Chapter 19

SAFETY AND FIRE PROTECTION

This Chapter contains general guidance on safety management at terminals and specific recommendations on the design and operation of fire detection and protection systems.

The guidance on fire-fighting equipment in this Chapter should be considered in conjunction with Chapter 5, which addresses fire-fighting theory.

19.1 Safety

19.1.1 Design Considerations

The layout and facilities at a terminal will be determined by many factors, including:

- Local topography and water depth.
- Access to the berth(s) - open sea, river, channel or inlet.
- Types of cargo to be handled.
- Quantities of cargo to be handled.
- Local facilities and infrastructure.
- Local environmental conditions and restrictions.
- Current and tide.
- Local and international regulations (e.g. escape routes, emergency stops).

Most of the decisions regarding layout of facilities will have been decided at the initial planning and design stage for the terminal. However, many terminals have developed over time and may be required to handle a greater variety of products, larger quantities of cargoes and larger tankers than were anticipated when the terminal was originally designed. Terminals may also be subjected to reduced throughputs or changing environmental conditions, new standards and/or legislation.

All terminals should be subjected to regular review to ensure that the facilities provided remain fit for purpose in the context of the operations being undertaken and current legislation. Such reviews should cover elements listed in the following sections, which will enable the terminal to maintain continuously the necessary level of safety.

19.1.2 Safety Management

Every terminal should have a comprehensive safety programme designed to deliver an appropriate level of safety performance. The safety programme should ensure that the following topics are addressed:

- Emergency management.
- Casualty response and casualty evacuation.
- Periodic fire and oil spill drills. These drills should address all aspects and locations of potential incidents and should include tankers at a berth.
- Feedback from emergency drills and exercise.
- Hazard identification and risk assessment.
- Permit to Work systems.
- Incident reporting, investigation and follow-up.
- Near miss reporting, investigation and follow-up.
- Site safety inspections.
- Safe work practices and standards of housekeeping.
- Personal Protective Equipment. The equipment provided and requirements for its use should include associated third parties - tug and mooring boat crews, mooring gangs or cargo surveyors for example.
- Safety meetings across the terminal's manning structure encompassing all personnel.
- Work team safety briefings.
- Pre-task safety discussions.
- Safety management of visitors, contractors and tanker's crew.
- On site training and familiarisation.

19.1.3 Permit to Work Systems - General Considerations

Permit to Work systems are widely used throughout the industry. The permit is essentially a document which describes the work to be done and the precautions to be taken in doing it, and which sets out all the necessary safety procedures and equipment. (Permit to Work systems are fully described in Section 9.3.)

For operations in hazardous and dangerous areas, permits should normally be used for tasks such as:

- Hot Work.
- Work with a spark potential.
- Work on electrical equipment.
- Diving operations.
- Heavy lifts.
- Entry into enclosed spaces (see Chapter 10).
- Work at heights and near waterfront.
- Opening of tank and line systems.

The permit should specify clearly the particular item of equipment or area involved, the extent of work permitted, the conditions to be met and the precautions to be taken and the time and duration of validity. The latter should not normally exceed a working day. At least two copies of the permit should be made, one for the issuer and one for the person at the work site.

The layout of the permit should include a check-list to provide both the issuer and the user with a methodical procedure to check that it is safe for work to begin and to stipulate all the necessary conditions. If any of the conditions cannot be met, the permit should not be issued until remedial measures have been taken.

It is advisable to have distinctive Permit to Work systems for different hazards. The number of permits required will vary with the complexity of the planned activity. Care must be taken not to issue a permit for subsequent work that negates the safety conditions of an earlier permit. For example, a permit should not be issued to break a flange adjacent to an area where a Hot Work permit is in force.

Before issuing a permit and during its validity, the Terminal Representative must be satisfied that the conditions at the site, or of the equipment to be worked on, are safe for the work to be performed, taking due account of the presence of any tankers that will be alongside while the work is being carried out.

19.2 Terminal Fire Protection

19.2.1 General

Fire safety at terminals is provided through overlapping levels of protection as follows:

- Prevention and isolation.
- Detection and alarm facilities.
- Protection equipment.
- Emergency and escape routes.
- Emergency planning.
- Evacuation procedures.

Fire safety at terminals requires an appropriate balance between good design features, safe operational procedures and good emergency planning.

Fire protection alone will not provide an acceptable level of safety. Fire protection measures should not interfere with mooring or other operations.

Fire protection measures are not effective in limiting the frequency and size of spills or in minimising sources of ignition.

Automatic detection of fire, and the subsequent rapid response of emergency personnel and fire protection equipment, will limit the spread of fire and the hazard to life and property at unmanned locations or at locations with limited numbers of personnel.

Fire protection facilities should be designed to contain and control fires that may occur in defined areas and to provide time for emergency exit.

Emergency exit facilities are needed to ensure the safe evacuation of all personnel from the affected area in the event that fire protection facilities do not successfully control a fire.

19.2.2 Fire Prevention and Isolation

Safety at terminals begins with fire prevention features inherently designed into the overall facility. Terminal fire-fighting equipment is usually dispersed around the site and much of it is exposed to the weather. To ensure that it is fit for use, it is essential that all fire-fighting equipment is regularly inspected, maintained in a constant state of readiness and tested periodically to ensure reliable operation. Terminals should ensure that all fire-fighting equipment is maintained under the control of a planned maintenance system. Careful design of a terminal is no guarantee that a safe operation will be achieved. The training and competence of personnel are of critical importance. Periodic simulated emergency drills, both announced and unannounced, are recommended to ensure operability of the equipment, operator proficiency in the use of equipment and familiarity with emergency procedures.

19.2.3 Fire Detection and Alarm Systems

The selection and fitting of fire detection and alarm systems at a terminal is dependent upon the risk exposure presented by the product being handled, tanker sizes and terminal throughput. This topic is discussed in more detail in Section 19.4.1.

The location of all detectors should take into account natural and mechanical ventilation effects, since heat is carried and stratified by convection currents. Other considerations, such as the ability of flame detectors to ‘see’ flames, should be taken into account. The advice of manufacturers and fire and safety experts should be sought, along with a compliance check against local regulations, before installation.

In general terms, automatic detection and alarm systems have the purposes of alerting personnel and initiating a system to respond with the aim of reducing loss of life and property due to fires or other hazardous conditions. These systems may have one or more circuits to which automatic fire detectors, manual activation points, water flow alarm devices, combustible gas detectors and other initiating devices are connected. They may also be equipped with one or more indicating device circuits to which alarm indicating signals, such as control panel indicator and warning lamps, outdoor flashing lights, bells and horns are connected.

19.2.4 Automatic Detection Systems

Automatic detection systems consist of mechanical, electrical or electronic devices that detect environmental changes created by fire or by the presence of toxic or combustible gases. Fire detectors operate on one of three principles, sensitivity to heat, reaction to smoke or gaseous products of combustion, or sensitivity to flame radiation.

Heat Sensing Fire Detectors fall into two general categories, fixed temperature devices and rate-of-rise devices. Some devices combine both principles (rate-compensated detectors). Generally, heat detectors are best suited for fire detection in confined spaces subject to rapid and high heat generation, directly over hazards where hot flaming fires are expected, or where speed of detection is not the prime consideration.

Smoke Sensing Fire Detectors are designed to sense smoke produced by combustion and operate on various principles, including ionisation of smoke particles, photo-electric light obscuration or light scattering, electrical resistance changes in an air chamber and optical scanning of a cloud chamber.

Gas (Product of Combustion) Sensing Fire Detectors are designed to sense and respond to one or more of the gases produced during the combustion of burning substances. These detectors are seldom a preferred option as fire tests have shown that detectable levels of gases are reached after detectable smoke levels.

Flame Sensing Fire Detectors are optical detection devices that respond to optical radiant energy emitted by fire. Flame detectors responsive to infra-red or ultraviolet radiation are available, but ultraviolet sensitive detectors are generally preferred.

19.2.5 Selection of Fire Detectors

When planning a fire detection system, detectors should be selected based on the types of fires that they are protecting against. The type and quantity of fuel, possible ignition sources, ranges of ambient conditions, and the value of the protected property should all be considered.

In general, heat detectors have the lowest cost and lowest false alarm rate, but are the slowest to respond. Since the heat generated by small fires tends to dissipate fairly rapidly, heat detectors are best used to protect confined spaces, or located directly over hazards where flaming fire could be expected. To avoid false alarms, the actuation temperature of a heat detector should be at least 13°C above the maximum expected ambient temperature in the area protected.

Smoke detectors respond faster to fires than heat detectors. Smoke detectors are best suited to protect confined spaces and should be installed either according to prevailing air current conditions or on a grid layout.

Photoelectric smoke detectors are best used in places where smouldering fires, or fires involving low temperature pyrolysis, may be expected. Ionisation smoke detectors are useful where flaming fires would be expected.

Flame detectors offer extremely fast response, but will warn of any source of radiation in their sensitivity range. False alarm rates can be high if this kind of detector is improperly used. Their sensitivity is a function of flame size and distance from the detector. They can be used to protect areas where explosive or flammable vapours are encountered because they are usually available in explosion-proof housings.

19.2.6 Location and Spacing of Fire Detectors

Fire detection at terminals is usually provided at remote, unmanned, high risk facilities, such as pumping stations, control rooms, and electrical switch gear rooms. Detectors may also be fitted at valve manifolds, loading arms, operator sheds and other equipment or areas susceptible to hydrocarbon leaks and spills, or that contain ignition sources.

To function effectively, fire detection devices must be properly positioned. Detailed requirements for spacing can be found in appropriate fire codes.

Heat, smoke and fire gas detectors should be installed in a grid pattern at their recommended spacing, or at reduced spacing for faster response. Each system should be engineered for the specific area being protected, with due consideration given to ventilation characteristics.

Detection systems for actuation of fire extinguishing systems should be arranged using a cross-zone array. In a cross-zone array, no two adjacent ionisation type detectors should be in the same detection circuit zone. The first detector actuated should activate the fire alarm system, while the actuation of a detector on an adjacent circuit should activate the fire extinguishing system.

19.2.7 Fixed Combustible and Toxic Gas Detectors

These gas detectors are designed to sense the presence of combustible or toxic gases to provide an early warning. They are used to provide continuous monitoring of potentially hazardous areas to safeguard against fire or explosion and for personnel protection from toxic gas leaks.

The operating principles of combustible and toxic gas detectors are similar to those for the product of combustion-gas sensing fire detectors. See also Sections 2.3 (Toxicity) and 2.4 (Gas Measurement).

Terminals that handle crude oil or products containing toxic components should consider installing fixed gas detection and alarm equipment in areas where personnel may be exposed. Consideration should be given to placing sensors in locations where leaks or spills could occur, for example loading arms, valve manifolds and transfer pumps, or where gas could accumulate due to inadequate ventilation. Toxic gas detectors may also be installed in the supply air intakes of pressurised control rooms and inside non-pressurised control rooms.

19.2.8 Locating Fixed Combustible and Toxic Gas Detectors

General considerations in positioning combustible and toxic gas detectors include the following:

- Elevations depending on relative density of air and any potential gas leakage.
- Possible flow direction of leaking gas.
- Proximity to potential hazards.
- Accessibility of detectors for calibration and maintenance.
- Sources of damage, such as water and vibration.
- Manufacturer’s recommendations for sensors connected to analysers.

19.2.9 Fixed Combustible and Toxic Gas Analysers

Continuous analysers are typically permanently installed, electrically operated devices for the continuous analysis of air samples for detecting combustible and toxic gases, often using multiple sensors.

The analysers may be of the remote detection type in which individual diffusion sensors are connected to the analysers by electrical cable. In this case, the central equipment is available either for installation in non-hazardous locations, such as pressurised control rooms, or in explosion-proof enclosures for location in hazardous areas.

The remote detection type, which uses remote diffusion detectors, provides rapid response and good reliability, making this the preferred design.

Alternatively, continuous analysers may also utilise a central detection unit in which samples are drawn from hazardous areas through tubing to the central location by means of a suction pump. Central diffusion detection units, utilising sample lines, are characterised by a relatively slow response time. Additionally, particulates must be taken into account and the lines must be heated to prevent condensation. Consequently, central detection units are not generally recommended.

Gas analysers should usually be provided with the following features and readout and alarm functions, in addition to continuous recording of data:

a) Channels for connection to individual diffusion detection sensors so that each sampling circuit can analyse samples continuously. Thus, when an alarm condition occurs, the analyser will home on the sensor registering the alarm and the alarm will remain actuated until manually reset.

b) The combustible gas analyser is calibrated in percentage of Lower Explosive Limit (LEL) and should be provided with a channel selector, indicator lamps to show the samples being analysed, and a meter. Visual and audible alarms should be provided for two levels of detection. The minimum level most frequently used is 20% LEL. The second or upper level of detection is usually 60% LEL. Silencing of the audible alarm should not extinguish the visual alarm until gas detection falls below the alarm level. Contacts are provided at the two levels of detection to permit automatic operation of a purging or fire prevention system.

c) Alarm levels should be adjustable and alarms may be actuated by contact meters, recorder limit switches, solid-state signal level detectors, or optical meter relays. Multi-level alarms can be provided with means to actuate ventilation equipment, to effect transfer pump shutdown, or to actuate fire extinguishing systems.

d) A means to disconnect the detectors safely from the actuating circuit. The disconnection capability is necessary for proper routine calibration and maintenance activities. A key-operated switch with supervisory alarm is recommended.

e) On complicated or extensive systems, the indication of alarms on a graphic display, such as an outline plan of a facility, is recommended.

f) Toxic gas analysers should be set to sound alarms at the monitored location and in the control room when the gas reaches the predetermined level, for example when an H_2S concentration reaches 5 ppm. Alarms should generally be both audible and visual.

g) The gas detector head assembly should be suitable for the electrical classification of the hazardous area and, if installed outdoors, should be weatherproof and corrosion resistant.

h) The detecting unit included in the head should provide adequate sensitivity and the necessary stability, under all conditions, to repeat any reading within ± 2% of the full scale range.

19.2.10 Fire Extinguishing System Compatibility

Where a detection system is part of an automatic fixed fire extinguishing system, complete compatibility between the systems is essential. Detection devices and systems that are highly susceptible to false alarms should be avoided, especially when they are connected to fixed fire extinguishing systems for automatic activation (see Section 19.3.5).

19.3 Alarm and Signalling Systems

An alarm and signalling system must perform four significant functions. It should:

- Rapidly transmit an alarm or signal to indicate the detection of fire before there is significant damage.
- Initiate a sequence of events to evacuate personnel in the vicinity of fire.
- Transmit an alarm or signal to notify responsible parties or initiate an automatic extinguishing system.
- Have the capability to automatically self-test and warn of malfunction.

19.3.1 Types of Alarm Systems

Alarm systems are used to indicate an emergency and to summon assistance.

There are many different types ranging from a local system providing an alert signal at the protected facility, to one which alerts at a remote station attended by trained personnel 24 hours per day, such as a fire or police station or a third party answering service.

The type of system installed at a particular location should be based on a thorough risk assessment with input from competent personnel in the field of fire protection, taking due account of any applicable local regulations.

19.3.2 Types of Signal

Fire alarm systems provide several distinct types of signal which can be audible, visual or both. They range from relatively simple trouble signals, such as alarms for power interruptions, through supervisory signals, such as when critical equipment is in an abnormal condition, to either coded or non-coded alarm signals sounded when a fire alarm is activated either continuously or in the form of a prescribed pattern.

19.3.3 Alarm and Signalling System Design

Any variation or combination of the types of alarm and signalling systems previously described can be used to meet local circumstances.

In a large terminal facility, or where the terminal is an integral part of a large plant or processing facility, a coded signal system is usually preferred. The facility should be divided into a grid system, with each area of the grid identified by a numbered code. The coded signal system should include a code transmitter that triggers an alert at the specific location and also activates the general alarm.

Emergency reporting can also be achieved by using a dedicated emergency telephone system. Additionally, manual fire alarm stations can be installed instead of, or to supplement, the telephone reporting system.

When a dedicated telephone system is used, a special telephone should be installed in the control room or supervisory station to receive emergency calls. The telephone should be capable of receiving incoming calls only and extensions should also be provided at other locations which have preliminary emergency responsibility.

The general alarm system should, as a minimum, consist of one or more air horns, electric horns or steam whistles which are strategically located to ensure maximum coverage throughout the terminal. The alarm should be clear, audible and distinctive from signals used for other purposes, and should be capable of being heard in all areas of the terminal regardless of background noise.

Auxiliary alarm devices should be provided for indoor locations or remote areas where the general alarm cannot be heard. These alarms may be bells, or air or electric horns. Whichever devices are provided, they should be the same throughout the facility and should be distinct from other warning devices.

19.3.4 Alternative Alarm and Signalling System Design

Although a coded alarm system is generally preferable for large terminals, a non-coded, announcement type system can be used. Either system can consist of telephones or manual fire alarm stations at strategic locations. Coded manual fire alarm stations can be connected to the general alarm to sound a coded signal without manual intervention. Non-coded stations can be arranged to show fire location on a fire alarm indicator in the central control room or supervisory station so that the attendant can energise the code transmitter. Both the coded or non-coded announcement type systems should be controlled from a central fire alarm control panel.

19.3.5 Interface Between Detection Systems and Alarm or Fire Extinguishing Systems - Circuit Design

Actuation relays, where required between detectors and alarm or extinguishing systems, should consist of closed loops that are normally de-energised, and that require an input of sufficient electrical energy to activate the alarm or extinguishing system. This arrangement will prevent a false activation of an alarm or extinguishing system upon loss of power. It also allows for provision of a separate fault signal upon power loss.

19.3.6 Electric Power Sources

Electric power should be available from two highly reliable sources. The usual arrangement is an alternating current (AC) primary power supply, with a trickle charger supplying an emergency battery system for standby power. In some locations, authorities may require an engine driven generator as a secondary power supply in case the primary supply fails.

The capacity of secondary power supplies varies with the type of alarm system and the requirements of local regulatory authorities. For local or proprietary alarm systems where signals are registered only at the terminal or plant central control room or central supervisory centre, battery size usually provides for loss of primary power for a minimum period of 8 hours and for at least 12 hours if the supply is not reasonably reliable.

In auxiliary and remote station systems where trouble signals from the loss of local operating power might not be transmitted to the receiving station, a 60 hour emergency power supply capacity is usually required in order that the emergency supply can operate the entire system if the power is cut over a weekend.

19.4 Detection and Alarm Systems at Terminals Handling Crude Oil, Petroleum and Chemical Products

19.4.1 General

The specification for the detection and alarm systems on terminals transferring crude oil and flammable liquids will depend on a number of factors that include the following:

- The commodities or products transferred.
- Tanker size and number berthed per year.
- Pumping rates.
- The proximity of hazardous equipment with respect to other equipment or hazards, i.e. equipment spacing, electrical area classification.
- The proximity of tankers to the terminal and to hazardous terminal equipment.
- The proximity of the terminal to residential, commercial or other industrial properties.
- The installation of emergency isolation valves.
- The number and nature of fixed fire extinguishing systems that are connected to detection and alarm systems.
- Whether the terminal is continuously manned or periodically unmanned.
- The ability of the emergency response unit at the terminal or within the terminal's organisation to provide a timely and effective response.
- Proximity to any outside emergency response units, and their capacity, availability and time of response.
- Requirements imposed by local regulatory bodies.
- The desired degree of protection beyond regulatory requirements.
- The degree of effective protection that a particular manufacturer's detection and alarm system offers.

The alarm system should have the capability to raise local audible and visual alarms and possibly a general alarm if the terminal is manned and depending upon local circumstances. It should indicate an alarm at a continuously attended central fire control panel showing the location of the activated detection and fire extinguishing system. Where fixed gas detection equipment is installed or the detection system covers more than a single detection zone, the panel should indicate the location of the activated gas detector.

Use of fire detection equipment that is designed to activate fixed fire-fighting equipment automatically may be advisable where a terminal extends away from shore in such a way that manual fire-fighting is difficult, dangerous or ineffective. This may also be advisable where fire-fighting boats are not available and accessibility with fire-fighting vehicles is poor, or at locations where trained fire-fighting personnel are limited in number and/or not always available for rapid response.

In most cases, a manually operated fire protection system is to be preferred. Upon actuation of a detector, the detection system should sound a local alarm and send a signal to a continuously attended control panel. If conditions warrant, the fire protection system may be manually activated by an operator, the fire brigade, or by personnel who monitor the alarm.

Equipment and terminal areas that are sometimes monitored with automatic fire or gas detection systems include transfer pumps, valve manifolds, loading arm areas, control rooms, electrical switch gear enclosures, operator's sheds, below deck areas, and other equipment or areas susceptible to hydrocarbon leaks and spills or that contain ignition sources.

19.4.2 Control Rooms/Control Buildings

When determining necessary detection and alarm equipment for control rooms, the first consideration should always be the requirements of local regulations. Once these have been met, the installation of additional gas and fire detection devices with associated alarm equipment depends on site specific factors such as control room pressurisation and attendance.

The following general detection and alarm facilities are suggested for all control rooms or buildings:

- Manual fire alarm stations should be provided at all exits. The operation of a manual fire station should sound a local alarm and should activate an alarm at the main fire control panel, if provided.
- A fire detection system should be installed in any area of a control building that is normally unattended. Each detector should raise a local alarm in the areas of the control room that are normally occupied and should activate an alarm at the main fire control panel located in a continuously attended area.
- Combustible gas detectors should be installed in the supply air intake vents of pressurised control rooms and inside non-pressurised control rooms. Each gas detector should sound a local alarm and should annunciate an alarm at a main fire control panel located in a continuously attended area.

Control rooms that are not continuously attended may sometimes be equipped with additional facilities. If the terminal handles volatile liquids, a fixed fire extinguishing system, activated automatically upon detection of combustible gas or fire, may be installed. The gas or fire detection system should then be arranged in a cross-zone array (see Section 19.2.6).

19.5 Fire-Fighting Equipment

Fire-fighting systems are required to protect potentially exposed equipment in order to avoid fire escalation and to minimise fire damage. Ideally, most fires should be controlled and extinguished by first isolating the source of the fuel and, if necessary and feasible, by extinguishing the fire with appropriate agents.

Where terminals have land connections with refineries or related installations, the fire-fighting system on the terminal is usually an integral part of the fire-fighting scheme for the whole of the complex.

Fixed fire-fighting systems should be capable of full operation by the personnel locally available within the first 5 minutes of the outbreak of a fire.

19.5.1 Terminal Fire-Fighting Equipment

In ports with many terminals or in congested industrial locations, the local authority or port authority may provide the main fire-fighting capability. The type and quantity of fire-fighting equipment should be related to the terminal size and location, the frequency of terminal use, and the additional factors identified in Section 19.1. Other relevant factors include the existence of reciprocal arrangements and the physical layout of the terminal.

Because of these many variables, it is impractical to make specific recommendations concerning fire-fighting equipment. Each terminal should be studied individually when deciding upon the type, location and use of the equipment.

In addition to national regulatory requirements, capability should be based on the general guidance contained within this Chapter and the outputs of a formal risk assessment. The risk assessment should take into account the following criteria for each berth:

- The sizes of tankers that can be accommodated on the berth.
- Location of the terminal and the berth.
- Nature of the cargoes handled.
- Potential impact of oil spillage.
- Areas to be protected.
- Regional fire response capability.
- Level of training and experience of local emergency response organisations.

19.5.2 Portable and Wheeled Fire Extinguishers and Monitors

Portable and wheeled fire extinguishers should be provided at every terminal berth on a scale relative to the size, location and frequency of use of the berth (see Table 19.1).

Portable fire extinguishers should be located so that a fire extinguisher can be reached without travelling more than 15 metres. Wheeled extinguishers should normally be located in accessible positions at each end of loading arm gantries or at the berth approach access point.

Fire extinguisher locations should be permanent and conspicuously identified by luminous background paint or suitably coloured protective boxes or cabinets. The top or lifting handle of a fire extinguisher should normally not be at a height of more than one metre.

Dry chemical extinguishers are recognised as the most appropriate type of extinguisher for the quick knock-down of small hydrocarbon fires.

Carbon dioxide extinguishers have little value at berths or on jetties, except at points where minor electrical fires could occur. However, enclosed electrical sub-stations or switch rooms located within terminals should be equipped with an adequate number of carbon dioxide extinguishers or should have a fixed carbon dioxide system installed.

Foam extinguishers with a capacity in the order of 100 litres of pre-mix foam solution are suitable for use at berths. They are capable of producing approximately 1,000 litres of foam and provide a typical jet length of about 12 metres.

Small foam extinguishers with capacities of about 10 litres are, in most cases, too limited to be effective in the event of a fire at a terminal.

Where portable foam/water monitors are recommended in Table 19.1, they may be either portable or wheeled, but should have a discharge capacity of at least 115 m^3/h of foam and water in solution.

At least two portable foam/water monitors should be provided for each wharf or jetty, together with adequate lengths of foam induction hose and fire hose to facilitate deployment at their maximum range.

19.5.3 Terminal Fixed Fire-Fighting Equipment

19.5.3.1 Fire Water Supply

Fire water at terminals is often provided by the unlimited supply available from the river, canal or dock basin.

Where the fire water supply is obtained from static storage, such as a tank or reservoir, then the reserve for fire-fighting purposes should be equivalent to at least 4 hours continuous use at the maximum design capacity of the fire-fighting system. The reserve for fire-fighting would normally be additional to that required by any other user taking water from the same static storage. The piping arrangements at such storage facilities should be arranged to prevent use of the fire-fighting reserve for other purposes and the integrity of the make-up water supply to such a reserve would need to be assured.

Fire water flow rates and pressures should be sufficient to cover both extinguishing and cooling water requirements for a fire that might realistically occur. For typical flow rates, reference should be made to Table 19.1.

19.5.3.2 Fire Pumps

Where practical, permanently installed fire pumps should be provided on a scale which will ensure adequate reserve capacity to allow for contingencies, such as fire pump maintenance, repairs or breakdowns during emergencies.

Electric motor, diesel engine and steam turbine driven pumps are acceptable. However, the choice of steam turbine and electric drivers should take into account the reliability of the steam and power supplies at a particular installation. Typically, a combination of diesel and electric driven pumps is preferred.

When the fire pumps are to be located on a wharf or jetty, a safe and protected location is essential in order to ensure that the fire pumps will not become immobilised during a fire at the terminal, or do not in themselves present a potential ignition source. When selecting a location for the fire pumps, consideration should be given to the loading gantry and the nearest moored tanker or barge.

Where practical, fire pump installations should be protected from a water surface fire penetrating the underside or below deck area of the installation. Protection may be achieved by structural barriers, booms or water spray systems. In this context, the fire pump should be installed on a solid deck. Whenever electric motor driven pumps are installed, the careful routeing and fire protection of power cables should be considered.

Installation	Minimum provisions
1. Tanker berth or wharf or jetty handling flammable liquids including materials in drums, and any product heated above its flashpoint.	Fire-main incorporating isolating valves and fire hydrants with a fire water supply of 100 m^3/h and / or guaranteed intervention by the local fire brigade. Fire-fighting equipment consisting of hand-held and wheeled fire extinguishers; fire hose; Portable equipment: - 2 x 9 kg portable dry chemical extinguishers - 2 x 50 kg wheeled dry chemical extinguishers
2. Tanker berth or wharf or jetty handling liquids with a flashpoint at or below 60ºC including materials in drums, and any product heated above its flashpoint. Tanker berth at a wharf or jetty handling tankers of less than 20,000 tonnes deadweight and less than one tanker per week.	Fire-main incorporating isolating valves and fire hydrants with a fire water supply of 100 m^3/h. Fire-fighting equipment consisting of: hand-held and wheeled fire extinguishers; fire hose; foam branch pipes; and portable or wheeled foam/water monitors designed for a minimum solution rate of 115 m^3/h. Static or trailer borne 3 m^3 bulk supply of foam concentrate. Portable equipment: - 2 x 9 kg portable dry chemical extinguishers - 2 x 50 kg wheeled dry chemical extinguishers
3. Tanker berth at a wharf or jetty handling more than one tanker per week of less than 20,000 tonnes deadweight.	Fire-main incorporating isolating valves and fire hydrants with a water supply of 350 m^3/h. Portable and wheeled fire-fighting equipment. Fixed foam/water monitors and appropriate bulk concentrate supplies. Jetty support structure protection (optional). Portable equipment: - 4 x 9 kg portable dry chemical extinguishers - 2 x 75 kg wheeled dry chemical extinguishers

Table 19.1 - Fire protection guidelines for terminals handling crude oil and petroleum products (excluding liquefied hydrocarbon gases)

19.5.3.3 Fire-Main Piping

Permanent fire water mains and/or foam-water solution mains should be installed in terminals and along the approach routes to berths. Mains should extend as near to the head of the terminal as possible and be provided with a number of accessible water take-off (hydrant) points.

The hydrant points generally consist of headers with individually valved outlets fitted with a fire hose connection suitable for the particular type of fire hose coupling in use locally. Isolating valves should be fitted so as to prevent the loss of all fire-fighting systems due to a single fracture or blockage of the fire-main network. The isolating valves should be positioned so that, in the event of fire-main failure in the berth area, there will still be a supply at the berth approach. Where the berth fire-main is extended from a shore installation, an isolating valve(s) should be provided at the shore side end of the wharf or jetty. Additional fire hydrants should then be provided upstream of an isolating valve.

Fire-main construction materials should be compatible with the water supply.

The minimum capacities and pressures for fire water mains are dependent upon whether the system is to be used for cooling or for the production of foam, and upon the length of jet required.

Where freezing conditions are encountered, fire-mains which are not maintained in the dry mode should be protected from freezing. In particular, where the fire water supply is obtained from an on-shore grid, any wet section of the grid should be buried below the frost line or otherwise protected from freezing. Buried fire-mains need to be suitably coated and wrapped to prevent corrosion. Cathodic protection might also be necessary

Drain valves should be conveniently and suitably located on the fire-mains, and flushing points should be provided at the extremities of the fire-main grid.

19.5.3.4 Fire Hydrants

The location and spacing of hydrants at terminals will generally be determined by the character of the facilities to be protected. At the berth or loading arm areas, it will often be difficult to achieve uniform spacing of fire hydrants, whereas on approach or access routes, uniform spacing can usually be achieved. For guidance purposes, hydrants should be spaced at intervals of not more than 45 metres in the berth or loading arm areas and not more than 90 metres along the approach or access routes.

Hose connections should be of a design compatible with those of the local or national fire authorities.

Hydrants should be readily accessible from roadways or approach routes and located or protected in such a way that they will not be prone to physical damage.

19.5.3.5 International Shore Fire Connection

The fire water system of marine terminals and berths that handle international tankers should have at least one International Shore Fire Connection, complete with nuts and bolts, through which water could be supplied to a tanker's fire-main if required for shipboard fire-fighting (see Section 26.5.3 and Figure 26.2).

The connection should be kept protected from the elements and located so as to be immediately available for use. The location and purpose of this connection should be made known to all appropriate staff and discussed during the joint completion of the Safety Check-List. One 63 mm hose connection should be provided for every 57 m^3/h of required pumping capacity.

19.5.3.6 Pump-In Points for Fire-Fighting Boats

If tugs or fire-fighting boats are available, they may be equipped to pump fire-fighting water into the terminal's fire-main system.

Pump-in points should be provided at suitable, accessible locations near the extremities of the fire-mains and preferably where fire-fighting boats/tugs can be securely moored. In an extreme emergency, a fire-fighting boat/tug can then be used to augment the fire water supply to the shore fire-main grid.

The hose inlets should have screw down valves and/or be fitted with non-return valves and be installed so as to minimise the possibility of hose kinking.

The location of these inlets should be distinctively highlighted.

19.5.3.7 Foam Systems

Foam concentrate should be properly proportioned and mixed with water at some point downstream of fire water pumps, and upstream of foam making equipment and application nozzles.

Fixed pipelines for expanded (aerated) foam are not recommended because the fully developed foam cannot be projected effectively due to loss of kinetic energy and high frictional losses through such systems.

The type of foam concentrate selected, i.e. protein, fluoro-protein, Aqueous Film Forming Foam (AFFF), or alcohol/polar solvent resistant type concentrate (hydrocarbon surfactant type concentrate), will depend upon the fuel type and formulation, whether aspirating or non-aspirating equipment is installed and ease of re-supply.

There are several systems that can be adopted for feeding foam concentrate into foam making equipment at the berths. Some of the principal systems are briefly described.

Direct Foam Pick-Up from Atmospheric Tanks

This method incorporates direct foam induction via a flexible pick-up tube connecting a monitor to an adjacent foam storage tank at atmospheric pressure, a tank truck, portable trailer or drum. One storage tank may be used to supply more than one fixed monitor. Such monitors would be positioned near ground or deck level.

Displacement Proportioner Foam Unit Utilising Pressure Vessels

This unit may comprise foam concentrate in one large pressure vessel, possibly of 4.5 cubic metres capacity, or two smaller pressure vessels of 2.3 cubic metres. The foam proportioner unit is positioned between the fire pumps and the downstream foam making equipment. The system functions by utilising by-passed fire-main water to pressurise the storage vessel and displace the foam concentrate from the storage vessel into a foam-main.

Sufficient hydrants should be provided on the foam-main from which portable foam making equipment, including monitors, can be operated.

Dedicated ‘Foam Concentrate’ Pipeline System Using Atmospheric Foam Tanks

This system comprises three main components:

1) Foam concentrate bulk storage in tanks or other vessels.
2) Foam pumps for delivering the foam concentrate into the foam pipeline grid. The pumps may be electric motor or water turbine driven using a bypass from the fire-main.
3) Pipeline grid, possibly of 75 mm diameter, traversing the berth approach and the berth, providing numerous take-off points for the attachment of foam induction hose for connecting portable or fixed equipment.

Where pipelines for foam solution or concentrate are provided, the lines should have a number of accessible take-off (hydrant) points which should be spaced not more than two or three standard hose lengths apart. Isolating valves should be fitted so as to retain the utility of the line in the event of fracture. Suitable pipeline drain valves and wash out facilities should be provided. A foam solution pipeline of this type should be designed for a minimum solution rate of 115 cubic metres/hour.

Foam concentrate can also be distributed through a smaller bore pipe system to the tanks supplying the inductors of fixed or mobile foam making appliances.

Variable Flow Injection Incorporating Atmospheric Foam Tank and Foam Pump(s)

This system involves pumping foam concentrate into a foam-main via a metering device or variable flow injector. The foam pump(s) would normally be driven by an electric motor and would take suction from an atmospheric foam tank.

The bulk foam concentrate supplies associated with any fixed foam monitor or foam-water sprinkler system should be sufficient to ensure continuous foam application until the arrival of adequate backup fire-fighting resources, either water-borne or land based. In any case, the bulk foam concentrate supply should be sufficient to ensure not less than 30 minutes of continuous foam application at design flow conditions.

19.5.3.8 Monitors (or Cannons)

Monitors may be used for foam and water, although specific types may be designed solely for foam. Large capacity monitors would normally be on a fixed mounting or on a mobile unit.

Monitors may be situated at berth or wharf deck level (normally only suitable at small terminals) or may be mounted on fixed towers.

Typically, monitors will provide a jet length of 30 metres and a jet height of 15 metres in still air.

Monitors may be manually controlled or remotely controlled either from the tower base or at a distance. Tower base controls may need special protection. Remote control can be achieved by electronic means, hydraulically or with a mechanical linkage. The remote control point for elevated monitors should be sited in a safe location. However, the selection of a safe location will depend upon the character and size of the berth involved. Where practicable, the monitor control point should be at least 15 metres from the probable location of fire.

The water monitors should be mounted at berth or wharf deck level and be fitted with variable nozzles capable of discharging either a spray or a jet. They should be located so as to be capable of cooling the berth structure, as well as the adjacent hull of a tanker. In some cases, it may be necessary to provide elevated water monitors in place of, or additional to, deck mounted monitors to allow water discharge above maximum freeboard height.

19.5.3.9 Below Deck Fixed Protection Systems

Below deck fixed protection systems have been installed when the terminal extends over water and away from shore in such a way that fire-fighting would be difficult or dangerous, or when fire-fighting boats are not available. In these situations, this type of system may be required in order to provide a safe base for operations during a tanker fire and is especially useful where large spill fires on the water beneath the berth are a possibility.

When fire-fighting boats are available to provide a quick response, a fixed water spray system may be installed below deck for cooling non-fire resistant, unprotected supports and exposed structure, in the event of a local fire on the surface of the water. The rate of discharge for such a system should be based upon a risk assessment taking into consideration issues that include the type of operations and the jetty lay-out.

When fire-fighting boats are not available or cannot provide a quick response to a fire, a fixed system of foam/water sprinklers may be installed below deck for cooling and protecting the supporting structure that is constructed of non-fire resistant, unprotected materials. Under these circumstances, such a system would provide rapid below deck fire control and extinguishment. The rate of discharge for such a system should be based upon a risk assessment taking into consideration issues that include the type of operations and the jetty lay-out. When supporting piles and beams are constructed with fire resistant materials, for example concrete, a fixed system of foam/water sprinklers discharging at reduced application rates may be acceptable, following risk assessment.

19.6 Water-Borne Fire-Fighting Equipment

Water-borne fire-fighting equipment, normally in the form of fire-fighting boats or fire tugs, can be highly effective, particularly when there is the scope to manoeuvre upwind of a fire.

In locations where fire-fighting boats are well equipped, continuously available and able to be in attendance very quickly from time of call, for example within 15-20 minutes, then the scale of fire-fighting equipment provided at a berth may be established after consideration of, and in relation to, the calibre of local water-borne fire-fighting equipment.

The water-borne fire-fighting capability is normally best provided by working tugs or workboats fitted with fire-fighting equipment, including foam facilities, which should be capable of tackling a deck fire on the largest tanker likely to use the port.

Where the fire-fighting capability of tugs is part of a terminal’s planned response to fires on tankers or on the terminal itself, they should be made available as soon as they are required if their contribution is to be effective. If these tugs are assisting a tanker berthing or unberthing at the terminal or in some other part of the harbour when a fire emergency occurs, arrangements should be made to ensure that they can be released in the shortest possible time to assist in fire-fighting. When these tugs are idle between routine tasks, they should be moored with easily slipped moorings, within easy reach and, where possible, within sight of the terminal, and must keep a continuous radio and visual watch on the terminal. Where the attendance of these fire-fighting tugs at a fire cannot be assured within a reasonable timescale, their contribution should not be included when assessing the fire-fighting requirements for the terminal.

In special circumstances, such as terminals handling a high number of tankers or harbours with multiple terminals, consideration may be given to the provision of a specifically equipped fire-fighting boat.

The decision to use tugs to assist in fighting a fire on a tanker or on the terminal, or to use them to unberth other tankers in danger of becoming involved, should be made by the person in overall charge of the fire-fighting and in conjunction with the harbour authority. Fire-fighting tugs should be equipped with UHF/VHF radio with separate channels for towing and fire-fighting and, when fire-fighting, they must be in direct contact with, and under the control of, the person in overall charge of the fire-fighting.

Tugs with fire-fighting equipment should be inspected regularly to ensure that their equipment and foam compound stocks are in good condition. Tests of the fire pump and monitors should be carried out weekly. The foam filling points on the tugs should be kept clear, so as to be immediately ready for use.

A decision should be made as part of the terminal emergency plan as to whether trained fire-fighters should board the tug or whether the crew will be used for fire-fighting duties. The decision should be supported with appropriate training for the designated fire-fighters.

19.7 Protective Clothing

All fire protective clothing gives some protection against radiant heat and consequently from burns. Conventional, heavy fire-fighting jackets are very good in this respect.

However, modern practice is to provide fire protective clothing that is manufactured from a lightweight, fire resistant fabric incorporating an aluminium covering, sometimes referred to as a fire proximity suit. This type of suit is not suitable for direct fire exposure. Heavier suits, termed fire entry suits, will allow personnel wearing breathing apparatus with suitable rescue and backup provisions to withstand direct flame exposure for a limited period.

Depending on local fire-fighting arrangements, provision at the terminal of a minimum of one or two complete sets of fire proximity and fire entry suits, including helmets, gloves and boots, may be advisable.

All protective clothing should be kept serviceable and dry. It should be properly fastened while being worn.

19.8 Access for Fire-Fighting Services

Parking areas should be provided for fire-fighting vehicles close to terminal approaches. The provision of a lay-by or ‘passing’ area on jetty approach structures should also be considered. Consideration must also be given to any limitations regarding the maximum axle weights for vehicles accessing berth structures.