Recommended Practice for Installation, Maintenance, and Lubrication of Pumping Units

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Recommended Practice for Installation, Maintenance, and Lubrication of Pumping Units

1 Scope

This recommended practice provides guidance related to the proper installation, care, and maintenance of surface mounted beam pumping units, varieties of which are described in API 11E. Information provided in this document is of a general nature and is not intended to replace specific instruction provided by the pumping unit manufacturer. This document further establishes certain minimum requirements intended to promote the safe installation, operation, and servicing of pumping unit equipment.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 11E-2013, *Specification for Pumping Units*

3 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1
base
The basic frame or skid to which a pumping unit is assembled. Typically is the structural element that interfaces with or is clamped to the foundation.

3.2
brake
Component of a pumping unit that is often composed of a disk or drum mounted on the reducer input shaft combined with a mechanism to impart a restraining friction torque and restrain the motion of all rotary joints.

3.3
carrier bar
Part of the pumping unit that supports the load of the sucker rod string through the polished rod clamp.

3.4
center bearing
Structural bearing assembly supporting the walking beam of a class 1 lever design pumping unit.

3.5
certified installation print
Drawing reviewed and approved (stamped) by a licensed professional engineer competent in the areas of site preparation, foundations, and proper mounting requirements of heavy industrial equipment.

3.6
cranks
Driving link in the four-bar linkage of a beam pumping unit that is located between the output shaft of the gear reducer and the pitman link.

3.7
cross-beam clamp
Device used to constrain the pumping unit to its supporting foundation. Often a beam-like member placed on top and spanning the base rails with anchor bolts joining it to the foundation anchorage.

3.8
equalizer
Connects the pitman links to the rear of the walking beam.

3.9
foundation
Structural element designed to support the pumping unit base and transmit loads into the earth via distributed contact with soil or piles.

3.10
horsehead
Component of a beam pumping unit designed to transmit force and motion from the walking beam to the flexible wireline.

3.11
pitman
Connecting link in the pumping unit mechanism between the cranks and the equalizer.

3.12
prime mover
Primary driving mechanism imparting rotary motion on the pumping unit system. Typically connected to the speed reducer via a belt drive. Common variants are electric motors and internal combustion engines.

3.13
pumping unit
Machine for translating rotary motion from a crankshaft to linear reciprocating motion for the purpose of transferring mechanical power to a downhole pump.

3.14
rod clamp
Clamping device that is affixed to the polished rod of the well for the purpose of either transmitting axial loads to other components such as the carrier bar or constraining motion.

3.15
samson post
Support member of the walking beam that has a bearing mounted to a fixed location atop which is attached to and provides the fulcrum location for the walking beam.

3.16
sheave
Rotating component of a V-belt drive designed to transmit power from the belts to the rotating shaft on which it is affixed or vice versa.

3.17
skidding
Horizontal movement as a result of dynamic forces from rotating cranks, counterweights, and other bodies.

3.18
tie-down clamp
Clamping device used to affix the pumping unit base to the foundation.

3.19
V-belt
Common method of transferring power from one rotary element to another. Typically connects the output sheave of the prime mover to the input sheave of the speed reducer.

3.203.20
wireline
Flexible element connecting the well's polished rod to the horsehead of the pumping unit.

4 Foundation and Site Preparation

4.1 General

The following discusses the typical role and requirements associated with the pumping unit foundation. It describes a general process of preparing a location to support a pumping unit installation.

Pumping units, by their nature, transmit very large forces to the supporting earth. Foundations provide a means of distributing these forces over a broad area allowing the soil and underlayment to generate sufficient strength and stiffness to withstand them while yielding only very small deflections. The stability and rigidity provided by the foundation and the site preparations necessary to constrain movement are essential in maintaining proper alignment and providing the pumping unit with long operational life. Many times, structural failures involving pumping units can be traced back to an insufficient foundation or poor site preparation practices.

The means by which pumping unit foundations transmit their loads into the earth take several forms ranging from simple surface contact with the underlying soil to driven or helical piles sunk deeply into the earth. In each case, the foundation must possess sufficient strength and stiffness to allow localized forces applied by the pumping unit to be adequately distributed over an area of soil contact or to a series of piers (piles) so that the local load bearing capacities of these elements are not exceeded. It is also often necessary for the foundation to possess sufficient mass to constrain dynamic up-lifting forces produced by some pumping unit models and prevent degradation of the soil contact interface under the foundation. The mass of the foundation also helps to stabilize the unit against skidding.

One area of particular importance is rigidity under load. The top surface of the foundation should remain as flat (planar) as possible under all operational loading conditions. The pumping unit base structure is typically clamped to the top surface of the foundation and excessive deflection can result in damage to the structural components or the pumping unit mechanism. The allowable deflection under load varies somewhat by pumping unit model but in general, the vertical deflections measured at the top surface of the foundation should not exceed 0.035 in. (0.9 mm) throughout the operating cycle. This measurement can be easily made using a dial indicator anchored on the ground while measuring at a point on the foundation surface.

4.2 Foundations Mounted on Grade

4.2.1 General

Foundations of this type typically derive their support through a distributed area of contact with the earth. This includes poured in place reinforced concrete slabs, precast concrete slabs, board mats, and certain other integrated portable pumping unit base structures that are specifically designed for similar distributed load bearing capability. These foundations often do not require any other form of anchorage to fix their location relative to the earth. They are, however, highly reliant on proper site preparation to provide the necessary stability and strength to resist pumping unit forces over time.

4.2.2 Site Preparation Recommendations for Foundations Mounted on Grade

4.2.2.1 General

The following requirements are performed for the initial site preparation.

— Contact a local geotechnical engineer to conduct an evaluation of the soil and installation site and provide a plan for preparations.

— Remove loose materials (scoria, etc.) surface vegetation, roots, and other organic materials from the soil that will underlie the pumping unit foundation.

— Excavate, back-fill, compact, and amend the soil with materials in accordance with the geotechnical engineering plan.

4.2.2.2 Site Drainage

The foundation site should be elevated slightly relative to the surrounding area such that water will tend to drain away from the foundation. Do not allow water to pool adjacent to or drain across the site.

4.2.2.3 Soil Load Bearing Capacity

The soil bearing strength should normally exceed 1500 lb/ft^2 (7323 kg/m^2). Select foundation design with sufficient soil contact area to distribute pumping unit loads appropriately. If necessary, amend the soil with materials designed to increase the bearing capacity beneath the foundation as recommended by the geotechnical engineer. Soil pressure should not exceed that of the bearing strength in any location.

4.2.2.4 Soil Stiffness

The required soil stiffness depends on the magnitude of the applied loads from the pumping unit, the ground contact area of the foundation, and the allowable vertical deflection of the foundation under load (see above). Pumping unit base loading information is typically available from the pumping unit manufacturer to use in selecting an appropriate foundation design.

4.2.2.5 Cold Climates

In cold climates, the soil often freezes to substantial depth in winter resulting in a condition known as frost heaving. Water entrained within the soil expands in volume and in more severe cases can affect pumping unit alignment. Subsequent thawing often results in extremely wet conditions near the surface that may affect the load bearing capacity of some soils. The geotechnical engineer may suggest lining the excavated pit with a geotextile barrier fabric to prevent migration of select fill and soil amendments away from the load bearing area. In severe frost heaving conditions, there may be advantages to mounting the foundation on piles.

4.3 Foundations Mounted on Piles

Foundations of this type derive their support from discreet piles (piers) that have been sunk into the earth to sufficient depth to achieve the required load bearing capacity. The piles are typically spaced at intervals beneath the foundation so as to concentrate their numbers in areas where the highest applied loads are predicted to occur. This form of foundation support has become popular in cold climate locations with substantial frost heaving or in locations where normal surface preparations may be impractical (marshes, etc). Pile supported foundations are often elevated above grade such that they rest completely on the piles and make no direct contact with the soil. This is common in cold climates where frost heaving might otherwise lift the foundation off the piles. Foundations used in this type of mounting are typically precast concrete pads, with embedded steel pads or plates to fix them to the top of the piles or steel fabricated mats. The design of the foundation must be sufficient to distribute the local pumping unit loads over a series of piles with the cumulative capacity to withstand them. The foundation stiffness should be sufficient to perform this function while limiting deflections to within the allowable limits for the pumping unit structure. Lateral support for the foundation is typically provided via diagonal bracing of the exposed piles or by supplemental attachment of the foundation to piles driven at an angle relative to vertical.

5 Installation of Pumping Units Using Foundation Bolts and Grouting Between the Block and the Pumping Unit Base

The following describes a basic process to properly mount the pumping unit on a concrete foundation in which final unit leveling is accomplished with wedges and then grouting under the base flanges. The base is then fastened to the foundation via embedded foundation bolts (anchors).

— Pour concrete foundation block to the certified (approved/stamped) drawing provided by the pumping unit manufacturer or operator. Locate foundation bolts accurately, using grouting tubes. Finish top of foundation, level and flat.

— After the foundation has hardened, strike a centerline from the center of the well tubing across to the top of the foundation using a chalk line as located by the certified installation drawing.

The pumping unit manufacturer shall provide the base with punched or scribed centerline marking on cross members at the front and rear of the base. On units with bolted-on extension bases, the centerline marking will be on the main base.

— Where practical, the pumping unit manufacturer should provide lifting points on major components to aid in installation or reconfiguration of the unit. The intended use and safe working load capacity of lift points should be described in the operator instructions or physically marked on the pumping unit structure.

— Set the base on the foundation, using wedges to support the base about 1 in. above the foundation. Line up center marks on the base with the chalk line on the foundation.

— Move the base to or from the well according to value shown on the foundation print for dimension from the base member to the centerline of well. Also, align the pumping unit base laterally with the centerline of the wellhead.

— Use wedges to level top of the base. Check level both lengthwise and crosswise of base at several points along its length.

— The manufacturer should provide a means for attaching plumb line on a longitudinal centerline of samson post top.

— After mounting the samson post on the base, drop a plumb line from the center of the samson post top to a centerline drawn on top of the foundation. If the plumb bob does not fall on centerline, readjust wedges or make other corrections.

The pumping unit manufacturer shall provide a longitudinal adjustment of the walking beam on the center bearing, or of the center bearing on the samson post, as a means of accurately adjusting the beam's alignment with respect to centerline of the well.

— After mounting the walking beam on samson post and connecting the pitmans to the cranks, drop a plumb line at the center of the horsehead (out from the arc plate of the horsehead a distance equal to one half of the diameter of the wire line) down to the center of the well tubing. Adjust the walking beam longitudinally or laterally so that the plumb bob will be within $^{1}/_{16}$ in. of the center of the well tubing. Check for proper tracking of wire line on horsehead.

— Apply grout material under the base completely filling the void between the concrete and the lower base flange and allow to harden before removing wedges. The cured grout material should be of sufficient compressive strength to support the combined pumping unit weight and well load.

— Uniformly tighten all foundation bolts and check tightness of all structural bolts. After running unit for two weeks, recheck tightness of all bolts. A common practice is to match mark the bolt head or nut and adjacent structure using a paint marker of a contrasting color so that any relative movement of the fastener can be visually detected at a distance.

6 Installation of Pumping Units Using Cross-beam Clamps or Methods Other than Foundation Bolts

The following describes a basic process to properly mount the pumping unit on a concrete foundation in which the upper mounting surface of the foundation has been previously prepared to the proper level and flatness. The pumping unit base is then affixed to the mounting surface of the foundation using cross-beam clamps or other methods.

Because the pumping unit base is to set directly on the concrete block, the top of the block should be hand troweled to an accurate, level, and planar surface. Flatness of the mounting surface should be held to no more than $^{1}/_{16}$ in. (1.6 mm) over 8 ft (2.4 m) in any direction when measured by straight edge.

— After the foundation has hardened, using a chalk line, strike a centerline from the center of the well tubing across the top of the foundation on centerline as located by certified installation drawing.

— The pumping unit manufacturer shall provide the base with punched or scribed centerline marking on cross members at the front and rear of the base. On units with bolted-on extension bases, the centerline marking will be on the main base.

— Where practical, the pumping unit manufacturer should provide lifting points on major components to aid in installation or reconfiguration of the unit. The intended use and safe working load capacity of lift points should be described in the operator instructions or physically marked on the pumping unit structure.

— Set the pumping unit base directly on the top surface of the block without wedges.

— Move the base to or from the well according to the value shown on foundation print for dimension from base member to centerline of the well. Also, align the pumping unit base laterally with the centerline of the wellhead.

— A check for level will, in most cases, be found reasonably satisfactory if the block has been properly prepared.

Manufacturer shall provide a means for attaching a plumb line on a longitudinal centerline of the samson post top.

— As noted above, in most cases a pumping unit set directly on the block will be found to be reasonably level and plumb. If this is not the case due to unavoidable mill tolerances of the height and squareness of the base beams, then it will be necessary to do some adjusting with wedges, and to either grout or shim in certain locations. If shims are used, it is advisable to weld them together and to the base beam to make certain that they remain in place.

— The pumping unit manufacturer should provide a longitudinal adjustment of the walking beam on the center bearing, or of the center bearing on the samson post, as a means of accurately adjusting carrier bar with respect to centerline of the well.

— After mounting the walking beam on samson post and connecting the pitmans to cranks, drop a plumb line at the center of the horsehead (out from the arc plate of the horsehead a distance equal to one half of the diameter of the wire line) down to the center of the well tubing. Adjust walking beam longitudinally or laterally so that the plumb bob will be within $^{1}/_{16}$ in. (1.6 mm) of the center of the well tubing. Check for proper tracking of wire line on horsehead.

— If wedges were used, grout under the base and allow grout to harden before removing wedges.

— Check the tightness of all structural bolts. After running the unit for two weeks, recheck tightness of all bolts. A common practice is to match mark the bolt head or nut and adjacent structure using a paint marker of a contrasting color so that any relative movement of the fastener can be visually detected at a distance.

7 Installation of Pumping Units on a Reinforced Concrete Portable Foundation

7.1 General

The following describes a basic process for mounting a pumping unit on a portable precast concrete pad foundation using cross-beam clamps or other methods. Functional requirements for proper pad installation are also discussed.

Manufacturers of concrete portable foundation shall provide a foundation with the following minimum specifications.

— Concrete used shall have a 28 day minimum compressive strength of 4000 psi (27.5 Mpa) with a maximum water to cement ratio of 6.0:1.

— Foundation design shall include reinforcing steel of sufficient size, quantity, and placement, including prestressing if used, to provide a resisting moment twice the static bending moment produced with two point pick up of the foundation.

— The size of the foundation will to some extent be determined by the physical dimensions of the unit, but it should be of sufficient dimensions to adequately support and stabilize the pumping unit. The design of the foundation shall be such that the maximum soil bearing pressure at any point on the foundation will not exceed the bearing pressure recommended for the area. Likewise, the foundation dimensions shall be chosen such that in conjunction with the soil stiffness (modulus of subgrade reaction), the allowable vertical deflections under operational loads are not exceeded. The soil pressure shall be calculated assuming a well load equal to the beam rating of the unit and including the gross weight of the unit and foundation.

7.2 Base Orientation

Base orientation is commonly dictated by the prevailing wind. The unit is placed so that the prevailing wind will blow well leakage away from the unit and prime mover. Units equipped with an engine prime mover should be oriented to provide maximum cooling for the engine radiator. Consideration shall also be given to drainage at the well site. The foundation location should utilize natural drainage to drain water and well fluids away from the foundation. When the natural gradient is incorrect or nonexistent, the site should be graded to provide drainage away from the foundation.

7.3 Site Preparation

Under most conditions the foundation area should be excavated to firm soil (consult a local geotechnical engineer per Section 1). Further compaction with a mechanical compactor to a maximum possible density is desirable. Level the compacted soil in two directions. Fill with sharp sand or pea gravel to a minimum depth of 2 in. (50 mm). Again, carefully level this fill in two directions.

In some localities it is necessary to build an elevated mound of compacted earth, caliche or gravel. This mound should be firmly compacted and of sufficient area at the top to prevent movement of the fill material from beneath the base. Level the site in two directions and cover with a minimum of 2 in. (50 mm) of sand and pea gravel and again level in two directions. Where concrete portable foundations will be installed over old foundations or walkways, all bolts and projections should be removed and a fill of 2 in. (50 mm) of sand or pea gravel should be placed between the old concrete and the new base.

7.4 Placement

Place the portable concrete foundation on the leveled fill, with centerline of foundations aligned with centerline of well, and set back the proper distance from well tubing center.

— Level foundations carefully in two directions.

— Using a chalk line, strike a centerline from the center of the well tubing across the top of the foundation.

— Mark on this centerline the distance from the well as specified by the certified installation print.

The pumping unit manufacturer shall provide the main structural base with punched or scribed centerline markings.

Where practical, the pumping unit manufacturer should provide lifting points on major components to aid in installation or reconfiguration of the unit.

The pumping unit structural base is set on the concrete portable base and the structural base is aligned with the chalked centerline and distance markings.

Manufacturer shall provide a means of attaching a plumb line on the longitudinal centerline of the samson post top.

7.5 Adjustment After Erection

After the erection of the samson post on the structural base, drop a plumb line from center of the samson post top. If the plumb bob does not fall within 1/4 in. (6 mm) of the chalk line centerline, check the structural base for lateral level. If the structural base is found to be not level and true, it will be necessary to shim under the feet of the samson post legs, or shim and grout between the unit base beams and the foundation top. If the samson post is one that is manufactured and shipped in individual pieces to be bolted together at the well site, misalignment can often be corrected by loosening the assembly bolts moving the center of the saddle bearing top over the chalk line and retightening the bolts.

After mounting the walking beam on samson post and connecting the pitmans to cranks, the walking beam should be checked to be sure it is parallel to unit centerline. This can be done by measuring the distance from the inside edge of the pitmans to each crank face. This gap should be the same on each side. If the gaps are unequal, loosen bolts holding the walking beam to the samson post top. Swing the beam until the gaps are equal.

The pumping unit manufacturer shall provide for longitudinal adjustment of the walking beam so than the carrier bar can be accurately adjusted over the center of the well tubing. This recommendation applies to units with center mounted beams. Units with end pivoted beams do not have longitudinal adjustment and the whole unit must be moved to center carrier bar over well tubing.

Move the walking beam longitudinally until a plumb line held at the center of the horsehead (out from the arc plate one-half the thickness of the wireline) will center directly over the well tubing. An alternate method is to hang the rods on the carrier bar and adjust the walking beam until the polished rod centers in the pumping tee. (The stuffing box is unscrewed and slid up the polished rod out of the way.) When this method is used, it should be first determined that the wellhead is level and the tubing and polished rod are in true vertical position and that the polished rod is neither crooked nor bent.

The pumping unit manufacturer shall provide for adjustment of the horsehead so that the tracks of the horsehead can be aligned with the wireline.

The horsehead should be adjusted so that the wirelines center on the tracks of the horsehead.

7.6 Bolts and Clamps

After a final alignment check has been made and necessary corrections made, install the foundation bolts and hold down clamps that may be required by the manufacturer’s certified installation drawing. Where a certified foundation print is not available, tie-downs should be placed as follows.

— One as near the well end of the unit as possible. One as near the rear samson post leg(s) as possible.

— One approximately 1 ft (0.3 m) in front of the gear reducer or gear reducer sub-base.

— One closely behind the gear reducer or gear reducer sub-base.

— On some very large units it is desirable to place an additional tie-down clamp between the front and rear samson post legs and directly under the gear reducer.

If top mounted cross-beam clamps are used, they should extend beyond the center web of the base beam. On large units having main base beam centerlines more than 30 in. (762 mm) apart, two rows of tie-down bolts are recommended (spaced as widely as practical within the span of the base beam rails). The design of the top mounted cross-beam clamps should be of sufficient cross section to resist bending moments induced by bolting forces with additional capacity to handle operational forces without yielding. Tighten clamps securely.

7.7 Postinstallation

Check the tightness of all structural bolts and counterweight bolts. After two weeks of operation, recheck the tightness of bolts. A common practice is to match mark the bolt head or nut and adjacent structure using a paint marker of a contrasting color so that any relative movement of the fastener can be visually detected at a distance.

Fill in on all sides of the concrete foundation with compacted earth to prevent water or well fluids from seeping under the concrete foundation. The slope of this fill should be a maximum of 1:6. A spray coating of oil will serve to make this fill more watertight.

Most pumping unit bases and concrete foundations are not designed to take continuous flexing and movement. Such movement will cause fatigue failure and breakage. Exceptions to this general rule are certain units that are designed with heaver main base members that require support only at front and rear ends.

With single cylinder engines, special consideration should be given to the extension base setting. A one-piece base of sufficient size and weight, auxiliary tie-downs, or earth anchors is often used. Proper care should be taken to avoid overloading these engines or to operating at “lugging” speeds to reduce the tendency to vibrate or bounce.

7.8 Maintenance After Installation

The foundation bolts should be checked at regular intervals to ensure that the unit does not move on its foundation. All structural bolts should be checked for tightness.

The grade around foundation should be maintained to insure that drainage is away from foundation and water does not seep under foundation.

If the concrete foundation shows evidence of rocking after installation, the fill can be thrown back and the foundation edge filled with sand. This sand will feed in under the foundation and arrest movement. This sand should be stirred with shovel or rake to insure free flow under the foundation. When movement stops, the compacted earth fill around the foundation should be restored.

Ensure that the unit structure is not overloaded and is properly counterbalanced. A unit that is overloaded or out of balance will cause undue loads on the unit that are transmitted to the foundation.

Any unit set on other than a grouted concrete base must be checked for level, both transversely and laterally, and stability while in motion.

8 Installation of Portable Wide Base Pumping Units on a Board Mat Foundation

8.1 General

The following section describes a basic process for mounting a pumping having an integrated, wide skid portable base. These units are typically mounted on a prepared site utilizing a board mat foundation.

8.2 Base Orientation

Base orientation is commonly dictated by the prevailing wind. The unit is placed so that the prevailing wind will blow well leakage away from unit and prime mover. With engine prime mover, placement should provide maximum cooling for the engine radiator. Consideration must also be given to drainage at the well side. The foundation location should utilize natural drainage to drain water and well fluids away from the foundation. When the natural gradient is incorrect or nonexistent, the site should be graded to provide drainage away from foundation.

8.3 Site Preparation

The selected site should be graded to level. An elevated mound of compacted earth, caliche, or coarse gravel should be built having outside dimensions, at the top, at least 2 ft (0.6 m) greater on each side than the outside base beams. Slope of the mound sidewall should be less than the natural slump of the material used. The height of this compacted mound should be a minimum of 6 in. (150 mm) in firm soil. In soil having poor bearing qualities or if the location will have poor drainage, the thickness of this compacted pad should be increased. A 4-in. (100-mm) thick coarse gravel fill, topped by a 2-in. (50-mm) thick sand fill should be placed uniformly on this pad. This fill should be carefully leveled in both directions.

Following the certified (approved/stamped) installation drawing, a mat of boards should be carefully placed on the sand fill and the level again checked in both directions. These boards should be placed at right angles to the direction of walking beam. Three inch (75 mm) by 12 in. (300 mm) timbers are commonly used. Larger timbers would be required for larger units. In damp areas the use of treated boards is advisable. These timbers should be long enough to extend 12 in. (300 mm) beyond sides of unit base beams. For maximum support a solid mat should be employed, leaving 2 in. (50 mm) to 3 in. (75 mm) gaps between adjacent boards. Minimum support would be three or four boards with 2 in. (50 mm) to 3 in. (75 mm) gaps under the front samson post legs, three or four boards placed under the rear samson post legs and gear reducer, and three or four boards placed at uniform intervals under the prime mover extension base.

8.4 Placement

For placement:

— using a chalk line, strike a centerline from the center of the well tubing across the top of the board mat;

— mark on this centerline the distance from the well as specified by the certified installation print.

The pumping unit manufacturer shall provide the main structural base with punched or scribed centerline markings.

Where practical, the pumping unit manufacturer should provide lifting points on major components to aid in installation or reconfiguration of the unit.

The structural base should be hoisted above the board mat and carefully lowered into position on the board mat. Any attempt to drag or slide the structural base into position will disturb board level and placement. This will make leveling of the base extremely difficult. The structural base should be carefully aligned with chalked centerline mark and well distance mark.

The manufacturer shall provide a means for attaching a plumb line on the longitudinal centerline of the samson post top.

8.5 Adjustment After Mounting

After mounting the samson post on the base, drop a plumb line from center of samson post to centerline on board mat. If plumb bob does not fall on the centerline, the base should again be checked for level. If structural base is found to be true and level, it will be necessary to shim under the feet of the samson post legs. If the samson post is one that is manufactured and shipped in individual pieces and bolted together at the well site, misalignment can often be corrected by loosening the assembly bolts, moving the samson post top into position, and then retightening the bolts.

After mounting the walking beam on samson post and connecting pitmans to cranks, the walking beam should be checked to be sure it is parallel to unit centerline. This can be done by measuring the distance from the inside edge of the pitmans to each crank face. This gap should be the same on each side. If the gaps are unequal, loosen bolts holding the samson post bearing base to the samson post top. Swing the beam until gaps are equal and then retighten all bolts.

The pumping unit manufacturer shall provide for longitudinal adjustment of the walking beam so that the carrier bar can be accurately adjusted over the centerline of the well. This requirement applies to units with center mounted beams. Units with end pivoted beams do not have longitudinal adjustment and the whole unit must be moved to center carrier bar over well tubing.

Move the walking beam longitudinally until a plumb held at the center of the horsehead (out from the arc plate one-half the thickness of the wireline) will center directly over the well tubing. An alternate method is to hang the rods on the carrier bar and adjust the walking beam until the polished rod centers in the pumping tee. (The stuffing box is unscrewed and slid up the polished rod out of the way.) When this method is used, it should first be determined that the wellhead is level and the tubing and polished rod are in a true vertical position and that the polished rod is neither crooked nor bent.

The pumping unit manufacturer shall provide for adjustment of the horsehead so that the tracks of the horsehead can be aligned with the wireline.

The horsehead should be adjusted so that the wirelines track in the center of the horsehead.

Fill the inside and outside of the unit structural base with sand to a level at least 1 in. above top surface of the boards. If the unit or base flexes under load, this sand will feed into the gaps created and stop flexing movement.

8.6 Postinstallation

Check tightness of all structural bolts and counterweight bolts. After two weeks of operation, recheck the tightness of all bolts. A common practice is to match mark the bolt head or nut and adjacent structure using a paint marker of a contrasting color so that any relative movement of the fastener can be visually detected at a distance.

Most pumping unit bases are not designed to take continuous flexing or movement. Such movement will cause fatigue failure and breakage. Exceptions to this general rule are certain units that are designed with heavier main base members that require support only at the front and rear ends.

With single cylinder engines, special consideration should be given to extension base setting. Auxiliary tie-downs on earth anchors are often used to minimize bounce and vibration. Proper care should be taken to avoid overloading these engines or to operating at “lugging” speeds to reduce the tendency to vibrate our bounce.

8.7 Maintenance of Board Mat Foundation

Maintenance of the board mat foundation includes the following.

— Replace any sand that may have worked out from under boards, after loosening with rake or shovel any hard or crusted sand that would prevent flow or feed of new sand under boards or base beam members.

— Ensure that the structural base is still level in a lateral direction. If level, check the position of the polished rod to be sure it still centers in pumping tee. Make necessary longitudinal adjustments of beam to center polished rod. If the unit is not level in a lateral direction, it should be releveled.

— Check tightness of all bolts, tie-downs, and earth anchors.

Any unit set on other than a grouted concrete base must be checked for level, both transversely and laterally. Additionally, the foundation and base should be visually observed (at a minimum) while the unit is in motion to verify its stability.

9 Lubrication of Pumping-unit Reducers

9.1 General

This section covers lubrication procedure for pumping-unit speed reducers using either gears or roller chains and sprockets. Consult the manufacturer's operating instructions for information regarding the recommended lubricant for your pumping unit.

The recommendations apply only when the gears and chain drives are designed and rated in accordance with API standards. The oil operating temperature range to which they apply is –50 °F (–45 °C) to +155 °F (69 °C).

It is not possible to adequately describe suitable lubricants by brief specifications or by SAE viscosity number or ISO viscosity grade alone. Further, adequate lubrication instructions cannot be condensed sufficiently to be placed on a nameplate on account of the many variables in operating conditions to which pumping units are subjected.

9.2 Selection of Oil

The proper oil for the pumping unit speed reducers is best chosen with the advice of a representative of a well-established supplier of lubricants and should be based on the service conditions that are established by the design of the reducer and the service conditions of the particular installation. For the assistance of the lubricant supplier, these conditions are summarized in Table 1 and Table 2.

The areas in contact on gear teeth, and on chains and sprockets, are relatively small and therefore the unit pressures produced in transmitting peak loads are correspondingly high. The gears, chains, and sprockets are designed to operate under these high pressures if the lubricant used is also capable of withstanding these unit pressures during the periods of peak loads.

Table 1—Range of Operating Conditions for Gear Reducer

API peak torque rating, inch-pounds (newton-meters)	6,400 to 2,560,000 (723 to 289,240)
Number of reductions	Double or single
Ratio, double reduction	25:1 to 32:1
Ratio, single reduction	9.4:1 to 11:1
Rpm of low-speed shaft or crankshaft	2 (Note 1) to 30 (Note 2)
Center, low-speed train, inches (millimeters)	6 to 36 (152 to 915)
Face, low-speed train, inches (millimeters)	3 to 14 (75 to 356)
Gear hardness, Brinell	160 to 300
Type bearings, crankshaft	Roller or bronze plain
Type bearings, intermediate or high-speed shaft	Roller
Lubricant capacity, gallons (liters)	4 to 235 (15 to 890)
Normal temperature rise above surrounding air, °F (°C)	0 to 25 (0 to 14)

NOTE 1 Some manufacturers require optional lubrication system equipment such as high speed gear wipers to maintain consistent lubrication when operating the reducer at less than 5 SPM.

NOTE 2 Maximum rating speed for gear reducers according to API 11E-2013 (Table 3) is 20 SPM.

Table 2—Range of Operating Conditions for Chain Reducer

API peak torque rating, inch-pounds (newton-meters)	26,000 to 228,000 (2,935 to 25,760)
Number of reductions	Single, double, or triple
Ratio, double reduction	19:1 to 26:1
Ratio, single reduction	6:1 to 14.55:1
Rpm. of crankshaft	4 to 30 (Note 2)
Center, low-speed train inches (millimeters)	13 to 42 (330 to 1,067)
Chain size, low-speed drive, pitch and strands	1-in. pitch triple strand to 2-in. pitch triple strand
Sprocket hardness, Brinell	225 to 400
Type bearings, crankshaft	Roller, tapered roller, or bronze
Type bearings, intermediate or high-speed shaft	Roller
Lubricant capacity, gallons (liters)	6 to 36 (22 to 137)
Normal temperature rise above surrounding air, °F (°C)	Depending on pumping speed and loading 0 to 25 (0 to 14)
NOTE 1 Maximum rating speed for gear reducers according to API 11E-2013 (Section 6.3.2) is 20 SPM.	

The temperature of the air in the vicinity of the reducer is of considerable importance in selecting oil of the proper viscosity. The viscosity of oil decreases with increasing temperature. Therefore, it is typically desirable to use oil with a higher viscosity for high air temperatures than for low air temperatures. For low-temperature operation, the oil should have sufficient fluidity to permit a free flow of oil through the lubricating channels in the reducer.

The operating temperature of oil in pumping-unit reducers normally will be from ambient air temperature to 25 °F (14 °C) above the air temperature. The temperature rise of oil will be negligible in slow-operating, lightly loaded reducers and will reach the upper limit in heavily loaded reducers operating at the higher speeds. The temperature of the oil in a reducer will become equal to the air temperature when the pumping unit is stopped for any appreciable time. Because most pumping units will be stopped at times, the lowest temperature of oil in a reducer usually will be the lowest air temperature reached in the locality where the pumping unit is operating. This is an important consideration when selecting a lubricant with the proper viscosity and pour point.

Synthetic gear lubricants, while typically more expensive than mineral oil based products, offer a distinct advantage in climates where ambient temperature varies widely. These lubricants often possess higher viscosity index values than their mineral oil counterparts indicating that their viscosity varies less with temperature. This often allows selection of higher viscosity grades for protection in warm conditions while still ensuring adequate flowing properties even in areas with low minimum ambient temperature. Lubricant suppliers can provide information regarding low-temperature performance characteristics of these lubricants as well as recommended replacement intervals.

For gear reducers, straight gear lubricants or extreme pressure gear lubricants are preferable to motor oils in that they separate quickly from water. Motor oils of equivalent viscosity may be used in an emergency, but practically all of them contain dispersants and detergents that may cause an emulsion to form if water is present.

Table 3 for gear reducers and Table 4 for chain reducers show the permissible range of operating temperatures for each viscosity and type of lubricant listed. In each case the minimum temperature is based on the ability of cold oil to flow properly through the lubricating channels in the reducer, and the maximum temperature is based on the ability of the hot oil to maintain adequate lubrication. The temperature ranges are wide to permit year-round operation with one viscosity grade of oil in localities where seasonal air temperature range will allow it. The operator should select the grade that best meets the desired temperature range. If the summer to winter range is too great for a single viscosity grade, use of a separate summer grade and winter grade will be necessary, depending on the time of year.

It is recommended that nameplates on pumping unit reducers minimally reference this recommended practice.

9.3 Changing Oil

In order to obtain long life from a pumping-unit reducer it is necessary at all times that the oil be of suitable viscosity and free from foreign material, sludge, and water.

To maintain proper viscosity, mineral oil based lubricants should be changed in the spring and fall if the seasonal air temperature range results in the temperature of the oil exceeding a range shown in Table 3 or Table 4.

Table 3—Viscosity Recommendations for Gear Reducers (Typical Mineral Oil Based Lubricants)

Application [a]	SAE Gear or Transmission Oil [b]	AGMA (ISO) Oil
0 °F to 140 °F (–18 °C to 60 °C)	90 extreme pressure (EP)	5 EP (ISO VG 220)
–30 °F to 110 °F (–34 °C to 44 °C)	80 EP	4 EP (ISO VG 150)

[a] Operating temperature of oil in a gear reducer on a pumping unit will normally range from air temperature to 25 °F above air temperature. The temperatures shown in the table are limiting values between which satisfactory lubrication can be expected.

[b] Synthetic lubricants, depending on their formulation, may possess a wider range of acceptable operating temperatures. Check with the synthetic lubricant manufacturer for viscosity/temperature relationships for your lubricant.

Table 4—Viscosity Recommendations for Chain Reducers

Temperature [a] of Oil SAE Viscosity Number in Chain Case °F (°C)	Automotive Engine Oil	Gear Oil
–50 to +50 (–45 to 10)	5W	—
–20 to +80 (–29 to 27)	10W	75
0 to +100 (–18 to 38)	20W	80
+10 to +125 (–12 to 52)	30	80
+20 to +135 (–6 to 57)	40	—
+30 to +155 (–1 to 68)	50	90

[a] Operating temperature of oil in a chain case on pumping unit normally will be from the air temperature to 25 °F (14 °C) above the air temperature. The temperature shown the tables are the limiting values between which satisfactory lubrication can be expected.

The method used to determine how often oil should be changed to maintain the desired condition is a matter of policy with the individual company. Some operators periodically inspect reducers and take samples of oil for laboratory analysis to determine the percentages of water and solid material in the oil. Checks may also be made on viscosity and other properties such as acidity. Oil is then changed whenever the analysis shows that the limit set for any one of the various factors has been exceeded (see Table 5).

Other operators depend upon periodic visual inspection to determine when to change oil. An inspection includes a look inside the reducer case and an examination of a sample of oil that has been drawn off the bottom of the reducer case and allowed to settle. Oil is changed when an inspection shows:

— deposits on the surfaces inside the reducer;

— emulsification of oil;

— sludging of oil;

— contamination of the oil with foreign material such as dirt, sand, or metal particles;

— sludging and emulsification of oil are usually found if there has been an excessive accumulation of water in the reducer.

Table 5—Recommended Oil Condemning Limits for Use When Evaluating Used Oil Test Results

Water contamination (emulsion)	2000 ppm (max)
Solid particulates	
Iron (Fe)	300 ppm (max)
Lead (Pb)	75 ppm (max)
Copper (Cu)	275 ppm (max)
Silicon (Si)	60 ppm (max)
Viscosity	
AGMA 5/ISO VG 220	>165 cSt @ 40 °C <288 cSt @ 40 °C
AGMA 4/ISO VG 150	>110 cSt @ 40 °C <198 cSt @ 40 °C
Acid number (AN) or total acid number (TAN)	Compare to values for new oil. Condemn when current AN or TAN value exceeds 4 times the value of new oil.

A small amount of water can accumulate in the bottom of the reducer due to condensation and ventilation. Such water should be drawn off to prevent accumulation to the point where it will be carried with the oil and cause emulsification or sludging.

The time interval between inspections to determine the condition of the oil depends upon operating conditions. Adverse conditions that may require inspection and change of oil as often as every three or four months include one of more of the following:

— intermittent operation,

— excessive dust,

— sulfur fumes,

— combination of high humidity with high variation in daily air temperature.

Under the most favorable conditions of minimum daily and seasonal temperature changes, low humidity, and freedom of atmospheric dust, a reducer may operate through one or more years before the oil is contaminated or deteriorated to the point that an oil change is required.

After petroleum solvent is used for flushing, all of the flushing agent should be removed and the reducer immediately refilled with a suitable oil. If the reducer is not immediately returned to operation, the unit should be operated for at least 10 minutes, or longer if necessary, to ensure that all surfaces are covered with a protective film of oil.

10 Lubrication Difficulties

Lubrication of pumping-unit reducers is a relatively simple problem if handled with the advice of a well-established supplier of lubricants and, under normal conditions, very little trouble is experienced. However, a combination of improper lubricant selection and extreme conditions of service may lead to any of difficulties that should be recognized and corrected (Table 6).

11 Basis for Selection of Lubricants

11.1 Conditions Established by Gear Design

The characteristics for a typical pumping unit geared reducer that is an enclosed, but vented, gear box are identified in Table 1.

Table 6—Difficulties: Cause Analysis and Remedy

a) Little or no oil being carried up by gears or chains and diverted into the bearing oil channels.	
Cause	**Remedy**
Under high-temperature conditions, oil may be too thin.	Either modify with a heavier oil of the same quality or drain and refill with an oil of proper viscosity. Consider synthetic lubricant.
Under low-temperature conditions, oil may be too viscous.	Either modify with a lighter oil of the same quality or drain and refill with an oil of proper viscosity. Consider synthetic lubricant.
Oil level may be too low.	Fill to proper level.
b) Unit starts difficult in cold weather.	
Cause	**Remedy**
Oil too heavy and too viscous.	Either modify with a lighter oil of the same quality, or drain and refill with a lighter oil. Consider synthetic lubricant.
c) Continuing and severe pitting or scuffing of gears in the presence of sufficient lubrication. (Some slight initial corrective pitting that soon stops is not abnormal.)	
Cause	**Remedy**
Gear may be overloaded, particularly at the load peaks. (This may be caused from improper application of the pumping unit, too large a subsurface pump, or incorrect counterbalancing.)	Reduce loading.
Oil may be of incorrect specification or oil may have lost its lubricity through use, emulsification with water, or contamination with foreign material.	Drain, flush, and refill with proper lubricant.
d) Pitting of active and inactive surfaces of pins and bushings in chain reducers. (Sprocket teeth and exterior surfaces of chain rollers and link plates will not necessarily be pitted.)	
Cause	**Remedy**
Corrosion due to the presence of water condensate, or other corrosive agent in the lubricant	Drain, flush, and refill with proper lubricant
e) Gears, sprockets, chains, or bearings are wearing or abrading (as distinguished from pitting or scuffing.)	
Cause	**Remedy**
Dirty oil.	Drain, flush, and refill with proper lubricant
f) Foam rises in box and, in some cases, leaks from shaft seals.	
Cause	**Remedy**
Incorrect lubricant or lubricant contaminated with kerosene from flushing operation.	Drain, flush, and refill with proper lubricant.
Oil level may be too high, particularly if unit is operating at high speed.	Lower oil to a proper level.
Loss or lack of antifoaming additive in oil.	Check with lubricant supplier for proper type and amount of antifoaming agent.
g) Oil milky in appearance as opposed to normal bright characteristics.	
Cause	**Remedy**
Oil may be emulsified with water, sometimes in combination with incorrect lubricant specification.	Drain, flush, and refill with proper lubricant.
Breather may be plugged.	Make sure that breather is open.

Table 6—Difficulties: Cause Analysis and Remedy

h) Heavy soapy sludge in case.	
Cause	**Remedy**
Incorrect lubricant.	Drain, flush, and refill with proper lubricant.
i) Excessive rusting and general corrosion of gears, sprockets, chains, or bearings.	
Cause	**Remedy**
Intermitted operation under humid conditions, water in case, improper lubricant, or deterioration of lubricant.	Drain, flush, and refill with proper lubricant. Some lubricants are available with rust-inhibiting agents.
Lack of ventilation.	Make sure that breather is open.
j) Difficulty: Sticky and insoluble deposits on gears and bearings.	
Cause	**Remedy**
Oil operated too long.	Drain, flush, and refill with proper lubricant.
Improper lubricant.	Drain, flush, and refill with proper lubricant.

Lubrication is achieved by dipping of the low-speed gear and of the intermediate gear of double-reduction units, which in turn carries oil up to pockets or channels leading to the bearings.

Gear loading is highly variable during the cycle but the peak loads are repeated on the same teeth of the low-speed gear.

11.2 Conditions Established by Design of the Chain Reducer

The characteristics for a typical pumping unit chain reducer that is an enclosed, but vented, roller-chain drive box are identified in Table 2.

Lubrication is achieved by dipping of the crankshaft chain and sprocket, and in the case of double-reduction units, the dipping also of the intermediate chain and sprocket that carry oil up to pockets or channels leading to reducer bearings.

Chain loading is highly variable during the cycle, but peak loads are repeated on the same teeth of the crankshaft sprocket.

11.3 Conditions of Service

Pumping-unit reducers are normally exposed to weather—sun, rain, wind, heat, cold. Some units are exposed to hydrogen-sulfide fumes; and, in many instances, units are exposed to fine drifting sand. Air temperature can vary from –50 °F (–45 °C) to 126 °F (52 °C) depending on location. Radiant sun heat contributes to temperature increases. In humid climates, temperature changes from day to night cause water-vapor condensation within drive enclosures.

Service can be continuous, or intermittent to the extent of a few hours per month.

Units are often operated by small operators in remote locations and with relatively infrequent attention. They may be distant from any source of lubricating oil other than a gasoline service station.

Operators tend, where possible, to operate the reducer as long as one to three years without an oil change.

12 Lubrication of Pumping Unit Structural Bearings

Pumping unit structural bearings range in design from oil bath plain type to antifriction roller type. The application in which they operate varies from full rotation to oscillation with highly varying load conditions. The consequences of a structural bearing failure can be catastrophic resulting in damage to property or personal injury. Proper lubrication selection and maintenance is essential to ensuring trouble-free long life for the pumping unit.

Most antifriction type structural bearings are grease lubricated. In some cases, such as the center bearing or equalizer bearing, the components do not rotate continuously but rather oscillate through relatively small angles at slow speed. The selected grease should possess a relatively high base oil viscosity and extreme pressure capacity yet remain soft enough at operational temperature to “slump” back into the bearing roller/race interface so that continuous lubrication can be maintained (see Table 7).

Table 7—Recommended Grease Properties

Temperature Range (°F)	Base Oil Type and Viscosity	Soap Thickener	Additives
>0 °F (–18 °C)	Mineral oil based 414-506 cSt. @ 40 °F AGMA #7 or ISO 460	NLGI #1 Lithium complex	Extreme pressure (EP), rust inhibitor
>–30 °F (–35 °C)	Mineral oil based 198-242 cSt. @ 40 °F AGMA #5 or ISO 220	NLGI #0 Lithium complex	EP, rust inhibitor

Grease containing synthetic base oil provides certain advantages relative to their mineral oil based counterparts. The viscosity index of the synthetic lubricant is typically much higher than mineral oil, meaning that its viscosity varies less with temperature. This can prove helpful in extremely cold climates particularly if the ambient temperature varies widely throughout the year. Check with grease manufacturer for acceptable operating temperature range for synthetic based grease.

Where practical, the manufacturer may provide a means of maintaining grease level in the structural bearing housings from ground level service points. This is often accomplished through use of hoses or piping attached to structural members connecting the overhead bearing assembly to a ground level grease fitting. Relief vents in the bearing housing can allow newly added grease to flush the bearing while avoiding overpressuring seals.

The lubrication maintenance interval for pumping unit structural bearing assemblies is typically six months.

Following the addition of new grease into the structural bearing assembly, a sample of the old grease should be taken from the relief port and examined for evidence of contamination (runny or milky) or metallic wear particles. If the grease is contaminated, it should be flushed from the housing and replaced with new grease of the proper specification. If metallic particles are found in the grease sample, it could indicate that a bearing failure is in progress and warrants a more in-depth inspection and potentially replacement of the antifriction bearing.

13 Maintenance

13.1 Wireline Maintenance

Pumping unit wirelines are typically comprised of one or more sections of wire rope anchored to the top of the horsehead and attached to a carrier bar (hanger) device for coupling onto the polished rod. The wireline is most often wrapped over a curved track on the horsehead such that as the horsehead articulates, the wireline will extend and retract from a point directly above the wellhead.

Caution—A failure of the wireline may result in sudden release of the well load and can lead to damage to property and/or injury to personnel.

Given the repetitive flexural motion and variable loading experienced by wirelines in service, it is of extreme importance that proper pumping unit alignment and horsehead adjustment be maintained. Proper horsehead/ wireline adjustment shall be checked at various stroke positions from top to bottom to verify that an upstream alignment issue internal to the pumping unit is not present.

Wirelines shall be regularly inspected looking for indications of wire breakage, corrosion, lack of lubrication or protectant, or signs of fatigue or excessive wear.

Periodically, the wireline should be serviced to replenish lubricant. This can typically be done by cleaning the rope with a wire brush and then applying a new coat of penetrating wire rope lubricant with a paint brush.

NOTE Do not use a solvent to clean the wire rope as this can strip away the internal lubricant, which can lead to accelerated wear and corrosion.

13.2 V-belt Maintenance

The most common means of transmitting power from the prime mover to the pumping unit is through a V-belt drive mechanism. Sheaves of various sizes can be selected to adjust the operating speed of the pumping unit.

V-belts, by their nature, transmit power through use of friction. As such, along with the sheaves they can be expected to wear over time. Loading, speed, alignment, and cleanliness have a significant effect on the rate of wear. Proper sheave alignment, selection of the appropriate number of belts, proper belt tensioning, and avoidance of contamination are effective methods to prolong the operating life of these components.

It is important that the rotating axis of the prime mover shaft and the pumping unit reducer input shaft are parallel. Failure to maintain parallelism between these shafts can lead to uneven belt tension in multibelt drives along with accelerated wear.

The reducer and prime mover sheaves should be adjusted so that they operate in the same plane. The prime mover can often be adjusted on its base by moving it inboard or outboard to accomplish this. Alternatively, the position of the sheave may be adjusted on the shaft. A common practice is to use a string stretched simultaneously across the inboard face of both sheaves to gage when the sheaves are coplanar.

In general, V-belts should be installed in the sheave grooves that are closest to the support bearings on the prime mover and reducer. This minimizes the overhung load exerted on the bearings and can increase their running life.

V-belts shall be tensioned according to the belt manufacturer's recommendations. A common recommended practice is that belts be tensioned such that they deflect a prescribed amount for a given force when pressed midspan between the sheaves at a given center distance. V-belt and sheave suppliers typically offer tools (i.e. tensiometers) designed to assist the operator in properly tensioning belts.

Belt guards shall be used on all V-belt drive mechanisms to protect personnel from injury and also to protect the belts from environmental exposure or contamination.

Periodically, V-belts and sheaves should be inspected looking for indications of excessive wear or cracking (see Figure 1). If the belt bottoms out in the sheave groove, the belt, sheave or both should be replaced.

Some belt and sheave manufacturers offer useful tools or gages to measure the sheave groove for evidence of wear. Consult the manufacturer regarding the availability of these items.

13.3 Brake System Maintenance

The pumping unit brake mechanism plays a key role in a multitude of installation and maintenance related tasks. Its proper function is essential in order to safely perform work on or around the pumping unit. Personnel should avoid entering the guarded areas of the pumping unit if it is suspected that the brake may not be functioning properly.

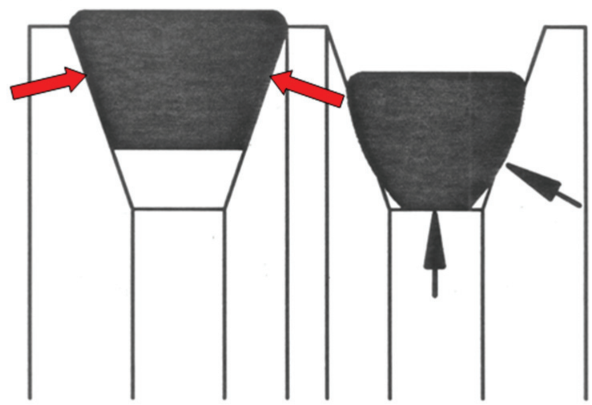

Figure 1—Proper V-belt and Sheave Groove Interface (left) vs Worn Belt and Groove (right) (Note Worn Belt Bottoming in Groove Reducing Belt Transmission Efficiency)

Pumping unit brakes are designed to have sufficient holding capacity to withstand the maximum counterbalance torque for the given unit design. However, the operator should never rely on the brake alone to restrain motion when working around the pumping unit. Proper unit shutdown and lock-out/tag-out procedures shall be followed (Section 14) for any instance when it is necessary to enter the pumping unit guarded areas. The pumping unit should be stopped with the cranks in the downward (six o'clock) position when servicing the brake.

Caution—The operator should bear in mind that during brake system adjustment or maintenance, it should not be relied upon to constrain the pumping unit's motion.

Additional measures should be employed to restrain motion in these instances. In addition to those described in Section 13, supplemental restraint measures may include but are not limited to:

— clamping the polished rod at the wellhead stuffing box,

— chaining the reducer V-belt sheave to the pumping unit base structure,

— chaining the equalizer down to the pumping unit base structure,

— chaining the crank arms to the pumping unit base structure.

Periodically inspect the condition of the brake linings. Brake friction linings, by their nature, are wearable components and with use will eventually need replacement. Certain types of brakes such as open faced band brakes and some disc brakes can be viewed from outside the crank guard area. Enclosed drum style brakes may require partial disassembly to check the condition of the linings. Worn or damaged linings shall be replaced immediately.

Inspect the brake control cable or linkage. If the unit is equipped with a flexible control cable, it should be inspected for damage such as kinked or pinched areas or for evidence of internal corrosion. Verify that the cable's internal elements move freely when actuated and that the end fittings are tight and in good repair. If the cable is damaged, it should be replaced.

Units equipped with rod or linkage brake controls shall be inspected for bent or damaged linkage components. Verify that all rotating joints in the brake linkage can move freely when actuated, are lubricated (if necessary), and are not obstructed by other equipment. Damaged components should be replaced.

The most common means of actuating the pumping unit brake is with a remote brake lever that is typically mounted outside the guarded areas. Periodically, the adjustment of the brake lever should be checked to verify that it can both fully engage the brake linings against the drum or rotor and, when fully disengaged, the linings lift clear such that no dragging occurs during pumping unit operation. It is recommended that the brake control is adjusted so that when fully engaged, there are still additional ratchet notches available on the lever assembly to allow for lining wear or cable stretch.

13.4 Structural Connection Maintenance

13.4.1 General

Static structural connections in the pumping unit are most often formed by either bolted, welded, or interference fit joints depending on the need for separating or adjusting them. Static joints, by definition are not intended to undergo relative motion while the pumping unit is in operation. However, these joints are crucial to the safety and longevity of the pumping unit system and a failure associated with one of these connections can be catastrophic.

13.4.2 Welded Joints

Welded joints in the pumping unit structure are normally subject to failure only in cases of overload, improper unit alignment, maladjustment, or from excessive vibration (as could occur from insufficient or improperly applied tie-down clamps). Care should be exercised during installation that structural components are not forced into place in such a way that a welded connection stores strain energy or is placed into service in an undue prestressed condition. Given the cyclic nature of pumping unit loading, such prestressed conditions can increase the chances of metal fatigue failure near or along the welded joint.

Pumping unit manufacturers often design the field-assembly connections of the pumping unit to be adjustable so that stored strain energy in the welded connections can be relieved or at least minimized. It is common practice to subassemble certain structural components on the ground prior to lifting into place for installation. In certain cases, it may be necessary to loosen bolted connections such that the structural members can shift or settle into the lowest strain energy state prior to completing the final bolt tightening. Consult the manufacturer’s instructions for the proper assembly and adjustment procedures.

13.4.3 Bolted Joints

The most common type of bolted structural joint in the pumping unit fastens two members together in a metal to metal grip. In other words, the members are designed to fit face to face together with bolts passing through them in such a way that they clamp the faces of the members together in compression. In such a joint, it is vital that the bolts are tensioned sufficiently to generate compression between the members substantially larger than any anticipated tension force to be transmitted through the joint. Bolts that are under-tightened will typically fail in fatigue when used in a cyclically loaded tension joint. Consult the manufacturer’s instructions for proper bolt tightening torque.

Shear type bolted connections (also a metal to metal type joint) are typically intended to generate sufficient clamping force between the mating members that friction between the clamped faces will prevent relative movement under operational loading. It is therefore crucial that bolts are tightened properly to create sufficient holding friction in the joint. Consult the manufacturer’s instructions for proper bolt tightening torque.

Bolted joints in which the connected members are not joined in a metal to metal grip (such as certain shaft clamps, tie-down clamps, etc.) are often tensioned to a lesser value than for those in the compressed metal to metal case. Consult the manufacturer’s instructions regarding these joints for the correct bolt installation torque.

It is recommended that bolted structural connections on new pumping unit installations be rechecked with a torque wrench following several day’s operation to address any loss of bolt tension that could result from fastener embedding, paint, or other soft material that may have been captured within the mating joint, vibration, or settling in the pumping unit foundation or base structure.

It is generally recommended that structural fasteners (bolts, nuts, etc.) be used only once.

13.4.4 Clamped or Press-fit Shaft Connections

13.4.4.1 General

A common method of fixing a structural member to a shaft is through the use of an interference fit. This type of fit is intended to create frictional restraint between the shaft and the hub of the mating mechanical member. Several methods of creating interference fit joints include (but are not limited to) press fitting, shrink fitting, or clamping. This type of connection is often used in pumping units to join shafts to gears, cranks, walking beams, equalizers, samson posts, and others. It is a static structural connection (not intended to experience relative movement between the mated parts) and should be monitored periodically along with other structural connections in the pumping unit.

13.4.4.2 Press or Shrink Fit Connections

This type of connection is commonly used to mount such components as gears, bearings, and crank arms. These are typically factory made connections and as such are usually not serviceable. They should, however, be visually inspected periodically by looking for signs of looseness such as rust-colored weeping coming from the interface or keyseat. These connections are often designed with a locking key to aid in preventing rotational slipping. Where visible, the end of the key should be examined for evidence of looseness or yielding.

13.4.4.3 Clamped Shaft Connections

The two most common types of clamped connections use either external clamping lugs or a preloaded taper interface.

13.4.4.4 External Clamps

This connection is commonly used to mount cranks, equalizer bearing shafts, center bearing shafts, and other structural joints. Bolts are typically used with a split lug or cap to reduce the diameter of the bore thereby generating radial interference preload between the lug and the shaft. The amount of joint friction is related to the amount of bolt torque applied during joint assembly so it is crucial that bolts are tightened properly. Joints of this type should be visually inspected periodically looking for evidence of loosening as indicated below. Bolt torque should also be verified regularly.

NOTE When multiple bolts are used in the same lug or cap, the torque of all bolts shall be rechecked prior to completion as tightening one bolt tends to relieve tension in neighboring bolts.

13.4.4.5 Preloaded Taper Interface

This connection is commonly used for mounting crank pins (wrist pins), cranks, sheaves, and brake hubs. The joint involves mating axially tapered pins, sleeves, or bores that generate radial interference preload as the tapers are compressed together axially. The axial force to compress the joint is usually supplied by a threaded element such as a nut or cap screw. The amount of joint friction is related to the amount of torque applied to the nut or cap screw during joint assembly so it is crucial that they are tightened properly. Joints of this type should be visually inspected periodically looking for evidence of loosening as indicated below. Bolt (or nut) torque should also be verified regularly.

Warning—Crankpins are of particular importance due to the severe consequences related failure. Failures involving crank pins are likely to damage other components of the pumping unit, adjacent property, or injure personnel.

Crank pins are rigidly mounted into the crank arm via a preloaded taper interface. The pin is typically tapered along its length in the area of the mounting interface. A matching taper is machined in the crank arm bore or sleeve depending on the manufacturer. It is critical that the tapered pin and bore accurately match, particularly near the outboard end (closest to the pitman connection) due to the omnidirectional nature and variability of the loads exerted on it by the pitman member. Improper crank pin fit will lead to pin failure. It is common practice when changing the stroke length of the pumping unit to perform a “blue check” of the crank pin/bore interface to verify proper fit.

13.4.5 Crank Pin Blue Check

The following process applies.

— Clean crank pin and bore removing all paint, grease, burrs, and debris.

— Apply three thin stripes of soft Prussian blue axially (at 120° intervals) along the tapered length of the pin.

— Carefully install the pin in the crank bore and tighten the nut to approximately one-fourth of the recommended torque.

— Loosen and dislodge the pin from the bore.

— Inspect the bore. Blue should transfer over at least 85 % of the mating interface length. Pay particular attention to the outer one-third of the bore interface length as this zone is exposed to the largest share of the crank pin loading.

13.4.6 Structural Inspection

Structural joints in the pumping unit should be inspected regularly for indications of loosening, weld failure, or other problems. Upon arrival at the well location, the operator should listen and watch for indications of damaged or loosened components in the pumping unit mechanisms. Watch for broken bolts or other hardware on the ground around the pumping unit that could indicate a compromised structural connection overhead. A common practice is to match mark fasteners or interference fit connections with a paint marker of contrasting color to aid in visually detecting if components have experienced relative movement (i.e. loosening).

Often, loose structural connections will exhibit rust or discoloration trailing from a bolt or from the mating interface were relative movement is occurring between parts. A propagating fatigue crack in a weld or structural member may also show similar indications. The ferrous wear products created by relative movement oxidize quickly in such instances and moisture from rain or condensation will often cause the loose joint to “weep” creating a telltale visual clue. Operators should watch for such evidence as an indication that a structural connection should be investigated and perhaps repaired.

14 Isolation/Restraint of Energy Sources—Lock-out/Tag-out Practice

14.1 General

Pumping units by their nature have large and heavy rotating parts. Even a temporarily stationary pumping unit has components that can start moving from the effects of gravity or from changing well conditions. Times of particular danger are during:

— unit installation,

— stroke change,

— counterbalance change,

— general unit maintenance,

— well servicing,

— while taking a dynamometer card reading.

Modern pumping units are often controlled by electronic well monitoring and control equipment. This equipment can cause the pumping unit to start, stop, or change operating speed without warning. Operators should never assume a stationary pumping unit is safe to work around unless its energy sources have been properly isolated, locked, and tagged out.

Before proceeding with the installation, operation or maintenance of a pumping unit, operators shall familiarize themselves with federal, state, and local laws, and company safety regulations. No personnel shall enter the pumping unit guard areas before completion of all safety and prework protocols.

It is recommended that a job safety assessment be conducted prior to initiating any work on the pumping unit. Identify any hazards associated with the worksite, such as:

— overhead impediments such as power lines that could hinder operation of cranes or lifting equipment;

— downed power lines or other hazards;

— trip or fall hazards around the work area;

— hazardous wildlife or plants;

— identify type of pumping unit along with operating controls and restraints;

— identify energy sources such as cranks, air cylinders, well load, electrical panels, overhead members, etc.;

— identify type of prime mover installed on the pumping unit along with controls used to operate it;

— perform a visual inspection of the pumping unit brake mechanism followed by a physical test to verify its proper operation and adjustment;

— listen and watch for indications of damaged or loosened components in the pumping unit mechanisms. Watch for broken bolts or other hardware on the ground around the pumping unit that could indicate a compromised structural connection overhead.

Continue with an on-site prework meeting being conducted with all participants describing the nature of the work to be performed, the equipment to be used, the planned sequence of tasks, and the avoidance of any hazards that have been identified.

Whenever performing maintenance on, or working around the pumping unit, always lock-out/tag-out all energy sources and secure the cranks against rotation.

It is not recommended that installation of or maintenance on pumping units be performed during inclement weather conditions such as thunderstorms.

Always install the unit and perform maintenance with the cranks at the 6 o'clock position when possible. If the cranks are straight down, no rotation will start if the carrier bar is not attached to the polished rod, or if the polished rod has been securely clamped at the stuffing box to hold well load and all the energy sources have been locked-out/tagged-out.

Never use the brake alone as a safety stop. Always use as many other methods as possible for backups along with your company's lock-out/tag-out procedure.

14.2 Recommended Shutdown and Lock-out/Tag-out Practice for Pumping Units Equipped with Electric Motors

The following practice applies.

— Check housing of motor control panel with voltage detector prior to touching to verify that no short or other voltage potential exists between the housing and ground.

— Shut off the prime mover.

— Using the brake control, gently stop the pumping unit such that the cranks are in the desired position. It is strongly recommended that the cranks and counterweights are oriented in the downward vertical (six o-clock) position. Once the pumping unit is at rest, fully engage the brake.

— Open the disconnect of the motor control panel to isolate the panel and all downstream equipment from the electric service.

— Install a lock on the disconnect lever of the control panel to prevent it being inadvertently engaged while maintenance is being performed. Install identifying tags on the lock or lever hasps as required by regulations.

— It is recommended that the on/off switch be tried again to verify that the system has been disabled.

— If practical, install a polished rod clamp directly above the wellhead stuffing box as an additional measure to arrest any downward rod motion.

— Engage positive stop devices such as brake pawl (if equipped) per manufacturer's recommendations. Note: always approach the pumping unit from the rear, avoiding the crank sweep area.

— As an additional measure, a chain shall be used to secure the brake or reducer sheave against rotation. The chain may be threaded through a hole in the brake drum or unit sheave and secured to an adjacent structural member or to the brake mounting trunnion. Make certain that the chain hooks are oriented so they will not become disconnected should movement occur. Some operators secure the chains using a come-along, or ratcheting load binder. The chain should be $^3/_8$ in. (10 mm) grade 80 alloy or better.

— Once the above steps are completed, the guards can be removed to allow access to personnel for maintenance.

— After maintenance has been completed and the guards have been replaced around the equipment, the lock-out/tag-out sequence above can be reversed to place the pumping unit back in service.

14.3 Recommended Shutdown and Lock-out/Tag-out Practice for Pumping Units Equipped with Internal Combustion Engines

The following practice applies.

— Disengage the drive train via the power take-off control lever.

— Using the brake control, gently stop the pumping unit such that the cranks are in the desired position. It is strongly recommended that the cranks and counterweights are oriented in the downward vertical (six o'clock) position. Once the pumping unit is at rest, fully engage the brake.

— Shut down the engine.

— Close and secure the fuel source valve.

— Bleed the accumulator tank.

— Secure the throttle control.

— If practical, install a polished rod clamp directly above the wellhead stuffing box as an additional measure to arrest any downward rod motion.

— Engage positive stop devices such as brake pawl (if equipped) per manufacturer's recommendations.

NOTE Always approach the pumping unit from the rear, avoiding the crank sweep area.

— As an additional measure, a chain shall be used to secure the brake or reducer sheave against rotation. The chain may be threaded through a hole in the brake drum or unit sheave and secured to an adjacent structural member or to the brake mounting trunnion. Make sure that the chain hooks are oriented so they will not become disconnected should movement occur. Some operators secure the chains using a come-along, or ratcheting load binder. The chain should be 3/8 in. (10 mm) Grade 80 alloy or better.

— Once the above steps are completed, the guards can be removed to allow access to personnel for maintenance.

— After maintenance has been completed and the guards have been replaced around the equipment, the lock-out/ tag-out sequence above can be reversed in preparation to place the pumping unit back in service. Follow the engine manufacturer's instructions to restart the engine.

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