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Preliminary Fire Extinguishing Tests with Handheld Bottles: A Comparison of Extinguishing Compounds

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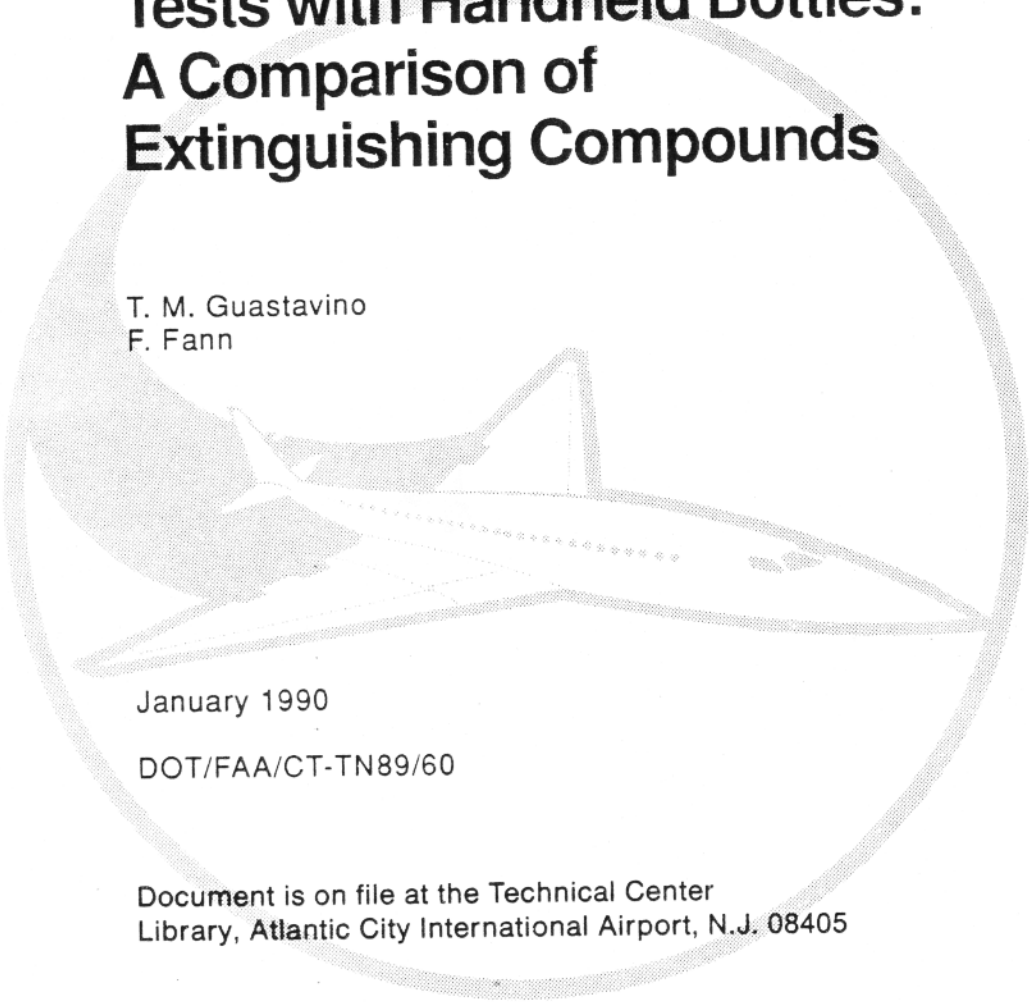

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16. Abstract

In 1982, the Federal Aviation Administration (FAA) Technical Center completed a test and evaluation project on use of handheld extinguishers in transport category aircraft. Some of the tests involved the comparative effectiveness of handheld extinguishers in a specific fire scenario: a triple non-fireblocked aircraft seat ignited with gasoline. The test work included the identification and quantification of effluent gas species produced by the fire and the extinguishing chemicals.

The present study describes the comparative effectiveness of the extinguishers used in the above tests and some newer systems in two distinct fire tests. The first test is the "crib" test used by Underwriters Laboratory, Inc. to rate handheld extinguishers. The second test is the same seat test used in the earlier work.

The tests employed aircraft approved water extinguishers and Halon 1211 extinguishers as benchmarks. New formulations using surfactants and extinguishing powders in aqueous solutions were tested against the benchmark performance levels. In these tests, certain new solutions were able to meet or exceed the performance of the benchmark agents.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

In 1982, the Federal Aviation Administration (FAA) Technical Center completed a test and evaluation project on use of handheld extinguishers in transport category aircraft. Some of the tests involved the comparative effectiveness of handheld extinguishers in a specific fire scenario: a triple non-fireblocked aircraft seat ignited with gasoline. The test work included the identification and quantification of effluent gas species produced by the fire and the extinguishing chemicals.

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INTRODUCTION

PURPOSE.

The purpose of this report was to investigate potentially new fire extinguishing formulations and compare them to systems currently used in aircraft. Two distinct fire tests were used for comparison of extinguishing agent effectiveness. The first was the "crib" test of Underwriters Laboratory, Inc., (reference 1). The second test employed aircraft triple seats in tests similar to those previously undertaken to evaluate the effectiveness of Halon 1211 extinguishers (reference 2).

BACKGROUND.

The halogenated family of chemical fire extinguishers is used almost universally for aircraft fire safety applications. Their effectiveness on all "classes" of fires, ease of application and the absence of problems like obscuration, slipperiness, and cleanup have made them a preferred system. The Federal Aviation Administration (FAA) investigated two versions of these systems in 1982 and reported no negative results with their usage. The present study was initially started to evaluate the capability of aircraft-approved Halon and water systems in fighting fires involving advanced carbon composite materials. Additional emphasis for this study was "The Montreal Protocol on Substances That Deplete the Ozone Layer" (reference 3). The implementation of the recommendations of the Montreal protocol would curtail the availability of the halogenated family of fire extinguishers. This study represents the initial step in a projected extensive program to investigate alternative fire fighting systems for use in aviation.

DESCRIPTIONS

CRIB TEST.

The Crib Test is described in "Standard for Safety: Fire Extinguishers Rating," UL 711, Underwriters Laboratory, Inc. (reference 1).

The wood crib is constructed of layers of 2 x 2 x 10-inch kilndried Spruce. The general configuration and support of the crib is illustrated in figure 1. The alternate layers are evenly spaced. A "1A" crib is made of 50 members in 10 layers of 5 members per layer. The outside members are nailed together for support.

The crib is constructed on angle iron supports placed on concrete blocks 16 inches above the floor.

Ignition of the crib is accomplished by the burning of 1 quart of normal heptane in a square pan, 21 x 21 x 4 inches, placed symmetrically under the vertical axis of the crib.

AIRCRAFT SEAT TEST.

The aircraft Seat Test is reported in DOT/FAA/CT-82/111 (reference 2). A triple "unblocked" aircraft seat* is doused with a liter of normal heptane and ignited immediately. The fire is permitted to burn for a period of time and then is attacked with extinguishers on three sides. Typical burning materials are polyurethane foam in the cushions and wool blends in upholstery fabrics.

The following observations and recordings are made for the seat test:

	Times Recorded Min.	Sec.	Comments
Dousing with Fuel	00	00	Amount of Fuel Used
Ignition	00	01	Start Fire
	00	15	Preburn Times
	1	00	Recorded
Start Extinguishing	1	00	Record Flame Control**, Effectiveness, Amount of Media Used, Restart?
End Test	3	00	Typical Test Time Ending, Record Results and Observations

*New regulations went into effect subsequent to the referenced extinguisher tests. These regulations led to use of fire blocking layers covering the urethane seat cushions. The present tests were done without blocking layers so that comparisons could be made with the earlier tests.

**Control is when the flames are stopped. Red smoldering may be present, but must not reflame within 2 minutes.

STATE OF THE ART SYSTEMS (See Figure 2)

Chemicals Used	Physical Form	Fire Class Capability
Sodium Bicarbonate	Powder	BC
Potassium Bicarbonate (Purple K)	Powder	BC
Ammonium Phosphate	Powder	ABC
Carbon Dioxide	Inert Gas	BC
Halon 1211	Vaporizing Liquid	ABC BC
Water	Tap Water	A
Loaded Stream***	Potassium Acetate Non-Freezing Water Solution	AB

***Meets "Class A" of Aerospace Standard AS245A, Water Solution-Type Hand Fire Extinguishers. Manufactured by Walter Kidde.

NOTICE . . .

BEFORE INSTALLING YOUR FIRE EXTINGUISHER, CAREFULLY READ THE FOLLOWING OPERATIONAL INSTRUCTIONS.

Be sure you understand the instructions so that there will be no delay if a fire occurs. Before using your extinguisher, also read the operating instructions on the extinguisher label carefully. Be sure you understand the instructions in this manual and on the extinguisher label. Also be sure that those persons having access to this extinguisher are informed of its operation. **The total discharge of extinguisher contents is a matter of seconds, therefore, any delay should be avoided.**

OPERATION AND USE

In case of fire . . .

1. Call the fire department.
2. Get everyone out.
3. Plan your retreat.
4. The contents are discharged by pressure — **DO NOT DISCHARGE AT A PERSON'S FACE — STAND A MINIMUM OF 6' to 10' FROM THE FIRE.**
5. Hold the extinguisher firmly in an **upright** position.
6. Stay low to avoid inhalation of smoke and aim discharge just under the flames, using a side to side motion, sweeping the entire width of the fire. For wall fires, start at the bottom, sweep from side to side, and progress upward.. For floor fires, sweep from side to side and move forward as fire diminishes to reach far edge of fire.
7. **NEVER** move into area where fire was burning even though it appears to have been extinguished. You could be trapped and burned if the fire reflashes.
8. **NEVER** use water extinguishers on electrical fires.
9. **NEVER** use extinguishers at distances of less than 6 to 10 feet.

FIRE EXTINGUISHERS AND AGENTS

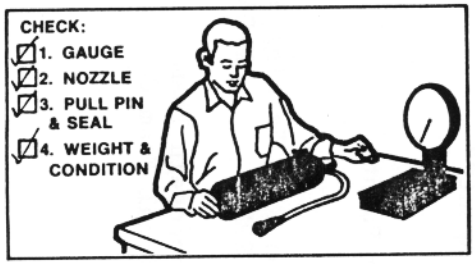
TYPE EXTINGUISHER	BASIC AGENT	MAY BE USED ON
Regular (ordinary) Dry Chemical	Sodium Bicarbonate	B C
Multi-Purpose (ABC) Dry Chemical	Ammonium Phosphate	A B C
Purple "K" Dry Chemical	Potassium Bicarbonate	B C
Carbon Dioxide	An Inert Gas	B C
Water	Tap Water	A
Halon 1211	Vaporizing Liquid	A B C B C
Loaded Stream	Potassium Acetate, Non-Freezing Water Solution	A B

INSPECTION & CARE

Be sure that the extinguisher is in its proper location so that there will be no delay in case of fire.

Your extinguisher should be checked once each month or more frequently if necessary to determine that:

1. The pointer on the pressure gauge is in the green operable area.
2. The nozzle opening has not been closed with some foreign object.
3. A ring pull pin is provided to prevent accidental discharge. This pin is secured by means of a plastic wire lockseal. On some models, the carry handle is sealed in place by a tape crossing over the lower portion. Check to make sure that the lockseal is intact. A broken lockseal is an indication of tampering and that there may have been a partial or total loss of contents.
4. Weigh the extinguisher at least every six months; and if below the weight designated under 'Maintenance' on the extinguisher label, the extinguisher should be recharged.



INSTALLATION

Extinguishers should be installed in accordance with the National Fire Protection Association* standard "Portable Fire Extinguishers," NFPA No. 10.

***Address — Batterymarch Park, Quincy, Mass. 02269**

Mount your extinguisher **upright** in a location that is easy to reach. Clean, dry locations near exits are recommended.

Be sure that mounting hardware (screws, rivets, etc.) is of the proper type and size to assure a positive mounting.

Your extinguisher should be mounted so that the top is not more than 3½ to 5 feet from the floor.

Do not locate in an area that will exceed 120°F. temperature.

Water extinguishers should be protected from freezing unless a loaded stream agent has been added.

Do not use any other than Badger's AC-40 Loaded Stream.

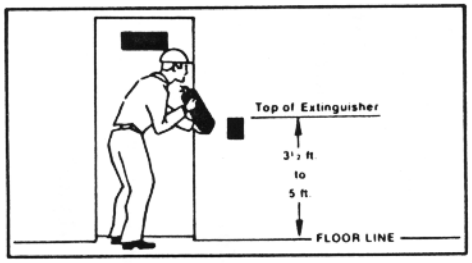


FIGURE 2. STATE OF THE ART SYSTEMS (2 of 2)

Water Solutions of Sodium Bicarbonate
and Potassium Bicarbonate (Purple K)
(Percent by Weight)

Formula No.	V	VI	VII	VIII
Potassium Bicarbonate	48*	25	---	---
Sodium Bicarbonate	---	---	48*	25
Ethylene Glycol	6	1	6	1
Water	46	70	37	70
Surfactant	---	3	7	3
Foaming Agent	---	1	2	1
Freezing Point	-5 °F	-5 °F	-5 °F	-5 °F
Comments	Viscous		Viscous	

*Maximum Practical Solution Concentrations

TEST RESULTS

STATE OF THE ART SYSTEMS.

ABC Power (2 3/4 lbs. min.)

Crib Test

	Time Min.	Sec.	Comments
Start Fire	00	00	
	01	10	Pan Fire Out
Start Test	10	00	
	10	10	One Bottle Used Fire Out
	15	00	No Restart

Seat Tests

	A Time Min.	Sec.	B Time Min.	Sec.	Comments
Douse with Fuel, Ignite	00	00			Pint of Fuel
Douse with Fuel, Ignite			00	00	Quart of Fuel
Start Test (A)	00	15			
	00	25			Fire Out, One Bottle Used
Start Test (B)			01	00	Seat Totally Burning
			01	50	3 Bottles Used, Good Flame Knock-Down, Burn Under Control
			03	00	No Reflaming

Potassium Bicarbonate Powder (2 3/4 lbs. min.)

1A Crib

	Time Min.	Sec.	Comments
Start Fire	00	00	
	01	10	Pan Fire Out
Start Test	10	00	4 Bottles Used
	12	00	Flames Down But Restarts Quickly
	12	10	End Test

Seat Test

	Time Min.	Sec.	Comments
Douse with Fuel	00	00	Quart of Fuel
Ignite	00	03	
Start PK Powder	01	03	
	01	30	2 Bottles Used Fire Out
	03	00	No Restart

Halon 1211

Crib Test

The handheld Halon 1211 bottle will not extinguish a "1A" crib fire (3 lbs.). It requires 3 bottles of Halon 1211 (9 lbs.) to extinguish a "1A" crib without fire restart (weights checked before and after tests).

Seat Tests with Halon 1211

	A Time Min.	A Time Sec.	B Time Min.	B Time Sec.	Comments
Douse with Fuel	00	00			Pint of Fuel
			00	00	Quart of Fuel
Start Extinguishing (A)	00	15			Upholstery Burning, But Not Foam
	00	25			Fire Out
Start Extinguishing (B)			01	00	Seat Totally Burning
			01	45	3 Bottles Used, Fire Still Burning
			02	00	Fire Smoldering, But Not Flaming
			05	00	Test Stopped With Water

This test was repeated with the same results.

NEW SYSTEMS.

Loaded Water Type

Formula No. I

Crib Test

	Time Min.	Sec.	Comments
Start Pan Fire	00	00	
	01	15	Fuel Consumed
Start Extinguishing	10	00	
	10	45	First Bottle
	11	30	Second Bottle Used Flames Out, But Glowing Coals Present
	15	00	Coals Glowing Red, But No Restart of Flames

Seat Tests

Seat Test With Loaded Water

	A Time Min.	Sec.	B Time Min.	Sec.	Comments
Start Fire	00	00			Pint of Fuel
			00	00	Quart of Fuel
Start Extinguishing (A)	00	15			Upholstery Burning
	00	45			Fire Out, One Bottle Used
Start Extinguishing (B)			01	00	Seat Totally Burning
			03	00	3 Bottles Used, Flames Out of Control
			03	30	Flames Growing

Loaded Water

Formula No. III

Crib Tests

	Time Min.	Sec.	Comments
Start	00	00	Start Fire
	01	20	Fuel Consumed
	10	00	Start Extinguisher
	10	45	Bottle Empty Flames Out Some Red Coals
	15	00	Red Coals Glowing No Flames
			Floor is very slippery

Water Solution of Potassium Bicarbonate

Formula No. V

Crib Tests

	Time Min.	Sec.	Comments
Start	00	00	
	01	15	Fuel Consumed
	10	00	Start Extinguishing
	10	45	Bottle Empty A Whitish Froth Covers the Wood, But Dissipates Slowly
	15	00	Fire Out, No Restart
			Floor Slippery

Water Solutions of Monoammonium Phosphate

Formula No. IX

Crib Tests

	Time Min.	Sec.	Comments
Start	00	00	
	01	15	Fuel Consumed
	10	00	Start Extinguishing
	10	45	Bottle Empty Fire Out No Coals
	15	00	No Restart

SUMMARY

Table 1 shows that, with use of various compositions of powders and surfactants in aqueous solution, a range of fire-fighting capabilities can be generated. This provides a promising approach for possible Halon substitutes for aircraft hand extinguishers.

Beyond fire-fighting effectiveness, there are other issues that would have to be addressed. They are primarily issues of shelf-life, corrosiveness, and freezing point.

CONCLUSIONS

1. Water solutions of the powder systems are more effective than the current loaded water systems employing potassium acetate.

2. Water solutions of the phosphates plus surfactant are the most effective systems.

3. A water solution of diammonium phosphate and surfactant performs superior to Halon 1211 in the wood crib test and equal to Halon 1211 in the urethane foam, wool fabric upholstery seat tests.

4. The acetate and phosphate salts work to retard restart of flaming in the tests. This is not true of the bicarbonates.

5. The length of time between ignition and start of extinguishing in the seat test is an influential parameter in the evaluation of the comparative effectiveness of the extinguishing materials. The longer the burn time, the more difficult to control.

6. The aircraft seat test fire responds to extinguishing more like a Class B fire than a Class A fire.

REFERENCES

1. Underwriters Laboratory, Inc., Standard for Safety: Fire Extinguishers Rating, UL 711.

2. Hill, R., and Speitel, L., In-Flight Aircraft Seat Fire Extinguishing Tests, FAA Report No. DOT/FAA/CT-82/111, 1982.

3. The Montreal Protocol on Substances That Deplete the Ozone Layer, 1986. (Federal Register/Vol. 52, No. 239, 1987.)

4. Solyer, I., Griffen, C., and Duvall, D., Intumescent Fire Extinguishing Solutions," U.S.Patent 4, 588, 510; 1986.