SUMMARY FOR WORK PERFORMED BY THE GERMAN ARMY ON FOAM EXTINGUISHING AGENTS MANUFACTURED BY MULTIPLE COMPANIES

TEST SUBSTANCE

Identity: A mixture containing perfluorooctanesulfonate, which may also be referred to as PFOS, FC-95, or as a component of FC-203. (1-Octanesulfonic acid) (CAS # 2795-39-3).

Remarks: The test sample is FC-203. Current information indicates it is a mixture of 1.34% PFOS, 35% diethylene glycol butyl ether, 37.85% water, 20% ethylene glycol, 2.66 % Sultone foamer, 3% sodium octyl sulfate, 0.1% sodium lauryl sulfate, and 0.05% tolyltriazole.

The following summary applies to a study done by the German Army for purposes of comparing the environmental properties of foam extinguishing agents from multiple companies, including 3M's FC-203. Data may not accurately reflect the environmental properties of the the fluorochemical component in the test sample.

STUDIES

10, 20, and 30 minute EC_{50} for *Photobacterium phosphoreum* (Microtox™), 72-hour EC_{50} for growth inhibition of Fresh Water Algae (*Scenedesmus subspicatus*), 24-hour EC_{50} for *Daphnia magna*, 48-hour LC_{50} to zebra barbling (*Brachydanio rerio*), Chemical Oxygen Demand and 5-day Biochemical Oxygen Demand

METHODS:

Microbics Microtox® "BASIC" Procedure

Algae growth inhibition per EPA guidelines dated 05-06-1982

Daphnia toxicity according to DIN 38412, Part 11

Zebra barbling toxicity according to DIN 38412, Part 15

RESULTS

Report Date: 3/29/90

The EC_{50} for *Photobacterium phosporeum* was 2500 ppm. It is not clear if this is for the 10, 20, or 30 minute exposure.

The 72-hour EC_{50} Growth Inhibition for Scenedesmus subspicatus was 160 ppm.

The 24-hour EC_{50} for *Daphnia magna* was 430 ppm.

The 48-hour LC_{50} for Zebra barbling (*Brachydanio rerio*) was 1634 ppm.

The Chemical Oxygen Demand (COD) was 41,200 mg O_2 / L

The 5-Day Biochemical Oxygen Demand (BOD5) was 21,500 mg O_2 / L

DATA QUALITY

Reliability: Klimisch ranking = 4. All study values come from a summary list only. No raw data or method documentation was available.

OTHER

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German Army

Investigations of toxic effects and biological degradability of foam extinguishing agents in the waste water

by Ekkehard Ising

1. Introduction

On April 15, 1985, the Federal Minister for Internal Affairs introduced a revised and expanded version of the

Index of Water Endangering Materials *)

The index lists the most important chemical compounds available on the market and divides them into four water endangering categories (WEC) according to their water endangering potential:

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

All chemical materials not yet listed in the catalogue, are considered water endangering until the authorized

Subcommittee for "Storage and Transportation of Water Endangering Materials" at the Federal Ministry for Internal Affairs

has decided about their classification.

In case of mixtures of materials, the incorporation into a water endangering category is decided according to the data measured on the mixture itself.

At the focus of the evaluation of a material regarding its endangering potential for the organisms living in water or using it - e.g. as a food - is its acute toxicity, especially for bacteria, algae, small crayfish, fish and mammals.

Tests on aquatic organisms (bioassays) are included among the procedures prescribed by the legislature for water and waste water evaluation.

It is generally accepted:

1. Principally, bioassays cannot be replaced by the chemical analysis.

2. Bioassays on the one hand and chemical/physical procedures on the other, complement each other (see among others: German Unified Procedures for Water, Waste Water and Sludge Examination, DIN 38412).

*) GMBl, Issue A, 36 No. 11 (1985), pages 173 - 252

During the evaluation of the effects of

- chemical parameters, e.g. toxic materials contained in water and

- physical parameters, e.g. supply of energy, water extraction

the attention should be paid to the use of prescribed test organisms and to the conformance to standard test conditions. The reproducibility and statistical validity of the results should be secured.

The following types of test organisms should be used in standardized bioassays in water and waste water:

- bacteria as chemoheterotrophs

- algae as primary producers

- protozoans as single primary and secondary consumers

- small crayfish as multicell consumers

- fish as multicell consumers with a central nervous system. At the same time, they are the final members in the aquatic food chains and collect persistent chemicals in their tissues.

Additionally, certain saprobic systems can be used in biotests as models of complete ecosystems. Particularly microcosms and activated sludge systems consisting of various bacteria, fungi, protozoans and worms.

2. Problem definition

According to the definitions in water supply law and waste water handling law including pertinent implementation procedures, the Federal defense forces are frequently quoted as the cause of harmful materials discharges to waters and communal waste water treatment plants.

Particularly during, e.g.

- use of extinguishing foams during trainings and actions

- transportation and storage of foam agent concentrates

considerable harm can be done to surface and ground waters.

To evaluate the danger potential of the foam concentrates not yet classified in the water endangering categories, their examination and military-internal temporary classification into water endangering classes is necessary. The Federal Office for Defense Technology and Acquisition in Koblenz, has authorized the defense scientific Service Office of the Federal Army to conduct the necessary research and the subsequent temporary Army-internal WEC classification.

The research, leading to establishing water endangering categories of foam extinguishing agent concentrates, produces at the same time values of acute organism toxicities of the, mostly 3%, application solutions.

3. Foam extinguishing agents and their bioassays

3.1 Total of 16 foam extinguishing agents representing 5 different kinds of foam agents were comparatively evaluated in bioassays (see 3.2) regarding acute toxicity of their application solutions to water organisms and subdivided into water endangering categories from the point of view of their concentrates.

In particular:

- 5 multi-range foam agents
- 6 film-forming foam agents
- 3 protein foam agents
- 1 film-forming fuorine-protein foam agent
- 1 special foam agent for deep-fry pan fires

The formulations of the foam extinguishing agents are proprietary information and unavailable to the public. After consultations with manufacturers, the following materials can be listed as toxic components:

- organic surfactants
- glycols (e.g. ethylenglycol, butyldiglycol)
- preservatives
- organic solvents
- organic acids
- inorganic salts

Presented test results are new and not yet revealed to the manufacturer companies. Therefore, product names cannot be published here. Hence, the result tables will have the product names substituted by class descriptions including running item number.

3.2 Listing of the bioassay used (short description of each test with the following result table - see 4.5 through 4.5).

3.2.1 Bioluminescence inhibition test with Photobacteria Phosphoreum in microtox analyzer, model 2055 (Beckman Co.)

3.2.2 Algae growth inhibition test according to the test guidelines of federal EPA dated 05-06-1982.

3.2.3 Daphnia short test according to DIN 38412, Part 11.

3.2.4 Fish test according to DIN 38412, Part 15.

3.2.5 Determination of the biochemical oxygen demand by the application solutions and their dilutions with water during 5 consecutive days (BOD 5).

Apparatus: Sapromat B12, Voith Co.

In comparison to BOD 5, the measurement included:

chemical oxygen demand of the application solutions and their dilutions (COD).

Apparatus: Dr. Lange digital photometer LP 1 W.

4. Results

The results will be described in the following (chapter 4.1 to 4.7) in the form of tables with associated text.

4.1 The bioluminescence inhibition test with Photobacteria Phosphoreum in microtox analyzer, model 2055 by Beckman Co.

4.1.1 Short description of the test

The test organism Photobacteria Phosphoreum is a marine bacteria. This kind of bacteria is present in immense quantities in the sea layers close to the surface and causes the so called marine phosphorescence. The underlying chemical process is a luciferine-luciferase process. Damages to the Photobacteria, e.g. due to intoxications, result in the inhibition of the luciferine-luciferase activity. The end effect is the reduction of the light emission.

This, in itself very simple, principle is used in the microtox analyzer:

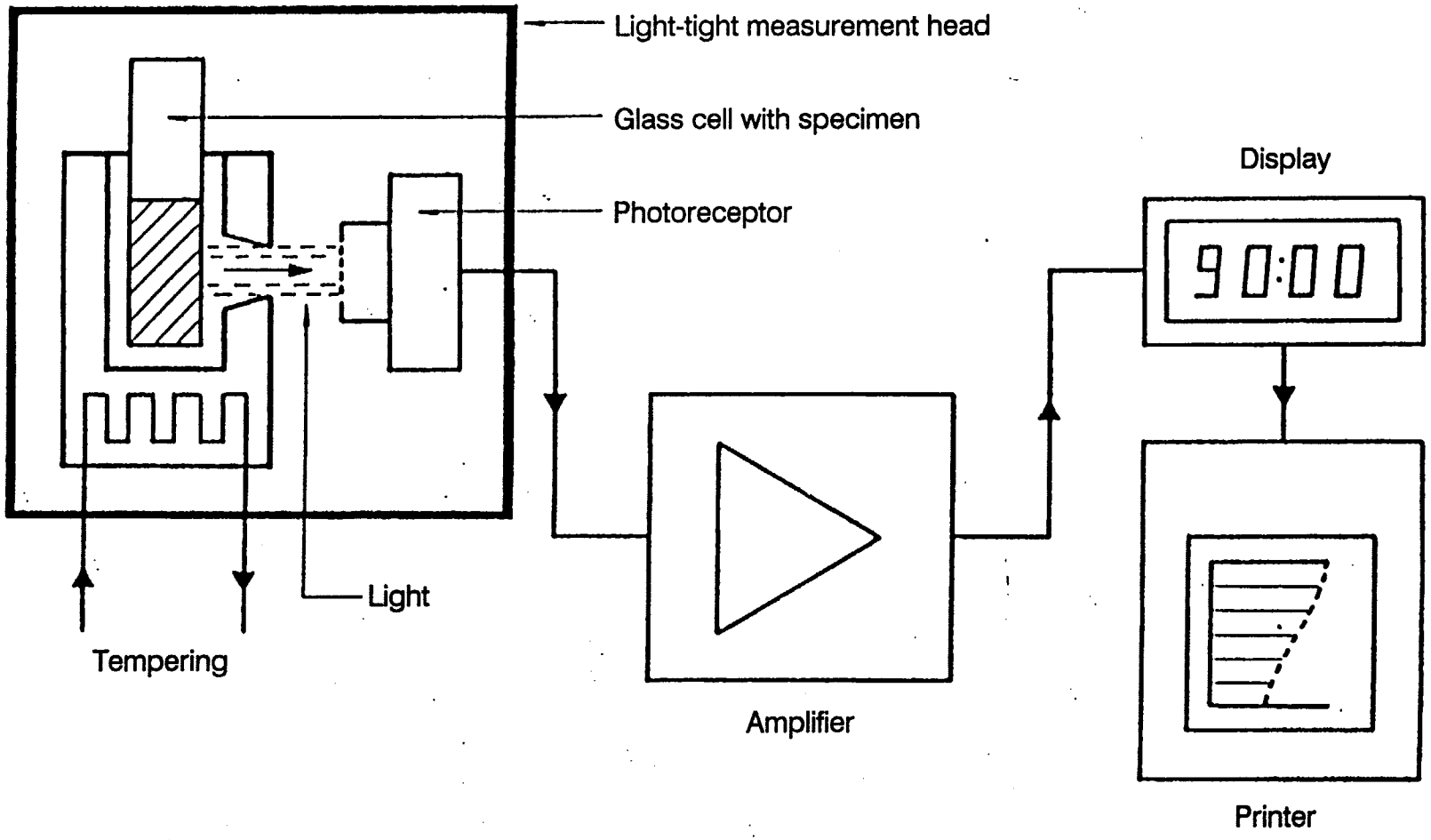
A light-transparent glass cell is placed in a light-tight measurement head. The glass cell contains 1 ml of a suspension with Photobacteria. The light emitted by the Photobacteria falls on a photoreceptor, is converted into electric energy, amplified, displayed and recorded.

The light quantity emitted by a specimen of untreated bacteria is set in the display to the value of 90%. This quantity is tantamount to: "natural, uninhibited light emission".

Specimen of equal quantity of bacteria and equal bacteria quality with toxic substances added respond with a reduction of the light emission. Accordingly, the display value lies between 90% and 0%. The 0%-value indicates that the photobacteria of the specimen treated in this way is not capable of light production any more.

Fig. 1: Measurement arrangement of microtox analyzer

Microtox®- Analyzer: Measurement configuration



4.1.2 The results of the bioluminescence inhibition test with Photobacteria Phosphoreum are assembled in Table 1.

In the first result column are the effective concentrations of the 16 tested foam agents in µl/l of water leading to a 50% inhibition of the light emission by the light bacteria (= EC50).

In the second result column are likewise effective concentrations leading to a 10% inhibition of the light emission (= EC10) and representing the so called toxicity thresholds of the foam agents to the Photobacteria.

The negative decimal logarithms of individual EC10 result after multiplication by the factor of -1 in so called evaluation and endangering figures of the individual foam extinguishing agents to Photobacteria Phosphoreum (see result columns 4 and 5).

According to the evaluation scheme of the "Commission for Evaluation of Water Endangering Materials", the determined evaluation and endangering figures (EE figures) indicate the following toxicity categories:

EE figures of 6.0 and higher	: Highly toxic to test organisms
EE figures 4.0 to 5.9	: Toxic to test organisms
EE figures 2.0 to 3.9	: Low toxicity to test organisms
EE figures under 2.0	: Generally non-toxic to test organisms

Table 1: Acute toxicities as EC50* and EC10** to photbacterium phosphoreum (Photoluminescent bacteria).
Criteria: Inhibition of the light power within 10 / 20 / 30 minutes (Classification of the foam agents according to decreasing toxicity)

Foam agents (FA)		EC50 in µl/l of water	EC10 in µl/l and mg/kg of water Toxicity threshold µl/l	mg/kg	negative decimal logarithm of the EC10	Evaluation and endangering figures for photobacterium phosphoreum
Multirange FA	No.2	6	0.6	0.61	-6.215	6.2
Multirange FA	No.1	7.5	0.9	0.92	-6.031	6.0
Multirange FA	No.4	15	1.7	1.79	-5.747	5.7
Multirange FA	No.5	25	1.7	1.75	-5.757	5.8
Multirange FA	No.3	25	6	6.0	-5.222	5.2
Film forming FA	No.2	2000	85	91	-4.041	4.0
Film forming FA	No.6	300	30	32	-4.495	4.5
Film forming FA	No.1	460	120	129	-3.889	3.9
Special FA		3000	150	216	-3.666	3.7
Film forming FA	No.5	2000	460	479	-3.320	3.2
FC-203	No.4	2500	600	632	-3.199	3.2
FC-206	No.3	15000	2000	2040	-2.690	2.9
Protein FA	No.3	5000	2000	2330	-2.633	2.6
Protein FA	No.1	30000	4000	4570	-2.340	2.3
Film forming fluorineprotein		30000	7500	8590	-2.066	2.1
Protein FA	No.2	30000	7500	9000	-2.046	2.0

* EC50 = Effective concentration of the foam extinguishing agent lowering the lightpower of the photobacteria by 50%
** EC10 = Effective concentration of the foam extinguishing agent lowering the lightpower of the photobacteria by 10%

The following evaluation of the bacteria toxicity of the foam extinguishing agents can be concluded from these data:

Highly toxic to Photobacteria are the multirange foam extinguishing agents No. 1 and 2.

Toxic to photobacteria are the multirange foam extinguishing agents No. 3, 4 and 5, as well as film-forming foam agents No. 2 and 6.

Low toxicity to photobacteria represent the film-forming foam agents No. 1, 3 (FC-206, 4 (FC-203) and 5, the three protein foam agents, the film-forming fluorine-protein foam agents as well as the special foam agent for deep-fry pan fires.

4.2 Algae multiplication inhibition test

4.2.1 The investigations of algae toxicity were conducted according to the assay guideline "Inhibition of the cell multiplication of green algae Scenedesmus Subspicatus CHOD" of the (German) Federal EPA dated 06.22.1982.

Scenedesmus subspicatus is a single-cell autotrophic organism with vegetative multiplication.

Stock cultures of algae were held in nourishment media according to the test guideline and transferred to a fresh medium once a week. Pre-cultures were set up 3 days before starting each assay to obtain cells in the exponential growth phase.

The experiments were conducted as static tests, i.e. the tested substance was added once in the desired concentration at the beginning of the incubation. For each concentration and control 2 Erlenmeyer flasks with 50 ml of nutritional solution were set up. The initial cell density was set to the value between 10,000 and 15,000 cells.

The test cultures were shaken once a day. The cell concentration was determined on the day 0, 3, 4 and 7 by means of an electronic cell counting device. The cell numbers were used to plot the growth curves and to calculate the multiplication inhibition which takes into consideration days 0, 3 and 4 according to the guideline. Day 7 was used for an after-observation.

From the concentration-effect curves, the values of EC10 and EC50 were determined.

4.2.2 The results of algae growth inhibition assay using Scenedesmus Subspicatus were put together in Table 2.

The table is built up according to the same scheme as table 1. The toxicity determination of individual foam agents for Scenedemus Subspicatus was conducted in the same way as that for photobacteria.

All foam agents with the exception of two protein foam agents should be designated as toxic to Scenedemus Subspicatus. Both of the mentioned protein foam agents have only weak toxicity to algae. The special foam agents for deep-fry pan fires can be considered a border case between toxic and weakly toxic agents.

It is conspicuous that one protein foam agent which was only weakly toxic in relation to bacteria is in the upper range of toxicity to algae, while one highly toxic to bacteria multi-range foam agent has been found in the mid-range of toxicity relative to algae.

Table 2: Acute toxicities as EC50* and EC10** to scenedesmus subspicatus (Fresh water algae).
Criteria: Inhibition of growth within 72 hours (Classification of the foam agents according to decreasing toxicity)

Foam agents (FA)		EC50 in µl/l of water	EC10 in µl/l and mg/kg of water Toxicity threshold µl/l	mg/kg	negative decimal logarithm of the EC10	Evaluation and endangering figures for S. subspicatus
Multirange FA	No.3	30	8	8.0	-5.097	5.1
Film forming FA	No.6	230	8	8.4	-5.076	5.1
Multirange FA	No.1	32	9	9.2	-5.036	5.0
Multirange FA	No.4	24	9	9.5	-5.022	5.0
Film forming FA	No.2	37	9	9.7	-5.013	5.0
Protein FA	No.2	225	10	12.0	-4.921	4.9
Film forming FA	No.3 FC-206	160	16	16.3	-4.788	4.8
Film forming FA	No.4 FC-203	160	16	16.9	-4.772	4.8
Film forming FA	No.5	105	22	23	-4.638	4.6
Film forming FA	No.1	355	36	39	-4.409	4.4
Multirange FA	No.2	68	38	39	-4.409	4.4
Film forming fluorineprotein		80	35	40	-4.398	4.4
Special foaming agent		105	56	81	-4.042	4.0
Protein FA	No.3	435	202	235	-3.629	3.6
Protein FA	No.1	6200	509	581	-3.236	3.2

* EC50 = Concentration inhibiting the growth by 50% after 72 hours
** EC10 = Concentration inhibiting the growth by 10% after 72 hours

4.3 Results of the Daphnia short-term assay

4.3.1 Test organisms in this case a 6 to 24-hours old instar of Daphnia Magna. The toxic effect of substances contained in water on Daphnia Magna is measured as the solution level or concentration (ppm, ppb) of the tested substances in which, after testing, certain percentage of Daphnia became immobile (effective concentrations for 10% and 50% of the animals = EC10 and EC50).

Test configuration

In a 25 ml beaker flask, 5 ml of standard water (so called dilation water) were filled. Then, 2 old animals are put in left to themselves for 24 hours without food. After that time, the old animals are removed. The neonates released in the meantime, were counted and the evaporated water replenished. Now, 5 ml of the toxicant solution are added into the beaker glass. This results in the solution of 10 ml and therefore represents the first level of dilation of the tested substance in water. Further levels are obtained in the same way.

To inhibit the natural swimming activity of the animals and to secure a possibly equal substance intake in all larvae, the test material is left in darkness for the next 24 hours; the counting of the still mobile instars follows thereafter.

Control breed

In parallel to each assay series, a determination of the EC10-value is conducted with the reference substance potassiumdichromate. The quantities used in this case are 0.9 - 1.9 mg/l of stock water. The test result is valid when less than 10% of Daphnia neonates became immobile in this control assay.

4.3.2 The results of Daphnia short-term test are collected in Table 3.

The configuration of the table again follows the scheme used in Table 1. Also the determination of the toxicity of individual foam agents to Daphnia is conducted just like in previous tests with Photobacteria and green algae.

All multi-range foam agents, film-forming foam agents up to the running No. 3 and the special foam agent for deep-dry pan fires, are toxic to Daphnia Magna. The remaining foam agents, i.e. the film-forming FA No. 3, the three protein FA and the film-forming fluorine-protein FA have low toxicity to Daphnia.

Generally, the multi-range and the film-forming foam agents are less toxic to Daphnia than to the bacteria.

Table 3: Acute toxicities as LC50* and LC10** to Daphnia Magna (Water flea);
Criteria: Loss of ability to swim within 24 hours (Classification of the foam agents according to decreasing toxicity)

Foam agents (FA)	LC50 in µl/l of water	LC10 in µl/l and mg/kg of water Toxicity threshold µl/l	mg/kg	negative decimal logarithm of the LC10	Evaluation and endangering figures for daphne magna
Multirange FA No.3	75	12	12.0	-4.921	4.9
Multirange FA No.4	58	13	13.7	-4.863	4.9
Multirange FA No.2	75	20	20.4	-4.690	4.7
Film forming FA No.1	600	20	21.6	-4.666	4.7
Multirange FA No.1	120	30	30.5	-4.516	4.5
Film forming FA No.2	200	30	32.2	-4.492	4.5
Film forming FA No.4 FC-203	430	30	31.6	-4.500	4.5
Film forming FA No.6	1500	45	47.3	-4.325	4.3
Special foam agent	75	45	65.0	-4.188	4.1
Multirange FA No.5	250	75	77.4	-4.111	4.1
Film forming FA No.5	3000	85	88.5	-4.053	4.1
Protein FA No.3	600	200	233	-3.633	3.6
Film forming FA No.3 FC-206	2000	300	305	-3.516	3.5
Protein FA No.1	7500	1900	2170	-2.664	2.7
Protein FA No.2	7500	3700	4440	-2.353	2.4
Film forming fluorineprotein	7500	3700	4240	-2.373	2.4

* LC50 = Concentration causing 50% immobility of the animals within the test period
** LC10 = Concentration causing 10% immobility of the animals within the test period

4.4 Results of the fish toxicity test

4.4.1 The investigation of the fish toxicity as well as fish holding and water quality were in agreement with the OECD guidelines. The zebra barblings (Brachydanio Rerio) had an average body length of 3.0 ± 0.5 cm. The mortality during the last two weeks of the stock holding was 0%.

The O_2 content and pH of the test solutions was determined at t = 0h, t = 48h and t = 96h (end of the experiment). During the experiment, there was no noticeable change of the O_2 content. The pH of the test solutions was 7.8 ± 0.2 at the beginning of the test.

The food supply was suspended 24 hours before the start of the test. The temperature of the solution was 23°C ± 0.5°C with constant light aeration through a glass capillary and a light/dark cycle of 16/8 hours.

In each concentration level, 10 fishes were put in the 10 liter test solution in a 15 liter full glass bowl under static test conditions and the number of dead determined after 24, 48, 72 and 96 hours. Uncertainties during the experiment were recorded.

The LC_{50} were calculated with a computer program according to Lichtfield and Wilcoxon 1949; LC_0 and LC_{100} resulted directly from the test.

4.4.2 The results of the fish toxicity test are compiled in Table 4.

The result representation and determination of the toxicity of individual foam agents to fish again follows the bacteria test (see 4.1.2).

Clearly, toxic to fish are only multi-range foam agents No. 2 and 4. The remaining multi-range foam agents No. 1 and 3, as well as the film-forming foam agents No. 1 and 2 can be assigned to a toxic/ weakly toxic transition range. Weakly toxic to fish are the film-forming foam agents No. 3 (FC-206, 4 (FC-203), 5 and 6, the protein foam agents No. 2 and 3, as well as the special foam agent for deep-fry fires. The film-forming foam agent No. 1 as well as the film-forming fluorine-protein foam agent are generally non-toxic to fish.

Table 4: Acute toxicities as LC50* and LC0** (48 hours) to Brachydanio rerio (zebra barbling);
Criteria: Mortality of the test animals within 48 hours (Classification of the foam agents according to decreasing toxicity)

Foam agents (FA)		LC50 in µl/l of water	LC 0 in µl/l and mg/kg of water Toxicity threshold		negative decimal logarithm	Evaluation and endangering figures for brachydanio rerio
Multirange FA	No.4	68	52	55	-4.260	4.3
Multirange FA	No.2	109	87	89	-4.051	4.1
Multirange FA	No.3	131	100	100	-4.000	4.0
Film forming FA	No.2	141	100	107	-3.971	4.0
Film forming FA	No.1	161	100	108	-3.967	4.0
Multirange FA	No.1	173	100	102	-3.991	4.0
Protein FA	No.3	1369	500	582	-3.235	3.2
Film forming FA	No.4 FC-203	1634	1000	1053	-2.978	3.0
Special FA		1880	1000	1442	-2.841	2.8
Film forming FA	No.3 FC-206	4086	2000	2036	-2.691	2.7
Film forming FA	No.5	3075	2000	2082	-2.682	2.9
Film forming FA	No.6	3075	2000	2100	-2.678	2.7
Protein FA	No.2	6524	4472	5370	-2.270	2.3
Film forming	flourineprotein	10000	10000	10000	-2	2
Protein FA	No.1	1000	10000	10000	-2	2

* LC50 = Highest tested concentration in mg/kg, at which 50 % of the test animals died
** LC 0 = Highest tested concentration in mg/kg, at which no test animals died

4.5 Determination of biochemical degradability

In Table 5, the figures of the chemical oxygen demand (COD) and the biochemical oxygen demand during the five consecutive days (BOD 5), expressed in mg O_2 per liter of water, were collected for 3% application solutions of the foam agents.

The level of the biochemical degradability of the tested substances can be sufficiently accurately determined from the ratio of COD to BOD 5. In an ideal case the COD to BOD 5 would be 1 : 1. Such ratio would describe an nearly quantitative biodegradation of a tested substance. Ratios of COD to BOD 5 of 1 : 0.5 signal an insufficient biochemical degradation.

The values presented in Table 5 point to the insufficient biochemical degradation of the multi-range foam agents No. 1 and 4 as well as the film-forming agent No. 3 (FC-206). During the categorization of the concentrates of these foam agents into a water endangering category, the characteristics of insufficient biochemical degradability is considered as negative ("Malus") and resulted in assignment to the next higher water endangering category (see 4.7).

Table 5: COD and BOD 5 of foam extinguishing agents

Foam extinguishing agent	COD of the 3% solution in mg of O_2/l of water	BOD5 of the 3% solution in mg of O_2/l of water	Ratio COD : BOD5	Evaluation of biochemical degradability within 5 days
Multirange foam agent				
No.1	43700	17500	1 ; 0.40	insufficient
No.2	47400	25900	1 : 0.55	probably insufficient
No.3	40300	30500	1 : 0.76	sufficient
No.4	52800	15200	1 : 0.29	insufficient
No.5	30100	25800	1 : 0.86	sufficient
Film-forming foam agent				
No.1	21000	15700	1 : 0.75	sufficient
No.2	34300	23200	1 : 0.68	sufficient
No.3 FC-206	24600	8700	1 : 0.35	insufficient
No.4 FC-203	41200	21500	1 : 0.52	probably insufficient
No.5	29700	21100	1 : 0.71	sifficient
No.6	21900	./. *)	./. *)	
Film-forming fluor-prot. FA	19600	12300	1 : 0.6	sufficient
Protein foam agent				
No.1	15000	13300	1 : 0.89	sufficient
No.2	14100	8700	1 : 0.62	sufficient
No.3	17100	14500	1 : 0.85	sufficient
Special foam agent	4600	no biochem. degr.	N/A	N/A

*) ./. = not measured

4.6 Determination of the water endangering figures and classification of the tested foam extinguishing agent concentrates into water endangering categories.

4.6.1 As already explained in the introduction, the "Commission for Evaluation of Water Endangering Materials" considered the acute toxicity to selected test organisms as a primary criteria for classification of a substance or a substance mixture into a water endangering category. A further important evaluation criteria was the biochemical degradability of the substance or substance mixture under consideration.

After consultations with some of the members of the "Commission for Evaluation of Water Endangering Materials" regarding the classification of 16 foam extinguishing agent concentrates, the determination of the mammals toxicity (LD50 oral), has been waived. Instead, in addition to the prescribed consideration of the

- acute bacteria toxicity and the
- acute fish toxicity,

the acute toxicities to

- algae and
- water flea

were taken into consideration during the classification of the tested foam extinguishing agent concentrates into water endangering categories.

4.6.2 In Table 6, the evaluation figures of the acute toxicities of the foam extinguishing agents to the test organisms, are presented in columns 2 through 5. According to the methods employed by the "Commission for Evaluation of Water Endangering Materials", the arithmetic averages of the evaluation figures result in the so called water endangering number (WEN) of the material under consideration (6th column). From the water endangering numbers determined in this way, the water endangering categories (WEC) are derived according to the following scheme:

WEN 6 and higher	- WEC 3
WEN 4.0 to 5.9	- WEC 2
WEN 2.0 tp 3.9	- WEC 1
WEN 1.9 and lower	- WEC 0

The classification of the tested foam extinguishing agent concentrates into the water endangering categories can be taken from the last column of Table 6.

Table 6: 1) Determination of water endangering figures (WEF) as an arithmetic average of the evaluation figures for the acute toxicity against bacteria, algae, water flea and fish.
2) The resulting classification into water endangering categories (WEC

Foam extinguishing agent	Evaluation figures for the acute toxicity against				Water endangering figure (WEF)	Water endangering class (WEC)
	Bacteria	Algae	~~Small crayfish~~ Daphnia	Fish		
Multirange FA No. 4	5.7	5.0	4.9	4.3	5.0	2
Multirange FA No. 5	5.8	N/A	4.1	N/A	5.2	2
Multirange FA No. 2	6.2	4.4	4.7	4.1	4.9	2
Multirange FA No. 1	6.0	5.0	4.5	4.0	4.9	2
Multirange FA No. 3	5.2	5.1	4.9	4.0	4.8	2
Film-forming FA No. 2	4.0	5.0	4.5	4.0	4.4	2
Film-forming FA No. 1	3.9	4.4	4.7	4.0	4.3	2
Film-forming FA No. 6	4.5	5.1	4.3	2.7	4.2	2
Film-forming FA No. 4 FC-203	3.2	4.8	4.5	3.0	3.9	1
Film-forming FA No. 5	3.2	4.6	4.1	2.9	3.7	1
Special FA	3.7	4.0	4.1	2.8	3.7	1
Film-forming FA No. 3 FC-206	2.9	4.8	3.5	2.7	3.5	1
Protein FA No. 3	2.6	3.6	3.6	3.2	3.3	1
Protein FA No. 2	2.0	4.9	2.4	2.3	3.0	1
Film-forming fluorine-protein	2.1	4.4	2.4	2.0	2.7	1
Protein FA No. 1	2.3	3.2	2.7	2.0	2.6	1

4.6.3 Under the pressure of the general active environmental consciousness, the question discussed to-date is:

> Should classification of the substance concentrate into a water endangering category be based on acute toxicity to the most sensitive member of a food chain?

Should this be the case, the categorization of the 16 foam extinguishing agent concentrates presented in Table 7 into water endangering categories would be the result.

4.7 The biochemical degradability of the

- multi-range foam material No. 1 and

- multi-range foam agent No. 4

is not sufficient.

This fact leads to a downgrading of the concentrates from the water endangering category 2 (see Table 6) to the water endangering category 3.

In case of the insufficiently biochemically degradable film-forming foam agent No. 3, the downgrading takes place from the water endangering category 1 (see Table 6) to the water endangering category 2.

Table 7: 1) Determination of water endangering figures (WEF) based on the evaluation figures for the most sensitive group of test organisms.
2) The resulting classification into water endangering categories (WEC)

Foam extinguishing agent	Evaluation figures for the acute toxicity against Bacteria	Algae	Small crayfish (Daphnia)	Fish	Water endangering figure (WEF)	Water endangering class (WEC)
Multirange FA No. 2	6.2	4.4	4.7	4.1	6.2	3
Multirange FA No. 1	6.0	5.0	4.5	4.0	6.0	3
Multirange FA No. 5	5.8	N/A	4.1	N/A	5.8	2
Multirange FA No. 4	5.7	5.0	4.9	4.3	5.7	2
Multirange FA No. 3	5.2	5.1	4.9	4.0	5.2	2
Film-forming FA No. 6	4.5	5.1	4.3	2.7	5.1	2
Film-forming FA No. 2	4.0	5.0	4.5	4.0	5.0	2
Protein FA No. 2	2.0	4.9	2.4	2.3	4.9	2
Film-forming FA No. 4 FC-203	3.2	4.8	4.5	3.0	4.8	2
Film-forming FA No. 3 FC-206	2.9	4.8	3.5	2.7	4.8	2
Film-forming FA No. 1	3.9	4.4	4.7	4.0	4.7	2
Film-forming FA No. 5	3.2	4.6	4.1	2.9	4.6	2
Film-form. fluorine-protein	2.1	4.4	2.4	2.0	4.4	2
Special FA	3.7	4.0	4.1	2./8	4.1	2
Protein FA No. 3	2.6	3.6	3.6	3.2	3.6	1
Protein FA No. 1	2.3	3.2	2.7	2.0	3.2	1

5. Final considerations

Presented

- data of the acute toxicity of the application solutions of foam extinguishing agents to water organisms

- data concerning biochemical degradability of foam extinguishing agents

- classification of the tested foam extinguishing agent concentrates into the water endangering categories based on

  o arithmetic averages of the evaluation figures of the acute toxicities

  o evaluation figures of the acute toxicities to the most sensitive organism in each case

have to be checked by the "Commission for Evaluation of Water Endangering Materials".

The Commission will evaluate the toxicity data established by the army and indicate if it should be considered complete or in need of further investigations.

The examination will also provide a determination concerning the procedures used for the classification of foam extinguishing agents into the water endangering categories.

Especially the latter result is of interest it is likely to set a precedence that could affect the commercial law of the European Community starting in 1992.