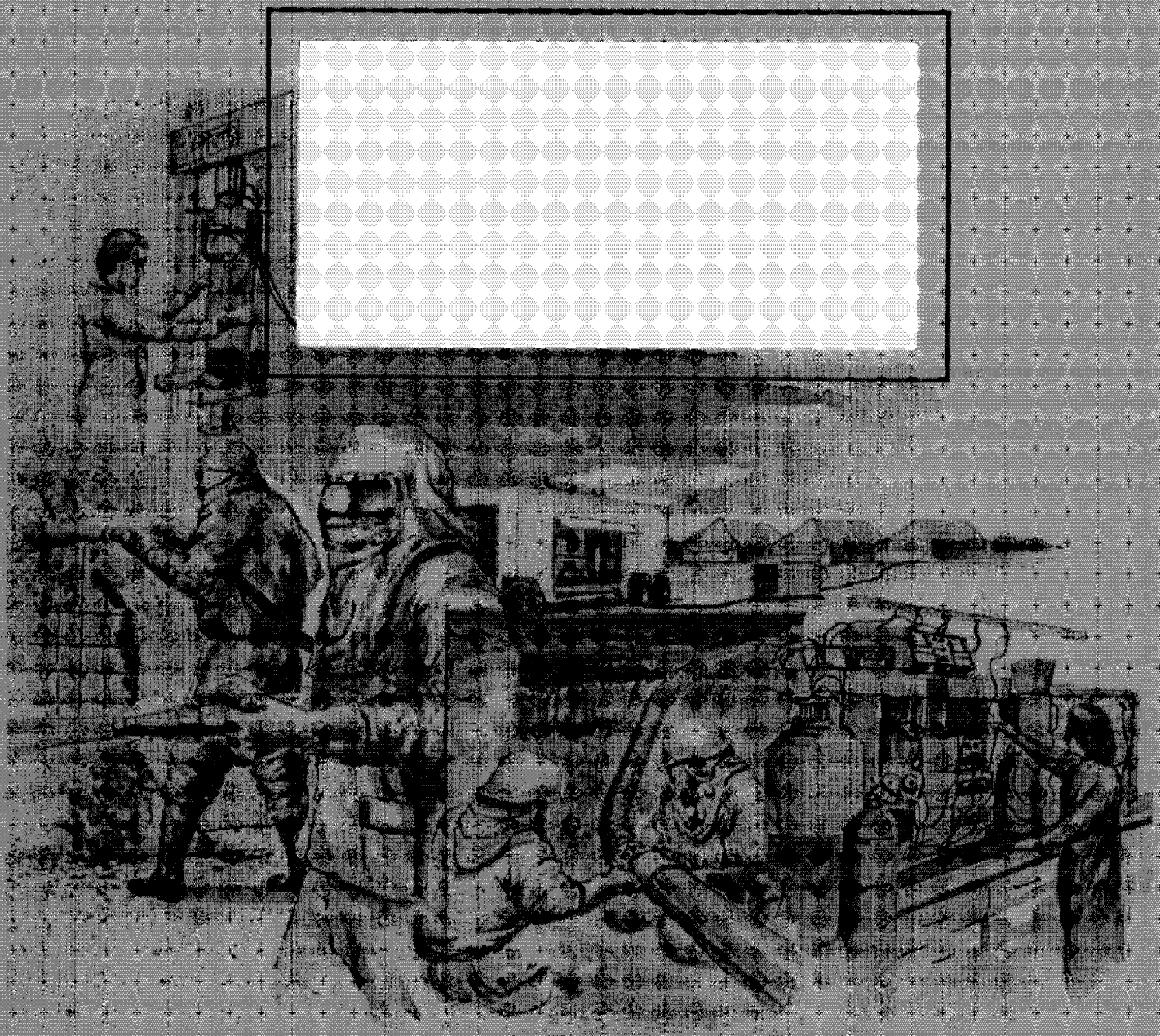
AFFF Interv

gency Working Group

Pyrocool
At Paperclip



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Agenda
AFFF Interagency Working Group Meeting

0900 - 0915	Opening Remarks	Mr. Bob Darwin NAVSEA
0915 - 0930	Agenda & Air Force AFFF Program	Capt Bob Tetla FIVCF
0930 - 1000	Agent Evaluation Program	Mr. Doug Nelson FIVCF
1000 - 1015	AFFF Phase I/II SBIR	Dr. Ed Kleiner Dynax Corp.
1015 - 1030	BREAK	
1030 - 1045	FAA Perspective on AFFF	Mr. Joe Wright FAA
1045 - 1100	NRL Perspective on AFFF	Dr. Joe Leonard NRL
1100 - 1115	AFFF Mil-Spec	Mr. Bob Darwin NAVSEA
1115 - 1200	Discussion	Capt Bob Tetla

AIR FORCE AFFF PROGRAM

ENVIRONMENTALLY ACCEPTABLE AFFF RESEARCH

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BACKGROUND

- CLEANUP
  - McDill AFB, Whiteman AFB, etc.
  - Large amount of money
- TRAINING
  - AFFF in ground from old pits
  - Not enough environmental fire pits
- AFFF HANGAR DUMPS

AIR FORCE HAS NEED FOR MORE ENVIRONMENTALLY ACCEPTABLE AFFF

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AFFF TECHNICAL PROBLEMS

- SOLVENT PROBLEM
  - 15 gallons of AFFF spilled is reportable (Glycol Ether)
- FOAM PROBLEM
  - Sewer plants cannot handle
- HIGH BIOLOGICAL OXYGEN DEMAND

- NEED FILM FORMING FOAM
  - Knockdown
  - Burnback

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BIODEGRADATION CONSIDERATIONS

MIL-SPEC AFFF

- BOD5/COD: 10%
- BOD20/COD: 80%

GOAL

- Aerobic Biodegradation
  - BOD5/COD 40%
  - BOD20/COD 100%
    - Change Solvent
    - Change Hydrocarbon Surfactant
    - Reduce Fluorocarbon Surfactant
    - Add Bacterial Spores
- Anaerobic Biodegradation

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MITIGATION METHODS

- BACTERIAL BREAKDOWN
  - At System Nozzle
  - Added to Tank/Lagoon
- ANTI-FOAMING AGENTS
- ULTRA-FILTRATION & ACTIVATED CARBON
- ULTRA-SOUND - Sonolysis at 440 KHz to 1MHz

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RESEARCH TARGETS

- MAINTAIN CURRENT PERFORMANCE
  - KNOCKDOWN
  - BURNBACK
- ELIMINATE GLYCOL ETHERS
- DECREASE FOAMING PROBLEMS
- INCREASE BIODEGRADABILITY
  - MORE BIODEGRADABLE HYDROCARBON SURFACTANTS
  - REDUCE FLUOROCARBON SURFACTANTS
  - ADDITION OF MICRO-ORGANISMS TO AFFF

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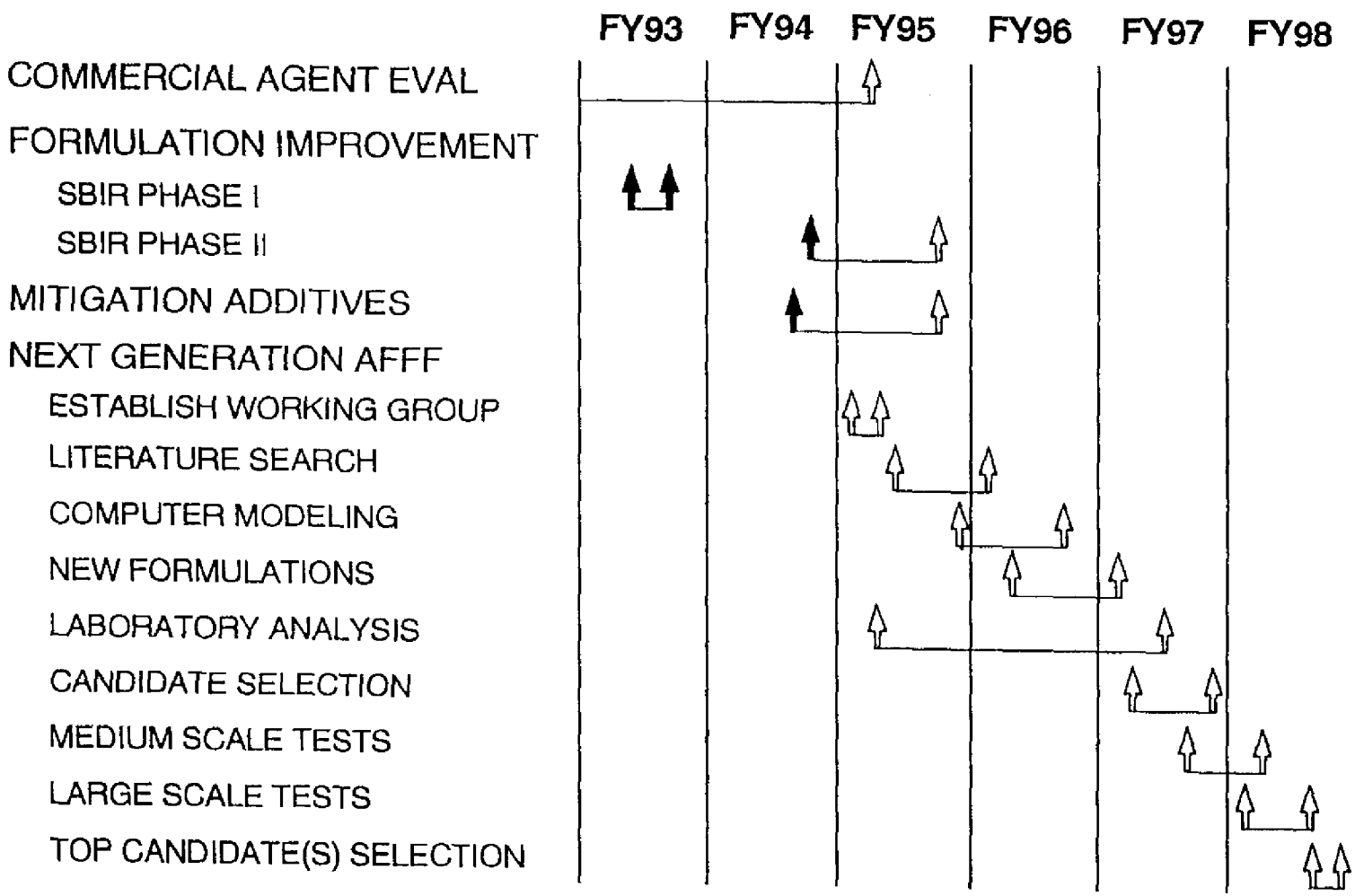
ENVIRONMENTALLY ACCEPTABLE AFFF



AFFFSCHD

AGENT EVALUATION PROGRAM

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PROJECT GOAL

ENVIRONMENTALLY ACCEPTABLE AFFF WITHOUT LOSS OF EFFECTIVENESS

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EVALUATION CRITERIA

- SOLVENT HAZARD POTENTIAL
- BIODEGRADABILITY
- TOXICITY - FISH / MICOORGANISMS
- EXTINGUISHMENT EFFECTIVENESS
- FLAME SPREAD RESISTANCE
- IMPACT ON DISPERSING EQUIPMENT

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SOLVENT

AGENT	SOLVENT
MIL-SPEC AFFF	BUTYL CARBITOL
CENTRIFOAM 903	HEXYLENE GLYCOL
PETROSEAL	HEXYLENE GLYCOL
FIREWATER 990	ETHOXYLATED NONYL PHENOL
FUEL BUSTER	ISOPROPYL ALCOHOL
PYROCOOL FEF	ISOPROPYL ALCOHOL
PETROTECH FE-2	ISOPROPYL ALCOHOL
MICRO BLAZEOUT	PROPYLENE GLYCOL
BCD	PROPYLENE GLYCOL
PHIREX +	PROPRIETARY
BRC II	PROPRIETARY
SP 911	NONE
FSR-100	NONE

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BIODEGRADABILITY

AGENT	% BOD5/COD
SP-911	4.8
FUEL BUSTER	7.2
MIIL-SPEC AFFF	8.4
CENTRIFOAM 903	9.1
FIREWATER 990	9.1
PHIREX +	10.2
PETROTECH FE-2	12.4
PETROSEAL	14.8
PYROCOOL FEF	17.6
BRC II	19.3
BCD	34.9
MICRO BLAZEOUT	43.8

TOXICITY

AGENT TYPE	TOXICITY TO FISH
PROTEIN FOAMS	LESS THAN AFFF
FLUOROPROTEIN FOAMS	SAME AS AFFF
HYDROCARBON SURFACTANT FOAMS	10X GREATER THAN AFFF

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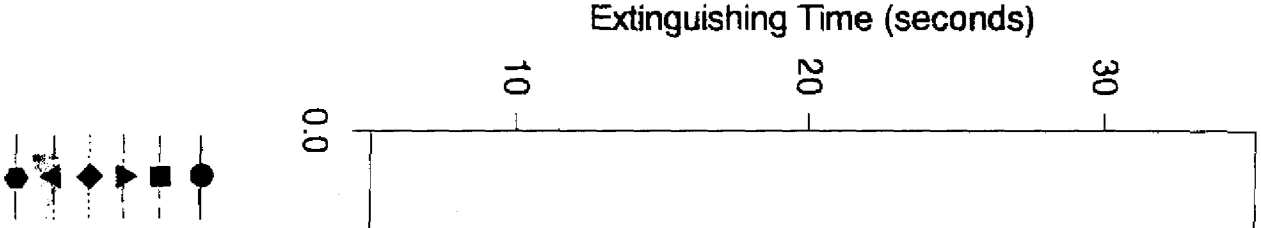

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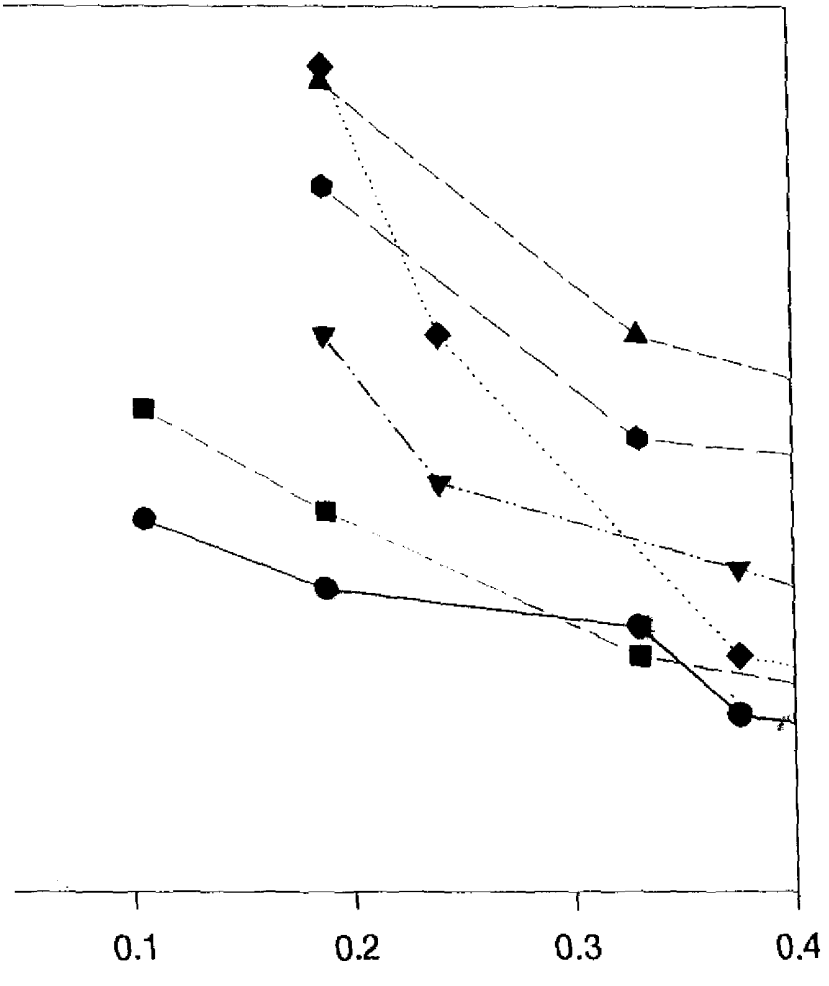
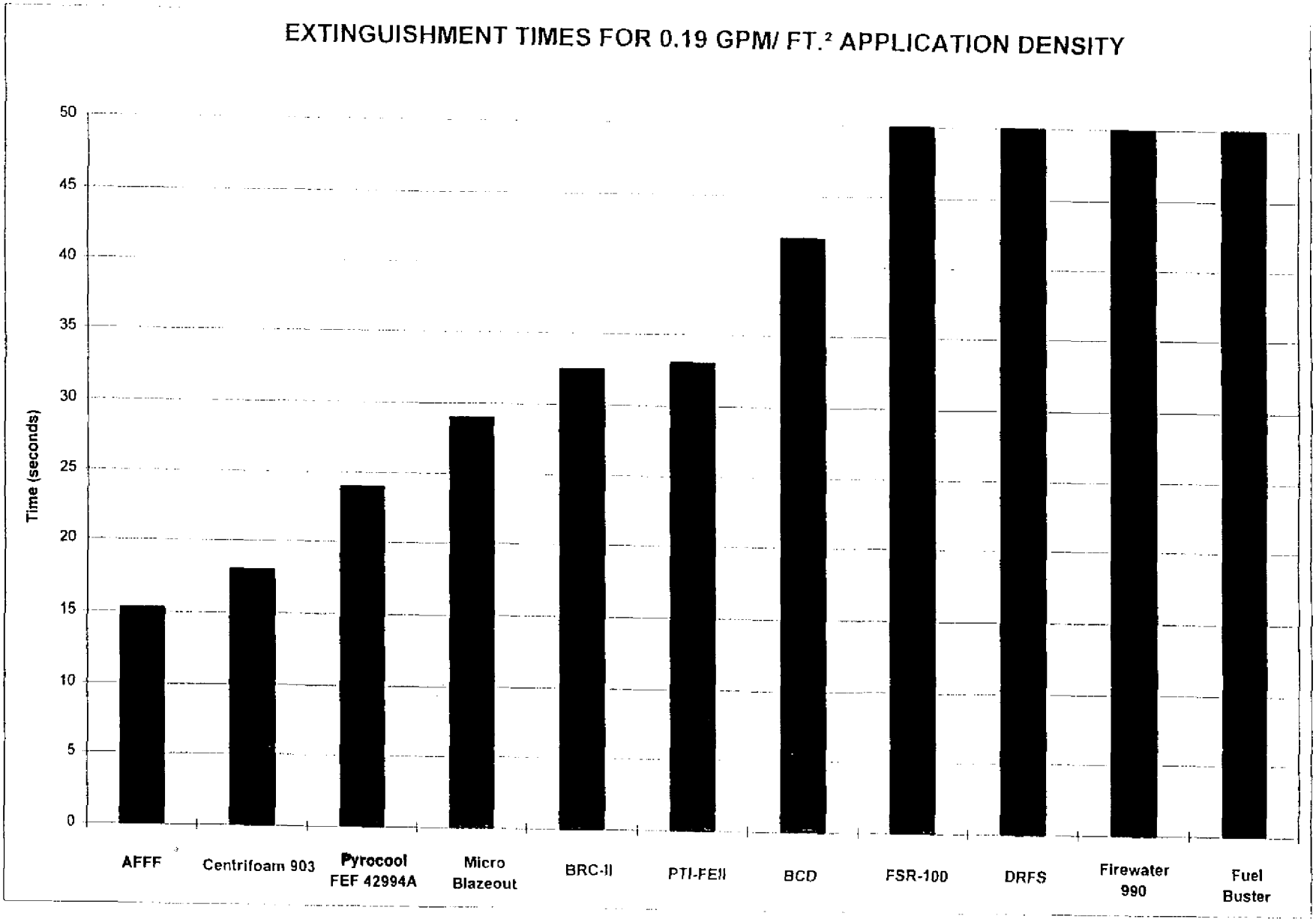
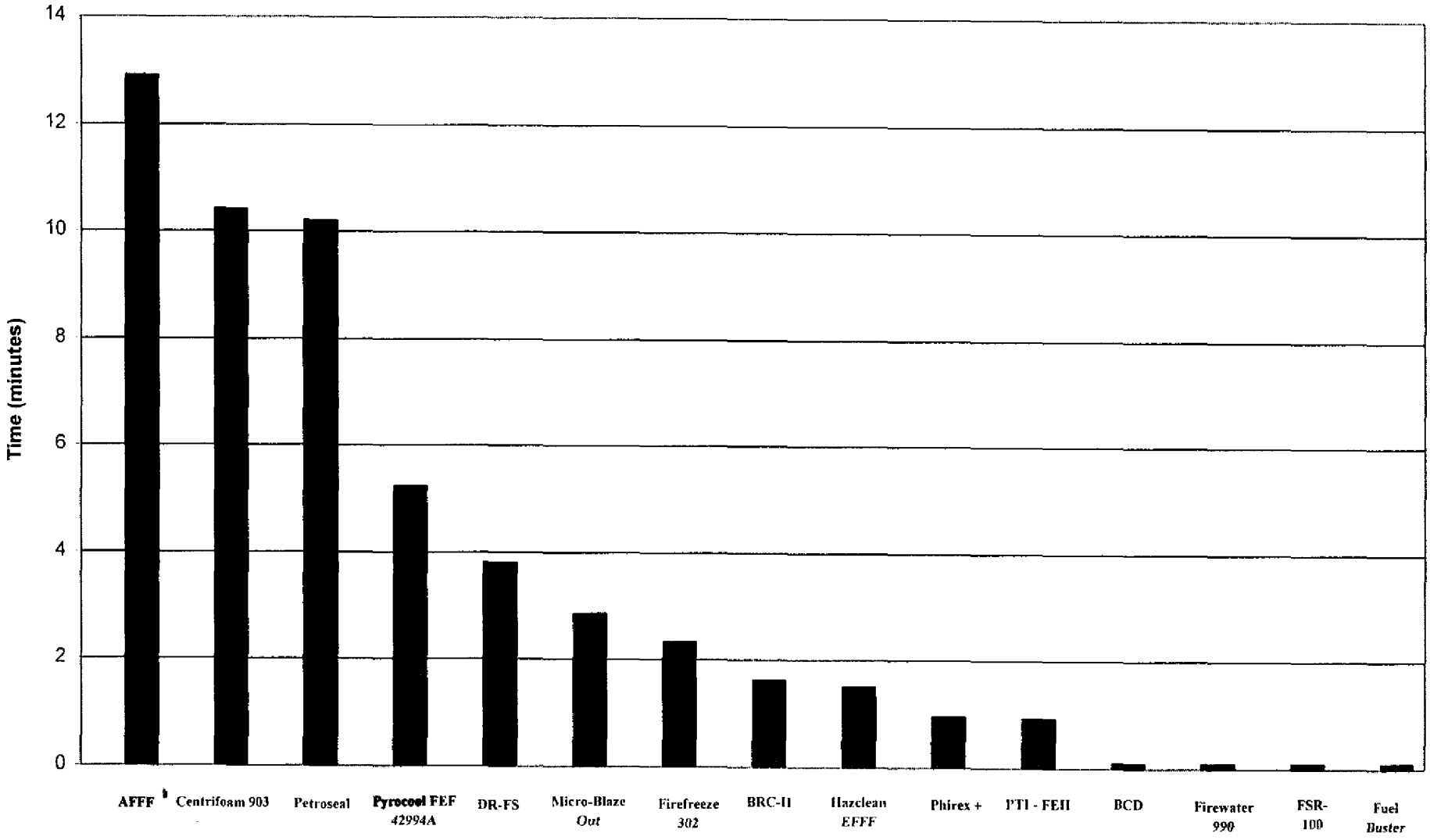
APPLICATION DENSITY



AFFF
CENTRIFOAM 903
BRC II - new
PTI-FEII
PYROCOOL-B
MICRO BLAZEOUT


EXTINGUISHMENT TIMES FOR 0.19 GPM/ FT.² APPLICATION DENSITY
Time (seconds)
0
5
10
15
20
25
30
35
40
45
50
AFFF
Centrifoam 903
Pyrocool FEF 42994A
Micro Blazeout
BRC-II
PTI-FEII
BCD
FSR-100
DRFS
Firewater 990
Fuel Buster

FLAME SPREAD RESISTANCE TESTS



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PROBLEMS FOR AIR FORCE EQUIPMENT

FIREWATER 990	DELIVER AT 0.75%	(METERING)
PYROCOOL FEF	DELIVER AT 1%	(METERING)
SP 911	DELIVER AT 20% OR 40%	(TANK)
FSR-100	SOLID, REQUIRES SPECIAL SYSTEM	(AGENT TYPE)
	MAY CAUSE CLOGGING	

OTHER AGENTS NOT A PROBLEM, METERED AT 3% OR 6%

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CONCLUSIONS

- SEVERAL AGENTS MORE BIODEGRADABLE THAN MIL-SPEC AFFF
- NO COMMERCIAL AGENT TESTED AS EFFECTIVE AS MIL-SPEC AFFF
- STAY WITH MIL-SPEC AFFF UNTIL NEW AGENT DEVELOPED
- OBTAIN EPA RELIEF ON BUTYL CARBITOL AS INTERIM MEASURE

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FUTURE DIRECTIONS

- TEST EMERGING INDUSTRY PRODUCTS
- STIMULATE INDUSTRY DEVELOPMENT OF IMPROVED AFFF
- COORDINATE DOD SPONSORED RESEARCH WITH INDUSTRY EFFORTS

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WRAP-UP

- RECOGNIZED PROBLEM
- MADE ANNOUCEMENT IN CBD FOR PRODUCT
- TESTED PRODUCTS
- CONTINUE RESEARCH PROGRAM
  - SBIR
  - S&T

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PHASE I/II SBIR

DR. ED KLEINER

PRESIDENT DYNAX CORP

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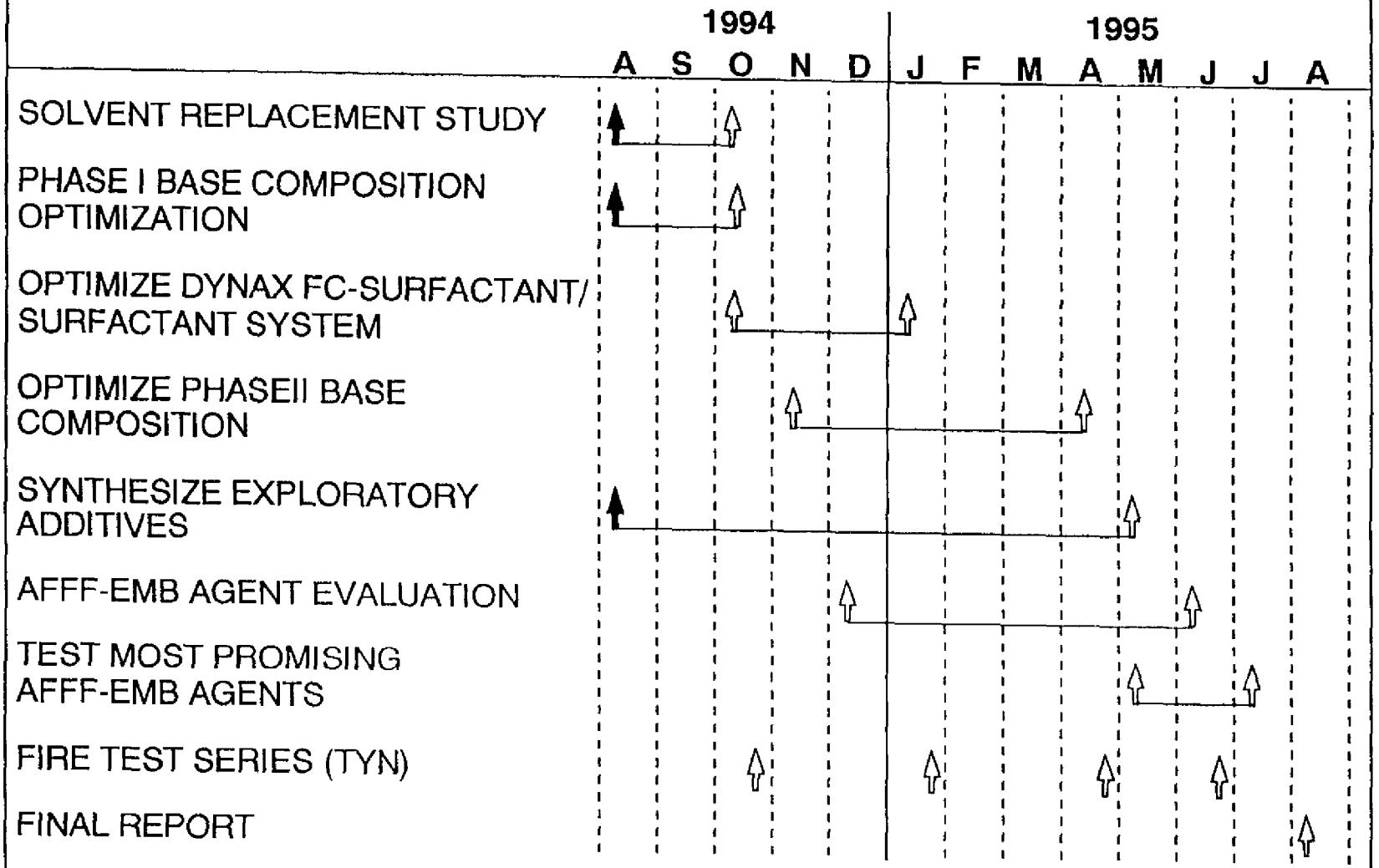
DYNAX PHASE II AFFF-EMB R&D



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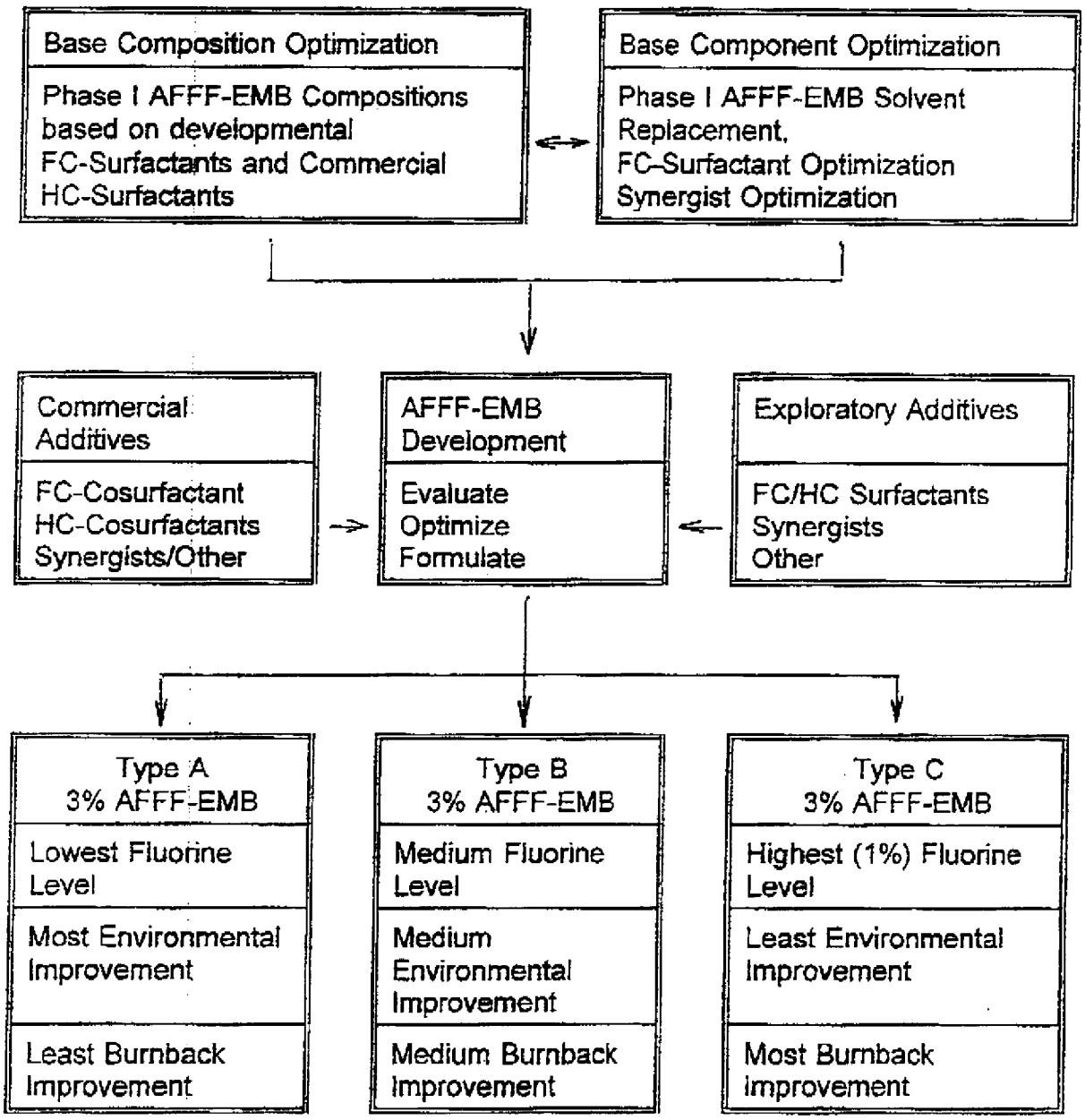
Phase II AFFF-EMB Development Scheme



Chemical and Physical Parameters for AFFF-EMB Concentrates, Solutions and Foams

Note: P-1 indicates parameters to be established for Phase II. Values quoted, indicates same parameters as for AFFFs meeting MIL-F-24385F.

Parameters	Values Type 3	Values Type 6	Application Publication	Test in MIL-F-24385F
Refractive index, minimum	P-1	P-1	-	4.7.1
Viscosity, centistoke			ASTM D445.74	4.7.2
Maximum at 5°C	P-1	P-1		
Minimum at 25°C	P-1	P-1		
Hydrogen ion concentration (pH)	7.0 to 8.5	7.0 to 8.5	-	4.7.3
Spreading coefficient, minimum	3	3	-	4.7.4
Foamability:			-	
Foam expansion, minimum	P-1	P-1	NFPA STD 412	4.7.5
Foam 25% drainage time, minutes, minimum.	P-1	P-1	NFPA STD 412	4.7.5
Corrosion rate:				
General				
Cold rolled, low carbon steel(UNS G10100), milli in/yr., maximum	1.5	1.5	ASTM E527	4.7.7.
Copper-nickel (9010)(UNS C70600), milli in/yr., maximum	1.0	1.0	ASTM E527	4.7.7.

Continued on following page.

Chemical and Physical Parameters for AFFF-EMB Concentrates, Solutions and Foams

Note: P-1 indicates parameters to be established for Phase II. Values quoted, indicates same parameters as for AFFFs meeting MIL-F-24385F.

Parameters	Type 3	Type 6	Application Publication	Test in MIL-F-24385F
Corrosion rate (continued):				
Nickel-copper (70-30) (UNS 04400), milli in/yr., maximum	1.0	1.0	ASTM E527	4.7.7.
Bronze (UNS C90500), milligrams maximum	100	100	ASTM E527	4.7.7.
Localized, corrosion resistant CRES) steel, (UNS S30400)	No Pits	No Pits		4.7.7.
Total halides, p/m, maximum	P-1	P-1	ASTM E527	4.7.8.
Dry chemical compatibility burnback, resistance time, seconds, minimum	P-1	P-1	-	4.7.9.
Environmental Impact:				
Toxicity, LC_{50}, mg/L, minimum	P-1	P-1	-	4.7.12.1.
COD, mg/L, maximum	P-1	P-1	-	4.7.12.2.
BOD_{20}, minimum	P-1	P-1	-	4.7.12.3.
COD				

Physical and Environmental Parameters for AFFF-EMB Agents

3% AFFF-EMB Parameters	TYPE A 3% AFFF-EMB	TYPE B 3% AFFF-EMB	TYPE C 3% AFFF-EMB	MIL-F -24385F 3% AFFF
Fluorine Content Limited to:	Low level	Med. Level	Max. 1%	Not Limited
Environmental Impact Improvement:	Very Much	Much	Limited	—
Burnback Resistance Improvement:	Limited	Much	Very Much	
Refractive Index, Minimum	NS[1]	MIL-F	MIL-F	1.3630
Viscosity, centistokes Maximum at 5° C Minimum at 25° C	 MIL-F MIL-F	 MIL-F MIL-F	 40 4	 20 2
Spreading coefficient, Minimum	3	5	6	3
Foamability: Foam Expansion, Minimum Foam ¼ Drain Time, Minutes, Minimum	 MIL-F MIL-F	 MIL-F 3.0	 MIL-F 3.5	 5 2.5
Total Halides, p/m, Maximum	MIL-F or 1500[2]	MIL-F or 1500[2]	MIL-F or 1500[2]	500
Environmental Impact: Toxicity, LC_{50}, mg/L, Minimum COD, mg/L_1, Maximum $\underline{BOD_{20}}$, Minimum COD	 1500[3] 500[4] 0.80[4]	 1000[3] 750[4] 0.80[4]	 1000[3] 750[4] 0.80[4]	 500 1000 0.65

1) Not to be specified; refractive index will be lower than MIL-F.
2) To be negotiated for Phase II; higher halide level (chloride) will leave more formulation possibilities open and corrosion specs can still be met.
3) No fish toxicities run in Phase I; improvements could be higher.
4) No COD and BOD determinations done in Phase I. Better values potentially achievable.

Fire Performance Parameters for AFFF-EMB Agents.

3% AFFF-EMB Parameters	TYPE A 3% AFFF-EMB	TYPE B 3% AFFF-EMB	TYPE C 3% AFFF-EMB	MIL-F-24385F 3% AFFF
Fluorine Content Limited to:	Low Level	Med. Level	Max. 1%	Not Limited
Environmental Impact Improvement:	Very Much	Much	Limited	—
Burnback Resistance Improvement:	Limited	Much	Very Much	—
28 Sq. Ft. Fire Foam application time to extinguish, seconds, maximum				
Half Strength	45 (3/4)	MIL-F	MIL-F	45
Full Strength	MIL-F	MIL-F	MIL-F	30
5 x Strength	MIL-F	MIL-F	MIL-F	55
Burnback Time of resulting foam cover, seconds, minimum				
Half Strength	300 (3/4)'	MIL-F	360	300
Full Strength	360	420	480	360
5 x Strength	240	300	360	200
50 Sq. Ft. Fire Foam application time to extinguish, seconds, maximum	MIL-F	MIL-F	MIL-F	50
Burnback Time of resulting foam cover, seconds, minimum	360	420	460	360
40 second summation	320	340	360	320

Note: Solvents in AFFF-EMB agents not on Hazardous Air Pollutant list of the 1990 Clean Air Act nor subject to SARA Title III, Section 313 regulations.

Abstract of Analysis of the Toxic Effects, COD and BOD of Fire Fighting Foams by the German Office for Defense Technology and Procurements (BWB), May 23, 1989.

Toxicity Tests, COD and BOD of Worst and Best Foam Candidates	Multi-Purpose Foams (5)	AFFF Agents (6)	FFFP Foam (1)	F-Protein Foam (3)
EC_{10} (μl water) for Photobacterium Phosphoreum[1]	0.6 to 6.0	30 to 2,000	7,500	2,000 to 7,500
EC_{10}(μl water) Scenedesmus subspicatus[2]	8 to 38	8 to 36	35	10 to 509
LC_{10}(μl water) for Daphnia Magna[3]	12 to 75	20 to 85	3,700	200 to 3,700
LC_{50}(μl water) for Brachydanio rerio[4]	68 to 173	144 to 3,075	10,000	1,369 to 10,000
COD of 3% solution (mg O_2/l water)	30,000 to 52,000	21,000 to 41,200	19,600	14,100 to 17,000
BOD_5 of 3% solution (mg O_2/l of water	15,200 to 30,500	8,700 to 23,200	12,300	8,700 to 14,500
BOD_5/COD	0.29 to 0.86	0.35 to 0.75	0.63	0.62 to 0.89

[1] Concentration (of foam substance) which reduces the light power of the photobacteria by 10%.

[2] Concentration which produces 10% growth inhibition of fresh water algae after 72 hours.

[3] Concentration in which 10% of test crustacea lost their buoyancy over 24 hours.

[4] Highest concentration tested in which 50% of the Zebra fish died within 48 hours.

FAA PERSPECTIVE

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FEDERAL AVIATION ADMINISTRATION

WL_FIVCF

NRL PERSPECTIVE

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