# Beam Pump - Safe Operation

## A Program Development Guide

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ENFORM The Safety Association for Canada's Upstream Oil and Gas Industry

By industry, for industry

## ENDORSEMENT

This document was developed by industry for industry. Enform gratefully acknowledges the support of the endorsing organizations in the development of this document.

- Canadian Association of Geophysical Contractors (CAGC)
- Canadian Association of Oilwell Drilling Contractors (CAODC)
- Canadian Association of Petroleum Producers (CAPP)
- Canadian Energy Pipeline Association (CEPA)
- Explorers and Producers Association of Canada (EPAC)
- Petroleum Services Association of Canada (PSAC)

## ABOUT ENFORM

Enform is the upstream oil and gas industry's advocate and leading resource for the continuous improvement of safety performance. Our mission is to help companies achieve their safety goals by providing practices, assessment, training, support, metrics and communication.

## AVAILABILITY

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## ACKNOWLEDGEMENT

Enform gratefully acknowledges the many individuals who volunteered their time and effort to complete this document.


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# LIST OF CONTENTS


1.0 Preface ... 1
1.1 Objective ... 1
1.2 How to use this guideline ... 1
1.3 Who should read what ... 1
1.4 Limitations ... 3
1.5 Regulations ... 3
1.6 Revision process ... 3
2.0 Executive summary ... 4
3.0 Introduction ... 5
3.1 Background ... 5
3.2 Terminology ... 5
3.3 Beam pump operation ... 5
3.4 Applicable OHS regulations ... 6
3.4.1 General duty clauses ... 6
3.4.2 Specifications and certifications ... 7
3.4.3 Applicable OHS regulations ... 7
3.5 Other relevant technical safety and energy regulations ... 8
3.5.1 Technical safety regulations: ... 8
3.5.2 Energy regulations: ... 8
4.0 People: roles and responsibilities ... 8
4.1 General ... 8
4.2 Owners and prime contractors ... 9
4.3 Employers and service providers ... 9
4.4 Manufacturers and suppliers ... 9
4.5 Individual workers and supervisors ... 9
5.0 Equipment: hazards and engineering controls ... 10
5.1 Beam pump design standards ... 10
5.2 Manufacturer specifications ... 10
5.3 Engineering design considerations ... 11
5.4 Identified equipment hazards and recommended engineering controls ... 11
5.4.1 Beam pump hazardous energy ... 11
5.4.2 Recommended engineering controls ... 12
6.0 Operations: work execution ... 14

6.1 General ... 14
6.2 Summary of work activities ... 14
6.2.1 Unit installation ... 14
6.2.2 Unit inspection and maintenance ... 15
6.2.3 Well optimization ... 16
6.2.4 Well servicing ... 16
6.2.5 Decommissioning and unit removal ... 16
6.3 Job planning and site safety management ... 16
6.4 Job safety assessment ... 18
6.5 Recommended work practices and procedures ... 18
6.5.1 Installation procedures ... 19
6.5.2 Operating and maintenance procedures ... 19
6.6 Isolation and lockout/tagout practices ... 19
6.7 Worker training and competency considerations ... 20
7.0 Learnings and recommendations ... 21
7.1 Leadership and safety culture ... 21
7.2 Risk tolerance and its effect on human error ... 22
7.3 Beam pump equipment and design considerations ... 22
7.4 Communications between prime contractors and service providers ... 22
7.5 Confirming supervisor and worker competencies ... 23
8.0 References ... 24
Appendices ... 25
Appendix 1: Beam pump related worker fatalities ... 26
Appendix 2: Summary of beam pump hazards ... 27
Appendix 3: Site safety planning guideline for beam pump activities ... 33
Appendix 4: Zero energy procedures (including an example lockout procedure) ... 34
Appendix 5: Glossary of terms ... 37

# 1.0 Preface

Most oil wells in Western Canada require some form of artificial lift. One common system of artificial lift is the pump jack, sucker rod and downhole pump assembly. This document focuses on pump jacks that use a system of counterweights and a beam to operate the downhole pump. It will refer to the surface equipment as a “beam pump”.

For the purposes of this guideline, the term “beam pump” refers to various styles of pumping units including: Conventional, Hydraulic or Special Geometry.

## 1.1 Objective

The objective of this guideline is to provide guidance about the hazards and risks of beam pump operations in the upstream Canadian oil and gas industry. This document will also provide information to help organizations develop safe practices and procedures.

## 1.2 How to use this guideline

Companies whose workers are exposed to beam pump hazards may use this guideline to:

- Assist with developing their beam pump safety program
- Provide processes, tools and additional resources to improve their program

This guideline is intended for, but not limited to:

- Oil and gas production companies
- Oilfield service providers and their workers
- Oilfield equipment suppliers

## 1.3 Who should read what

This guideline adopts a management system approach to controlling beam pump hazards. This approach assumes that managing and controlling the hazards associated with beam pump operations begins long before a worker steps onto a lease. Everyone has a role to play, from project engineers to equipment suppliers to operations managers, supervisors and workers. Table 1 provides a summary of the sections within the guideline that apply to each person’s roles and responsibilities.

**Table 1 – Who should focus on which sections of the guideline?**

| If you are responsible for: | These sections are important to: |
|---|---|
| Job planning and design of beam pump installations including:<br>• Owner/Operator/Licensee<br>• Owner's representative<br>• Prime Contractor<br>• Completions or operations engineer<br>• Safety specialist or advisor<br>• Project lead | Pay special attention to:<br>• Section 3.0 – Introduction<br>• Section 4.0 – People: Roles & Responsibilities<br>• Section 5.0 – Equipment: Hazards and Engineering Controls<br>• Section 6.0 – Operations: Work Execution<br>• Section 7.0 – Learnings and Recommendations<br>Also consider:<br>• Appendix 1 – Beam Pump Related Worker Fatalities<br>• Appendix 2 – Summary of Beam Pump Hazards<br>• Appendix 3 – Site Safety Planning Guideline for Beam Pump Activities<br>• Appendix 4 – Zero Energy Procedures |
| Work supervision including installation, operations or maintenance of beam pumping units including:<br>• Prime Contractors' representative<br>• Construction site supervisor<br>• Operations foreman or supervisor<br>• Contractor foreman or supervisor<br>• Subcontractor supervisor | Pay special attention to:<br>• Section 3.4 – Applicable OHS Regulations<br>• Section 4.0 – People: Roles & Responsibilities<br>• Section 5.4 – Beam Pump Equipment Hazards<br>• Section 6.0 – Operations: Work Execution<br>• Appendix 2 – Summary of Beam Pump Hazards<br>• Appendix 3 – Site Safety Planning Guideline for Beam Pump Activities<br>• Appendix 4 – Zero Energy Procedures<br>Also consider:<br>• Section 7.0 – Learnings and Recommendations<br>• Appendix 1 – Beam Pump Related Worker Fatalities |
| The day-to-day work to install, operate or maintain a beam pumping unit including:<br>• Production operator<br>• Service and supply contractor<br>• Other field worker | Pay special attention to:<br>• Section 3.4 – Applicable OHS Regulations<br>• Section 5.4 – Beam Pump Equipment Hazards<br>• Appendix 2 – Summary of Beam Pump Hazards<br>• Appendix 4 – Zero Energy Procedures<br>Also consider:<br>• Appendix 1 – Beam Pump Related Worker Fatalities |
| Manufacturing or supply of new or used beam pump units including:<br>• Design engineers<br>• Sales representatives | Pay special attention to:<br>• Section 3.4 – Applicable OHS Regulations<br>• Section 4.4 – Manufacturers and Suppliers<br>• Section 5.0 – Equipment: Hazards and Engineering Controls<br>Also consider:<br>• Section 7.0 – Learnings and Recommendations |

## 1.4 Limitations

This guideline has been developed with reference to industry-related publications. However, it is not exhaustive. The reader should also refer to published standards and applicable legislation for guidance. This document is intended as a guideline, not as a compliance standard.

## 1.5 Regulations

Each provincial and federal occupational health and safety jurisdictional authority has a well-established occupational health and safety regulatory framework. The Occupational Health and Safety legislation in each jurisdiction defines the responsibility for employers, supervisors and workers to work safely and follow safe work practices. It is the employer's legal obligation to ensure that employees adhere to current regulatory requirements. This includes the required qualification and competencies of all supervisors and workers.

## 1.6 Revision process

Enform Guidelines are developed by industry for industry. Enform acts as an administrator and publisher.

Each guideline is reviewed on a three year cycle. Technical issues or changes may prompt a re-evaluation and review of this guideline in whole or in part. For details on the guideline creation and revision process, visit the Enform website at www.enform.ca.

This is the first edition. The next scheduled review will take place three years from the date posted on the title page.

**Revision History**

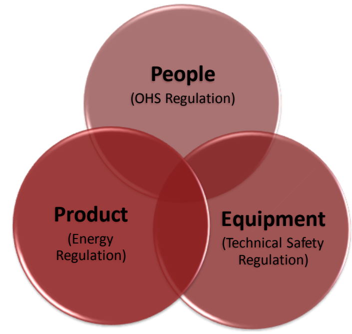
| Edition | Release date | Scheduled review date | Remarks and changes |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

# 2.0 Executive summary

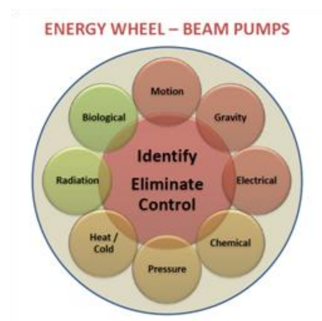
This guideline was developed by industry in agreement with Alberta Occupational Health and Safety following a tragic incident where a worker was fatally injured. Recent and historic incidents highlight the hazard controls that are needed to ensure the safety of workers working on or near beam pumps. Key issues addressed in this guideline include:

1. **Applicable regulations**: Owners, Prime Contractors and Employers with workers involved in beam pump operations need to be aware of and address the various regulations that apply to the installation, operation and maintenance of a beam pump. These include occupational health and safety, technical safety and energy regulations.

   The regulations that apply to beam pump operations are discussed in Section 3 of this guideline.




2. **Beam pump hazards**: The hazards on well sites with beam pumping units must be controlled properly to eliminate or adequately mitigate risk to workers. Owners, Prime Contractors and Employers must understand their responsibilities and the types of hazards that may be present in order to ensure that appropriate controls are applied. Roles and responsibilities are discussed in Section 4. Potential beam pump hazards and controls are discussed in Section 5.




3. **Work execution**: The types of hazards workers might encounter vary depending on the task. The tasks required to complete a job evolve over the well's lifespan, beginning at installation and continuing through to decommissioning and unit removal.

   Beam pump operations are discussed in Section 6, including job planning and procedural considerations.

4. **Learnings & recommendations**: As part of the work used to prepare this guideline, Enform retained the help of safety specialists to complete an occupational health and safety hazard assessment and task analysis. The assessment included an evaluation of industry fatalities and contributing factors.

   A variety of contributing factors such as culture, risk tolerance, design considerations, communications and supervisor and worker competency are discussed in Section 7.

# 3.0 Introduction

## 3.1 Background

Most oil wells in Western Canada require some form of artificial lift. One common system of artificial lift is the pump jack, sucker rod and downhole pump assembly. This document addresses specifically pump jacks that use a system of counterweights and a beam to operate the downhole pump. It will refer to the surface equipment as a “beam pump”.

For the purposes of this guideline, the term “beam pump” includes various styles of pumping units including: Conventional, Hydraulic or Special Geometry.

This guideline was developed by industry in agreement with Alberta Occupational Health and Safety following a tragic incident where a worker was fatally injured. Since 1997, at least 10 worker fatalities related to beam pumps have occurred in Western Canada.

A review of recent and historic incidents reinforces that workers must be aware of hazards associated with beam pumps. More importantly, the incidents highlight the hazard controls that are needed to ensure the safety of workers working on or near beam pumps. A summary of beam pump related worker fatalities is included in Appendix 1.

**Since 1997, at least 10 worker fatalities related to beam pumps have occurred in Western Canada.**

**The majority of these worker fatalities involved the workers being struck by the counterweight.**

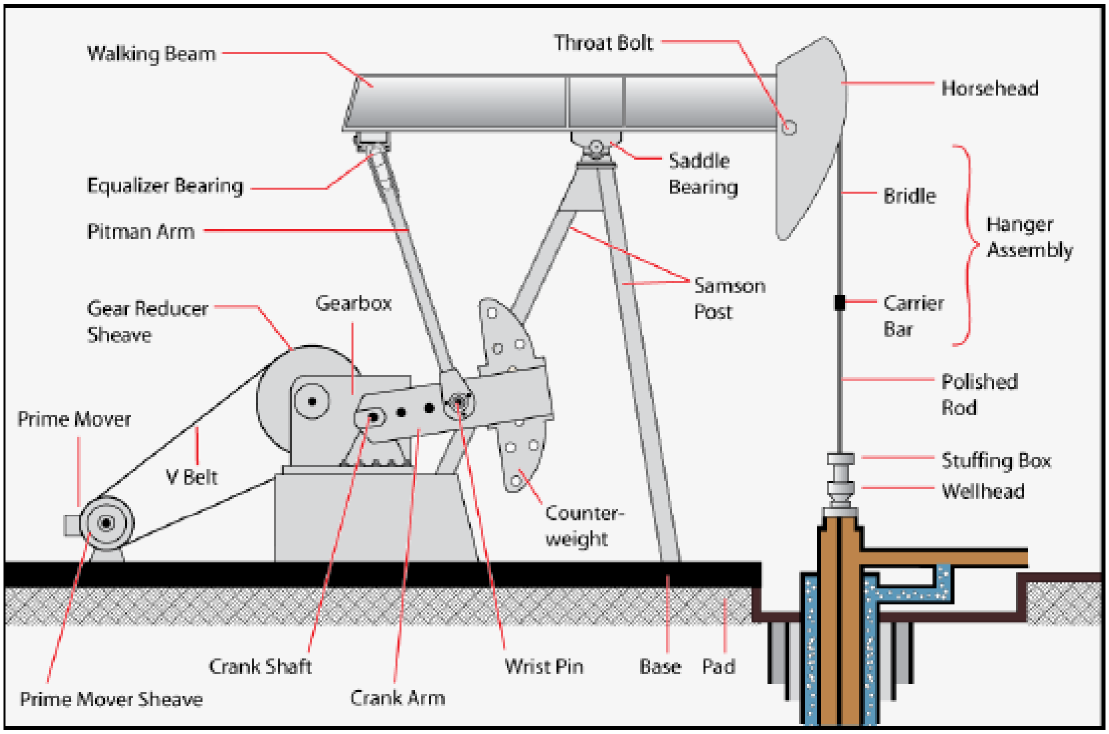
## 3.2 Terminology

For the development of this guide, beam pump was chosen as the term of choice. Pump jack and rod pump are two other common terms used to refer to a beam pump. Other less-used terms include: sucker rod pump, rod lift pump, pumping unit, artificial lift system or horse head pump. A glossary of common terminology is included in Appendix 5.

## 3.3 Beam pump operation

One common method of artificial lift is using a beam pump on the surface, attached to a rod string, which is connected to a fluid pump inserted inside the well tubing at the bottom of the well. The beam pump unit strokes the rod string up and down to operate the downhole pump, which lifts the oil from the reservoir to the surface. The figure below shows a typical beam pump and the common terms.

**Figure 1 – Typical beam pump** (2009, reprinted with the permission of HDC Human Development Consultants Ltd.)




Beam pump units are powered by an electric motor or a gasoline engine, called a prime mover. A gear box and drive assembly reduces the beam pump speed as required for the application.

## 3.4 Applicable OHS regulations


Occupational health and safety legislation defines responsibilities for workers, supervisors, and employers to prevent injuries and illnesses.

### 3.4.1 General duty clauses

Commonly referred to as the “General Duty Clause”, every province and territory in Canada has occupational health and safety legislation that describes the obligations of employers and workers. While the specific wording varies from province to province, the intent is the same:

> *Everyone who undertakes, or has the authority, to direct how another person does work or performs a task is under a legal duty to take steps to prevent bodily harm to that person, or any other person, arising from that work or task.*

Important elements of the due diligence needed to meet the general duty of care obligation include:

- Confirming worker competency
- Identifying and controlling hazards
- Conforming with, or exceeding, industry standards
- Monitoring the worker to verify that their performance is acceptable

### 3.4.2 Specifications and certifications

Employers must ensure that equipment is of sufficient size, strength, and design. Whenever there is a question about how equipment is to be used, maintained or operated, the answer should be found in the manufacturer's specifications or specifications certified by a professional engineer.

Although employers are required to comply with the manufacturer's specifications, the regulations provide the employer with the flexibility to modify specifications. In these cases, a professional engineer must certify such modifications.

### 3.4.3 Applicable OHS regulations

There are a number of OHS regulations in each province that may apply to beam pump safety. The following sections are suggested for reference, but are not an exhaustive list of all regulations that may apply.

| | | |
|---|---|---|
| Alberta: | • Part 6 | Cranes, hoists and lifting devices |
| | • Part 8 | Entrances, walkways, stairways, ladders |
| | • Part 9 | Fall protection |
| | • Part 14 | Lifting and handling loads |
| | • Part 15 | Managing the control of hazardous energy |
| | • Part 21 | Rigging |
| | • Part 22 | Safeguards |
| British Columbia: | • Part 10 | De-energization and lockout |
| | • Part 11 | Fall protection |
| | • Part 12 | Tools, machinery and equipment |
| | • Part 13 | Ladders, scaffolds and temporary work platforms |
| | • Part 14 | Cranes and hoists |
| | • Part 15 | Rigging |
| Saskatchewan: | • Part X | Machine safety |
| | • Part XII | Scaffolds, aerial devices, elevated work platforms |
| | • Part XIII | Hoists, cranes and lifting devices |
| | • Part XIV | Rigging |
| | • Part XVI | Entrances, exits and ladders |
| Manitoba: | • Part 4 | Entrances, exists, stairways and ladders |
| | • Part 16 | Machines, tools and robots |
| | • Part 23 | Cranes and hoists |
| | • Part 28 | Scaffolds and other elevated work platforms |

## 3.5 Other relevant technical safety and energy regulations

In addition to OHS regulation, it is important to keep in mind other regulations that are related to the design, installation and operation of wells and well pumping equipment along with the related equipment hazards.

### 3.5.1 Technical safety regulations:

Several provincial technical safety codes' regulations apply to beam pump installations such as:

- Electrical: Electrical installations must comply with the Canadian Electrical Code.
- Gas: Natural gas or propane is often used for fuel to operate beam pump engines. These installations must comply with gas safety codes including CSA B149.1 Natural Gas and Propane Installation Code.

### 3.5.2 Energy regulations:

Energy regulations in each province also affect the design and operation of beam pumps including:

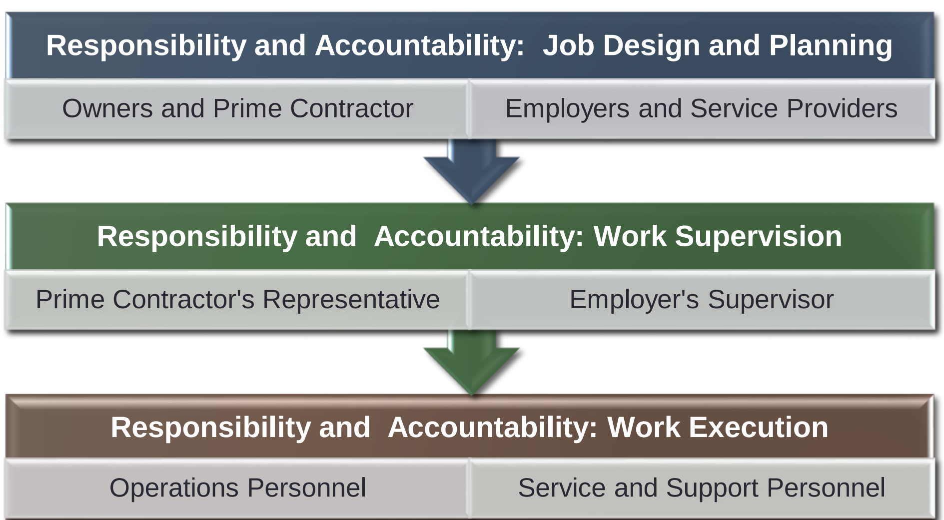
- Pipeline pressure protection and emergency beam pump controls and shutdowns
- Leak prevention and the elimination of any off-lease odours (i.e. $H_2S$)
- Wellhead installations and well control, including blowout prevention equipment

# 4.0 People: roles and responsibilities

## 4.1 General

Occupational Health and Safety legislation provides the framework and defines the responsibilities for workers, supervisors and employers to follow safe work practices. The legislation also defines the Prime Contractor responsibilities.

**Figure 2: Roles and responsibilities**



## 4.2 Owners and prime contractors

As the well licensee, Western Canadian oil and gas producers maintain ownership of the well site and responsibility for the associated equipment. In most cases, the oil and gas producer companies also retain Prime Contractor responsibility for all work and all workers coming onto their sites.

In most cases, the Prime Contractor will designate a representative who is responsible for ensuring that service providers understand the Prime Contractor's expectations and that the service provider's work is consistent with the Prime Contractor's work requirements, including worker safety.

Often, beam pump work is supervised and completed by the service provider's personnel. However, depending upon the nature of the lease and overall scope of work to be completed, multiple service provider companies may be required to work on the well site at any given time. Coordination of the work between the multiple service providers is the responsibility of the Prime Contractor.

## 4.3 Employers and service providers

With the exception of minor inspections and some minor maintenance work, industry practices involve the use of service providers to complete the majority of the work on beam pumps. In most circumstances, service providers will provide the manpower needed to complete the beam pump work. The service provider's employees typically include a project foreman, service technicians, and labourers. Depending upon the scope of work, a variety of specialists may also be required. These workers may work for the service provider or multiple service providers. The types of workers required could include crane operators, welders, heavy equipment operators, service rig personnel, truckers, and pile operators.

In each case, individual employers are responsible for ensuring that:

- The workers are familiar with the equipment and the relevant manufacturer's specifications and recommended procedures for the beam pump they are working with.
- Directions respecting the safe installation and operation of the beam pump and associated equipment are readily available to the workers responsible for the work.
- The workers understand the risks associated with working near or on the beam pumps.

## 4.4 Manufacturers and suppliers

Manufacturers and suppliers have a number of responsibilities that play an important role in the safe installation and operation of a beam pump. These include:

- Ensuring that the equipment being supplied is safe when installed, is operated in accordance with the manufacturer's directions and is compliant with OHS regulations.
- Providing directions respecting the safe use of any tool, equipment, machine or device to be used at the workplace by workers.

## 4.5 Individual workers and supervisors

While the roles and responsibilities of the Prime Contractor and Employer are significant, the responsibility of individual workers and supervisors also needs to be emphasized. Workers must take responsibility for their own health and safety at the workplace insofar as they are able. Specific safety considerations when working on or near a beam pump include:

- Install and operate the beam pump and associated equipment as per the manufacturer's directions. When in doubt, refer to the equipment manual.
- Follow proper procedures
- Ensure equipment guards and protective devices are in place and working as designed.
- Use personal protective equipment and protective devices required by the hazards.
- Report hazards, including missing or defective equipment or protective devices.

# 5.0 Equipment: hazards and engineering controls

## 5.1 Beam pump design standards

The principle industry standards for the design, installation and maintenance of beam pumps are:

- API Specification 11E: Specification for Pumping Units
- API Recommended Practice 11G: Recommended Practice for Installation, Maintenance and Lubrication of Pumping Units
- API Specification 11ER: Recommended Practice for Guarding of Pump Units

## 5.2 Manufacturer specifications

Beam pump manufacturer's specifications, procedures and instructions provide technical information that supports the development of operational practices to protect workers from beam pump hazards. The beam pump unit's design controls these hazards.

The following requirements need to be communicated to the manufacturer when ordering a new beam pump unit to ensure the unit is suitable for the planned service:

a) Required well lifting capacity

b) Required sucker rod size in alignment with the well depth, rod design or other mechanical well parameter

c) Total sucker rod string mass (weight) in the well

d) Potential extra loads due to the well configuration, friction, and dynamic loading

e) Required gear configuration and resulting gear loading expressed as gear reducing rating. This defines the required lifting energy input.

f) Required load capability of the beam pump structure to accommodate the sucker rod string weight and additional loads

g) Required maximum stroke length

The combined requirements of gear reduction rating, structure loading capacity, and maximum stroke length should be available to identify the specific beam pumping unit and its necessary maintenance.

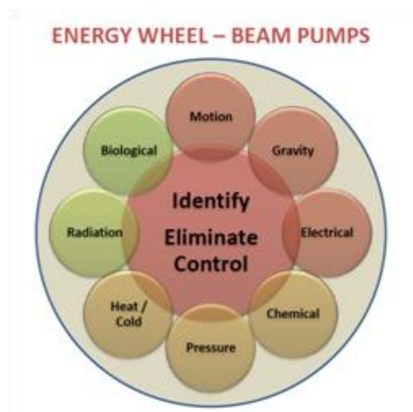
## 5.3 Engineering design considerations

A beam pump unit is a heavy piece of industrial equipment. The Owner and Prime Contractor are responsible for ensuring that qualified technical personnel are used for the design of the installation including site preparation, foundation and proper mounting requirements. Considerations include:

- Methods of computing or measuring well loads are the responsibility of the Owner and Prime Contractor, not the responsibility of the manufacturer or supplier. It is recommended that the approximate polished rod loads and gear reducer torque values are confirmed with the manufacturer.
- A beam pumping system analysis indicates whether the calculated loading on the gear reducer is within the design limits of the equipment. This analysis is the responsibility of the Owner or Prime Contractor and should be included in the operational practice and equipment procedures.
- Design personnel must be aware of actual loads that the beam pump may be exposed to during the life cycle of the well.
- Based upon the manufacturer’s specifications, the technical personnel must determine the applicable well requirements and environmental operational conditions for safe operation of the beam pump. For example, mounting the brake cable horizontally can limit water intrusion and subsequent freezing in winter months. Technical and safety information should be available in the equipment’s operating manual published by the manufacturer. Most manufacturers also provide technical and training support.
- The Owner’s design requirements should be clearly communicated by dimensional drawings, datasheets, or other appropriate documentation. The drawings and site plans should identify the necessary approvals and reviews. It is recommended that a licensed professional engineer is used to review and provide stamps once technical personnel have completed their drawings and site plans.
- When the original equipment manufacturer’s specifications are available, they should be consulted in developing beam bump operating practices and equipment procedures. In those cases where manuals are not available or do not provide sufficient guidance to meet the General Duty of Care, it is the responsibility of the Owner or Prime Contractor to ensure that the appropriate operating practices and procedures are developed.

## 5.4 Identified equipment hazards and recommended engineering controls

### 5.4.1 Beam pump hazardous energy




Typical hazards associated with oil and gas operations need to be considered. Hazardous energy associated with beam pumping equipment include:

**Motion**:

- Rotating and reciprocating parts of the beam pump
- Pulleys and belts connecting the beam pump and motor
- Beam-driven chemical pumps or gas compressors
- Pinch point locations associated with moving equipment

**Gravity**:

- Overhead hazards such as the counterweights and horsehead that may involve stored energy
- Suspended loading
- Falling hazards when working on ladders or raised platforms

**Electrical**:

- Overhead and buried powerlines
- Electrical supply lines (permanent and temporary)
- Electrical heat tracing
- Instrumentation and controls
- Cathodic protection
- Static electricity (blowing down vents, loading or unloading trucks)

Other potential hazards associated with beam pump installations include:

**Chemicals and hazardous substances**:

- Combustible gas
- Flammable hydrocarbon fluids (crude oil, condensate)
- Produced water (brine)
- Fuel gas (natural gas or propane)
- Hydrogen sulphide ($H_2S$)
- Benzene, toluene, ethylbenzene, and xylenes (BTEX)
- Production chemicals (waxing inhibitors, corrosion inhibitors, $H_2S$ scavengers, methanol, glycol, engine coolants, lubricants, well serving chemicals and acids)
- Carbon monoxide from building heaters, pump engines or idling vehicles

**Pressure**:

- Pressurized wells and pipelines, including associated pigging equipment
- Blocked wells or pipeline due to hydrate or ice plug formation

**Heat and cold**:

- Engine exhaust piping
- Friction (polished rods can reach very high temperatures)
- Wellhead piping, depending on reservoir conditions
- Ambient temperatures and its effect on equipment i.e. frozen brake cables

**Radiation**:

- NORM (Naturally Occurring Radioactive Material)

A summary of the types of hazardous energy associated with beam pump systems and recommended controls is included in Appendix 2.

### 5.4.2 Recommended engineering controls

Beam pump manufacturers recommend a variety of hazard controls during installation and when the beam pump is in use.

**Installation**:

The manufacturer's recommended practices for the installation of beam pumps include the following:

- Foundation and site preparation with consideration to site drainage, soil bearing capacity, soil stiffness and cold climate effects
- Installation of pumping unit bases with consideration to foundation design, lifting points on major components and connection of the pumping unit to the foundation
- Adjustment after erection including levelling and alignment
- Post-installation inspection and maintenance procedures to confirm the integrity of the installed equipment

**Guarding**:

Enclosures usually provide the greatest degree of protection against moving parts of mechanical equipment. Guardrails sometimes offer less effective protection than enclosures of proper dimension. In general, the American Petroleum Institute (API) recommends the use of guard rails for slow moving equipment such as cranks, counterweights and horseheads. Both enclosures and guardrails should be strong enough to withstand the impacts and loadings imposed on them without collapsing against the mechanism they are protecting.

Items that must be guarded include:

- Sheaves and belts
- Cranks, counterweights and air counterbalance tanks
- Flywheels

**Additional hazard control measures**:

The API Recommended Practice for Guarding of Pump Units notes a number of additional methods for addressing beam pump equipment hazards. These include:

- Caution signs and colour coding
- Pumping unit brake
- Ladders and platforms
- Labeling of 'no go zones'

These hazard controls should be addressed when purchasing a beam pump unit and associated equipment.

# 6.0 Operations: work execution

## 6.1 General

The key work activities over the life of a beam pump are summarized in the following figure:


Each type of work activity has different hazards and associated controls. The different work activities are discussed in the following section.

## 6.2 Summary of work activities

### 6.2.1 Unit installation

This work involves unloading equipment and assembly of the beam pump unit. The beam pump unit is brought to the site on flatbed trucks and off-loaded. The components of the beam pump unit include large metal pieces that need to be lifted safely to offload and place them.

Prior to proceeding with the unloading, installation, operation, service or maintenance of a beam pumping unit, all operators and workers must familiarize themselves with safe work procedures. No personnel should ever enter the pumping unit guard areas before all safety and pre-work protocols are completed.

A job safety assessment must be conducted prior to initiating any work on the beam pumping unit. This assessment should include the identification of any hazards that are associated with the worksite. These may include, but are not limited to:

- Overhead impediments such as power lines
- Trip or fall hazards around the site
- Potentially hazardous wildlife or plants
- Identification of the type of beam pumping unit, including:
  - Energy sources
  - Type of prime mover installed on the unit
  - Operational controls
  - The condition of the foundation
  - Age of the equipment contained within the pumping unit
  - Maintenance and service reports

The job safety assessment must include a visual inspection of the site, as well as a check for damaged or loosened components. This could include broken bolts and other hardware. This inspection will also be used to prepare the work plan.

The assessment must include:

- A detailed outline of the work
- Confirmation of the skills required to complete the work
- Nature of the work
- Sequence of tasks
- Identification and control of any hazards.

### 6.2.2 Unit inspection and maintenance

Maintenance work is required to keep the beam pump unit in operational condition. This involves fluid changes, lubrication, and parts repair and replacement. Simple tasks may include bearing brake cable greasing, part replacements, and brake adjustments.

Some maintenance and inspection tasks need to be performed when the beam pump is in motion. In such cases, documented step-by-step procedures must be in place.

Routine service and maintenance charts need to consider all aspects of the worksite. Workers should check the foundation to make sure that no cracks have appeared and that no damage has occurred. A routine service should also include maintenance of the board mat foundation. Workers must look to make sure that the structural base is still level. Finally, workers must check all bolts, tie-downs, and earth anchors to make sure they are tight.

Routine servicing and maintenance covering lubrication procedures for pumping-unit speed reducers must follow the manufacturer's operating instructions. Workers must ensure the proper fluids are used based on the manufacturer's requirements or a well-established lubricant and fluid supplier's advice.

A detailed checklist for workers should include areas on the gear teeth, chains, sprockets, saddle bearing caps, brakes and brake cables and all other equipment on the beam pumping unit. Any wear and tear must be reported and replacements installed as required. Additional inspections and work deemed necessary by the Owner and Prime Contractor should be documented.

Whether a detailed servicing, maintenance review, or routine work is being performed, it is critical that all workers are provided with the proper training and information to ensure safe work practices and procedures are followed at all times.

Beam pump inspections may be minor or major. Minor inspections are completed on a regular basis, often daily. The schedule for minor inspections is set by the Prime Contractor. Minor inspections usually involve visual and auditory reviews of the equipment in operation, as well as fluid checks. Occasionally, minor maintenance work may be performed as part of a minor inspection job. Minor inspections usually involve one or two workers. For example, an operator could perform the inspection with or without an assistant.

Major inspections are typically completed once or twice per year. The frequency is determined by the Prime Contractor. Major inspections involve a more thorough review of fluids and equipment. Maintenance work - including minor repairs and greasing components - may also be performed as a part of a major inspection. Service provider companies who specialize in major inspection work may become involved in this process.

### 6.2.3 Well optimization

Many beam pump units are equipped with specialized equipment that is used to calculate efficiencies. This data is analyzed to optimize fluid production. The optimization work may include altering the stroke length, adjusting the weight distributions, and adjusting the speed of the beam pump. It can also involve increasing or decreasing the size of the beam pump unit on site.

### 6.2.4 Well servicing

Well servicing involves connecting or disconnecting the beam pump unit to the polished rod and down-hole assembly. Beam pump service work is usually completed by well servicing contractors with direction from the Prime Contractor. Prior to the work being performed, the Prime Contractor must complete proper hazard assessment and safe work plans. Manufacturer specifications and well history may be used to develop regular maintenance schedules.

Workers must be aware of the beam pump's condition. For example, it might be unbalanced if the polished or sucker rods have parted and when service work requires the counterweights to be at the "twelve o'clock" position. Some situations may require a mobile crane to lift or lower the counterweights in order to bring the beam back into its correct position.

Servicing a pumping unit also involves an inspection. During the servicing, workers must check the structural joints of each piece of the beam pumping unit. The inspection should check for any indication of loosening, weld failures, damage, and general wear and tear.

### 6.2.5 Decommissioning and unit removal

Decommissioning and unit removal involves disassembling the beam pump unit. The beam pump unit is loaded onto flatbed trucks and removed from the site. The beam pump is composed of several large and very heavy pieces. It is imperative that these pieces are lifted safely as they are loaded onto the flatbeds. For each component, the Prime Contractor must obtain accurate lift weights and then relay that information to the Service Provider. The Service Provider is responsible for removing and loading the beam pump components. Service Providers must also be advised about manufactured lift points and components; they need this information in order to identify and use appropriate rigging practices.

The decommissioning work must also include a detailed outline of the work to be performed. A detailed work plan must address job safety and emergency response plans. All workers on the site must be properly trained and provided with the detailed work, safety and emergency plans prior to decommissioning.

It is critical to ensure all hazardous materials are properly contained before loading them for removal from the site. Equipment must be properly prepared for transport to ensure safety during shipment.

## 6.3 Job planning and site safety management

Safety planning and risk mitigation begins in advance of arriving on the job site. Before work starts, job pre-planning and site reviews must be completed. This will help determine how much work needs to be done before the job starts; it will also allow workers to assess and plan for hazards. The five main job planning objectives include:

1
- Review and confirm the planned operations and activities

2
- Communicate the overall work plan and site safety plan to all contractors

3
- Provide a job-specific orientation to all workers entering the job site

4
- Monitor operations to confirm completion of job objectives, including safety

5
- Complete and submit post-operations documentation

The following areas should be covered in pre-job planning and pre-job safety meetings:

1. Scope of the work: What are we here to do? What equipment is required?
2. Review safe work documentation from the Prime Contractor. The documentation must identify all known hazards on the location and appropriate controls for those hazards.
3. Review the site safety plan and, if required, a simultaneous/concurrent operations plan.
4. Conduct a job safety assessment. Review and confirm job scope, hazards, and controls with applicable workers.
5. Establish and apply energy isolation procedures.
6. Identify, mitigate and control the hazards. The hazards depend on the scope of work, the location of the job site, and well-specific conditions.

Other considerations include:

- Information regarding the equipment should also be available to the service provider during the job planning meeting. Job planning should include a review of written work procedures. The procedures are then tailored to the field site requirements of each job site; service providers and their workers review the plan. Written procedures must be accessible either electronically or in a paper-based format.
- Written procedures should be based on manufacturer’s operating manuals or work procedures created by the Service Company or Prime Contractor. They should address the required order of tasks and important safety information, including energy isolation.
- On-site job safety meetings should include an inspection of the work site to identify hazards, confirm equipment issues and discuss the work plan, including equipment placement and lay down before work starts. Required documentation should be completed following the review.

Recommended site safety planning guidelines for beam pump operations is included in Appendix 3. A high level overview of the hazards and key learnings that have resulted in fatalities is provided in Appendix 4 to be used at on-site job safety meetings.

## 6.4 Job safety assessment

A job safety assessment (JSA) should be conducted prior to starting work on a beam pumping unit. Specific considerations include:

- Identify overhead impediments that could hinder the operation of cranes and lifting equipment, including overhead power lines. This includes access roads into the worksite.
- Confirm the type of beam pumping unit being used, along with associated operating controls and restraints.
- Confirm the type of prime mover and the kind of controls used to operate the beam pump. This includes any automated start-up or shutdown timers or controllers.
- Identify all hazardous energy sources including cranks, air cylinders, well load, electrical panels and overhead members.
- Listen and watch for indications of damaged or loosened components in the pumping unit's mechanisms. Watch for broken bolts and other hardware on the ground around the pumping unit: these could indicate a compromised structural connection overhead.
- Check the condition of all guards and barriers to confirm they will protect workers from moving equipment.
- All energy sources must be effectively isolated. Ensure rotating equipment and weights are properly secured against rotation.
- All individuals working on the beam pump must lock-out all energy sources. Tags must be used to identify the worker.
- Perform a visual inspection of the pumping unit brake mechanism followed by a physical test to verify its proper operation and adjustment. Horizontally mounted brake cables may be prone to water infiltration and subsequent corrosion and freezing.

  Note: **Never use the brake alone as a safety stop**.
- Check general lease conditions, including trip or fall hazards, near the work area.

A detailed summary of types of hazards associated with work related to beam pumping operations and the recommended controls is included in Appendix 2. These need to be considered by workers when conducting a job safety assessment.

## 6.5 Recommended work practices and procedures

To ensure that workers are fully protected from beam pump hazards, companies must incorporate manufacturer specifications and safety information into safe operational practices and equipment procedures. This is highlighted in Section 5.4 of this guideline.

There are a variety of tasks related to beam pump operations that may need to be completed. The following tasks must be considered when evaluating the need for written procedures and assessing the competency of those workers required to complete these tasks.

### 6.5.1 Installation procedures

Work related to the installation of beam pumps must be completed in accordance with the manufacturer's recommendations. Installation procedures that deserve specific mention include:

- Use of cranes and lifting equipment
- Working at heights

### 6.5.2 Operating and maintenance procedures

Operating and maintenance procedures include:

- Shutting down pumping system, including:
  - Short-term shutdown and lockout
  - Long-term shutdown and lockout

  Note: lockout recommendations are discussed in more detail in the following section.
- Start-up of beam pump system (engine and motor driven systems)
- Checking pressure safety switches
- Checking and pigging connected flow lines
- Putting bottom-hole pumps on/off tap
- Changing stuffing box packing
- Lubricating pumping units

In all cases, procedures related to the repair and maintenance of a beam pump unit need to be completed in accordance with the manufacturer's recommended practices.

## 6.6 Isolation and lockout/tagout practices

Beam pump units consist of heavy, moving parts that can start moving from the effects of gravity or as a result of changing well conditions. Times of greater risk for workers occur during:

- Unit installation
- Pump stroke changes
- Counterbalance changes
- General unit maintenance
- Well servicing
- Performance of dynamometer card readings

Many beam pump units are equipped with automated control equipment that can cause a beam pump to start, stop or change operating speed without warning. **No worker should enter the guarded area on a pumping unit until all safety and work protocols have been completed**. This includes ensuring that all hazardous energy sources are controlled.

Workers must review appropriate written safe work procedures before conducting work on a beam pump unit. It is critical to ensure that competent workers conduct isolation and lockout procedures before attempting work on a beam pump unit. As a minimum, clear, written procedures must be available to workers that address the following:

1. Confirm that the prime mover is shut down. In the cases of engines, the power take-off must be disengaged and the fuel gas supply must be closed and locked. Electric motors must be switched off at the electrical panel and the disconnect switch locked in the “off” position.
2. Using the brake control, gently stop the pumping unit in the desired position. API strongly recommends that the cranks and counterweights are oriented in the downward “six o’clock” position. Once stopped, the brake can be fully engaged.
3. Engage positive stop devices such as the brake pawl (if so equipped) or hydraulic sheave lock as per the manufacturer’s recommendations.
4. If practical, install a polished rod clamp directly above the wellhead stuffing box as an additional measure to prevent any downward rod motion.
5. Additional measures must be used to ensure that the beam and counterweights do not move during the work process. In some cases, a chain or hydraulic sheave lock can be used to immobilize a drive sheave. In some cases, an engineered strap device may be installed over the beam and attached to the beam pump base. It is critical to develop and follow safe work procedures to protect workers until the beam pump is effectively immobilized.
6. Workers must be aware when a beam pump unit may be in an unbalanced condition, such as when the polished or sucker rods have parted or when the horsehead has been removed. Some cases may require the use of a mobile crane to lift or lower counterweights; this allows for correct beam positioning in order to complete service work.

An example work procedure is included in Appendix 4 – Short-term Shutdown and Lockout.

## 6.7 Worker training and competency considerations

Competency refers to the combination of the skills, knowledge, training, and experience possessed by workers that allow them to be capable to complete the work required with minimal or no supervision. Competency requirements can be reflected in a formal competency profile that lists the required job tasks and describes the necessary skills, knowledge, training and experience required to successfully complete them.

Currently there is not a standardized industry training program for workers on beam pump units. However, there are a number of useful programs related to work on pumps, such as:

- Enform’s Artificial Lift Systems course
- Lufkin's Pumping Unit Operation and Maintenance training course
- HDC Human Development Consultants Describe and Operate Beam Pump training modules
- Weatherford's Artificial Lift course
- Weatherford’s Pumping Applications training course

Many service companies have an on-the-job training and competency development program. It is the Prime Contractor’s and Employer’s responsibility to ensure that their workers are competent to complete the tasks required.

# 7.0 Learnings and recommendations

Safety must be a key consideration whenever work is being performed on pumping units. By being aware of relevant safety regulations, the hazards that are present, and the manufacturer's recommended practices that are reinforced in this guideline, each organization will be able to evaluate their own policies, practices and procedures to help ensure worker safety on and around pumping sites.

## 7.1 Leadership and safety culture

A commitment to safety should not only be a priority, but a value that shapes decision-making all the time, at every level within an organization. Strong leadership is essential to an organization's culture: company culture influences worker behaviour and safety, so leadership is crucial in relation to safety culture. Tasks may be delegated, but responsibility and accountability will always remain with the senior leaders, so it is critical that they promote an environment that encourages safe behaviour.


Leadership's primary goal should be to implement a system that ensures facilities and equipment are correctly maintained and operated. Equipment should not fail or be operated in such a way as to cause or substantially contribute to a major incident.

The following leadership principles are essential components of a safety culture[1]:

- Understand the risks associated with assets under their control
- Understand and validate how work is controlled and performed within those assets
- Understand and influence (reduce) the risk acceptance of their workers
- Learn from incidents, both internal and external to the company, and act appropriately
- Understand which indicators must be measured to ensure they have a full, clear operational picture consistent with the lifecycle of the asset
- Have mechanisms in place that allow operations to be adjusted in response to internal feedback and information from external sources

Each of these principles are evident when looking at the fatalities and injuries associated with beam pump incidents and recurring failures to properly guard equipment or to shut down and lockout equipment when working on or near unguarded equipment.

1 *Reference: OGP Report #452, Shaping Safety Culture through Safety Leadership*

## 7.2 Risk tolerance and its effect on human error

Work on and near beam pumps is a regular part of the oil and gas industry. Since workers are familiar with the tasks and equipment, they may become complacent or underestimate the high level of risks associated with their work. Training, awareness and reinforcement of key risk tolerance factors should be considered for all workers who work on and near beam pumps, including an awareness that:

- Complacency can set in when working near the equipment. This can be addressed by using risk assessments and job planning tools to review the incidents that have occurred within industry and to reinforce the potential risks if procedures are not followed.
- Workers may underestimate the seriousness of an outcome; they must be aware of how serious beam pump-related incidents can be. Relaying statistics on the number of serious injuries and fatalities can help control this risk factor. See Appendix 1.

In addition, workers may become overconfident in the equipment they use. They might overestimate the braking device's effectiveness. Workers must understand that the brake alone may not be sufficient and that the equipment must be secured against movement before any work is performed.

## 7.3 Beam pump equipment and design considerations

Beam pump equipment design varies significantly with age. In fact, this inconsistency poses a serious challenge to managing the hazards associated with beam pump operations. This impacts the consistency of energy isolation practices, especially on work sites where older equipment is still in use.

Some beam pump configurations do not allow access to the sheave, making it difficult - or impossible - to use a sheave chain to isolate energy. Another challenge is that many types of equipment do not have locking pawls: using the brake is not a reliable system without a second "layer of protection" to ensure the beam pump unit is effectively isolated from inadvertent movement. Consider using a hydraulic sheave lock, which enables the sheave to be safely isolated from outside the swing area.

Some existing beam pump designs do not take into consideration the ongoing maintenance and service work that has to be completed on the equipment. Improved design must be considered to accommodate the workers' need to access and work on equipment. Improved design, which could increase ease and consistency of energy isolation, must be considered. Improvements to accommodate the workers' need to access and work on equipment would have an immediate and significant impact. Installation of engineered lifting points could reduce rigging hazards. Wider concrete pads would improve workers' access to the beam pumps and could reduce work hazards.

## 7.4 Communications between prime contractors and service providers

Incomplete or lack of planning is a significant risk factor on beam pump work sites. Written work procedures, equipment information (brand, age, size of equipment, etc.), specifications and other planning information must be shared by the Prime Contractor with the service provider in the planning phase. This information must be available for review on site during work completion. An important component of planning is a field site visit.

The field site visit improves paper-based planning: it facilitates an effective site assessment, which includes an authentic review of the hazards on site, the work to be completed, and the energy isolation procedures required. This gives work crews an opportunity to review the equipment and note any inconsistencies that would require them to make adjustments to the work procedures and equipment requirements.

Communication between the project foreman and the beam pump crew must be effective. Consistent use of hand signals will improve communication during crane lifts. Use of a remote control on picker trucks will allow the operator and service technician to maintain eye contact.

## 7.5 Confirming supervisor and worker competencies

Supervisor and worker competency is a key factor in the successful installation, operation, maintenance and decommissioning of beam pump units. A formal competency profile is necessary to reduce inconsistencies in worker competency. Such a profile outlines the critical tasks required for all personnel, including both the project foreman and service technicians. Workers must be able to perform standard rigging and energy isolation processes. They must also be knowledgeable enough to recognize improper use of rigging equipment and ineffective energy isolation practices.

# 8.0 References


1. Alberta Occupational Health and Safety: Fatality Report:
   a. Worker Crushed by Pumpjack Counterweight, November 9, 2009
   b. Worker Crushed by Oilwell Pumpjack's Rotating Counterweight, May 14, 2009
2. American Petroleum Institute Recommended Practices
   a. API 11E, 18th Edition, November 2008
   b. API Specification 11ER: Recommended Practice for Guarding of Pump Units, 3rd Edition, November 2009
   c. API 11G, Recommended Practice for Installation, Maintenance and Lubrication of Pumping Units, 5th Edition, November 2013
3. Dictionary for the Oil and Gas Industry, University of Texas
4. EHS Partnerships Ltd., An Occupational Health and Safety Hazard Assessment and Task Analysis of Beam Pump Operations in Alberta, British Columbia and Saskatchewan, Report prepared for Enform November 2012
5. HDC Human Resource Development Consultants Ltd., Describe and Operate Beam Pump, Module C: Describe Beam Pump Operations, February 2009.
6. International Association of Oil and Gas Producers (OGP), Report #452, Shaping Safety Culture through Safety Leadership
7. Schlumberger Oilfield Glossary

# Appendices

# Appendix 1: Beam pump related worker fatalities

The following incidents highlight the hazards of working on or in the variety of energized beam pumps. The lessons learned from these fatalities have been incorporated into the development of this guideline.

| Date | Description* |
|---|---|
| May 1997 | *Saskatchewan*: A worker was pinned between the walking beam on the beam pump and the bottom of the tubing board on the rig. The worker then became unpinned resulting in a fall of 20-25 feet to the ground. |
| July 1999 | *Saskatchewan*: A worker was on site obtaining inventory serial numbers when he was pinned in between the counterweight arm and the beam pump's base. |
| 1999 | *British Columbia*: A worker was removing a safety chain on the beam pump when the counterweight came down and struck the worker. |
| February 2001 | *British Columbia:* An operator was on site to thaw an ice plug/hydrate which formed in the piping between the wellhead and the Presco switch. The beam pump, operating with no high pressure shutdown, over-pressurized a rebuilt ratigan end cap. The operator was overcome by $H_2S$ released from the failed equipment. |
| May 2009 | *Alberta*: As a worker was picking up debris, he was struck in the head by one of the beam pump's rotating counterweights, knocked to the ground and then crushed by the counterweight. |
| June 2010 | *Alberta*: While installing insulation on the fuel gas line supplying the beam pump, a worker was killed when the arm of the counterweights struck the worker in the head. |
| November 2011 | *Alberta*: A worker was performing maintenance on a beam pump brake assembly at an oil lease. While working in close proximity to the beam pump unit he was crushed under the counterweights (part of the beam pump structural assembly). The beam pump was stopped but not locked out at the time of the accident. |
| January 2012 | *Saskatchewan*: An experienced well operator entered the area between the drive motor and the gear housing to check the oil site glass on the beam pump engine. The worker slipped and fell. He was fatally injured when struck by the counterweights. |
| June 2012 | *Saskatchewan*: The derrickman on a service rig was pinned between the horsehead and the monkey board of a service rig. |
| October 2014 | *Manitoba*: A worker died after being struck by a beam pump arm. |

*As cited in various occupational health and safety jurisdiction fatality reports in Western Canada.

## Appendix 2: Summary of beam pump hazards

The following tables list the types of hazards common to well sites with beam pumping systems. Examples of each type and recommended control methods are also listed. This list is taken from HDC Human Development Consultants Ltd.

### Table A2.1—Types of hazardous energy common to beam pumping systems

| Types* of hazardous energy | Wellsite sources | Recommended control (lockout) |
|---|---|---|
| Electrical energy | low-voltage and high-voltage equipment and conductors, including cathodic protection systems | ▪ move power disconnect handle at motor starter cabinet to off position; lock out and tag power disconnect handle<br>▪ lock out and tag cathodic protection system<br>▪ use correct tools and grounding devices as required<br>▪ disconnect and/or lock out temporary power sources |
| Kinetic energy | moving equipment (e.g. engine, gear reducer, cranks, counterweights, beam) | ▪ shutdown/lockout and tag main fuel gas supply valve to engine<br>▪ install brake pawl, encage sheave lock and/or chain brake drum to prevent brake release or slippage<br>▪ install slings and chains to restrain beam, counterweights, horsehead<br>▪ install lock to prevent sling/chain removal |
| | moving materials:<br>▪ production and fuel gas flows<br>▪ pneumatic (air, fuel gas, nitrogen) systems | ▪ isolate and lock out wellhead valves<br>▪ lock out fuel supply to engine<br>▪ lock out pneumatic energy sources (e.g., nitrogen supply to clutch, instrument air supply) |
| Potential energy | coiled, suspended, or elevated components (e.g., horsehead, polished rod, counterweights) | ▪ clamp or chain components to prevent movement<br>▪ install locks to prevent clamp/chain removal |
| Chemical energy | energy released by chemical reaction | ▪ close/lock out chemical injection supply lines |
| Thermal energy | heat energy (e.g., in steam, hot water, fire, gases, and liquefied gases) | ▪ close, lock out, and tag steam supply lines<br>▪ close, lock out, and tag propane, diesel supply lines |
| Radiation | ionizing or non-ionizing radiation sources (e.g., wireline equipment) | ▪ isolate/lock out/shield radiation source when not in use |

*Types as cited in *WorkSafeBC: Lockout:* Workers' Compensation Board of British Columbia, 2008.

**WARNING**

Use as many lockout methods as needed to prevent *any* unexpected release of hazardous energy during the work.

**WARNING**

Always:

- follow your company's specific lockout/tagout procedures
- fully document the lockout

## Table A2.2—Types of hazards associated with work related to beam pumping operations

| Type of hazard | Wellsite examples | Controls |
|---|---|---|
| **Objects, motion, force** | | |
| Slippery surfaces | frosty metal or concrete surfaces, ice, mud, small oil spills on concrete base | ▪ remove ice/snow from stairs, ladders, walkways<br>▪ sand slippery surfaces<br>▪ clean up surface spills; use absorbent pads |
| Uneven ground surfaces | tire ruts, hidden ditches or holes (e.g., badger or gopher holes) | ▪ cover open holes, pits, ditches<br>▪ have site graded before freeze up<br>▪ have gravel laid |
| Ladders, raised platforms | falling off ladder during rod tap or stuffing box packing change | ▪ position ladder carefully<br>▪ secure proper footing<br>▪ use recommended fall protection |
| Objects lying on the floor or ground | pipes, temporary cables, parts, tools, planking | ▪ put objects back in their proper storage location after use |
| Obstructions | low hanging pipes, low building doorways, structural supports | ▪ use personal protective equipment (PPE) (e.g., coveralls, gloves, hard hats, safety glasses, safety footwear)<br>▪ use warning signs |
| Pointed objects | protruding valve stems, levers | ▪ mark, flag, or paint |
| Rotating or reciprocating equipment | engine flywheel | ▪ most flywheels only have a guard on one side<br>▪ to prevent entanglement, follow company policies regarding hair, jewellery, and clothing<br>▪ take extreme caution to keep fingers, hair, etc. away from rotating flywheel (e.g., when leaning over to check engine lube oil level do not put your hand on back side of guard) |
| | beam-driven chemical injection pump | ▪ most beam-driven chemical injection pumps do **not** have guards on the actuator arm or cable<br>▪ to prevent entanglement, follow company policies regarding hair, jewellery, and clothing<br>▪ take extreme caution to keep hands, fingers, etc. away from reciprocating components |
| | Beam pump counterweights – heavy rotating parts can start moving from the effect of gravity, especially during stroke change, unit maintenance, well servicing, and while taking readings | ▪ beam pump may be fenced; ensure gate is blocked open to provide an escape route<br>▪ some sites have wellhead guardrails to keep personnel and animals out of area below the horsehead. Before working at wellhead, swing guards out of the way to provide ready escape route.<br>▪ before working at beam pump (or within fence):<br>– stop beam pump<br>– use counterweight position dictated by required work<br>– secure crank against rotation by either (i) blocking, chaining, and locking out brake to prevent movement or (ii) using slings to restrain beam and horsehead and/or counterweights<br>▪ maintenance personnel need a safe work permit to enter fenced wellhead area |

| Type of hazard | Wellsite examples | Controls |
|---|---|---|
| Rotating or reciprocating equipment (continued) | polished rod | ▪ polished rod does **not** have guard<br>▪ stay away from polished rod path<br>▪ do not place hand or fingers between polished rod and stuffing box (pinch point)<br>▪ polished rod is very hot; wear long gauntlet gloves and avoid contact |
| | belts | ▪ belt guard |
| | horsehead | ▪ ensure horsehead is securely bolted/clamped to walking beam<br>▪ use tag lines to position horsehead when removing or lowering wellhead equipment<br>▪ do **not** stand below horsehead |
| Crush points | ▪ where walking beam attaches to samson post (at saddle bearing)<br>▪ at beam pump counterweight/ crank arm/pitman arm assembly<br>▪ at beam-driven chemical injection pump arm<br>▪ at space between the bottom rod clamp and the top of the stuffing box | ▪ take extreme caution to keep fingers, hands away from pinch points<br>▪ on downstroke, there should be a minimum 15 cm (6 inches) distance between top of stuffing box and bottom clamp on polished rod |
| Driving | ▪ driving many hours on bad roads<br>▪ large animals (e.g., deer, moose) crossing the road | ▪ do not drive when fatigued<br>▪ slow down and stay alert at known animal crossings |
| Excessive physical exertion: heavy lifting, strains/sprains | ▪ replacing valves, moving drums (barrels) and other heavy items | ▪ get help<br>▪ use crane or winch |
| **Hazardous materials** | | |
| Pressurized/ combustible gas | a casing gas leak could ignite, causing a fire or explosion | ▪ monitor piping/valving/pressure gauges daily for leaks<br>▪ monitor combustible gas levels (%LEL) |
| Hydrogen sulfide ($H_2S$) gas | when the product is sour, gas emissions contain $H_2S$ | ▪ read MSDS and take recommended precautions (e.g., wear self-contained breathing apparatus [SCBA])<br>▪ monitor $H_2S$ concentrations |
| Carbon monoxide (CO) gas | emitted by building heaters, idling vehicles | ▪ read MSDS and take recommended precautions<br>▪ monitor CO, oxygen concentrations before entering wellsite buildings<br>▪ ensure beam pump engine exhaust piping has no leaks and directs exhaust gases upwards, away from personnel work areas, vehicle traffic areas<br>▪ do not use vehicle exhaust to provide heat or to thaw ice plugs in piping |

| Type of hazard | Wellsite examples | Controls |
|---|---|---|
| Carbon monoxide (CO) gas (continued) | | ▪ for vehicles:<br>– maintain vehicle exhaust system; promptly repair any leaks to prevent CO from entering truck cab<br>– minimize idling periods in idling vehicle, open window slightly to admit fresh air |
| Methane ($CH_4$) gas | production tanks vent methane and other volatile organic compounds to atmosphere | ▪ read MSDS and take recommended precautions<br>▪ monitor combustible gas levels (%LEL) |
| Dewaxing chemical | continuous dewaxer injection system (tank, beam injection pump), pressure truck dewaxer injection, downhole batching | ▪ read MSDS and take recommended precautions to minimize exposure |
| Corrosion inhibitor | chemical injection system (local tank, injection pump) | ▪ read MSDS and take recommended precautions to minimize exposure |
| Methanol | continuous methanol injection system (local tank, methanol injection pump) | ▪ read MSDS and take recommended precautions to minimize exposure |
| Beam pump engine coolant | coolant system (beam pump engine, coolant tank) | ▪ read MSDS and take recommended precautions to minimize exposure |
| Glycol for line heater | heat tracing system | ▪ read MSDS and take recommended precautions to minimize exposure |
| Production sample test reagents | Solvent/demulsifier for measuring basic (bottom) sediment and water | ▪ read MSDS and take recommended precautions to minimize exposure |
| **Non-ambient conditions** | | |
| Pressure | pigging lines | ▪ use PPE (safety glasses, etc.)<br>▪ before opening pig trap door, make sure trap is completely drained and at 0 kPa<br>▪ stand to one side when opening trap door<br>▪ open/close valves slowly |
| Weather: extreme cold, extreme heat, rain, snow | working outdoors during winter months | ▪ wear properly insulated winter clothing, including hats, gloves, and footwear<br>▪ maintain radio/phone contact with central control room |
| | muddy, slippery roads or slippery ground | ▪ drive at correct speed for road conditions and visibility<br>▪ install tire chains during winter months |
| | hot/cold metal surfaces | ▪ use PPE (insulated gloves, etc.) |
| | frozen brake cable | ▪ mount brake cable horizontally and/or seal cable housing on vertical mounts<br>▪ grease brake cable by way of grease nipples |
| Oxygen-deficient atmospheres, confined spaces | tanks, containment dikes, buildings, pits, etc. | ▪ follow company's Confined Space Code of Practice<br>▪ use SCBA and provide safety watch<br>▪ monitor oxygen and other gas concentrations |

| Type of hazard | Wellsite examples | Controls |
|---|---|---|
| Animals | wild game (e.g., bears, moose, elk), livestock, snakes, venomous insects at wellsite | ▪ stay alert<br>▪ use PPE (safety boots, etc.) |
| Heat | engines, polished rod | ▪ use PPE (gloves, etc.) |
| Working alone | | ▪ maintain radio/phone communications with central control room<br>▪ check in at regular intervals |
| **Electricity** | | |
| Current electricity | electric motor, VFD, cathodic protection, heat tracing | ▪ label electrical panels to identify equipment controls<br>▪ wear insulated work gloves and use properly rated extension cords<br>▪ lockout and tag electrically-driven equipment before servicing<br>▪ keep hand clear of wiring when adjusting cathodic protection |
| | removing valves or blinds from piping protected with cathodic protection | ▪ shut off and lockout cathodic protection<br>▪ install jumper cables across gap |
| | electrical lines (temporary or permanent) | ▪ identify safe distances from electrical lines |
| Static electricity | draining a vessel/pipe into a pail | ▪ do not use plastic pails<br>▪ before draining into a pail, ground pail or use metal bonding strap |
| | loading/unloading trucks | ▪ ensure grounding cable is in good condition<br>▪ attach grounding cable before loading/unloading flammable liquids<br>▪ prevent sparks; sparks would ignite fuel vapours |
| **Radiation** | | |
| NORM (naturally-occurring radioactive material) | commonly present in:<br>▪ propane fuel<br>▪ scale and sludge in downhole tubing and equipment | ▪ do not breathe dust, mist or fume, use PPE (respirator)<br>▪ use PPE (gloves and disposable coveralls to keep NORM off of work cloths and body)<br>▪ use specific time, distance, and shielding controls recommended to minimize NORM exposure<br>▪ monitor NORM levels (use personal or portable radiation monitor) |
| Other radioactive sources | well testing equipment that uses radioactive sources (e.g., X-ray equipment) | ▪ read MSDS and take recommended precautions to minimize exposure<br>▪ monitor radiation levels (personal/portable monitor)<br>▪ keep out of range |
| **Changes** | | |
| Changing time | Time changes can impact driver hazards including | ▪ get extra rest while adjusting to time change<br>▪ drive with caution |

| Type of hazard | Wellsite examples | Controls |
|---|---|---|
| | ▪ time of day and glare from sun (low on the horizon) occurs later/earlier than previously. Glare in driver's eyes can cause accidents.<br>▪ change to/from daylight saving time can add to driver fatigue | ▪ reduce driving speed or pull over when sun is low on horizon |
| Changing weather conditions | spring conditions (warm daytime temperatures, cold nights) cause icy conditions | ▪ reduce driving speed<br>▪ on slopes, provide sand for traction<br>▪ install tire chains<br>▪ do not travel |
| Changing wellsite personnel and activities | several contractors on wellsite | ▪ designate site supervisor<br>▪ plan work sequence<br>▪ perform site hazard assessments (all parties)<br>▪ hold pre-job safety meetings (all parties) |
| Changing temperatures | unseasonably cold temperatures cause hydrates or ice plugs to form in production flow lines, fuel gas supply lines | ▪ insulate wellhead, production, and fuel gas lines to prevent hydrate formation<br>▪ develop and follow site-specific procedures for removing hydrates |

# Appendix 3: Site safety planning guideline for beam pump activities

The following flow diagram has been prepared to assist site supervisors in preparing a safety plan for the activities they are supervising. Remember: The main focus of any plan is to ensure that employees, supervisors and workers know the scope of the planned work, their roles and responsibilities related to the planned work and confirmation of the job hazards and the controls need to complete that work safely and effectively.

**Complete Pre-Job Planning**

- Review and confirm construction plans issued by engineers for planned project activities.
- Notify field operations of pending construction work. Identify any area-specific operating or communication requirements.
- Complete and sign-off Notice of Worksite Supervisor.
- Review Worksite Safety Plan Checklist
- Confirm insurance and WCB coverage for contractors prior to commencing work.

**Obtain Work Clearance**

- When applicable, obtain work clearance from operations. Can use either a Work Permit or a Lease Turnover Statement.
- Review project roles and responsibilities. Project Supervisor/operations/contractors.
- Confirm who is responsible for shutting in site, lockout/tagout, purging out-of-service, hot work permits etc.
- Confirm any potential operating/lease hazards with operations. Discuss any landowner issues.
- If required, develop Simultaneous/Concurrent Operations Plan for sites with operating facilities or multiple-activity sites.

**Emergency Planning**

- Obtain and review copy of Corporate/Site-Specific Emergency Response Plan (ERP). Confirm emergency call-down.
- Confirm and post local emergency numbers. Confirm muster point and evacuation route, especially in operating facilities.
- Confirm need for Injured First Aid Transportation Plan. Ensure required safety services and equipment are available.
- Maintain a Worker/Visitor Sign-in Log to track all personnel on location.

**Orientation & Meetings**

- Provide a Site-Specific Worksite Safety Orientation with contractor supervisors and/or workers.
- Confirm worker orientations and training certifications.
- Identify lead contractor when conducting multi-contractor, high-risk jobs.
- Assign responsibility for leading Pre-Job Safety Meeting. ***
- Confirm contractors are completing Daily Tailgate Safety Meetings. ***

**Hazard ID & Control**

- Identify and communicate job and worksite hazards with contractors. Review applicable regulations.
- Review lease access. Confirm road safety practices and communicate to all contractors.
- Confirm equipment spectications and manufacturer standards (when available).
- Confirm contractors are completing hazard assessments and equipment inspections. Request Hazard Alerts. ***
- Complete a high-risk hazards control plan if needed. Prepare a Task-specific Hazard/Job Safety Assessment. ***

**Review High-Risk Procedures**

- Equipment Lockout/Tagout: Confirm equipment lock out requirements and need for additional hazardous energy isolation.
- Confined Space Entry***: Whenever entering a confined space. Also consider use for restricted spaces.
- Electrical: Identify any work near overhead powerlines. Also consider cathodic protection and heat tracing.
- Fire and Explosion Prevention (Hot Work)***: If fire/explosion hazard identified.
- Critical Lifts: Identify any critical lifts and prepare an appropriate lift plan.
- Fall Protection***: Written fall protection plan required if working over 3 meters.

**Ensure required Work Permits are being issued.**

**Monitor Operations**

- Monitor operations for changing hazards and operating conditions. Review with workers and address as required.
- Monitor operations for compliance. Complete Health and Safety Forms as required. Specific considerations include the following:
- Stakeholder Concern: Complete for any landowner complaints including noise, use of access, off lease odours.
- Incident Investigation Report***: Complete for any incidents on location.

**Start-up & End-of-Project Records**

- Review commissioning and start-up procedures. Complete facility start-up.
- Complete Pre-Startup/Operational Readiness Review in cooperation with operations, as required.
- Close Out Lease Turnover-Handback/Work Clearances/Work Permits with field operations. Clean up worksite.
- Compile and submit safety records with end-of-project checklist for review.

***Acceptable to use either Prime Contractor or Service Provider forms to document activities as noted.

# Appendix 4: Zero energy procedures (including an example lockout procedure)

The following procedure is included as an example of the type of information that needs to be communicated to workers responsible for the installation, operation and maintenance of a beam pump. This procedure is taken from HDC Human Development Consultants Ltd. As noted in Section 6.6 of this guideline, the shutdown and lockout of a beam pump unit is one of several tasks requiring workers to demonstrate their competence in order to complete the required work safely.

## Recommended procedure for the short-term shutdown and lockout of a beam pump unit

WARNING

This section describes locking out the beam pump with the counterweights in the **6 o'clock** position. If the counterweights are stopped in a different position, more stringent lockout methods (e.g., using load-rated slings and chains) may be required. Follow your company's lockout procedures.

Beam pumping systems are often shut down for up to one day for routine maintenance or minor repairs. The oil well operator shuts down and locks out the system in preparation for the work.

In a short-term (up to a day) shutdown:

- specific parties may need to be notified
- the beam pumping system is shut down and locked out
- if required, valving at the wellhead and on flowlines to downstream production facilities is closed and locked out
- the shutdown is documented

Before the Shutdown

- If necessary, notify:
  - your company's production engineer
  - the fluid hauling contractor

### Shut down beam pumping system

For an **engine driven** system:

- disengage the clutch
- set the brake (counterweights in 6 o'clock position)
- let the engine idle for a few minutes to cool down
- close the main fuel gas supply valve to the engine

For **motor-driven** system:

- switch the local motor control switch to OFF
- set the brake (counterweights in 6 o'clock position)

### Lock out prime mover (engine)

After the engine and beam pump have been shut down and the main fuel gas supply valve to the engine is closed, install a lock and tag on the main fuel gas supply valve.

After locking out the fuel supply, perform all other lockouts needed to work safely (e.g., mechanically lock out the beam pump, which is described later in this section).

### Lock out prime mover (motor)

WARNING

- To prevent electrical shock:
  - ensure the lease is graded to prevent water from accumulating in the vicinity of electrical installations
  - carry a rubber mat to stand on when operating the power-disconnect handle at the motor starter cabinet/control box
- Do **not** operate the power-disconnect handle unless the motor has first been shut off at the local motor control switch. The power-disconnect handle is **not** an ON/OFF switch.
- When operating the power-disconnect handle, stand beside the motor starter cabinet, face *away* from the cabinet door, and use your non-dominant hand. Facing away from the door protects your face if an arc flash occurs.

NOTE

The power-disconnect handle is used as follows:

- When preparing the motor for lockout, the motor is first shut off at the local ON/OFF switch. Only then should the power-disconnect handle at the motor starter cabinet be moved to the OFF position and then padlocked and tagged.
- When it is safe to restart the motor, the tag and padlock are removed, the power-disconnect handle is moved to the ON position, and the motor can then be restarted using its local ON/OFF switch.
- If a power-disconnect handle is in the TRIP position, a current overload occurred.
- For additional details about the motor starter and other electrical controls, refer to Module B, Section 4.2.

After shutting down the motor and beam pump, lock out the motor:

- at the motor starter cabinet, install a padlock and tag on the power disconnect handle
- for extra assurance (optional), also lock out the local motor control switch

After locking out the motor, perform all other lockouts needed to work safely (e.g., mechanically lock out beam pump components as described below).

### Mechanically lock out pumpjack components

After the energy supply to the prime mover (engine or motor) has been locked out, all beam pump components that could unexpectedly move or release energy must be immobilized and mechanically locked out to prevent injury or equipment damage.

WARNING

Stay out of the crank arm's swing path and away from any other potentially moving parts when securing and/or locking out beam pump components. If the crank arm moves, the counterweights could move and crush you.

The methods used to immobilize and lock out beam pump components vary, depending on the reason for the shutdown, the equipment, and the company's specific lockout procedures. For example, sometimes:

- a safety pin is inserted at the brake's hand lever
- a pawl (block of curved steel) or other type of block is inserted to prevent the brake drum from moving
- a chain is wound through the brake drum, tightened, and locked in position

- a chain is wound through the gear reducer sheave and around the crank arm, tightened, and locked in position
- load-rated slings and/or chains are used to secure the walking beam to anchor points at the base of the beam pump; the chain is tightened and locked in position

WARNING

Slings and chains can fail. Use more than one mechanical lockout method to ensure beam pump components will **not** move during the work.

After completing *all* types of lockout needed to prevent injury or equipment damage during the work, record details of each lockout in the daily log.

## Appendix 5: Glossary of terms

| | |
|---|---|
| Base | is designed to hold the beam pumping unit and prime mover. It may also be referred to as the foundation. |
| Beam Pump | sometimes referred to as “pump jack”, it transfers the prime mover’s rotary motion to the reciprocating (up/down) motion required to operate the subsurface pump. |
| Beam Pump Structure | includes all of the components between the carrier bar and the speed reducer output shaft. |
| Beam Pumping Unit | is the machine for translating rotary motion from a crankshaft to linear reciprocating motion for the purpose of transferring mechanical power to a downhole pump. |
| Brake | is the component of the unit that is made of up a disk or drum mounted on the reducer input shaft together with an apparatus to restrain the motion of all of the rotary joints. |
| Bridle | is a wire cable and is connected to the carrier bar. It tends to wear at the location where it makes contact with the horsehead. |
| Carrier Rail | moves in a perfectly vertical line directly over the wellhead. |
| Centre Bearing | is the assembly which supports the walking beam of a class 1 lever design pumping unit. |
| Certified Installation Print | is the drawing that has been prepared, reviewed and approved by a licensed, professional engineer who is qualified to handle the areas of site preparation, foundations and proper mounting requirements of heavy industrial equipment. |
| Counterweight | is attached to the crank arms and rotates with the crankshaft, rotating upwards they store the energy. |
| Cranks | is the link found in the four-bar linkage of a beam pumping unit that is situated between the output shaft of the gear reducer and the pitman link. |
| Crank Pin Bearing | is sometimes known as wrist pins, it forms part of the crankshaft assembly and is connected to the crank arm. |
| Cross-beam Clamp | is the piece of equipment used to restrict the pumping unit to its supporting foundation. Sometimes a beam is placed on top and spans the base rails with anchor bolts that joint the clamp to the foundation anchors. |
| Equalizer | connects the pitman links to the back of the walking beam. |
| Equalizer Bearing | connects the equalizer to the walking beam. |
| Foundation | is the base that supports the pumping unit and transmits the loads into the ground using distributed contact points with the earth or the piles. |
| Gear Reducer | has gears to convert the prime mover’s high speed, low-torque output to the low-speed, high-torque output that the pumping unit needs. It is housed inside a gearbox. |
| Horsehead | is sometimes also known as the mulehead, it is attached to one end of the walking beam and is positioned so that the polished rod is directly over the wellhead. It is the component of a beam pumping unit designed to transmit force and motion from the walking beam to the flexible wireline. |

| | |
|---|---|
| Hydraulic Sheave Lock | is a hydraulic fork inserted into the sheave to stop the rotation of the gear box and can be engaged from outside the swing area. |
| Pawl | is a device inserted into the brake ratchet to stop the rotation of the gear box. |
| Pitman | is the link that connects the pumping unit mechanism between the cranks and the equalizer. |
| Prime Mover | is the main driving mechanism imparting rotary motion on the pumping unit system. Normally it is connected to the speed reducer via a belt drive. It is often an electric or internal combustion engine. |
| Pumping Unit | is the equipment that has been designed to mechanically lift liquid out of the wells. It converts the rotary mechanism of the motor to a vertical reciprocating motion to drive the pump shaft. |
| Rod Clamp | is the clamping device that is attached to the polished rod of the well for the purpose of transmitting loads to other components or constraining motion. |
| Samson Post | consists of three or four legs of rolled steel, sufficiently strong enough to support the walking beam, horsehead, equalizer, pitman arms, and more than twice the peak sucker road load. |
| Sheave | is a rotating component of a V-belt drive that is designed to transmit power from the belts to the rotating shaft. |
| Skidding | is a horizontal movement which results from dynamic forces from rotating cranks, counterweights. |
| Speed Reducer | the mechanism located between the belt drive and the cranks to transmit rotary power while reducing speed and increasing torque. |
| Tie-down clamp | is a clamping device that is used to attach the pumping unit base to the foundation. |
| V-Belt | is a method used to transfer power from one rotary piece of equipment to another. It typically connects the output sheave of the prime mover to the input sheave of the speed reducer. |
| Walking Beam | transmits energy from the prime mover to the sucker rod string. |
| Wireline | is a strong flexible cable connecting the well's polished rod to the horsehead. |

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