CRUDE OIL AND PETROLEUM PRODUCTS STORAGE TERMINALS

INTRODUCTION

This PRC Guideline presents guiding principles for loss prevention and control for crude oil and petroleum products storage terminals. They are intended as a tool for evaluating the widely diverging protection levels provided at these facilities.

Storage terminals are facilities for the storage of oil and/or petrochemical products and from which these products are usually transported to end user or further storage and distribution facilities. Storage terminals are usually situated close to oil refineries or in locations where marine tankers containing products can discharge their cargo. Some terminals are connected to pipelines from which they draw their supplies and depots can also be fed by rail, by barge and by road tanker.

A storage terminal is a comparatively unsophisticated facility. The only processing that takes place in some terminals is the injection of additives into the product stream.

Key Protection Features

The key protection features for a storage terminal are:

- Tank spacing to prevent the spread of a fire from one tank to another
- Overfill protection
- Dikes for spill control
- Fixed fire protection systems for tanks
- Water and foam supply
- Pre-emergency plans with specialized disaster control organizations

POSITION

Management Programs

Terminals range in size from very small product storage or crude gathering terminals to very large, complex storage terminals. The management of some small terminals may be at a central location responsible for a number of terminals. Any loss prevention program will usually be handled by this central management, but the program should still incorporate all of the features covered in *OVERVIEW* (PRC.1.0.1). When developing this program, pay particular attention to the following important areas:

Hazardous Materials

Develop a program to determine the pertinent physical and chemical properties of all products. Choose test conditions that best represent all possible operating conditions.

Establish routine procedures for testing physical and chemical properties of all incoming materials to confirm properties required for safe operating conditions.

Process Hazard Evaluation

Design all operations to be inherently safe by the use of instrumentation. Protect piping, tanks and pressure vessels by providing adequate pressure relieving devices. Provide intermediate alarms to allow the operator time to take corrective action. Provide automatic shutdown for selected equipment wherever possible without endangering other terminal operations. Provide redundant instrumentation for all critical controls. Include both separate signal transmitters and receivers in redundant loops. Install a comparator to notify operators when control and redundant signals differ significantly.

To limit the amount of materials released by equipment failure, include in the shut-down systems, block valves, venting, and purging or flooding of equipment with a nonhazardous fluid. Combustible vapor detectors should actuate these shut-down systems where appropriate.

Consider combustible vapor detectors as a means of detecting accidental releases of gases or liquefied gases.

Design and specify equipment considering all possible operating conditions, both normal and abnormal. Pay particular attention to suitability of the equipment and piping to handle the materials and to withstand external environmental influences.

Operator Training

Enforce adherence to written operating procedures. Educate all operators in the hazards of the process and functions of the safety control equipment. Forbid operations when any of the safety equipment is out of order. Train operators in manual emergency shut-down procedures. Give operators written authority to implement those procedures.

Schedule periodic re-education and training of the operators at least annually. Include testing to assure proper performance of all assigned duties with particular emphasis on emergency shutdowns.

Pre-Emergency Planning

The pre-emergency plan found in PRC.1.0.1 may be used to develop a customized plan which should include the following features:

- A fire and disaster alarm system.
- An emergency communications system, including radio where needed.
- An adequately trained, staffed and equipped organization of employees for firefighting, release mitigation and other duties. Small terminals with few or no employees on site may have to rely on outside organizations to meet these needs.
- A planned program of cooperation with neighboring plants and with public firefighting and disaster control organizations. These plans, especially those involving disaster control organizations should be documented and contracts with disaster control organizations properly signed to avoid unnecessary delays in a major incident.

Preventive Maintenance and Inspection

Inspect, test and maintain storage tanks, piping, instrumentation, electrical equipment, and pressure/vacuum relief devices according to a schedule established with proper consideration of both design and service conditions. Include nondestructive testing, IR scanning and vibration analysis in inspection techniques. Establish a detailed record keeping system, including life extension forecasts or projections.

Inspect, test and maintain fire protection equipment in accordance with PRC.12.0.2 and PRC.12.5.1.

Management of Change

Apply all management programs to any changes made to the facility's physical arrangements or procedures. Pay particular attention to the following areas:

- Conduct a process hazards evaluation for all new or modified equipment. Determine the need for new or different safety equipment or measures.
- Whenever the use of equipment is changed from one service to another, or when other changes are made, examine the inspection and maintenance program and modify it as necessary. Monitor daily operating changes.
- Verify new construction materials and all maintenance parts and supplies as conforming to original (or modified) design specifications.
- Incorporate a program for handling new construction, including the control of outside contractors.
- Update operations procedure manuals after each modification that results in a change in operating procedure.
- Review and follow through expeditiously on all inspection recommendations from insurance, code enforcement and regulatory agencies.

Other Management Programs

Incorporate these programs into the loss prevention and control program:

- Welding, cutting and other "hot work" permit programs.
- A program for handling impairments to fire protection equipment using AXA XL Risk Consulting's "RSVP" program.
- Smoking regulations.
- Plant security and surveillance.

Spacing and Layout

Fires or explosions in congested terminals have resulted in extensive losses. A good layout with adequate spacing between hazards is therefore essential to loss prevention and control.

Properly separate atmospheric storage tanks from each other by an adequate distance. Additional segregation is required between pressure storage tanks and other facilities. See PRC.2.5.2 for details.

Locate loading racks at least 250 ft (76 m) from atmospheric storage tanks, 350 ft (107 m) from pressure storage tanks and 200 ft (61 m) from other facilities.

Locate all open flame devices, such as heaters, boilers and stoves, or the buildings in which they are contained at least 100 ft (31 m) from any vapor hazard area. See PRC.2.5.2 for details.

Locate product pumps outside of tank dikes.

Do not pass piping for one tank or group of tanks through a dike enclosure of another tank or group of tanks. Locate pipes to minimize exposure from drainage channels.

Overfill Prevention

The majority of fires in terminals is caused by overfilling of tanks due to instrumentation failure and operator error. In the Buncefield, UK terminal fire in December 2005 a tank was overflowing for over 40 minutes during filling operation causing a major fire which took over 32 hour to control.

The tank should be equipped with high liquid level detectors with alarms so that personnel can quickly shutdown or divert product flow and with high high liquid detectors triggering automatic shut-down or diversion of product flow. The instrumentation must be electrically supervised to verify operation. Operators should cross-check the filling operation by calculating the expected duration of the filling operation using the fill rate and the tank volume.

Diking

The most important feature in minimizing a loss in a terminal is diking tanks. Dike each tank individually with an enclosed area large enough to contain the contents of the tank. If a number of tanks must be located in a common dike, consider them subject to a single fire incident. Do not locate pressure storage tanks inside dikes containing atmospheric storage tanks.

Where terminal space limitations do not allow adequate spacing and individual diking of tanks, employ a “remote impounding” means of spill control. This concept is covered in NFPA 30. Also apply this concept to truck loading rack spills.

Drainage

Provide drainage facilities to carry accidentally spilled flammables away from pump areas, loading racks and pipe racks. Design the drainage facilities to effectively and rapidly carry spills, fire protection water and rain water simultaneously to a safe location without exposure to adjacent facilities. This may require diversionary curbs, trenches, collection sumps, skimmers, separators and holding ponds or basins. Design general area grading with the anticipation that normal drainage facilities may overflow. See PRC.2.5.3 for details.

Construction

Construct buildings of steel frame with corrugated metal siding and concrete floors. Insulation and other interior finish should be noncombustible. Avoid load-bearing masonry wall construction.

Locate product pumps and compressors in the open. If housed in buildings, provide adequate natural ventilation to prevent accumulation of explosive concentrations of vapor. Avoid buildings with basements. Where natural ventilation is not adequate, provide supplemental mechanical ventilation to prevent explosive concentrations. Provide alarms to actuate upon ventilation failure.

Anchor tanks against any flood or earthquake hazard. Avoid using any combustible tank insulation. Provide fire truck access to all tanks.

Provide structural supports for pressure storage tanks with a 2½ h rated fireproofing by UL 1709. See PRC.2.5.1 for details.

Water Supplies

Provide a water supply capable of supplying the largest foam system and/or water spray system in the terminal and of providing the cooling water for the exposed tanks. A terminal with tanks of individual capacity up to 100,000 bbl (15,800 m^3) should have a fire water system capable of delivering at least 3000 gpm (11,340 L/min) at 90 psi (6.2 bar) to all areas of the terminal. Terminals having larger tanks require additional water capacity based on an individual analysis.

The water supplies should be capable of supplying the required flow for a period of 4 h.

The water distribution system should be of buried pipe. Design with loops and sectional control valves such that with one section of the distribution system out of service, at least 50% of the pumping capacity can be provided in any of the high-valued areas. See PRC.14.1.1.1 and PRC.14.5.0.1 for details. Avoid using sea or salt water supplies.

Hydrants and Hose

Use fire hydrants of a standard, double outlet design with pumper suction outlets. In areas subject to freezing, also use frostproof design. Locate hydrants so no portion of any building, structure or tank is more than 250 ft (76 m) from a hydrant and no hydrant is within 50 ft (15 m) of any building, structure or tank. See PRC.14.5.0.1 for details.

Provide an adequate amount of hose, nozzles, portable deluge sets and other equipment. Locate either on motorized apparatus or in hose houses throughout the facility where adequate trained personnel exist.

Foam Protection

Provide fixed or semi-fixed foam equipment, including an adequate supply of foam concentrates to protect all areas where flammable or combustible liquids are stored or handled. Use foam concentrates that are compatible with the liquids to be protected, i.e., polar or nonpolar solvents. The amount of foam concentrate provided should be adequate to extinguish a fire involving the largest storage tank. Design the foam installation in accordance with NFPA 11 and PRC.12.3.2.1. Foam equipment and supplies may also be supplied from responding fire departments and mutual aid. Arrange for additional foam supplies within a 1 h delivery time.

Motorized Apparatus

Use motorized foam/water pumper apparatus to provide foam production and storage capability in facilities. Provide sufficient staff to operate the apparatus. For small terminals, responding fire departments, mutual aid organizations or both can supply fire fighting equipment and manpower.

Fixed Water Spray Systems

Install fixed water spray systems on all horizontal or vertical pressure storage vessels. Install water spray or deluge systems on all storage spheres. Water-weir systems are acceptable.

Provide tanks exposed by other tanks or process equipment with waterspray systems to protect the exposed segments of the tank shell. Provide similar protection for very large oil storage tanks. See PRC.12.2.1.2 for details.

Provide deluge systems for loading and unloading stations. See PRC.9.2.1.1 for details.

Instrumentation

Provide high-level alarms and high high-level filling shutdown devices on all tanks. Provide high-temperature and low-liquid-level alarms on tanks with heating coils. Alarms are to sound in a constantly attended location. In addition, provide high-pressure alarms on pressure storage tanks.

Electrical Equipment

Install electrical equipment and wiring in accordance with NFPA 70.

DISCUSSION

The recommendations in this PRC Guideline do not contain detailed protection design criteria. Guidance in developing specifics may be found in the following publications:

- American Institute of Chemical Engineers: Center for Chemical Process Safety, various publications.
- American Institute of Chemical Engineers: “Loss Prevention,” various volumes.
- American Institute of Chemical Engineers: “Safety in Air and Ammonia Plants,” various volumes.
- American National Standards Institute: Standards (such as ANSI B31.3-1987, “Chemical Plant and Petroleum Refinery Piping”).
- American Petroleum Institute: various publications.
- American Society of Mechanical Engineers: Standards (such as “Boiler and Pressure Vessels Code”).
- European Federation of Chemical Engineering: “Loss Prevention and Safety Promotion in the Process Industries,” various symposia.
- AXA XL Risk Consulting: “PRC Guidelines,” various sections.
- National Fire Codes.

- Vervalin, Charles H., “Fire Protection Manual for Hydrocarbon Processing Plants,” Volumes 1 and 2, Gulf Publishing Co.