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From: Commanding Officer, Naval Research Laboratory
To: Commanding Officer, Naval Facilities Engineering Service Center (Code ESC421 Lee)

Subj: AQUEOUS FILM FORMING FOAM (AFFF) ALTERNATIVES: COD AND BOD VALUES

Encl: (1) Two copies of subject report

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AQUEOUS FILM FORMING FOAM (AFFF) ALTERNATIVES: COD AND BOD VALUES

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INTRODUCTION

Military Specification Aqueous Film Forming Foam (AFFF) (reference (1) is used worldwide to combat liquid fuel fires. It is the best available agent for rapid fire extinguishing and burn back resistance of aviation, shipboard, chemical process and petrochemical hydrocarbon fuel pool fires. The very chemical structures contained in the film forming agent formulations that make them effective for fire fighting also result in potential bioaccumulation in human tissues and potential toxicity. The trend is clearly toward stricter regulation of the chemicals in AFFF and of the discharge of AFFF into the environment.

There are several potential options to address issues related to AFFF impact on the environment. In the short term, there is current technology that appears to be able to reduce the quantities of these environmentally unacceptable chemicals needed to fight a fire. Additionally, there are other existing agents with potentially less environmental impacts than AFFF that may meet some of the current fire protection requirements. An investigation of the currently available agents is needed to determine if these agents can meet current fire protection requirements.

The Naval Research Laboratory, in conjunction with the Naval Facilities Engineering Service Center, has conducted a test program to evaluate environmentally friendly fire fighting foam candidates submitted as AFFF alternatives (reference (2)). The objective of this program was to determine the extent to which commercially available or newly developed agents with potentially less environmental impact can meet the current fire protection requirements of the AFFF military specification. The main difference of these alternative agents, in comparision to Military Specification AFFF formulations, is the absence or significant decrease of fluoro-surfactants. This project did not attempt to substantiate the stated "environmental friendliness" of the submitted agents. The fire fighting performance and selected foaming properties were evaluated to assess the suitability of submitted products as alternatives.

RESULTS

Of the fourteen candidate formulations submitted to the AFFF alternative program, seven demonstrated sufficient fire fighting performance to merit the second phase of the evaluation (reference (2)). Table 1 shows the test results of preliminary screening evaluation of the seven candidates, analyzed for Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) to assess their degradability and environmental impact.

Table 1

# Agent*	Foam Type	COD, mg/L Required Values Max.	**COD mg/L Test Values**	BOD_{20}/COD Required Values Min.	**BOD_{20} Test Values**	**BOD_{20}/COD Test Values**
2	3%	1,000,000	**590,000**	0.65	**290,000**	**0.49**
4	3%	1,000,000	**270,000**	0.65	**180,000**	**0.67**
5	3%	1,000.000	**220,000**	0.65	**180,000**	**0.80**
6	3%	1.000.000	**490,000**	0.65	**350,000**	**0.70**
10	3%	1,000,000	**190,000**	0.65	**120,000**	**0.63**
13	6%	500,000**	**470,000**	0.65	**340,000**	**0.72**
14	3%	1,000,000	**490,000**	0.65	**360,000**	**0.75**

* Agent numbers correspond to those designated in reference (2).
** 6% concentrate has half the maximum allowed COD value of 3% foam. (Twice the amount is used per foam quantity.)

MIL-F-0024385F sets a maximum on the COD value and a minimum proportion of which must be degradable as measured by BOD_{20}. All samples met the COD requirement; most met the BOD/COD requirement. A more meaningful measure of environmental impact may be the magnitude of the remainder of the COD value subtracting the BOD value. A number of additional factors must also be considered in ascertaining a product's environmental impact. These include aquatic toxicity to various relevant species, compatibility with wastewater treatment plants, presence and concentration of solvents (e.g. glycols and glycol ethers), as well as the proportion and composition of the fluorine-containing components. This information will enable meaningful further down selection for achieving environmentally acceptable alternative firefighting foams, but is beyond the scope of this project.

A more general appreciation of the technical issues involved in AFFF reformulation, and correlation between the physical properties (such as dynamic surface tension, viscosity, propensity to produce foam) and the performance tests (such as fire extinguishment time, burn back resistance and drainage rate), should be established. Such a technology base will greatly facilitate candidate evaluation and future improvements.

REFERENCES

1. Military Specification MIL-F-0024385F, 7 January 1992, Fire Extinguishing Aqueous Film Forming Foam (AFFF) Liquid Concentrate for Fresh and Seawater

2. "Aqueous Film Forming Foam (AFFF) Alternatives," NRL Ltr Rpt 6180/0149, 22 April 2003