# CRUDE OIL AND PETROLEUM PRODUCTS PUMPING STATIONS

## INTRODUCTION

This PRC Guideline presents guiding principles for loss prevention and control for crude oil and petroleum products pumping stations. See PRC.17.3.4 for loss prevention guidelines if the pumping station is associated with a tank farm.

## PROCESSES AND HAZARDS

For reasons of efficiency, economy, and safety, the preferred method of moving large quantities of petroleum or petroleum products on land is by dedicated, large diameter, buried, transmission pipeline. Due the friction loss created by liquids moving through the piping the pipelines experience pressure losses over the length of the piping. To address this pumping stations are located at regular intervals along the pipeline to boost the pressure to desired levels.

Typically, a pumping station has multiple centrifugal pumps arranged in parallel with block valves and check valves at each pump, so that any pump can operate independently of the rest. In addition, the pipeline itself has a check-valve-equipped bypass at the point of connection to the pumping station, so that the total failure of any one pumping station will not completely shut down the pipeline.

The loss of a pumping station while not stopping the flow of product through the pipeline will decrease the flow rate. Given the value of the product being moved through the pipeline the business interruption loss caused by the destruction of a pump station will typically exceed the associated property damage loss. This therefore justifies the cost of protecting the facility.

The crude oil and petroleum products being moved through these stations are flammable and combustible liquids. A release of these materials could result in a major fire or explosion in the station. The pumps may be driven by a variety of internal combustion engines and electric motors, all of which are subject to various types of mechanical breakdown. This can lead to significant physical damage to the equipment and controls for the station. It could also result in a material release and subsequent fire.

The other major factor in loss control at these stations is the lack of direct human supervision. Most of these stations are unmanned and located in sparsely populated areas. A fire or other problem can go unnoticed for extended periods of time unless proper monitoring and controls are in place. In addition, even after a problem is detected, the nearest fire or maintenance personnel may be too far away for a timely response.

For these reasons, pumping station operators need to place a strong emphasis upon automatic and remote detection, alarms, ESD systems, and operating/loss control systems.

## LOSS PREVENTION AND CONTROL

### Management Programs

Good loss prevention management programs are the first line of defense against a major incident at a site. These programs can help prevent a major breakdown or release and insure the site is adequately protected. When developing these programs, pay particular attention to the following important areas:

- Preventive maintenance and inspection program, including metals inspection, piping inspection, vibration analysis and nondestructive testing programs
- Operator training programs including on site and remote operators
- Welding, cutting and other “hot work” permit programs
- A program for self inspection of fire protection equipment
- A program for handling impairments to fire protection equipment
- A program for control of outside contractors
- Smoking regulations
- A pre-emergency plan
- Housekeeping
- Management of change

### Station Layout and Construction

Space separation is the most effective loss control method. All support areas including service buildings, control rooms, MCC/Electrical buildings, boiler houses and utility areas should be separated from the pump area by at least 100 ft (31 m).

Locate pumps in the open or under an open-sided canopy of noncombustible construction whenever possible. If the pumps must be housed in a fully enclosed building the building should be of noncombustible construction. Buildings with steel frames, corrugated metal siding, and concrete floors are preferred. Insulation and other interior finish should be noncombustible. Do not use load-bearing masonry wall construction.

Provide adequate fresh air natural ventilation to pump houses and any other buildings with a combustible gas or vapor hazard. Have sufficient floor openings in buildings with basements. Where natural ventilation is not adequate, provide mechanical ventilation. Provide alarms to actuate upon ventilation failure, and send an alarm signal to a constantly attended location.

### Water Supplies

Provide two automatic fire pumps with diesel engine drivers installed in accordance with NFPA 20 and PRC.14.2.1. Locate the pumping equipment in an unexposed noncombustible building, reserved for fire pump service only. The pumps should be sized based upon the expected fire protection demands taking into account automatic sprinkler/waterspray systems and manual firefighting demands. Guidance for determining this demand can be found in PRC.14.1.1.1.

The pumps should take suction from tanks or reservoirs sized to provide a minimum of 4 h supply with the pumps operating at their rated capacities.

Provide an independent, looped, underground, fire protection water system. The system piping diameter should be not less than 6 in. (150 mm). Provide adequate sectional control valves. See NFPA 24 and PRC.14.5.0.1 for details.

Provide hydrants and hydrant monitors at strategic locations around the station. The type of hydrant used should be determined in consultation with the local fire departments expected to use them to insure they are compatible with their equipment. At a minimum locate hydrants so no portion of any building or structure is more than 250 ft (76 m) from a hydrant and no hydrant is within 50 ft (15 m) of any building or pumping area.

## Fixed Fire Protection

Provide automatic water spray or foam protection for the pump/driver area of the pump house or over these units, if located in the open. See PRC.12.2.1.2 for details. Where water spray is present, provide adequate drainage to a safe location. See PRC.2.5.3 for details.

Provide automatic total flooding gaseous extinguishing agent protection, such as carbon dioxide, for the room or building housing any auxiliary or control equipment. As an alternate protection method, provide automatic sprinklers and smoke detectors for the room and automatic total flooding gaseous extinguishing agent protection for the underfloor area. See NFPA 12 and PRC.13.3.1 for details. If a total flooding carbon dioxide system protects a room or building, see PRC.13.3.2 for additional details.

## Manual Fire Protection

Provide portable fire extinguishers suitable for the occupancy in all buildings. See NFPA 10 and PRC.13.7.1.1 for additional guidance in extinguisher selection and location. Depending upon the size of the station, provide one or possibly two wheeled 150 lb. (67.5 kg) dry chemical extinguishers.

## Shutdowns for Pumps and Drivers

Monitor the following pump and driver features and arrange them to automatically shut down the pumps under abnormal conditions. See Table 1 for a summary of the recommended shutdowns. These shut downs should be arranged so the equipment cannot be restarted until the shutdown has been manually reset at the station. This is to insure the equipment cannot be used until the reason for the shutdown has been investigated and addressed.

## Station Control Valves

Provide listed shutoff valves in both the suction and discharge lines of the station to permit safe isolation of the station from the pipeline. Separate the valves and remote control switches from the station buildings, and label them. Provide power-operated valves with means for backup manual operation.

## Emergency Shutdown System

Provide an emergency shutdown system (ESD) to shut down and secure the station in a safe shutdown condition as quickly as possible. The ESD should accomplish the following:

- Close the station and unit suction and discharge line control valves.
- Shut off the fuel supply or shut down power to the driver of the pump.
- Actuate visible and audible alarms both locally and at a remote control point.
- Locate remote control stations (RCS) for the emergency shutdown system 250 ft (76 m) or more from the pump house.
- At unattended locations, in addition to the previously mentioned remote control stations, actuate emergency shutdown by:
    - Diffusion-head-type combustible gas detectors in pump houses and other vapor hazard buildings.
    - Heat-actuated or ultraviolet fire detectors.
    - Unauthorized entry monitors.
    - Failure of the ESD pilot or control system.
    - Low pipeline pressure.

Sound alarms at a remote constantly attended location upon actuation of the station ESD system.

**TABLE 1**
**Recommended Interlocks For Pumps And Drivers**

| Type | Internal Combustion Engines | Gas Turbines | Electric Motors | Reciprocating and Rotary Gear Pumps | Centrifugal Pumps |
|---|---|---|---|---|---|
| High- cooling water temperature | X | | | | |
| Low oil pressure and level | X | | | | |
| Overspeed | X | X | | | |
| Vibration | X | X | X | X | X |
| Turbine overspeed (if turbocharged) | X | | | | |
| High exhaust temperatures | | X | | | |
| Flame failure | | X | | | |
| High bearing temperature | | X | X | | X |
| Low and high lube oil pressure | | X | | | |
| Low oil level | | X | | | |
| High case temperature | | | X | | X |
| Overload | | | X | | |
| Loss of air purge (if required) | | | X | | |
| Low and high voltage | | | X | | |
| Phase reversal | | | X | | |
| Loss or imbalance of phase | | | X | | |
| Axial displacement | | X | | | |
| Low suction pressure | | | | X | X |
| High discharge pressure | | | | X (at each stage) | X |
| Low discharge pressure | | | | X | X |

## Equipment Design

Install a pressure relief valve in the discharge line between each pump and its first discharge block valve. Size each relief valve to limit the pressure in the piping and equipment to 10% above the maximum allowable operating pressure. Discharge the vent lines from the relief valves to a safe location.

Provide drain lines from both ends of the pump to drain all flammable or combustible liquids from a seal failure to a safe location. If the station is unattended, arrange a level switch on the drain sump to shut down the pump and close the pump isolation valves.

Internal combustion engine drivers should receive air through filtered air intakes. Locate the intakes outside the building on the side furthest from the suction and discharge lines. LEL detection should be provided in the air intake designed to shut the engine down upon activation.

All hydrocarbon piping and all piping that carries any hazardous fluid or any fluid under pressure should be designed, manufactured, installed, inspected and tested in accordance with the appropriate section of the ASME B31.1 and B31.3 piping code series and any applicable U.S. Department of Transportation or local codes. Locations outside the U.S. must comply with the country code and any local codes that apply, but should also comply with the applicable ASME code(s) if the ASME code(s) is/are more restrictive. In all cases, join pipe and fittings by welding. When welding is not practical, use welded flanges. When flanged connections are not practical, for example, in small diameter instrument piping, ensure that the piping or tubing is properly braced to avoid stress or vibration damage, particularly at the connection to the larger pipe or machine casing.