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IN REPLY REFER TO  
3905  
Ser 6180/0415  
OCT 05 2000

From: Commanding Officer, Naval Research Laboratory  
To: Commander, Naval Sea Systems Command (Code 05R42 E Minor)  
Subj: RESULTS OF QUALIFICATION TESTING OF 3% (L15603B) AND 6% (L15606B)  
AQUEOUS FILM FORMING FOAM (AFFF) LIQUID CONCENTRATE FIRE  
EXTINGUISHING AGENT MANUFACTURED BY THE 3M COMPANY.  
Ref: (a) NAVSEA Letter 03Q-1999/0626 of 1 September 1999, "Authorization to Perform  
Qualification Testing on 3M Chemicals."  
Encl: (1) Two copies of subject report.

1. In accordance with reference (a) 3M Company's 3% (L15603B) and 6% (L15606B) AFFF were tested for compliance with Military Specification MIL-F-24385F (SH), Amendment 1, 5 August 1994. Detailed results of these tests are forwarded for your review as enclosure (1).
2. 3M Corporation's 3% (L15603B) and 6% (L15606B) AFFF as supplied by the manufacturer complied with the requirements of the Military Specification MIL-F-24385F (SH), Amendment 1, 5 August 1994.
3. 3M Corporation's 3% (L15603B) and 6% (L15606B) AFFF are recommended for inclusion in the Qualified Products List, QPL-24385-28, 21 April 1994.
4. The Naval Research Laboratory technical point of contact is Dr. Frederick W. Williams, Code 6180, (202) 767-2476, e-mail: [fwilliam@ccs.nrl.navy.mil](mailto:fwilliam@ccs.nrl.navy.mil).

  
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By direction

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(Code 05L4)

**Subj: RESULTS OF QUALIFICATION TESTING OF 3% (L15603B) and 6% (L15606B) AQUEOUS FILM-FORMING FOAM (AFFF) LIQUID CONCENTRATE FIRE EXTINGUISHING AGENT MANUFACTURED BY THE 3M COMPANY.**

**Ref:** (a) NAVSEA letter 03Q-1999/0626 of 1 September 1999, "Authorization to Perform Qualification Testing on 3M Chemicals".  
(b) Military Specification, "Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate, for Fresh and Seawater," MIL-F-24385F, (SH) Amend. 1, 5 August 1994.  
(c) Qualified Products List, QPL-24385-31, 21 April 1994, which lists products that have been qualified in accordance with reference (b).

1. 3M Corporation submitted a 3% Aqueous Film Forming Foam Fire Extinguishing Agent, designated as L15603B, Lot 1, and a 6% Aqueous Film Forming Foam Fire Extinguishing Agent, designated as L15606B, Lot 1, to the Naval Research Laboratory (NRL) for qualification testing (reference (a) for compliance with the requirements of reference (b)). 3M Corporation's 3% and 6% AFFF passed the criteria for qualification and inclusion in reference (c) required by reference (b). The results of the qualification testing are presented in Tables 1 through 7.

2. The contents of each table are briefly outlined as follows:

- a. Table 1: Chemical and Physical requirements.
- b. Tables 2a and 2b: 28 ft<sup>2</sup> Fire Performance Test, fresh concentrate.
- c. Tables 3a and 3b: 50 ft<sup>2</sup> Fire Performance Test, fresh concentrate.
- d. Tables 4a and 4b: Concentrate Stability 28 ft<sup>2</sup> Fire Performance Test, aged concentrate.
- e. Tables 5a and 5b: Solution Stability 28 ft<sup>2</sup> Fire Performance Test, aged solution.
- f. Tables 7a and 7b: Agent Compatibility 28 ft<sup>2</sup> Fire Performance Test, aged concentrates.

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**Table 1. Chemical and Physical Requirements for Concentrates or Solutions**

| Requirement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Pass / Fail Criteria                                    | 3% L15603B Results                                                                                           | Pass / Fail Criteria                                    | 6% 15606B Results                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Refractive index, minimum                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1.363                                                   | 1.38                                                                                                         | 1.358                                                   | 1.36                                                                                                         |
| Viscosity (Centistoke)<br>Maximum @ 5°C<br>Minimum @ 25°C                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 20<br>2                                                 | 16<br>10                                                                                                     | 10<br>2                                                 | 8<br>6                                                                                                       |
| Hydrogen Ion Concentration (pH)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 7.0 to 8.5                                              | 8.26                                                                                                         | 7.0 to 8.5                                              | 8.28                                                                                                         |
| Spreading Coefficient, dynes/cm, minimum                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 3                                                       | 18.2                                                                                                         | 3                                                       | 18.2                                                                                                         |
| Film Formation and Scalability                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | No sustained ignition                                   | No ignition                                                                                                  | No sustained ignition                                   | No ignition                                                                                                  |
| Foamability:<br>Foam Expansion Ratio, minimum<br>Fresh Agent Test: Fresh Water / Sea Water<br>Stability Test, concentrate: Fresh Water / Sea Water<br>Stability Test, solution: Fresh Water / Sea Water<br>Compatibility Tests: Fresh Water / Sea Water<br><br>Foam 25% Drainage Time, minutes, minimum<br>Fresh Agent Test: Fresh Water / Sea Water<br>Stability Test, concentrate: Fresh Water / Sea Water<br>Stability Test, solution: Fresh Water / Sea Water<br>Compatibility Tests: Fresh Water / Sea Water | 5.0:1<br><br><br><br><br><br><br>2.5                    | <br>8.5 / 6.4<br>8.1 / 7.6<br>7.5 / 7.8<br>8.5 / 6.6<br><br>4.2 / 4.2<br>4.2 / 4.5<br>4.5 / 5.3<br>5.3 / 3.5 | 5.0:1<br><br><br><br><br><br><br>2.5                    | <br>8.7 / 5.7<br>8.4 / 5.6<br>8.0 / 7.7<br>8.8 / 9.0<br><br>3.6 / 4.1<br>4.1 / 4.1<br>4.3 / 4.1<br>6.3 / 6.2 |
| Corrosion Rate:<br>General<br>Cold rolled, Low carbon steel (UNS G10100)<br>mili in/yr, maximum<br>Copper-Nickel (90-10) (US C70600)<br>mili in/yr, maximum<br>Nickel-Copper (70-30) (US N04400)<br>mili in/yr, maximum<br>Bronze (UNS C90500), milligrams maximum<br>Localized, corrosion-resistant (CRES) steel, UNS S30400                                                                                                                                                                                     | <br><br><br>1.5<br><br>1.0<br><br>1.0<br>100<br>No pits | <br><br><br>0.0926<br><br>0.00015<br><br>0.0054<br>0.0275<br>No pits                                         | <br><br><br>1.5<br><br>1.0<br><br>1.0<br>100<br>No pits | <br><br><br>1.277<br><br>0.0012<br><br>0.0646<br>0.0618<br>No pits                                           |
| Total Halides, ppm maximum                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 500                                                     | 286                                                                                                          | 250                                                     | 124                                                                                                          |
| Dry chemical compatibility, burn -back resistance time<br>360 seconds minimum                                                                                                                                                                                                                                                                                                                                                                                                                                     | 360                                                     | 400                                                                                                          | 360                                                     | 440                                                                                                          |
| Environmental impact:<br>Toxicity, LC <sub>50</sub> , mg/L, minimum<br>COD, mg/L, maximum<br>BOD <sub>20</sub> minimum<br>COD                                                                                                                                                                                                                                                                                                                                                                                     | 500<br>1,000,000<br>0.65                                | 1000><br>625,300 mg/L<br>0.83                                                                                | 1,000<br>500,000<br>0.65                                | 1000><br>280,000<br>0.70                                                                                     |
| Fluorine content, mg/L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | -----                                                   | 10,800 mg/L                                                                                                  | -----                                                   | 5,250 mg/L                                                                                                   |
| Stratification : Stability Test<br>Compatibility Test                                                                                                                                                                                                                                                                                                                                                                                                                                                             | None<br>None                                            | None<br>None                                                                                                 | None<br>None                                            | None<br>None                                                                                                 |
| Precipitation, % by Volume: Stability Test<br>Compatibility Test, 1:1 Ratio Mixes<br>Compatibility Test, All Agent Mix                                                                                                                                                                                                                                                                                                                                                                                            | < 0.05<br>< 0.05<br>< 0.05                              | < 0.05<br>< 0.05<br>< 0.05                                                                                   | < 0.05<br>< 0.05<br>< 0.05                              | < 0.05<br>< 0.05<br>< 0.05                                                                                   |
| Container cap opening torque (average)                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 50 in/lbs max                                           | 50/lbs                                                                                                       | 50 in/lbs max                                           | 50/lbs                                                                                                       |

**Table 2a. 28 ft<sup>2</sup> Fire Performance Test Results:  
3M 3% L15603B Fresh Concentrate.**

| PROPERTY MEASURED                  | EXTINGUISH TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|------------------------------------|--------------------------|--------------|------------------------|--------------|
| Fresh Water Full Strength          | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 500          |
| Fresh Water Half Strength          | 45 Sec (Max)             | 41           | 300 Sec (Min)          | 525          |
| Sea Water Full Strength            | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 520          |
| Sea Water Half Strength            | 45 Sec (Max)             | 28           | 300 Sec (Min)          | 520          |
| Quintuple Strength (15%) Sea Water | 55 Sec (Max)             | 27           | 200 Sec (Min)          | 460          |

**Table 2b. 28 ft<sup>2</sup> Fire Performance Test Results:  
3M 6% L15606B Fresh Concentrate.**

| PROPERTY MEASURED                  | EXTINGUISH TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|------------------------------------|--------------------------|--------------|------------------------|--------------|
| Fresh Water Full Strength          | 30 Sec (Max)             | 21           | 360 Sec (Min)          | 490          |
| Fresh Water Half Strength          | 45 Sec (Max)             | 34           | 300 Sec (Min)          | 420          |
| Sea Water Full Strength            | 30 Sec (Max)             | 23           | 360 Sec (Min)          | 566          |
| Sea Water Half Strength            | 45 Sec (Max)             | 29           | 300 Sec (Min)          | 430          |
| Quintuple Strength (15%) Sea Water | 55 Sec (Max)             | 30           | 200 Sec (Min)          | 420          |

**Table 3a 50 ft<sup>2</sup> Fire Performance Test Results:**  
**3M 3% L15603B Fresh Concentrate**

| PROPERTY MEASURED       | EXTINGUISHMENT TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES | 40 SECOND SUMMATION | ACTUAL TOTAL |
|-------------------------|------------------------------|--------------|------------------------|--------------|---------------------|--------------|
| Sea Water Full Strength | 50 Sec (Max)                 | 36           | 360 Sec (Min)          | 440          | 320 (Min)           | 369          |

**Table 3b 50 ft<sup>2</sup> Fire Performance Test Results:**  
**3M 6% L15606B Fresh Concentrate**

| PROPERTY MEASURED       | EXTINGUISHMENT TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES | 40 SECOND SUMMATION | ACTUAL TOTAL |
|-------------------------|------------------------------|--------------|------------------------|--------------|---------------------|--------------|
| Sea Water Full Strength | 50 Sec (Max)                 | 36           | 360 Sec (Min)          | 470          | 320 (Min)           | 369          |

**Table 4a. 28 ft<sup>2</sup> Fire Performance Stability Test Results:**  
**3M 3% L15603B Aged Concentrate.**

| PROPERTY MEASURED         | EXTINGUISHMENT TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|---------------------------|------------------------------|--------------|------------------------|--------------|
| Fresh Water Full Strength | 30 Sec (Max)                 | 22           | 360 Sec (Min)          | 475          |
| Fresh Water Half Strength | 45 Sec (Max)                 | 36           | 300 Sec (Min)          | 465          |
| Sea Water Full Strength   | 30 Sec (Max)                 | 22           | 360 Sec (Min)          | 540          |
| Sea Water Half Strength   | 45 Sec (Max)                 | 29           | 300 Sec (Min)          | 520          |

**Table 4b.** 28 ft<sup>2</sup> Fire Performance Stability Test Results:  
3M 6% L15606B Aged Concentrate.

| PROPERTY MEASURED         | EXTINGUISHMENT TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|---------------------------|------------------------------|--------------|------------------------|--------------|
| Fresh Water Full Strength | 30 Sec (Max)                 | 22           | 360 Sec (Min)          | 510          |
| Fresh Water Half Strength | 45 Sec (Max)                 | 39           | 300 Sec (Min)          | 420          |
| Sea Water Full Strength   | 30 Sec (Max)                 | 21           | 360 Sec (Min)          | 540          |
| Sea Water Half Strength   | 45 Sec (Max)                 | 35           | 300 Sec (Min)          | 515          |

**Table 5a.** 28 ft<sup>2</sup> Fire Performance Stability Test Results:  
3M 3% L15603B Aged Solution.

| PROPERTY MEASURED         | EXTINGUISHMENT TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|---------------------------|------------------------------|--------------|------------------------|--------------|
| Fresh Water Full Strength | 30 Sec (Max)                 | 24           | 360 Sec (Min)          | 450          |
| Sea Water Full Strength   | 30 Sec (Max)                 | 24           | 360 Sec (Min)          | 480          |

**Table 5b.** 28 ft<sup>2</sup> Fire Performance Stability Test Results:  
3M 6% L15606B Aged Solution.

| PROPERTY MEASURED         | EXTINGUISHMENT TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|---------------------------|------------------------------|--------------|------------------------|--------------|
| Fresh Water Full Strength | 30 Sec (Max)                 | 26           | 360 Sec (Min)          | 450          |
| Sea Water Full Strength   | 30 Sec (Max)                 | 23           | 360 Sec (Min)          | 490          |

3. The AFFF agents from the QPL, reference (c), used for the Compatibility Tests were from NRL stock, and are listed in Table 6a and 6b. The 3M concentrates (L15603B and L15606B) were mixed individually with each of the three concentrates in a 1:1 volume ratio, and with all the concentrates listed in Table 6 in a 1:1:1:1 volume ratio. These concentrate mixtures were aged in accordance with reference (b) and then used to prepare the solutions used for fire performance testing. *A slight cloudiness at the bottom of the container of the mixture of all the agent concentrates was noted. The cloudiness disappeared with agitation prior to mixing the working solutions.*

**Table 6a.** 3% AFFF Agents from the Qualified Products List used in the Compatibility Fire Performance Test.

| QUALIFIED AGENT | MANUFACTURER                                 | LOT / BATCH | DATE OF MANUFACTURE |
|-----------------|----------------------------------------------|-------------|---------------------|
| Angus           | Angus Fire Armour, Corp.                     | 010493      | May 1993            |
| 3EM             | Chubb National Foam (CNF)                    | 91175       | May 1991            |
| FC-203CF        | Minnesota, Mining & Manufacturing, Co., (3M) | 101         | March 1991          |

**Table 6b.** 6% AFFF Agents from the Qualified Products List used in the Compatibility Fire Performance Test.

| QUALIFIED AGENT | MANUFACTURER                                 | LOT / BATCH | DATE OF MANUFACTURE |
|-----------------|----------------------------------------------|-------------|---------------------|
| Angus           | Angus Fire Armour, Corp.                     | 010493      | May 1993            |
| 6EM             | Chubb National Foam (CNF)                    | 91175       | April 1991          |
| FC-206CF        | Minnesota, Mining & Manufacturing, Co., (3M) | 101         | March 1991          |

**Table 7a. 28 ft<sup>2</sup> Fire Performance Concentrate Compatibility Test Results:**  
**3% Aged Concentrates.**

| QUALIFIED AGENT  | PROPERTY MEASURED | EXTINGUISH TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|------------------|-------------------|--------------------------|--------------|------------------------|--------------|
| Angus            | Fresh Water       | 30 Sec (Max)             | 23           | 360 Sec (Min)          | 525          |
| Angus            | Sea Water         | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 480          |
| Chubb 3EM        | Fresh Water       | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 640          |
| Chubb 3EM        | Sea Water         | 30 Sec (Max)             | 25           | 360 Sec (Min)          | 540          |
| 3M-FC203CF       | Fresh Water       | 30 Sec (Max)             | 27           | 360 Sec (Min)          | 450          |
| 3M-FC203CF       | Sea Water         | 30 Sec (Max)             | 25           | 360 Sec (Min)          | 460          |
| All of the Above | Fresh Water       | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 465          |
| All of the Above | Sea Water         | 30 Sec (Max)             | 30           | 360 Sec (Min)          | 510          |

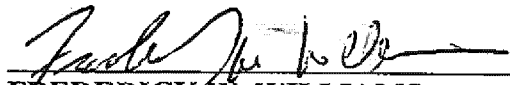
**Table 7b. 28 ft<sup>2</sup> Fire Performance Concentrate Compatibility Test Results: 6% Aged Concentrates.**

(Solutions for fire performance tests were mixed at full strength)

| QUALIFIED AGENT  | PROPERTY MEASURED | EXTINGUISH TIME CRITERIA | ACTUAL TIMES | BURNBACK TIME CRITERIA | ACTUAL TIMES |
|------------------|-------------------|--------------------------|--------------|------------------------|--------------|
| Angus            | Fresh Water       | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 496          |
| Angus            | Sea Water         | 30 Sec (Max)             | 28           | 360 Sec (Min)          | 460          |
| Chubb 6EM        | Fresh Water       | 30 Sec (Max)             | 21           | 360 Sec (Min)          | 675          |
| Chubb 6EM        | Sea Water         | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 550          |
| 3M-FC206CF       | Fresh Water       | 30 Sec (Max)             | 24           | 360 Sec (Min)          | 520          |
| 3M-FC206CF       | Sea Water         | 30 Sec (Max)             | 25           | 360 Sec (Min)          | 550          |
| All of the Above | Fresh Water       | 30 Sec (Max)             | 23           | 360 Sec (Min)          | 540          |
| All of the Above | Sea Water         | 30 Sec (Max)             | 22           | 360 Sec (Min)          | 500          |

4. 3M Corporation's 3% AFFF, L15603B, Lot 1, and 6% AFFF, L15606B, Lot 1, are recommended for inclusion in the Qualified Products List (reference (c)).





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