GAS COMPRESSOR STATIONS

INTRODUCTION

This PRC Guideline presents guiding principles for loss prevention and control for gas compressor stations. They are intended as a tool for evaluating the widely diverging protection levels provided at these facilities.

POSITION

Management Programs

Because of the relatively small size of most gas compressor stations, management will usually supervise a number of stations from a central location. This central management usually handles loss prevention programs which should follow the intent of *OVERVIEW* (PRC.1.0.1). In developing these programs, give particular attention to the following important areas:

- Preventive maintenance and inspection, including:
  - nondestructive metals testing.
  - Infrared testing
  - relief valve testing
  - turbine inspection Including borescope, interlocks, air filters, etc.
  - Emergency Shutdown System (ESD) testing
  - gas detector testing and Calibration.
- Operator training including training effectiveness evaluation.
- Welding, cutting and other “hot work” permits.
- A program to perform hazard evaluations on existing and new stations.
- A program for management of change, including handling of new construction.
- A program for inspection of fire protection equipment.
- A program to supervise impairments to fire protection equipment.
- A program for control of outside contractors.
- Smoking regulations.
- A pre-emergency plan.

Plant Layout and Separation

Spatial separation is the most effective loss control method. Design separation into a plant during its very early planning stages. Key spacing recommendations are:

- Locate the main gas transmission line at least 350 ft (110 m) from the gas compressor building.
- Locate all other buildings and structures at least 350 ft (110 m) from the main gas transmission line and from the gas compressor building.
- Locate all open flame devices, such as heaters, boilers or stoves, or the buildings in which they are contained, at least 100 ft (30 m) from any gas hazard area, gas lines or gas handling buildings.
- Detach generators at least 100 ft (30 m) from gas hazard locations, if electric current is generated on the premises.

See PRC.2.5.2 for details.

Construction

Construct buildings of steel frame with corrugated metal roofs and walls and concrete floors. Use only noncombustible insulation and other interior finish. Avoid using load-bearing masonry wall construction. Ensure all buildings and equipment are grounded.

Provide gas compressor buildings and any other buildings with a combustible gas or vapor hazard with adequate, fresh air, natural ventilation to prevent accumulation of explosive concentrations of gas. Install sufficient floor openings for adequate ventilation in buildings with basements. Wherever portable combustible gas analyzers find inadequate natural ventilation (gas concentrations above 25% of LEL), provide mechanical ventilation of at least 1 cfm/ft^2 (0.3 m^3/min/m^2) of floor area. Provide alarms to actuate upon ventilation failure.

Water Supplies

Provide two automatic fire pumps, each rated at not less than 500 gpm (1900 L/min) and 125 psi (8.6 bar), and install them in accordance with NFPA 20. The pumps should be driven by diesel engines. Pumps, drivers and control panels should be listed by a nationally recognized testing laboratory. Locate pumping equipment in an unexposed noncombustible building, reserved for fire pump service only.

The pumps should take suction from tanks or reservoirs sized to provide a minimum of 2 h water supply with the pumps operating at their rated capacities.

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

Supervision

Provide alarm and supervisory service covering:

- Fire alarm signals from the discharge of all extinguishing systems (sprinklers, water spray, carbon dioxide, etc.) and from the activation of all fire detection systems.
- Supervisory signals from the closure of fire protection system control valves (water, carbon dioxide, etc.).
- Supervisory signals which monitor the high and low air pressure of dry pipe sprinkler systems.
- Supervisory signals which monitor the integrity of fire protection water supplies (tank low level and low temperature, fire pump running, driver/controller availability, driver trouble).
- An approved combustible gas detection system interlocked to sound an alarm upon concentration of 25% of the LEL, and shutdown of the system upon detection of 50% of the

LEL. The shutdown should include closing all inlet and discharge gas lines and opening blowdown valves.

This supervision should be monitored at a constantly attended location. See PRC.11.0.1.

Hydrants and Hose

Install fire hydrants of standard, double outlet design. In areas subject to freezing, install hydrants of frostproof design. Do not install hydrants with pumper connections. 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 structure.

At opposite ends of the facility, erect two, all metal, hose houses with each house containing at least 250 ft (76 m) of 1½ in. (40 mm) hose arranged on a wheeled cart. Provide at least two combination straight-stream/spray nozzles and adequate hydrant wrenches for each hose house.

Fixed Fire Protection

Provide automatic water spray protection for the compressor/driver area of the compressor building or over these units if located in the open. See PRC.12.2.1.2 for details.

Provide automatic total flooding gaseous extinguishing agent protection, such as carbon dioxide, for the room or building housing 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 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.

If the compressor and/or driver is enclosed in a metal cabinet, provide automatic total flooding gaseous extinguishing agent protection inside of the cabinet.

Portable Fire Protection

Provide portable fire extinguishers, suitable for the occupancy, in all buildings. Provide at least one 30 lb (14 kg) dry chemical unit in each compressor building.

Depending upon the size of the station, provide one or possibly two wheeled 150 lb (68 kg) dry chemical extinguishers.

Shutdowns for Gas Compressors and Drivers

Monitor the following compressor and driver features and arrange them to automatically shut off and vent the engine or turbine fuel gas supply or to shut off power to electric motor drivers. See PRC.17.3.2.A for a summary.

Internal Combustion Engines

- High cooling water temperature
- Low oil pressure and level
- Overspeed
- Vibration
- Turbine overspeed (if turbocharged)

Gas Turbines

- High exhaust temperatures
- Overspeed
- Flame Failure
- Vibration
- High bearing temperature
- Low and high lube oil pressure

- Low oil level
- Axial displacement

See also PRC.6.1.2.1, PRC.6.1.2.2 and PRC.6.1.2.3 for additional details.

Electric Motors

- High bearing temperature
- High case temperature
- Overload
- Loss of air purge (if required)
- Vibration
- Low and high voltage
- Phase reversal
- Loss of phase

Reciprocating Compressors

- Low suction pressure
- High discharge pressure at each stage
- High discharge temperature
- Vibration
- Scrubber high liquid level

Centrifugal Compressors

- Low seal oil pressure
- Vibration
- Surge
- Low suction pressure
- High discharge temperature
- Scrubber high liquid level

Gas Control Valves

Provide suitable gas shut-off valves safely detached in both the suction and discharge lines of the station to permit safe isolation of the station from pipe line gas feed. Separate the valves and remote control stations from station buildings by at least 250 ft (76 m). Clearly label the valves and remote control stations.

Use gas pressure to operate powered valves. Provide an emergency gas reservoir of adequate volume to maintain pressure if gas pressure in the pipeline is lost. In addition, provide all power operated valves with means for manual operation.

Emergency Shut-Down System

Provide an emergency shut-down system (ESD) to remove the equipment in the station from service and to secure the station in a nonhazardous condition in as short a time as possible. Design such a system individually for each station. The system should accomplish the following:

- Close the station and unit gas suction and discharge line control valves.
- Blow down station and unit piping to a location where the gas will not create a hazard.
- Shut off and vent fuel gas supply or shut down power to driver of compressor.
- Actuate visible and audible alarms either locally or at a remote control point.
- Cut off all electric equipment and shut off fuel to all open flame devices.

Provide a minimum of two remote manual control stations to actuate the main line, power operated, valves. Locate one remote control station (RCS) for the ESD 250 ft (76 m) or more from any gas pumping building or gas line. Locate the second RCS 250 ft (76 m) or more from the other RCS, gas line or both, or gas pumping building, or shield by topography or structures to remain accessible at all times.

At unattended locations, in addition to the previously mentioned remote control stations, actuate emergency shutdown automatically by:

- Diffusion-head-type combustible gas detectors in the compressor building, the turbine building and other gas hazard buildings.
- Heat actuated or ultraviolet fire detectors.
- Unauthorized entry monitors.
- Scrubber high liquid level.
- Failure of the ESD pilot or control systems.
- Pipeline break.

Alarms from the unattended station should sound at an attended location which should be able to actuate the station ESD, and shut down each compressor individually.

Equipment Design

Install pressure relief valves in the discharge line between the compressor and the first discharge block valve for each stage of compression. Size the relief valve to limit the pressure in piping and equipment to 10% above the maximum allowable operating pressure. Discharge the vent lines from the relief valves upward to atmosphere above the eave line of the building.

If a common vent system is provided, equip any manual bypass lines around the relief valves with check valves to prevent gas from entering the compressor area should equipment be down for repairs with a bypass valve left open.

Internal combustion engine drivers should receive air through filtered air intakes which should be located on the outside of the building on the opposite side from the gas headers and compressor relief valve vent lines.

All pressure gas piping and fittings should conform to ASME “Code for Pressure Piping” or other similar standards. Limit the use of bolted flange pipe, valves and fittings. Do not use small size threaded nipples and small size threaded piping in gas service since they are prone to fatigue failure from vibration.

Protect buried piping against corrosion by coating with protective materials or by cathodic protection.

DISCUSSION

Gas compressor stations can be used to collect natural gas from wells or refineries, as a pressure-booster or relay station in a cross-country gas transmission pipeline, or to pump gas back into underground storage areas for reserve supply. In a gas transmission pipeline system, compression is accomplished by compressor stations usually placed at 40 to 100 mile (64 to 160 km) intervals along the pipeline.

Gas will typically enter the site through the station valves, then pass through a scrubber or filter (to collect any particulate and/or liquids, such as concentration), then pass through the compressors. The natural gas compressor can be driven by a turbine, electric motor, or gas engine.

- Turbine Systems- Turbine compressors gain their energy by using up a small proportion of the natural gas that they compress. The turbine itself serves to operate a centrifugal compressor, which contains a type of fan that compresses and pumps the natural gas through the pipeline.
- Electric Motor Systems- Some compressor stations are operated by using an electric motor to turn the same type of centrifugal compressor. This type of compression does not require the

use of any of the natural gas from the pipe, however it does require a reliable source of electricity nearby.

- Engine Systems- Reciprocating natural gas engines are also used to power some compressor stations. These engines resemble a very large automobile engine, and are powered by natural gas from the pipeline. The combustion of the gas powers pistons on the outside of the engine, which serves to compress the natural gas.

While gas compressor stations have the hazards of natural gas handling, they do not possess any large liquid holdup. In addition, the natural gas is not reactive or subjected to high temperatures. As a result, losses at these stations usually originate in the machinery. Accordingly, emphasis is placed on monitoring the equipment and providing shut-down interlocks as needed.

The other major factor in loss control at these stations is the lack of direct human supervision. Most of these stations are small and located in sparsely populated areas. As a consequence, most of them are unattended. This trend is continuing as advances in data processing make possible ever more powerful automated controls. A fire or other problem can go unnoticed for extended periods of time. Even after a problem is detected, the nearest fire or maintenance personnel may be too far away for a timely response.

For these reasons, place a strong emphasis upon automatic and remote detection, alarms and ESD systems, and operating and loss control systems.

Losses at these stations often originate in, or at least involve, lubricating oils, seal oils or hydraulic fluids. Therefore, if it is possible to avoid the use of such materials, consider doing so. By using magnetic bearings, lube oil systems can be eliminated. Dry seals do not require seal oil. Hydraulic systems can use low hazard fluids or be replaced by pneumatic or electrical systems.

In 2003, a survey, Fire Prevention and Control in Compressor Buildings, was conducted by the Interstate Natural Gas Association of America (INGAA) Foundation in order to determine what types of active and passive fire controls are being used and the incidence of fires. Some key points of the study were as follows:

- The survey represented about 46 operating companies and approximately 1372 compressors stations (and 4,163 compressor units).
- Of the 4,163 compressor units (1,012 turbines and 3,151 reciprocating), about 7.4% were equipped with active fire suppression and 92.5% were equipped with passive fire protection.
- Six fires were reported with damage in excess of $500,000 ($640,000 in 2014). All reported fires occurred at turbine units, which were 24.3% of the survey units. (Fire incident frequency rate is 1.44×10^{-4}).
- Five of the six incidents with damage in excess of $500,000 ($640,000 in 2014) occurred at units with passive fire protection; one incident occurred at location with active fire protection.
- Conclusion- Fire incident frequency rate for reported fires is no higher for units with only passive fire protection controls.

The natural gas pipeline industry general follows the U.S. Department of Transportation (US DOT) guidelines. The document 49 CFR Part 192 prescribes minimum safety requirements for pipeline facilities and the transportation of gas. This document includes provisions for some basic alarm detection and shutdown features, but doesn't really address fire protection from lube oil fires.

COMPRESSOR INTERLOCKS

TABLE 1
Recommended Interlocks For Gas Compressors And Drivers

Type	Internal Combustion Engines	Gas Turbines	Electric Motors	Reciprocating Compressors	Centrifugal Compressors
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		
Low and high lube oil pressure		X			
Low oil level		X			
High case temperature			X		
Overload			X		
Loss of air purge (if required)			X		
Low and high voltage			X		
Phase reversal			X		
Loss of phase			X		
Axial displacement		X			
Low suction pressure				X	X
High discharge pressure				X (at each stage)	
High discharge temperature				X	X
Scrubber high liquid level				X	X
Low seal oil pressure					X
Surge					X