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3.8 MECHANICAL SYSTEMS

3.8.1 Introduction

Mechanical components discussed in this chapter include machinery for bascule, swing, vertical lift, and rolling lift bridges. The machinery includes the span drive machinery and the stabilizing machinery.

The purpose of this chapter is to discuss basic inspection of mechanical components that should be performed as part of a scheduled maintenance program. This manual often references the American Association of State Transportation and Highway Officials (AASHTO) Movable Bridge Inspection, Evaluation, and Maintenance Manual, as well as other text. This manual is to be used as a "field guide", which shall be used with the other referenced material if a deficiency is found that may not be corrected with normal maintenance practices.

All machinery components are related to and function as a system with the electrical and structural components. This means that a deficiency found at one item would most likely affect other elements. The elements are categorized for ease of reference, but often relate to the other elements in that assembly.

3.8.2 Open Gearing

Open gearing refers to gears that are not contained in a sealed housing. The gears are supported by shafting and bearings that are mounted onto fabricated or cast metal structural supports or framing. During initial installation, they were most likely mounted in the field and aligned by positioning the bearings with respect to the supports with shim material. Most likely the gear mesh will be as installed, but distortion of the supports, deterioration of the fasteners, deterioration of the shims may result in an abnormal alignment and/or wear of the open gears. Wear of open gearing is compounded by the constant exposure to weather and the presence of abrasive, foreign materials that lodge in the gear mesh.

The most common type of open gearing found on movable bridges is spur gearing. Spur gears transmit power and regulate the speeds of parallel shafts. This is commonly found for rack and pinions (see Figure 3.5.2.1-1). In order to transmit power between two shafts set at an angle (not in parallel), bevel gear sets are commonly used. These are often utilized on swing bridges. On some older bridges, open worm gearing was utilized, which transmits power between perpendicular shafting, and often was designed to be self-locking. This is appropriate for use at end-wedges for swing bridges and span locks for bascules.

3.8.2.1 Gear Alignment

As discussed previously, gears may be misaligned due to incorrect installation, or deterioration of the elements that support the gearing, that has resulted in a "shift" in the alignment. If any misalignment is found during inspection, the proper remedy should be established and implemented or the misalignment may result in accelerated wear, and undo stress on the gear teeth.

Maintenance inspection for gear alignment should include:

1. Viewing the patterns in the grease that are left behind during operation. The pattern should show even contact across the full tooth width at the pitch line. If the pattern is heavier on one edge of the tooth, or the pattern is not along the pitch line. This indicates that the shafts are not parallel to one another.

2. If the grease patterns indicate misalignment, the second step is to determine the amount of misalignment. This is achieved by measuring the backlash between the mating gears. Backlash is the space between adjacent non-contacting teeth. This can be measured using feeler gages and should be measured to ± 0.003 inch. These measurements can be used to calculate the required shaft realignment in order to correct the gear misalignment.

3. Bevel gear alignment is more commonly found to be misaligned. The same procedure should be followed as for spur gears. Common misalignment can be heavier contact at the heel portion of the tooth, or at the toe portion of the tooth, which most likely indicated that the shafting is not aligned at a true 90-degree angle with respect to each other.

3.8.2.2 Gear Wear

Detailed examples of types of wear are described and pictured within the American Association of State Transportation and Highway Officials (AASHTO) Movable Bridge Inspection, Evaluation, and Maintenance Manual.

Maintenance inspection for gear wear should include:

1. Inspection of the tooth surface, which should be smooth at the contact area. Scoring or deep gouges are sure evidence of deterioration of the tooth surface.

2. Inspection of the tooth roots for cracks (this is the area of highest bending stress)

3. Inspection of the tooth for “fins” that may form due to plastic flow of the steel.

Refer to the AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual for methods to measure wear.

3.8.3 Enclosed Gearing

Gear sets that are mounted in dust-proof, oil-tight, housings are generally referred to as enclosed gearing. On bridges these assemblies are usually speed reducers. In most cases, they are engineered and manufactured by companies that specialize in mechanical power transmission equipment.

Older custom reducer housings were commonly made of cast iron or cast steel. Shafting was usually supported within sleeve type bronze or Babbitt bearing bushings. Newer custom reducer housings are usually fabricated with welded steel. They are most likely equipped with anti-friction roller or ball bearings. Housings of mass-produced standard reducers are still cast from various grades of iron and steel.

Types of gear reducers include:

1. Parallel Shaft Reducers
2. Bevel Reducers
3. Differential Reducers
4. Planetary Reducers
5. Worm Gearings
6. Gear Motors

The most common type of lubrication for enclosed gearing is splash lubrication. The action of the gearing lifts the oil at the bottom of the housing and splashes it over the gear teeth and bearings. Many bearings are provided with grease fittings, where splash lubrication is not practical, e.g., vertically mounted shafts. Manuals specific for each bridge should be referenced for actual lubrication type.

Maintenance inspection of enclosed gearing should include the following items:

1. Visually inspect gearing through inspection ports in speed reducer housings.
2. Visually inspect reducer supports for cracks or deterioration.
3. Inspect each mounting bolt for tightness, damage, and deterioration.
4. Inspect the reducer housing, in particular at the mounting feet or flanges for cracks or damage.
5. Inspect each bolt that connects the top and bottom housing halves for proper tightness.
6. For sleeve-type bearings – check seals and packing for oil leaks. Measure clearances between shaft journal and bushing, if accessible. Watch during operation for any excessive movement of the shafts.
7. For anti-friction type bearings – check seals for oil leaks. Watch during operation for any excessive axial movements of the shafts.
8. Determine oil level by external level gage. Fill as required.
9. During operation – listen for any abnormal noises. Feel the bearing housings with the fingers; they should not become hot to the touch. No evidence of housing or fastener movement should be present.

3.8.4 Bearings

3.8.4.1 Sleeve Bearings

A sleeve bearing is a fixed cylinder (also referred to as sleeve or bushing) in which a shaft journal rotates. The sleeve is usually made of bronze (or on older bridges, Babbitt) and is held to a fixed point within a steel housing. Housings are usually split in order to remove the shaft for repairs. The top half is bolted down to the base, and the base bolted to the steel structure. Often the sleeve bearing is provided with a flange that acts as a thrust surface to hold the shaft horizontally positioned.

A sleeve bearing requires lubrication between the sliding surfaces of the journal and bushing. Normally one or more grease fittings are located at the top of the housing. A path is drilled through the housing, and bushing, and meets with grooves machined into the surface of the bushing. The groove is usually in a spiral pattern, which helps to lubricate the entire surface of the journal.

Maintenance inspection of sleeve bearings should include the following items:

1. Inspect bearing supports, mounting bolts, and grout pads for cracks, damage, and deterioration.

2. Inspect mounting bolts and cap bolts for tightness.

3. Inspect bearing housing for cracks and damage.

4. Inspect bushing and flange for cracks and damage.

5. Confirm that during lubrication, old grease exits from the space between the journal and bushing.

6. During operation, note any movement of the bearing or support. This will indicate damage to the system that may need repair.

7. During operation, note any movement of the shaft within the bushing. Any excessive radial movement indicates wear to the bushing. If excessive movement is found, other parts of the system may be adversely affected. They should be closely inspected and evaluated.

8. Clearance between the shaft and the bushing should be measured, using feeler gages, and measurement recorded.

9. Feel the exterior housing of the bearing after operation. The bearing should remain cool to the touch. Any heat generation may indicate improper lubrication, or damage to the bearing.

3.8.4.2 Anti-Friction Bearings

Anti-friction bearings include roller bearings and ball bearings. Typically heavy-duty spherical roller bearings are used to transmit power. Lighter duty ball bearings are commonly used for instrumentation that drives electrical control feedback devices. In general, the clearances of the bearing are set during installation, and the unit is sealed for operation. Little wear occurs at these bearings, so wear measurements are not required. Indications of potential problems or failure of an anti-friction bearing are overheating, unusual noises and shaft or bearing vibration. Some contributing factors include too much or inadequate lubrication, dirt, rust or foreign materials in the bearing, a faulty ball or roller, seal failure, and loss of clearance or preloading.

Maintenance inspection of the anti-friction bearings should include the following items:

1. Examine bearing supports, mounting bolts, and grout pads for cracks, damage, and deterioration.

2. Inspect mounting bolts and cap bolts for tightness.

3. Inspect bearing housing for cracks and damage.

4. Lubricate bearing and confirm grease enters the bearing and purges through the exit port.

5. During operation, note any movement of the bearing or support. This will indicate damage to the system that may need repair.

6. During operation, listen to each bearing for any unusual noises. Anti-friction bearings should operate smoothly and quietly.

7. Inspect the seals for damage and proper sealing. Excessive lubricant is a warning flag.

8. Feel the exterior housing of the bearing after operation. The bearing should remain cool to the touch. Any heat generation may indicate improper lubrication, or damage to the bearing.

9. If possible, open housing and visually inspect accessible portions of rollers and races. Check for internal contamination.

3.8.4.3 Trunnion Bearings

Trunnion bearings refer to the rotation point for bascule bridges and the main bearings for the sheaves on the vertical lift bridges. The trunnion bearings can be either sleeve type or anti-friction type bearings. Maintenance inspection of the trunnion bearings is the same as for bearings in general.

In-depth inspection of the trunnion bearings for vertical lift bridges is recommended due to a history of fatigue crack formation. This should be scheduled based on the design and use of the bridge. This type of inspection would involve disassembly of the bearing caps and visual, dye-penetration, magnetic particle, and ultrasonic testing of the shaft fillet.

3.8.5 Shafts & Couplings

Shafts transmit torque from one rotating part to another. Shafts ends are usually connected by couplings, which are secured to the shaft by an interference fit, and key.

3.8.5.1 Shafts

Maintenance inspection of shafts should include the following items:

1. Inspect keyways and shoulders for cracks. Suspect cracks should be further inspected by non-destructive testing methods.

2. During operation, inspect shafts for excessive radial movements and vibration.

3.8.5.2 Couplings

Couplings are manufactured in large variety, but can be categorized into three general groups: rigid, flexible, and adjustable. Rigid couplings are commonly found on older bridges, and basically clamp shaft ends together. Flexible type couplings are designed with internal elements that allow for misalignment during operation due to distortion of the bridge structure. The intent is to avoid bending the shafts. They also simplify shaft installation by allowing slight misalignment at the joints. Adjustable couplings are in span drives of connected tower lift bridges and other drives that require angular adjustment with time because of wire rope stretch, etc. They are also used to index electrical control devices. The AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual gives detailed descriptions of the different types of couplings.

Maintenance inspection of couplings should include the following items:

1. Inspect keyways for cracks.

2. Visually inspect for corrosive deterioration and cracks.

3. Check flange bolts for tightness.

4. Flexible couplings may fail without proper lubrication. Check for adequate lubrication.

5. For flexible couplings, inspect all seals and gaskets for leakage of lubricant. It is important to lubricate the couplings in accordance with the manufacturer's recommendations, so as not to damage the seals from over-lubricating.

6. During operation, make sure couplings rotate smoothly and free of noise. Noise would indicate inadequate lubrication or misalignment of the shafts greater than the tolerances of the coupling.

7. Disassemble housings or covers. Inspect condition of internal flex grids and coupling hub teeth.

3.8.6 Buffer Cylinders

The purpose of a buffer cylinder is to provide a mechanical means to control the deceleration of the span at the fully closed and/or the fully open positions. Usually the buffers are large pneumatic cylinders, although hydraulic energy absorbers are used. The major components of the air buffer cylinder include: the cylinder housing, the piston, the piston rod, inlet and outlet piping, and the strike plate. Gravity (or spring pressure for horizontally mounted buffers) extends the piston rod, filling the void in the cylinder with air. Upon operation, the piston end hits the strike plate, and the air is forced out of the valving of the cylinder thus dampening the span movement.

Maintenance inspection of the buffer cylinders should include the following items:

1. Inspect for damage or deterioration to the external housing and components.

2. Inspect for damage or deterioration of the mounting bolts.

3. During operation, observe the piston and note if it does not fully extend from the cylinder when the span is moved.

4. During seating, listen for the sound of air being pushed past the outlet valving, it should be evident. Listen for air leakage through the inlet piping. Air leakage indicates the check valve is faulty.

5. During seating the buffers should provide controlled seating of the span. Observe the seating of the span and record any abnormalities.

If the buffer does not function properly with the guide bushing adequately lubricated, the buffer assembly should be serviced by a mechanical contractor.

3.8.7 Live Load Bearings

Live load shoes are found on trunnion bascule, rolling lift bascule, and vertical lift bridges. The function of the live load shoe assemblies is to transfer vehicular live load from the span to the pier/approach span when the span is in the closed position. The locations of the live load shoes are typically at all four corners of a lift span, and can be found in front of or behind the center of rotation for bascule bridges. The assembly consists of a shoe with a rounded surface (mounted to the span) and a flat strike plate mounted to the pier (or other fixed structure). Both are secured with mounting bolts and are provided with shims for adjustment of the span position.

Maintenance inspection of the live load reactions (bearings) should include the following items:

1. Inspect mounting bolts to determine if they are tight.

2. Inspect the bolts and shims for deterioration.

3. Inspect contact surfaces of shoe and strike plate for deformations and wear.

4. Inspect that firm contact exists between shoe and strike plate. If a gap exists, it should be measured with feeler gages and re-shimmed to make it tight.

3.8.8 Span Locks

Span locks are used to transfer vehicular live load between the leaves of a double-leaf bascule bridge, and to ensure the span is in the closed position for single-leaf bascule and vertical lift bridges. The assembly typically consists of a forged steel lock bar that is driven into a receiving socket. On the drive end are additional sockets that guide and support the lock bar.

The sockets are typically welded or cast housings equipped with adjustable wear shoes. Adjustment is made by adjusting the shim material. The lock bar is operated within the sockets by a crank mechanism, which is driven by gearing and a motor. Linear lock bar operators are also common.

Maintenance inspection of the span locks should include the following items:

1. Inspect sockets for adequate lubrication.
2. Inspect sockets and shoes for cracks and damage.
3. Inspect mounting bolts for tightness and deterioration.
4. Inspect locks under traffic. There should be little, if any, relative span movement. If movement is observed, gaps between bar and sockets should be measured with feeler gages and recorded.
5. Inspect operation of the lock bar mechanism. Individual elements should be inspected as described in individual component sections.

3.8.9 Rolling Lift Bascules

3.8.9.1 Treads and Tracks

On rolling lift bridges, the weight of the leaf during operation is transferred from the curved segmental girders to the flat tracks through the treads. The treads are constructed with sockets that engage mating pintles or lugs on the tracks as the leaf rolls. These serve to position the span during operation and provide resistance against wind forces.

Maintenance inspection of the tread plates should include the following items:

1. Inspect the mounting bolts that attach the treads to the segmental girder.
2. Inspect the contact surfaces for even wear across the width of the tread and track.
3. Inspect the treads and tracks for cracks.
4. Inspect the treads and tracks for surface deformation.
5. Inspect the lugs or pintles and sockets for wear and interference.
6. Inspect the segmental girders and track girders for cracks. Pay particular attention to the angles between web and flange.

3.8.9.2 Centering Devices

To ensure roadway alignment of a rolling lift bridge, a centering device is usually located at the toe of each span. The two-part device consists of a tapered male piece and female pieces that gradually align the span horizontally during seating.

Maintenance inspection of the centering device should include the following items:

1. Inspect for adequate lubrication.

2. Inspect for uneven wear that may indicate span misalignment.

3. Inspect fasteners for tightness and deterioration.

4. Inspect housing for cracks and damage.

5. Observe device during operation. Under normal conditions, the device should not encounter much sideward force.

3.8.10 Vertical Lift Bridges

3.8.10.1 Wire Ropes and Terminations

Wire ropes are used to connect the vertical lift span to the counterweights located in the towers. Wire ropes are also used to operate span drive vertical lift bridges. In both cases, the type of inspection is the same. Termination points include open spelter sockets affixed to each rope end. Rope clips and wedge sockets are often used for operating rope terminations at the operating drums.

Maintenance inspection for wire ropes should include the following items:

1. Inspect for surface cracks on the outer strands of the rope. Note any cracks or broken wires.

2. Inspect for rust due to inadequate lubrication. “Rust-bound” ropes are particularly dangerous and most likely will cause a failure.

3. Inspect wire ropes for abrasive wear in the form of flat spots on the outer wires of the strands. Flat spots greater than ¼ inch long for ropes under 1-inch diameter and greater than ½ inch long for ropes over 1-inch diameter should be brought to the attention of the engineering staff.

4. Inspect for damage due to abuse. Any large debris that may hit the wire rope will most likely nick the surface, weakening the wire rope. Any damage should be noted and reported.

5. Inspect lubrication coverage. If surface rust starts on the wire rope, the lubrication frequency should be re-evaluated by the engineering staff.

6. Observe the wire ropes during operation. Note any interference that may be rubbing the wire rope.

Maintenance inspection for wire rope terminations should include the following items:

1. Inspect point of contact with wire rope. This is the place most likely to collect moisture and corrode the wire strands.

2. Inspect the socket for cracks and damage.

3. Inspect the socket pins for full engagement and excessive clearance.

4. Inspect cotter pins used to hold the socket pins in place. Note any deterioration.

5. Inspect integrity of zinc in end of each socket.

3.8.10.2 Counterweight Sheaves and Drums

Counterweight sheaves are large diameter, angular-grooved drums, located at the top of the towers, over which the counterweight ropes are draped, supporting the entire weight of the span and counterweight during operation. Operating drums are located on the span, and are grooved in a spiral fashion in order to store several wraps of wire rope. These operating ropes are paid-out and taken-in during operation.

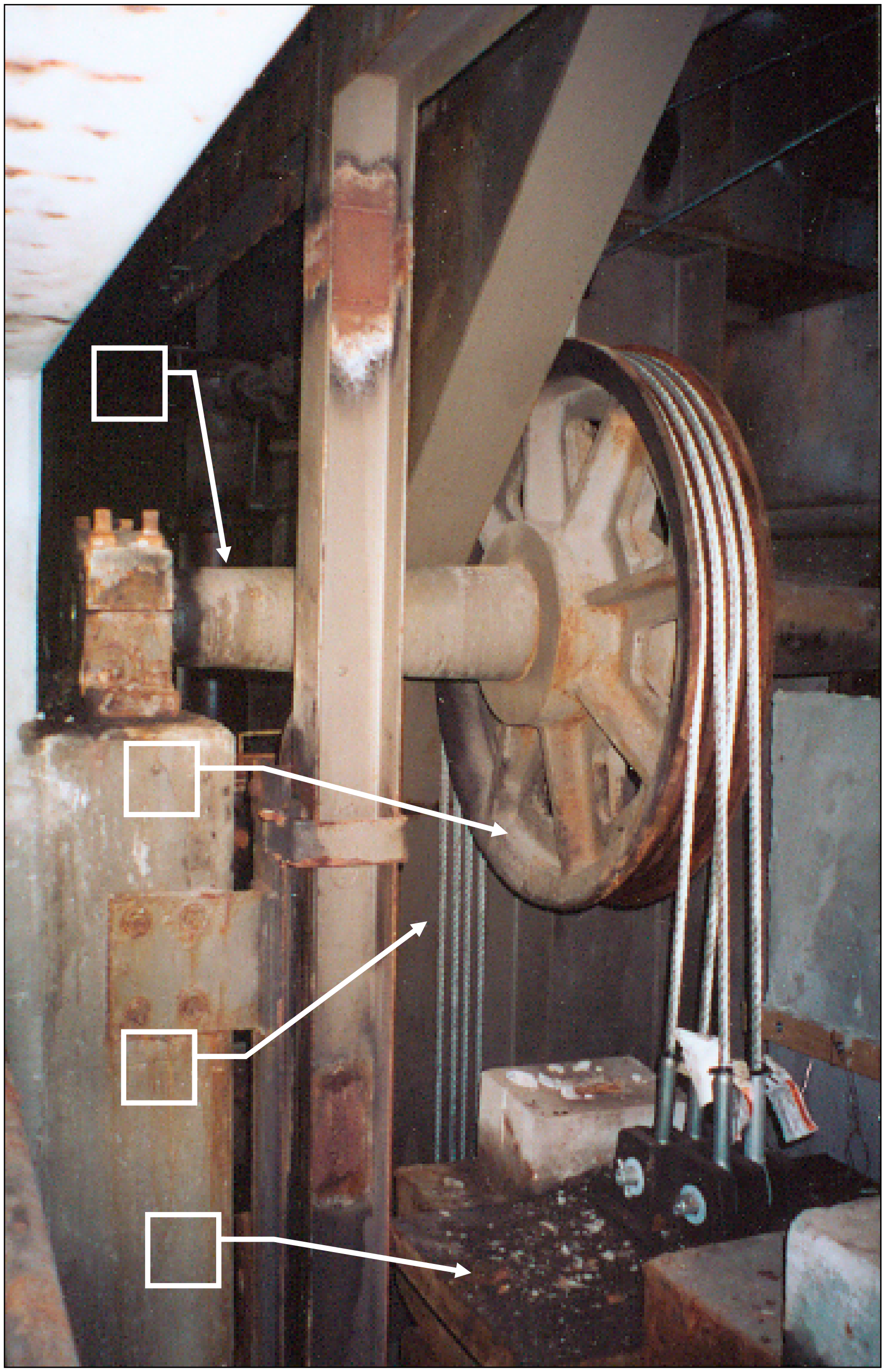
For both types, the grooves are cut to a specific dimension in order to properly space adjacent ropes and support the rope without crushing it. Both drums and sheaves are supported by shafts, and within bearings as discussed in Section 3.8.4.

Maintenance inspection for sheaves and drums should include the following items:

1. Inspect rope grooves for adequate lubrication, signs of rust or corrosion, and the presence of debris.

2. Inspect for indications of rubbing between ropes and between ropes and grooves.

Figure 3.8.10.2-1 depicts the counterweight system at one corner of the St. Paul Avenue Bridge in Milwaukee. This is a balanced pit-drive vertical lift. The significant components are flagged in the figure. The vertical wide-flange steel shape shown is part of the traffic resistance gate located overhead.



a Trunnion c Counterweight Ropes
b Counterweight Sheave d Counterweight

Figure 3.8.10.2-1: Counterweight System, St. Paul Avenue Bridge in Milwaukee.

3.8.10.3 Equalizing Systems

A number of pit-drive vertical lift bridges are operational in Milwaukee. Some are balanced pit-drive vertical lift spans as described in Section 3.3.5.1. Milwaukee's lift span bridges of this type are raised and lowered by hydraulic cylinders. The spans are guided vertically at each corner of the span by "lifting posts" (which do not actually lift the spans). Lifting posts typically are rigidly connected to the end floorbeams and fascia girders. Skewing of the lift span during raising and lowering is typically restrained (in both the longitudinal and transverse directions) by wire rope equalizing systems in older structures. More modern structures use position transducers to replace the transverse and longitudinal equalizing cables and sheaves.

The equalizing systems on three Milwaukee bridges (St. Paul Avenue, Michigan Street, and Wells Street), will be described with the aid of reeving diagrams and photographs. The reeving diagrams are schematic and are not drawn to scale. When viewing these diagrams, the reader should recall that these rope systems are not counterbalancing systems (the counterbalance ropes are a separate system) and they are not span drive ropes (the span is lifted by hydraulic cylinders). Because there is no standard designation for these systems, they will be denoted as moving-drum, stationary-drum, and sans-drum. These terms are most descriptive of the Milwaukee systems.

Moving Drum Equalizing System

Figure 3.8.10.3-1 is a schematic of a moving-drum equalizing system. It is denoted as moving-drum because the drum is attached to the end floorbeam or fascia girder of the lift span (the movable part of the bridge). The system nearly equalizes the vertical motion of the two lifting posts (subject to changes in rope length due to elastic deformations and temperature). This is necessary because the center of gravity of the span may not coincide with the center of effort of the lift cylinders and because of differential friction between the two sets of lifting post guide rollers due to wind and other forces. Such effects tend to cause the span to rise canted.

In the planar system, as shown in Figure 3.8.10.3-1, there are two wire ropes. One rope is fastened to the pier wall by the adjustable anchorage at "1" and then passes under the sheave "2" which is mounted on the bottom of the lifting post. From there it rises to sheave "3" and is wrapped around the drum at "4" before passing over a sheave at "5" and descending to an anchorage on the fixed structure at "6". Sheaves "2", "3", "5", and drum "4" are mounted on the moving structure. For clarity, the drum is shown as being in two parts, which are connected by a shaft. A single drum, properly grooved, would serve as well. Also, the cables need not be continuous about the drum; they can be discontinuous with terminations at the drum.

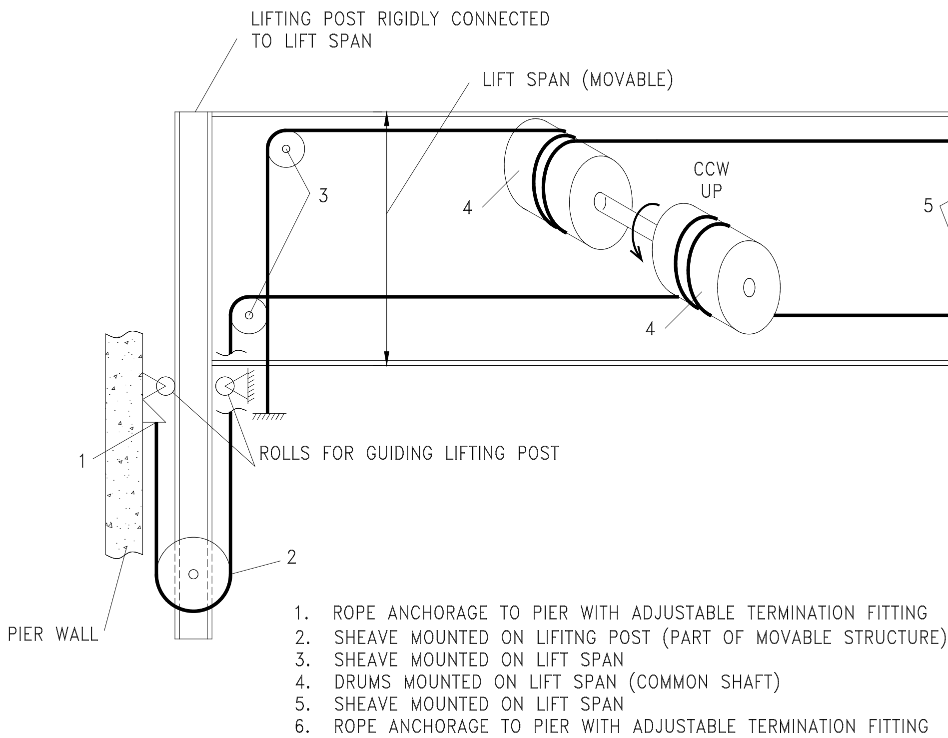
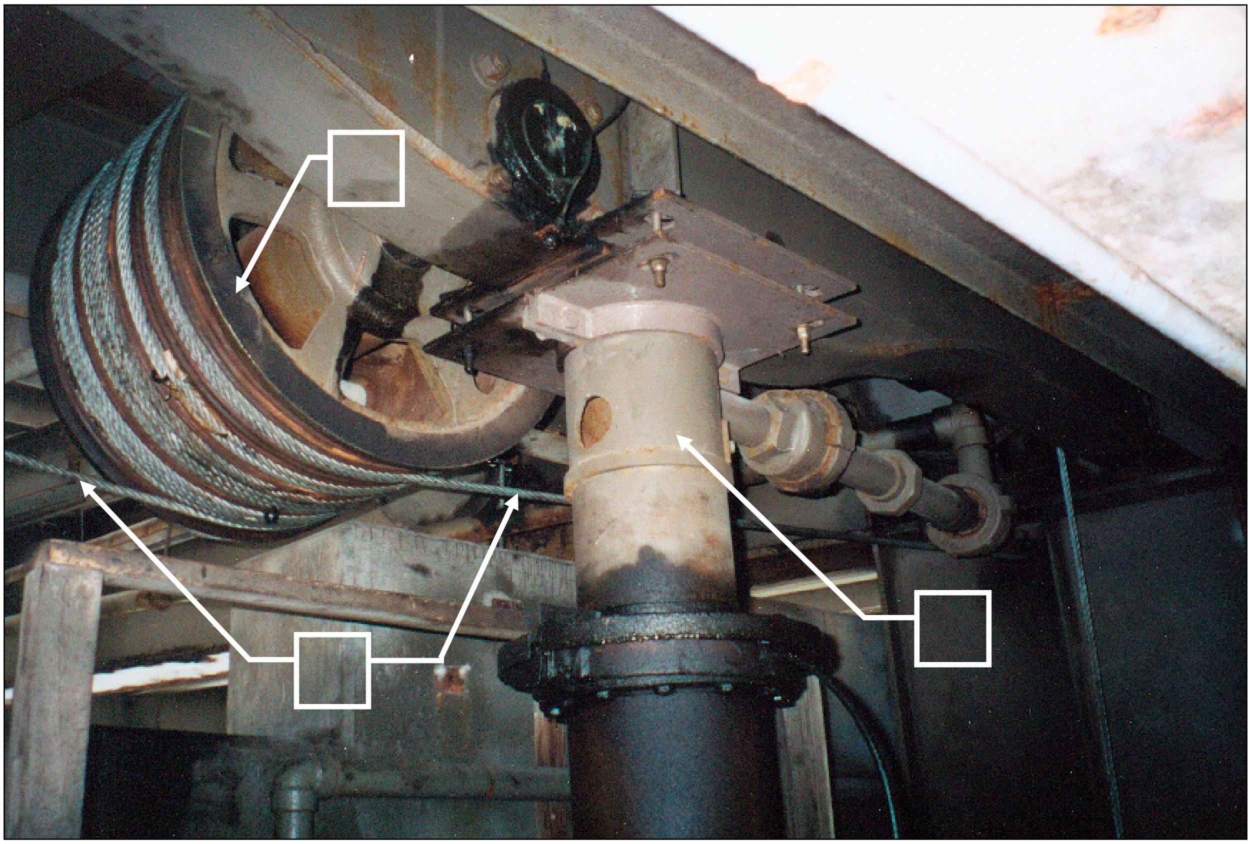


Figure 3.8.10.3-1: Moving-Drum Equalizing System.

St. Paul Avenue Bridge is equipped with four moving-drum equalizers; one at each end of the floorbeam and one parallel to each fascia girder. Figure 3.8.10.3-2 depicts one of the drums mounted to the westerly end floorbeam.



a Drum b Transverse equalizer rope c Lift cylinder

Figure 3.8.10.3-2: Transverse Equalizer Drum, St. Paul Avenue Bridge in Milwaukee.

Stationary-Drum Equalizing System

In the stationary-drum wire rope equalizing system the drum and the sheaves over which the horizontal segments of rope stretch are mounted on the pier (the stationary part of the bridge). Figure 3.8.10.3-3 depicts the system used on the Michigan Street Bridge to equalize vertical motion of the lifting posts and minimize transverse skew. There are two transverse systems, one on each pier. At this bridge, skew control in the longitudinal direction (span-wise) is accomplished using sans-drum wire rope equalizing systems, which are described subsequently.

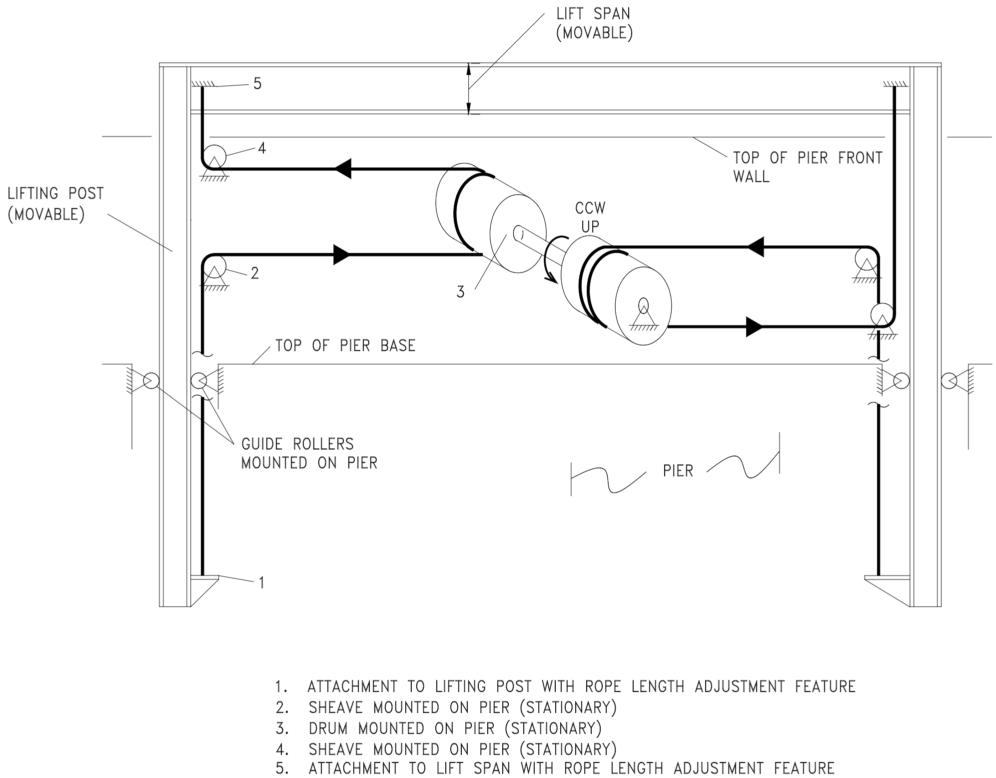


Figure 3.8.10.3-3: Stationary-Drum Equalizing System.

Sans-Drum Equalizing System

Wire-rope equalizers can be reeved without the use of wrappings around a drum. In fact, the equalizers of earlier pit-drive vertical lift bridges did not have drums. A schematic diagram of a drum-less, or sans-drum, equalizer is shown in Figure 3.8.10.3-4. All sheaves are mounted on the moving structure. The arrangement of the parts on the lower end of a lifting post of the Michigan Street Bridge is depicted in Figure 3.8.10.3-5. As mentioned previously, the sans-drum system is used for longitudinal (span-wise) equalization on the Michigan Street Bridge. Stationary drum systems are in place for transverse equalization on this bridge.

The Wells Street Bridge has two sets of sans-drum equalizer systems that are oriented diagonally in plan; each set connects the lifting posts in the opposite corners of the left span. The effectiveness of this arrangement, especially in the transverse direction, is dependent on the torsional rigidity of the lift span (framing plus decking).

In general, the effectiveness of wire rope equalizers is dependent on their axial stiffness; i.e., the elongation of the rope when it is stressed by the skewing action of the bridge. Hence, it is important that the ropes have adequate pretension. Turnbuckles or threaded fittings are provided at the anchorages for adjustment. The rope anchorage with take-up adjustment fittings in place at the Wells Street Bridge is depicted in Figure 3.8.10.4-1.

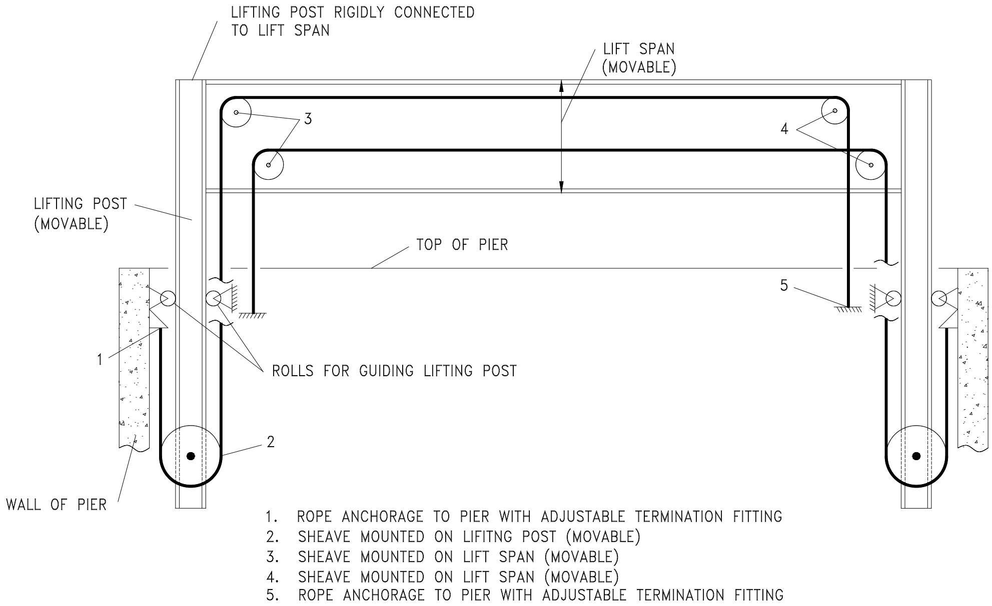
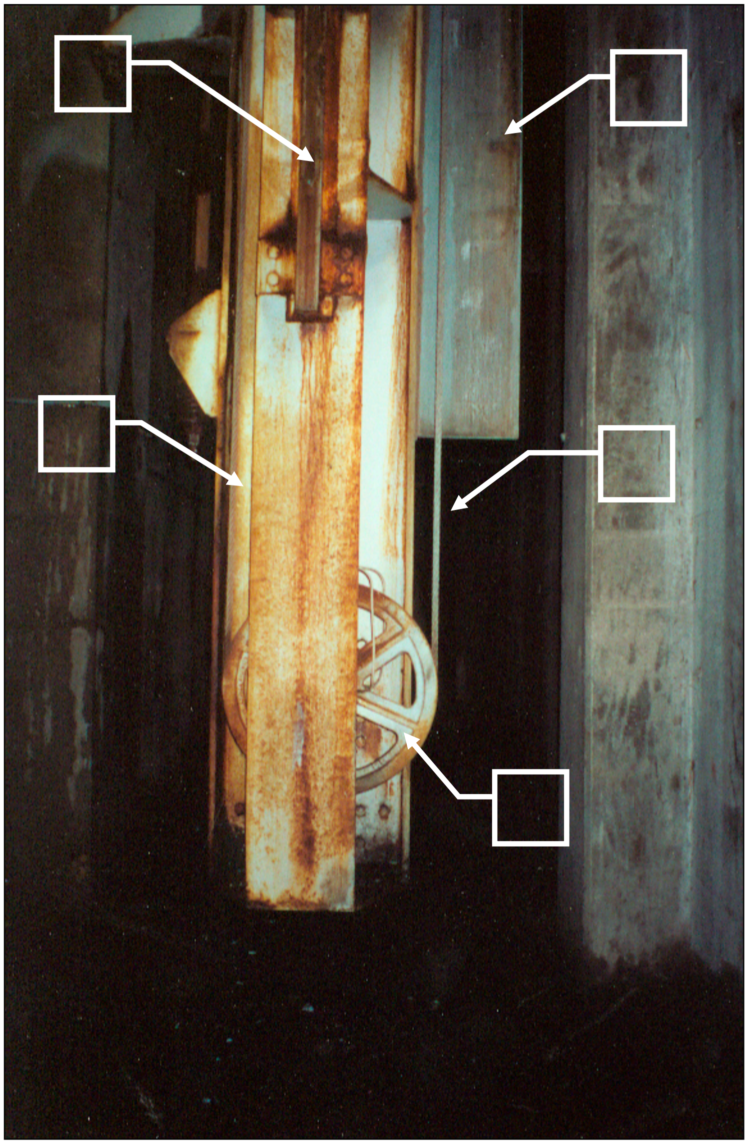


Figure 3.8.10.3-4: Sans-Drum Equalizing System.



a Plate clamp rail
b Lifting post
c Guide rail
d Equalizer rope for longitudinal system
e Lower sheave

Figure 3.8.10.3-5: Bottom of Lifting Post, Michigan Street Bridge in Milwaukee

Position Transducer Equalizing System

Older structures use mechanical methods to ensure the lift span of a moveable structure opens and closes uniformly. As described in the previous sections this is performed through the use of transverse and longitudinal equalizing cables and sheaves. Newer structures are now relying more on technology to replace this system. The Wisconsin Avenue structure was rehabilitated in 2012 and its mechanical equalizing system was replaced with a position transducer equalizing system. Transducers are placed on each hydraulic cylinder within the structure and networked together by wires. During the opening and closing of the lift span, the transducers "communicate" with each other to determine where the bridge is positioned.

The transducers then self-correct by altering the rate of cylinder movement. The benefit of this system is the removal of hardware from the bridge and the need for continual maintenance on the moveable parts.

3.8.10.4 Span and Counterweight Guides

Span guides are used to restrict lateral and longitudinal movement of the span during operation. Counterweight guides are used to restrict movement of the counterweight as they travel within the towers. Typically roller guides are used as span guides, and sliding guides are used as counterweight guides. Guide rails are located along the tower legs, and are for contact with the guides against any side wind loads.

Maintenance inspection for span and counterweight guides should include the following items:

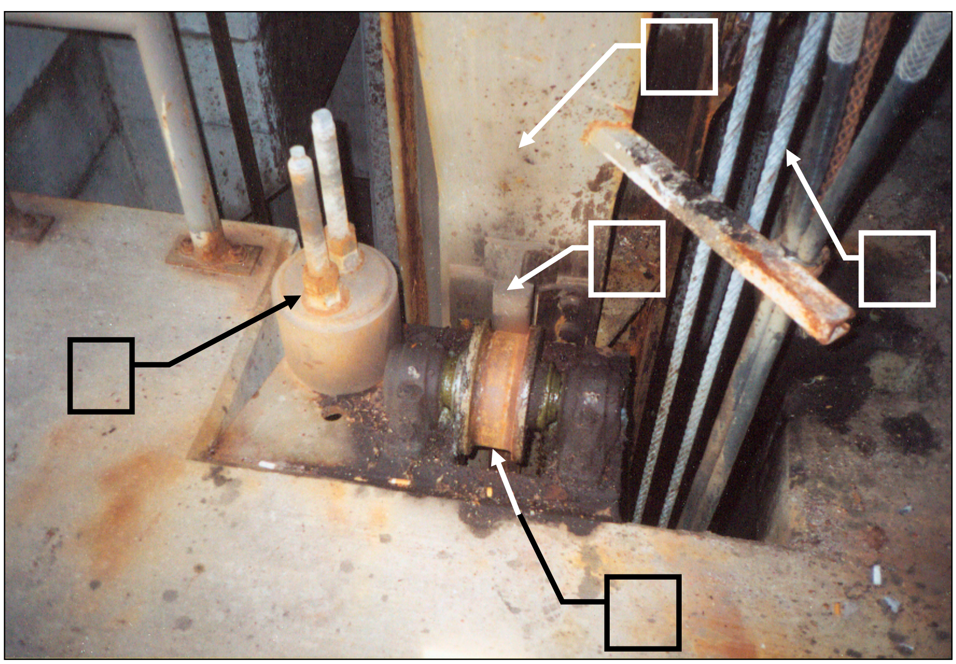
1. Inspect guide clearance the entire length of lift. This should reveal any damage to the rail.

2. Rotate rollers to ensure proper operation.

3. For sliding guides, be sure rails are adequately lubricated the entire length.

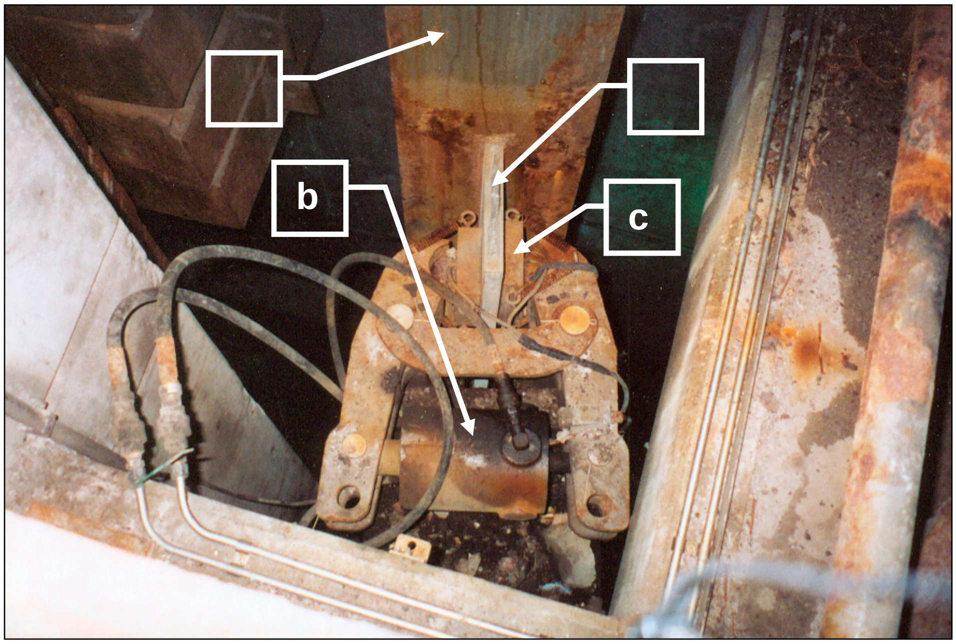
Figure 3.8.10.4-1 depicts the guide rail and guide rollers for the Wells Street Bridge. For this bridge the guide rail should not be lubricated because the sides of the rail head serve as the “brake drum” for the rail clamp brake.

A typical rail clamp brake is shown in Figure 3.8.10.4-2 for the St. Paul Avenue Bridge in Milwaukee. Here the “brake drum”, a long rectangular bar, was not part of the original construction. It was welded to the lifting post sometime thereafter and then the rail clamp was installed.



a Guide roller	d Equalizer ropes
b Guide rail	e Rope take-up
c Lifting post	

Figure 3.8.10.4-1: Guide rail detail, Wells Street Bridge in Milwaukee.



a Lifting post	c Rail clamp shoes
b Hydraulic cylinder	d Plate clamp rail

Figure 3.8.10.4-2: Rail clamp, St. Paul Avenue Bridge in Milwaukee.

3.8.10.5 Auxiliary Counterweight and Balance Chains

Auxiliary Counterweights

During operation, auxiliary counterweights are used to offset the shifting weight of main counterweight ropes as they travel from one side of the sheave to the opposite side. The systems consist of counterweights, with guides and rails, sheaves, wire ropes, and termination points. All sections for inspection of individual elements apply to the auxiliary counterweight systems.

Balance Chains

Balance Chains are an alternative method to offset the differential of the main counterweight rope weight during operation. The system consists of large chains that terminate at the towers at one end, and the bottom of the counterweight at the other. As the span is lifted, the chain weight is transferred from the counterweight to the tower.

Maintenance inspection of the balance chains should include the following items:

1. Observe during operation. Note any frozen links that kink the chain during operation.

2. Inspect cotter pins normally used to secure chain pins. These commonly wear during operation. Excessive wear should be noted and reported.

3. Inspect termination points for any loose or deteriorated fasteners.

3.8.11 Swing Bridges

3.8.11.1 Center Pivot Bearings

For center pivot swing bridges, the entire weight of the span rotates about and is supported by the center pivot bearing. The center pivot bearing may be a bronze disc type or an anti-friction type spherical thrust bearing.

Maintenance inspection for both types of bearings should include the following items:

1. Inspect exterior of housing for cracks and damage.

2. Inspect mounting bolts for tightness and deterioration.

3. Note any loud or unusual noises during operation, bearings should operate quietly and smoothly.

4. Inspect oil level at site gage.

3.8.11.2 Balance Wheels and Track

For center pivot type swing bridges, balance wheels are utilized to stabilize the span from any side wind force on the span. The wheels are set to a small clearance (approximately 0.1 inch) with tapered track, and only make light contact due to imbalance and/or wind loads.

Maintenance inspection of balance wheels should include the following items:

1. Check for clearance between wheel and track with wedges driven.

2. Rotate each wheel to check for freedom.

3. Lubricate bearing and check purge points.

4. During operation, note which wheels make contact. Only two adjacent wheels should make contact at one time. Any additional contact indicates an uneven track, improper installation of balance wheel, or worn balance wheel bearing, and/or worn pivot bearing.

5. Inspect track and fasteners for deterioration and cracks.

3.8.11.3 Rim Bearings

A rim bearing swing span has a large number of large tapered rollers that rotate between an upper and lower track. This system supports the entire weight of the span during operation.

The tapered rollers are held in alignment with the center of pivot, by radial tension rods that connect to a central hub. This hub rotates about a vertical pin mounted to the pier.

Maintenance inspection for rim bearings should include the following items:

1. Check radial tension rods for relative tension. Note any excessively loose or tight rods.

2. Observe rollers during operation. All rollers should rotate with no sliding. No abnormal noises should be heard.

3.8.11.4 End Lifts and Center Wedges

End Lifts

The ends of a swing bridge deflect during operation, and must be raised to meet the approach roadway level. This acts to stabilize the span under vehicular traffic. Several types of end lift machinery are used including: end wedges, end toggles, and eccentric cams. Most systems utilize crank mechanisms to lock the devices in place. The mechanisms are usually driven by a system of gears and a motor.

Maintenance inspection for the end lifts should include the following items:

1. Inspect contact of shoe with base (mounted on rest pier).

2. Inspect housings and components for cracks and damage.

3. Inspect mechanisms for damage, in particular in the form of twists.

4. Inspect drive machinery as described under sections for individual elements.

5. Observe operation of system. Note any hesitations, or interference.

Center Wedges

The function of center wedges is to relieve the center pivot bearing for live load. Wedges are driven in place between a base casting mounted on the pier and an upper guide casting mounted to the underside of the span. The operation of the wedge is similar to that of the end lift devices.

Maintenance inspection for the center wedges should include the following items:

1. Inspect contact of wedge with base (mounted on rest pier).

2. Inspect contact surface with wedge withdrawn. Note any scoring or gouging of the surface.

3. Inspect housings and components for cracks and damage.

4. Inspect mechanisms for damage, in particular in the form of twists.

5. Inspect drive machinery as described under sections for individual elements.
6. Observe operation of system. Note any hesitations, or interference.