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THE ENVIRONMENTAL IMPACT OF FIREFIGHTING FOAM CONCENTRATES

- CONTEMPORARY MANAGEMENT CONSIDERATIONS FOR THE CHIEF FIRE EXECUTIVE -

STRATEGIC ANALYSIS OF FIRE PREVENTION PROGRAMS

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I. ABSTRACT

In early 1990 the Refinery Terminal Fire Company (RTFC) was notified that it would need to relocate its fire training academy. The training academy, specifically designed to train refining, petroleum and petrochemical firefighters, utilized unleaded gasoline as the primary fuel source and used firefighting foams and dry chemical extinguishing agents throughout virtually all training activities.

The Fire Company immediately initiated study and planning to relocate the existing facility. The most significant aspect of the relocation project was the need to comply with current environmental practices and regulations, specifically that of wastewater treatment and the need to prevent water and ground pollution. Experience with the existing RTFC fire training academy indicated that foam concentrates were the greatest challenge for wastewater design due to their inherent foaming qualities and the tendency to form an emulsion with hydrocarbon fuels.

Additionally, the Fire Company had previously experienced incidents where the entrance of firefighting foam concentrates into refinery wastewater plants caused significant disruption to the treatment facility. It was hoped that answers discovered in the area of fire training academy wastewater treatment, might lead to some revelation with regard to emergency operations.

The approach to research, in general, was to conduct a search for publications in the area of fire training academy design and the area of foam toxicity; visit relevant fire training academies to evaluate their wastewater treatment schemes and identify any allied research being conducted; and validate findings through discussion with technical experts.

While a significant amount of published literature was reviewed, very little was determined to be pertinent to the research. In some cases, where applicable data was identified, it was countered by an opposing claim. In general, this research area is not well documented, and fire professionals will have to rely upon their own evaluation of subject matter as identified by their own research. However, a goal of this research effort was to begin to substantiate the current knowledge and research base related to the subject, so that fire professionals, who may in the future have similar questions, will not have to start their investigation from scratch.

Six fire training academies in England and Scotland were toured in order to review their wastewater treatment approach. Results are included in the report. The research also revealed eighteen findings which were considered to be applicable to Chief Fire Executives at large.

It was clear at the conclusion of this applied research project that the RTFC would have to, through its design team and consulting environmental engineers, conduct an independent study to develop a definitive wastewater treatment strategy for the proposed fire training academy. The first step of the research was an on-site evaluation of the Offshore Fire Training Centre in Montrose, Scotland. Upon return, additional recommendation was made to continue the research and ten individual tasks were defined.

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III. ACKNOWLEDGEMENTS

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Bob Andrews
Corpus Christi, Texas
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IV. INTRODUCTION

The Refinery Terminal Fire Company (RTFC or Fire Company) was formed in 1948, one year after the famous Texas City, Texas ship explosion, as a non-profit corporation to provide quality emergency response and training services to member owners of refineries, industrial or manufacturing plants, terminal tank storage and oil docks in the Corpus Christi Bay Area.

Today, RTFC's membership has expanded to include the sixty (60) facilities of twenty-three (23) member corporations and the Port of Corpus Christi Authority.

The Fire Company has operated a fire training academy on leased property owned by Koch Refining Company since 1975. The training academy offers training for flammable liquids firefighting as well as structural and incipient stage firefighting. The training academy, specifically designed for training refining, petroleum and petrochemical firefighters, incorporates firefighting simulation props similar to those found at Texas A&M University, Lamar University and the University of Nevada at Reno. Propane and unleaded gasoline are the primary fuels used at the training academy through fire extinguisher, pump seal, pit (large spill), overhead loading rack, and process unit firefighting projects (props). Firefighting foams and dry chemical extinguishing agents are used extensively throughout all training activities. Environmental protection features at the training academy reflect those which were considered prudent during the initial construction of the facility in 1975.

In early 1990, the Fire Company received notification from Koch Refining Company that due to their refinery expansion, the Fire Company would need to relocate the fire training academy. The Fire Company immediately initiated study and planning to relocate the existing facility. The most significant aspect of the relocation project was the need to comply with current environmental practices and regulations, specifically that of wastewater treatment and the need to prevent water and ground pollution.

The purpose of this applied research project was three-fold;

1. To identify all existing information regarding wastewater treatment at flammable liquids fire training academies, with emphasis on the treatment of firefighting foam concentrates.

2. To identify information regarding the environmental impact and toxicity of firefighting foam concentrates as it related to fixed fire protection systems and manual fire suppression efforts.

3. To identify current management considerations for chief fire executives as they relate to firefighting foam concentrates and the environment.

The approach to research, in general, was to conduct a search for publications in the area of fire training academy design and the area of foam toxicity; visit relevant fire training academies to evaluate their wastewater treatment schemes, and identify any allied research being conducted; and validate findings through discussion with technical experts.

This applied research project was designed to answer the following specific questions:

1. What publications are available relative to the environmental impact or toxicity of firefighting foam concentrates?

2. What have other, existing, fire training academies done to address the treatment of wastewater containing firefighting foam concentrates?

3. Is there a fire training academy with a model wastewater treatment system, which could be copied or enhanced to meet the current needs of the RTFC training academy design team, thus providing economies in design and expediting the project?

4. If answers are not found within the United States, should the research be extended internationally?

5. If this applied research report does not fully satisfy the research needs of the Fire Company, what is the recommended course of action to complete the work?

6. What findings, if any, which have resulted from this applied research project, are worthy of consideration by chief fire executives in the management of their organizations?

V. BACKGROUND AND SIGNIFICANCE

At the beginning of this applied research project, the Refinery Terminal Fire Company was initiating action to relocate its existing fire training academy. The most significant challenge associated with the facility relocation was the wastewater treatment required in order to operate.

A brief evaluation of schools teaching flammable liquids firefighting in the United States determined, that not only would existing fire school designs not be acceptable in today's environmental climate, but the existing schools were all under some pressure to clean-up their existing operations.

The RTFC fire training academy project team, was faced with five immediate problems:

1. No effective wastewater design strategy for a fire training academy which taught flammable liquid firefighting was readily identifiable.

2. Fire training academies are so rare, that environmental engineers, while having experience in almost every municipal and industrial wastewater application, have no standard design data for the types of contaminants found at a flammable liquids fire training academy, specifically firefighting foams and dry chemical extinguishing agents.

3. Experience with the existing RTFC fire training academy indicated that foam concentrates were the greatest challenge for wastewater design due to their inherent foaming qualities and their tendency to form an emulsion

with hydrocarbon fuels. Manufacturing and technical literature regarding the treatment of firefighting foams in wastewater systems was not readily identifiable. The environmental effects of dry-chemical extinguishing agents were considered to be of secondary importance, as it was felt that environmental impact was limited to mostly pH and to solids removal and disposal.

4. Without a wastewater strategy, the proposed fire training academy could not operate, and without a design for the wastewater system, the project cost could not be scoped. Quite obviously, funding would not be possible with-out a properly defined cost estimate.

5. The existing training academy was scheduled to close December 31, 1991 and time was at a premium. The mission of the design team was to ensure that the new facility would be ready as quickly as possible, so that the time period between the closing of the existing facility and the opening of the new facility would be minimized.

The benefit to obtain answers to the questions pertinent to the new fire training academy had other significant applications to the Refinery Terminal Fire Company.

The Refinery Terminal Fire Company specializes in industrial firefighting. The predominant risk in the facilities protected are related to flammable liquids. The Fire Company regularly inventories in excess of 50,000 gallons of firefighting foam concentrate of several types and manufacture.

The RTFC uses firefighting foam concentrates regularly. In most cases, operations are very successful and there are no complications nor negative impact secondary to the firefighting operation. However, in some cases, as was found subsequent to the fire extinguishment of a fire in an internal floating roof tank on April 5, 1991, the use of firefighting foam caused a significant disruption to the refinery's wastewater treatment plant.

Prior efforts to try to determine why the entrance of firefighting foam concentrates into refinery wastewater plants caused, at times, facility upsets, had proved to be very difficult both from an investigative and a technical standpoint. Further, the only practical way of learning if other facilities had a similar problem was through individual inquiry based upon the "informal professional network". Unfortunately, this method of research is fraught with shortcomings, and in most cases, while "gut feelings" may appear plausible, one needs facts which can be validated in order to correctly reach conclusions. Why, in some cases, foam concentrates upset refinery wastewater plants remained a legitimate question to the Fire Company. There was hope at the beginning of the applied research project, that answers discovered in the area of fire training academy wastewater treatment, might lead to some revelation with regard to emergency operations.

In order to address the problems and concerns currently facing the organization, this applied research project addressed the environmental impact of foam concentrates in general, with the intention that the solutions, when identified, could be applied to both training and operational concerns.

An additional goal of this research project was to begin to substantiate the current knowledge and research base related to the subject, so that fire professionals, who may in the future have similar questions, will not have to start their investigation from scratch.

The National Fire Academy Course, Strategic Analysis of Fire Prevention Programs, advocates "the exploration of alternative methods of providing fire protection more effectively and/or more economically for your community."[1] The course also suggests that "Elected officials, administrators, members of the business community, and firefighters themselves are searching for ways to reduce the risk and cost of natural and manmade disasters."[2]

This applied research project, "The Environmental Impact of Firefighting Foam Concentrates - contemporary management considerations for the chief fire executive" relates to the National Fire Academy SAFPP Course in the following ways:

1. Fixed fire protection systems use firefighting foam concentrates for special hazards applications.

2. Fire training schools train students in the proper technique of applying firefighting foam which yields a more effective suppression effort. Many students are facility employees trained in incipient stage firefighting, or are members of plant emergency organizations. These students are traditionally categorized under, and their activities included in, the fire prevention and protection programs of industrial occupancies.

3. The cost benefit of utilizing firefighting foam concentrates, both through fixed fire protection systems and through manual suppression efforts, cannot be maximized, if damage to the environment occurs as a consequence.

While this applied research project had significant bearing upon specific research required by the Refinery Terminal Fire Company, many of the findings discovered through the research, may have application to chief fire executives at large. These findings have been listed in Section X, the "Implications" section of this report, and are provided for mere consideration and reflection.

VI. LITERATURE REVIEW

A. Publication Review - Fire Training Academy Design

A significant literature review was conducted to obtain information about fire training academy design. It was hoped that these sources would contain specific data about environmental protection and wastewater treatment and potentially reference the impact of firefighting foam concentrates.

It was the intent of the research to learn from the experiences of similar facilities so as to expedite research and reduce the cost of the pending environmental engineering study for the proposed RTFC fire training academy. The goal of the research was to attempt to obtain information to qualify the following three design limits:

1) How contaminated, in general, is the wastewater generated by live-fire training exercises using hydrocarbon fuel and utilizing firefighting foam concentrate and dry-chemical extinguishing agents?

2) How clean must the wastewater be before it can be discharged in an environmentally responsible and lawful manner?

3) Is there a fire training academy presently operating with a wastewater treatment system which can serve as a model for the proposed RTFC training academy in Corpus Christi?

A total of thirty-nine (39) articles from periodicals pertaining to fire training academies were reviewed. Thirty-seven (37) contained no information regarding wastewater treatment at the training facility.

Only one article was considered significant to the research, "Water Supply and Fire Service Training" by Carolyn S. Garcia.[3] Her article, contained in the appendix, reviewed the practices and designs of seven (7) facilities that conduct live fire training and how they had cleaned up their water supplies. Those facilities were the Arkansas Fire Academy, Texas A&M University Firemen's Training School, Nassau County Fire Service Academy, Oklahoma State University, Ohio State Fire Academy, Mississippi State Fire Academy, and South Carolina Fire Academy. However, while the article contained descriptions of the basic wastewater treatment scheme, the article did not include sufficient engineering or design data to assist in wastewater treatment design of the proposed RTFC training academy.

An additional article "Are You at Risk? Fire Fighting with Contaminated Water"[4] discusses the occurence of benzene in public water supplies which may be used by firefighters, acceptable health standards established by government agencies and protective measures to be considered by firefighters. While design information was not included, the article did suggest allowable benzene levels, which might be applied to establish wastewater quality.

National Fire Protection Association (NFPA) 1402, "Guide to Building Fire Service Training Centers"[5] states in section 4-5.1 "Federal, state, and local environmental protection agencies need to be consulted. The results of these consultations should facilitate obtaining the necessary permits and licenses. Also, these consultations should address the problem of wastewater (treatment and disposal) and pollution (air, water and noise). The facts gleaned from these agency contacts may be of use when the architect is consulted." However, specific engineering or design guidance is not given in this NFPA Guide.

Federal Aviation Administration Advisory Circular 150/5220-17, "Design Standards for an Aircraft Rescue and Firefighting Training Facility"[6] contains information regarding "environmental factors" and a "sanitary sewer connection". The circular also contains design drawings and specification for a "weir" and a "vented fuel/ water separator". However, the design does not state what the anticipated quality of wastewater will be after treatment.

B. Publication Review - Firefighting Foam Concentrates

Foam manufacturers were polled in order to obtain environmental information for their products. In general, the most common source of material information is the Material Safety Data Sheet (MSDS) for each foam concentrate being evaluated.

As is typical with most MSDS, there is no standard format and the information is presented without consistency between the different manufacturers. Some manufacturers will provide specific environmental data such as:

> ENVIRONMENTAL DATA:
>
> 96-Hr. LC50, Bluegill Sunfish (Lempomis Macrochirus) = 1500 mg/1; 96-Hr. LC50, Fathead Minnow (Pimephales Promelas) = 1700 mg/1; 48-Hr. EC50, Daphnia Magna = 2800 mg/1; COD = 0.35 g/g; BOD = 0.21 g/g.

Other manufacturers do not list specific environmental data within their Material Safety Data Sheet. Environmental data is also referred to as Toxicological Data on some MSDS.

Specific Product Environmental Data (PED) was obtained from 3M through their Environmental Laboratory - 3M Environmental Engineering and Pollution Control. Environmental Product Data was obtained for their Light Water Brand Aqueous Film Forming Foam Concentrates FC-203 and FC-203A[7] and their Aqueous Film Forming Foam/Alcohol Type Concentrate FC-600.[8]

Product Environmental Data, such as that published by 3M, goes into much greater detail regarding environmental impact compared with that found in a Material Safety Data Sheet. 3M's Product Environmental Data includes information on biodegradation, treatability, effect on microbial respiration, aquatic toxicity, effects on vegetation, and recommended disposal.

It became clear to the author during the research, that it is extremely difficult for the layperson to adequately comprehend and compare the environmental characteristics of the myriad foam concentrates available on the market today. The Chief Fire Executive would be well advised to solicit the assistance of an environmental professional who would provide accurate, practical interpretation of the data.

The recommended approach to disposal of foam concentrate, in one case, was to "bleed to wastewater treatment system in accordance with local regulations. Reduce discharge rate if foaming occurs. Diluting one gallon of FC-600 with 100,000 gallons of sewage eliminates foaming in aeration basins."[9]

None of the foam manufacturers contacted indicated that they had any specific data regarding recommendations for the treatment of their products in wastewater treatment systems, but all offered to assist in future research as requested.

There was no study identified through the initial literature search which compared the environmental impact of one foam, or one family of foams, versus another.

Several individuals proficient in foam technology suggested that the most applicable determination of foam toxicity was the test criteria in the U. S. Military Specification "Fire Extingushing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate, for Fresh and Seawater," MIL-F-243 85D, October 1989. Hence, if a foam concentrate was listed as meeting the "MIL-Spec", one could be reasonably sure that the concentrate met the minimum toxicity requirements. Of course, foams which are not of the AFFF type (such as Alcohol Type and Flouroprotein) are not tested against the MIL-Spec and subsequently are not evaluated by the toxicity test.

Chief Fire Executives may also be interested in the appearance of language contained in most foam concentrate MSDS which advise the reader that "This product contains the following toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and 40 CFR 372". In other words, a fire department could have enough foam concentrate in inventory to require them to report the ownership of one or more toxic chemicals under SARA Title III.[10] Would this mean that following the use of the foam at an emergency the fire department would be responsible for reporting the release of the one or more toxic chemicals aforementioned?

Several reports containing data on foam tests and comparisons were also reviewed. In all but two cases, the sources were not sufficiently documented to include the document in this research report. Their omission is still academic, however, as in all of the cases, the emphasis was on foam performance and not toxicity nor the environmental affects of the concentrate.

One report, by Hughes Associates, Inc., entitled "A Comparative Analysis of Film Forming Fluoroprotein Foam (FFFP) and Aqueous Film Forming Foam (AFFF) for Aircraft Rescue and Firefighting Services" was reviewed.[11] Again, the only reference to environmental performance was by listing the AFFF MIL SPEC Environmental Impact component of the specification which deals with biodegradability, fish kill, BOD/COD in an effort to assure an environmentally safe product.

The literature review process identified only one publication specifically related to fixed fire protection systems. This publication, from Headquarters United States Air Force, was entitled "Engineering Technical Letter (ETL) 86-8: Aqueous Film Forming Foam (AFFF) Waste Discharge Retention and Disposal" (see appendix).

Much of the Letter is significant to this applied research project. The Policy of the United States Air Force is as follows:

> a. General. Direct discharges of foam solution into watercourses can violate stream water quality standards, and will therefore be contained to prevent discharges from entering streams or leaving the installation. AFFF solution discharges can adversely impact biological wastewater treatment processess and can cause foaming in aeration basins and similar plant components if the AFFF concentrations exceeds limits stated below. If discharge is to a domestic wastewater treatment plant,

the amount of the AFFF concentrate in the plant influent shall not exceed 100 parts per million (PPM) by weight for a 6% mixture or 50 PPM for a 3% mixture (a 3% solution is more restrictive at the plant due to the strength of its concentrate). For an on-base wastewater treatment plant, the above concentrations will require that the discharge be contained and bled into the influent of the sanitary plant at a controlled rate. If an installation's wastewater collection system is connected to a regional wastewater system, no restrictions may be imposed on the discharge of AFFF wastewater provided the foam concentration in the regional system's plant influent is within the previously specified limits. Additional restrictions may be imposed by the regional system authorities. Permission should be obtained from the regional system authorites prior to project development.[12]

The Letter also contains provision for flow diversion and containment. Specifically:

"c. Containment. Once the AFFF discharge has been diverted into the storm drainage system, it shall be contained for controlled disposal. Containment of the discharge shall be by temporary or expedient measures which will be incorporated into the installation's Spill Prevention Control and Countermeasures (SPCC) Plan."[13]

The only publication identified, which included definitive wastewater quality parameters, was located by the RTFC Training Academy Design Team during preliminary discussion with the Wastewater Services Division of the City of Corpus Christi. The design team was attempting to determine if the city wastewater treatment plant, which was located near the proposed fire training academy site, would be able to accept the wastewater stream generated by the academy. Further, if pretreatment was required by the Wastewater Services Division, what were the requirements for influent to the wastewater plant?

The answers to the design team's questions were found in a publication by the City of Corpus Christi Department of Public Utilities-Wastewater Services Division, entitled "Ordinance - Commercial & Industrial Waste Disposal & Pretreatment."[14] The Wastewater Services Division, sets specific pretreatment program discharge limits for Total Petroleum Hydrocarbons (TPH); Lead; Benzene; Benzene, Toluene, Ethyl Benzene, Xylene (BTEX); pH; Total Suspended Solids (TSS); Total Disolved Solids (TDS); Color, Biological Oxygen Demand (BOD); and Oil and Grease.

The City of Corpus Christi, Wastewater Services Division, pretreatment discharge limits were accepted to be the definitive standard for the wastewater quality of the proposed fire training academy wastewater stream, unless a more suitable standard was discovered during the research.

As of April 1, 1991, the review of all fire service publications identified at that time yielded a virtual vacuum with regard to locating specific, quantitative data, from which to design a wastewater treatment facility for the proposed RTFC fire training academy. The search for a method to extract foam concentrates from the training academy wastewater stream was expanded to Europe.

VII. PROCEDURES

Procedures were developed to continue research due to the unsuccessful literature review.

Research was conducted in France and the United Kingdom from May 11 through May 25, 1991.

A. Second International Oil and Petrochemical Forum - Reims, France.

Two papers, relevant to the research project, were presented at the Second International Oil and Petrochemical Forum, sponsored by Angus Fire, in Reims, France, 13-15 May, 1991.

Mr. Rodney Camp of Camp & Associates, South Africa, in his presentation "Fire Control and the Environment,"[15] reviewed how pollution by hydrocarbons occurs, and discussed general methods for prevention (see appendix). He discussed different methods of hydrocarbon clean-up including bioremediation. Camp reminds the audience that the use of foam, rather than water, may reduce the overall water pollution and treatment quantities, and that the negative environmental effects of the use of foam concentrates may be far exceeded by the pollution created by the fire or emergency event.

Camp submits that the use of protein based foams "actually enhance the plant growth of legumes and thus accelerates our hydrocarbon bioremediation."[16] However, Camp cautions that "if pure protein based concentrate should ever enter a still holding of water, than as with any other organic overload the Biological

Oxygen Demand (B.O.D.) may increase and thus enforced aeration of the water may be required during the biodegradation so as to maintain an aerobic process rather than allow an anaerobic one."[17]

Camp also informed the audience that South Africa fire training acadamies utilize water recirculated through a "Wetland". This approach was not found anywhere during the research of United States training academies. Camp states "At fire schools we are continually re-circulating water supplies. It is general practice to feed this effluent through a gravity separator to remove floating hydrocarbons, but the water should then be fed through a "Wetland" to give nature the opportunity to biodegrade any materials such as foam compounds. Wetlands consist of filter ponds which contain Macrophyt plants such as Typha and Phregmytes. These plants take oxygen from the atmosphere to below the liquid surface and thus maintain any aerobic biodegradation necessary."[18]

Inquiry of RTFC environmental engineers[19] revealed that the utilization of artificial wetlands in the United States is a technology which is just beginning to be evaluated by the United States Environmental Protection Agency (EPA). The drawback appears to be the quantity and the cost of real estate necessary to have a sufficiently sized wetland to accommodate the typically large firewater flows required of a fire training academy. Camp, in private discussion, advised that he possessed no design criteria for the size of wetlands for specific fire school demands, but allowed that the technology was available through consulting environmental engineering firms in South Africa.

Camp's final analysis regarding the environmental impact of foam concentrates was "In summary, if you apply sound all encompassing engineering design and application, and choose a protein based foam, you will make life easier for yourselves in helping to protect the environment."[20]

Mr. Jonathan Brittain, of Angus Fire, UK, in his presentation "Foams: The Environmental Challenge" reviews the benefits firefighting foam concentrates have made to society and the fire service, and submitted that "the profusion of new environmental legislation has led water authorities to take a much greater interest in the environmental fate of foam and in turn presented fire professionals with a new challenge."[21]

Brittain believes that "The "Environmental Challenge" now facing fire professionals is to minimise the impact of fire fighting foam concentrates on the environment. Doing this will not only help companies to conform to regulations requiring that they use the best available technology not entailing excessive cost to minimise the environmental effects of their operations, but it will also help to alleviate the strain on the environment from man-made products in general"[22].

Brittain makes several significant and applicable points in his paper:

1. The discharges of most man-made substances into the aquatic environment are predictable and therefore carefully controlled. Consequently their concentrations tend to be quite low, usually well below 1% or 1,000 parts per million (ppm). Domestic detergent is a good example. It is present in numerous consumer products like washing-up liquids and shampoos, and is washed into the environment everyday by millions of people. Its concentration is carefully monitored and controlled by water authorities from release through to removal at water purification plants.

Conversely, foam being used at emergency fire incidents can be discharged into the environment in unpredictable and uncontrolled circumstances. Moreover, the very high water capacities of modern fire fighting equipment can produce flow rates that are comparable to small rivers. Foam premix can run off from the fire and gush into the local water environment at levels much higher than those normally expected by water authorities. In the incident related in his paper, it was a foam "raft" with an estimated concentration of 10,000 ppm being swept downstream that caused a fish-kill in Switzerland in 1987.

2. Professional fire fighters know that there are certain types of fires that threaten human lives and property which can only be tackled successfully and reliably with foam, these include flammable liquid fires at aircraft crashes, refineries and petrochemical plants.

3. Fixed Foam Systems are more efficient that manual firefighting, requiring the consumption of less foam concentrate. The minimum foam solution application rate recommended by NFPA is 0.16 gpm/sq ft for mobile monitors compared to only 0.1 gpm/sq ft for fixed systems.[23]

4. Recently, firefighters have begun collecting foam into collecting basins after use to allow controlled disposal after the emergency is over.

5. Brittain submitts that the environmental properties of foam concentrates currently on the market vary enormously, and states that more recently, firefighters have taken the step of selecting the more environmentally favorable types of foam concentrate.

6. Comparing the environmental properties of different foams means obtaining environmental data from manufacturers and independent test laboratories before making a purchasing decision. This in turn means learning the language of technical jargon.

Brittain's paper includes a good review of environmental jargon and explains the basic differences between the chemical composition of the different foam "families". He further states in his paper:

> "Perhaps not surprisingly foams produced from natural protein have been found to be much gentler on the environment than those based on synthetic detergent. A major independent study undertaken by German government scientists in 1989[24] subjected sixteen commercially available foam concentrate products to a host of rigorous toxicity and biodegradability studies. Protein-based foams were found to be both substantially less toxic and more biodegradable than those based on synthetic detergent. Protein-based foams were found on average to be less toxic to every organism by factors ranging from 9 for fish to 40 for water flea. Of all the protein based foams tested FFFP emerged as the most environmentally favourable of all. In one test a FFFP gave an LC_{10} of 7,500 ppm compared to a value of only 0.6 ppm for a synthetic detergent based AR-AFFF, making it a remarkable 12,500 times less toxic!"[25]

It is the thrust of Brittain's presentation that "independent studies show that foam concentrates produced from natural protein can be much gentler on the environment than those based on synthetic detergent."[26]

B. Fire Training Academy Design - England and Scotland

Six (6) fire training academies, all of which conducted "live" flammable liquids fire fighting, were toured 21 - 23 May 1991. At each school, curriculum, physical facilities, field operations including the utilization of fuels and fire extinguishing agents, and the approach to wastewater treatment, were reviewed.

The Esso Fawley Refinery discharges its wastewater stream to the refinery wastewater treatment system.

The Fire Service College at Morton-In-Marsh during a typical day utilizes at least 45,000 litres (11,889 U. S. gallons) of water. The College constantly re-cycles water used in exercises through a complex system of pumps and a modern filtration system. Unfortunately, specific design details of the wastewater treatment system were not available at the time of visit. However, Divisional Officer Bernard Bannon was able to locate a member of the design team which designed the wastewater system, and offered his assistance in contacting him.

The Lancashire County Fire Brigade International Training Centre at Washington Hall, at the time of the visit, had already determined that its present wastewater approach was not adequate. Training Centre staff provided copies of research reports which identified the shortcomings of the present approach and recommended areas of study for improvement. At the time of the visit, funding for environmental improvements was being sought, and Centre personnel offered to provide more definitive wastewater design data, once it became available subsequent to project funding.

The Civil Aviation Authority Fire Service Training School at Teeside Airport utilized a fuel/water separator design which met the discharge requirements by the local River Authority. Design data was not available on site, however, school staff provided the name of the engineering firm which designed the wastewater treatment facility.

The Grampian Fire Brigade's Aberdeen Fire Training Center utilized a small sand filter for wastewater purification. No design data was available and the size of the wastewater equipment appeared to be too small to handle the anticipated wastewater volume at the proposed RTFC fire training academy.

The most applicable and significant wastewater system reviewed during the evaluation was found at the Offshore Fire Training Centre in Montrose, Scotland. The design, organization and operation of the school was very similar to both the existing RTFC fire training academy, and also the larger facility which was being proposed. Their petrochemical client base was directly applicable to RTFC's mission.

With a design capacity of 500,000 gallons per day and provision for peak flows of 4,000 to 6,000 gallons per minute, the Centre's wastewater treatment facility was the only facility evaluated during the trip which was directly relevant to the design capacity of the proposed RTFC training academy. The fact that the wastewater system at the Centre was both operational and effective, provided the real-life working example which was originally sought.

The Centre wastewater system routinely recovers 25 per cent of the kerosene fuel used for firefighting projects and met the requirements for wastewater discharge quality as dictated by the local Rivers Authority. The Centre uses kerosene as its primary liquid fuel rather than unleaded gasoline due to kerosene's increased safety due to its higher flashpoint, its easier separation in environmental treatment systems, its economy, and its lack of benzene, toluene and xylene constituents.

Centre staff offered to introduce the RTFC design team to the design/construction engineers who built the facility and indicated that all designs would be made available for our review and future use. Centre staff also offered to introduce the RTFC design team to the environmental engineers who originally developed the wastewater design scheme.

In summary, the research which was conducted in Europe finally yielded the answer which was being relentlessly pursued, "Is there a fire training academy presently operating with a wastewater treatment system which can serve as a model for the proposed RTFC training academy in Corpus Christi?". The answer was "Yes". The model was the Offshore Fire Training Centre, in Montrose, Scotland.

VIII. RESULTS

Material Safety Data Sheets (MSDS) developed by foam manufacturers for their firefighting foam concentrates provided some information regarding the environmental impact or toxicity of the foam. However, there is variation in both the form and the content of Material Safety Data Sheets produced by different manufacturers which makes comparison difficult.

Some manufacturers, such as 3M, produce additional publications which provide Product Environmental Data in greater specificity. This information is more useful in analyzing the environmental impact and toxicity of firefighting foam concentrates, however, the technical jargon is best interpreted by an environmental professional.

The only testing procedure identified, which measured the toxicity of firefighting foam concentrates, was the U.S. Military Specification MIL-F-243 85D. This test, however, only applies to foam concentrates of the Aqueous Film Forming Foam (AFFF) type.

The United States Air Force issued a technical letter in June of 1986 which discussed Aqueous Film Forming Foam (AFFF) waste discharge retention and disposal. The letter addresses the method to be used for disposal of AFFF but does not provide specific wastewater treatment technology.

Mr. Rodney Camp, in his presentation, submits that protein based foams are environmentally superior to synthetic foams.

Mr. Jonathan Brittain, in his presentation, cites the only scientific study identified during this research, which compares the environmental impact of several different foams and foam types. That study, commonly referred to as the BWB report, was entitled "Analysis of the Toxic Effect and the Biological Breakdown Capabilities of Foam Extinguishing substances in Waste Water"[27]. Mr. Brittain submits that protein-based foams were found to be both substantially less toxic and more biodegradable then those based on synthetic detergent. Unfortunately, since the BWB report was published in 1989, several of the newest firefightng foam concentrates available on the market today, were not tested. The BWB report, however, remains the sole research effort, identified by this applied research project, which compared several foam concentrates based solely upon environmental factors.

As this research project was nearing completion, applicable Technical Information was provided by 3M Industrial Chemical Products Division. This paper, entitled "An Environmental Evaluation of AFFF" (see appendix), was issued in August of 1991, and cites a "German Army Study: Independent Classification of Fire Extinguishing Agents". The 3M paper advised that "The German Army has conducted a study in which the environmental properties of 16 fire extinguishing foam agents were evaluated". The source of the German Army Study is cited by 3M as an article authored by Matthias Gahlen entitled "Schaumeinstaz und Umweltschutz" and published in March 1991 issue of the German magazine Brandschutz/Deutsch Feuerwehr Zeitung.

It is unclear if the study referred to in the 3M Technical Information paper is an article about the BWB report, or if it is a totally independent research effort. However, according to the 3M paper, their newest foam concentrate, Light Water Foam Concentrate ATC FC-600, was not tested in the German Army Study to which they refer.

In no case was detailed information regarding the specific treatment of firefighting foam concentrates in wastewater treatment facilities, or recommendations for the design of a fire training facility, available from any firefighting foam manufacturer. However, all of the manufacturers contacted expressed a cooperative attitude and offered to assist where they could.

Thirty-nine articles from periodicals were reviewed in an attempt to ascertain what existing fire training academies in the United States have done to address the treatment of wastewater containing firefighting foam concentrates. Only one article, "Water Supply and Fire Service Training" by Carolyn S. Garcia, was applicable to the research project. However, while the article described the basic wastewater treatment scheme utilized at seven fire training academies, there was not sufficient design data to assist the RTFC Training Academy Design Team in the design of our proposed fire training academy.

Likewise, Federal Aviation Administration Advisory Circular 150/5220-17 "Design Standards for an Aircraft Rescue and Firefighting Training Facility" provides a wastewater treatment scheme but does not provide specific data regarding the effectiveness of the recommended design.

No data was identified throughout any of the research which addressed the level of contamination, in general, of wastewater generated by live-fire training exercises using hydrocarbon fuel and utilizing firefighting foam concentrate and dry-chemical extinguishing agents.

Six (6) fire training acadamies which conducted "live" flammable liquids firefighting were toured in England and Scotland in an effort to obtain applicable data for the RTFC Fire Training Academy Relocation Project. The wastewater treatment facility at the Offshore Fire Training Center in Montrose Scotland was the only facility directly relevant to the design demands of the proposed RTFC training facility. The Center staff offered to provide all design, construction and operating data for their facility.

IX. DISCUSSION

Overall, I was surprised that so little published information was located during this applied research project. It often seemed that for every claim regarding firefighting foam toxicity, both written and verbal, there existed an equal and opposite claim (sort of the Einstein Theory of Foam Toxicity).

An example of which was the conflicting conclusions of the German BWB report, which concluded that of all the protein based foams tested, FFFP emerged as the most environmentally favorable of all, countered by the 3M cited German report which concluded that two AFFF concentrates considered in the study were ranked in Class 1, the lowest Water Endangering Class (WEC) of any fire extinguishing product considered in the study.

Of course, both arguments are somewhat moot, since to the best of my knowledge, the three foam concentrates currently getting the most significant marketing attention by their manufacturers, Angus' Alcoseal, Chubb National Foam's Universal Gold, and 3M's Light Water 3% / 6% ATC, were not evaluated by the German BWB report, nor presumably the German Army Study cited by 3M in their technical information.

While many sources present that protein based foams are environmentally more friendly than their synthetic based counterparts, their opponents expostulate that fluoroprotein foams are manufactured with synthetic fluorochemicals, similar to those found in the manufacture of synthetic based foam concentrates.

So in the final analysis regarding the environmental impact of foam concentrates, there doesn't appear to be any study published by an independent source which compares neither the environmental impact nor the toxicity of the three predominant foam concentrates in the North American market.

And in the final analysis with regard to the questions of the RTFC Fire Training Academy Design Team, it became clear to me that the Refinery Terminal Fire Company would have to conduct its own research, through its consulting environmental engineers, to obtain a definitive wastewater treatment strategy for the new fire training academy. Subsequently, I will recommend that the Design Team begin its research by studying, in great detail, the design and operation of the Offshore Fire Training Center in Montrose, Scotland.

There was hope at the beginning of this applied research project that answers discovered in the area of fire training facility wastewater treatment might lead to some revelation with regard to emergency operations. Unfortunately, that revelation did not materialize.

It is hoped that this applied research project will encourage debate, spur research, and enhance the position that the environmental impact of firefighting foam concentrates is a meaningful issue worthy of study by the fire protection profession.

As with any research project, the content of the report is directly related to the information and facts reviewed. Quite logically, information may only be reviewed if it is "discovered". It is reasonable to suspect that somewhere there exists a report which answers some of the questions posed in this applied research project, perhaps even a report or two, which directly refutes the results contained in this report. Some of this "undiscovered" information I may have been simply remiss at locating through the proper source. However, I also suspect that some of this "undiscovered" information is classified as "confidential and proprietary" by its owner.

I do believe that this applied research project has helped the Refinery Terminal Fire Company. The RTFC is poised to spend several million dollars on a new fire training academy. Attempting through research, to learn as much about wastewater treatment at similar facilities, before formal design and construction, was certainly a meritorious project. Learning about the Offshore Fire Training Center at Montrose, Scotland was of particular significance.

Additionally, this research has revealed several findings which may have application to chief fire executives at large. These findings are listed in the next section of this report.

IX. IMPLICATIONS

Firefighting foams are required to quickly contain and extinguish fires involving flammable liquids which threaten human lives and property, especially those fires at aircraft crashes, refineries and petrochemical plants. The advantages of firefighting foams have been known to fire professionals for years.

The use of firefighting foam concentrates to achieve fire control reduces the negative effect of the flammable liquid and the related fire on the environment. The adverse effects to the atmosphere are usually the most obvious result of the fire, and the smoke and soot produced by the fire contain particulate matter, volatile organic compounds, and possibly certain hazardous air pollutants known as "air toxics". Not so readily obvious are the effects on soil, groundwater, streams and rivers. If partially burned liquid runs off into a river, lake or stream, the effects on fish, aquatic birds, and other wildlife can be devastating. Again, by controlling these fires faster through the use of firefighting foams, the impact to the environment is reduced.

Firefighting foam concentrates, in and of themselves, however, also pose an impact to the environment. These foams also have the capacity to disrupt or overwhelm public and industrial wastewater treatment facilities. Fire professionals will, in the future, be required to respond to environmental legislation and post incident investigation of foam utilization with greater regularity. Fire professionals will be quizzed on whether or not the environmental impact of the fire was increased or decreased through their decision to apply firefighting foams.

This applied research project has revealed several findings which may be of use to Chief Fire Executives.

1. Virtually all fire training acadamies utilitzing flammable liquids and firefighting foam concentrates will be under increasing pressure in the future to improve their operations environmentally.

2. The use of firefighting foam concentrates may upset municipal and industrial wastewater treatment facilities.

3. Fixed fire protection systems typically require a lower application rate than manual firefighting efforts. Subsequently, less firefighting foam concentrate is discharged through a fixed system, thereby reducing the wastewater disposal requirement.

4. Fire codes should reflect that where environmental damage could occur, increased effort is needed to contain and manage the runoff produced by both the incident and the mitigation efforts.

5. The Chief Fire Executive should assure that water supplies used by firefighters, both at their training academy, and through their usual fire protection water systems, are healthy to the firefighter from an industrial hygiene perspective.

6. State and local water authorities should be consulted to obtain specific and accurate guidance for water quality concerns.

7. The manufacturers of fire control agents should be able to provide specific toxicity and environmental data for their products. Fire professionals should not accept anything short of complete cooperation.

8. Chief Fire Executives would be well advised to solicit the assistance of an environmental professional who can provide accurate, practical interpretation of technical environmental data.

9. Dilution of a waste stream is not considered the prudent environmental solution (i.e. The solution to pollution is not dilution).

10. The only independent toxicity test used in the United States is that of the Military Specification for AFFF. Non-AFFF type foams do not meet the specification and subsequently, are not tested.

11. Some constituents of firefighting foams are covered by Section 313 of the Emergency Planning and Community Right to Know Act of 1986 and 40 CFR 372. Fire agencies may have enough foam concentrate in inventory to require them to report the ownership of one or more toxic chemicals under SARA Title III.

12. The use of articicial wetlands for the treatment of wastewater containing hydrocarbons and firefighting foam, such as those utilized in other countries, may be a technology eventually used in the United States.

13. Foams being applied at emergency fire incidents may be discharged at rates that are comparable to small rivers. In these cases, the "slug" of foam which initially enters the body of water may have a concentration in excess of 10,000 ppm. It is this slug of foam which is responsible for fish kill and the poisoning of other aquatic life which occurs before the slug is diluted.

14. Command officers must be trained in the benefits and risks associated with the use of firefighting foam concentrates, be aware of the mitigation choices available to them, and fully understand the impact of implementing their mitigation strategy.

15. The collection of firewater runoff containing firefighting foam concentrates into a containment basin, allows the incident commander to release the wastewater into treatment facilities at a controlled rate, and prevents the wastewater from coming into contact with the environment.

16. The environmental properties of firefighting foam concentrates vary. Concerned Chief Fire Executives should solicit assistance from environmental professionals or a testing laboratory during the process of foam concentrate selection.

17. Chief Fire Executives, if unable to obtain research results within the United States, should not hesitate to obtain help from their international counterparts.

18. Material Safety Data Sheets for foam concentrates do not always utilize the same format, nor contain the same information.

19. Fire professionals, as a group, should require the development of an independent firefighting foam toxicity test (through a national standards organization such as UL or NFPA) which could be applied to all foam concentrates in order to provide a consistent evaluation of their environmental impact and toxicity.

20. Fire professionals should demand that firefighting foam manufacturers develop foams not only based upon performance but also upon environmental impact.

21. Fire professionals are advised to work with local, state and federal water and wastewater authorities before the occurance of major incidents in order to preplan specific sites and release scenarios.

XI. RECOMMENDATIONS

It was clear at the conclusion of this applied research project that the Refinery Terminal Fire Company would have to, through its design team and consulting environmental engineers, conduct an independent study to develop a desfinitive wastewater treatment strategy for the proposed fire training academy.

Wastewater samples were obtained from each of the major training stations at the existing fire training academy. In one training area, samples were collected before and after a test burn. The other training areas were not used during the sampling period, but collected water was sampled from sumps and containment curbing. A sample was also obtained from the wastewater pond. The samples were analyzed for conventional pollutants and nutrients as well as hazardous constituents and toxic organic compounds. Based upon these test results, environmental engineers began developing treatment and disposal options for the proposed fire training academy.

The RTFC Fire Training Academy Design Team, comprised of the author, the RTFC Division Chief for Training, the project architect, managing civil engineer, and senior environmental engineer flew to Scotland June 9-13, 1991 to evaluate, in detail, the Offshore Fire Training Centre at Montrose. The visit was of indeterminable value to the project team. A significant amount of documentation was obtained during the site visit and additional documentation of significance was identified for acquisition. The treatment facilities at the centre were studied in detail and the centre's efforts relating to regulatory coordination were reviewed. Additional study surrounded the centre's scheme for kerosene recovery, sludge withdrawal and air quality testing.

The result of the Montrose evaluation was that the Offshore Fire Training Centre (OFTC) was a well maintained facility with a high degree of environmental awareness and concern. This was attributed to the high quality of personnel and management at the facility as well as the influence of the OFTC clients including several larger U.S. based petrochemical companies. However, the general conclusion reached by our environmental engineers was that the regulatory structure in Scotland is still fairly primitive as compared to the United States. Monitoring requirements, effluent limitation, inspections, and enforcement all appeared to be less stringent than those to which the U.S. environmental engineers were accustomed.

Subsequently, recommendations were made which incorporated the basic wastewater treatment scheme utilized at the Offshore Fire Training Centre, but enhanced the design to meet U.S. federal, state and local water quality requirements. Those recommendations included the following tasks:

1. Evaluation of diesel, raffinate, Jet A, Jet B, and kerosene as ignition sources with respect to wastewater characteristics, constituents, cost, treatability, student and employee contact, and regulatory constraints for wastewater disposition. Information souces will include material safety data sheets, literature sources, information obtained from other training facilities, and regulatory correspondence.

2. Coordination with Fairhursts and Associates, Dundee, Scotland, to obtain sample analyses of raw wastewater, finished wastewater, and sludge in the existing kerosene wastewater treatment operation at the Offshore Fire Training Centre (OFTC) in Montrose. The RTFC

environmental engineers will submit a sampling plan and analytical methods to Fairhursts in order to obtain laboratory quality control comparable to U.S. laboratories. Analytical and sampling costs will be negotiated by Client with Fairhursts.

3. Correspondence with Tayside (Scotland) Regional Council in order to obtain all analytical data generated on the effluent characteristics of the OFTC. This data will be evaluated with respect to regulatory requirements and disposal needs at the proposed facility in Corpus Christi.

4. Evaluation of published specifications for foam and dry chemical fire extinguishing agents. Initiate correspondence with foam and chemical manufacturers to ascertain exposure limitations and recommeded treatment chemicals to contain or degrade foaming agents.

5. Evaluation of technical, economic, and regulatory constraints of three scenarios for wastewater treatment at the new facility: 1) fuel separation, treatment, and discharge to the City of Corpus Christi Allison Wastewater Treatment Plant (WWTP), 2) treatment to a reusable quality with minimum blow-down to the Allison WWTP, and 3) treatment of a side-stream to reusable quality with the volume determined by economic constraints of discharge surcharge vs. reuse treatment costs.

6. Evaluation of the need for segregating wastewater from project areas

by chemical usage to minimize treatment requirements and maximize reuse potential.

7. Preliminary calculation of treatment unit sizing based on projected wastewater flow-rates, treatment requirements determined for the three scenarios in Item 5, and makeup water quality criteria determined from client information and information developed from above scope items.

8. Correspondence with vendors of candidate treatment systems to determine equipment requirements and cost estimates.

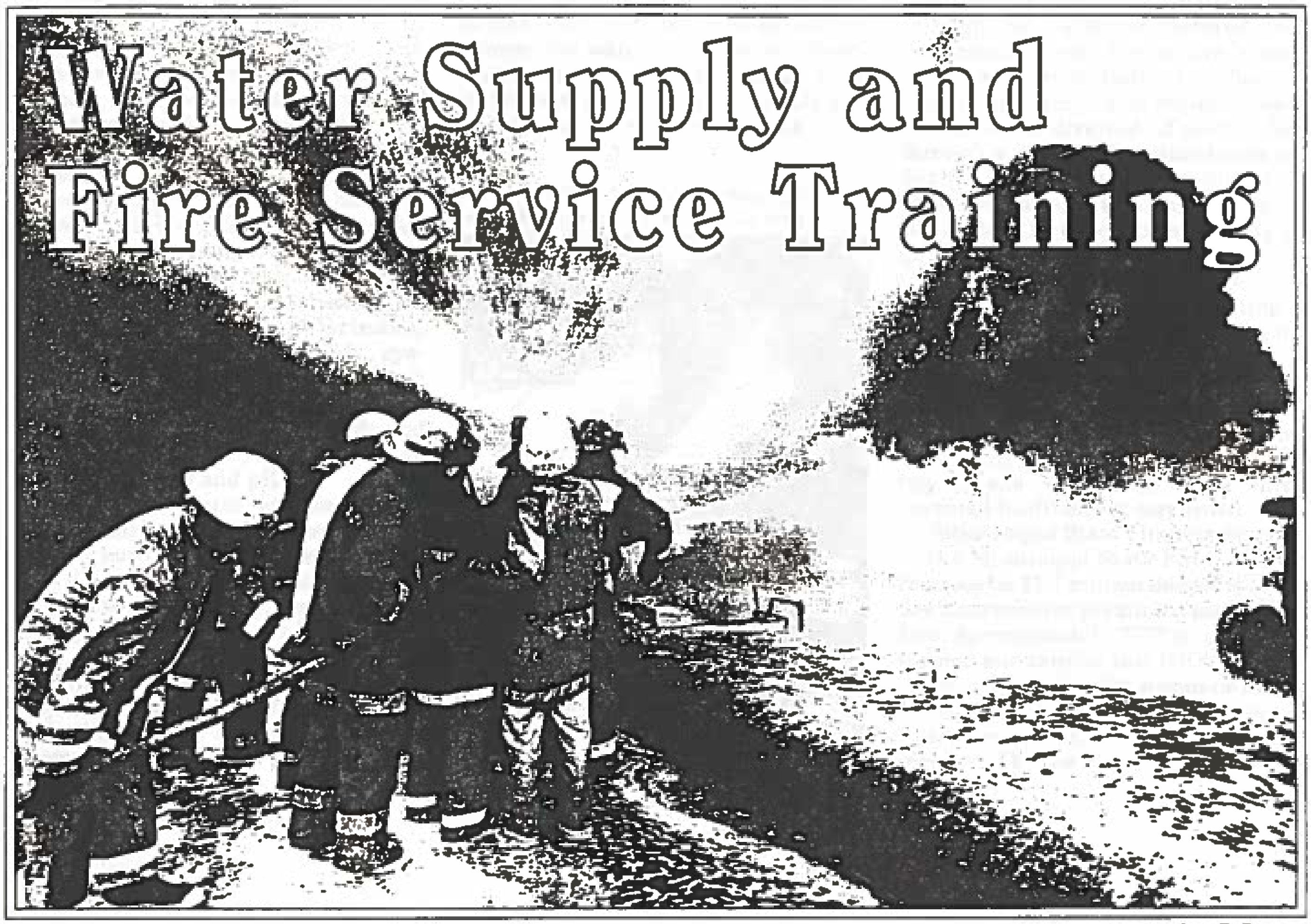
9. Preliminary cost estimates for complete wastewater treatment system based on vendor costs, cosntruction costs, operation and maintenance costs, and regulatory costs.

10. Preliminary engineering report documenting above evalutaions including recommendations for most cost-effective, and environmentally compatible treatment scenario. Report will contain scope of any additional analyses necessary to be perfomed prior to design, estimated schedule of design and construction, and estimated costs of design and construction of the treatment facility.

XII. APPENDIX

- Water Supply and Fire Service Training
- Engineering Technical Letter (ETL) 86-8: Aqueous Film Foaming Foam (AFFF) Waste Discharge Retention and Disposal
- Fire Control and the Environment
- FOAMS: The Environmental Challenge
- Light Water Foam Systems - Technical Information "An Environmental Evaluation of AFFF"

Water Supply and Fire Service Training



All photos Glen E. Ellman

Putting the "wet stuff on the red stuff" is a saying that has been a part of fire service lingo for a long time. But, what if there was no "wet stuff" to put on the "red stuff"? Every time a nozzle is cracked open in training, there can often be as much money coming out of the hose-line as water. In a study of some of the nation's top state-run fire service training facilities, participants indicate water is still the number one extinguishing agent used today. However, what the water costs may be drying up some facilities' resources. Whether it is because of Environmental Protection Agency regulations, state agencies, county ordinances or public opinion, today's firefighter training schools are cleaning up their environmental acts.

Facilities that conduct live-fire training that participated in the study were the Arkansas Fire Academy, Texas A&M University Firemen's Training School, Nassau County Fire Service Academy, Oklahoma State University, Ohio State Fire Academy, Mississippi State Fire Academy and South Carolina Fire Academy. As stated above, water is the top extinguishing agent at each of these facilities. But, with the changing chemical make up of the products burned by today's society, comes a change in extinguishment methods.

Foams are being used more frequently in training. Although initially more expensive than water, foams are absolutely necessary. Aqueous film-forming foam (AFFF) seems to be the popular choice. (The Nassau County, New York, Fire Service Academy, however, does not use foam any longer because it interferes with its oil separation process.) Dry chemicals follow as the third most popular choice of extinguishing agent.

Wood pallets and hay are the most popular fuels for non-industrial firefighting projects. And, water is used almost exclusively for fighting these kinds of training fires. But, using water is not as easy for some of these schools as turning on the faucet. For some of the facilities studied, it is a complicated and expensive process in both money and manpower. All of the facilities participating in the study are regulated by the Environmental Protection Agency. However, according to Roger Meacham, EPA Region Six spokesman, the state agencies regulating these facilities all meet, and usually exceed, EPA requirements. State agencies. Meacham says, are the first line of authority.

Here, then, is a list of the fire service training facilities studied and how they have cleaned up their water supplies:

Texas A&M University Firemen's Training School

Of the facilities studied, the Texas A&M University Firemen's Training School has the largest budget and facility, but also the most regulations. This facility, which earns its $3 million annual budget through student fees, state appropriations and grants, spends almost $50,000 annually on licensing fees, water quality tests and treatments.

The facility, which trains almost 25,000 students annually, is regulated by the Texas Water Commission and the Texas Air Quality Board. To keep these permits current, Texas A&M must spend

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an additional $125 each month.

The school has 31 training projects ranging in size from a small five-foot by five-foot pit to a 60-foot by 80-foot pit. There are also LPG projects, multi-story projects, elevated projects, a five-story drill tower, an 87-foot rescue tower, a shipboard firefighting project, six classrooms, a fire station, dormitory and support facilities. The school has both above- and below-ground storage tanks. It also has monitoring wells to check for ground water contamination.

Tests are run annually to check for EP toxicity, PCBs, total chlorinated hydrocarbons, DDT, ignitability, cyanides, sulfides and corrosiveness. Each week, tests are run checking for NH3N, phenols and MBAs. Tests are conducted on a daily basis for BOD, TSS, TDS, oil and grease, COD and pH.

To prevent water erosion of the grounds, all Texas A&M's burn training projects have cement pads around them with drains to route the water through oil separators and retention pads. The facility has a semi-closed loop system with a single discharge point. All firefighting water is collected from the projects through a series of gravity drains and a lift station. The collected water passes through two oil separators and is routed by gravity to an aerating retention and settling pond. The water level in this pond is maintained by two lift pumps. The water is pumped to a fresh-water pond. The main fire pumps drain water from the fresh-water supply and firefighting water to the projects.

Water is still the top extinguishing agent used at the facilities surveyed for this article.

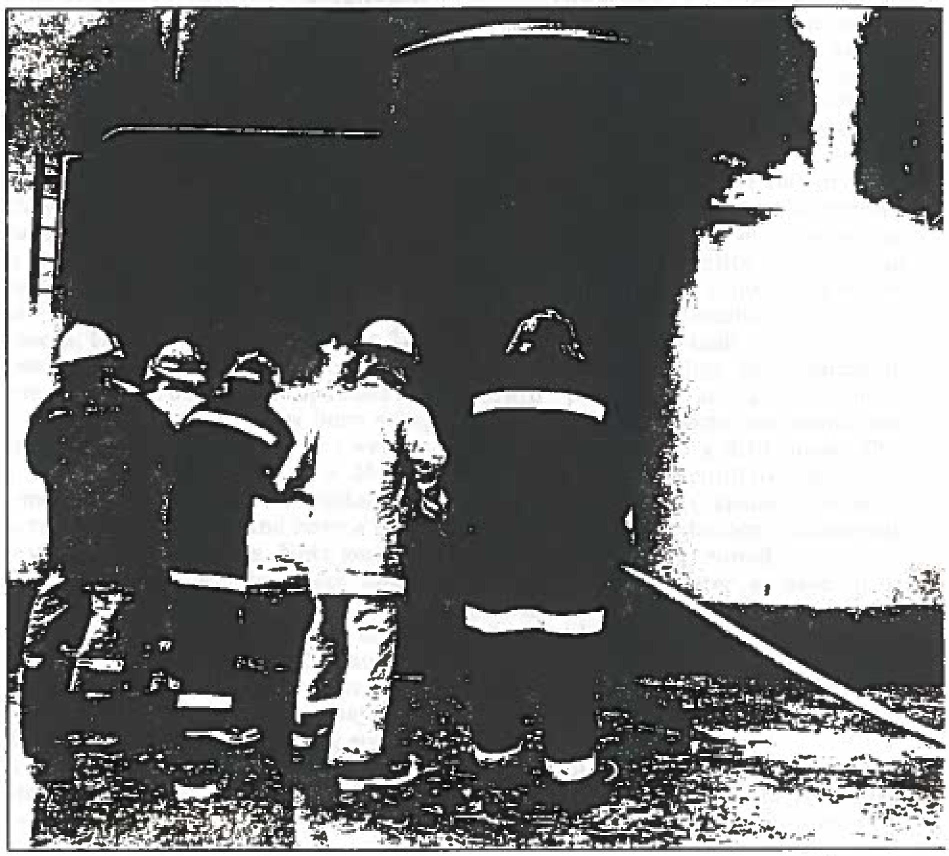
A single-point outfall is located in the fresh-water pond. All water going through the outfall is metered on a continuous basis. The entire system contains approximately 3.1 million gallons. Rain water can be routed through the system or diverted off the fire field through a series of diversion boxes and ditches. Engineering design studies are being conducted at this time to upgrade the system in order to meet EPQ requirements of the future.

By far, this facility is the most regulated of all those participating in the survey. Texas is a highly industrialized state and according to Texas A&M's training field manager Jack Donovan, the State of Texas almost "over compensates" to ensure it does not violate any of the ever-changing federal regulations, especially where state-operated facilities are concerned.

Mississippi State Fire Academy

The Mississippi State Fire Academy receives its $1.7 million budget through fire insurance tax premiums and student fees. Approximately 7000 students are trained annually at this facility.

Although the facility spends no money on water quality tests, licensing fees or water treatment, it is regulated and monitored by the Mississippi Bureau of



To be ecologically responsible, fire academies that use large quantities of water during training evolutions should recycle.

Pollution Control. Domestic water quality tests are conducted annually by the Mississippi State Health Department. Some of the facility's projects include a fire research laboratory, a chemical/refinery project, compressed gas fire project, vertical and horizontal tank fires and support facilities.

To combat erosion around burn projects, the facility has concrete borders in addition to terracing, drainage ditches and catch basins. This facility's water system consists of a 2.5 million-gallon reservoir connected to a closed loop. Additionally, there is a five-acre lake with depths to 40 feet. This water source is used through dry hydrants connected to an open system. Most of the water is recycled. Although the facility does not have monitoring wells to check ground contamination, it has an oil separator and two holding ponds adjacent to the burn area for surface water.

Nassau County, New York, Fire Service Academy

The Nassau County Fire Service Academy receives its $1.2 million funding by contract with Nassau County. The school performs 26,000 student contact hours annually.

The facility spends no money on water permits, licensing fees or water quality tests. However, it is regulated by the New York State Department of Environmental Conservation, which works with the facility to ensure there are no pollution problems and that services are not interrupted. The academy has three burn buildings, pits, a propane area, an extinguisher area, a reserve tower and a pumper test building. Burn projects are surrounded by pavement.

There are water storage tanks both above and below ground. The facility has monitoring wells to check for ground water contamination. No water quality tests are conducted here because the facility does not recirculate any water. After oil separation, water is discharged into the sanitary sewer. Although operational expenses are minimal, according to training field director Robert Lincoln, several million dollars are being spent to clean up past ground water pollution and to upgrade drainage and oil/water separation systems.

Ohio State Fire Academy

The Ohio State Fire Academy is funded by a percentage of fire insurance premiums collected in that state. The facility has an annual budget of $980,000 and trains 1400 students each year.

The school spends no money on water permits, licensing fees or water quality tests. However, $4000 is spent annually to clean the facility's oil separator sys-

tem. The facility has below-ground storage tanks and a three-acre lake. There are monitoring wells to check for groundwater contamination. To prevent erosion around firefighting projects, each project is surrounded by grass, stones, concrete or paved areas.

All water used for training flows into the sewer system through an oil separator and then into the lake. The lake has a drain—an open system. All pits are concrete and all burn areas are protected by special concrete reinforcements. The facility sits on 39 acres. Last year, $1,300,000 was spent upgrading the training grounds that included concrete burn pits and a new burn structure. New water runoff drains were included. Also included was a 250-foot concrete ditch where instructors can actually place a spill and have a recovery unit practice skills. Next year, another $830,000 will be spent on improvements.

The Ohio State Fire Academy is regulated by the Ohio EPA. This agency's regulations give the facility permission to burn for training purposes, says Dale Zwicker, the facility's training supervisor. According to Zwicker, however, the state regulations include specific limitations.

Arkansas Fire Academy

The Arkansas Fire Academy is funded by state appropriations. It has an annual budget of $850,000 and trains approximately 14,000 students—1000 at its training field and 13,000 on an extension basis.

The facility's environmental concerns are all handled by the state's environmental academy. The environmental academy uses the facility as a training aid for its students, conducting water treatment tests and studies, freeing the fire academy of the task.

The 22-acre facility has flammable liquid projects, smoke projects, structural burn projects, confined-space rescue projects and a drill tower. The facility has above-ground storage tanks. To prevent erosion around projects, drains are strategically located to provide proper drainage and runoff.

After training water is used, it is distributed to two separation ponds prior to being released. There is no mechanical or chemical separation system. Heavy particles settle in the pond, lighter particles are skimmed manually from the surface.

South Carolina Fire Academy

The South Carolina Fire Academy, which has an annual budget of $500,000, is funded by state appropriations and trains 8000 students each year. Although this facility does not purchase water permits or pay licensing fees, it does spend $400 annually on water-quality tests. The South Carolina Fire Academy is regulated by the South Carolina Department of Health and Environmental Control and pays approximately $35 monthly to keep its permits current.

City water is used and the facility spends approximately $5000 annually on water treatment. According to Training Field Supervisor James Bowie, because city water (which has been treated for domestic use) is used, the cost of the facility's water is much higher than using water from any other natural source.

Among the facility's projects are flammable liquid projects, LPG projects, extinguisher projects, burn structures, confined-space rescue projects and hazardous material handling projects. Each burn project is surrounded by pavement; gravel surrounds flammable liquid pit projects. The South Carolina Department of Health and Environmental Control conducts grab tests from discharge water and from ground water in test wells. This agency also regulates the amount of oil/grease and suspended solids that are allowed in the system. It also regulates the permit requirements and has the authority to close the burning area. The facility has below-ground storage tanks. There are no water storage pits; once water is used, it is not recycled. Water goes through natural drainage and through an oil separator before being discharged.

Oklahoma State University–Fire Service Training

Oklahoma State University–Fire Service Training is probably best known for its production of IFSTA training manuals. This facility is funded by state appropriations. Approximately 300 students are trained annually here and another 15,000 trained on an extension basis. It has an annual budget of approximately $600,000.

The facility, which is situated on approximately 10 acres, includes a burn structure, warehouse/classroom, evolution building and five burn projects. Each burn project is surrounded by gravel to prevent erosion. The facility is regulated by the Oklahoma State Department of Health. No money is spent annually on water permits, licensing fees, water quality tests or water treatment. Water storage tanks are above-ground. There is one retention pond. The facility has no ground water contamination monitoring wells. Water used in burn projects is retained in an open pond and evaporation is used for disposal.

Summary

Although the EPA has 10 regional districts and headquarters based in Washington, DC, the bulk of environmental responsibility rests with the individual states and ultimately, with these facilities. Water supplies are essential for the very operation of these firefighter training facilities, compliance with any regulations handed down by federal and/or state governments imperative. The cost of water for some facilities may be high, but not nearly as high as not paying the money and manpower bill.

Today, with all the attention being given to environmental concerns (whether it be groundwater contamination, protecting the ozone layer or recycling) the management of firefighter training facilities could find themselves held even more accountable to environmentalists. Efforts being made by these facilities to provide good recirculation and/or oil separation could go a long way to ensure firefighters in this country are allowed to continue live-fire training.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, D.C.
20332-5000

0 4 JUN 1986

REPLY TO ATTN OF: LEEE

SUBJECT: Engineering Technical Letter (ETL) 86-8 : Aqueous Film Forming Foam (AFFF) Waste Discharge Retention and Disposal

TO: ALMAJCOM/DEE AFRCE-ER AFRCE-CR AFRCE-WR AFRCE-BMS AFRCE-SAC AFIT/DET NGB/DEE AF/REX AFDW/DEE

1. Purpose. This ETL provides design guidance and policy on collection, containment, and disposal of wastewater discharges from preaction AFFF sprinkler systems to be installed in new or existing hangar facilities under the Military Construction Program (MCP). AFFF collection and containment facilities previously installed according to the AFR 88-15 are exempt from this ETL. Paragraph 15-74j of the interim draft edition of AFR 88-15, Criteria and Standards for Air Force Construction, will be revised to incorporate the guidance contained in this ETL. The current policy of allowing permanent collection and containment facilities to retain AFFF wastewater discharges from hangar facilities is not cost effective or practical. Design guidance and policy included in this ETL blends minimal amounts of new construction with the installation's Spill Prevention Control and Countermeasures (SPCC) Plan to contain and dispose of an AFFF discharge.

2. This ETL is effective upon receipt and is applicable to all military construction projects described in para 1 above to include those currently under design.

3. Referenced Publications.

a. AFR 8-7, Air Force Engineering Technical Letters (ETL).

b. AFR 88-15, Air Force Design Manual - Criteria and Standards for Air Force Construction.

4. Policy.

a. General. Direct discharges of foam solution into watercourses can violate stream water quality standards, and will therefore be contained to prevent discharges from entering streams or leaving the installation. AFFF solution discharges can adversely impact biological wastewater treatment processes and can cause foaming in aeration basins and similar plant components if the AFFF concentrations exceeds limits stated below.. If discharge is to a

RO
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ROM
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ROS

domestic wastewater treatment plant, the amount of the AFFF concentrate in the plant influent shall not exceed 100 parts per million (PPM) by weight for a 6% mixture or 50 PPM for a 3% mixture (a 3% solution is more restrictive at the plant due to the strength of its concentrate). For an on-base wastewater treatment plant, the above concentrations will require that the discharge be contained and bled into the influent of the sanitary plant at a controlled rate. If an installation's wastewater collection system is connected to a regional wastewater system, no restrictions may be imposed on the discharge of AFFF wastewater provided the foam concentration in the regional system's plant influent is within the previously specified limits. Additional restrictions may be imposed by the regional system authorities. Permission should be obtained from the regional system authorities prior to project development.

b. Flow Diversion. Normally hangar floor drains are connected to the sanitary sewerage system, after passing through an oil water interceptor or separator. Containing an AFFF discharge within the sanitary sewerage system may not normally be feasible without incurring substantial sanitary operational problems. If this is the case, the main drain line from the floor drains will be intercepted at a point prior to the entrance of domestic sewage into the line. A diverter box or manhole should be installed, with a diverter line, to connect to the storm drainage system. Flow diversion into the storm drainage system shall be accomplished by gravity flow conditions. High volume pumping is not practical and not recommended. The inlet of the diverter line shall be higher than the sanitary drain line to permit normal floor drainage to flow to the oil interceptor/separator and then to the sanitary sewerage. The sanitary sewer line outlet from the diverter box shall be designed to close when a high volume flow enters the diverter box/manhole. This is to prevent an uncontrolled AFFF discharge into the sanitary sewerage system. Other means for diverting the AFFF discharge may be employed provided that its design is adequate to meet the above conditions and that the system is cost effective when compared with above diversion system. For existing hangars changes to hangar floor drains will not normally be required. New piping to the storm drainage system will be designed to discharge waste foam within thirty minutes after activation of the AFFF system if permitted by the capacity of the existing floor drain line. In any event the capacity of the new piping will be at least equal to that of the existing floor drain system piping. It is not the intent to replace existing drainage piping for the purpose of increasing the AFFF discharge capacity.

c. Containment. Once the AFFF discharge has been diverted into the storm drainage system, it shall be contained for controlled disposal. Containment of the discharge shall be by temporary or expedient measures which will be incorporated into the installation's Spill Prevention Control and Countermeasures (SPCC) Plan. The method and location of containment shall be determined by the designer. The containment procedures to be included will be based on expedient control measures.

d. Responsibility of Designer. It will be the MCP project designer's responsibility to design any new construction required to divert and contain an AFFF discharge. Development of any procedures to contain and dispose of the AFFF wastewater will also be the designer's responsibility. The installation's SPCC plan will be modified to include these procedures. The plan will be modified by the designer with concurrence from the Base Civil Engineer.

FOR THE CHIEF OF STAFF

JARRELL S. MITCHELL, Colonel, USAF
Chief, Engineering Division
Directorate of Engineering & Services

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cc: HQ AAC/DEPV
HQ SAC/DEPV
HQ AFLC/DEV
HQ AFSC/DEMV
HQ AFRES/DEPV
HQ AFSPACECOM/DEV
ANGSC/DEV
1100 ABG/DE
HQ AFESC/DEM
DAEN-ECE-S
NAVFAC (Code 04/05)
AF/LEEV
AF/LEEC

SECOND INTERNATIONAL OIL AND PETROCHEMICAL FORUM

REIMS • FRANCE
13 - 15 MAY 1991

Fire Control and the Environment

by

Mr Rodney Camp
Camp & Associates, South Africa

Rodney Camp is actually a civil engineering graduate who joined Mobil Oil in Africa back in 1955. Rodney's career with Mobil spanned some 32 years up to 1987 when he chose to take early retirement and set up his own consultancy company. During his time with Mobil, Rodney was responsible for Accident and Fire Investigation and has been involved in most of the major fire incidents which have occurred in the African continent over this period.

Rodney has been actively involved during his whole career in the formulation of Fire and Safety and Environmental Standards, and is an active member of a number of Associations including the N.F.P.A.

He is at present Environmental Adviser to the South African Oil Industry Environment Committee.

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FIRE CONTROL AND THE ENVIRONMENT

Pollution by hydrocarbons can occur when :-

- *a) They penetrate the soil and or enter the ground water.*
- *b) They enter riverine systems.*
- *c) They enter the sea.*

Prevention Involves :-

- *a) Detection.*
- *b) Emergency Shut Down (E.S.D.).*
- *c) Containment.*

Disaster planning must include pre-planned overflow locations of containment systems, especially under fire conditions. Once pollution or a spill has occurred the following sequence has to take place :-

Contain

Recover

Clean Up.

When the hydrocarbon hits open water the clean up involves skimming and absorbing. When the hydrocarbon has polluted the soil you have the option of removing the soil to an approved site for treatment and bringing in clean replacement or of in-site bioremediation.

Now the word bioremediation has been coined by the Americans and is used instead of biodegradation.

This latter process involves the action of certain bacteria in the soil digesting the hydrocarbons and metabolising them into protein, water CO_2.

When polluted soil is removed to an approved site and then treated we refer to this as "Land Farming".

Bioremediation involves encouraging the hydrocarbon hungry bacteria that naturally occur in the soil to multiply and develop a liking for the particular hydrocarbon. These bacteria require water, oxygen and nutrient. To meet these needs we apply an agricultural fertiliser Mono Ammonia Phosphate, till or plough the soil to aerate it and lightly water. Our experience in Southern Africa, from when we first started biodegradation in 1963, is that a light treatment at frequent intervals gives the most rapid results. Typical is a weekly treatment for three months.

Now, if there is a fire, or if foam blanketing takes place to prevent a fire. involving hydrocarbons, how does this effect or complicate the later bioremediation?

1) *The application of cooling water reduces the holding capacity of spill controls and leads to more rapid spread of hydrocarbons or oxygenates. It. therefore, is far wiser to use foam for cooling, it reduces the volume of water by 77.5%.*

   (In this situation cling is an important factor, and one which cannot be judged when applying foam in the normal fire school practice ground, as repeated fires build up an oily soot on the structures preventing cling. which is different to a first time fire situation).

   The new Ocean Terminal for the new Synfuels plant in South Africa has cooling rings around the upper kerb angle which are fed with foam.

2) *When using <u>protein</u> based foams we actually enhance the plant growth of legumes and thus accelerate our hydrocarbon bioremediation. The Angus protein based foams have an excellent biodegradability well in excess of 90% at 28 days (i.e. Biodegradability = BOD X 100 / COD). Apart from their biodegradability their bacterial toxicity is virtually zero, that is the LC10 is > 5,000ppm.*

   If pure protein based concentrate should enter a still holding of water. then as with any organic overload the Biological Oxygen Demand (B.O.D.) may increase and thus enforced aeration of the water may be required during the biodegradation so as to maintain an aerobic process rather than allow an anaerobic one.

3) *With regard to air pollution the quicker we put the fire out the better, hence pre-planning is vital as is the adequate application of foam. Knock the fire out with protein based foam and avoid :-*

   a) *The need for excessive cooling.*

   b) *Atmospheric pollution.*

   c) *Aggravation of soil and or water clean up.*

<u>FIRE SCHOOLS</u>

At fire schools we are continually re-circulating water supplies. It is general practice to feed this effluent through a gravity separator to remove floating hydrocarbons, but the water should then be fed through a "Wetland" to give nature the opportunity to biodegrade any materials such as foam compounds.

Wetlands consist of filter ponds which contain Macrophyte plants such as Typha and Phragmytes. These plants take oxygen from the atmosphere to below the liquid surface and thus maintain any aerobic biodegradation necessary.

SUMMARY

In summary, if you apply sound all encompassing engineering design and application, and choose a protein based foam, you will make life easier for yourselves in helping to protect the environment.

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SECOND INTERNATIONAL OIL AND PETROCHEMICAL FORUM

REIMS • FRANCE
13 - 15 MAY 1991

Foams : The Environmental Challenge

by

Mr Jonathan Brittain
Angus Fire, UK

Jonathan Brittain graduated in chemistry in 1985 from the University of Surrey.

After a spell of working on the research and development of chemical fuel additives, he joined the Marketing Division of the precious metals company, Johnson Matthey. His responsibilities included the marketing of a range of industrial precious metal-based products to the world's glassmaking trade.

Since 1989 he has been working at Angus Fire as Product Manager responsible for the marketing of foam concentrate products.

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Fire fighting foam was helping to protect the environment long before the recent upsurge of interest in environmental issues.

In addition to its primary role of helping professional fire fighters to prevent loss of life and damage to property, foam also provides protection against the environmental risk posed by all flammable liquid fires. Such fires can chemically transform seemingly innocuous substances into dangerous combustion products, cause emissions of harmful greenhouse gases, and allow hazardous chemicals to escape into the environment.

Recently, environmental concerns have focussed on whether foam concentrate itself could in any way affect the environment. Strictly speaking, all human activities in some way affect the environment. Even our primary activity of breathing increases the amount of carbon dioxide in the atmosphere, thus contributing to the greenhouse effect! So perhaps the question we should really be asking ourselves is whether or not foam concentrates could ever exert a significant impact on the environment.

This is perhaps best answered by relating an incident which took place in Switzerland in 1987[1]:

> "A rapidly spreading fire broke out in the dispatch warehouse of a tyre dealer on December 17th. Despite using large volumes of water, the fire service were unable to bring the blaze under control. The officer in charge therefore decided to make an attempt to extinguish the fire with synthetic multigrade foam. 15,000 l/min of foam/water mixture had to be used to bring the fire (which had in the meantime taken hold of a wide area) under control. A total of 25 tons of foam compound was consumed in the process. *The mixture of water and foam ran into a stream passing close by destroying virtually the whole of its fish stocks*".

Events like this are not common and the fact that they at worst involve fish-kills would suggest that foam is a comparatively harmless material. But while such relatively minor incidents as fish-kills would probably have slipped by unnoticed in the past, the profusion of new environmental legislation has led water authorities to take a much greater interest in the environmental fate of foam and in turn presented fire professionals with a new challenge.

THE ENVIRONMENTAL CHALLENGE

The "Environmental Challenge" now facing fire professionals is to minimise the impact of fire fighting foam concentrates on the environment. Doing this will not only help companies to conform to regulations requiring that they use the best available technology not entailing excessive cost to minimise the environmental effects of their operations, but it will also help to alleviate the strain on the environment from man-made products in general.

Foam producers can play a major role in meeting this challenge by demonstrating care and forethought in the selection of materials and in formulation. There are also steps that fire fighters themselves can take.

DILUTION OF POLLUTION IS NO SOLUTION

The potential for any substance to interact with the environment depends largely on the quantities involved, or as Paracelsus the 15th century Father of Toxicology put it "All substances are poisons; the dose is the only difference between a poison and a remedy".

There is a tendency sometimes to assume that foam in the environment must always be so heavily diluted that it could never pose an environmental risk. This is understandable given that the percentage of foam concentrate required to make up foam premix solutions is typically only 1% to 6% by volume, and that most foam that ends up in the environment is to be found in large bodies of water such as sewers, rivers, streams, lakes and estuaries. However, it is the *way* in which foam is discharged into the environment that explains how such a comparatively harmless material can sometimes effect the environment.

The discharges of most man-made substances into the aquatic environment are predictable and therefore carefully controlled. Consequently their concentrations tend to be quite low, usually well below 1% or 1,000 parts per million (ppm). Domestic detergent is a good example. It is present in numerous consumer products like washing-up liquids and shampoos, and is washed into the environment everyday by millions of people. Its concentration is carefully monitored and controlled by water authorities from release through to removal at water purification plants.

Conversely, foam being used at emergency fire incidents can be discharged into the environment in unpredictable and uncontrolled circumstances. Moreover, the very high water capacities of modern fire fighting equipment can produce flow rates that are comparable to small rivers[2]. Foam premix can run off from the fire and gush into the local water environment at levels much higher than those normally expected by water authorities. In the incident related earlier for example, it was a foam "raft" with an estimated concentration of 10,000 ppm being swept downstream that caused the fish-kill.

So when considering the probable environmental concentration of foam at any particular fire risk, it is advisable to give the benefit of any doubt to the environment itself rather than to assume that high levels cannot be reached. *Dilution of pollution is no solution!*

MEETING THE CHALLENGE

In facing up to the Environmental Challenge we should first of all ask ourselves whether foam is really needed. This is perhaps the easiest question to answer! Professional fire fighters know that there are certain types of fire that threaten human lives and property which can only be tackled successfully and reliably with foam. These include flammable liquid fires at aircraft crashes, refineries and petrochemical plants. Water is the only alternative extinguishing agent that can be applied cost-effectively to flammable liquid fires. But water is heavier than liquids like gasoline and so when applied it plunges through the burning fuel only serving to agitate and spread the fire. Fortunately, low density water or "foam" forms a blanket on the surface of the fuel that "finds the fire", extinguishes it and provides the essential post-fire security.

A fundamental principle of environmentalism is to avoid using excessive quantites of any material that puts a strain on the environment. Using as little foam concentrate as is needed to extinguish and secure the fire has in fact always been standard procedure for fire fighters given the cost of foam concentrates. Furthermore, advances in technology over the years have made possible dramatic reductions in usage levels. The development of film forming foams (FFFP, AFFF) has meant lower extinguishment times and correspondingly lower usage levels. Also, modern Fixed Foam Systems now provide greater operational efficiency and so lower foam consumption[3]. The minimum foam solution application rate recommended by NFPA is 0.16 gpm/sq ft (6.5 $l/m^2/min$) for mobile monitors compared to only 0.1 gpm/sq ft (4.1 $l/m^2/min$) for fixed systems [4].

Another preventative measure that has already been taken up by fire fighters is to channel foam into collecting basins after it has been used. Retaining foam in this way is of course only appropriate where the location of the fire risk is well defined, and has the drawback of high installation costs.

More recently fire fighters have taken the step of selecting the more environmentally favourable types of foam concentrate. *The environmental properties of foam concentrates currently on the market vary enormously.* While this fact did not attract much attention in the past, it is becoming increasingly important to today's environmentally aware foam users.

Comparing the environmental properties of different foams means obtaining environmental data from manufacturers and independent test laboratories *before* making a purchasing decision. This in turn means learning the language of environmental jargon!

ENVIRONMENTAL JARGON

While fire professionals are familiar with fire jargon like "AFFF" and "knockdown", environmental terms like "LC_{50}" and "COD" can seem mind-boggling. In fact there are really only two expressions to be aware of, namely "aquatic toxicity" and "biodegradability".

Aquatic toxicity tests provide information on how poisonous a foam is. The result is an "LC_{50}", which is the lethal concentration at which 50% of the test organisms die within a fixed time period. Sometimes the more demanding LC_{10} or even LC_0, which is effectively the highest concentration that has no observable effect on the test organisms, are recorded. Values are usually available on algae, water flea and fish to simulate the links in the food chain. Generally speaking the higher the LC_{50} the better. However, given the very high levels which foam can on occasions reach in the environment, it should be at least the 1,000 ppm which is sometimes quoted and preferably much higher.

The biodegradability of a foam is a measure of how readily it is broken down by bacteria in the environment. The bacteria literally eat the foam and extract oxygen from the surrounding water in the process. The biodegradability is determined by carrying out two different tests and comparing the results. The first test measures the "Chemical Oxygen Demand (COD)", which is the total amount of oxygen required to degrade a standard amount of foam. The lower the COD the better because less oxygen will be stripped from the environment. The second test measures the "Biochemical Oxygen Demand (BOD)". This is a measure of the foam's propensity to consume that oxygen within a specified time period. The "Biodegradability" is the BOD expressed as a percentage of the COD.

ENVIRONMENTALLY FAVOURABLE FOAMS

Before addressing in detail the wide variation in environmental properties demonstrated by foam products, it may be useful to briefly summarise the main types of foam currently available.

There are two generic foam types - one based on hydrolised protein, the other on synthetic detergents. Major technological advances have been made in both over the years. Synthetic detergent based Aqueous Film Forming Foam (AFFF) was developed twenty five years ago. It was the first type of film-forming foam, and as such provided a significant improvement on the extinction performance of the products then on the market. More recently, in the 1980's Film Forming Fluoroprotein (FFFP) was introduced to the market by Angus Fire offering not only film forming capability but also the superior burnback resistance of protein-based foams. From an environmental standpoint this fundamental difference in composition between the two generic types of foam is critical.

FOAM TYPES

Protein based	Synthetic detergent based
Standard Protein*	Syndet
Standard Fluoroprotein*	Aqueous Film Forming Foam (AFFF)*
Film Forming Fluoroprotein (FFFP)*	

* Alcohol Resistant (AR) versions available

Perhaps not surprisingly foams produced from natural protein have been found to be much gentler on the environment than those based on synthetic detergent. A major independent study undertaken by German government scientists in 1989[3] subjected sixteen commercially available foam concentrate products to a host of rigorous toxicity and biodegradability studies. Protein-based foams were found to be both substantially less toxic and more biodegradable than those based on synthetic detergent. Protein-based foams were found on average to be less toxic to every organism by factors ranging from 9 for fish to 40 for water flea. Of all the protein based foams tested FFFP emerged as the most environmentally favourable of all. In one test a FFFP gave an LC_{10} of 7,500 ppm compared to a value of only 0.6 ppm for a synthetic detergent based AR-AFFF, making it a remarkable 12,500 times less toxic!

Similar results have also been obtained in tests commissioned by Angus Fire at the Huntingdon Research Centre, Europe's largest independent biological safety contract research organisation, and the UK Water Research Centre.

It is worth emphasising the significance of these results. Throughout industry choices are having to be made between using those products that have traditionally been seen as the most effective and those which are found to be the kindest to the environment. In the area of fire fighting where the top priority is to put the fire out and save lives, to use a low performance foam for environmental reasons would be difficult to justify. Fortunately, fire fighters do not face such a dilemma. The latest FFFP type foams that have demonstrated the lowest environmental impact are also, based on the best information available, the fastest growing foam type in modern industry.

The environmental superiority of protein-based foams is not difficult to explain. Hydrolised protein occurs naturally in the environment as a result of the breakdown of animal and plant proteins, and is so low in toxicity that it is commonly used in human foodstuffs. In contrast synthetic detergents do not occur in Nature and are not used in human foodstuffs! In addition protein-based foams contain more environmentally benign foam boosters.

Foam boosters are added to both generic types of foam to enhance the foaming properties of the base materials. Most protein-based foams contain the glycol foam booster Hexylene glycol at low levels, while synthetic detergent based foams need either of the two glycol ethers Ethylene glycol mono-butyl ether or Diethylene glycol mono-butyl ether at somewhat higher levels. Hexylene glycol is about ten times less toxic than either of the two glycol ethers, giving protein-based foams another significant environmental edge.

FOAM BOOSTERS - FISH TOXICITY[6]

	Bluegill sunfish (Leopomis macrochirus) 96 hr LC_{50} (ppm)
Protein based foams	
Hexylene Glycol	> 10,000
Synthetic detergent based foams	
Ethylene glycol mono-butyl ether	1,490
Diethylene glycol mono-butyl ether	1,300

SUMMARY

Fire fighting foam helps to protect the environment by protecting against the environmental risk posed by all flammable liquid fires.

The "Environmental Challenge" now facing fire professionals is to minimise the environmental impact of foam concentrates.

Foam concentrate can sometimes reach high levels in the environment.

The environmental properties of foam concentrates currently on the market vary enormously.

Independent studies show that foam concentrates produced from natural protein can be much gentler on the environment than those based on synthetic detergent.

THINK GLOBALLY, ACT LOCALLY

Fire fighting foam is used in industry above all else to save lives and protect valuable assets, but the implications of it escaping into the environment cannot be ignored.

Arguably, the most important principle to emerge from the public debate on the environment is best summed up in the simple phrase "Think globally, Act locally". We can all do something, no matter how small, to help protect the environment. Today professsional fire fighters are uniquely placed to make a major contribution to protecting the environment. Not only can they continue to reduce the environmental risk posed by flammable liquid fires, but they can also use those fire fighting foams which are gentler on the environment to do it.

The environment is already benefiting from the research which has been carried out in this area, with foam users in certain countries already switching to environmentally sound protein-based foams. This can only continue however if more foam users gain an insight into the real opportunity which now exists for them to help the environment and help themselves at the same time. *All other things being equal, fire fighters can now make choices on ecological grounds about which product they buy.*

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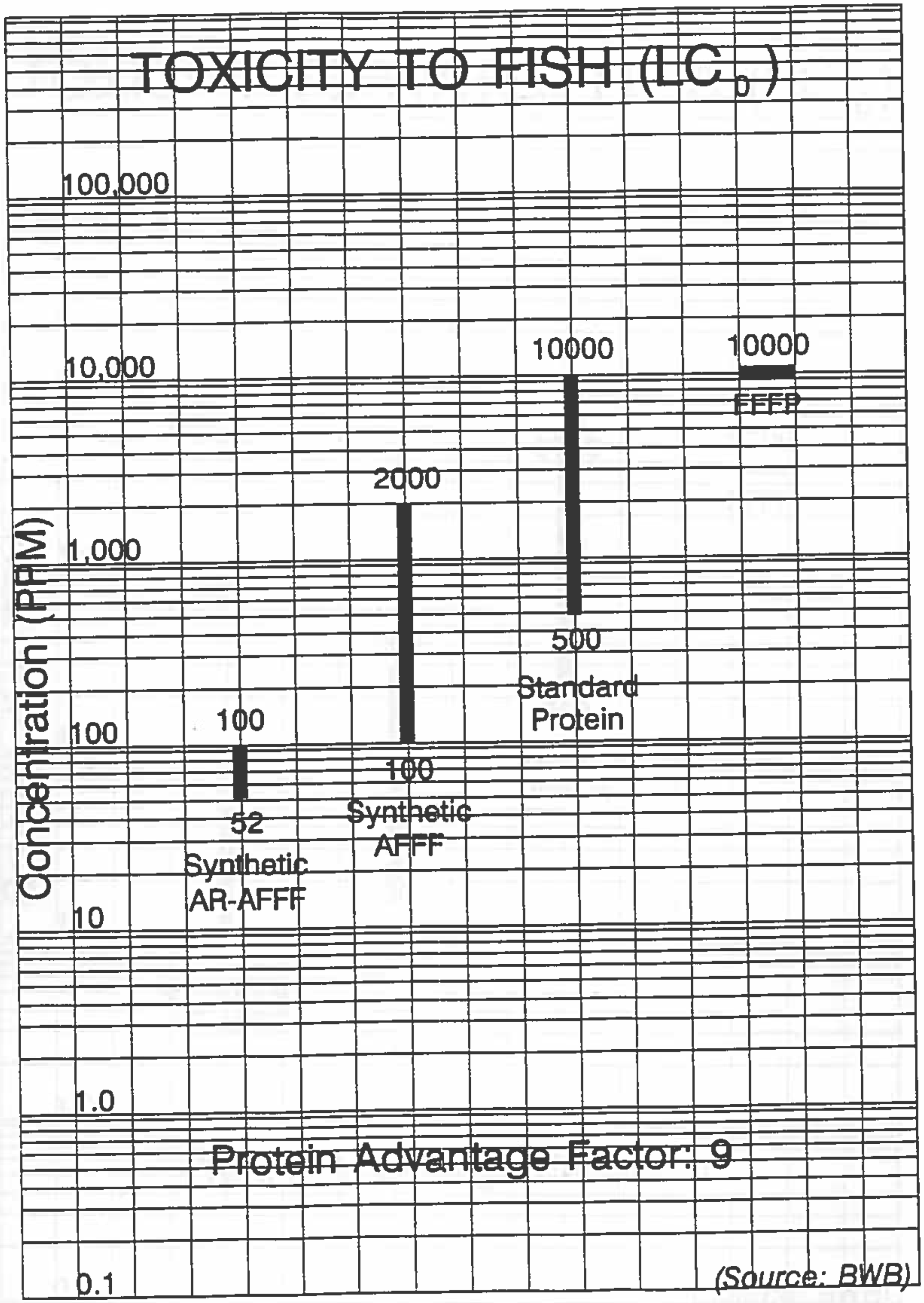
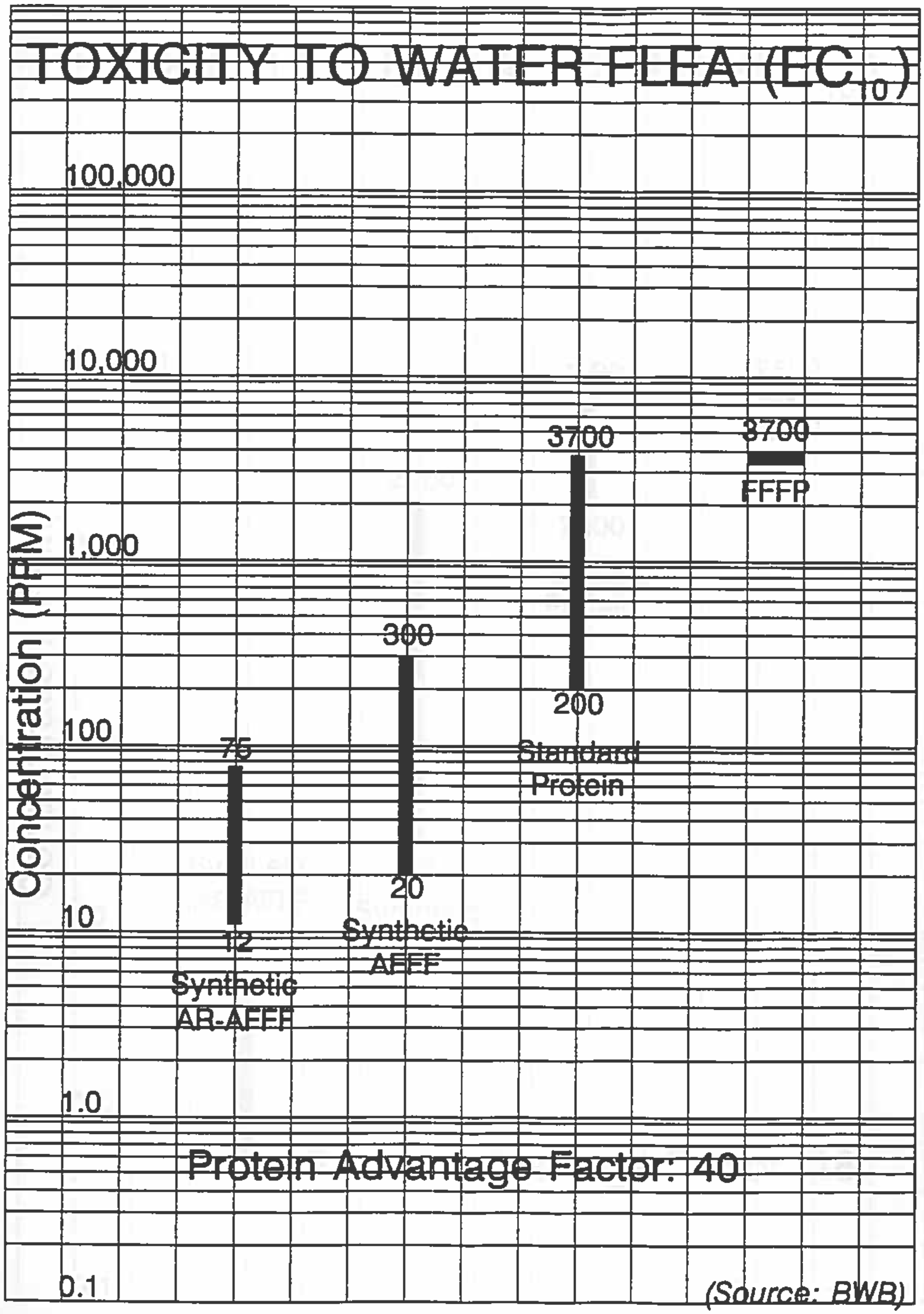
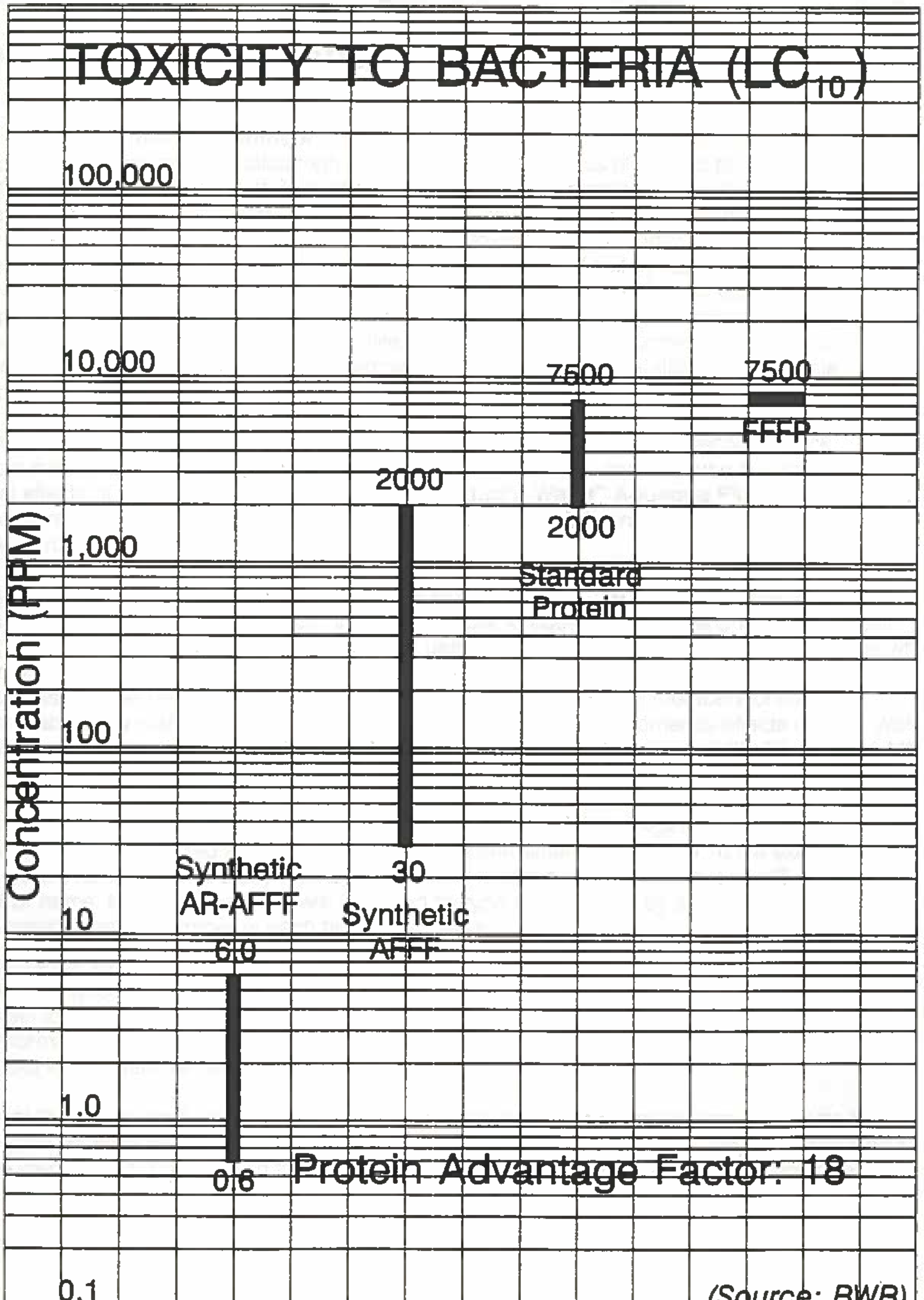

TOXICITY TO FISH (LC_0)
100,000
10,000
1,000
100
10
1.0
0.1
Concentration (PPM)
100
52
Synthetic
AR-AFFF
2000
100
Synthetic
AFFF
10000
500
Standard
Protein
10000
FFFP
Protein Advantage Factor: 9
(Source: BWB)



TOXICITY TO WATER FLEA (EC_{10})
Concentration (PPM)
100,000
10,000
1,000
100
10
1.0
0.1
75
12
Synthetic
AR-AFFF
300
20
Synthetic
AFFF
3700
200
Standard
Protein
3700
FFFP
Protein Advantage Factor: 40
(Source: BWB)


TOXICITY TO BACTERIA (LC10)
Concentration (PPM)
100,000
10,000
1,000
100
10
1.0
0.1
7500
2000
Standard
Protein
7500
FFFP
2000
30
Synthetic
AFFF
Synthetic
AR-AFFF
6.0
0.6
Protein Advantage Factor: 18
(Source: BWB)

Light Water™ Foam Systems

Technical Information

An Environmental Evaluation of AFFF

Introduction: AFFF and the Environment
The consequences of a fire may be catastrophic not only because of loss of life and property, but also because of damage to the environment. The adverse effects to the atmosphere are usually the most obvious. The smoke and soot produced by a fire contain particulate matter, volatile organic compounds, and possibly certain hazardous air pollutants known as "air toxics." Not so readily apparent are the adverse effects on soil, groundwater, streams, and rivers. Major contamination of soil by fuels or other flammable liquids can occur when storage tanks are ruptured. Groundwater contamination may occur if the spilled material seeps into the ground. If the partially burned flammable liquid runs off into a river or stream, the effects on fish, aquatic plants, birds, and other wildlife can be devastating. In addition, the disposal of the charred remains of fuel storage tanks, ships, or aircraft, can create particularly difficult solid waste disposal problems.

Clearly, the most important aspect of fire fighting is quick extinguishment, not only because quick extinguishment minimizes loss of property and life, but it is also the best way to reduce the negative environmental effects of a fire on the air, soil, and water. **3M Light Water™ Aqueous Film Forming Foam (AFFF) concentrates help to rapidly extinguish fires and are an integral part of an effective fire fighting program.**

Product Environmental Data Availability: Extensive laboratory testing has been done to determine the environmental effects of Light Water products, including toxicity to aquatic organisms and biological and chemical degradability. Standard testing methods were used and Product Environmental Data Sheets which contain a summary of this test data are available for each of 3M's fire extinguishing foam concentrates. These data sheets may be obtained from field service representatives or from members of the 3M Environmental Laboratory staff. Questions regarding any aspect of the environmental effects of Light Water fire extinguishing agents can be directed to the 3M Environmental Laboratory, Bldg. 2-3E-09, St. Paul, MN 55133.

German Army Study: Independent Classification of Fire Extinguishing Agents
The German Army has conducted a study in which the environmental properties of 16 fire extinguishing foam agents were evaluated.[1] The study was a "blind" study in that products were not identified by manufacturer or name. Instead, products were identified by type of agent and by an arbitrary number. The types of agents and the number of each type tested were:

- 5 multi-range foam agents
- 6 film forming foam (AFFF) agents
- 3 protein foam agents
- 1 film forming fluoroprotein foam (FFFP) agent, and
- 1 special foam agent for deep-fry pan fires.

The identities of the tested products have not been publicly stated by the German Army. However, the German Army did disclose to 3M that two of 3M's AFFF products (FC-203 and FC-206) were included in the study. The identifying numbers used for the 3M products in the study were also made known to 3M.

Litho in U.S.A

3M Industrial Chemical Products Division

3M Center Bldg. 223-6S-04
St. Paul, MN 55144-1000

3M

The environmental tests performed in the German Army study were:

1. Acute toxicity to the marine photoluminescent bacterium *Photobacterium phosphoreum* using the Microtox™ system.

2. Algae cell multiplication inhibition test using *Scenedesmus subspicatus* as the test organism with an exposure time of 72 hours.

3. Acute toxicity to *Daphnia magna* after exposure for 24 hours.

4. Acute toxicity to zebrafish (*Brachydanio rerio*) after exposure for 48 hours.

5. Chemical Oxygen Demand (COD) and 5-day Biochemical Oxygen Demand (BOD_5) of a solution of the foaming agents in water.

After collecting the test results for each test on all 16 fire fighting agents, the results from the individual tests were averaged using a logarithmic scale in order to assign each of the extinguishing agents to a "Water Endangering Class" or WEC. Assigning WECs by averaging the individual test data simplified the large quantity of data generated in the study and it allowed the German Army to arrive at a single number for the environmental effects of the tested products.

Four Water Endangering Classes were established:

WEC 0 generally harmless materials
WEC 1 mildly harmful materials
WEC 2 harmful materials
WEC 3 very harmful materials

Of the 16 fire extinguishing agents considered in the test, 8 agents were assigned to WEC 1, and 8 agents were assigned to WEC 2. ***The two 3M fire fighting agents included in the study were assigned to WEC 1.***

Confusing Environmental Claims

Recently the German Army study has been used to support environmental claims about certain classes of foam products. Unfortunately, these claims cite only portions of the study while omitting the study's conclusions. This has led to unnecessary confusion for customers.

The important conclusion of the German Army environmental effects study can be stated as follows: THE TWO 3M LIGHT WATER AFFF CONCENTRATES CONSIDERED IN THE STUDY WERE RANKED IN CLASS 1, THE LOWEST WATER ENDANGERING CLASS (WEC) OF ANY FIRE EXTINGUISHING PRODUCT CONSIDERED IN THE STUDY. One final point about the German Army study is that 3M Light Water Foam Concentrate ATC™ FC-600 was not included in the study.

Further confusion is caused when environmental claims use phrases such as "fully biodegraded," "gentler to the environment," "natural" ingredients versus "synthetic" or "man-made" ingredients, and so on. The use of these expressions is unfortunate because they are imprecise and, more importantly, they have not been defined by legislative or regulatory action, or by standards organizations such as the ASTM or the ISO.

Some of these claims can be easily disputed. For example, regarding the use of "natural" to describe film forming fluoroprotein (FFFP) foams: These products are manufactured with synthetic fluorochemicals, as are fire fighting agents from other manufacturers. The best approach is to avoid using these ambiguous terms until they are clearly defined by the appropriate authorities.

"Microtox" is a trademark of Microbics Corp.

Conclusion: The Benefit of Quick Extinguishment

There are many factors to be considered in selecting fire extinguishing agents, but perhaps the most important aspect of fire fighting products from an environmental point of view is also the most important aspect from economic and safety points of view: quick extinguishment. Obviously, the best way to minimize the disastrous environmental effects of a fire is to put it out quickly. Quick extinguishment will not only reduce the amount of smoke and soot produced by a fire, but quick extinguishment means that the use of fire extinguishing agents will be kept to a minimum, too.

The success of 3M AFFF products has been well documented by the extinguishments of numerous major petroleum fires throughout the world. Moreover, these AFFF products have been found to be more effective extinguishing agents than FFFP products in studies conducted by U.S. government agencies, the U.S. military, and other independent testing organizations.[2]

In one government study, several extinguishing agents, including 3M's Light Water ATC AFFF and an alcohol-resistant FFFP foam, were evaluated on a U.S. mil spec 50 square feet hydrocarbon fuel fire. Results of the study show that the extinguishment time measured for the FFFP foam was twice that measured for Light Water ATC AFFF (84 sec. vs. 42 sec.), even though the application rate of the FFFP foam was 50% greater.[3]

Consequently, one could conclude that the amount of FFFP agent used to extinguish the test fire would be three times the amount of Light Water ATC agent—a important factor when considering overall environmental impact. In addition, because the extinguishment time using FFFP foam was twice as long, the release of smoke and soot from the burning fire would conceivably be twice as great as from a fire extinguished with Light Water ATC AFFF.

Clearly, using a more effective extinguishing agent can help avoid unnecessary environmental concentrations and the excessive release of damaging combustion by-products. And, overall, the negative environmental effects of a fire on the air, soil and water can be minimized.

[1] The German Army study was published as "Schaumeinsatz und Umweltschutz," Matthias Gahlen. Brandschutz/Deutsch Feuerwehr Zeitung, March 1991

[2] Performance comparisons between AFFF and FFFP foam can be obtained from several sources. For instance, tests conducted by the U.S. Naval Research Laboratories and other organizations have been compiled and published for NFPA by Hughes Associates, Inc. (June 1990). In the NRL research, a commercial FFFP concentrate was tested on mogas and n-Heptane. When applied at the same concentrations as a military specification grade AFFF, the FFFP foam, in all cases, took longer to extinguish the fire—in some cases up to 30% longer.

[3] Federal Aviation Administration independent study; presented at the International Conference on Aviation Fire Protection, Interlaken, Switzerland, September 22-24, 1987.

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