MARSH

Energy Practice

RISK ENGINEERING POSITION PAPER – 01

ATMOSPHERIC STORAGE TANKS

SOLUTIONS…DEFINED, DESIGNED, AND DELIVERED.

MARSH & McLENNAN COMPANIES

CONTENTS

1. BACKGROUND

There have been numerous incidents in the oil, gas, and petrochemical industry involving atmospheric storage tanks. Data has been compiled by a reputable operator in the USA that indicates that overfilling of atmospheric storage tanks occurs once in every 3300 filling operations. In 2009 there were two separate incidents just days apart, one in Jaipur, India (October 29), and one in San Juan, Puerto Rico (October 23) that demonstrated the destructive capabilities of incidents at terminals and tank farms.

The Buncefield incident in the UK in December 2005 resulted in an independent investigation commissioned by the Health and Safety Commission in the UK. As a result of this, more guidance has been provided to designers and operators of facilities. Such guidance has been included within this position paper.

2. OBJECTIVE

The objective of this position paper is to define the standards that would be expected of a very good atmospheric storage facility in the oil, gas, and petrochemical industry. These standards are also reflected in the Marsh Energy Risk Ranking criteria. They can be used to determine risk improvement opportunities and also to provide detailed advice to clients seeking to improve their atmospheric storage facilities.

3. SCOPE

The scope of this position paper includes:

- Guidance on the appropriate selection of atmospheric tank design for class of product to be stored.
- Guidance on layout and spacing.
- Guidance on appropriate means of ensuring primary containment.
- Suitable design of secondary containment.
- Detection arrangements for loss of primary containment and fires.
- Fire protection arrangements.
- Examples of loss incidents involving atmospheric storage tanks.

4. SELECTION OF ATMOSPHERIC STORAGE TANKS

The layout and general design of a storage facility should be based upon considerations of safety, operational efficiency, and environmental protection. A primary consideration is ensuring that the design of the storage tanks themselves is suitable for the classification of the hydrocarbon being stored.

The table below summarises the design of tank suitable for each class of hydrocarbon:

CRUDE OIL DERIVATIVE CLASS	DEFINITION	RECOMMENDED STORAGE TANK DESIGN	
		Floating Roof	Fixed Roof
Class 0	Liquefied petroleum gases (LPG)	✗	✗
Class I	Liquids which have flash points below 21°C	✓	✗
Class II (1)	Liquids which have flash points from 21°C up to and including 55°C, handled below flash point	✓	✓
Class II (2)	Liquids which have flash points from 21°C up to and including 55°C, handled at or above flash point	✓	✗
Class III (1)	Liquids which have flash points above 55°C up to and including 100°C, handled below flash point	✗	✓
Class III (2)	Liquid which have flash points above 55°C up to and including 100°C, handled at or above flash point	✗	✓
Unclassified	Liquids which have flash points above 100°C	✗	✓

5. LAYOUT AND SPACING

Ideally, tank layout should be optimised to ensure that there is sufficient access to tanks for fire fighting and to minimise the risk of escalation in the event of a tank fire.

Minimum spacing for tanks is specified in the table below, although Marsh would advocate a minimum separation distance of 1x the diameter of the largest tank with an absolute minimum of 15 metres, as such a distance provides sufficient access for fire fighters.

FACTOR	MINIMUM SEPERATION FROM ANY PART OF THE TANK
Between adjacent fixed-roof tanks	Equal to the smaller of the following: (a) The diameter of the smaller tank. (b) Half the diameter of the larger tank. (c) Not less than 10m (Marsh advocate 15m).
Between adjacent floating-roof tanks	10m for tanks up to and including 45m diameter. 15m for tanks over 45m diameter. (The spacing is determined by the size of the larger tank).
Between a floating-roof tank and a fixed-roof tank	Equal to the smaller of the following: (a) The diameter of the smaller tank. (b) Half the diameter of the larger tank. (c) Not less than 10m (Marsh advocate 15m).
Between a group of small tanks and any tank outside the group	15m
Between a tank and the site boundary, any designated non-hazardous area, process area or any fixed source of ignition	15m

Source: HSG 176. The storage of flammable liquids in tanks.

One notable exception is the separation between crude tanks, where the destructive effects of a boil over can extend from 5 to 10 diameters. Therefore consideration should be given to locating crude tanks at the edge of tank farm installations and with the largest practical separation from adjacent tanks.

These distances should only be used in conjunction with appropriate levels of fire protection (see below). In the event that tanks are existing and do not conform to the above spacing, then additional fire protection should be considered.

Floating roof tanks, with external metal domed roofs extending over the entire roof area (i.e. internal floating roof tanks or tanks fitted with geodesic domes), may be considered as fixed roof tanks for the purpose of tank location and spacing.

5.1 BUNDS (DYKES)

Above-ground tanks should be completely surrounded by bund walls (see also Secondary Containment). These should be designed to offer protection to fire fighters. Therefore the bund wall should be located so that a reasonably close approach can be made to a tank fire.

Fire fighting screens and steps should be located at various points around the bund wall to assist the positioning and protection of fire fighting personnel and equipment.

Bunds would normally be constructed from earth or preferably concrete and should be largely impervious to liquid and capable of withstanding hydrostatic and hydrodynamic pressures to which they could be subjected. Earthen bunds should be fitted with a water resistant liner and whilst grass growth is acceptable, it should be regularly maintained and kept short.

Tanks should ideally be located alone within their own bunds, although whenever tanks share a common bund, intermediate walls up to half the height of the main bund walls and no more than 0.5 metres high should be provided to control small spillages from one tank affecting another.

Bund floors should drain to a single location complete with sump for the regular removal of water from rainfall or firewater testing. Drains should normally be kept closed, with the drain isolation valve situated outside the bund.

6. PRIMARY CONTAINMENT

It is essential that the risk of loss of containment is properly managed. This can be achieved by the proper design, operation, maintenance, and inspection of tanks. Ideal practice is outlined below.

The most effective way to prevent a major accident at any site is the continued provision of suitable primary containment of the flammable materials. This is achieved through the suitable design, construction, and maintenance of the storage systems in accordance with standards.

For guidance on the most appropriate standards to use for the design and construction of atmospheric storage tanks, refer to the UK Health and Safety Executive's review of standards, Mechanical integrity management of bulk storage tanks, which can be found at the following website address:

http://www.hse.gov.uk/research/rrpdf/rr760.pdf

Outlined below is a summary of the features considered to be the most appropriate for a modern facility:

- Double seals on floating roof tanks (NB foam dam heights should be above the height of the upper rim seal to provide suitable protection against a rim seal fire).
- High level alarm and independent back-up high level instrument (with executive action only if appropriate).
- Continuous automatic monitoring of tank contents, including "rate of change" during filling/emptying.
- Anti-rotation devices on floating roof tanks.
- Closed water drains.
- Single skin floors.
- Tank floor leak detection on double-floor tanks. This is normally comprised of an instrument to detect loss of vacuum in the inter-floor space.

6.1 TANK DESIGN AND OPERATION

Tanks should be designed to a relevant standard, such as API 650 or BS EN 14015.

In some instances single skin bottom tanks are a better option than double-bottomed tanks as these provide the optimum conditions for ensuring integrity of the tank floor by the inspection of tank floor plates. Disadvantages of double-bottom designs include settlement, product entrapment, and modification to nozzle compensating plates.

Where double-bottomed tanks are provided, additional inspection measures should be provided in accordance with a relevant standard such as EEMUA 183 or BS EN 14015. Leak detection should also be provided on double-bottomed tanks.

TANK ROOFS

Double deck roofs on floating roof tanks are preferred to single deck roofs with external pontoons as they are more stable and less likely to lose buoyancy.

For floating roof tanks, the water drains to remove rainwater from the roof should be normally closed. To ensure roofs are emptied of rainwater, procedures should be in place and followed for the opening and re-closure of valves.

Whenever valves are left normally open, then the following measures should be put in place:

- Hydrocarbon detection in drained water with automatic isolation.
- Testing of operability of isolation valves and detection systems (see overleaf).

VENTS

Tanks should be provided with a weak seam/frangible roof construction, or with an emergency vent suitably sized for the worst case relieving scenario, to prevent overpressure under all relief conditions. Emergency vents should comply with relevant standards, such as API 2000.

Wherever a fixed roof tank is used for the storage of materials with a flash point below 21°C (generally on day tanks, not recommended for large bulk storage tanks), then flame arresters should be provided on the vents to prevent ignition of the flammable vapours burning back into the tank. In warmer climates, where product surface temperatures could exceed 21°C, flame arresters should be used wherever maximum surface temperatures could be within 10°C of the flash point.

Flame arresters should be included in preventative maintenance routines to ensure they do not become blocked by scale, paint, ice or other materials. Flame arresters are not recommended for use when the material being stored is liable to polymerise or foul the arrester. Due to the potential for blockage, conservation vents (vacuum and pressure relief) should not be fitted with flame arresters.

Fixed roof tanks can be fitted with a gas blanket (normally nitrogen) to maintain an inert atmosphere in the vapour space. Nitrogen supply pressure should be just above atmospheric, but sufficient to displace any liquid pumped out. As a back up, a vacuum breaker should be provided in the event that nitrogen supply is lost.

Vents or vapour recovery systems (often venting back to the source vessel) are required. These should be designed to relieve pressure slightly above that of the nitrogen and at a suitable margin below the design pressure of the storage tank.

RIM SEALS & FOAM DAMS

Double rim seals (of fire-resistant construction) are preferable to single seals. Due to irregularities during the construction phase of large floating roof tanks, it is likely that a single seal will not maintain a 100% seal between the tank roof and tank wall along the entire height of the tank wall. Therefore, a second seal will improve the likelihood of achieving a tight seal, will reduce emissions, and minimise the risk of rim seal fire.

When installing double rim seals, the height of the second, upper rim seal should be below the height of the foam dam to ensure coverage whenever rim seal pourers are activated.

Foam dams should be provided with intermittently-spaced gaps to allow the drainage of rainwater. However, if the gaps are too large or too numerous, they may affect the ability to form a single continuous foam barrier in the event of a fire.

OVERFLOW

Consideration should be given to providing suitable overflow systems to ensure that in the event of a tank overfilling, the tank contents are safely routed into suitable secondary containment. Additionally, the overflow route should be designed to minimise turbulent flow, reduce the surface area of flammable hydrocarbon, and reduce the generation of flammable vapours, such as through splashing. Particular care needs to be taken with strengthening rings and firewater dispersion rails around tanks which

are specifically designed to maximise spread of fluids over a tank's surface.

For existing tanks, consideration should be given to modifications of tank top design and to the safe-re-routing of overflowing liquids.

VALVES

All important valves on atmospheric tanks should be labelled and their function indicated.

Fire-safe shut off valves should be provided, preferably automatic and remotely operated shut off/isolation valves (ROSOV/ROIV). They must be fitted close to the tank on both the inlet and outlet connections. Valves must either conform to an appropriate standard, such as BS EN ISO 10497 or equivalent international design, or should be of intrinsically fire-safe design. Such features include:

- Metal-to-metal seats (secondary metal seats on soft-seated valves are acceptable).
- Must not be of cast-iron construction.
- Should not be wafer-bolted (sometimes referred to as long bolt flanges).

In regions subject to a high risk of earthquake and/or rapid ground-acceleration, the isolation valves and actuators should also be secured directly to the tank wall and not to the ground. Anchoring the valve to surrounding structures or the ground could result in the valve separating from the tank during excessive vibrations.

Features of the ROIV should be:

- Fail safe (or if not fail safe have a back-up power supply, especially if the emergency plan requires the tank to be drawn down in an emergency).
- It should not be possible to auto-reset the ROIV.
- Adequate margin of safety for shutting off the valve, with at least 150% torque available from fully open to fully closed.
- No manual operation or override (e.g. hand wheels) which may inhibit the operation of the ROIV.
- Suitable integrity and performance to satisfy the safety integrity level (SIL) requirements.
- Designed to minimise pressure surges on system pipework and couplings, particularly ship to shore flexible pipes.

Tank drainage valves should be blanked off when not in use. Whenever operations to remove accumulations of water from underneath the product are to be conducted, isolation of the drain should be achieved by the use of two valves in series. The second valve can be a temporary installation.

PIPING

In areas where earthquake is a significant exposure, all associated piping on storage tanks should have step geometry to allow flexing in the piping and prevent puncturing of the tank during an earthquake.

Suitably designed seismic hangers should be provided in earthquake zones, and pipe supports should have fire protection within fire hazard zones, e.g. within the bunded area.

TESTING

Before filling tanks with flammable liquids, leak testing of the installed tank and associated pipework is required. Hydraulic testing should only be used (i.e. not pneumatic) as stored energy in hydrotesting is substantially lower, and inherently safer. However, air may be used as a means of applying pressure to water-filled tanks and piping.

Salt water should not be used to hydraulically test systems containing stainless steel.

HOUSEKEEPING

Debris within bunds should be kept at an absolute minimum. In addition to the checks within formalised inspection and maintenance routines, operators should also conduct frequent checks of tanks and their components as part of their routines to ensure that the tanks are kept in a reasonable condition. A sample of items to check is included in Appendix B.

7. SECONDARY CONTAINMENT

Whilst priority should be given to preventing loss of primary containment, adequate secondary (and sometimes tertiary) containment is necessary for the protection of the environment and to contain any spillages. In atmospheric tank applications, secondary containment will be provided by bund walls.

Bund capacity should be sufficient to contain the largest predictable spillage. A bund capacity of 110% of the capacity of the largest storage vessel within the bund will normally be sufficient. When estimating bund capacity, the space occupied by other tanks should be taken into account.

7.1 BUND INTEGRITY (LEAK TIGHTNESS)

Bund wall and floor construction should be leak tight. This includes the provision of leak tight expansion joints between different casts of concrete in bund walls and wherever there are penetrations in the wall for pipes. Surfaces should be maintained crack free, and without any discontinuities, and without any failed joints that may allow liquid migration.

As observed in major incidents, such as the Buncefield fire of 2005, the joints in concrete bund walls are particularly susceptible to the effects of fire and/or subsequent cooling. Therefore, to maintain integrity, joints should be capable of resisting fire. Ideally, steel plates (waterstops) should be fitted across the inner surface of bund joints and fire sealants should be used to replace or augment non-fire resistant materials. Similarly, joints to wall and floor penetrations need to be protected against the effects of fire.

Whenever designing protection plate, consideration should be given to avoiding weakening the wall structure in relation to resistance to fire, hydrostatic, and hydrodynamic forces.

Bund penetrations should be avoided unless alternative over-wall routings are not practical. On existing bunds, fitting steel collars or bellows to improve fire resistance at pipework penetrations may introduce local corrosion initiation sites in the pipework and is not recommended unless corrosion prevention can be assured. Where corrosion can not be prevented, joints should be improved by replacing existing sealants with fire-resistant sealants.

Bund floor penetration joints are inherently weak as failure of the integrity is difficult to predict and detect and may continue for some time unnoticed. Consequently, floor penetrations should not be incorporated into new bund designs. Existing bund floor penetrations should be eliminated wherever practicable. Where flexible sealants are used in floor penetration joints, these should be replaced with fire-resistant sealants.

There have also been a number of significant accidents resulting from leaks of hydrocarbons from tanks through the base of storage tanks. Therefore the provision of a suitable impervious base (ideally concrete with a membrane liner) or floor leak detection on double floor configurations should be provided.

7.2 TERTIARY CONTAINMENT

Tertiary containment need only be concerned if there is a significant risk of secondary containment being insufficient to prevent an escalation to a major accident affecting personnel, assets, or the environment. Firewater containment is one such example. Implementation of tertiary containment should therefore be a risk-based decision. However, tertiary containment should be:

- Independent of secondary containment.
- Capable of fully containing foreseeable firewater and liquid pollutant volumes on the failure of secondary containment.
- Impermeable to water and foreseeable entrained pollutants/ hydrocarbons.
- Of cellular configuration to allow segregation and limit the extent of spread of pollutants and/or fire.
- Robust under emergency conditions, e.g. loss of electrical supply.
- Capable of allowing the controlled movement of contained liquids under normal and emergency conditions.
- Capable of aiding the separation of water from pollutants (e.g. oil/ water separator).
- Able to manage rainwater and surface waters.

More guidance on tertiary containment can be found in documentation including CIRIA 164 and PPG18.

8. OVERFILL PROTECTION

All tanks should be fitted with a suitably high integrity overfill protection system, which should be designed to SIL 1 as a minimum, depending upon the risks associated with failure.

Overfill protection systems should be automatic and physically and electronically separate from the tank gauging system, i.e. have an independent level gauging system and back-up level switch or duplicated level gauging system.

However, justification for a single combined gauging and overfill protection device could be made if the integrity of the instrument is sufficient for the risk of failure.

Tank gauging systems should have a high level alarm (LAH) to alert operators to the status of the tank which gives sufficient time to interrupt the filling operation and the subsequent activation of the back-up overfill protection device high-high level alarm (LAHH). This should also take into account any thermal expansion of the fluid within the tank. It is important that LAH should not be used to control routine filling.

Analogue sensors are preferred to digital (switched) sensors (i.e. there are two analogue sensing elements on the tank), as these are able to alert whenever there is a fault in the primary level sensor before reaching high level.

Electro-mechanical servo gauges should be avoided for use with flammable materials as these are intricate devices considered to be vulnerable to a number of potential failure modes. Modern electronic gauge sensors, such as radar gauges, should be used instead.

Where practical the LAHH should have an executive action to interrupt the filling operation by closing the isolation valve and/or stopping the pump. Features of a LAHH are:

- It should be set at or below the tank's rated capacity.
- Activation of the LAHH is to initiate a shutdown.
- LAHH may be limited to an audible/visual alarm to alert a human operator to rake the required action. Actions required must be specified and well documented. NB – such options are not suitable for SIL 1 systems.
- The trip function should include an audible/visual alarm to prompt a check that the trip function has been successful.

In some cases it may be necessary to terminate the transfer in a more gradual fashion, such as by limiting the closure rate of the isolation valve to avoid damaging overpressures in upstream pipework. Due allowance must be given to the maximum filling rate between LAHH being activated and the isolation valve finally closing.

The site receiving any batch or delivery must have ultimate control and responsibility for stopping the transfer and should have local systems and valves to stop the operation. This should not therefore be under the sole control of an automatic system or operators at a remote location.

Tank level instrumentation and information display systems should be of sufficient accuracy and clarity to ensure safe planning and control of product transfer into tanks.

It is preferable for tanks to be continuously and automatically monitored for rate of level change during transfer operations to match the actual rate of transfer with expected rates. This would give an early indication that the main level gauging system was not functioning correctly or that the incorrect tank was being filled. During normal storage operations, such a tool could also notify operators of a significant loss of containment.

It is not within the scope of this document to detail the SIL determination or its implications. However the following points should be noted:

- It is the dutyholder's responsibility to meet latest international standards, IEC 61511 is a current good standard.
- The appropriate SIL required should be specified before designing and installing overfill protection systems.
- Layer of protection analysis (LOPA) is a suitable methodology to determine SIL.
- As overfill protection systems normally function infrequently, they should be periodically tested in their entirety to ensure they will operate when required.

9. MAINTENANCE AND INSPECTION

All tanks must undergo regular external and internal (out-of-service) inspections to ensure their integrity, and as such a written scheme of examination should be provided. Overall guidance on the suitable methods and frequency of such inspections are detailed in EEMUA 159 and API 653.

Individuals responsible for the formulation of schemes of inspection and for the inspection of tanks should be competent and have the appropriate qualification for tank inspection and for the grade of materials used in construction. As a minimum, personnel should be competent to The Welding Institute's (TWI's) certification scheme for welding and inspection, or equivalent.

External inspections should be conducted on a higher frequency than internal inspections based upon risk based inspection (RBI) requirements, or as stated in the relevant codes. If active degradation mechanisms are found, then more frequent inspections should be conducted.

Particular attention should be given to insulated storage tanks, as corrosion under insulation, and the quality of external coatings applied prior to insulation, can have a significant effect upon tank integrity.

Thorough internal inspection can only be achieved by removing a tank from service, cleaning it, and then conducting, as a minimum:

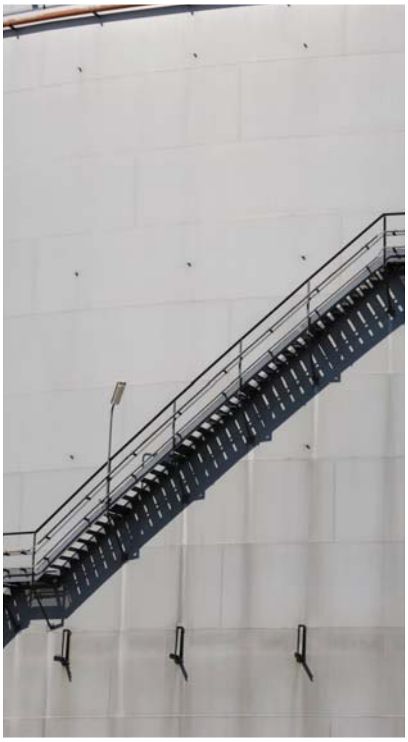
- Full floor scan.
- Internal examination of shell to annular floor weld.
- Non destructive examination (NDE) of annular plate and shell nozzles.
- Visual inspection.

Deferral of internal inspections should be risk assessed and approved by a suitably competent person. Particular attention should be given to tanks that have had no previous internal inspection, as the probability of floor failure will increase with every year that the recommended interval is exceeded. In such cases, it is unlikely that a deferral could be justified.

Failure of either a top or bottom floor in double-bottomed tanks (as detected through the failure of vacuum between plates) should be rectified within one year. Continued operation in the interim period pending repair should be supported by a technical justification supporting its fitness for purpose.

Tank repairs and modifications are specialist activities and should only be conducted by suitably qualified personnel with appropriate qualification (as specified above).

Water drains on floating roof tanks should also be formally included in routine maintenance if normally left open, including a check that isolation valves can be closed. The detection systems for hydrocarbons should also be tested on a regular basis. All tests should be formally documented.



Pontoons should be included in formal maintenance and inspection regimes as loss of pontoons (as a result of corrosion or long-term removal of pontoon cap) will affect the stability and buoyancy of the deck. The presence of flammable vapours within a pontoon also increases the risk of vapour cloud explosion (VCE) within a pontoon.

The functional integrity of overfill protection systems is critical to ensuring primary containment. Overfill protection systems may be in a normally dormant state without being required to operate for many years. For this reason, periodic testing is an essential element in assuring their continuing integrity.

10. LEAKAGE AND FIRE DETECTION

It should be noted that leakage, overflow, and fire detection are mitigation layers and not preventative layers, and are therefore of secondary priority to overflow and leak protection.

10.1 LEAK DETECTION

Whilst flammable gas detection in storage areas is considered to be a good measure (for highly flammable materials), the dispersion of flammable vapours is complicated to predict, so effective gas detection may not always be practical.

More effective detection of leaks is likely to be provided by liquid hydrocarbon detectors. Typical locations would be in the bund drain, gutter or sump, where hydrocarbons would accumulate. Such systems may be subject to failures or spurious alarms (e.g. due to water collecting in the bund), therefore consideration should be given to using multiple detectors at more than one location. Initiation of such alarms should also initiate an interruption of any transfer operation. This is of particular importance at terminals that are normally unmanned.

Ideally closed circuit television (CCTV) should be provided, with suitable resolution and lighting in tank and bund areas to give operators assistance in detecting tank overflows. Operators should not be expected to monitor these constantly, therefore CCTV should be provided with systems that detect and respond to changes in conditions and then alert operators to those changes.

FIRE DETECTION

For floating roof tanks, rim seals should be constantly monitored by the use of linear heat detection. These should be located close to the top of the seal, and not on the foam dam, where they are less effective in detecting fires.

Point heat detectors are generally of less use for large storage tanks, other than in the vicinity of vents, given the large areas that need to be covered. Therefore, optical flame detectors, providing a large zone of detection, should be used for bunded areas.

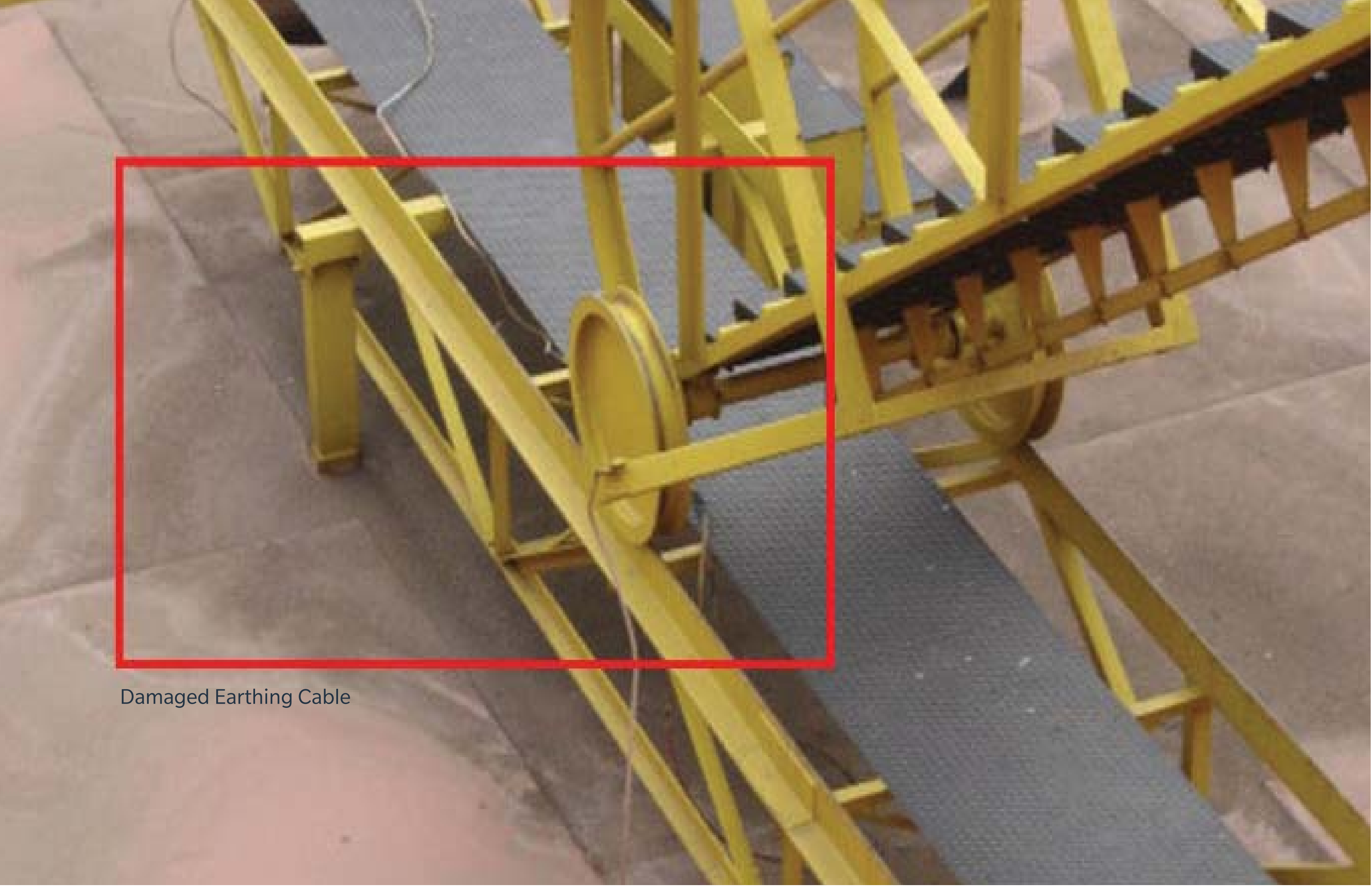
10.2 FIRE PREVENTION AND PROTECTION

BONDING AND EARTHING

By nature of the storage of flammable liquids, flammable atmospheres are to be expected in the vicinity of vents, rim seals, and within the tanks themselves. To minimise the risk of ignition the tank and ancillary equipment should be fully bonded and earthed (grounded). A maximum resistance of 10 ohms to earth is recommended.

Special attention should be made to the earthing connection between the tank wall and the roof of a floating roof tank. Sliding shunts (contactors) between the wall and roof often do not maintain a good contact, thus overloading those shunts which are maintaining a connection. Therefore, an adequate number of shunts should be provided and checked to ensure that contacts are maintained.

Due to the rising and falling of the floating roof, excess lengths of earthing cable are required in the vicinity of the walkway providing access to the floating roof. The earthing cable can often be severed when it is trapped between the wheels of the access walkway and the rails upon which it rolls, as in example shown overleaf. Retractable grounding systems on modern tanks would address this.



Damaged Earthing Cable

One of the most common sources of ignition for large tanks is lightning. Therefore, the provision of suitable lightning protection with bonding and earthing would help to minimise this. NFPA 780 Standard for the Installation of Lightning Protection Systems provides more details on the specification of lightning protection systems.

Some installations are provided with lightning masts intended to act as preferential routes for lightning to discharge itself, as opposed to via the storage tank. This concept is not proven and some parties suggest that such masts act to attract lightning to the vicinity of the storage tanks. Therefore, these are not currently considered to be a robust mitigation against the effects of lightning.

Some materials are susceptible to the effects of static during splash-filling. Therefore, measures should be taken in such instances to prevent the generation of electrostatic charges.

It is possible that floating roofs can become unstable and sink, maybe as a result of rainwater accumulation, or failure of flotation devices.

Often, foam is applied to provide a blanket to suppress vapour emissions and prevent ignition. However, if this occurs on tanks storing materials, such as naphtha, that are susceptible to ignition from splash-filling, careful consideration should be given prior to the application of foam. If foam is to be applied, for example in the event that electrical storms are expected, then this should be gently applied along the shell wall and not by splash-filling to the surface of the material.

ZONING

A detailed assessment of the hazardous area classification (HAC) of the storage tank, ancillary equipment, and bunded area must be conducted. This should take into account the class of material being stored.

The specification of spark-inducing equipment should be suitable for the HAC zones location and should be made in accordance with relevant electrical standards, such as IP (Institute of Petroleum) Model Code of Safe Practice Part 15, ATEX 95, ATEX 137 or BS 5345.

11. FIRE FIGHTING SYSTEMS

Protection systems and fixed fire fighting installations should be provided and comprise fixed/semi-fixed foam systems and cooling water sprays. Additionally, access to the tanks for mobile fire fighting appliances, equipment, and materials should be provided giving multiple points of attack with no dead-ends.

In many cases it is safer and more practical to allow a tank fire to burn itself out; for instance, when there is no chance of escalation to other tanks, little environmental exposure or where the risks of fighting the tank fire are greater than not fighting it. Two notable exceptions are:

- Rim seal fires – these will take a long time to burn out.
- Crude tank fires – these are susceptible to boilovers due to the presence of water.

Broad principles of water and foam application are given below. More details are given in the Energy Institute's Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations. Alternatively, NFPA 11 Standard for Low-, Medium-, and High-Expansion Foam can be used as a reference.

As for process plant, dedicated fire-preplans should also be compiled for storage installations. These should specify type of attack, firewater and foam application rates, location of hydrants, semi-fixed installations and mobile apparatus, firewater containment, and worst case scenarios. It is not within the remit of this position paper to detail emergency plans, but API 2021, Management of Atmospheric Storage Tank Fires, provides some guidance in this matter.

Emergency response personnel should receive training on the fire preplans, and regular exercises should be conducted to assess the suitability of the preplan.

11.1 WATER SYSTEMS

Provision should be made for the application of cooling water to fixed roof tanks containing products adjacent to those containing Class I or II (petroleum) or wherever there is less than 1 x diameter of the largest tank between adjacent tanks. In particular, there should be cooling wherever there is less than 15 metres access between tanks.

Where water is to be applied to tanks, water application rates should be:

- 2 lpm/m^2 for exposed tanks.
- 10 lpm/m^2 for engulfed tanks (to vertical and inclined surfaces).

Source: IP 19. Model Code of Safe Practice Part 19.

Water application should be provided by either fixed or semi-fixed systems. It is unlikely that mobile tenders would have sufficient capacity for water storage to mount a prolonged cooling water attack on a storage tank.

Water should not be applied to the roof area of floating roof tanks as this may result in the destabilisation and sinking of the roof.

11.2 FOAM FIRE FIGHTING SYSTEMS

Whilst being a good cooling medium for tanks, water is not a suitable fire extinguishing medium for hydrocarbon fires. Therefore, foam is used for such applications. The design of foam fire-fighting systems, be they fixed or mobile, should be suitable for the types of fires they would be required to extinguish (or suitable for the cooling of adjacent equipment/tanks). Therefore each facility needs to have its own tailored fire fighting system. Important issues to consider when designing and installing a fire fighting system include:

- Foam and the foam injection/proportioning systems must be compatible (also important if the supplier of foam is changed).
- Hydraulic design of foam systems must be specified.
- Foam selection must be appropriate for the type of fire likely e.g. aqueous film forming foam (AFFF), should not be selected for polar solvents.
- Correct proportioning of foam that may otherwise result in foam that does not flow (too little water) or that quickly goes back to solution (too much water).
- Provision of facilities to aid the maintenance or testing of firefighting systems.

- Location of equipment, e.g. monitors not too far from tanks for foam application to tank surface.
- Attention to any faults in the fabrication and installation of hardware, e.g. check valves installed the wrong way round, transport packing still present around air inductors.

Once a system has been designed and installed, it is critical that it is tested. Whilst this may be expensive, it is critical to ensure that the system actually completes the job it is intended to do. Ideally, systems should be tested at the manufacturers as it is then cheaper, quicker and easier to rectify any mistakes.

FLOATING ROOF TANK FIRES

Rim seal fires are the most common type of fire on floating roof tanks. There is little chance of these escalating to other tanks or turning to full surface tank fires if the design, maintenance, and layout of the tanks is suitable. This should not be considered a rule, however, as a poorly maintained tank could lose its integrity or be vulnerable to subsequent explosions, perhaps as a result of vapour ingress into one of the pontoons.

Rim seal protection should only be used on certain types of roofs (i.e. double deck, steel pontoon, etc). Pan roofs for example, should have full surface protection.

The application of foam from a remote monitor (i.e. one outside the bund) would not represent best practice as it can create roof instability and potentially escalate the incident.

Additionally, remote monitors are wasteful of foam and cannot direct the jet so accurately as the objective is to apply foam to the rim seal as quickly and gently as possible (irrespective of the roof level) and to retain a complete foam seal for as long as possible.

The most common and (arguably) most effective method to control a rim seal fire is the application of foam via fixed rim seal pourers on the top of the shell wall. Even with simple, fixed purpose-built systems, such as rim seal pourers, there is the danger that basic errors can be made so that the system does not operate as intended. Such examples that should be avoided are:

- Top of foam dam below the top of the rim seal – this is especially an issue where secondary rim seals have been added to the tank to reduce tank emissions. The top of the foam dam should be at least 50 mm above the top of the rim seal, but ideally about 150 mm.
- Too many or too large gaps at the bottom of the foam dam. The purpose of the dam is to hold the foam in position around the circumference of the tank to reduce the amount of foam needed. This ensures efficient application to the rim seal and prevents unnecessary loads being placed on the tank roof. With large gaps at the bottom of the dam, a significant quantity of foam could leak to the roof. However, small, intermittently spaced drains should be provided to allow rainwater to drain away.
- Incorrect spacing of the foam pourers. Modern foams can flow in excess of 30 metres if proportioned correctly, although if there are changes to the foam type, foam proportion or even water supply, then the flow characteristics could be affected so that a foam seal is not possible.
- Forced/irregular addition of foam. The intention is to apply foam gently down the side of the tank shell so that it forms an even blanket within the rim seal area. If the pourer has been incorrectly positioned it may not apply the foam in such a way, e.g. catching on the top edge of the seal, resulting in splashing and loss of foam to the roof.
- Foam pourers located too high on the tank, exposing them to wind and impairing their passage to the rim seal itself.

To overcome these issues, tests should be conducted on the system to ensure it operates correctly. Depending upon the number of tanks being protected, annual testing frequency would be appropriate.

Inspections should be conducted regularly to ensure air inlets to foam generators are clear and that foam pourers are not blocked by, for example, birds' nests. Other good features to aid inspection or fire fighting in the event of a system failure are:

- Walkway around the top of the floating roof tank – this can be the wind girder with a handrail around the circumference. This allows for the pourers to be accessed for maintenance or for fire fighters to access the roof with manual hoses.

- Provide a foam hydrant at the top of the tank (preferably at the top of the stairs) for fire fighters in the event of rim seal pourers becoming blocked. This also requires less equipment to be carried up the tank in the event of a rim seal fire. Careful consideration needs to be given as to the safety of personnel when attempting such a tactic.
- It is important that foam can be applied equally well when the floating roof is at high level and when it is at low level.

Other foam delivery systems that are more complex to varying degrees are:

Catenary systems – foam applied to the rim seal by local generators located directly within the foam dam through a supply line attached to the roof via the rolling ladder.

Coflexip system – foam solution is applied in the same way as a catenary, although the supply pipe runs up from low level through the tank itself via a "coflexip" flexible pipe.

"One shot" systems – an extinguishing agent (such as obsolete Halon) is applied at the rim seal in a single burst extinguishing the flames. Whilst potentially effective as an initial extinguisher, these do not prevent re-ignition and require all the parts, including cylinders, being placed on the roof. For that reason, Marsh does not recommend such an approach.

FIXED ROOF TANKS

Similar systems can be applied to fixed roof tanks, with foam application to the surface of the product through a fixed or semi-fixed system, or even sub-surface allowing for the foam to float to the surface of the product. NFPA 11 standard for low, medium, and high-expansion foam provides a guide as to which products and materials can be protected by such systems.

Example of sub-surface foam application apparatus

11.3 APPLICATION RATES

A minimum of 40 minutes' attack should be envisaged in order to have a reasonable chance of success in extinguishing a fire, and foam stocks should be sufficient for this duration; a duration of 60 minutes is preferred for crude oil tank fires.

Typical application rates for foam solution are shown below, although foam manufacturer's advice on the type of foam and application should always be sought:

TYPE	RATE (l/min/m^2)
APPLIED WITH MOBILE EQUIPMENT	
Pool fires	5-10*
Fixed roof tanks, Class I product	5-10*
Fixed roof tanks, Class II/III product	5
APPLIED WITH FIXED OR SEMI-FIXED EQUIPMENT	
Fixed roof tank with pourer outlet	4
Base injection (oils only)	4
Floating roof rim seal fires	12
Floating roof tanks (roof area), projected foam	6.5
Floating roof tanks (roof area), fixed pourers	4

Source: Energy Institute's Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations

*The higher rate may be applied to Class I products, including gasoline containing up to 10% of oxygenates.

NFPA 11, standard for low, medium, and high-expansion foam also provides similar application rates, although there are some minor differences.

12. REFERENCES TO INDUSTRY LOSSES

Examples of Industry losses have been included in Appendix C.

13. REFERENCES TO INDUSTRY STANDARDS

Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations. Energy Institute, February 2007. ISBN 978-0-85293-437-1.

BS EN 14015. Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above. February 2005.

BS EN 61511-1:2004/IEC 61511-1:2003 Functional safety. Safety instrumented systems for the process industry sector.

BS EN ISO 10497:2004. Testing of valves. Fire type-testing requirements. British Standard/ European Standard/International Organisation for Standardisation.

HSG 176. The storage of flammable liquids in tanks. HSE. ISBN 0 7176 1470 0.

CIRIA Report 164: Design of Containment Systems for the Prevention of Water Pollution from Industrial Accidents. January 1997. Construction Industry Research and Information Association. ISBN 086017476X.

PPG 18. Planning Policy Guidance 18: Enforcing Planning Control. December 1991. ISBN 9780117525542.

HSG 244. Remotely Operated Shutoff Valves (ROSOVs) for Emergency Isolation of Hazardous Substances - Guidance on Good Practice. October 2004. ISBN 0717628035.

API 650. Addendum 3 - Welded Steel Tanks for Oil Storage. October 2003. American Petroleum Institute.

API 653. Tank Inspection, Repair, Alteration, and Reconstruction, Third Edition. December 2001. American Petroleum Institute.

API 2000. Venting Atmospheric and Low-pressure Storage Tanks, Sixth Edition. November 2009. American Petroleum Institute.

API RP 2350. Overfill Protection for Storage Tanks in Petroleum Facilities, Third Edition. January 2005.

NFPA 11 Standard for Low-, Medium-, and High-Expansion Foam, 2010 Edition.

Buncefield. The Final Report of the Final Investigation Board. December 2008. Buncefield Major Incident Investigation Board. http://www.buncefieldinvestigation.gov.uk/reports/index.htm#final

Safety and environmental standards for fuel storage sites. December 2009. Process Safety Leadership Group.

http://www.hse.gov.uk/comah/buncefield/fuel-storage-sites.pdf

EEMUA PUB N° 159 - User's guide to the inspection, maintenance, and repair of above ground vertical cylindrical steel storage tanks. January 2003. Engineering Equipment and Materials Users' Association.

EEMUA PUB N° 183 - Guide for the Prevention of Bottom Leakage from Vertical, Cylindrical, Steel Storage Tanks. January 2004. Engineering Equipment and Materials Users' Association.

RR760 - Mechanical integrity management of bulk storage tanks. HSE.

http://www.hse.gov.uk/research/rrpdf/rr760.pdf

Note: RR760 provides a summary of relevant codes and standards for the assurance of mechanical integrity in storage tanks. These provide an assessment of the most appropriate standards for different elements of maintenance and design of facilities.

14. APPENDICES

APPENDIX A - ASSESSMENT CHECKLIST

The following checklist is based on a very good rated atmospheric storage tank facility and can be used to assess the quality of that facility and identify any gaps or areas for improvement.

ELEMENT/FEATURE	CRITERIA
Containment	All tanks separately bunded and sized for 110% of capacity. Bund walls sized and designed to contain and prevent bund overtopping (may include tertiary containment).
Layout/Spacing	Meets risk-based tank spacing evaluation and risk evaluation available. Non-crude inter tank spacing equal to or greater than one diameter of largest tank and at least 15 metres. Crude oil tanks separated by five tank diameters to prevent risk from boilover.
Instrumentation	HLA, HHLA (totally independent includes tappings, transmitters, etc.) linked to automatic shutdown of feed. Temperature indicator. LLA, LLLA (independent) linked to automatic shutdown of pump out and complete with on-line diagnostic capability (i.e. not simple switch). Shutdown system and components SIL rated in accordance with application and location. All indicators to control room. Continuous mass balance system for tank farm. Online blending.
Construction	Double welded seals on floating roof. Weather shield. Concrete base with impervious membrane and sides sloped away from base weld. Anti rotation device on floaters. Earthing, lightning conductors. Good access to pontoons, and handrails on access walk way around periphery. Auto bottom water drain. Tank floor leak detection with double floor. Roof drainage: rainwater receptors and spill over connections to product (limits water level to 10").
Selection	As appropriate to class of product.
Drainage of Bunds	Grading to pump pit sump. Impermeable bund material.
Equipment and Pipework	Buried common inlet/outlet pipework and no equipment within bund area.
Bund Construction and Condition	No penetrations or gaps in the walls. Any gaps in bund walls should be sealed appropriately with a fireproof material. Concrete faced earth wall. Consideration given to preventing bund overtopping.
Gas Detection	Bunds fitted with flammable gas detectors for low flash point materials capable of sustaining a VCE. Detectors interlocked with tank filling system to interrupt transfer.
Fire Detection	Linear Heat Detection or fusible-link/ tube (for rim seals only). Systems are self monitoring with status indication to HMI (Human/Machine Interface).
Fixed Fire Protection - Floating Roof	Multi-head foam pourers with foam dam for all tanks. Shell cooling water spray, or use of multiple monitors with proof of response capability. Supply from two separate locations. Foam for bunded area. Fixed system supplies foam. Fixed radiant protection on exposed walls.
Fixed Fire Protection - Cone Roof	Subsurface foam injection (for non-polar compounds, otherwise foam chambers). Roof and shell cooling. Foam for bunded area - dual supply. Fixed systems.
Fixed Fire Protection - Cone roof with internal floater	Foam pourers. Roof and shell cooling; bund protection with foam - dual supply. Fixed system.

APPENDIX B - MECHANICAL COMPONENT CHECKLIST FOR FLOATING ROOF TANK INSPECTIONS

Cleanliness

- Debris on roof?
- Ponding or rainwater on roof?

Leakage

- Signs of oil or holes on roof?

Roof Drains

- Clogging of roof drain screen mesh?

PV Vent Mesh

- Clogging of PV vent mesh?

Emergency Roof Drain

- Clogging of emergency drain mesh?

Weather Shields/Seals

- Damage or corrosion?
- Excessive gaps between seal and shell?

Pontoon Compartments

- Presence of water or oil?
- Covers tight?

Earthing Cable

- Damage on cable or connections?

Guide Poles

- Damage on guide pole rollers?

Rolling Ladder

- Damage on wheel?

Roof Drain Valves

- Ease of movement?

Bottom of Shell

- Water pooling?
- Corrosion?
- Vegetation?

APPENDIX C - LOSS INCIDENTS

The application of the measures specified in this document should minimise the risk of a major accident occurring at a storage facility or individual storage tank.

The table below gives some examples of incidents that have resulted in loss of containment to illustrate that they should not be considered as rare events. Data has been compiled by a reputable operator in the USA that indicates that overfilling occurs once every 3,300 filling operations.

LOCATION	DATE	FUEL RELEASED	CONSEQUENCE
Jacksonville, Florida, USA	1993	Unleaded petrol/ gasoline	190 m^3 released. The spill ignited, leading to a major explosion and fire.
Coryton, UK	1997	Unleaded petrol/ gasoline	81 m^3 released. Spill contained within bund – no ignition.
Belgium	2001	Hexene	Approximately 90m^3 released. Spill contained within bund – no ignition.
Sour Lake, Texas, USA	2003	Crude oil	80 m^3 released. Spill contained within bund – no ignition.
Torrance, California, USA	2004	Jet fuel	Approximately 10m^3 released. Spill contained within bund – no fire or explosion.
Bayonne, New Jersey, USA	2004	Fuel oil	825 m^3 released. Oil contained on tank farm. – no fire or explosion.
Casper, Wyoming, USA	2004	Unleaded petrol/ gasoline	Up to 1270 m^3 released. Spill contained within bund – no ignition.
Rensselaer, NY, USA	2005	Unleaded petrol/ gasoline	0.4-4 m^3 released. Spill contained within bund – no ignition.

LOCATION	DATE	FUEL RELEASED	CAUSE	CONSEQUENCE
Fawley, UK	1999	Crude oil (400 tonnes)	Corrosion of tank base	No injuries or off-site effects. All of the oil was recovered from primary containment.
Milford Haven, UK	2005	Kerosene (653 tonnes)	Leak from damaged sump escaped through permeable floor of bund	No injuries, but nearby gardens, farmland, and stream contaminated. All wildlife killed in stream.
Antwerp, Belgium	2005	Crude oil (26,000 tonnes)	Catastrophic failure of storage tank as a result of corrosion	Overtopping of the bund wall occurred due to sudden release.
Plymouth Harbour, UK	2005	Kerosene (tonnage uncertain)	Corrosion of the tank base and a permeable bund base	No injuries. Kerosene entered into the ground.
Coryton, UK	2006	Gas oil (121 tonnes)	Tank overfilled, oil escaped from bund by defective drain valve	No injuries or harm to the environment.
Poole Harbour, UK	2006	Diesel oil (19 tonnes)	Diesel escaped through damaged base plate and through cracks in concrete bund floor	No injuries. Pollution of ground but not of the harbour.

Incidents with similarities with the Buncefield incident of 2005 are summarised below.

LOCATION	DATE AND TIME	COMMENTS – BACKGROUND	COMMENTS – EXPLOSION
Houston, Texas, USA	April 1962	'Severe leak' from gasoline tank. Almost windless conditions. Ignition near adjacent highway.	Described as a blast, but no details are available.
Baytown, Texas, USA	27 January 1977	Overfilling of a ship with gasoline.	Few details are available, but it is likely that there would have been congestion.
Texaco, Newark, New Jersey, USA	7 January 1983 After 00.00 hrs	Overfilling of a tank containing unleaded gasoline. 114-379 m^3 (80-265 tonnes) of gasoline released. Slight wind, ignition source 300m away.	Relatively uncongested area. High overpressure reported but not quantified. Three minor explosions preceded the main blast.
Naples Harbour, Italy	21 December 1985	Overfilling of a tank containing unleaded gasoline. 700 tonnes escaped. Low wind speed (2 m/s).	Relatively congested area. The tank overtopped 1.5 hours before ignition. Various overpressures estimated from damage analysis but they are minimum values (e.g. 48 kPa).
St Herblain, France	7 October 1991 04:00 hours	Leak of gasoline from a transfer line into a bund. Wind <1 m/s. 20 minutes delay, ignition in car park c. 50 m away. Volume of flammable cloud est 23,000m^3.	Presence of parked petrol tankers may have been sufficient to generate turbulence. High overpressures produced but not quantified.
Jacksonville, Florida, USA	2 January 1993 03:15 hours	Overfilling of a tank containing unleaded gasoline. 50,000 gallons (190m^3, 132 tonnes) released.	High overpressure produced but not quantified.
Laem Chabang, Thailand	2 December 1999 23:25 hours	Overfilling of a gasoline tank. Few details.	High overpressure produced but not quantified. Relatively low congestions in the area.

Below are statistics on the frequency of incidents taken from the LASTFIRE project, a group of operating companies sharing information on the prevention and protection of fires in large atmospheric storage tanks. This data is valid up to 2006 and should not be seen as comprehensive.

SPILLS AND INITIAL FIRE EVENTS

	LOSS OF CONTAINMENT			INITIAL FIRE EVENT				
	ONTO ROOF	SUNKEN ROOF	INTO BUND	RIM SEAL	SMALL BUND	LARGE BUND	SPILL ON ROOF	FULL SURFACE
Nº of Incidents	55	37	96	55	3	2	1	1
Frequency (x10-3/ tank year)	1.6	1.1	2.8	1.6	0.09	0.06	0.03	0.03

RIM SEAL FIRE FREQUENCY BY REGION

COUNTRY/REGION	NIGERIA	SOUTHERN EUROPE	NORTHERN EUROPE	NORTH AMERICA	VENEZUELA	THAILAND	SINGAPORE	SAUDI ARABIA
Nº of Fires	7	13	15	9	2	3	2	1
Tank Years	333	6,247	15,264	4,611	159	224	1,035	3,392
Frequency (x10-3/tank year)	21	2	1	2	13	13	2	0.3
Thunderstorm days/year	160	30	20	40	60	70	120	10

FULL SURFACE FIRE ANALYSIS

- One escalation in 55 rim seal fires (roof pontoons contained flammable vapour and/or liquid).
- One escalation in two bund fires impinging on tank shell.
- One escalation from a spill fire on a roof.
- One full surface fire in 37 sunken roof incidents.
- Escalation to two downwind tanks in one full surface fire (volatile fuel).
- One boilover in six full surface fires. Note: of the six fires, one was a crude tank which resulted in a boilover. It should always be assumed that a crude tank full surface fire will boilover.

THE ENGINEERING SERVICES TEAM

Marsh's Risk Engineering Services team has been established for over 25 years and is uniquely qualified to provide risk managers and underwriters with the essential information they need to determine the right limit and scope of cover and the right price.

Each member of the team is a qualified engineer, with practical experience in design, construction, operation, and maintenance across a broad range of oil, gas, and petrochemical risks.

They have all been trained in advanced insurance skills, in the ability to assess and analyse risk, and to communicate effectively and frequently in more than one language.

The goal is to build bridges between risk engineering, insurance and risk management, and between the client and the underwriter. At the same time, the comparative skills of the team permit a benchmarking system which gives a global opinion of the risk, assessed against peer plants world-wide.

From the earliest planning stage to the last operational phase, the engineering services team is able to contribute practical and cost-effective advice, and assistance.

In addition to tailored programmes, the team has a series of core packages, covering everything from managing a major emergency to risk reduction design features, and safe working practices.

The Engineering Services team uses its breadth of expertise, experience and its practical knowledge and skills to communicate a real understanding of physical risks, your insurance implications and the commercial operating environment.

For further information, please contact your local Marsh office or visit our web site at: marsh.com

BEIJING
Tel: +86 10 6533 4070
Fax: +86 10 8529 8761

CALGARY
Tel: +1 403 290 7900
Fax: +1 403 261 9882

CAPE TOWN
Tel: +27 21 403 1940
Fax: +27 21 419 3867

DUBAI
Tel: +971 4 223 7700
Fax: +971 4 227 2020

HOUSTON
Tel: +1 713 276 8000
Fax: +1 713 276 8888

LONDON
Tel: +44 (0)20 7357 1000
Fax: +44 (0)20 7929 2705

MADRID
Tel: +34 914 569 400
Fax: +34 913 025 500

MOSCOW
Tel: +7 495 787 7070
Fax: +7 495 787 7071

MUMBAI
Tel: +91 226 651 2900
Fax: +91 225 651 2901

NEW YORK
Tel: +1 212 345 6000
Fax: +1 212 345 4853

OSLO
Tel: +47 22 01 10 00
Fax: +47 22 01 10 90

PERTH
Tel: +61 8 9289 3888
Fax: +61 8 9289 3880

RIO DE JANEIRO
Tel: +55 21 2141 1650
Fax: +55 21 2141 1604

SAN FRANCISCO
Tel: +1 415 743 8000
Fax: +1 415 743 8080

SINGAPORE
Tel: +65 6327 3150
Fax: +65 6327 8845

Marsh is one of the Marsh & McLennan Companies, together with Guy Carpenter, Mercer, and Oliver Wyman.

The information contained herein is based on sources we believe reliable and should be understood to be general risk management and insurance information only. The information is not intended to be taken as advice with respect to any individual situation and cannot be relied upon as such.

In the United Kingdom, Marsh Ltd is authorised and regulated by the Financial Conduct Authority.