC terminal blocks. The rest of the PLC system and cabinet all appear to be in good condition (See Photo E-07 and Photo E-08) all terminations appeared tight and there were no signs of excessive heat buildup. The interior was clean and the wiring bundled together on the floor of the cabinet.

5.7 UNINTERRUPTABLE POWER SUPPLY (UPS)

The UPS was visually inspected and found to be in generally good condition. The UPS is a commercial/industrial unit installed to maintain power to the PLCs. No deficiencies were identified with the UPS (See Photo E-09).

5.8 CONTROL DESK

Bridge operation is controlled from the control desk located in the control room in the bridge house. It is a vertical style cabinet with a small desk portion housing the controls used by the operator in operating the bridge. It was operating correctly at the time of the inspection and appeared to provide complete system information. In addition, the control desk is equipped with selsyn north and south span position indicators, AC voltmeters and amp meters, and emergency stop button and several control switches to operate the span. The interior of the desk was in good condition, with all wiring appearing secure and no debris. All terminations appeared tight and there were no signs of excessive heat buildup (See Photo E-10 and Photo E-11).

5.9 LEAF DRIVE MOTORS

The span drive motors were inspected and found to be in good condition. Each leaf is provided with two (2) - 75 HP wound rotor leaf drive motors. The bridge is provided with total of four (4) - 75 HP motors, manufactured by Harnishfager. The span drive motors have the following nameplate data:

SERIAL	1301-91-991	TYPE	HEW-444X
PROD NO.	444M 1205-E	MAX AMPS.	95
PH	3	HZ	60
HP	75	ENCL	TENV
RPM	870	STYLE	
VOLTS	230/460	TIME RATING	30

The motors are securely bolted to their supports. Terminal boxes were found to be in good condition and securely attached to the motor frames, with the interiors clean, well terminated and the insulation on the splices in good condition. The brushes on all motors are only making approximately 40 percent contact; under the the intermittent duty the effort required to ensure greater contact is not warranted. The previous inspection noted scoring on the brushes – this was not noted. The interiors of the motors do not show evidence of over greasing. During several bridge operations of the span, there was no excessive vibration, heat buildup or noise noted. All conduit and wiring were found to be securely intact and in satisfactory condition (See Photo E-12 and Photo E-13). Insulation resistance readings are in the Appendix and show all motors are in good condition. During the inspection the enclosures were cold indicating that either anti-condensation heaters are not provided or are not operational.

Each motor is provided with a secondary resistor to shape the speed torque characteristics. The resistors all appeared in good condition; although some cover hardware is missing and should be replaced.

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5.10 MOTOR BRAKES

The leaf drive brake system was inspected and found to be in good condition. Each leaf is provided with two motor brakes and two machinery brakes. The brakes are of the electro-hydraulic thrustor type, acting on brake wheels pressed onto the motor extended rear shafts and the gearbox input shafts. The brake thrustor motors and frames are all in good condition, with no noted wear or deterioration. Each brake is provide with an enclosure to prevent debris from building up on the mechanisms – these were all in good condition, (See Photo E-14). Each brake is provided with three limit switches to indicate manual release, on and off, and for control interlocking. All the limit switches are functional and in very good condition although several of them need to have additional mounting hardware to securely fasten them, (See Photo E-15). The hand release limit switches for the brakes on the South Leaf Span Drive Motors have been adjusted by rotating the nonadjustable limit switches on one of the mounting screws. The switch should be reset to so that at least two screws are used to hold it in place to assure that the switch performs its function in a reliable manner. The previous inspection noted poor insulation resistance values for some of the brakes. All brake were tested at their disconnect switches and the values were greater than 500 megohms which indicates that the motors are in good condition. ~~During the inspection the enclosures were cold indicating that either anti-condensation heaters are not provided or are not operational.~~

The two machinery brake heaters were functioning and 1 of 2 motor brake heaters were functioning.
1

5.11 DISCONNECT SWITCHES

The disconnect switches are in good condition. Each drive motor, span lock motor and brake motor is provided with heavy duty, in-sight disconnect switches, located at the span drive motors and brakes, span locks and room unit heaters. All switches were found to be in good operating condition. There was no evidence of rust or corrosion although there was some oxidation on some of the dual rated ground terminal lugs. Those switches operated correctly. The enclosures for all disconnect switches are rated NEMA 4X stainless steel. The exterior and the interior of the motor disconnect switches were all dry and free of corrosion. It was noted that the interlock on the handle mechanism for the south span motor no. 4 is intermittent and the door doesn't have to be closed to close the switch.

5.12 SPAN LOCK MOTOR

Each leaf is provided with one span lock which holds the span in the fully seated position. The motors are located in the center of the span between the bridge girders. Span lock motors were inspected and found to be in good condition. All span lock motors operated smoothly with no vibration, heat build-up or noise (See Photo E-16). During the inspection the enclosures were cold indicating that either anti-condensation heaters are not provided or are not operational.

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The span locks motors are manufactured by Reuland and have the following nameplate data:

SERIAL	915608A-2	TYPE	NOA53-79.69
PROD NO.	0010E-18AH-0019	FRAME	182
PH	3	HZ	60
HP	1	ENCL	TENV
RPM	1200/13	STYLE	AER
VOLTS	460	TIME RATING	30
AMPS	2.1		

Each motor is provided with an electric brake assembly. The brakes are provided with manual release mechanisms and a hand crank shaft extension for the motor. The motor and brake associated with the toe locks are provided with individual disconnects switches. The current drawn by the toe lock motors was data logged and the graphs are provided in the Appendix. The recorded currents indicate that the motors are operating at close to nameplate operating currents of 2.1 amps.

5.13 ROTARY CAM LIMIT SWITCH

The rotary cam limit switches were inspected and found to be in good condition (See Photo E-17). The span position limit switches are eight position cam switches, giving positive feedback for the interlocking of the drives, controlling the navigation lights and providing position indication icons on the panel view. The switches are in good condition with no excessive exterior corrosion and securely connected on the interior. The switches have been provided with desiccant pellets to keep the interiors dry (See Photo E-20). The previous inspection noted excessive corrosion on one of the cam switches. This was not found during this inspection. The toe locks have been provided with seven circuit cam switches and were in good condition. The previous inspection noted a plug and cord heater for the span lock limit switches – this was not noted.

5.14 LEAF SEATED LIMIT SWITCH

The leaf seated indication consists of four plunger operated leaf seated switches. Each span is provided with two plunger type seated limit switches, one switch on each side of the span. The switches contact a strike plate on the pier to indicate span seated to the control house. The span seated limit switches were securely closed and there was no evidence of water entry (See Photo E-19).

The South span seated switch #2 Seated Limit Switch was found to have a bent plunger. It is recommended to replace or fix the plunger (See Photo E-18).

5.15 NAVIGATION LIGHTING

Unable to check green lights during inspection. 1

Navigation lighting was inspected and found to be in fair condition. There are fender navigation lights on the west pier fender and east pier fender. There are two pivoting bascule clearance navigation lights at the toe end of the leafs, one on the north side of the north leaf and one on the south side of the south leaf. These are considered outboard and are red and green to control marine traffic. There are also two fixed navigation lights at the toe of each leaf, one on the north side of the south leaf and one at the south side of the north leaf. These are considered inboard, are red and also are

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to control marine traffic and can only be seen from the water when the opposite leaf is partially raised to assure that marine traffic is notified that the bridge is not completely open even if one leaf is fully open (See Photo E-21 and Photo E-22). The outboard lights remain red until leaves are fully raised, at which point the red extinguishes and the green illuminates. Due to maintaining rail traffic operational, the inspection of the span operations were conducted one leaf at a time and it could not be determined if the navigation lights change to green with both spans opened. Some lamps need to be replaced – specifically noted were south leaf south green lamps and the south leaf north inner red lamp.

The fender system is provided with fender lights essentially in conformance with USCG regulations. These were all operational at the time of the inspection, however the type SOW cable interconnecting the fixtures has numerous failures on the one hole straps and the cable is not firmly fastened – additional two hole type straps should be provided to properly secure the cables.

5.16 GENERAL LIGHTING

The general lighting is in good condition. The control house general purpose lighting is in good condition. The remainder of the bridge lighting is composed of industrial fixtures mounted on each leaf in the area of the machinery and on the access steps. The span locks are not provided with receptacles or fixtures as reported in previous report. The previous report noted failed receptacle covers and exposed terminals – this was not noted.

Clamps added. 1

5.17 CONDUIT AND RACEWAY

The conduit and raceway system on the bridge is in generally good condition, with no obvious corrosion or major failures although there are many conduits that are loose or ~~have missing conduit clamps.~~ Much of the below deck conduit is supported on electrical framing channel supports secured to the structure with beam clamps. This type of connection can be problematic in a high vibration environment and requires regular maintenance. Damaged flexible conduit attached to north span position indicator was found ~~which needs to be replaced~~ (See Photo E-23 and Photo E-24).

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to be taped. Flex conduit from span motor #2 tachometer / speed switch hub at pull box has sealant over it.

5.18 JUNCTION BOXES

The junction and pull boxes are in good condition, with minimal corrosion noted. All boxes were securely closed and there was no evidence of water entry or moisture.

5.19 WIRE AND CABLE

The wire and cable is in good condition. The wire and cable are housed in conduit, raceways, cabinets and boxes. An insulation resistance test was performed on the 600 volt class motor cables which were found to be acceptable. In examining the MCC, it was noted that some field wiring is No.14 AWG as opposed to the AREMA specified No.12 AWG. It would not be necessary to replace the non-compliant wiring.

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5.20 ENCLOSURES

The enclosures are in generally good condition.

5.21 TELEPHONE

The telephone system is in good condition.

5.22 RADIOS

The radio system is in good condition. The radio is used by the operator to communicate with railroad and marine traffic.

5.23 CLOSED CIRCUIT TELEVISION SYSTEM

Closed circuit television system was not provided on the bridge. It is recommended to provide closed circuit television system with the display monitor located in the control house to display the camera views of various locations around the bridge span and navigation channel. It will allow the operators to check the span and the channel before proceeding with the operation of the span and to monitor the activity in the bridge vicinity.

5.24 MARINE SIGNALLING HORN

1

1

horns

horns were

The bridge is provided with ~~a~~ USCG mandated marine signaling ~~horn~~. The ~~horn was~~ operational, and some of the poor mounting details noted in the previous report had been corrected. Nonetheless, the conduit connections are poor, with the inlet connector ~~taped~~ to reduce moisture entry and the horn installation in generally poor condition. It is recommended that the horn and its associated conduit be replaced.

North Horn - Sealant material has been placed over inlet connector.
South Horn - Inlet connector was still taped.

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APPENDIX A

ELECTRICAL READINGS

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NO REVISIONS

Insulation Resistance Readings

Feeder	Insulation Resistance (MΩ)
Span Motor #1	>999 MΩ
Machinery Brake #1	>999 MΩ
Motor Brake #1	>999 MΩ
Span Motor #3	>999 MΩ
Machinery Brake #3	>999 MΩ
Motor Brake #3	>999 MΩ
Span Motor #2	>999 MΩ
Machinery Brake #2	>999 MΩ
Motor Brake #2	>999 MΩ
Span Motor #4	>999 MΩ
Machinery Brake #4	>999 MΩ
Motor Brake #4	>999 MΩ

All readings taken at the device disconnect switches. Overall, the insulation of the motors and conductors throughout the electrical system is in good condition.

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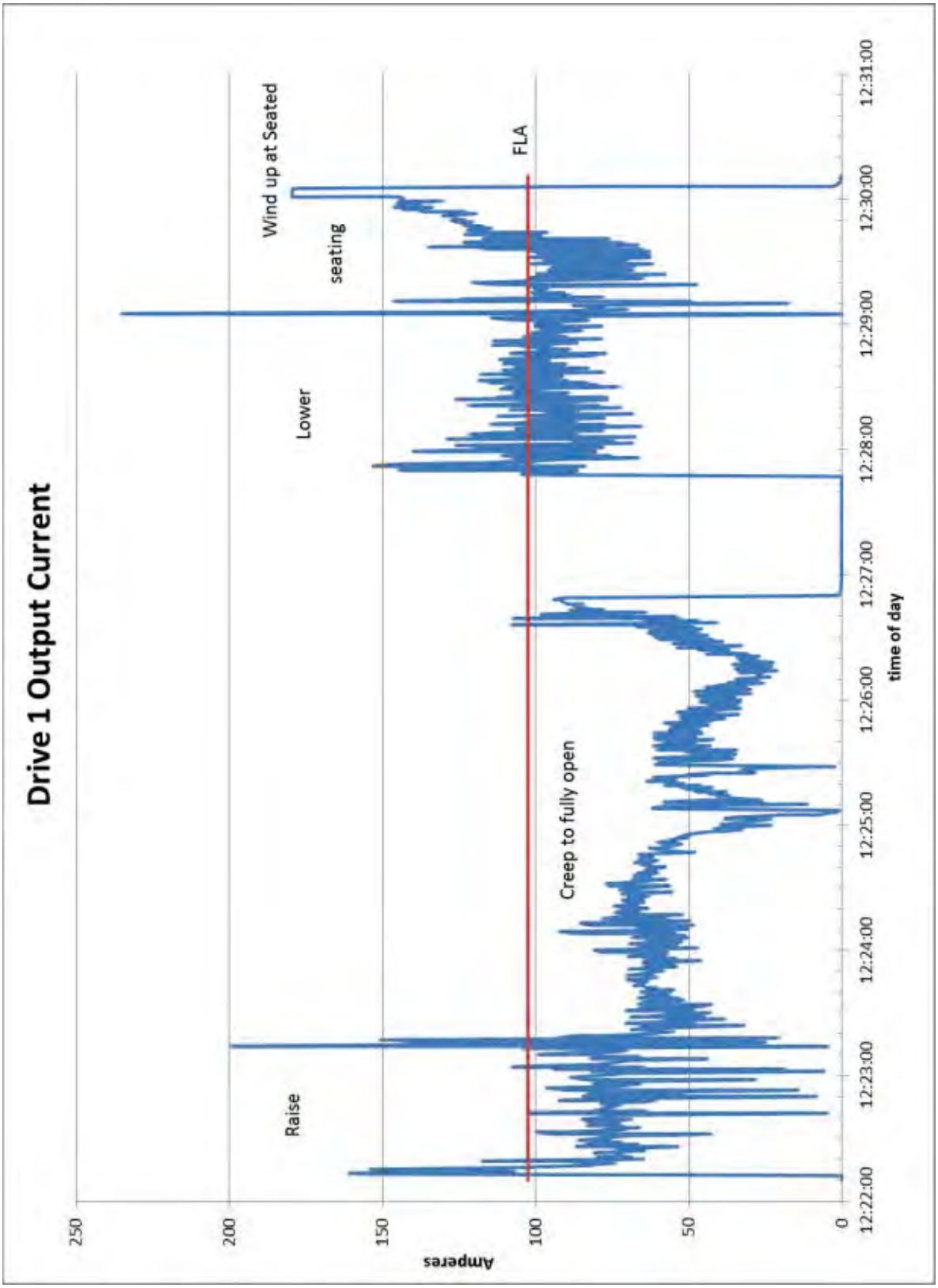

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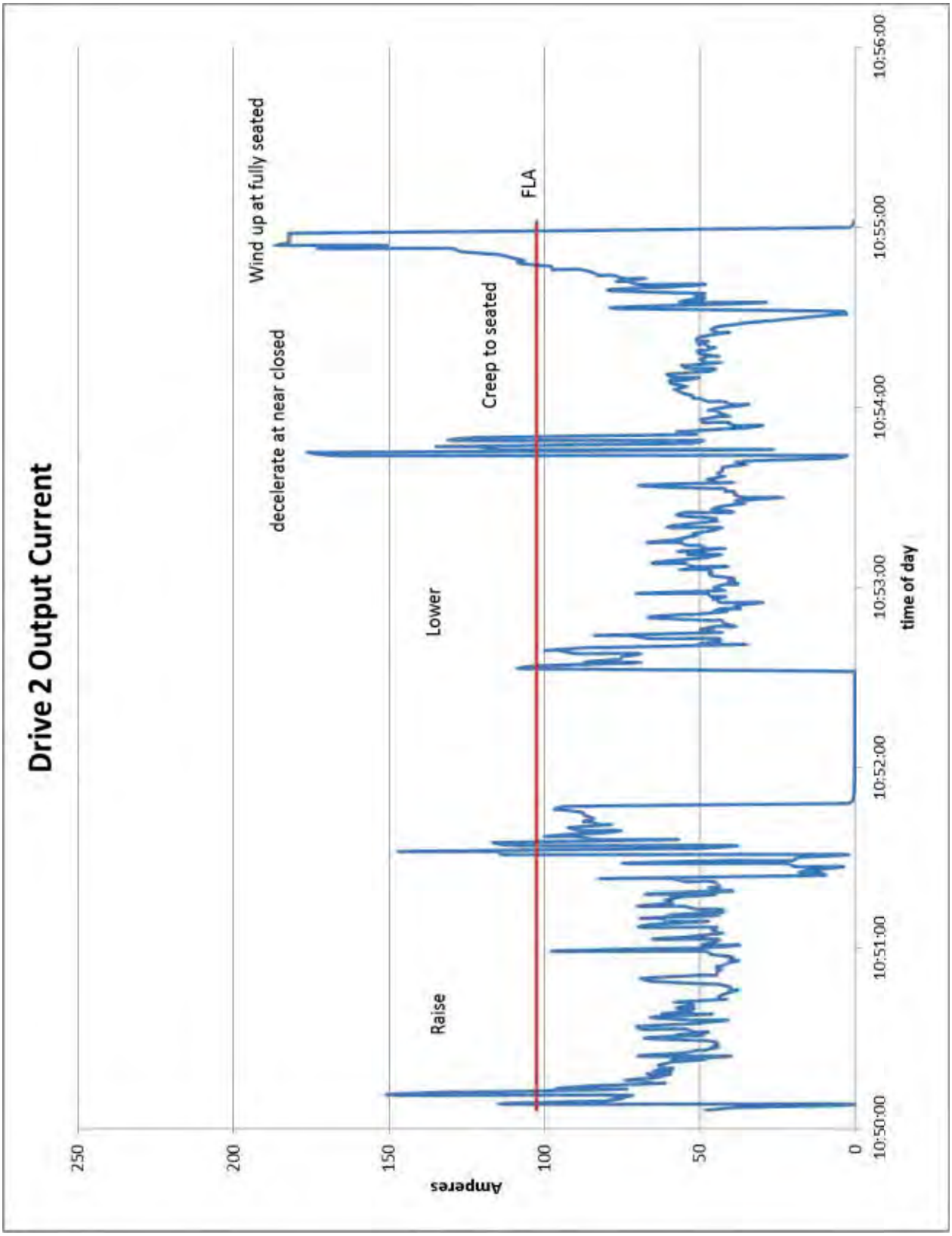

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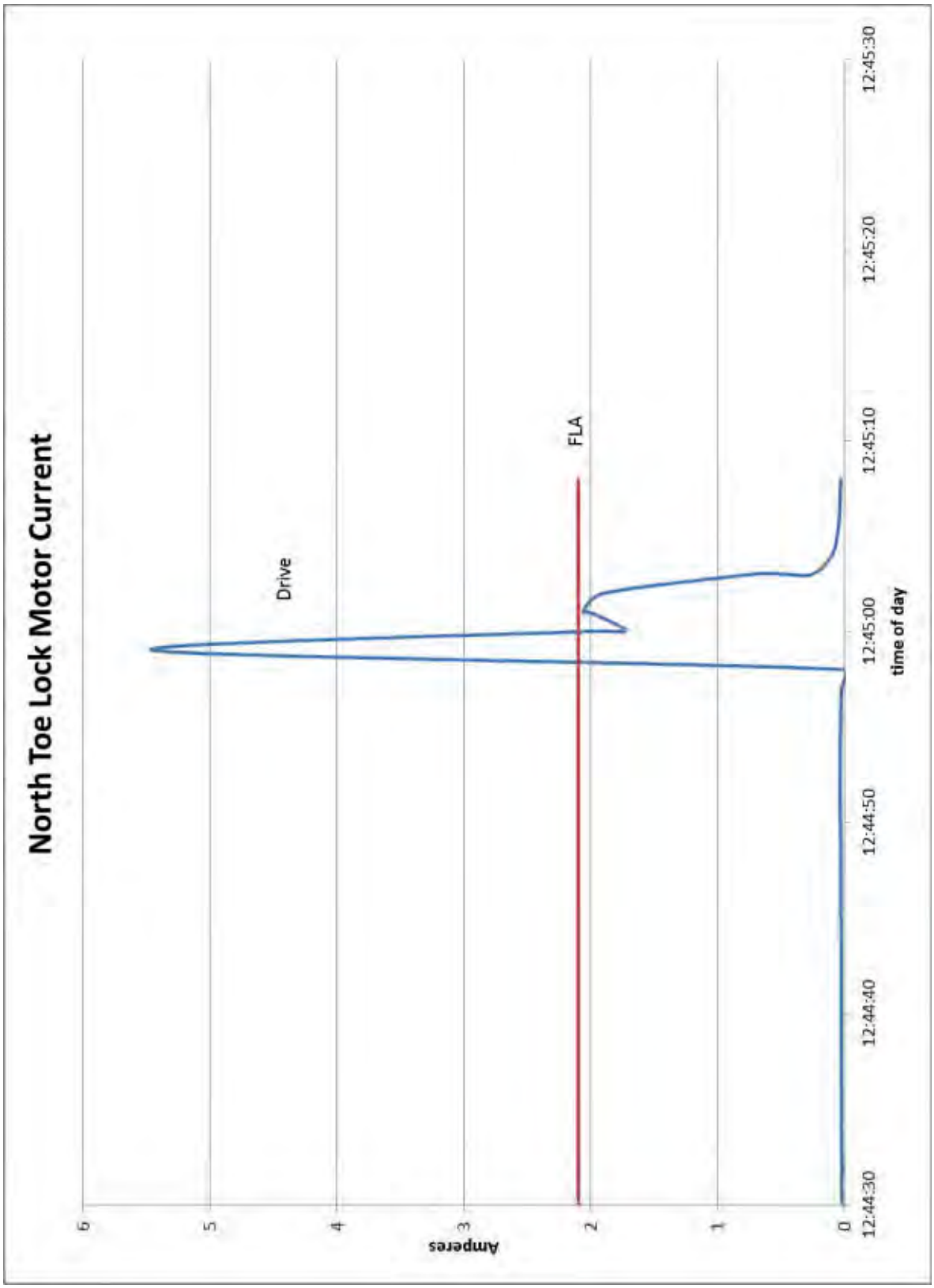
NO REVISIONS



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APPENDIX B

ELECTRICAL PHOTOS

Photo E-01. Motor Control Center (MCC).

Photo E-02. Inside MCC.

Photo E-03. Typical contactor contact assembly showing minimal signs of wear.

Photo E-04. Span motor drive cabinet front panel selector switches.

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Photo E-05. Inside span motor drive cabinet.

Photo E-06. Primary resistor.

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Photo E-07. PLC enclosure.

Photo E-08. PLCs processors located in the PLC enclosure.

Photo E-09. Uninterruptable Power Supply (UPS).

Photo E-10. Operator's Control Desk.

Photo E-11. Operator's Control Desk voltmeter, ammeters, bridge Position Indicator and PanelView display.

Photo E-12. Typical span drive motor.

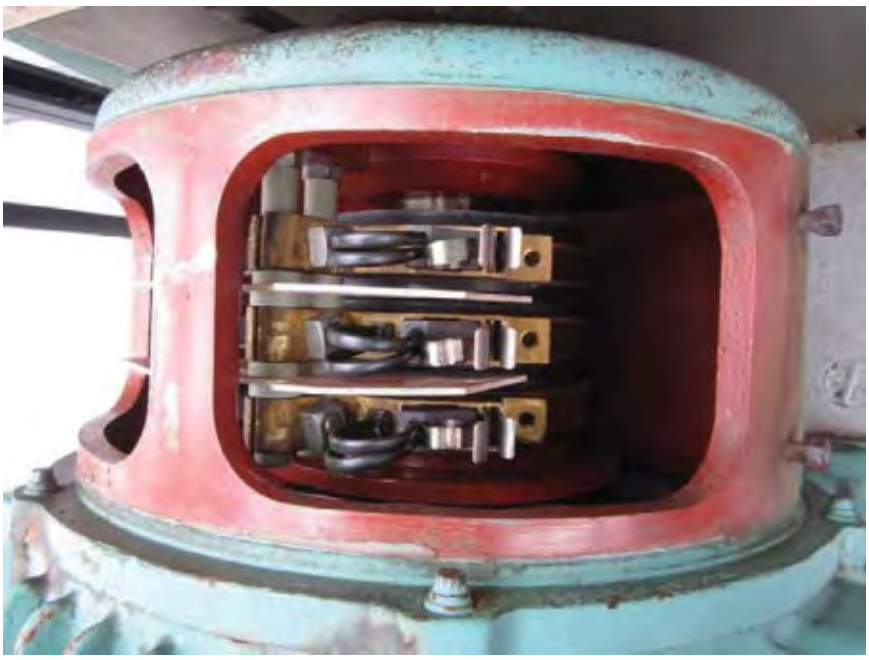

Photo E-13. Typical Leaf drive motor brushes and holders.

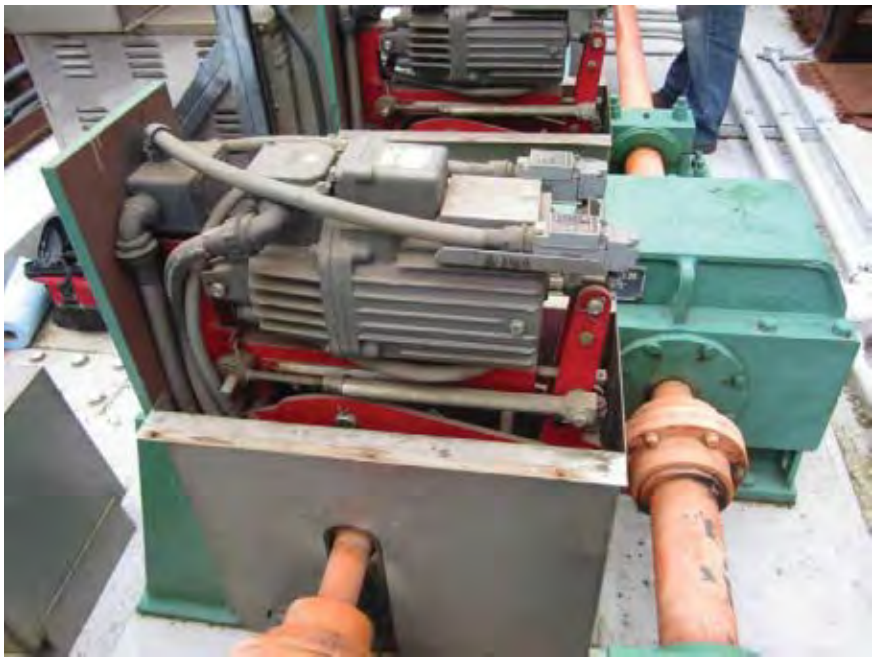

Photo E-14. Typical motor brake.

Photo E-15. Typical motor brake limit switch.

Photo E-16. Span lock motor.

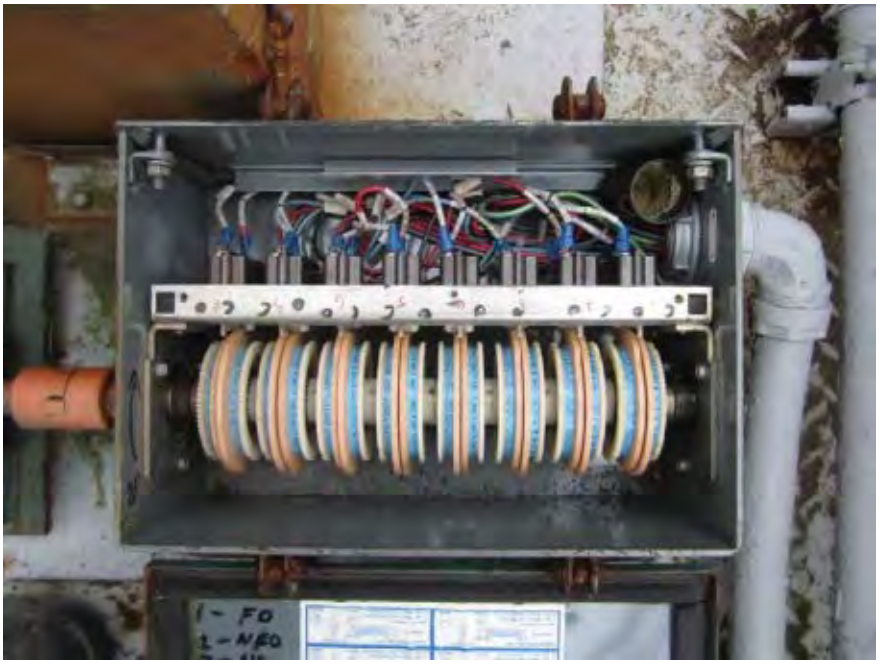

Photo E-17. Span rotary cam limit switch.

Photo E-18. Seated limit switch with bent plunger rod.

Photo E-19. Typical Interior of Seated Limit Switch.

Photo E-20. Typical Span Position Indicator.

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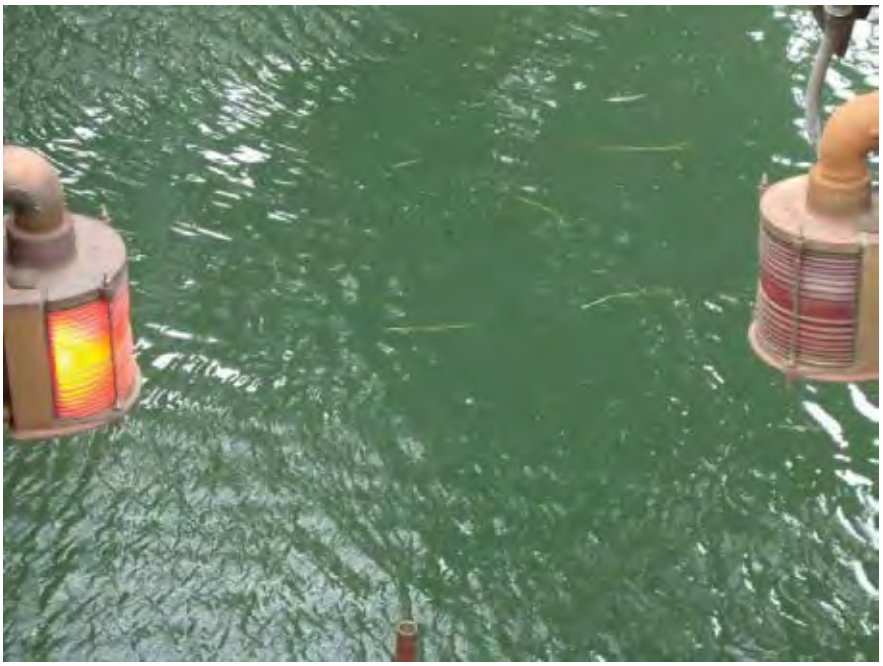

Photo E-21. In-board Navigation Lights.

Photo E-22. Navigation Lights on Fender.

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Photo E-23. Damaged Flexible Conduit Attached to North Span Position Indicator.

Photo E-24. Span Position and Speed Indicator.

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APPENDIX C

ELECTRICAL PHOTO LOG/CONTACT SHEETS

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04/07/2013

PHOTO LOG	Project	300-097	MNRR Main Line:
	Bridge	08080R	Over Housatonic

PHOTO NUMBER	PHOTO DESCRIPTION
1	The Operator's Control Desk
2	The Operator's Control Desk Panel View display
3	The Operator's Control Desk
4	The Operator's Control Desk
5	Inside The Operator's Control Desk
6	Inside The Operator's Control Desk
7	PLCs processors located in the PLC enclosure
8	PLCs processors located in the PLC enclosure
9	PLCs processors located in the PLC enclosure
10	Allen Bradley panel view
11	Inside Span Motor Drive Cabinets
12	Inside Span Motor Drive Cabinets
13	Span Drive #2
14	Motor Control Center
15	Inside MCC Typical contactor contact assembly showing minimal signs of wear.
16	Inside MCC Typical contactor contact assembly showing minimal signs of wear.
17	Inside MCC Typical contactor contact assembly showing minimal signs of wear.
18	Power distribution cabinet
19	Power distribution cabinet
20	Power distribution cabinet
21	Power distribution cabinet
22	Inside MCC
23	Inside MCC
24	Inside MCC
25	Inside MCC
26	Inside MCC
27	Lighting Panel
28	Transformer
29	Inside MCC
30	Inside MCC
31	Inside MCC
32	Inside MCC
33	Inside MCC
34	UPS
35	UPS
36	Span drive motor
37	Span drive motor
38	Tachometer and Speed switch
39	Span locks Rotary Cam Limit Switch
40	Span locks Rotary Cam Limit Switch
41	Span locks Rotary Cam Limit Switch
42	Span locks Rotary Cam Limit Switch
43	Span locks Rotary Cam Limit Switch
44	Tag details

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45	Typical motor brake limit switch
46	Typical span drive motor
47	Typical span drive motor
48	Typical span drive motor
49	Typical span drive motor
50	Typical span drive motor
51	Typical span drive motor
52	Typical span drive motor
53	Pier light
54	Pier light
55	Conduits
56	Conduits
57	Conduits
58	The Operator's Control Desk voltmeter, ammeters, bridge position indicator and PanelView display
59	The Operator's Control Desk voltmeter, ammeters, bridge position indicator and PanelView display
60	Fully seated limit switch
61	Fully seated limit switch
62	Fully seated limit switch
63	Span lock motor tags
64	Span lock motor
65	Rotary Cam Limit Switch
66	Rotary Cam Limit Switch

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ELECTRICAL APPENDIX D

MOVABLE SPAN NUMERICAL CONDITION INSEPECTION REPORT: ELECTRICAL COMPONENTS

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04/07/2013

MOVABLE SPAN
NUMERICAL CONDITION INSPECTION
REPORT ELECTRICAL COMPONENTS

COMMON COMPONENTS		BASCULE SPANS		LIFT	
COMPONENT TITLE	NCR*	COMPONENT TITLE	NCR*	COMPONENT TITLE	NCR*
WIRING AND CABLE	7	SPAN SEATED LIMIT SWITCH	5	FESTOONED CABLE	N/A
CONDUIT AND RACEWAY	7	TOE LOCK MOTORS	6	SPAN SEATED LIMIT	N/A
UTILITY SERVICE	8	HEEL LOCK MOTORS	-	SPAN LOCKS	N/A
SPAN DRIVE MOTORS	6			WEDGE MOTORS	N/A
SWITCHGEAR	N/A			DRIVE SYNC. SYSTEM	N/A
MOTOR CONTROLS	7				
CONTROL DESK	7	**SWING SPANS**		**MISC COMPONENTS**	
PLC CONTROLS	7	END OF TRAVEL LIMIT	N/A		
ROTARY CAM LIMIT SWITCH	7	SWITCH			
SPAN POSITION INDICATOR	8	CENTERING DEVICE	N/A		
SUBMARINE CABLE	N/A	WEDGE MOTORS	N/A		
DISCONNECT SWITCHES	7	JACK MOTORS	N/A		
GENERAL LIGHTING	7				
ROADWAY LIGHTING	N/A				
TRAFFIC SIGNS	N/A				
TRAFFIC GATES	N/A				
RESISTANCE BARRIERS	N/A				
NAVIGATION LIGHTS	7				
STANDBY GENERATOR	N/A				

ELECTRICAL CONDITION OVERALL RATING: 6 - 7

INSPECTION DATE: 03/2012

*NCR IS AN ACRONYM FOR NUMERICAL CONDITION RATAING; SEE BELOW:

NUMERICAL CONDITION RATING INFORMATION

9 NEW: Excellent functional performance
8 EXCELLENT: Performs intended function with very high degree of reliability and effectiveness
7 GOOD: Preforms with high degree of reliability and/or effectiveness
6 FAIR: Performs with little reduction in reliability and/or effectiveness
5 ADEQUATE: Performs with moderate reduction in reliability and/or effectiveness
4 MARGINAL: Performs marginal: corrective action required within one year
3 POOR: Performance poor and/or unreliable: corrective actions required within six months
2 URGENT: Span operation highly unreliable or dangerous and should be restricted: corrective action required as soon as possible
1 CRITICAL: Movable span operation prohibited pending replacement or repair
0 FAILURE: Movable span will not operate without replacement or repair
N/A Not Applicable