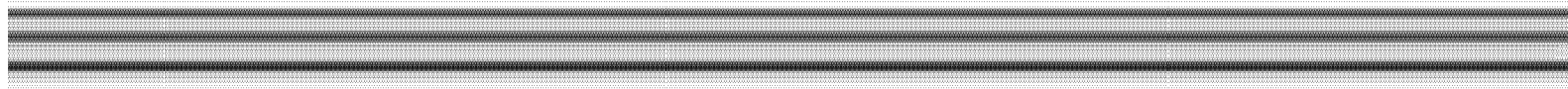
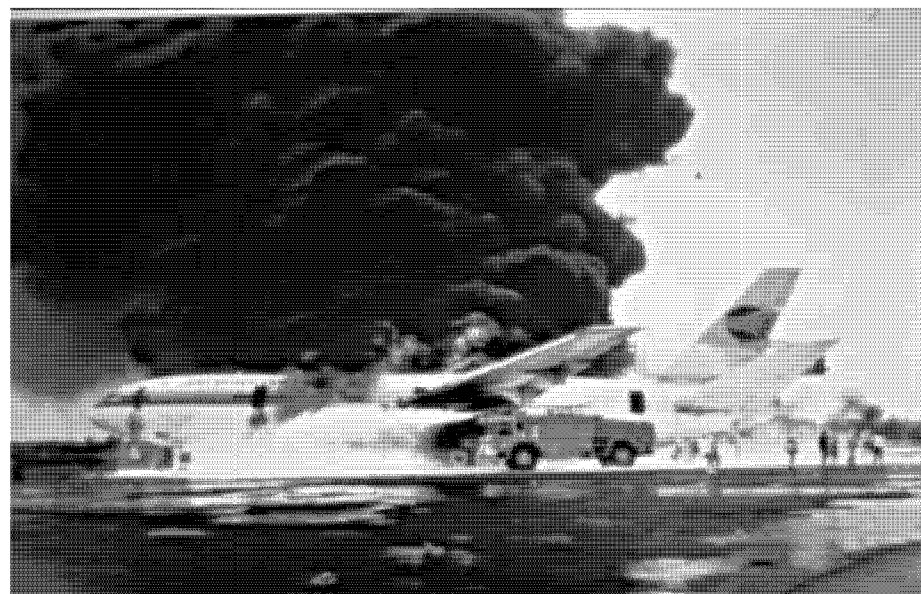
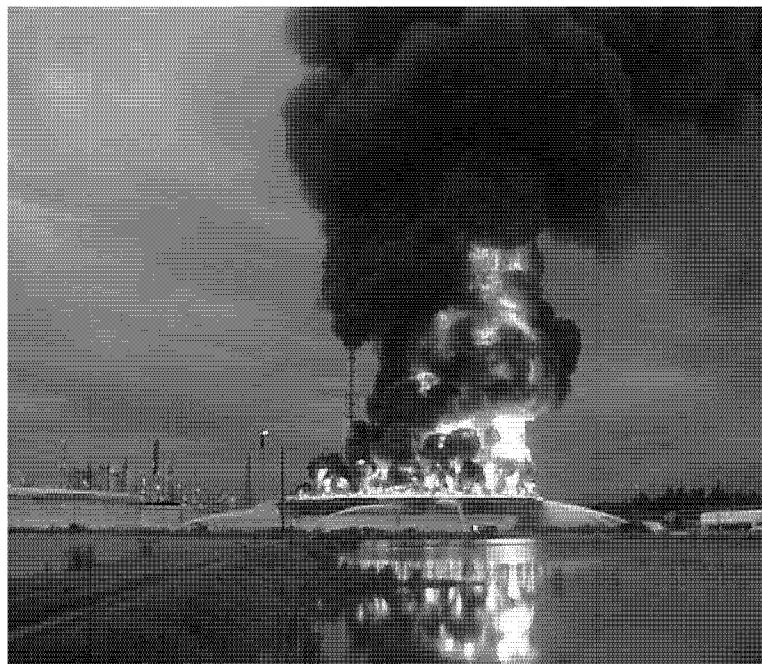


Environmental and Regulatory Update on Fire Fighting Foams

***Tom Cortina
NFPA World Safety Conference
June 2, 2008***



Overview

- **Fire Fighting Foam Coalition (FFFC)**
- **Background**
- **PFOS Regulations**
- **Perfluorocarboxylic Acids (PFCAs)**
- **EPA Global Stewardship Program**
- **Perfluorohexanoic Acid (PFHxA)**
- **6:2 Fluorotelomer Sulfonate (6:2 FtS)**
- **Aquatic Toxicity**
- **Alternative Fuels**
- **Wastewater Treatment**
- **Minimizing Emissions**



Fire Fighting Foam Coalition

- **FFFC is a non-profit corporation that was formed to represent the AFFF industry's interests on issues related to the environmental acceptability of fire fighting foams**
- **The coalition provides a focal point for industry technical reviews, development of industry positions, and interactions with the EPA and other relevant organizations**
- **Members are AFFF manufacturers, fluorosurfactant manufacturers, and distributors**



Fire Fighting Foam Coalition

- Board members of FFFC:

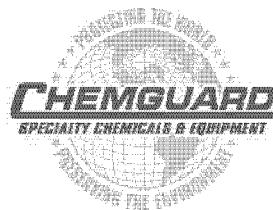
Ansul (Tyco)

Chemguard

DuPont

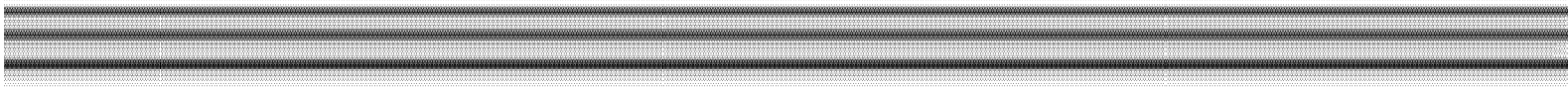
Dynax

Kidde (UTC)



FFFC Activities

- **FFFC has provided EPA with information on AFFF:**
 - **Amount of fluorosurfactant actives used in the manufacture of AFFF in the U.S.**
 - **Chemical structure of the fluorosurfactants used in major telomer-based AFFF formulations (CBI)**
 - **Mechanics of film formation**
 - **Groundwater monitoring data from DoD fire training areas**
 - **U.S. Inventory of ECF-based and telomer-based AFFF**
 - **Overview of Foams, Market Channel, Environmental Fate**



Background

- **Aqueous film-forming foams (AFFF) are highly effective agents used to fight hydrocarbon fuel fires in military, industrial and municipal settings**
 - **Aircraft Rescue Fire Fighting (ARFF)**
 - **Refinery/Petrochemical**
 - **Marine** - Ships and Oil Platforms
 - **Military** - Aviation and Marine
 - **Industrial Fixed Systems** - Aircraft Hangars, Warehouse Storage, Loading Racks, etc.



Background

- All AFFF fire fighting agents contain fluorinated surfactants (fluorosurfactants)
- Fluorinated surfactants are a key ingredient:
 - no other class of surfactants can provide the required low surface tension (15 to 17 dynes/cm)
 - fluorinated surfactants provide positive spreading coefficient and enable film formation on top of lighter fuels



Background

- Fluorinated surfactants have been produced from fluorochemicals manufactured by two methods:
 - Electrochemical fluorination (ECF) - 3M
 - Telomerization (telomer) - Asahi
Clariant
Daikin
DuPont
- Only a very small percentage (3-6%) of the overall global production of these fluorochemicals has ever been used in AFFF



Background

- 3M only manufacturer that has stopped production of AFFF (2002)
- Fluorosurfactants in AFFF made by 3M contain and degrade into perfluorooctyl sulfonate (PFOS), which has been regulated in the US, Europe, and Canada
- Other AFFF manufacturers continue to produce AFFF for both commercial and military applications
- Fluorosurfactants in telomer-based AFFF do not contain or degrade into PFOS



Background

- Since 3M ended AFFF production, there has been speculation about similar environmental issues with telomer-based AFFF
- Speculation that telomer-based AFFF can break down into perfluorooctanoic acid (PFOA) or other perfluorocarboxylic acids (PFCAs) and may eventually be regulated
- Speculation that the degradation products of telomer-based AFFF may have environmental and toxic properties similar to PFOS



PFOS Regulations

- **US EPA regulations do not restrict the use of existing stocks of PFOS-based (3M) AFFF**
- **European Union regulations require existing stocks of PFOS-based foams to be removed from service by June 27, 2011**
- **EU member countries must provide inventory of PFOS-based foams to EC by December 2008 - US inventory about 4.5 million pounds in 2004**
- **Proposed regulations in Canada require existing stocks of PFOS-based AFFF to be removed from service 5 years after regulation is final (2013)**



PFCAs

- **Telomer-based AFFF is not made with PFCAs**
- **In October 2003 an EPA workgroup determined that telomer-based foams are not likely to be a significant source of PFCAs in the environment**
- **EPA workgroup concluded that existing data "provided no evidence that these fluorosurfactants biodegrade into PFOA or its homologs..."**
- **Telomer-based AFFF may contain trace levels of PFCAs such as PFOA and perfluorohexanoic acid (PFHxA)**



Global Stewardship Program

- EPA is addressing emissions of PFCAs through a global stewardship program
- Under the EPA program, telomer manufacturers are working towards elimination of trace levels of PFOA, PFOA precursors, and related higher homologue chemicals from finished products by 2015
- Confirms FFFC's message of last 7 years that EPA is unlikely to ban or severely restrict the use of telomer-based products such as AFFF



Impact of EPA Program

- EPA stewardship program is focused on eliminating telomers with eight or more carbons (C₈ or above)
- The majority (over 75%) of the fluorosurfactants used in telomer-based AFFF are derived from six-carbon molecules (C₆)
- Some current AFFF formulations contain over 95% C₆-based fluorosurfactants, but others contain a higher percentage of C₈ and above
- Higher homologue chemicals can provide some positive characteristics related to foam effectiveness



Impact of EPA Program

- In order to comply with the EPA stewardship program, manufacturers will be introducing new or reformulated products over the next few years that contain only C₆-based fluorosurfactants
- New products are expected to retain all of the same fire suppression capabilities as existing AFFF agents
- New products would be expected to contain less fluorine and have a smaller environmental impact
- Changes to formulations may require products to be re-qualified under the milspec or other specifications



PFHxA

- **Telomer-based AFFF may contain trace levels of perfluorohexanoic acid (PFHxA), which are not being addressed by the EPA stewardship program**
- **Although we know of no direct evidence, it is speculated that telomer-based AFFF may break down in the environment to PFHxA**
- **Extensive data presented at an EPA information forum in June 2006 and at the Reebok conference in September 2007 provides a very favorable initial toxicology profile for PFHxA**



6:2 FtS

- It has been determined based on groundwater monitoring studies that the 6:2 fluorotelomer sulfonate (6:2 FtS) is likely the primary breakdown product of the C₆ fluorosurfactants contained in telomer-based AFFF - $\text{C}_6\text{F}_{13}\text{CH}_2\text{CH}_2\text{SO}_3^-$
- Recent studies on AFFF-type surfactants likely to break down to the 6:2 FtS show the following:
 - Low in acute and sub-chronic toxicity
 - Low in aquatic toxicity
 - Negative for genetic and developmental toxicity
 - Not bioaccumulative according to regulatory criteria
 - Significantly lower than PFOS in biopersistence



Aquatic Toxicity

- **Toxicity assessment for fire fighting foams focuses on aquatic species**
- **Less effective fire fighting foams that do not contain fluorosurfactants (fluorine-free) are often marketed as being environmentally friendly**
- **To directly compare different agents, FFFC sponsored aquatic toxicity testing of six different commercially available fire fighting foams**



Aquatic Toxicity

- **Agents tested:**
 - **Wetting Agent**
 - **Fluorine-free Foam A - 3% concentrate**
 - **Fluorine-free Foam B - 3% concentrate**
 - **Milspec AFFF - 3% concentrate**
 - **AR-AFFF - 3% concentrate**
 - **UL AFFF - 3% concentrate**



Aquatic Toxicity

- 96-Hour LC50 Test in Fingerling Rainbow Trout

Agent	LC50 (mg/L)
Wetting Agent	1.06
Fluorine-free Foam A	65
Fluorine-free Foam B	71
Milspec AFFF	2176
AR-AFF	3536
UL AFFF	5657

Lower number = higher toxicity



Aquatic Toxicity

- 96-Hour LC50 Test in Fathead Minnows

Agent	LC50 (mg/L)
Wetting Agent	0.887
Fluorine-free Foam A	171
Fluorine-free Foam B	171
Milspec AFFF	884
AR-AFF	1487
UL AFFF	1726

Lower number = higher toxicity



Aquatic Toxicity

- Not surprising that fluorine-free foams would have higher aquatic toxicity than AFFF
- Contain higher concentrations of hydrocarbon surfactants and solvents, which are more toxic than fluorosurfactants
- Milspec AFFF has more hydrocarbon surfactants and solvents than AR-AFFF, AR-AFFF has more than UL AFFF



Aquatic Toxicity

- Just because a fire fighting foam does not contain fluorosurfactants does not mean that it is less toxic or more “environmentally friendly”



Alternative Fuels

- Increased use of alternative fuels, especially ethanol, raises concerns related to the use of different types of fire fighting foams
- In response to these concerns the industry organized the Ethanol Emergency Response Coalition (EERC)
- EERC sponsored testing of six different types of fire fighting foams against two different ethanol fuels



Alternative Fuels

- **Ethanol Emergency Response Coalition (EERC) - Alternative Fuels Testing Program**
 - **Foam Agents**
 - **AR-AFFF, AFFF, AR-FFFP, FP, class A foam, emulsifier**
 - **Test Protocol**
 - **UL 162 - topside and sprinkler testing**
 - **Fuels Tested**
 - **Denatured ethanol (E95) and gasohol (E10)**



Alternative Fuels

- **EERC Testing Results**
 - **Denatured ethanol (E95) fires are most effectively extinguished with AR type foams (AR-AFFF & AR-FFFP)**
 - **Gasohol (E10) fires may be extinguished using AFFF or AR-AFFF, but increased application rates may be necessary for burn back resistance**
 - **AR-AFFF was the only agent that was successful in all fire test scenarios**



Wastewater Treatment

- Oil refinery in Missouri had fire in bulk plant resulting in 1.1 million gallons of wastewater containing gasoline, diesel fuel, combustion byproducts, fire fighting foam agents
- State DNR issued a Hazardous Substance Emergency Declaration requiring characterization and removal/disposal
- Company contacted FFFC for help in dealing with the fluorosurfactants in the wastewater



Wastewater Treatment

- **Dr. Martial Pabon of DuPont has done research on treating water contaminated with fluorosurfactants using activated carbon**
- **Company successfully treated 1.1 million gallons of wastewater in 15 days using granular activated carbon (GAC) in a trailer-mounted system**
- **Dr. Pabon believes that similar operation could be performed without having to pump the foam by using a different type of activated carbon**



Wastewater Treatment

- Dr. Pabon has done additional research on other methods to treat wastewater, including nanofiltration, ultrafiltration, and reverse osmosis
- 30 million liters of wastewater from Buncefield fire contaminated with PFOS-based and telomer-based foams has been treated using GAC, reverse osmosis, and other methods
- Always major clean-up issues after a large oil fire
- Fluorosurfactants do not present a unique problem



Minimize Emissions

- Follow applicable industry standards on the design, installation, and maintenance of foam systems and extinguishers
- Minimize false discharges from fixed foam systems by using approved detection, actuation, and control systems as required by industry standards
- Use non-fluorosurfactant training foams
- Provide for containment, treatment, and proper disposal of foam discharges



Summary

- **Telomer-based AFFF agents are persistent, but are not generally considered to be significant environmental toxins**
- **Major perceived threat to the future of telomer-based AFFF was that it could break down in the environment to PFCAs and would eventually be regulated by EPA**
- **EPA is addressing emissions of PFCAs through a voluntary global stewardship program**



Summary

- **Some reformulation of AFFF fluorosurfactants in the next few years to comply with EPA program**
- **Expect new agents to have same or increased effectiveness with reduced environmental impact**
- **Recent testing shows that alcohol resistant foams (AR-AFFF) provide the best extinguishment of ethanol-based fuel fires**
- **Wastewater containing fluorosurfactant foams has been effectively treated using GAC, reverse osmosis, and other membrane processes**



- **FFFC is pleased to provide information on AFFF:**

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