STORAGE TANKS

LARGE DIAMETER TANKS - (OVER 250 FT {76 M} IN DIAMETER)

Storage tank fire fighting with fixed systems is a calculated art with pre-defined processes. The devices used to apply foam to the burning fuel surface are fixed to the tank and if serviceable will put the finished foam directly where it is needed – on the fuel surface.

Fuel oil storage tank fires are few and far between, even though there are upwards of 650,000 above ground oil storage facilities, with more than 3 million individual storage tanks in the U.S. alone. With this quantity of tanks, the potential for fire exists, but based a review of statistics; the safety record is obviously very good. However, tank fires do occur and they can grow to become political and legal nightmares.

In the event of a fire in a large diameter tank without a fixed system, an alternative method of fire suppression must be sought. Current NFPA standards do not recognize the use of monitors on storage tanks larger than 60 ft. (18.28 m) in diameter. However, there have been successful extinguishments using monitors on tanks up to 190 ft. (57.9 m.) These successes have been achieved due to improvements in technology, larger capacity foam monitors, better application techniques and new more efficient foam concentrates. The logistics involved in this type of operation are quite extensive and must be preplanned, prior to the event. In other words, if the location of the fire is not supported by the appropriate resources it is necessary to consider the following factors, before the fire occurs.

- Personnel
- Equipment
- Water supply
    - °Foam Solution
    - °Cooling
- Foam concentrate

If there is a problem when using ground-based monitors, it is that they require a number of factors to be synchronized if total extinguishment is to be achieved. Since the device is not attached to the tank, a degree of accuracy is required to ensure that the foam stream actually lands inside the tank on the fuel surface. This is easier said than done, since ambient conditions, such as wind can adversely affect the stream range and accuracy. Thermal updrafts with speeds in excess of 70 mph (120 kmph) can also adversely affect the foam stream, carrying away the some of the foam bubbles. For these reasons, the application rate is increased over that used for fixed systems. A typical fixed system application rate for a fuel storage tank containing a typical hydrocarbon is 0.1-gpm/ft. (4.1 lpm/m.) When the same tank is attacked with ground based monitors the application rate is increased to 0.16-gpm/ft. (6.5 lpm/m.) In addition the foam concentrate run time is increased from 55 minutes, for a fixed system up to 65 minutes, when ground based monitors are used.

Using mobile, ground based equipment means that personnel are initially required to position and man this equipment. Additional personnel are then required to relieve those people, particularly in adverse weather conditions. In some cases, particularly in hot humid climates, firefighters can maintain a position on the fire-line for no more than 30 minutes at a time. Therefore, contingencies must be made for this eventuality.

Appropriate equipment that can produce the desired flow rate with enough range to actually reach the fuel surface is paramount for a successful extinguishment. In addition, the proper amount of foam concentrate accurately proportioned with water for the prescribed time will greatly aid in a successful event.

Unfortunately, it is not a perfect world, so other conditions such as wind, equipment failure loss of water and fire conditions can all generate problems for firefighters dealing with a large diameter tank fire.

Water supplies are critical, since without water, foam solution cannot be generated and the chance of a successful extinguishment dramatically reduced. Consideration must be given to adequate flow rate, pressure and quantity. Large volumes of water are required and this is typically delivered in 5 inch (127 mm) or larger diameter fire hose. This LDH (large diameter hose) is used to provide high volumes of water to the monitor nozzles with low friction loss in the delivery hose.

Cooling water should be used sparingly. This is perhaps obvious, but quite often ignored in the heat of a tank fire.

Cooling water takes away from the water supply required to fight the fire and may collect in a dike, thus causing overflow of the dike and a worsening of the overall incident. In other words, “floating” hydrocarbon fuel out of the collection area and spreading the fire into other areas of the plant or community.

In the event of a tank fire, there might be other tanks in the immediate vicinity that may be considered an exposure risk. In some cases, cooling of these exposures might be appropriate and can reduce radiant heat effect from the involved tank fire. Cooling water can be applied with monitors, but fixed spray systems attached directly to the tank are more efficient, since they apply an effective and even water film coverage over the whole surface area of the tank shell. NFPA 15 gives some guidance about the suggested applications rates.

Foam concentrate supplies are also critical. In all preplan teachings it is stated that if enough foam concentrate to achieve extinguishment in accordance with the design is not on-site, do not start to fight the fire. This is good, sound and accurate advice. Essentially, if the fire is not extinguished before the foam concentrate is exhausted, the fuel surface will eventually become fully reinvolved again. The minimum amount of foam concentrate required must support the fire fighting operations for the monitor at the design rate for 65 minutes. Where large diameter tanks are involved, this is a significant amount of foam concentrate and may require that supplies be obtained from a mutual aid organization.

The logistics of supplying foam concentrate, for a large fire, at the required rate, can be quite traumatic for the uninitiated. Supplies of foam concentrate for large diameter tank fires can be consumed at a rate exceeding one (1) 55 gallon (208 litre) drum every ten seconds. For the most part, supplies of foam concentrate for large diameter tank fires should be contained in nothing smaller than a 275-gallon (1,040 litre) tote, or more appropriately, supplied in an over-the- road tanker.

In the event extinguishment is to be attempted, it should begin as soon as possible, providing the logistics are available to support the operation. When large diameter tanks are involved in fire, the radiant heat output is significant and escalation of the incident, to surrounding plant or other tanks becomes a reality. Furthermore, extinguishment becomes more difficult due the longer pre-burns which produce increased fuel temperatures, buckling or deformation of the tank shell and if crude oil is involved, the real possibility of a “boil-over”.

Extinguishment of a large diameter tank fire does not end when the fire goes out. Once extinguished, the fire must stay extinguished, which typically means additional application or replenishment of the foam blanket. Quite often, more foam concentrate is used in post-fire operations, as is used in the actual extinguishment.

Large diameter tanks present additional risks with special considerations:

- Physical size
- Thermal updraft
- Foam loss
- Foam travel
- Water supply

Their physical size means larger surface areas with more heat radiation and faster thermal updrafts, both of which dramatically affect the performance of the foam being applied. NFPA 11 suggests that foam will only travel about 100 ft. (30 m) across a flammable liquid fuel surface. This is therefore a major consideration when planning for a fire in a tank where the diameter exceeds about 220 ft. (67 m) since the unanswered question is – will the foam fully cover a totally involved burning fuel surface.

In accordance with NFPA 11, the application rate when using mobile equipment for fuel oil storage tanks is 0.16-gpm/ft. (6.5 L/min/M.) However, large diameter tanks or tanks containing flammable liquids with a boiling point less than 100° F (38° C) may require higher application rates. Crude oils have a wide range of boiling points and may also require high application rates up to 0.2-gpm/ft. (8.1 L/Min/M.)

CALCULATION PROCEDURES

Typically, fuel oil storage tanks are round and to determine the amount of water and foam concentrate required the surface area of the tank must be calculated. To determine surface area, the formulae;

πr^2 is required.

Using a 300 ft. (91.4 m) diameter tank as an example, the following would be a typical calculation to determine water and foam concentrate requirements;

$$\pi \times (150 \times 150) = 70{,}686 \text{ sq.ft.}$$

While NFPA 11 suggests 0.16-gpm/ft., it might be prudent to select a higher application rate based on the physical size of this tank. So 0.20-gpm/ sq. ft. (8.1 lpm/m) might be more realistic;

70,686 Sq. ft. x 0.2 gpm/ft. = 14,138 gpm

Using a 3% foam concentrate means

424 gpm of 3% foam concentrate.

(That is eight [8] 55 gallon {208 litre} drums every minute.)

With a 65 minute rum time is;

27,568 Gallons of foam concentrate.

The water demand would be:

13,713 Gpm for 65 minutes =891,350 gallons of water.

COOLING WATER:

The amount of water required for cooling can be based on a number of application rates ranging from 0.05 gpm/ ft. (2.0 lpm/m) up to 0.25 gpm/ft. (10.2 lpm/m) of exposed steel surface. If a conservative rate of 0.1 gpm/ft. (4.1 lpm/m) is applied to about 50% of the vertical tank shell wall of an adjacent 300 ft. (91.4 m) diameter storage tank. This would mean the following calculation:

$$(\pi\ d \div 2) \times \text{Tank height}$$

$$(\pi \times 300 \div 2) \times 48 = 22,620 \text{ sq. ft.}$$

22,620 sq. ft. x 0.1 gpm/ft. = 2,262 gpm of cooling water

For 65 minutes = 147,027 gallons of cooling water.

Dealing with a large diameter tank fire involving a hydrocarbon fuel lends itself to the application of a low expansion foam from a non-air aspirating nozzle. This type of finished foam is very fluid and will cover the burning surface very quickly. However, the longevity of this foam is short, since the bubble structure, while deliberately weak, does not promote long foam blanket life.

Present technology utilizes large capacity non-aspirated straight stream/full fog nozzles, applying foam over-the-top of the tank shell with direct impingement to the fuel surface. This is probably the most violent of applications for a foam and can result in degradation or destruction of the foam blanket preventing total extinguishment. Tests have shown that when foam is applied from a stationary nozzle, the foam blanket can "swirl" around the fuel surface in a single direction and can get contaminated with fuel; char and then the foam blanket will effectively burn. This is particularly true with the highly volatile fuels, such as premium gasoline and to a lesser extent with diesel or the heavier fuels. To prevent this, it is suggested that some small oscillations of the nozzle are made, thus disrupting the "swirling" motion and allowing the foam blanket to be "wetted" and preventing the burning effect.

The foam of choice tends to be the alcohol resistant, aqueous film forming foam or AR-A.F.F.F. This particular foam concentrate has superior foaming qualities when compared to a regular A.F.F.F. concentrate due to the additional additives, which promote a more stable foam blanket. This stability is required of a foam blanket when applied to polar solvents, since part of the foam blanket is sacrificed to promote formation of the polymeric film on the fuel surface of an alcohol or water miscible fuel.

While there are commercially available monitors that have flow rates exceeding 15,000 gpm (56,775 lpm), which by themselves meet the application rate {(0.2 gpm/ft.) (8.1 lpm/m)} for the 300 ft. (91.4 m) diameter tank, it is perhaps prudent to use two or more smaller, yet more manageable monitors with lower flow rates to achieve the same result. Using the smaller monitors means that they can usually be placed in service very quickly, since conventional large diameter hose can be deployed more easily than extra large diameter hose.

By dropping two or more monitor streams onto the fuel surface in the same area produces an extremely high local application density on the fuel surface, which promotes a high degree of "foam-survivability" in a very hostile atmosphere.

POLAR SOLVENTS

There is little or no data available for large diameter tanks containing polar solvent fuels. However, it can be stated with some degree of certainty that the application rates for these risks will be significantly higher than those stated for hydrocarbon fuels. In view of these considerations Buckeye should be consulted to determine an appropriate application rate.

In some cases, the fire may not be confined to the tank; there may be a fire in the dike area, which can also involve the pumping or process equipment. In this case foam would be incapable of extinguishing three-dimensional fires, which may be under pressure or simply gravity-fed. These fires originate with flange leaks or manifold failures, which means a supplementary media such as dry chemical would be required. Several methods are available to deliver the dry chemical and these would involve simultaneous application with a twin-agent nozzle or applying the dry chemical with a water stream to gain additional distance. Foam will successfully extinguish the two-dimensional fire or fuel spill and dry chemical will effectively extinguish the three-dimensional fire.

There will continue to be advances in equipment and fire extinguishing agents for this particular risk and these improvements will be passed on to the user, such that they can improve their chances for a successful extinguishment.

There is however a responsibility of the end-user to methodically prepare for an incident involving a large diameter tank fire. It is necessary to prepare a proper pre-plan and test it! Promote regular training and maintain the equipment to ensure that it will function properly on the day. Then never forsake good safety and engineering practices, to minimize the risk and effectively "design-out" the catastrophe.