Pumping Unit Safety Design Considerations

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Abstract:

Pumping units, with their tremendous power, inertia, heavy moving components, and height have come under the scrutiny of safety departments for service companies and operators alike. Safe operation of this equipment is a matter of developing sound, strictly enforced, operational procedures and pumping unit design.

This paper will examine several approaches by various manufacturers and after market companies to enhance the safe installation, maintenance, and operation of the pumping unit.

Introduction:

Due to the large amount of equipment that is utilized by oil companies in their various operations, it may be difficult for operations, safety and materials personnel to be familiar with all of the different safety options and products available from pumping unit manufacturers. Therefore we have attempted to provide an overview of products and features manufactured by several different companies as they apply to standard conventional pumping units so that they may be considered when writing an overall safety policy and as a tool when specifying equipment. Special design pumping units (long stroke units, air balance units, and hydraulic units) have many of their own special safety features that address hazards unique to their application. In an effort to provide information that **is** applicable to a large portion of the units operating, these special design units, and their safety features are not covered here.

Neither the authors, their respective employers, nor The Southwest Petroleum Short Course should be construed as having made any recommendations regarding the selection of any safety equipment over another, the application, effectiveness or suitability of any device, option, or feature. Selection of safety options, and procedures must be made, solely by the reader, in the context of an overall safety and operations program. Readers should contact the manufacturers of the various products to determine their suitability and effectiveness.

Portions of **API** RP11ER "Recommended Practices for Guarding of Pumping Units" are reprinted here solely for the convenience of the reader and to illustrate various guarding. The above parties make no specific recommendation as to clearances in this paper.

Mechanical Isolation:

There are several methods used by various manufacturers to mechanically isolate any stored mechanical energy in the pumping unit. Most manufacturers recommend redundant mechanical isolation systems.

Brake pawl

This is a pivoting arm (figure A1) that is attached to the gearcase on one end and can be swung down into the slotted brake hub casting at the other end. The pawl has a protrusion, which matches the slot in the brake hub casting, preventing the brake hub, and thus the output shaft from turning. This of course is designed to prevent movement of the cranks, beam and horsehead. Locking pins are sometimes provided to ensure that the pawl either stays in the open, or locked position.

Chaining Provisions

Many manufacturers utilize an open spoke gearbox sheave or brake hub that provides a convenient place for chains to be used to accomplish mechanical isolation at the sheave. Chaining of the cranks can provide this isolation as well when the cranks are properly positioned.

Beam Chain

There are some instances where well maintenance work must be done with the crank arms in the up position. This is not a desirable position for the cranks to be in from a safety standpoint. The cranks can easily move in either direction and gain a tremendous force from inertia and counterbalance. At least one manufacturer offers as an option, an eye attached to the bottom of the walking beam and the top of the skid. With chains properly attached to each eye and tensioned, this system can also help to immobilize the pumping unit.

Guarding:

The pumping unit has several areas where guarding becomes an issue. OSHA requires that guarding be provided between the prime mover sheave and the gearbox sheave, around the crank arms, the gas engine flywheel, and in certain instances, the horsehead/carrier bar, and under the walking beam on small units where insufficient head room exists. API bulletin, "API RP11ER" (revised 1990) offers a reference for clearances, dimensions and construction of the various guards (see figures **A2** and A4). OSHA Standard 29 CFR 1910.212 specifies requirements for general industry guarding.

Crank Guards

Manufacturers typically offer both an open rail, and a mesh crank guard. Clearances between the closest moving object and the outside of the guard should be determined when choosing the type and the permissible opening sizes between the rails, or mesh openings. Often, after-market crank guards are manufactured to be only long enough so that the cranks do not hit the guards. This can obviously result in collision with a taller object (person?) outside the crank guard. Therefore adequate clearance must be allowed between the outside of the guards and the total diameter of the crank swing when measured horizontally.

Gates, doors or small removable panels, offer access to guarded areas without having to move large panels which can pose the risk of back injury or muscle strain. Provisions can be made for locks to prevent unauthorized access.

Gas Engine, Bridle/Carrier Bar

Guarding in these areas require many of the same considerations and options as the crank guards, such as clearance, open rail versus mesh etc. OSHA and the "API RP11ER" publications, again provide useful material to aid in your selection of options for these hazards.

Belt guards

Most original equipment manufacturers offer a full-length enclosed (3 sides) belt guard. Often the belt guard can be ordered with a removable bottom, allowing the total enclosure of the belt drive system. (Consideration should be given to belt operating and ambient temperatures, as excessive heat can have a detrimental effect on belt life). Canadian standards permit the use of a partial belt guard covering only the motor sheave and the portion of the belts that extend beyond the crank guards. The intention of this partial guard is to allow for servicing of the motor sheave without having to remove a large full size belt cover. The requirement in the US is to use a full-length guard.

Sheave doors or panels are an option. These doors offer access to the sheave (usually just the motor sheave) so that it can be changed, or to allow measurements without having to remove the belt guard. Generally, access to the gearbox sheave is only achieved by removing the belt guard, due to the size of the sheave.

The belt guard can also be manufactured with a bolted seam near the motor sheave to allow complete access to the motor sheave, without requiring the removal of the whole belt guard. One after market company and pumping unit manufacturer are conducting tests on a composite belt guard designed to be light enough to be removed without a winch truck.

Tie-Off and Fall Protection:

Tie-off and fall protection is an area that safety departments have struggled to optimize, due to the wide variety of equipment and the very nature of the operational and maintenance procedures. This is an area that has seen a lot of innovation recently from both original equipment manufacturers and after market manufacturers as well.

At least one original equipment manufacturer provides either a tie-off rail or cable (Figure A5) along the walking beam allowing workers to have access to the entire length of the beam while remaining tied-off. One manufacturer uses a cable that runs nearly the entire length of the beam. This system requires only two attachment brackets (one at each end) instead of several required with the rail system. To access the entire length of the beam, the rail system requires detachment and reattachment of the lanyard several times, whereas the lanyard can remain attached to the cable for the entire time.

The after market provides a retrofit device that is similar in nature to the cable design. Another series of devices are designed to clamp on the flange of the I-beam and serve as an anchor for tie-off purposes.

Several companies offer as retrofit devices, climb assist equipment. This equipment is marketed for use on ladders, inclines, stairs etc. The product consists of either a track, or cable and a trolley to which a lanyard or safety harness can be attached to provide fall protection. The track or cable is attached to a ladder; the trolley assembly is connected to the safety harness and then attached to the cable or track. During assent the trolley is disengaged, and follows the climber with little resistance, but during a fall the trolley's locking system is engaged automatically and arrests the fall.

Caged ladders are the most common means of fall protection in our industry. These ladders are offered by almost all manufacturers and have been utilized in the field for many years. OSHA 29 CFR **1910.27** outlines fall protection requirements for fixed ladders. API RP 11ER "Recommended Practice for Guarding Pumping Units" offers guidelines based on ladder length, as to when the ladders must be caged.

While ground level grease lines and self-lubricating bearings are normally considered a convenience item their role as a safety device cannot be ignored. The self-lubricating bearing can eliminate the need to re-lubricate bearings. Ground level grease lines can at least reduce the need to climb, in some cases twenty or more feet off the ground, to lubricate conventional saddle or tail bearing assemblies.

Some oil companies have removed the pumping unit ladders in an attempt to comply with safety standards. This has left service companies and maintenance crews with the challenge of how to safely complete their assigned duties without the use of the ladder normally provided on the unit. A solution has been provided utilizing two methods. Pumping unit service trucks with integral ladders attached to their lifting poles and the availability of portable man lifts which can be provided on a rental basis.

Horsehead and Bridle Considerations:

Horsehead Retention

Due to the heavy loads encountered during beam pumping, the walking beam, rods and bridle can have considerable stored energy due to deflection of the structure, bridle stretch, and rod stretch. When a sucker rod parts at a shallow depth the sudden release of the stored energy could result in unsecured components, normally held in place by their own weight, and the well load, to come loose and fall off.

Because it is necessary to remove the horsehead for well maintenance and repair, provision must be made for its easy removal. The major pumping unit manufacturers accomplish this balance between safe operation and easy removal by utilizing a pin run through the horsehead and a bracket on the beam, simultaneously. **A** locking feature to prevent the pin from working out of the hole is an added measure. Some manufacturers provide a hinged head so that the head need not be removed for well maintenance, although removal would still be required for some repairs.

Manufacturers, in and effort to lock the bridle in place on the horsehead, prevent slippage during bridle parts and when negative polished rod load occurs, employ various methods from hooks, to cover plates.

Lifting Eyes:

Potential hazards from overhead equipment lifted during assembly, repair and maintenance are a serious concern, particularly for pumping units, due to their weight and height. Improper lifting preparation, windy conditions, slipping chains, and unmarked centers of gravity increase the danger of these operations. At least one manufacturer provides lifting eyes (figure A5) on major structural components, gearboxes, weights, crank guards, and rhe belt guard, while providing handles on the gearbox lid for its safe movement. Lifting eyes encourage the use of proper lifting equipment rather than the temptation to attempt to pick up a crank guard section or belt guard by hand.

Maintenance and Repair Manuals:

Almost all of the **OEM** manufacturers publish an installation, maintenance and repair manual illustrating the proper use of safety features, chain placement, mechanical isolation, maintenance techniques and recommended maintenance intervals. A properly maintained pumping unit is a key to its safe operation.

Miscellaneous:

Paint

Contrasting paint colors indicating pinch points and trip hazards, can be an effective safety device. An examination of safety logs indicates that a considerable number of injuries are due to these hazards. Increasing awareness and visibility of these hazards has proven the value of this simple and economical feature.

Inspection Covers

Convenience and safety are served simultaneously by gearbox designs that offer adequate, lightweight, inspection covers so that maintenance inspections can be performed without having to remove large, heavy gearbox covers.

Conclusion:

These items presented singly may seem obvious, Indeed all of these individual components have been a part of safety programs for various producers and service companies. However, the authors have found a shortage of literature dealing with all these options in one concise document. With the huge importance of providing our employees and contractors with a safe working environment, safety options and features must be given at least equal consideration to the proper sizing, price, and availability of the equipment.

Acknowledgements:

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References:

1. **API** Recommended Practice 1IER (RP 11**ER)** Second Edition, January 1, 1990 "Recommended Practice for Guarding of Pumping Units

2. OSHA Standard **29** Code of Federal Regulations 1910

Figure A1 - Brake Pawl

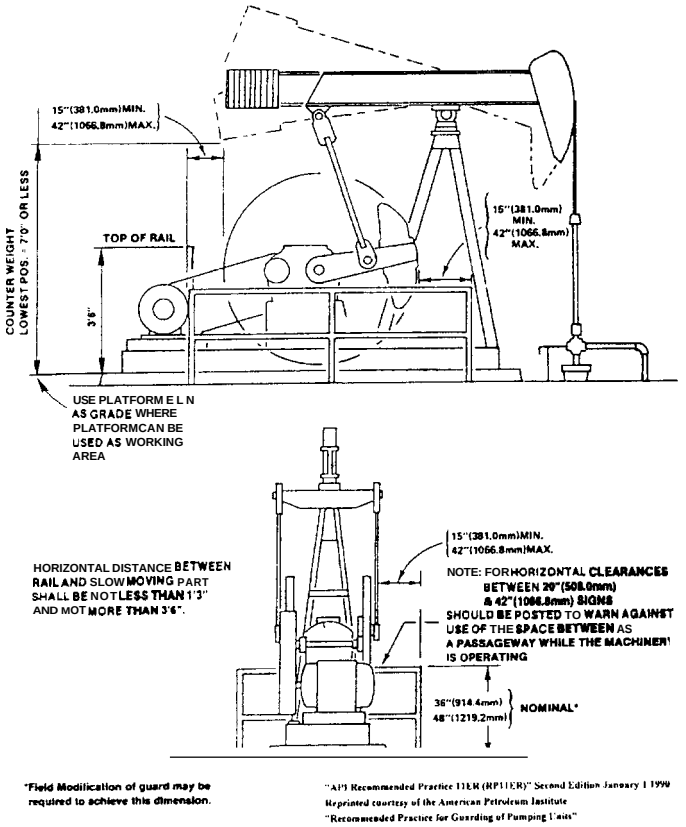

Figure **A2** - Example of Counterbalance Guard

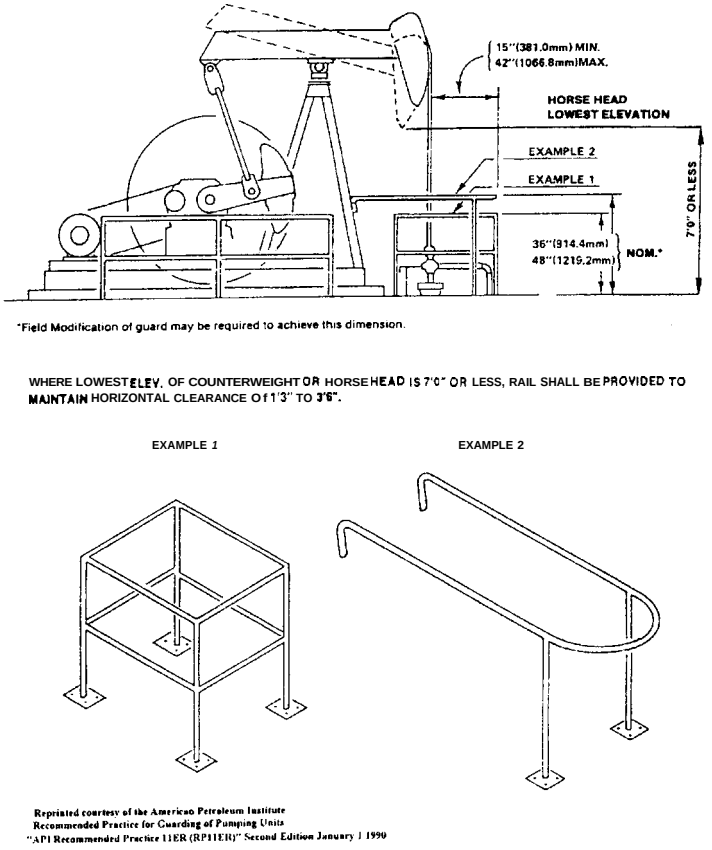

Figure **A4** - Examples of Hoi-sehead Guards

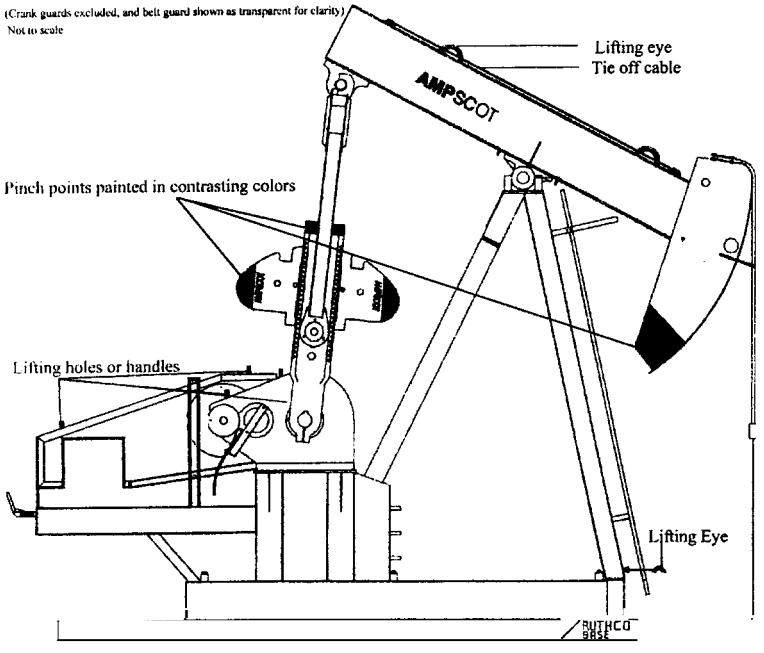

Figure **A5**