Foam concentrate usage and options

Note: The situation regarding current developments of firefighting foam and legislative controls on foam usage is changing constantly and rapidly. This document describes, to the best knowledge of the LASTFIRE Group, the situation at the time of writing, but neither the LASTFIRE Coordinators nor LASTFIRE Members accept any responsibility for the accuracy of the information in this document or for any use of the information presented.

Summary of Main Points

1. The LASTFIRE Group is committed to assessing new technologies which potentially provide more efficient foam application and hence less foam usage through performance based testing based on the principles of the LASTFIRE test.

   Any new application technology and/or new extinguishing agents must be able to demonstrate equivalent performance or a formal recognition shall be made that there will be an effect on extinguishing efficiency and that this has been shown to be acceptable through a Risk Assessment.

2. The LASTFIRE Group, having developed a best practice typical procurement specification for extinguishing performance shall extend this guidance to include operational and storage related requirements.

3. LASTFIRE members, whilst always committed to meeting local legislation, are also committed to putting measures and practices in place that minimise the possibility of offsite foam discharge or run-off, and associated firewater runoff, for foams of any type, in any circumstances as part of an overall commitment to minimising environmental consequences of their operations.

4. The LASTFIRE Group shall continue to work with other industry groups and monitor changes in legislation that effect the use of firefighting foams due to environmental issues but stress the commitment to minimising environmental damage whatever legislation is in place through containment of foam run off and developing practices that reduce foam usage.

5. LASTFIRE Members shall insist on full, independently certified, environmental and health effect data prior to procurement of any firefighting foam so that appropriate measures and policies can be put in place to minimise adverse effects. This is particularly relevant to any newly developed foam.

6. LASTFIRE Members shall review the effect of any foam concentrate used on or proposed for their sites on the efficiency and effectiveness of their Waste Water Treatment Plant and oily water separators.

7. LASTFIRE members, recognising the need to assure the performance of foam systems, shall develop and document test methods that minimise foam discharge without jeopardising the

integrity of the system. Where discharge of foam with the potential for adverse environmental consequences is unavoidable, the foam shall be contained and disposed of in an appropriate manner.

8. LASTFIRE members, being committed to realistic ongoing training of responders, shall use appropriate training foams with no fluorosurfactant content and overall reduced environmental effects but still apply appropriate containment and disposal policies where practicable based on full analysis of environmental data from the manufacturer.

9. The LASTFIRE Group is committed to ensuring that Scenario Specific Emergency Response Plans are in place for storage tank related incidents at facilities and that these will take into account the containment and eventual disposal of any foam solution or firewater run-off and recognise that management of these fluids will be necessary during events.

Position Paper and Commitments

1. Executive Summary and Overall Conclusions

This document is intended to describe the current situation regarding the availability and use of firefighting foam for storage tank related application, recognising ever increasing controls and restrictions due to concerns regarding the health and environmental effects of what have been previously regarded as, and proven to be, the most suitable extinguishing agents for the application.

LASTFIRE members are committed to minimising the environmental effects of their operations as well as ensuring safe operations, safe incident response strategies and reducing losses through fire incidents.

The ideal goal is to have an effective “drop-in” replacement firefighting foam having the same levels of proven performance for tank firefighting, similar proven shelf life and physical characteristics and minimal environmental impact. However, based on recent studies and test work carried out by LASTFIRE, this is not the situation currently although it is recognised that developments are ongoing. In any case it is not just proven firefighting effectiveness that must be considered before changing to alternative agents. It is also necessary to have guarantees regarding long term availability and acceptance as well as considering other aspects such as compatibility with existing stocks if required; suitability for use with site storage containers, application equipment and pplication rates; storage stability; appropriate physical properties to allow accurate proportioning or flow in piped systems; and mutual aid compatibility considerations. It is considered that whilst improvements in new formulations with apparent lower environmental consequences are occurring relatively rapidly, these have not yet reached the stage where extinguishing effectiveness for tank fires and all the other requirements mentioned here have been proven to consistently match that of earlier agents within commercially available products. This applies to both Fluorine Free and the new C6 fluorosurfactant based concentrates. In addition, the cost of changing to new agents might be significantly greater than implementing other measures such as providing better containment and having appropriate disposal protocols in place to limit environmental consequences so site specific conditions have an effect on the policy to be adopted for the long term.

The LASTFIRE Group await the final decisions on the various aspects of relevant legislation that is pending so that a definitive position is known and decisions for the long term can be taken.

The LASTFIRE group recognise the workload that this places on foam concentrate suppliers and is committed to working with them to ensure that appropriate firefighting agents are available for storage tank and general application. However, LASTFIRE has also seen cases where a manufacturer has changed a formulation in order to reduce environmental effects but has not made end users aware of this and the consequent potential effect on performance. This is not acceptable.

The LASTFIRE Group will constantly monitor ongoing developments and pending legislation. Meanwhile, policies and processes will be developed to minimise foam discharge and develop strategies through formal preplanning to contain firewater and foam run-off and dispose of them in a manner that does not result in any significant environmental effect wherever practicable. It is also recognised that in some cases a policy of Controlled Burn Down (CBD) might be the most appropriate option when comparing the environmental impact of this strategy, including effects of particulates and other emission impacts on local communities, with that of applying foam with, for example, release to groundwater and other local watercourses. Of course the main focus of efforts will, as ever, be on incident prevention. (See also Section 4)

LASTFIRE is currently developing an audit tool that allows foam users, recognising site specific local risk factors, to assess their current strategies for foam procurement, storage, usage, containment and eventual disposal in order to ensure that risk to the environment is as low as is reasonably practicable without jeopardising safety or extinguishing capability if that is the chosen strategy. This document will include extensive guidance on minimising environmental effects during testing and training as well as during incidents.

LASTFIRE members are committed to meeting any environmental regulations but will lobby authorities if they consider that any proposed controls have an impact on safety or are unreasonable or impracticable to apply within a specified time frame. In addition, members will lobby for a reasonable time frame for any required changeover – and this should be in the order of at least 10 years and without the need for change if it can be shown that a site has sufficient measures in place to contain all run off for credible incidents as identified in formal Risk Assessments such as those required under the Seveso directive in Europe. (In other words a change to an alternative foam concentrate would only be required when the existing concentrate has been used or has deteriorated to such an extent that it would no longer be effective.)

In particular LASTFIRE members have taken all appropriate steps to ensure that they no longer store or use foam concentrates containing PFOS on a global basis.

2. Introduction and Background

The LASTFIRE Group, a consortium of international oil storage companies and related associates reviewing and developing best practice guidance in storage tank fire risk reduction, is committed to minimising risk to life safety and the environment whilst also protecting their business in a cost effective and efficient manner.

The emphasis of Fire Hazard Management of all oil processing and storage companies is always on incident prevention through the implementation of design standards, process monitoring and control and operating practices. It must be accepted, however, that incidents, including fires, will happen, however infrequently. In the case of atmospheric tank related incidents these can range from small spill fires to multi – tank and full surface bund fires. For all credible events it is important to have a response strategy that minimises consequences, particularly to life safety and the environment, but also to company business, public concern and asset value. Response strategy can include, but is not limited to identification of ideal foam and ideal application rates and application methods suitable to the fuel. Developing a suitable response strategy will also reduce the risk of incident escalation and ensure the minimum quantity of foam and water resources are used, with minimal associated firewater runoff which could contain toxic or harmful components, and minimise collection and disposal costs.

The original LASTFIRE study, completed in 1997, concluded that tank fires should not represent an ongoing major life safety or environmental risk if managed to a preplanned and professional response strategy. The main risk in such incidents is to business and public image. This fact is often not realised when emotive discussions without a true background knowledge are held.

Ultimately the selected response is a site specific risk based decision in line with the procedure outlined in Energy Institute Model Code of Practice Part 19 – Fire Precautions at Refineries and Bulk Storage Terminals as shown in the diagram below.

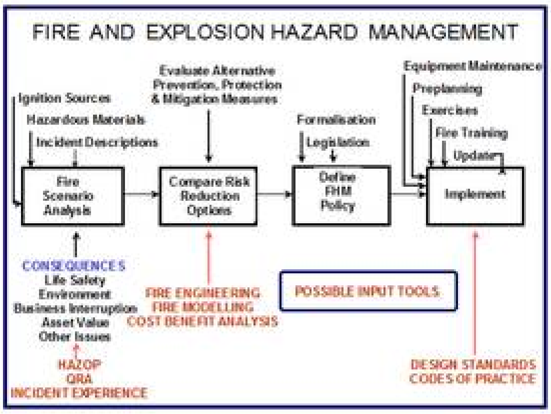


Figure 1 – The fire Hazard Management Process

This process does take into account that in some countries there are prescriptive requirements for levels of storage tank fire response capability.

For many decades one of the major mitigation risk reduction tools available to tank fire responders has been firefighting foam. More and more efficient foam concentrates have been developed along with improved methods of application – although of course the relatively low number of incidents means that field experience of actual application to major tank fires is also relatively low.

One particular development leading to a hugely significant increase in foam effectiveness was the introduction of fluorosurfactants which allowed greater flexibility in application techniques as the foam was able to resist fuel pick up when applied forcefully and had improved flow capability to improve speed of extinguishment (and a resultant reduction in risk of escalation).

An issue that has grown in recent years is the knowledge and understanding of potential adverse environmental and health issues associated with application of foam. This was highlighted in 2000 by the announcement of one major foam concentrate manufacturer, 3M, of their voluntary withdrawal from the market. It has been stated that 3M executives indicated their decision was based on their pursuit of responsible environmental management. The particular concern was one specific type of fluorosurfactant , known as PFOS, which had been found to be persistent, bioaccumulative and toxic (PBT). There had also been concerns, it is understood, of health effects on workers at PFOS production plants.

Since 2000 further concerns have been expressed about other fluorosurfactants, such as those known as PFOA based, and in some parts of the World restrictions on their usage have been introduced or are being proposed. Indeed, PFOS is already being POP listed under the UN Stockholm Convention [15], and has been banned from use in the European Union [17] and Canada [18] for some years. In particular the USA's Environmental Protection Agency introduced a stewardship programme to

- *commit to achieve, no later than 2010, a 95 percent reduction, measured from a year 2000 baseline, in both facility emissions to all media of PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals, and product content levels of these chemicals.*
- *commit to working toward the elimination of these chemicals from emissions and products by 2015.*

Of course there are many other chemicals other than fluorosurfactants in fire fighting foams, not all of them as rigorously studied for environmental impacts as fluorochemicals which usually account for 1-3% of the foam concentrate. Previously there have been environmental concerns associated with other chemicals commonly used in foam concentrates such as butyl carbitol (a Gylcol Ether) forcing manufacturers to modify formulations but these changes were not so significant as the possible reduction in performance with the removal of fluorosurfactants.

This situation has led to development of new products based on fluorosurfactant free and lower chain length fluorosurfactants claiming to be environmentally friendly – but, based on experience of LASTFIRE testing, the performance is not necessarily to the same level as the more conventional foam types. In the case of the lower chain length fluorosurfactants (such as "C6" foam types) this observation might not be directly caused by the use of different fluorosurfactants but by formulation changes for commercial or other reasons. Whatever the reason, lower levels of performance are being noted when critical fire tests such as the LASTFIRE test are carried out but they might not be noticeable in less demanding fire tests intended for spill fire application. It is therefore erroneous to state that new formulations are equivalent to the older types based on a relatively easy fire test intended for general purpose use. Critical fire tests, such as the LASTFIRE test for storage tank fire application, are available to establish performance on the small scale but, naturally, with new products end users like to have practical large scale experience too if possible. It is possible that a fire test validated by experience for earlier types of foam requires revalidation when different types are introduced but the test acceptance criteria should not be modified just so new formulations can pass as has been suggested in some cases.

In addition, it is not just fire performance and environmental concerns that are critical to effective usage – storage characteristics, compatibility with existing equipment, shelf life, dry chemical compatibility, physical properties and long term availability are all important parameters and it is essential that any decision on future policies, including, if necessary, changing all foam concentrate stocks to different types, must be based on a proper evaluation of all these aspects.

This Position Paper outlines the LASTFIRE Group's ongoing commitment to develop policies and practices supporting facilities operated by members in having incident mitigation practices in place appropriate to the risk, taking into account environmental consequences of the incident and the response to it as well as the commitment to constantly monitor developments and work with all interested parties, including legislators and suppliers, to ensure that new products and/or application techniques are appropriate to the industry needs.

3. Scope and Limitations

This document is intended as a summary of current issues related to the safe use and availability of firefighting foams and their effects on the environment. It is an attempt to clarify the situation for end users and set best practice, practical guidance on minimising the potential for harm to the environment but maintaining a capability to control and/or extinguish tank related fire incidents safely and efficiently.

It is not intended as a scientific review of foam constituents and their effect on the environment.

Whilst evert effort has been made to ensure the accuracy of this document, it is again emphasised that neither the LASTFIRE Project Coordinators nor LASTFIRE Members individually or collectively accept any liability/responsibility for the accuracy of the information in this document or for any use or unintended interpretation of the information presented.

With rapidly changing circumstances and legislation and limited performance and environmental effect information on new formulations of foam concentrates it is not possible to be definitive on which foam types will be the most appropriate for any specific facility or what foam concentrates will be available in the future. Currently it is therefore difficult to provide specific guidance on long term strategies for foam selection.

It is the responsibility of end users to ensure that they understand and meet any relevant local legislation including environmental protection regulations.

4. Response Strategies

Prior to outlining the current situation, it is appropriate to discuss overall policy options related to storage tank fire response.

The selected response strategies can be defensive through a “Controlled Burn Down” (CBD) approach (taking care to consider all potential outcomes, including release of harmful substances) or offensive through provision of response equipment or systems such as fixed foam application systems or mobile foam application packages using monitors, the final decision being based on local site conditions including the risk and the availability of resources from internal company and external sources. The options are represented schematically below in Figures 4.1 – 4.3.

Controlled Burn Down

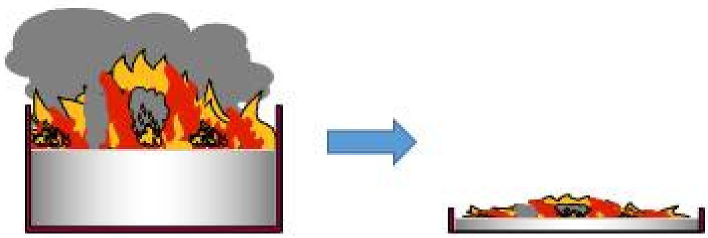


Figure 4.1a Schematic of Controlled Burndown Strategy

Figure 4.1b – "Before and After" photographs resulting from a Controlled Burn Down strategy

Although a policy of Controlled Burn Down might, at first sight, seem unacceptable because of issues such as large smoke plumes being created, the possibility should not be dismissed out of hand in all cases. Whilst it is generally speaking the natural reaction to attack a fire with the intention of extinguishing it, in practice the least environmentally damaging strategy might be to let the fuel burn out whilst ensuring that no escalation occurs by ensuring that adjacent tankage or other facilities are cooled as necessary. The UK's Environment Agency has long recognised that such a policy might be the best from an environmental point of view having published a report in 2000 entitled "Environmental Effect of Controlled Burns (Environment Agency Technical Report P388)" which recognises this, and suggests the "Best Practical Environmental Option" should be used to minimise environmental impacts.

Nobody wants a large smoke plume that can last for extended periods in the case of a tank fire but equally the environmental and health consequences should not be overstated. Extensive air quality measurements carried out during and after the Buncefield fire for the Department for Environment, Food and Rural Affairs and other organisations, and, for example, by the USA's EPA during the Magellan's Kansas City Tank Fire did not identify any significant widespread air quality effects at ground level.

It has been claimed also, by those with limited practical experience of firefighting, that Controlled Burn Down in the case of a tank fire results in greater contamination of firefighters' clothing with higher associated potential health consequences. Whilst recognising the importance of minimising exposure to harmful material, in reality taking a "passive" approach of Controlled Burn Down rather than an offensive extinguishment attack would normally mean lower levels of firefighter clothing contamination and, in any case, professional firefighters are trained in donning and removing protective clothing to minimise potential contact with harmful contaminants followed by appropriate laundering of the clothing.

System application

Figure 4.2 Schematic of Extinguishment by fixed system

In theory the use of fixed systems for tank fires or bund fires should result in fast, efficient extinguishing with full containment of the foam applied so that it can be treated and disposed of properly after any incident. In practice of course there are issues related to testing and assurance meaning that foam might have to be discharged outside the hazard being protected to avoid damage to plant or equipment. In any case, in many situations it is cost prohibitive to provide reliable fixed foam systems for every tank and bund. In addition, fixed systems are more prone to damage during a fire before foam application is started or possibly overpressures that might be developed in any explosion preceding the fire. This is more likely to be an issue with fixed roof or internal floating roof tanks than it is with open top floating roof tanks but in all cases it is important to include design features to minimise such effects.

Monitor application

Figure 4.3 Schematic of Extinguishment by Mobile monitors

The provision of high capacity mobile monitor packages to manage large tank related incidents has undoubtedly become widespread over recent years because of their flexibility and proven application, having been used to extinguish fires in tanks up to approximately 80m diameter with high performance fluorosurfactant based foam concentrates. This forceful application will encourage considerable mixing of foam with volatile fuels, which necessitates the foam being oleophobic or fuel shedding. The “monitor” application nozzles of the LASTFIRE test are designed to simulate this application.

Proven capability should be reflected in the risk assessment and choice of foam agent being used. In particular any demonstration claiming to show effective performance should be analysed in detail to ensure that it reflects appropriate “real life” conditions in terms of preburn time, application rate, application technique, fuel type etc.. This statement is particularly true for large diameter storage tank application with forceful application techniques and a requirement for relatively long foam travel over the burning liquid surface.

5. Foam Standards/Approvals

It is generally accepted within the fuels storage and related industries that the design standards to be used for assessing the application rates and quantity of foam concentrate required for any particular purpose are:

- National Fire Protection Association 11 – Foam Systems
- EN13565-2 - Fixed firefighting systems — Foam systems Part 2: Design, construction and maintenance

These are very similar, as would be expected. Both provide design data in terms of the minimum application rate of foam solution (foam concentrate mixed with water) to be applied per unit fire area and minimum discharge times to be provided. The main differences between the two standards are that in the case of large diameter storage tank full surface fires the EN document gives more definitive guidance for allowances for losses of foam from wind and thermal updraught effects, recommends increasing application rate requirements according to tank diameter and also recognises that foam quality is important in that higher application rate requirements are stated for lower quality concentrates.

In reality there has been very little extensive detailed test programmes to develop these standards so they are based on incident experience and a limited amount of test work but over a very long period so LASTFIRE recognises both these standards and considers them to be proven and validated as design rules for application of conventional foam systems. Because of the way they have been developed they include safety factors in terms of application rates to allow for various situations that might occur in a real incident. For example, a typical application rate for system application to full surface hydrocarbon tank fires is 4lpm/m^2. A good quality foam concentrate applied efficiently can extinguish a fire at 50% of this or less. It is though important to maintain a safety factor for real situations. Both standards can be considered to be prescriptive in terms of design rules although both standards contain a statement along the lines of:

> *Nothing in this standard is intended to restrict new technologies or alternative arrangements, provided that the level of safety prescribed in this standard is not lowered, and supported by documented evidence/test reports.*

However, as they are both based on prescriptive design rules rather than performance based rules, it is very difficult in practice to prove that a new development in foam application or a completely different type of system application is "equivalent" other than by large scale testing. This problem is compounded when it is recognised that several committee members of such standards are employees of foam system and foam concentrate supply companies and as such could have a vested interest in maintaining the status quo. LASTFIRE recognises this is a major problem for innovative solutions trying to demonstrate that they provide the same level of protection using novel application techniques but have worked with application equipment suppliers to develop test programmes to demonstrate equivalency and see this as an important part of developing improved response techniques with new foams or other extinguishing mechanisms.

6. Foam concentrate performance test

The LASTFIRE Group developed a performance based foam assessment test designed to reproduce real tank fire conditions and real application techniques on a small scale. This was done in recognition of the fact that common standard tests such as EN1568, UL162, MIL-F-24385C or CAP168 were designed primarily for general purpose use or a rapid rescue spill fire situation. For example, CAP168 is designed specifically to replicate the situation in aircraft crash fires where the obvious priorities are rapid knockdown and establishment of a secure access/egress capability for rescue purposes. The LASTFIRE Group therefore considered that a test specifically for tank situations where the priorities are secure extinguishment and burnback resistance are the priorities was required. The test protocol was based on initial work carried out by Mobil Research and Development and handed over to LASTFIRE for completion. A foam concentrate proven in large scale tests and real incidents was used as the benchmark and different application techniques based on current industry practice were included in the test. (System application simulating semi-gentle application of foam down the inner wall of the tank shell from a foam chamber/top pourer, semi-aspirated foam forceful application simulating non-aspirating "Big Gun" nozzle monitors and aspirated foam forceful application simulating aspirating monitor cannon application.) During the test development, foam characteristics from the small scale test nozzles were compared against those from typical equipment used in the industry to check that they represented real conditions.

Input to the test protocol and classification ranking was sought from tank operators, member company fire responders, external responders and manufacturers including organisations such as Angus Fire, Solbergs, Williams Fire and Hazard Control and the Rotterdam Europoort Unified Fire Brigade to ensure that all relevant parties thought that it was appropriate to the application.

Features of the test aimed specifically at simulating conditions at real tank fire incidents compared to previously available standard tests included:

- Longer preburn prior to foam application to provide hotter metal temperatures and test sealing capabilities of the foams
- Higher freeboard above fuel surfaces to allow high metal temperatures to build up
- Obstructions in foam travel to simulate tank distortion and issues such as partially sunken roofs
- Application techniques in line with available application equipment
- Application rates approximately 50% of design rates in the recognised Standards to provide a safety factor

A ranking system was developed based on firefighter application and concentrated on extinguishing efficiency but also included elements of vapour suppression and burnback resistance.

The test has established itself as the most relevant critical fire test for tank fires and is used in conjunction with more general tests such as EN1568 and UL162 as part of a detailed foam procurement procedure by many companies. However, it is recognised that with new foam concentrates with different mechanisms of operation it might be necessary to revalidate the test with larger scale experiments

The LASTFIRE fire test is intended primarily as a batch acceptance test for end users, with any test certificate relating purely to the sample tested, but has also been used by manufacturers as part of new product development testing. It is, specifically, not a generic certification test. The importance of this aspect has been highlighted by recent test experience as formulations change due to withdrawal of some constituents available to manufacturers because of environmental concerns. Specifically C8 chain fluorosurfactants have been replaced in many formulations with C6 chain types and in some situations there have undoubtedly been consequent changes in performance. This is not necessarily of course due to the C6 change in its own right but could be because of any formulation change for commercial or other reasons. In some cases it has been noted that the manufacturer has kept the same trade name for the foam concentrate but the fire performance is undoubtedly reduced compared with previous formulations. This is considered by LASTFIRE members to be a totally unacceptable practice as it can lead to a false understanding of the performance and the efficiency of foam attack with potential effect on the efficiency of the extinguishing efforts.

The comments above emphasise the fact that batch testing of the specific batch allocated for a particular order is critical in order to ensure that the concentrate delivered has the required performance and this is even more important with new formulations. In other words, factory testing of the batch destined for the order in question should be carried out. This might not be practicable or cost effective for small orders but experience has shown that it adds minimal per litre cost for bulk orders over 10,000 litres. LASTFIRE has developed a typical foam concentrate procurement specification that includes such features and can be adapted to any generic foam type. This document is currently being updated to include aspects such as accelerated ageing to demonstrate, as far as is practicable, extended shelf life which have become more critical with new formulations.

LASTFIRE, recognising that the current situation might require novel approaches, strongly supports the development of performance based standards that are based on practical requirements rather than prescriptive design standards. It is considered that the LASTFIRE test could be the basis for performance based testing of new developments for managing tank fires provided that similar safety margins between test rates and design rates are included. For example, a test could be developed to assess the performance of CAF (Compressed Air Foam) based systems for tank fires. Currently LASTFIRE is developing and implementing test programmes to evaluate the performance of new formulation foams on bund and tank fires. The intention is to verify small scale testing, such as the LASTFIRE test, with larger scale tests (e.g. 10m+ diameter tank fires).

Figure 6.1 Photos form latest LASTFIRE bund fire testing

It is also recognised that there are new developments other than foam based measures that have been proposed. These include the use of solid fire resistant spheres or glass beads applied to the fuel surface to prevent vapour emission. Whilst these have been shown to effectively control and extinguish test fires, it is considered that application techniques currently are not proven for large diameter tanks so further testing is required to demonstrate flow of the materials and practicability of application in large volumes or possibly developing hybrid solutions using combinations of products..

In addition, there have been, of course, proposed developments in tank structures, such as unsinkable, fire resistant floating roofs which could lead to only considering rimseal fires rather than full surface fires as design events for some facilities thus significantly reducing foam usage.

The LASTFIRE Group is committed to assessing new technologies which potentially provide more efficient foam application and hence less foam usage through performance based testing based on the principles of the LASTFIRE test.
Any new application technology and/or new extinguishing agents must be able to demonstrate equivalent performance or a formal recognition shall be made that there will be an effect on extinguishing efficiency and that this has been shown to be acceptable through a Risk Assessment

7. Foam Types and Properties

Foam has been the primary extinguishing agent for tank fires for more than 80 years and as would be expected there have been major developments in efficiency and effectiveness over that period. One major advancement was the introduction of fluorosurfactants meaning that it was no longer necessary to apply the foams very gently because the surfactants gave oleophobic (fuel shedding) properties to the foam whereas, before this development, foam plunging into the fuel picked up fuel and was degraded rapidly or burnt off as it resurfaced from submergence, which is of course now a potential risk when fluorosurfactants are removed from foam concentrates. (All foams perform more effectively with less forceful application but in reality is very difficult to achieve totally gentle application, even with effective fixed foam systems.)

In the past there has been great emphasis on the different generic families of foam concentrates – for example, fluoroprotein, aqueous film forming foam (AFFF), synthetic detergent etc. - and their relative merits, but, in reality, to the firefighter, what really matters is not what the foam is made from but what fire performance it can achieve.

Although extinguishing efficiency is obviously the most important property required from a firefighting foam, there are other properties which have an important role in safe, effective firefighting. These include:

- Efficient and effective vapour suppression
- Forming a reliable, and self-healing, cohesive blanket
- Ability to prevent fire re-establishing itself or permitting unexpected escalation – "burnback" resistance
- Heat resistance
- Ability to seal against hot surfaces and prevent edge flickers
- Stability
- Flowability
- Fuel resistance – oleophobicity, resistance to breakdown by volatile hydrocarbons (eg. Gasoline), and water soluble fuels (eg. Alcohols) etc.

In addition there are issues not related to firefighting performance that will have an impact on which concentrate is the optimum for any specific facility:

- Cost
- Potential single source restrictions
- Standardisation on site and across multiple sites if necessary
- Compatibility with other concentrates that might be used such as mutual aid resources
- Shelf Life, stability over time, with no gelling or phase separation issues
- Viscosity, ease and accuracy of proportioning and effectiveness of uniform mixing into the water stream using equipment n site
- Storage conditions – temperature range, use of compatible materials to minimise corrosion risks, etc.
- Usability in equipment on site – aspirating vs non-aspirating equipment, suitability for existing/ specified foam proportioning delivery systems (viscosity etc.)
- Long term avaialbility

The LASTFIRE Group has found that in some cases manufacturers have developed foam concentrates that give excellent extinguishing performance but have physical characteristics that make them impractical to use. This has been particularly true with the generic type of "Multi-Purpose" (Alcohol Resistant) Aqueous Film Forming Foams and Fluorine Free foams (F3) where, in the worst case, it has proved virtually impossible to get the liquid out of containers, particularly at low temperatures.

Thus, any foam concentrate procurement specification should not be limited to extinguishing performance only but also include guarantees related to storage conditions (usually recognising that the concentrate should be kept (and operated) within certain temperature limits) and suitability for use with equipment on site.

The LASTFIRE Group, having developed a best practice typical procurement specification for extinguishing performance shall extend this guidance to include operational and storage related requirements.

8. Environmental Constraints – pending legislation etc.

It must be recognised that discharge of any chemical has some environmental impact. For example, the UK's Water Resources Act 1991 S 85 (1) defines a pollutant as "any poisonous, noxious or polluting matter or any solid waste matter to enter any controlled waters." (Matthew Gable, UK Environment Agency, Senior Emergency Planner, June 2014 - Fire Fighting Foam and the Environment). This is a very broad definition which includes almost any substance not naturally occurring in the water course.

The potential for environmental damage by any foam type or any firewater runoff is now widely recognised as shown by the notice seen adjacent to a stream on the outskirts of London:

See also "Major Accidents to the Environment" published by Elsevier for case studies, and a 2014 article by the Environment Agency focussing on these issues".

The type of environmentally beneficial application of firefighting foam scenario depicted in some supplier's literature as below as an example cannot be regarded as the real situation.

It is therefore important to minimise the risk of foam of any type, either in its concentrated form or as solution, entering open water or being discharged to open ground. In tank fire situations this is, nominally, easier than with other hazards such as jetties. Secondary containment – bunding – is normally sized to take at least 100% of the contents of the largest tank and should contain most of any foam run off when applied to a tank. However, some foam application might fall outside the bunded area or the bund volume for some scenarios might not be sufficient to contain all firewater and foam application, particularly if higher than anticipated application rates are required or the foam is slower to provide control, or has a tendency to pick up fuel, with significantly larger volumes required to be effective. Therefore, it will be necessary to have strategies in place to divert and contain the run off to other areas such as adjacent bunds wherever possible, without releasing it to waste water treatment plants or separators that might not be able to accommodate the flows and volumes. (See Preplanning for Foam Usage below.) Such policies should be part of Scenario Specific Emergency Response Plans (SSERPs) and take account of such potential problems as contamination of other areas, unintended incident escalation or possible floating and movement of storage tanks or damage to other equipment or pipework in the bunds.

Legislation varies from country to country and although it is necessary to meet local legislation, this does not necessarily mean that best practice is achieved or that no environmental damage will be caused.

LASTFIRE members, whilst always committed to meeting local legislation, are also committed to putting measures and practices in place that minimise the possibility of offsite foam discharge or run-off, and associated firewater runoff, for foams of any type, in any circumstances as part of an overall commitment to minimising environmental consequences of their operations.

Currently, in most of the World, there is at least a commitment, if not actual specific legislation, to ban the use of PFOS containing foams. Those facilities that still have some should not use it but instead quarantine it prior to disposal through appropriate channels which normally means high temperature incineration.

When replacement of any foam occurs, it is recognised that thorough cleaning of all storage vessels and equipment is required, but this is even more critical where PFOS containing foams have previously been used in order to ensure that remaining residues do not create an unacceptable environmental consequence.

Typical advice regarding this can be found on:

http://www.netregs.org.uk/library_of_topics/emergency_response/pollution_incident_resp_plan/preventing_pollution_firefight.aspx

There is pending legislation and guidance being developed in some countries related to the use of other types of fluorosurfactants. In addition, one piece of legislation has been implemented – see (a) below.

Examples include:

a) Queensland, Australia Foam Policy.

This piece of legislation has now been implemented. The LASTFIRE Group has held webinars and workshops discussing it to understand it in detail and its consequences as it is possible it might be used as a template for other legislation elsewhere. A link to the document itself can be found at:

http://www.ehp.qld.gov.au/assets/documents/regulation/firefighting-foam-policy-notes.pdf

It is LASTFIRE's understanding that the main aspects of the legislation are:

- Foams containing PFOS must be withdrawn from service and replaced as soon as possible and no longer used in any situation.
- Foams containing PFOA & PFOA precursors are to be withdrawn from service as soon as practicable.
    - Stocks must be secured pending disposal. These materials are to be managed and disposed of as regulated waste
    - PFOA precursor compounds, and their higher homologues, including any compounds that potentially degrade or convert to PFOA, such as 8:2 fluorotelomer derivatives

- AFFF's are NOT banned: "Pure C6" fluorinated foam concentrates can be used
- However, the following requirements must be met:
    - C6 purity compliant foam (Earlier formulations based on or containing C6 fluorosurfactants are unlikely to be compliant)
    - No releases directly to the environment
    - All releases of PFC Foam (including C6 based) must be fully contained on site in impervious bunds (includes firewater, run-off)
    - All firewater, wastewater, runoff and other wastes must be disposed of as regulated waste
    - Includes correct disposal of contaminated soils.
- Fluorine Free Foams
- Must not contain any persistent toxic organic compounds
- Can be contained on site and disposed through:
    - Irrigation to land / Degrade in-situ / on-site ponds, or drains
    - Disposal to sewer / wastewater treatment plant
    - BOD and acute toxicity - same short term concerns as Fluorinated Foams
- Direct Discharge of fully biodegradable FFF foam is acceptable but:
- Direct Discharge to Land – keep 50m away from waterways where possible
- Direct Discharge to waterways – if full containment not possible (minimise impact)
- Limits set for classifying Readily and Fully Biodegradable:
- Firewater that contains significant levels of contaminants, such as hydrocarbons, chemicals or fire combustion products needs to be considered on a case-by-case basis.
- It is recognised that all firefighting foam / run-off has the potential to cause environmental harm
- Disposal of foam containing PFOS, PFOA, precursors & higher homologues
    - Disposal plan must be drawn up within 6 months.
    - Must not be used in activities that may result in their release to the environment on or off the user's site
- Foams / water containing fluorinated organic compounds must not be released to the environment
    - All PFC foam solution, run-off, tank clean out etc. must be captured in impermeable bunds.
    - Taken away and treated as regulated waste (cannot dilute)
    - Costs of soil and groundwater remediation
    - Cost / damage to unrelated industries
- Where a direct release to land and aquatic environment is unavoidable
    - Only fully degradable non-persistent foam can be used

- It is stated that "Short term acute impacts, even if locally severe, are far preferable to the potential for long-term impacts that cannot be remediated with persistent and possibly toxic contaminants."

Industry is currently assessing the practicability and cost of implementing this legislation.

b) European Chemicals Agency PFOA Restriction Report

European Chemicals Agency (ECHA) is continuing with their development and consultation on a proposal by Germany and Norway that would restrict the manufacture, use and sale of PFOA and PFOA-related substances.

Details can be found at:

http://echa.europa.eu/documents/10162/3b6926a2-64cb-4849-b9be-c226b56ae7fe

The initial proposal included a 2 ppb concentration limit for PFOA and related substances that cannot be achieved in the production of firefighting foam that contain fluorosurfactants, including C6 types, and would effectively ban the sale and use of fluorinated foams in the EU if not changed. Comments from industry, including a suggestion that the limit should be restricted to 1 ppm, were submitted and ECHA have issued a second draft.

In this second draft the limits were raised to more practical levels and a derogation for firefighting foams was included up to 1000ppb (1ppm) of PFOA and for each PFOA related substance. Comments are now being made with the foam manufactures generally accepting the new limits subject to some provisos and clarifications but others, notably the German environmental legislator strongly opposing them. At the time of writing this current document the period for comments was nearly finished and it is anticipated that ECHA will respond with a third draft or finalised document having given due consideration to them. If the original proposed limits were to be adopted then this, apart from them probably being so low that no proven detection process can detect within such a tolerance, would probably mean that firewater ringmain systems are above this limit due to past contamination and would of course lead to very high costs for disposal and clean up, if indeed this is practicable at all.

c) EPA SNUR on LCPFACs

The USA Environmental Protection Agency (EPA) has proposed a Significant New Use Rule (SNUR) on long-chain perfluoroalkyl chemicals (LCPFACs). This SNUR would act as a ban on the manufacture, import or processing after 2015 of LCPFACs, including C8 and PFOA based substances, for any new use and any existing uses that are not ongoing. It is intended to provide a regulatory backstop to the US EPA 2010/2015 PFOA Stewardship Programme – see:

http://www.epa.gov/oppt/pfoa/pubs/stewardship/

This programme calls for fluorosurfactant manufacturers to:

- Commit to achieve, no later than 2010, a 95 percent reduction, measured from a year 2000 baseline, in both facility emissions to all media of PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals, and product content levels of these chemicals.
- Commit to working toward the elimination of these chemicals from emissions and products by 2015.

Because of this SNUR, foam manufacturers are transitioning to C6 based fluorosurfactants instead of C8 based materials. Progress reports can be found on the website referenced above.

As proposed, the SNUR would be expected to have minimal impact on the production and use of fire fighting foams as once all current foam manufacturers have fully transitioned to the use of only short-chain (C6) fluorochemicals, the SNUR would effectively stop anyone else from manufacturing or importing fire fighting foams that contain LCPFACs by requiring them to notify EPA prior to undertaking the activity.

d) Environment Canada

Environment Canada has proposed regulations on PFOA and LC-PFCAs (C8) which would prohibit the manufacture of AFFF containing LC-PFCAs, but would continue to allow the use, sale, and import of AFFF containing LC-PFCAs

From the above it can be seen that although there is a considerable amount of pending legislation related to fluorosurfactants containing foams for storage tank application, the only major specific regulations, other than general environmental protection measures already in place, currently relate to PFOS containing concentrates which should have been removed from service and disposed of correctly several years ago in most of the World. However, it does appear that, as more and more pressure builds, at some stage there will be some restrictions on the use of fluorosurfactants containing foams over and above those existing for all foam concentrates. At that stage cost-effective remediation options like adsorption onto modified clays from firewater run-off may need to be considered. Over one million litres of contaminated water containing PFOS and PFOA from Defence sites has successfully been treated in Australia using this modified clay technology, and it has removed fluorochemicals to below the reporting level of 5ppb24-25.

e) Norway

In June 2014 the Norwegian Ministry of Environment implemented a restriction on the manufacture, import and export of PFOA and related to liquids such as foam concentrates this level was set at 0.001%, equivalent to 10mg / Kg. Norway appears to be a strong proponent of reducing levels of all PFCs to negligible levels.

f) Denmark and Sweden

Sweden and Denmark both have national “chemical action plans” for evaluation of hazardous chemicals including perfluorinated chemicals.

A detailed survey by the The Danish Environment Agency of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl substances states, regarding short chain C6 fluorotelomer surfactants, ” The short-chain homologues have a better toxicological profile and do not bioaccumulate to the same extent as the long-chain substance as they are excreted more rapidly from both humans and organisms in the environment, but they are still persistent in the environment. The short-chain homologues and their precursors (e.g. fluorotelomers based on short-chain fluorochemistry) generally seems to have a better human health and environmental profile than the substances based on long-chain fluorochemistry, but it is difficult on the current knowledge to assess to what extent nonfluorinated substances could be alternatives of less concern to the long-chain PFASs for some applications.”

It also concludes that “Many of the non-fluorinated alternatives are not very persistent and bioaccumulative, but some of them are more toxic than the PFCs. However, there is a lack of public data on the properties of the non-fluorine alternatives to the PFCs, which often are protected by commercial secrecy, and because most academic research has been on the polyfluorinated chemicals".

g) CONCAWE

CONCAWE have published a document related to the Environmental fate and effects of poly- and perfluoroalkyl substances (PFAS) specifically aimed at fire fighting foams.

It is available for download on theCONCAWE website

https://www.concawe.eu/uploads/Modules/Publications/rpt_16-8.pdf

It can be seen that the position related to the introduction of legislation is still not definite in most cases. LASTFIRE will continue to monitor the situation.

h) EN1568

EN 1568 – a foam performance standard test protocol. Primarily intended for general purpose foam application assessment is currently being revised. It is likely that the next revision, due for publication in 2018, will incorporate a section related to environmental issues and provide guidance on requirements for a standardized minimum level of environmental data to be provided by suppliers.

The LASTFIRE Group shall continue to work with other industry groups and monitor changes in legislation that effect the use of firefighting foams due to environmental issues but stress the commitment to minimising environmental damage whatever legislation is in place through containment of foam run off and developing practices that reduce foam usage.

9. Environmental Data

There are many aspects of environmental effects that require analysis before being able to determine appropriate application, usage, spill cleanup and disposal of any foam concentrate and foam solution made from it. Environmental effect experiments are expensive to carry out and it has been noticed that not all manufacturers provide sufficient information to enable detailed review.

At a minimum, the following data should be provided in order to allow environmental specialists to make an informed opinion on the necessary measures that should be introduced to procure, store, test, use and dispose of a foam concentrate or foam solution in a responsible manner, recognising that the foam must have already demonstrated the ability to extinguish fires efficiently prior to this analysis:

- DO - Dissolved Oxygen, the amount of free oxygen available for organisms
- BOD - Biological Oxygen Demand - the loading placed on the DO by organisms in the water body
- Persistence in the environment
- Bioaccumulation
- Toxicity
- COD - Chemical Oxygen Demand- the loading placed on the DO by chemicals in the water body with a 28 day Biodegradability BOD/COD >65% Persistence - Under REACH the threshold for persistence in fresh/estuarine water is a half-life of >40days and for marine waters is a half-life of >60 days40.
- Bioaccumulation - Under REACH the preferred experimental conditions for BCF test are those reported in the OECD 305 guideline. The threshold for bioaccumulation uses the

BioConcentration Factor threshold of BCF > 2000 L/kg (whole organism weight) = 3.3 in Log unit41. This increases to BCF > 5000 L/kg = 3.7 in Log unit as a threshold for very Bioaccumulative.

- Aquatic toxicity – The OECD Test Guideline TG203/C.1 allows conducting a limit test, where fish are exposed to a single concentration (100 mg/L). If no mortality is observed at this concentration it is concluded that the LC50 is greater than 100 mg/L and in consequence the substance not toxic to fish42. REACH threshold for Chronic Ecotoxicity is <0.01mg/L 41

Such information must be provided based on certified test results for recognised laboratories. It is also important to have sufficient data to ensure that all protective measures for firefighters or others handling the product are in place to minimise any short or long term health effects.

This requirement applies to all proportioning grades of foam concentrate. For example, it would be anticipated that if mixed at the correct proportioning rate, the final solutions of different grades (1%, 3% 6%) would have the same environmental effect per litre but this would still require verification through testing of each concentrate in its own right.

LASTFIRE Members shall insist on full, independently certified, environmental and health effect data prior to procurement of any firefighting foam so that appropriate measures and policies can be put in place to minimise adverse effects. This is particularly relevant to any newly developed foam.

10. Effect on Water Treatment and Separators

It has been noted that the constituents of some foam concentrates, particularly strong detergents, emulsify fuels in such a way that efficient operation of oily water separators does not occur, thus allowing fuel to pass through into the separator discharge. As there are various waste water treatment plant processes it is also possible that new foam concentrate constituents will have an adverse effect on their operation.

LASTFIRE Members shall review the effect of any foam concentrate used on or proposed for their sites on the efficiency and effectiveness of their Waste Water Treatment Plant and oily water separators.

11. Foam Concentrate Developments

Over recent years there have been two major focus points for manufacturers:

- Changing fluorosurfactants based products to C6 types rather than C8
- Development of Fluorine Free foam

Recent LASTFIRE testing has shown that some manufacturers have not been able to achieve the same levels of performance with C6 based product, for whatever reason, as they had with C8. It has also been noted that in some cases involving Batch Acceptance Testing the performance of the foam concentrate has not been the same as was previously seen, even though exactly the same name has been on the containers. It is suspected that is because formulations have changed – specifically to incorporate C6 fluorosurfactants - and the manufacturer has maintained the name of the concentrate. Such actions are considered totally unacceptable by LASTFIRE. Of course this reduction in performance might have been due to other reasons but it emphasises the need to batch test foam concentrates rather than rely on generic certification. This has always been the focus of the LASTFIRE test as described previously although sometimes manufacturers claim “LASTFIRE Approval” based on a previous test result, although no such certification exists.

It has been noted that at a recent international conference one manufacturer stated that changing to a C6 formulation meant either a reduction in performance r an increase in price. Manufacturers are obviously under pressure to remain competitive as well as produce highly efficient products. LASTFIRE recognize that in some cases there will be a balance between cost and performance.

Regarding experience with Fluorine Free (FF) foams, LASTFIRE testing has undoubtedly shown that improvements in formulations have occurred since their introduction although, as yet, no commercially available fluorine free foam has shown the same level of consistency or high performance that had become the norm with good quality Multi-purpose AFFFs or Fluoroprotein foams. One typical issue that has been noted with some FF foams is the tendency for small flickers of flame to occur for extended periods of time some distance (50-150mm) from the test tank wall. Although not proven, it does appear to be some constituents of the foam itself burning and the effect has been most noticeable when the test is carried out using seawater to make the premix. These flickers reduce the overall scoring in the test and in some cases cause a “FAIL” classification because they continue to burn even when the total test period is completed. With the more conventional foams there are sometimes flickers of flame where the foam does not form a good seal against the tank shell but these are from fuel vapours.

In practice the continuous burning observed with some FF foams and indeed some new C6 formulations, might not be a problem as tactics could be adopted to agitate the foam that is still burning by additional application of foam and so gain full extinguishment. However, ideally all flickers should self-extinguish and, in order to incentivise manufacturers to achieve further improvements, there is no intention currently to alter test criteria.

It must be noted that these comments refer to tank fire application.

Unsurprisingly, neither the newer C6 based nor the Fluorine Free formulations have been proved in real large diameter tank fires as such incidents are very rare. The LASTFIRE test is designed to simulate true fire conditions and the benchmark for achieving good results was based on a foam type proven in major incidents. Provided that application methods and recommended foam solution application rates remain the same then the test should still be a good indicator of performance in real incidents but if application techniques or rates change then changes will be required in the protocol. In any case, the new formulations should still be subjected to larger scale tests

As part of the assurance process, the LASTFIRE Group has, as standard, adopted the policy of testing foams that claim to be Fluorine Free for fluorosurfactant content. In one case significant levels were found. This might have been due to contamination at the factory rather than a deliberate attempt to mislead, but once again shows the need to check manufacturers’ data and demand independent certification wherever possible.

Overall it is concluded that to date no new development either of C6 based or FF formulations has been able to achieve the same levels of extinguishing performance demonstrated by previously proven high quality concentrates for tank fire application. (It is emphasized that not all the older formulations on the market could be considered as high quality.) However, the developments that have been achieved, as shown through LASTFIRE testing, are encouraging. The ideal situation would be that equivalent performance can be achieved so that current application rates and application equipment can be used with confidence.

It should be noted that some FF foams have exhibited very long drainage times using conventional foam making equipment and even greater stability using CAF systems, which, provided that the foam is not too stiff to travel over a fuel surface, could offer very significant advantages in terms of longer term vapour suppression and a reduction in the amount of foam required to continuously "top up" a foam blanket after extinguishment has been gained.

One concern regarding the introduction of newer formulations is that they are brought to the market without sufficient testing to guarantee long term stability. At least one manufacturer has recalled some products on finding that some batches separated over a period of time.

12. Testing of Foam Systems and Equipment

It is obvious that having installed a foam system or procured foam equipment it is critical to ensure that it is performing in accordance with its specification. The main aspects of Foam Systems assurance, as described in the International Oil and Gas Producers Association guidance on Fire Systems integrity Assurance (http://www.ogp.org.uk/pubs/304.pdf) are:

- Response time
- Application method
- Foam Quality produced
- Expansion
- Drainage Time
- Proportioning Rate
- Application Rate
- Foam Coverage/Spread
- Duration of Discharge
- Vapour Suppression
- Suitability of Concentrate Type

It is important to specify equipment and system components that can be tested without uncontained discharge of foam wherever possible but it is obvious that not all these criteria can be tested without full discharge.

Ideally it should be possible to discharge test the system using the foam that is used on site and contain any discharged foam and dispose of it appropriately although this could be expensive and not be practicable in all cases.

End users should therefore develop maintenance and test procedures that test systems such that they are confident that they will work effectively when required. For example, it might, based on site specific requirements, be sufficient to test the following aspects of a rimseal foam pourer system and be satisfied that it will perform sufficiently effectively in a real incident, especially if it had been fully discharged for commissioning tests as it should have been:

- Foam concentrate extinguishing performance to a recognised standard such as LASTFIRE under controlled conditions
- Physical properties of foam concentrate on an annual basis to demonstrate that no significant deterioration has occurred
- Type certification of the pourer by a recognised authority (e.g Underwriters Laboratories) with manufacture to acceptable QA/QC standards
- Regular flow testing of the system with water to demonstrate no blockages

- Regular routine checks of foam generator air inlets and check that air suction is achieved during water tests
- Proportioning rate checks using a more environmentally benign product having the same physical characteristics as the real foam under system operating conditions*.
- A regular visual check of the integrity and drainage capability of the foam retaining dam
- Competency, availability and safety of manual back up for foam application in case the system fails to completely extinguish the fire.

* Details of a typical method of using environmentally benign "surrogate" foam concentrates to check proportioning rate accuracy can be found at:

http://www.vectorfire.net/PS%20Support/Planit%20Safe%20Test%20Procedure%201-05.pdf

The Firefighting Foam Coalition in USA has published their "Best Practice Guidance for Use of Class B Firefighting Foams" that also endorses the use of surrogate concentrate, training foams or water equivalency as a method of avoiding fluorinated foam use for system testing, vehicle testing and calibration, plus staff training.

Alternatively, training foams might be used provided that they have the same physical properties as real concentrates and that they have been fully assessed for environmental consequences.

LASTFIRE members, recognising the need to assure the performance of foam systems, shall develop and document test methods that minimise foam discharge without jeopardising the integrity of the system. Where discharge of foam with the potential for adverse environmental consequences is unavoidable, the foam shall be contained and disposed of in an appropriate manner.

13. Training

There are training foams available that are claimed to have lower environmental effects than actual firefighting foams. However, it is understood that in some cases these are just weaker solutions of the same chemicals.

It is therefore necessary to still obtain full data from a manufacturer to assess the need or otherwise for containment and ultimate disposal. Ideally the foam should demonstrate similar or lesser firefighting performance than the real concentrate so that responders still have realistic training.

One option might be to use a concentrate without any fluorosurfactants content for training purposes but maintain current stocks for real incidents.

LASTFIRE members, being committed to realistic ongoing training of responders, shall use appropriate training foams with no fluorosurfactant content and overall reduced environmental effects but still apply appropriate containment and disposal policies where practicable based on full analysis of environmental data from the manufacturer.

14. Changing Foam Concentrate

In the event that a site, for whatever reason, decides to change a foam concentrate, it is not just the general firefighting effectiveness that must be considered. Other aspects that must be addressed include:

- Thorough cleaning of storage vessels and/or equipment to ensure removal of old stock

- Verification that long chain residues in the cleaned tanks are below the 1,000ppb ECHA restriction level, particularly when F3 agents are being used
- Safe disposal of any remaining residue
- Compatibility of new concentrate with on-site storage containers and storage conditions
- Compatibility of new concentrate with existing fuels on-site
- Compatibility with system materials (valve seals, pipework etc)
- Proven effectiveness with site water – fresh, brackish, salt etc.
- Effect on proportioning rate and any adjustments that might be required to pumps, orifice plates etc.
- Suitability for use with application equipment – aspirating, non-aspirating, forceful, gentle, etc.
- Full environmental and health effects data to establish containment, clean up, health and safe usage issues
- Effect on wastewater treatment plants. (Some new agents, for example, might cause emulsification and effect operation of separators, some may be substantially more toxic than others.)

It can thus be seen that it is not just a case of a drop-in replacement although some manufacturers might try to persuade end users that this is the case. Another commercial concern is the long term availability of the new product. With such a rapidly changing industry and increasing environmental restrictions it is important to ensure that the product will be available for a reasonable period of time. The current situation is similar to that occurring when Halon firefighting agents were withdrawn from service. Immediately many alternative agents were marketed, often claiming to be drop-in replacements. Many of these have subsequently been withdrawn either because of new restrictions or commercial non-viability.

15. Public Concerns

It is known that in some areas there has been considerable public concern related to run off of contaminated water containing firefighting foams, particularly when measurable levels of contaminants associated with firefighting foam have been detected in waterways and reservoirs. This has predominantly been focussed on PFOS and PFOA as emerging contaminants of high concern. These have also mostly been associated with run off from training facilities, particularly related to those defence and aviation related incidents or training where there tends to be greater regular usage than in tank terminals. Examples of this and related information can be found at the following websites:

http://www.gov.gg/pfos

http://www.abc.net.au/local/stories/2011/09/21/3322890.htm

Such concerns emphasise the need to contain spillages or firewater run-off on site. It is understood that in some cases legal action is being considered.

16. Preplanning for Foam Usage

Scenario Specific Emergency Response Plans (SSERPs) have long been recognised as a vital part of risk reduction. This is an approach emphasised in Energy Institute Model Code of Practice Part 19 – Fire Precautions at Refineries and Bulk Storage Terminals. Typical templates are provided that can be modified to suit local requirements. Previously SSERPs for storage tank applications have tended to concentrate on application of foam to the fire with associated cooling of exposed surfaces including adjacent tankage. A critical part of developing SSERPs has been the quantification of foam concentrate and water requirements using Calculation Sheets based on typical standards such as NFPA 11 for foam flow and total quantity requirements and EI 19 for cooling of adjacent tankage.

In practice there has not been so much consideration of what happens to the foam or contaminated firewater after application. Generally speaking it has been assumed that this will be held in the surrounding bund or in the tank itself and then treated in Waste Water Treatment Plants. There has been little or no formal analysis and quantification of the capability of site systems to cope with this.

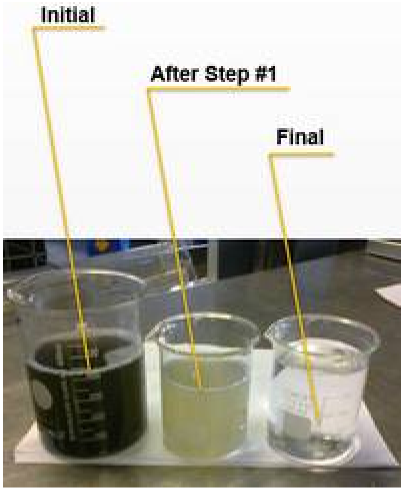
The Buncefield incident in 2005 in particular highlighted the need to consider foam and firewater run-off and containment as part of preplanning for tank related incidents. During the Buncefield event there was a debate regarding the pros and cons of mounting an extinguishing attack, recognising that whilst every effort was to be made to reduce uncontained offsite runoff there would be some with associated environmental consequences. During the Buncefield event contaminated foam/water runoff was pumped to an adjacent storage terminal and contained in bunds – a policy which in itself was not without risk as tank foundations might have been jeopardised or, in the extreme, tanks could have floated off their pads. Of course contamination of the bunds occurred but contained the run-off so that it could be dealt with after the event. Despite these precautions and best efforts there was considerable offsite run off and environmental damage.

It is therefore now recognised that SSERPs should consider foam/firewater run-off containment, potential remediation to reduce impacts and concentrate contaminants into smaller volumes prior to and, indeed, post incident disposal.

The LASTFIRE Group is committed to ensuring that Scenario Specific Emergency Response Plans are in place for storage tank related incidents at facilities and that these will take into account the containment and eventual disposal of any foam solution or firewater run-off and recognise that management of these fluids will be necessary during events.

17. Foam Contaminated Firewater Treatment

Incineration of contaminated firewater is, as would be expected, very expensive. A process has been developed whereby the fluorosurfactant contaminants are separated from the water, thus reducing the overall quantity of material that is to be incinerated and consequently reducing the cost. This involves a two stage process of initial electocoagulation followed by reverse osmosis. It has been used after actual incidents to clean up firewater run-off. There are a number of other remediation options available including granular activated carbon, reverse osmosis, membrane or nano-filtration, ion exchange or mixtures of these technologies, and adsorption onto modified clays has successfully treated well over 1 million litres of fluorinated surfactant run-off water in Australia removing PFOS and PFOA contaminants down to below the reporting level of 5ppb, and appears to be relatively cost-effective24. A similar adsorption clay product mixed with activated carbon has also been shown to be capable of remediating fluorinated soils and waste water25. It should of course be remembered that in practice such run off is likely to contain other contaminants such as unburnt fuel. The process could also possibly be used to reduce the amount of material for incineration from foam concentrate if required although this has not been investigated in any detail. The picture below shows the contaminated run-off after the two stages of the process.



Further information on the process can be found at the following website:

http://www.researchgate.net/publication/232412442_Purification_of_firefighting_water_containing_a_fluorinated_surfactant_by_reverse_osmosis_coupled_to_electrocoagulationfiltration

18. Useful Reference Sources and Further Information

- US EPA - Perfluorooctanoic Acid (PFOA) and Fluorinated Telomers

http://epa.gov/oppt/pfoa/pubs/faq.html

- The JOIFF Standard on Foam

http://joiff.com/docs/GuidelineonFoamEnglish.pdf

- US CRC Care Case Study related to firefighting foams and ground/water contamination

http://www.crccare.com/case-study/fighting-fire-fighting-foam

- Access to document Fire Fighting Foams with Perfluorochemical – Environmental Review by Dr Seow of Department of Environment and Conservation, Western Australia

http://www.hemmingfire.com/news/fullstory.php/aid/1748/The_final_definitive_version_of__91Fire_Fighting_Foams_with_Perfluorochemicals__96_Environmental_Review_92,_by_Dr_Jimmy_Seow,_Manager,_Pollution_Response_Unit,_Department_of_Environment_and_Conservation_Western_Australia.html

- Information on incidents that have led to ground or water contamination and possible clean up issues

http://www.hemmingfire.com/news/fullstory.php/aid/1961/Foam:_the_cost__96_and_still_counting!.html