NASA CR-152056

STUDY TO DEVELOP IMPROVED FIRE RESISTANT AIRCRAFT PASSENGER SEAT MATERIALS PHASE I

By Edward L. Trabold

(NASA-CR-152056) STUDY TO DEVELOP IMPROVED FIRE RESISTANT AIRCRAFT PASSENGER SEAT MATERIALS, PHASE 1 (Douglas Aircraft Co., Inc.) HC A06/MF A01 CSCL 01C

N78-11042

Unclas

G3/03 52881

Prepared Under Contract No. NAS 2-9337 By

McDonnell Douglas Corporation

Douglas Aircraft Company

3855 Lakewood Blvd.

Long Beach, California 90846

for

Ames Research Center
National Aeronautics and Space Administration

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PREFACE

This is the Final Technical Report submitted under contract NAS-2-9337 in the NASA FIREMEN program. The report covers the period 15 October 1976 through 15 July 1977 (Reference 1).

This program was sponsored by the Chemical Research Projects office of Ames Research Center, Moffett Field California. Mr. Larry L. Fewell was program monitor under direction of Dr. John Parker.

The program was performed at Douglas Aircraft Co., McDonnell Douglas Corporation, Long Beach, California. Mr. Edward L. Trabold was Principal Investigator and Program Director at Douglas Aircraft Co. and was assisted by the Adhesives/Textiles Lab and the Instrumental Chemical Analysis Lab. The subcontractor associated with the program was Massachusetts Institute of Technology, with a program under the direction of Dr. G. C. Tesoro assisted by Dr. Albert Moussa.

All data is submitted unpublished, in confidence, to NASA-Ames.

ABSTRACT

The Phase I "Study to Develop Improved Fire Resistant Aircraft Seat Materials" involved the procurement and testing of a wide range of candidate materials. These improved fire resistant nonmetallic materials were subjected to tests to evalute their thermal characteristics, such as burn, smoke generation, heat release rate and toxicity. In addition, candidate materials were evaluated for mechanical, physical and aesthetic properties. Other properties considered included safety, comfort, durability and maintainability. The fiscal year 1977 and the projected 1980 cost data were obtained for aircraft seat materials.

The above factors were used to evaluate materials for use in aircraft seating and specific materials were selected for Phase II testing.

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1.0 INTRODUCTION AND DISCUSSION

1.1 Introduction

The NASA Fireman Program has been established to provide a technology base for improved fire resistant materials for aircraft. This "Study to Develop Improved Fire Resistant Aircraft Seat Materials" is an important part of the "Fireman Program" (Reference 2).

There are approximately 300 passenger seats in a modern, wide bodied, commercial jet aircraft. These seats contain approximately 2400 pounds of potentially combustible materials. It is not surprising, therefore, that passenger seating has been singled out for special consideration in a program to improve aircraft fire safety.

It should be noted that aircraft passenger seats are usually airline furnished and obtained from companies in the aircraft seat industry. It is unlikely that any individual aircraft seat manufacturer supplying a highly customized, limited market item could sponsor and carry out a fire resistant seat program of this magnitude. NASA sponsorship was essential to the program's initiation and success.

The individual objectives of the overall seat program have been identified as follows:

1) Development of a data base for improved materials.
2) Design and fabrication of full-scale seats from data base material.
3) Testing of full-scale seats in the Cabin Fire Simulator (CFS)
4) Testing full-scale seats in airline operational service.
5) Analyzing and reporting design performance, materials data and preparation of material and seat specifications.

The resulting seat designs are expected to provide significantly improved fire resistance.

1.2 Discussion

This report covers Phase I of the multiphase fire resistant seat materials program. During this phase of the program, candidate materials were identified and sampled in coordination with the material suppliers. Contacts with suppliers were accomplished initially by visits and subsequently by telephone and letter. Referrals were an important source of contacts, and industry cooperation throughout was found to be outstanding. A list of companies contacted during Phase I is found in Table 1.

Sampled materials were screened, mechanical data was obtained from suppliers where possible, and advanced testing was conducted. Advanced testing included heat release rate; animal toxicity and flash fire propensity. The cost data developed for the selected materials is based on 1980 commercial availability from data primarily furnished by material suppliers.

COMPANY	ADDRESS	CONTACT
American Kynol	251 N. Maitland Ave. Altamonte Springs, FL 32701	Michael Storti
E. R. Carpenter Co., Inc.	La Mirada, CA	H. Ledesma
Celanese Fibers Marketing Company	Box 1414 Charlotte, NC 28201	Robert H. Jackson
Collins & Aikman	P.O. Box 1599 Charlotte, NC 28232	Vernon C. Smith
Collins & Aikman Automotive Division	P.O. Box 550 Albemarle, NC 28001	Joseph R. Palladino
Dan River Inc.	2291 Memorial Drive Danville, VA 24541	John M. Terpay
Dow Corning Corp.	Midland, Michigan 48640 Los Angeles, CA	Robert Kuhn Robert Hart Earl Beck
E. I. DuPont de Nemours	Wilmington, Delaware 19898 Elastomer Chemicals Dept. Textile Fibers Div.	John R. Galloway R. S. Tobey William C. Long R. S. Tobey
Expanded Rubber & Plastics Corp.	14000 S. Western Ave. Gardena, CA	John Dixon
Fire Safe Products	2617 Poe St. St. Louis, MO 63114	Paul Vance
Firestone Tire & Rubber Co.	Central Research Laboratories Akron, OH 44317	David P. Tate
General Electric Co. Silicone Products Dept.	Waterford, NY 12188	Donald L. Finney C. Yonclas
General Tire & Rubber Co.	Akron, OH 44329	W. J. Van Essen
W. R. Grace & Co.	7379 Route 32 Columbia, MD 21044	A. B. Holmstrem Robert N. Murch
Hardman Aerospace Macrodyne Industries, Inc	1845 S. Bundy Dr. Los Angeles, CA 90025	Robert M. Oppegard
Horizons Research Inc.	23800 Mercantile Rd. Cleveland, OH 44122	Dr. Wainer Arthur Gerber

INDUSTRY CONTACTS PHASE I

TABLE 1

COMPANY	ADDRESS	CONTACT
JA-Bar Silicone		R. Lisofski G. R. Jacobs
Kirkhill Rubber Co.	300 East Cypress Ave. Brea, CA 92621	R. Cannemeyer
Langenthal International Corp.	Design Center Northwest P.O. Box 81045 Seattle, Wash. 98108	Dale Havens
H. Lelievre	13 Rue Du Mail 75002 Paris, France	J. Lenoir
Mobay Chemical Corp. Plastics & Coatings Div.	Pittsburgh, PA 15205	Walter Becker J. F. Szabat
Monsanto	800 N. Lindbergh Blvd. St. Louis, MO 63166	K. McHugh
Mosites Rubber Co., Inc.	P.O. Box 2115 Fort Worth, TX (Rep 37 East Duarte Rd. Arcadia, CA 91006)	John Winkler
Reeves Bros.	Reeves Bros. R&D Center P.O. Box 26596 Charlotte, NC 28213	David C. Priest
Rhodia, Inc.	600 Madison Ave. New York, NY 10022	H. L. Kenvin
Ronsil		Wm. Arthur
Rubatex Corp.	Bedford, VA 24523	K. E. Balliet
Silicone Engineering Ltd.	Brookhouse, Blarkburn Lancashire, BB16JE England	B.E.T. Rostron
Solar Division International Harvester	2200 Pacific Highway San Diego, CA 92138	Wm. A. Compton John F. Hussey
Toyad Corp.	Latrobe, PA 15650	Gardner A. A. Fredericks R. H. Morford
Ultra Systems, Inc.	2400 Michelson Dr. Irvine, CA 92715	K. L. Paciorek
Aerospace Div. Universal Oil Products	Bantam, CT 06750	A. C. Copeland M. J. Dodd K. Taylor

INDUSTRY CONTACTS PHASE I

TABLE 1 (Cont'd)

COMPANY	ADDRESS	CONTACT
Uniroyal Plastic Co.	Mishawaka, Ind. 46544	Jill R. Skalecki
Weber Aircraft	Burbank, CA	Gordon Cress

INDUSTRY CONTACTS PHASE I

TABLE 1 (Cont'd)

A technical data base was developed for material selection and design in subsequent phases of the program that will increase in complexity and scale.

Additional related data on joint design under thermal load is being developed by Dr. G. C. Tesoro and staff at Massachusetts Institute of Technology (M.I.T.) under Grant No. NSG-2204 from NASA. Thermoplastic material data has been developed by Lockheed Aircraft Co. for their fire resistance characteristics under contract NAS 2-8835.

The data obtained and reported for individual products are for the specific conditions stated and are not necessarily representative of results obtainable in other test methods, procedures, or conditions. The data is intended for use in selection of materials for the Phase II Program. Any other use must be carefully considered, taking into account the major impact of design and other conditions which affect performance of any material. This data shall not be used for sales or promotional purposes or as a basis for discrediting any product or group of products mentioned herein.

2.0 SYMBOLS AND ABBREVIATIONS

av	average
Btu	British thermal unit
°C	degrees Celsius (centigrade)
cc	cubic centimeter
cm	centimeter
cm^2	square centimeter
DAC	Douglas Aircraft Company
dm^2	decimeter square
°F	degrees Fahrenheit
FAA	Federal Aviation Agency
FAR	Federal Aviation Requirements
ft	feet
g/cc	grams per cubic centimeter
g/m^2	grams per square meter
hr	hour
in	inch
kg	kilogram
kg/cm^2	kilogram per square centimeter
kg/m^2	kilogram per square meter
kw	kilowatt
lb	pound
lb/ft^2	pounds per square foot
lb/ft^3	pounds per cubic foot
m	meter
mm	millimeter
min	minutes
NASA	National Aeronautics and Space Administration
NASA-Ames	National Aeronautics and Space Administration, Ames Research Center
N	Newton
PBI	Polybenzamidazole
psi	pounds per square inch
sec	second
TC	thermocouple
TGA	thermal gravimetric analysis
W	watt

3.0 TESTING

3.1 Purpose

The Phase I program involved the progressive screening and testing of candidate seat materials in order to identify those materials offering significant performance improvement under thermal load. Screening tests were selected based on reasonable fire threats to identify the types of properties related to inflight fire situations. Major areas of emphasis in the test program were flammability, smoke generation, fire induced toxicity, flash fire propensity and heat release. A general schematic of the test program is shown in Figure 1. The data base developed in Phase 1 can be used to make selections of multilayer material combinations for testing in Phase II and can be used for other fire safety research.

3.2 Material Classification

For purposes of comparison in this report, materials have been classified by anticipated end use in new designs under three categories as follows:

1. Decorative fabric covering (Material No. 100 Series.)
2. Fire blocking layers (Material No. 200 Series.)
3. Cushioning layers (Material No. 300 Series.)

Other materials for armrest covers thermoplastic covers, and doors, etc. when available were classified under miscellaneous and limited data is reported. In order to classify materials, it was necessary to examine the screening data and performance test data as well as raw material limitations such as available thickness, and manufacturing limitations such as forming temperature. Many of the new thermally resistant fabrics could not meet color fast requirements in the dyed form except for blends in which the natural color could be used in the decorative pattern. Those not colorfast had to be classified as Category 2. In some cases, the new fabrics were too easily abraded for Category 1 use. Some foams could not be made in sufficient thickness to be used in Category 3 and had to be considered a Category 2 material. It is believed that this type of analysis and classification has facilitated comparison of data and provided increased utility.

3.3 Screening Tests

All materials were first screened to current FAA burn requirements. Screening tests consisted of a series of selected small scale laboratory tests. The combination of these screening tests represented a significantly higher fire resistance performance standard than laboratory test standards currently imposed on aircraft seat materials. (See Table 2.)

The modified burn test was the only nonstandard test that was conducted. The modification took into account that the standard burn test permits melting material to be removed from the direct flame by the very mechanism of melting and in affect reducing exposure time to the flame for those materials.

PHASE I MATERIAL TEST PROGRAM

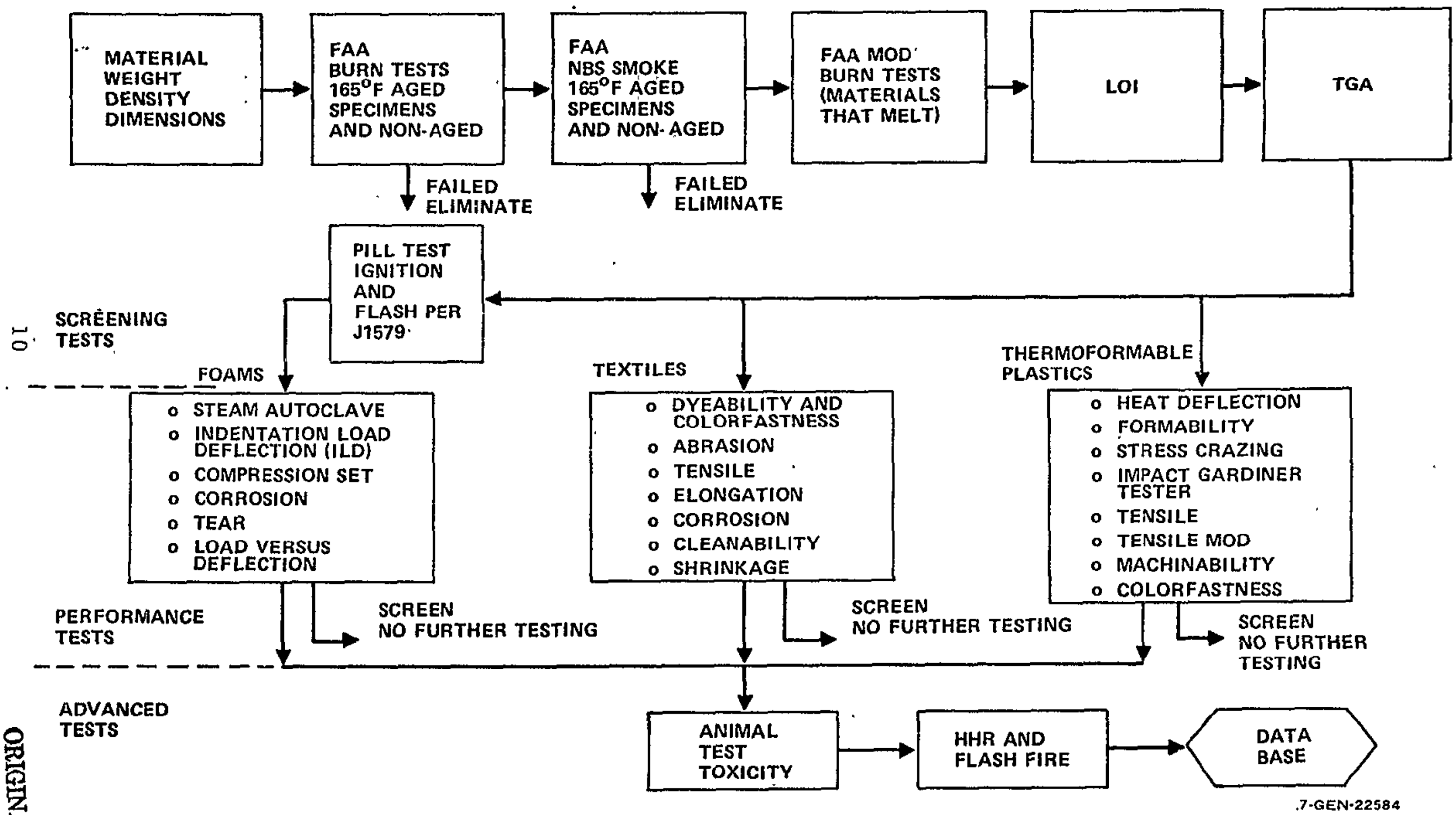


FIGURE 1

FABRIC		FOAM	
PROPERTY	TEST METHOD	PROPERTY	TEST METHOD
Screening:			
Weight	*Method 5041	Density	ASTM 1564 Suffix W
Burn	**FAR 25.853(b)	Burn	**FAR 25.853(b)
	**FAR 25.853(a)		**FAR 25.853(b) Mod.
NBS Smoke	***Tech Note 708	NBS Smoke	***Tech Note 708
		Ignition	ASTM D2859
		LOI	ASTM D2863-70
		TGA	@ 20°C per minute in air
LOI	ASTM D2863-70		
TGA	@ 20°C per minute in air		

*Federal Test Method Standard No. 191, Textile Test Methods

**Federal Aviation Regulations Part 25 Airworthiness Standards: Transport Category Airplanes

***NBS Technical Note #708; Test Method for Measuring the Smoke Generation Characteristics of Solid Materials

SCREENING TEST METHODS

TABLE 2

The modified vertical burn test that was developed was essentially the standard 12-second vertical burn test per F.A.R. 25.853(b) (equivalent to DMS 1511 and FTMS 191 Method 5903). The exception was the method of holding the specimen as follows:

Each specimen was clamped in such a manner that the back face was in direct contact over the entire surface with a single layer of MIL-C-9084 glass fiber cloth type 1XA (Style 1582) and that the two long edges were held securely. The frame was such that the exposed area was at least 2 inches wide and 12 inches long. The direction of the specimen corresponding to the most critical burn rate was parallel to the 12-inch direction. Foam specimens were 1/2 inch thick.

Materials for which fire retardant additives provided flammability resistance were tested for persistence of the retardant when aged at (165°F) for 72 hours and then retesting for burn per FAR 25.853(b). The two materials showing the greatest change were then tested for smoke per NBS Technical Note 708 to determine any affect of aging on smoke generation. Testing for persistence after laundering or dry cleaning was not conducted. Materials that were sampled and screened were tabulated and are reported in Table 3. The results of screening tests are reported in Tables 4 thru 6. Results of aging tests are reported in Table 7.

The candidate materials were tested for weight loss by standard procedures using a DuPont Instrument Company Thermal Analyzer. Approximately 5 to 15 mg samples were introduced into the sample cup and heated at a rate of 20°C per minute in a low flow of dry air (75 ml/min). Rates of weight loss versus temperature (time) were recorded by potentiometric recorder until no further weight loss was detected (usually in 30 to 35 minutes). TGA curves are shown in Figures 2 thru 4.

3.4 Performance Tests

Tests for mechanical and physical properties, identified as performance tests, are specifically identified in Table 8. These tests were standard test methods and were performed and reported by the material supplier unless otherwise indicated in the data. Performance test results are reported in Tables 9-11. Tests were selected such that materials passing the performance tests would at least equal performance requirements of current seat materials. This includes expected service performance of assemblies made from these materials which must later be proven by service experience.

3.5 Advanced Tests

Selected materials from the screened materials were tested to fire related advanced tests as follows:

3.5.1 Flash Fire Propensity - Modified NBS Flash Fire Cell

The NBS Flash Fire Cell was modified in design and fabricated to NBS and DAC specifications. It was constructed of heavy wall pyrex glass, duplicating as closely as possible the size and configuration described in Reference 3.

MATERIAL NUMBER	PRODUCT NUMBER	MATERIAL DESCRIPTION	TRADE NAME	SUPPLIER
100	ST7193-29	100% nylon, Airgard treated 11.4-12.6 oz/yd^2 Landscape fabric	Landscape	Collins & Aikman Corp.
101	20787	52.5% Kermel/47.5% Wool 277 g/m^2	-	H. Lelievre, Paris
102	OL618	100% Cotton doubleknit 10± 5% oz/yd^2 (LI spec 33)	-	Langenthal International Corp.
103	69-407	100% Nomex 8.4-9.7 oz/yd^2 Tulsa (drapery fabric)	Tulsa	Collins & Aikman Corp.
*104	ST7427-112	90% Wool/10% Nylon fabric 12.2 to 14.0 oz/yd^2 Sun Eclipse	Sun Eclipse	Collins & Aikman Corp.
105	7979	50% Kynol/50% Nomex 10.7 oz/yd^2 fabric	"No Burn" Fabric	Collins & Aikman Corp.
106	Nylon Gold 1902	Nylon Gold/Vonar 3 Neoprene foam backing	-	DuPont de Nemours
107	Urethane Coated Nylon	Urethane Elastomer coated Nylon fabric	-	Reeves Brothers
200	#24	100% Kynol fabric twill weave	Kynol	American Kynol, Inc.
201	#1110	70% Kynol/30% Nomex permanent press finish 6.2 oz/yd^2	Kynol	American Kynol, Inc.

* Baseline Fabric

LIST OF MATERIALS SCREENED
TABLE 3

MATERIAL NUMBER	PRODUCT NUMBER	MATERIAL DESCRIPTION	TRADE NAME	SUPPLIER
202	#1090	70% Kynol 30% Nomex 4.6 oz/yd^2 with permanent press finish	Kynol	American Kynol Inc.
203	B-104S	100% Kynol batting on polyester scrim-needle punch	Kynol	American Kynol Inc.
204	40-9010-1	PBI fabric natural unstabilized 5.1 oz/yd^2 2 x 1 twill	-	Celanese Fibers Marketing Co.
205	40-4010-1	PBI batting 4 oz/yd^2 natural unstabilized from staple	-	Celanese Fibers Marketing Co.
206	35-4020-1	Black batting 4 oz/yd^2 (proprietary)	-	Celanese Fibers Marketing Co.
207	Kynol on Remay scrim batting	Remay spun bonded polyester fabric needled with 100% Kynol fiber 2.8 oz/yd^2	"Flameout"	Dan River, Inc.
208	Neoprene foam	1/16" Neoprene foam with 1-2 oz/yd^2 cotton scrim	Vonar #1 Interliner	DuPont de Nemours
209	Neoprene foam	2/16" Neoprene foam with 1-2 oz/yd^2 cotton scrim	Vonar #2 Interliner	DuPont de Nemours
210	Neoprene foam	3/16" Neoprene foam with 1-2 oz/yd^2 cotton scrim	Vonar #3 Interliner	DuPont de Nemours
211	Nylon Gold 1902	See No. 106		

LIST OF MATERIALS SCREENED
TABLE 3

MATERIAL NUMBER	PRODUCT NUMBER	MATERIAL DESCRIPTION	TRADE NAME	SUPPLIER
212	Upholstery Fabric	Durette upholstery fabric	Durette	Fire Safe Products, Inc.
213	SE5559	Elastomer, silicone rubber S.G. 1.33	-	General Electric (Waterford, NY)
214	Nomex III	Aramid fabric	Nomex III	DuPont de Nemours & Co.
215	Kermel	Kermel fabric 250 g/m^2 amide-imide	Kermel	Rhodia, Inc.
216	400-11	Durette Batting	Durette	Fire Safe Products, Inc.
300	FG215	Glass fiber block cushion edge grain blocking of glass fibers	-	Expanded Rubber and Plastics Corp.
301	R-207080	APN phosphazene open cell foam 0.14 g/cc	APN foam	Firestone Tire & Rubber Co.
302	9907-13	Urethane foam, flexible	Hypol	W. R. Grace & Co.
303	EXP1408	Silicone Rubber sponge 11 lb/ft^3	-	Kirkhill Rubber Company
304	14183-B	Silicone rubber sponge 11.8 lb/ft^3	Mosites	Mosites Rubber Co., Inc.

LIST OF MATERIALS SCREENED
TABLE 3

MATERIAL NUMBER	PRODUCT NUMBER	MATERIAL DESCRIPTION	TRADE NAME	SUPPLIER
305	#510	Silicone rubber sponge 0.21 g/cc	-	Silicone Engineering Ltd. England
*306	H-45C	Urethane foam 0.03 g/cc	-	E. R. Carpenter Co., Inc.
307	HL1-7-77	Neoprene foam, open cell	-	Toyad Corp.
308	Koylon Firm	Neoprene foam, open cell 0.14 g/cc	Kaylon	Uniroyal Inc.
400	170	Silicone Adhesive	Sylgard	Dow Corning Corp.
401	-	Carpet mod acrylic	Brunswall	Brunswall Corp.
402	-	Polyphenylenesulphone PPS Thermoplastic	Radel	Union Carbide
403	57-1825	ABS thermoplastic sheet	Royalite	Uniroyal
404	10052-72D	Rigid urethane foam	Hypol	W. R. Grace & Co.

* Baseline Fabric

LIST OF MATERIALS SCREENED
TABLE 3

TEST & TEST METHOD	UNITS	ST-7193-29 FABRIC (100) C & A	20787 KERMEL BLEND (101) H. LELIEVRE	OL618 COTTON KNIT (102) LANGENTHAL	69-407 NOMEX (103) C & A	ST-7427-112 WOOL/NYLON (104) * C & A	7979 KYNOL BLEND (105) C & A	NYLON GOLD & VONAR 3 (106) DUPONT	#15691 COATED NYLON (107) REEVES BROS.
Weight/Area	g/m^2	389	290	335	311	457	319	1367	295
Thickness		–	–	–	–	–	–	–	–
Density	g/cc	–	–	–	–	–	–	–	–
Burn Test FAR 25.853b									
Burn Time	sec.	3 6	0 0	0	0 0	1 1	0 0	282**	0 0
Burn Length	mm	71.1 71.1	114.3 127.0	114.3	71.1 66.0	58.4 66.0	58.4 63.5	261.6**	124.5 116.8
Drip		1 1	ND ND	ND	ND ND	ND ND	ND ND	ND	1 0
NBS Smoke Tech Note 708									
Nonflaming	90 sec	4	21	40	2	28	2	–	12
	4 min	12	38	41	3	73	6	–	43
Flaming	90 sec	10	21	8	6	64	11	–	30
	4 min	33	37	13	12	127	19	–	46
LOI ASTM D 2863	warp%	27	30	28	31	33	30	–	22
	fill%	26	50	28	32	31	32	–	
Pill Test Ignition ASTM D 2859		Slight burning of fabric 3/4"d on foam	No burn char in area of pill on foam	–	No burn char in area of pill on foam	Char in area of pill on foam	Char in .5" area on foam	–	No burn 1" dia. char
TGA	Total weight loss %	98	95	–	98	98	88		93

* Baseline
**Failed requirements
testing discontinued

SCREENING TEST DATA - DECORATIVE FABRIC COVER

TABLE 4

Test & Test Method	Units	#24 Kynol (200) AKI	#1110 Kynol Blend (201) AKI	#1090 Kynol Blend (202) AKI	B-104S Kynol 100% (203) AKI	40-9010-1 PBI (204) Celanese	40-4010-1 PBI (205) Celanese	35-4020-1 Blackbatting (206) Celanese	Flameout Kynol (207) Dan River
Weight/Area Thickness	g/m^2	244	200	159	213	172.9	118.7	142.4	95
Density	g/cc								
Burn Test FAR 25.853b Burn Time Burn Length Drip	 sec. mm.	 1 1 58.4 58.4 ND ND	 0 0 78.7 73.7 ND ND	 0 0 73.7 73.7 ND ND	 0 0 63.5 61.0 ND ND	 0 0 30.5 30.5 ND ND	 0 0 35.6 30.5 ND ND	 0 0 43.2 48.3 ND ND	 0 0 58.4 58.4 ND ND
NBS Smoke Tech Note 708 Nonflaming Flaming	 90 sec. 4 min. 90 sec. 4 min.	 0 1 0 1	 0 1 3 6	 2 2 4 6	 4 8 11 16	 1 2 0 1	 1 2 0 1	 0 2 1 0	 2 8 3 3
LOI ASTMD 2863	warp % fill %	34 33	30 29	29 29	35 34	39 40	37	38	31
Pill Test ignition ASTM D 2859		-	-	-	-	Material charred & shrank on foam	-	0.8 in char area around pill	No burn char in area of pill on foam
TGA	Total weight loss %	100	98	98	99	-	-	98	100

SCREENING TEST DATA - FIRE BLOCKING LAYERS

TABLE 5

Test & Test Method	Units	Vonar #1 Neoprene (208) DuPont	Vonar #2 Neoprene (209) DuPont	Vonar #3 Neoprene (210) DuPont	Durette Upholstery (212) Fire Safe Products	SE-5559 Silicone Elastomer (213) G.E.	Nomex III Fabric (214) DuPont	Kermel Fabric (215) Rhodia	400-11 Durette Batting (216) Fire Safe Products
Weight/Area Thickness	g/m^2	42.5	723	954	322	2516 @75mm	254	250	
Density	g/cc	-	-	-	-	1.31	-	-	
Burn Test FAR 25.853b Burn Time BBurn Length Drip	 sec. mm.	0 0 66.0 55.9 ND ND	0 0 50.8 40.6 ND ND	0 0 43.2 40.6 ND ND	0 0 33.0 33.0 ND ND	0 3 2.5 2.5 ND ND	2 0 68.6 68.6 ND ND	1 2 55.9 61.0 ND ND	0 0 15.2 17.8 ND ND
NBS Smoke Tech Note 708 Nonflaming Flaming	 90 sec. 4 min. 90 sec. 4 min.	 22 34 30 43	 30 57 45 78	 40 98 70 136	 0 3 8 15	 0 11 7 26	 1 5 8 16	 3 10 6 16	 0 1 6 11
LOI ASTM D 2863	warp % fill %	38	41	62	46	40	27	30 29	-
Pill Test ignition ASTM D 2859		No burn char in pill area	No burn char in pill area	No burn char in pill area	No burn 4 in. dia. char	No burn char in area of pill	No burn .6 in. dia. char around pill	-	-
TGA	Total weight loss %	-	-	62	98	15	-	100	-

SCREENING TEST DATA - FIRE BLOCKING LAYERS

TABLE 5 (Cont'd)

Test & Test Method	Units	FG125 Glass Fiber Blocks (300) Exp. Rubber	R-207080 APN Phosphazene (301) Firestone	9907-13 Hypol Foam (302) W. R. Grace	EXP1408 Silicone Foam (303) Kirkhill	14183-B Silicone Foam (304) Mosites	#510 Silicone Foam (305) Silicone Eng	H-45C Urethane Foam (306)* ER Carpenter	HL1-7-77 Neoprene Foam (307) Toyad
Weight/Area	g/m^2	-	-	-	-	-	-	-	-
Thickness		-	-	-	-	-	-	-	-
Density	g/cc	.03-.06	0.14	0.20	0.15	0.19	0.21	0.03	0.12
Burn Test FAR 25.853b									
Burn Time	sec.	0	0	0	3	0	89	1	0
Burn Length	mm	2.5	21.0	2.5	22.9	38.1	20.3	21.1	25.4
Drip		ND	ND	ND	ND	ND	ND	ND	ND
NBS Smoke Tech Note 708									
Nonflaming	90 sec.	5	14	49	47	42	2	51	45
	4 min.	8	113	181	163	118	17	134	115
Flaming	90 sec.	4	43	153**	31	51	54	27	84
	4 min.	6	89	335**	67	115	100	37	165
Colorfastness Method 5660	Light	-	-	-	-	-	-	-	-
Method 5651(B)	Crocking	-	-	-	-	-	-	-	-
LOI ASTM D 2863	warp % fill %	33	41	-	33	31	29	23	45
Pill Test Ignition ASTM D 2859		-	No burn .6-.7 in char area	-	No burn .4" char area	No burn char in pill area	No burn char in pill area	1" deep hole x 1.9" D	No burn char in pill area
TGA	Total weight loss %	24	58	-	43	50	52	99	60

* Baseline material
** Failed requirements

SCREENING TEST DATA - CUSHIONING LAYERS & MISC.

TABLE 6

Test & Test Method	Units	Koylon (Firm) Neoprene (308) Uniroyal							
Weight/Area Thickness	g/m^2	- -							
Density	g/cc	0.14							
Burn Test FAR 25.853b Burn Time Burn Length Drip	 sec. mm	 0 0 30.5 35.6 ND ND							
NBS Smoke Tech Note 708 Nonflaming Flaming	 90 sec. 4 min. 90 sec. 4 min.	 107 222* 122 231*							
-	-	-							
LOI ASTM D 2863	 warp % fill %	 29							
Pill Test Ignition ASTM D 2859		No burn char in pill area							
TGA	Total weight loss %	62							

* Failed recommended limits

SCREENING TEST DATA - CUSHIONING LAYERS & MISC.
TABLE 6 (Cont'd)

Test & Test Method	Units	170 Sylgard ADH (400) Dow Corning	Carpet Mod Acrylic (401) Brunswall	Radel PPS (402) Union Carbide	57-1825 ABS Royalite (403) Uniroyal	10052-72D Rigid Urethane Foam (404) W. R. Grace			
Weight/Area Thickness	g/m^2	-	644 -	-	1687 -	-			
Density	g/cc	-	-	-	-	-			
Burn Test FAR 25.853b			FAR 25.853a						
Burn Time	sec.	.11	0 0	-	0 1	0			
Burn Length	mm	10.2	149.9 144.8		43.2 45.7	2.54			
Drip		ND	ND ND		ND ND	ND			
NBS Smoke Tech Note 708 Nonflaming	90 sec. 4 min.	3 14	-		-	55 160			
Flaming	90 sec. 4 min.	8 17		0 2		71 181			
Colorfastness Method 5660 Method 5651(B)	Light Crocking	- -	-	Severe stain 50SFH	- -	-			
LOI ASTM D 2863	warp % fill %	28	-	-	32 30	61			
Pill Test Ignition ASTM D 2859		-	-	-	-	-			
TGA	Total weight loss %	-	-	-	-	-			

SCREENING TEST DATA - MISC.

TABLE 6 (Cont'd)

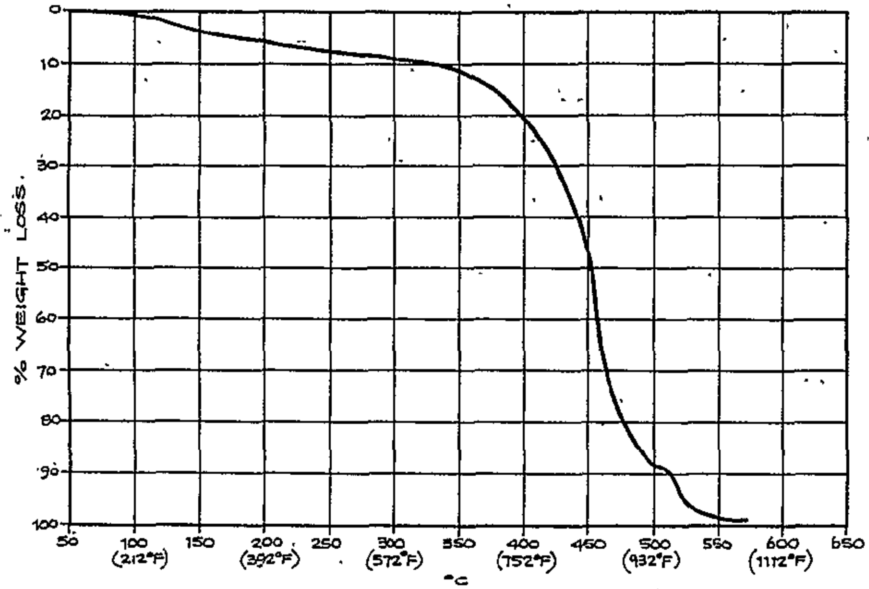
MATERIAL	MAT'L NO.	NONAGED (1) FLAME TIME, SEC.	NONAGED (1) BURN LENGTH INCH	NONAGED (1) BURN LENGTH mm	NONAGED (1) FLAME TIME OF DRIPS, SEC.	AGED** (1) FLAME TIME, SEC.	AGED** (1) BURN LENGTH INCH	AGED** (1) BURN LENGTH mm	AGED** (1) FLAME TIME OF DRIPS, SEC.
ST-7193-29 Fabric	(100)	2	2.7	68.6	1	1	2.5	63.5	0
#20787 Fabric	(101)	0	4.5	114.3	ND	1	5.1	129.5	ND
ST 7427-112 Fabric	(104)	1	2.3	58.4	ND	2	2.7	68.6	ND
OL618 Fabric	(102)	0	4.5	114.3	ND	0	4.6	116.8	ND
Vonar #3 Foam	(210)	0	1.7	43.2	ND	0	2.0	50.8	ND
14183-B Silicone Foam	(304)	0	1.5	38.1	ND	0	0.9	22.9	ND
HL Neoprene Foam	(307)	0	1.0	25.4	ND	0	1.0	25.4	ND
H-45C Urethane Foam	(306)	1	2.8	71.1	0	0	5.0	127.0	0
#510 Foam	(305)	89	0.8	20.3	ND	53	0.6	15.2	ND
Exp 1408 Foam	(303)	3	0.9	22.9	ND	0	0.7	17.8	ND

MATERIAL	MAT'L NO.	NONAGED (2) TEST	NONAGED (2) MAX. D_S IN 90 SEC	NONAGED (2) MAX. D_S IN 4 MIN	AGED** (2) TEST	AGED** (2) MAX. D_S IN 90 SEC	AGED** (2) MAX. D_S IN 4 MIN
#20787 Fabric	(101)	FLAMING	20 21 23 Av 21	35 37 39 Av 37	FLAMING	28 20 25 Av 24	44 36 39 Av40
H-45C Urethane Foam	(306)	NONFLAMING	44 51 58 Av 51	113 132 157 Av134	NONFLAMING	43 41 41 Av 42	127 132 132 Av130

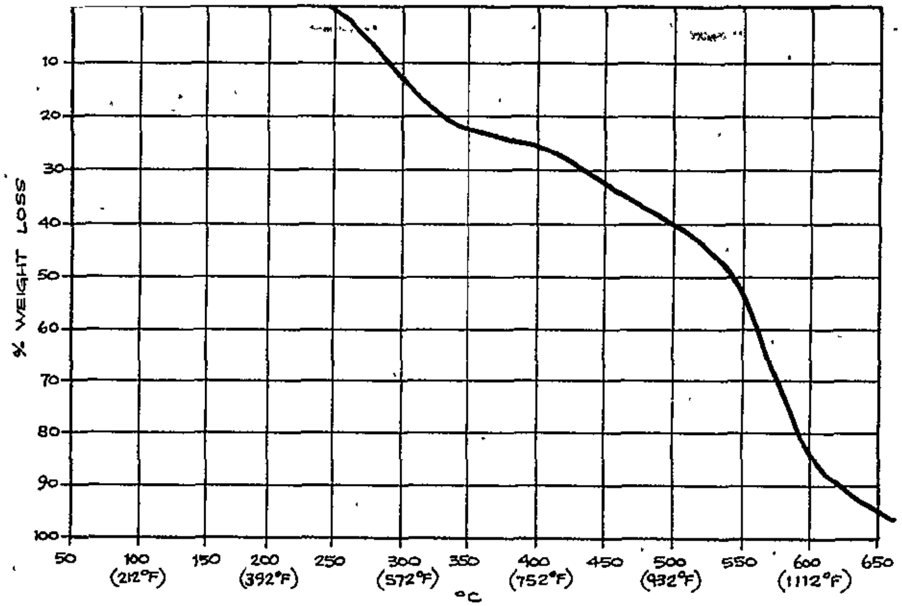
(1) Fed Aviation Regulations Part 25 Test 25.853b
**Material aged 72 hours at 165°F
(2) NBS Technical Note 708; Test Method for Measuring the Smoke Generation of Solid Materials
ND = No drippings

SMOKE AND BURN TEST RESULTS AGED VS NONAGED MATERIALS

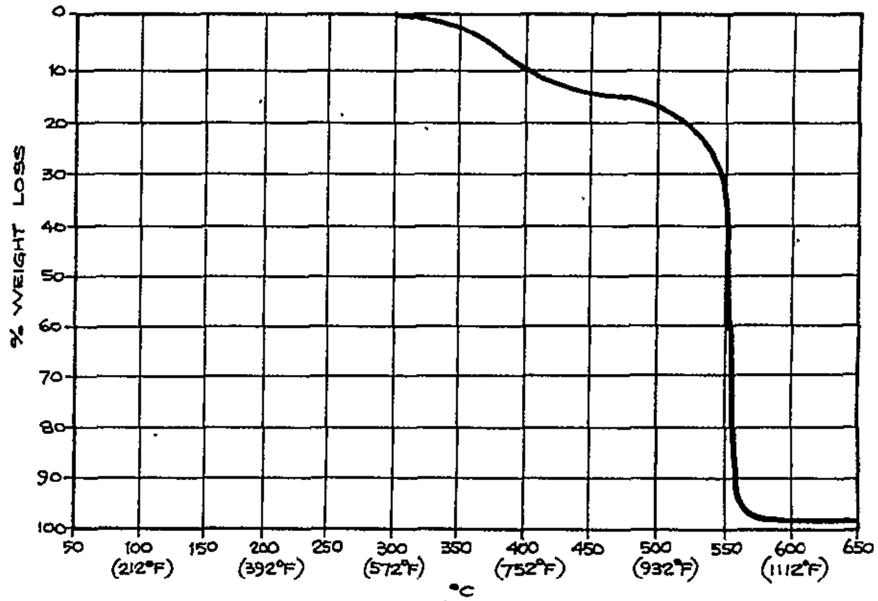
TABLE 7



(100)



(101)



(103)

FIGURE 2. TGA RESULTS - DECORATIVE FABRIC COVER

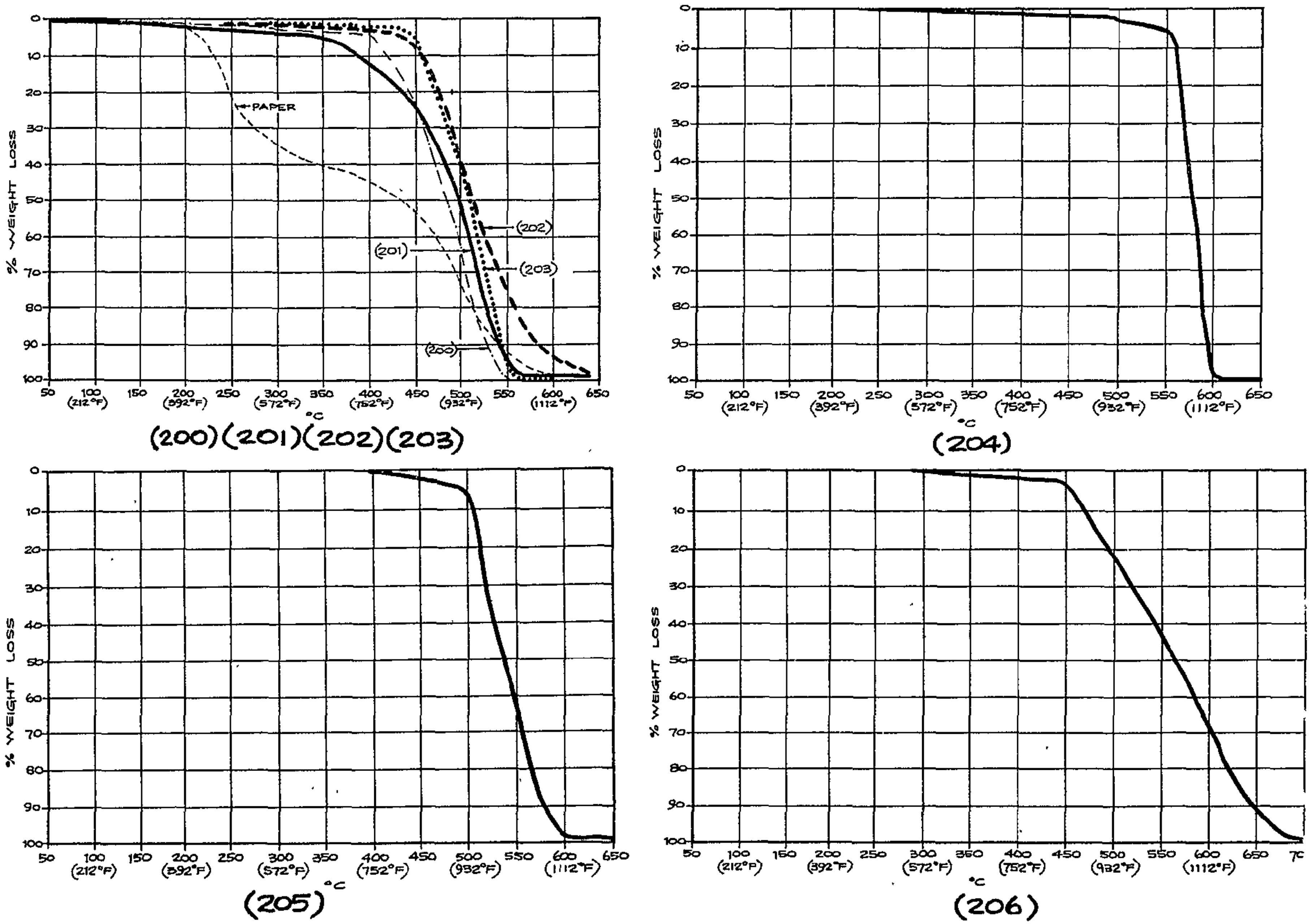


FIGURE 3. TGA RESULTS - FIRE BLOCKING LAYERS

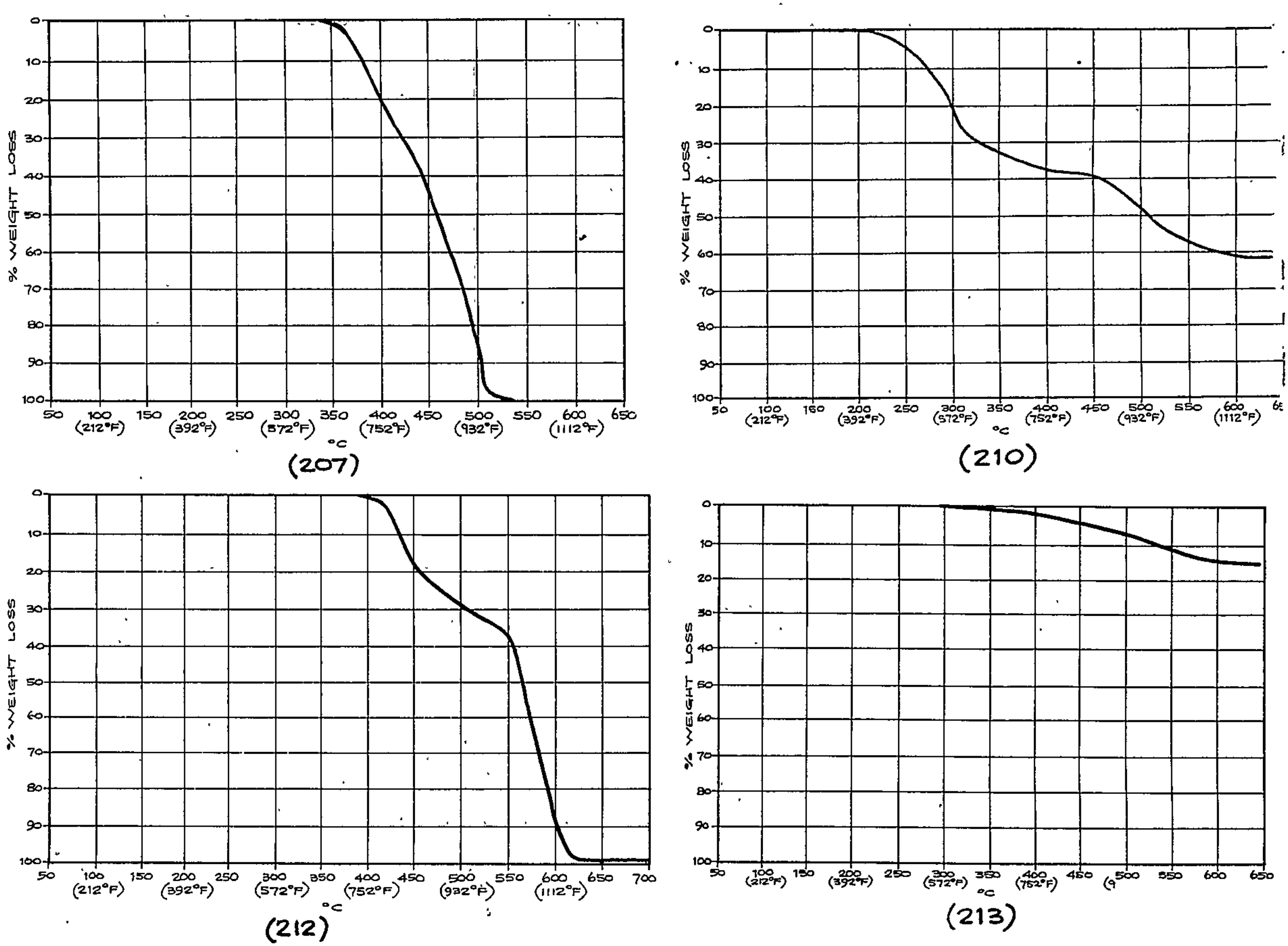
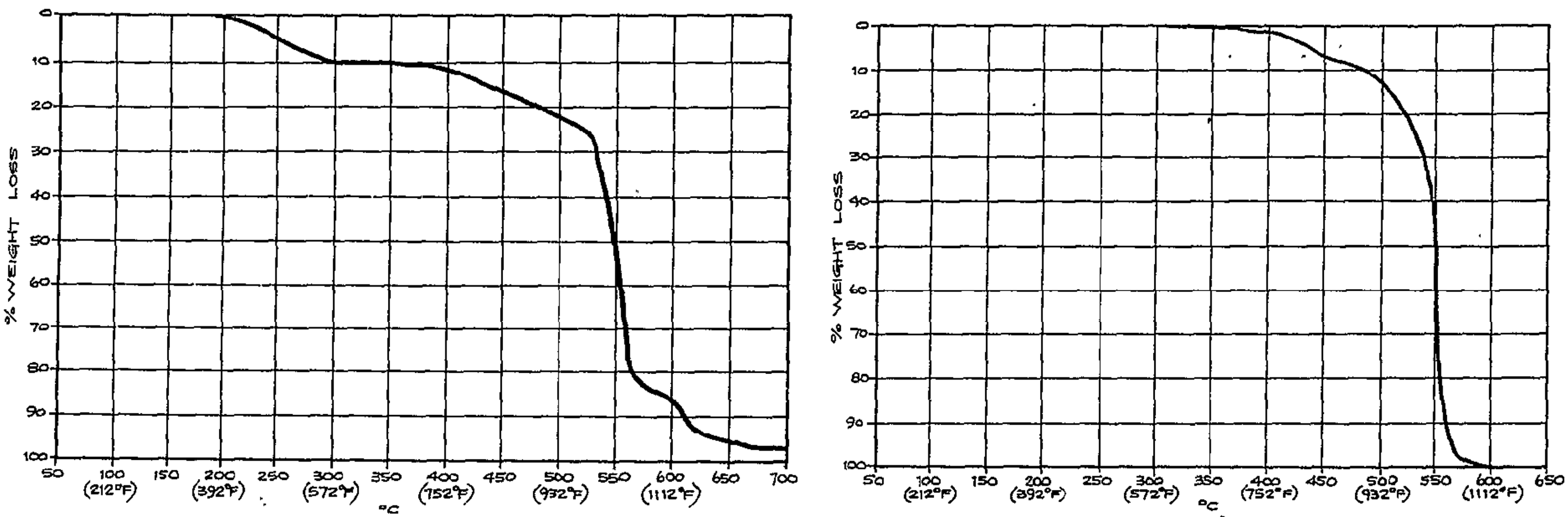


FIGURE 3. (CONT'D) TGA RESULTS - FIRE BLOCKING LAYERS



(214) (215)

FIGURE 3. TGA RESULTS - FIRE BLOCKING LAYERS
(CONT'D)

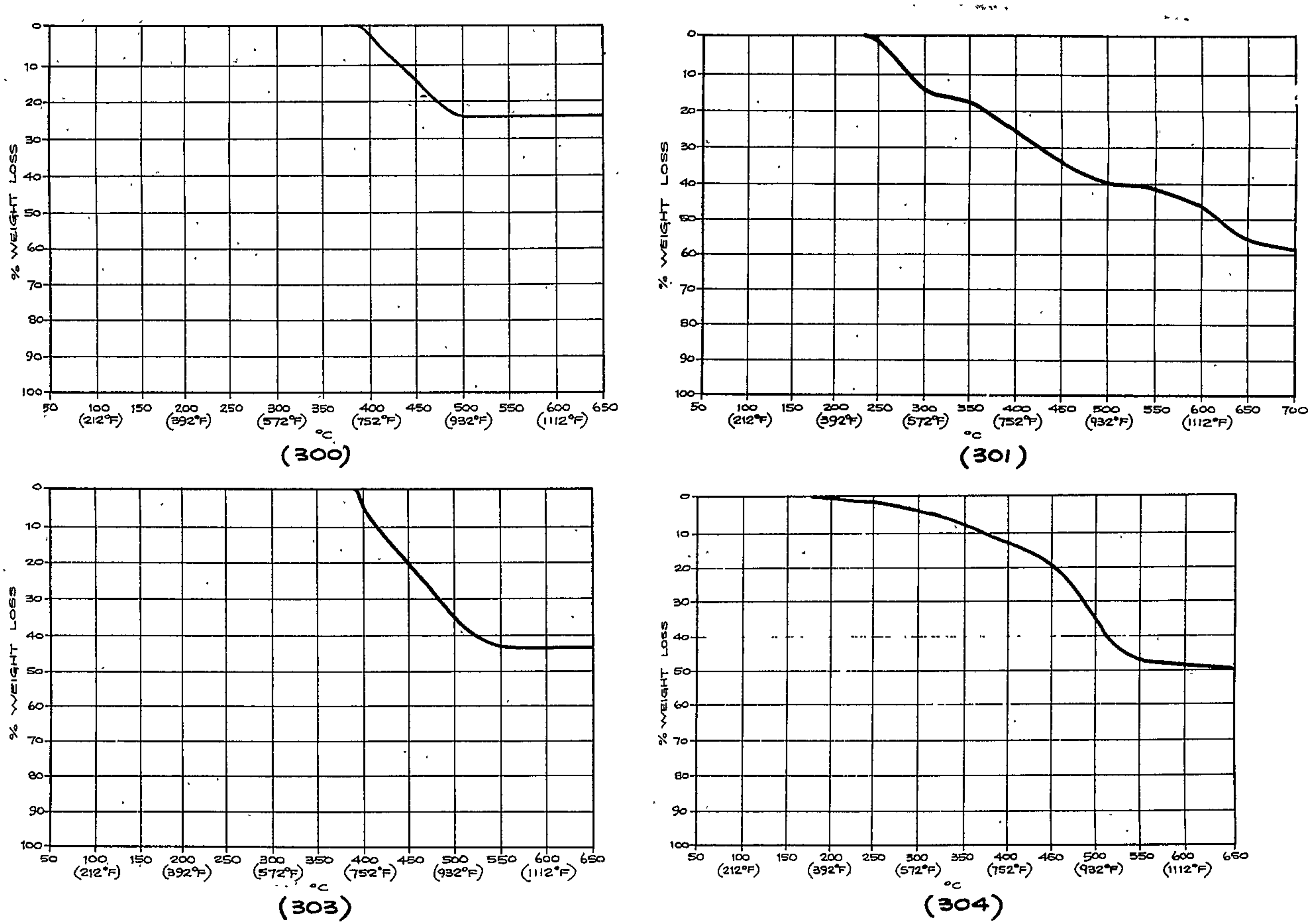


FIGURE 4. TGA RESULTS - CUSHIONING LAYERS

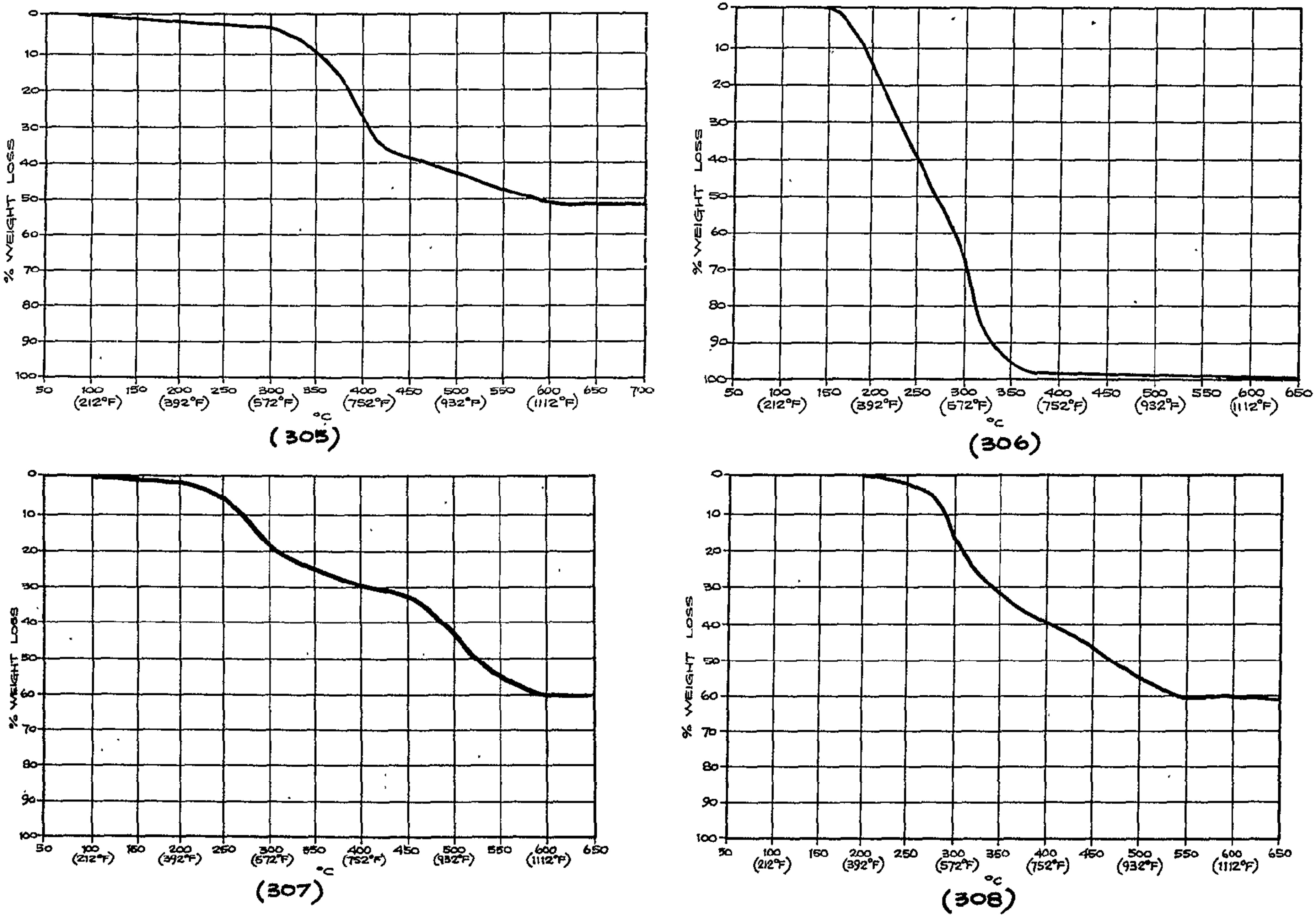


FIGURE 4. TGA RESULTS - CUSHIONING LAYERS (CONT'D)

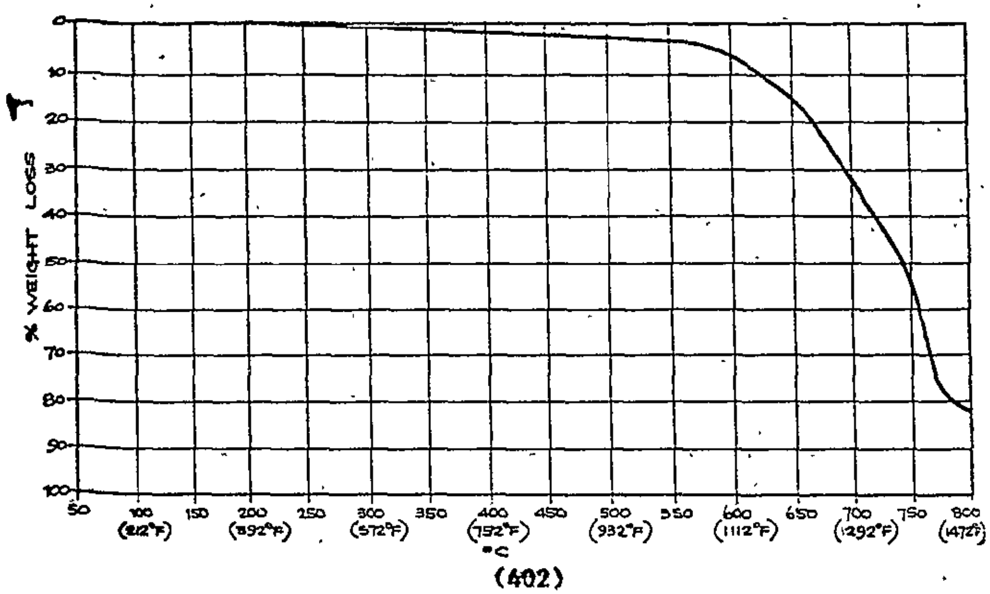


FIGURE 4. TGA RESULTS - CUSHIONING LAYERS

FABRIC		FOAM	
PERFORMANCE			
Tensile	*Method 5100	Steam Autoclave	ASTM 1564 Sect.5-11
Ultimate Elongation		Indentation Load Deflection (ILD) @ 25%, 65%	ASTM 1564 Method A Sect. 19-25
Tear	*Method 5132		
Shrinkage	*Method 5580	Compression Set	ASTM 1564 Sect. 12-18
Colorfastness	*Method 5660 *Method 5651(B)	Corrosion	DPS 8.86
Corrosion	DPS 8.86	Tear	ASTM 1564 Suffix G
Cleanability	*Method 5580		
Abrasion	*Method 5306		

(DPS - Douglas Process Standard)

*Federal Test Method Standard No. 191, Textile Test Methods

PERFORMANCE TEST METHODS

TABLE 8

TEST	TEST METHOD	ST7193-29 Fabric (100) C & A	20787 Kermel Blend (101) H. LeLievre	OL618 Cotton Knit (102) Langenthal	69-407 Nomex (103) C & A	ST7427-112 Wool/Nylon (Baseline) (104) C & A	7979 "No Burn" Kynol Blend (105) DuPont
Tear	* Method 5132 kg lbs.	>6.4 >6.4 >14.1 >14.1	4.0 3.1 8.8 6.8	>6.4 >6.4 >14.1 >14.1	>6.4 >6.4 >14.1 >14.1	>6.4 4.8 >14.1 10.6	>6.4 >6.4 >14.1 >14.1
Colorfastness	* Method 5660 Light * Method 56561(B) Crocking	20SFH 40SFH Exc. Exc.	20SFH 40SFH Exc. Good	20SFH 40SFH Fair Fair Little or no transt.	20SFH 40SFH Poor Poor	20SFH 40SFH Exc. Fair	20SFH 40SFH Poor Poor
Corrosion	DPS 8.86	-	-	-	-	-	-
Cleanability	Method 5580	-	-	-	-	-	-
Abrasion	*Method 5306	-	-	Poor (1)	-	Broke Pooryarns (1)	-
Abrasion	ASTM 1175 Abrade #8 Cotton Duck	-	-	-	-	22 Cycles	-

*Federal Test Method Standard No. 191, Textile Test Methods

(1) 750 cycles 1000g
C5-10 Wheel

PERFORMANCE TEST RESULTS - DECORATIVE FABRIC COVER

TABLE 9

TEST	TEST METHOD	Nylon Gold & Vonar Backing (106) DuPont		#15691 Coated Nylon (107) Reeves Bros.					
Tear	*Method 5132 Kg.	2.5	3.2	>6.4	>6.4				
	lbs.	5.5	7.0	>14.1	>14.1				
Color Fastness	*Method 5660 Light	20SFH	40SFH	20SFH	40SFH				
	*Method 5651(B) Crocking	Good	Good	Good	Good				
Corrosion	DPS 8.86	-		-					
Cleanability	Method 5580	-		-					
Abrasion	*Method 5306	-		-					
Abrasion	ASTM 1175 Abrade #8 Cotton Duck	-		-					

* Federal Test Method Standard No. 191, Textile Test Methods

PERFORMANCE TEST RESULTS - DECORATIVE FABRIC COVER

TABLE 9 (Cont'd)

TEST	TEST METHOD		#24 Kynol (200) AKI	#1110 Kynol Blend (201) AKI	#1090 Kynol Blend (202) AKI	B-104S Kynol Needle Punch (203) AKI	40-9010-1 PBI Fabric (204) Celanese	40-4010-1 PBI Batting (205) Celanese
Compression Set	ASTM 1564 Sect 12-18		–	–	–	–	–	–
Corrosion			–	–	–	–	–	–
Tear	ASTM 1564 Suffix G		–	–	–	–	–	–
Tensile	*Method 5100		–	–	–	–	–	–
Ultimate Elongation			–	–	–	–	–	–
Tear	*Method 5132	kg	>3.18 –	>3.18 1.85	2.76 >3.18	3.14 >3.18	– –	1.46 1.33
		lbs.	>7 –	>7 4.07	6.07 >7	6.92 >7	– –	3.21 2.92
Shrinkage	*Method 5580	%	–	–	–	–	–	–
Colorfastness	*Method 5660	Light	–	–	–	–	–	–
	*Method 5651(B)	Crocking	–	–	–	–	–	–
Abrasion	*Method 5306		–	–	–	–	–	–
Thermal Cond.	ASTM C 177		–	–	–	–	–	–

*Federal Test Method Standard No. 191, Textile Test Methods

PERFORMANCE TEST RESULTS - FIRE BLOCKING LAYERS

TABLE 10

TEST	TEST METHOD	35-4020-1 Black Batting (206) Celanese	"Flameout" Kynol Needled Remay (207) Dan River	Vonar #1 Neoprene Foam (208) DuPont Mfg. by (Nafi	Vonar #2 Neoprene Foam (209) DuPont Division of	Vonar #3 Neoprene Foam (210) DuPont Chriscraft)	Durette Upholstery (212) Fire Safe Prod.
Compression Set	ASTM 1564 Sect 12-18	-	-	-	D1055 50% 22hrs 72° 70%	-	-
Corrosion		-	-	-	-	-	-
Tear	ASTM 1564 Suffix G	-	-	-	-	-	-
Tensile	*Method 5100	-	-	-	-	-	-
Ultimate Elongation		-	-	-	-	-	-
Tear	*Method 5132 kg.	1.01 .91	-	-	-	-	>6.4 >6.4
	lbs.	2.24 2.01					>14.1 >14.1
Shrinkage	*Method 5580 %	-	-	-	-	-	-
Colorfastness	*Method 5660 Light	-	-	-	-	-	-
	*Method 5651(B) Crocking	-	-	-	-	-	-
Abrasion	*Method 5306	-	-	-	-	-	-
Thermal Cond.	ASTM C 177	-	-	-	-	-	-

*Federal Test Method Standard No. 191, Textile Test Methods

PERFORMANCE TEST RESULTS - FIRE BLOCKING LAYERS

TABLE 10 (Cont'd)

Test	Test Method	SE5559 Silicone Elastomer (213) G. E.	Nomex III Fabric (214) DuPont	Kermel Fabric (215) Rhodia			
Compression Set	ASTM 1564 Sect 12-18	-	-	-			
Corrosion		-	-	-			
Tear	ASTM 1564 Suffix G	-	-	-			
Tensile	*Method 5100	(1250 PSI)	-	-			
Ultimate Elongation		(530%)	-	-			
Tear	*Method 5132 kg. lbs.	-	5.4 3.3 11.8 7.2	4.4 6.2 9.6 13.6			
Shrinkage	*Method 5580 %	-	-	-			
Colorfastness	*Method 5660 Light	-	-	-			
	*Method 5651(B) Crocking	-	-	-			
Abrasion	*Method 5306	-	-	-			
Thermal Cond.	ASTM C 177	-	-	-			

*Federal Test Method Standard No. 191, Textile Test Methods

PERFORMANCE TEST RESULTS - FIRE BLOCKING LAYERS

TABLE 10 (Cont'd)

TEST	TEST METHOD	H-45C Urethane Foam * (306) E. R. Carpenter	HL1-7-77 Neoprene Foam (307) Toyad	Kaylon Firm Neoprene Foam (308) Uniroyal			
Steam Autoclave	ASTM 1564 Sect 5-11		No change in comp. deflection or set	-			
Indentation Load Deflection (ILD)	ASTM 1564 Method A Sect 19-25	10.2cm (4 in) thickness	6.4cm 2.5 in thickness	-			
newtons per $3.2dm^2$ 25%	25%	195.7N-222.4N (44-50 lbs)	164.6N (37 lbs)				
(lbs. force per 50 in^2) 65%	65%	-	725N (163 lbs)				
Compression Set	ASTM 1564 Sect 12-18 ASTM D1055 @50%	@80% = 5% @90% = 10%	10-15%	-			
Tear	ASTM 1564 Suffix G		1.2 lb	-			
Tensile	ASTM 1564	4.4N (1.0 lb)	8-10psi elong. 300-360%	-			

*Baseline

PERFORMANCE TEST RESULTS - CUSHIONING LAYERS

TABLE 11 (Cont'd)

TEST	TEST METHOD	FG215 Glass Fiber Blocks (300) Expanded Rubber	R-207080 APN Phosphazene Foam (301) Firestone	9907-13 Hypol Foam (302) W. R. Grace	EXP1408 Silicone Foam (303) Kirkhill	14183-B Silicone Foam (304) Mosites	#510 Silicone Foam (305) Silicone Engr.
Steam Autoclave	ASTM 1564 Sect 5-11	-	-	-	-	2.5p 2.6% 16psi 1.9%	-
Indentation Load Deflection (ILD)	ASTM 1564 Method A Sect 19-25	12.1cm (4.75 in) thickness					
newtons per 3.2dm^2 (lbs. force per 50 in^2) 25%	25%	41.9N (9.4 lbs)	- (1)	155.7N (35 lbs)	-	1334.4N (300 lbs)	1334.4N (300 lbs)
65%	65%	252.6N (6.8 lbs)	- (1)	889.6N (200 lbs)		12232.0N (2750 lbs)	9563.2N (2150 lbs)
Compression Set	ASTM 1564 Sect 12-18	-	-	32%	@50% = 19.6% deflection	@50% = 30% deflection	-
Tear	ASTM 1564 Suffix G	-	-	-	-	1.85 lb/in	-
Tensile	ASTM 1564	-	-	3.6kg 8 lbs Elong.=144%	-	-	-

* Baseline
(1) Development material

PERFORMANCE TEST RESULTS - CUSHIONING LAYERS

TABLE 11

The cell was modified, as shown in Figure 5, by incorporation of a minature, electrically powered, pyrolysis tube furnace in a demountable side arm of the apparatus. It was anticipated that this feature would permit faster and more reproducible heating regimes than provided by the NBS external heater design. See Reference 3.

Further important modifications have been incorporated. A thermocouple junction was inserted through the septum at H_2, Figure 5, with the junction positioned in the center of the main vertical tube. This TC and the TC probe inserted in the sample within the pyrolysis tube were connected respectively in series to a dual channel recorder. During a test, the output from the sample pyrolysis zone TC and the main tube TC were recorded simultaneously on the same chart. The latter TC automatically detected a flash fire front traveling vertically upward as the test proceeded.

A cycle control and timer with counter connected to the 10 KV transformer spark generator was set to cycle the 1 cm spark in the base of the cell for approximately 0.5 sec with a repetition rate of 6 per minute. The heat generated in the air inside the main tube was detected on the recorded TC trace as a short upscale pulse each time the ignition source spark was cycled. Power for the pyrolysis combustion tube heating coil was supplied by a variac transformer (20 amp) and adjusted manually to preselected wattage level. This pyrolysis assembly permitted the selection of virtually any heating profile (max. approx. 600^{o}C/min.) by adjustment of the voltage level. (See Figure 5.) The coil wire was found to be uniform in output; theoretical heating levels (thermal flux) from 0.1 to 4 watt cm^2 (over internal surface of the pyrolysis tube) were attained.

Test Procedure -

The candidate materials were tested using the following selected pyrolysis heating regime and operational procedures.

(a) A 0.5 g sample, weighed to ±0.0001 g was inserted in a preweighed heating coil/pyrolysis tube assembly.

(b) The pyrolysis tube with the sample was installed in the side tube as shown in Figure 5, and connected to the variac power source.

(c) The pyrolysis zone TC probe was inserted through the entrance tube in cap/joint D (Figure 5) and plugged into the ice point electronic reference. The recorder range for this output was set on 50 mv/FS.

(d) The flash fire detector TC was inserted through port H_2, connected to the ice point electronic reference and the recorder range set to 5 mv/FS.

(e) The cycle time was set for a 0.5 sec. spark at 10 sec. intervals and the counter set to zero.

(f) The dual pen recorder was started at a paper transport speed of 6.25mm per minute.

(g) Each experimental run was initiated by switching on the pyrolysis coil power, the spark cycle time and depressing the hand-held record event marker switch to mark time zero on the recorder chart. Power to the pyrolysis tube was smoothly and rapidly (<5 sec.) adjusted to 5.5 amp (at 19.1 volt).

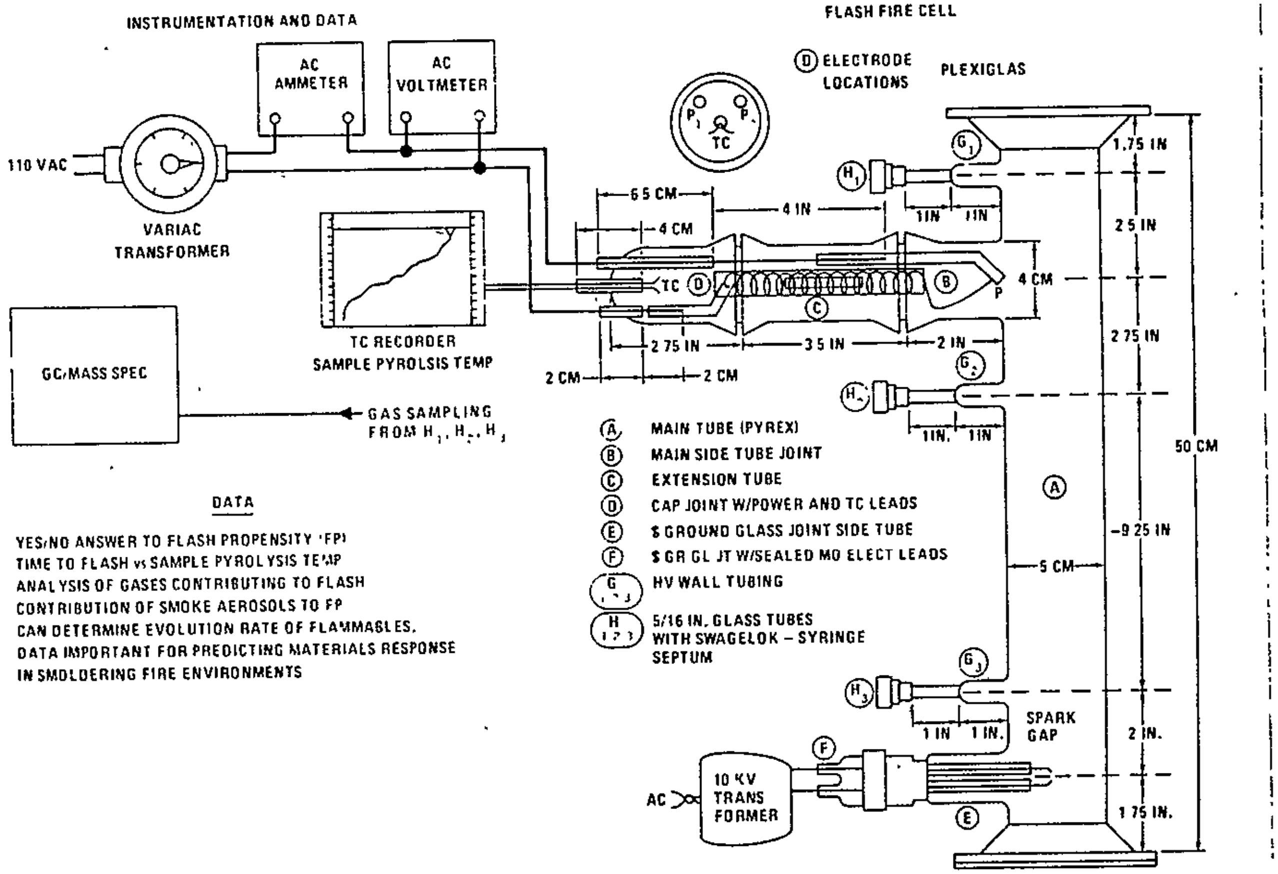


FIGURE 5. NBS FLASH FIRE CELL

(h) The outlet at the internal end of the pyrolysis tube was observed and the event marker switch was depressed to mark the recorder chart at the time of first appearance of smoke.

(i) Visual appearance, estimated quantity and color of smoke, and relative intensity (light, sound, flame front travel) or violence of a flash reaction was noted.

(j) When a flash occurred, additional air was allowed to enter momentarily into the bottom of the cell by depressing the spring loaded flow-off cap. Multiple flashes were detected and visually assessed for intensity.

(k) Experimental runs continued for 5 minutes (30 spark source cycles) at which time power was shut off and the experiment terminated.

(l) After cooling, the pyrolysis tube and sample were weighed to obtain the char residue.

(m) The flash fire cell was disassembled and cleaned preparatory to the next test.

Flash Fire Test thermocouple traces are shown in Figures 6 thru 36. Test results are reported in Table 12.

3.5.2 Animal Toxicity Tests

The exposure chamber used in the animal toxicity tests was developed and modified by Spieth (Reference 4) from an original design employed by Gaume (Reference 5). The equipment provided for pyrolysis and combustion products to be generated directly in the chamber and for a motor driven exercise wheel to be driven at 6 rpm to provide a constant level of animal activity, during the period of exposure. The toxicity test chambers were constructed of rectangular clear glass jars sealed at the top with plexiglas lids. The lids permitted rapid demounting from the glass chambers. They had the exercise wheel and drive mechanism, electrical power leads, radiation heat shield, gas sampling, and temperature measuring tube feed-throughs integrally assembled as shown in Figure 37.

A close-cell silicone rubber gasket, held in place with bunge cords and clamps, sealed the chamber. Test samples weighing 0.1-2 grams were loaded in the 26 ga. chromel A heating coil and inserted into a Vycor glass pyrolysis tube. This assembly was, in turn, inserted into an aluminum oxide felt roll which effectively insulated the pyrolysis tube during the decomposition phase of a determination. The microcombustion/pyrolysis tube was suspended inside the chamber by connecting the heating coil leads to the electrical power leads mounted on the lid.

An aluminum foil heat shield was placed between the pyrolysis tube unit and wheel to reduce the heating of the exercise wheel during a run.

A magnetically driven stirring was placed behind the exercise wheel to provide rapid mixing of the gases and smoke with the air in the chamber as evolution occurred, completing the assembly.

MAT. 100
AIRGARD NYLON
ST 7193-29

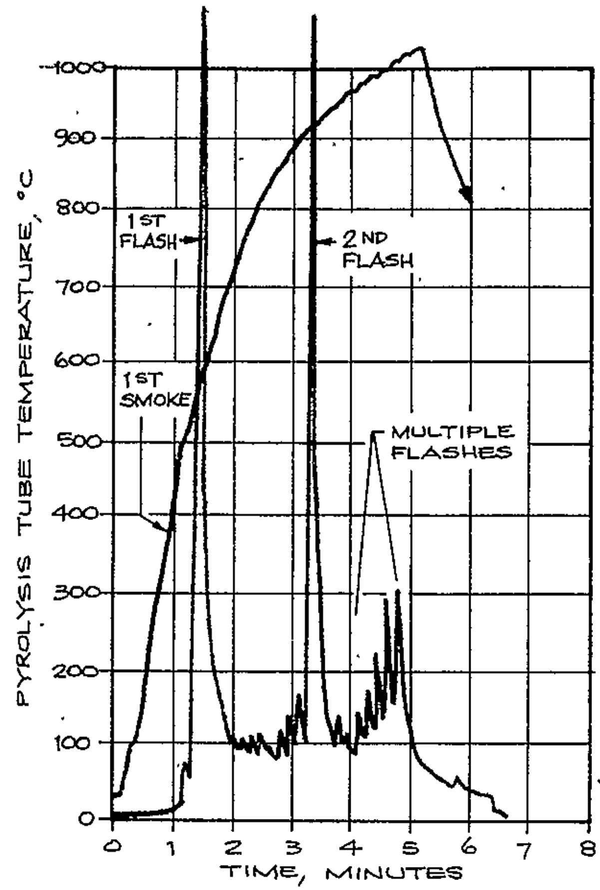


FIGURE 6. FLASH FIRE TC TRACE - (100)

MAT. 101
KERMEL/WOOL FABRIC
20787

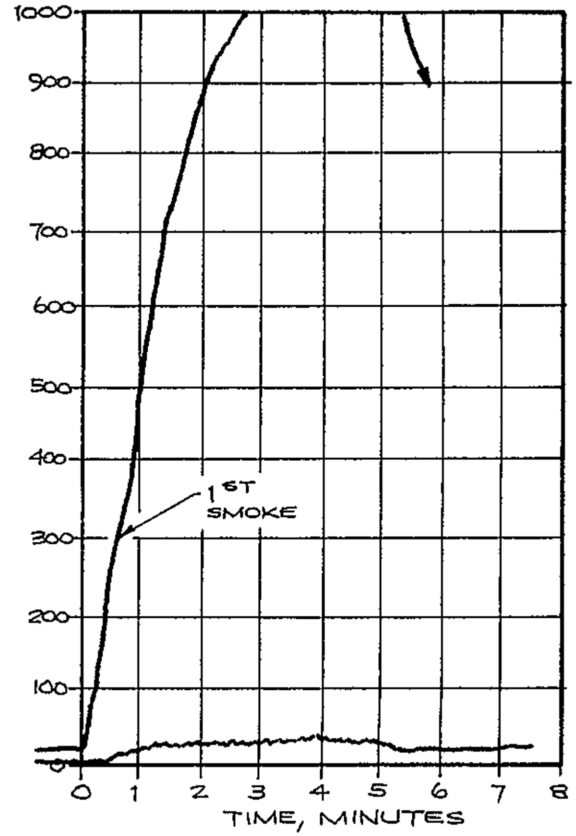


FIGURE 7. FLASH FIRE TC TRACE - (101)

MAT. 103
NOMEX UPHOLST. FABRIC
69-407

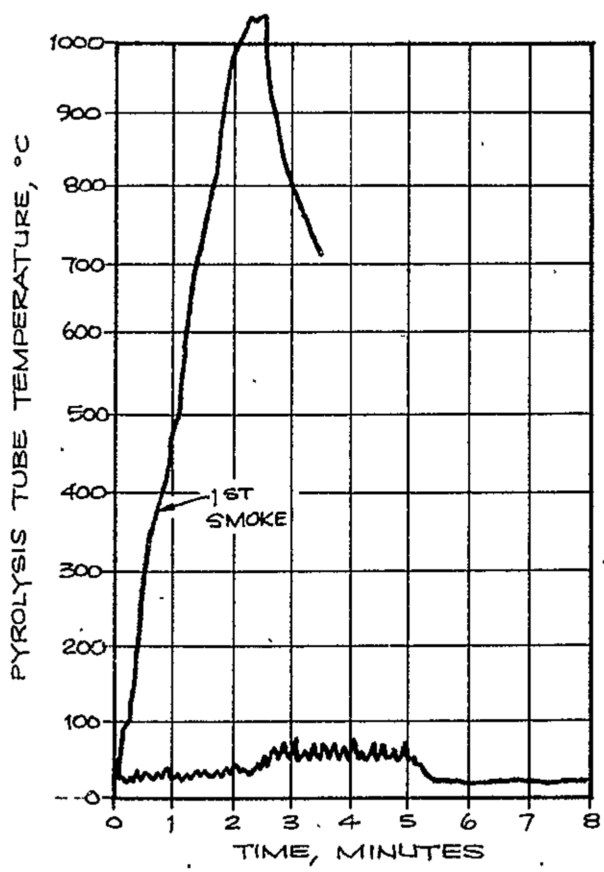


FIGURE 8. FLASH FIRE TC TRACE - (103)

MAT. 104
UPHOLST. FABRIC, 90% WOOL/10% NYLON
ST-7427-112

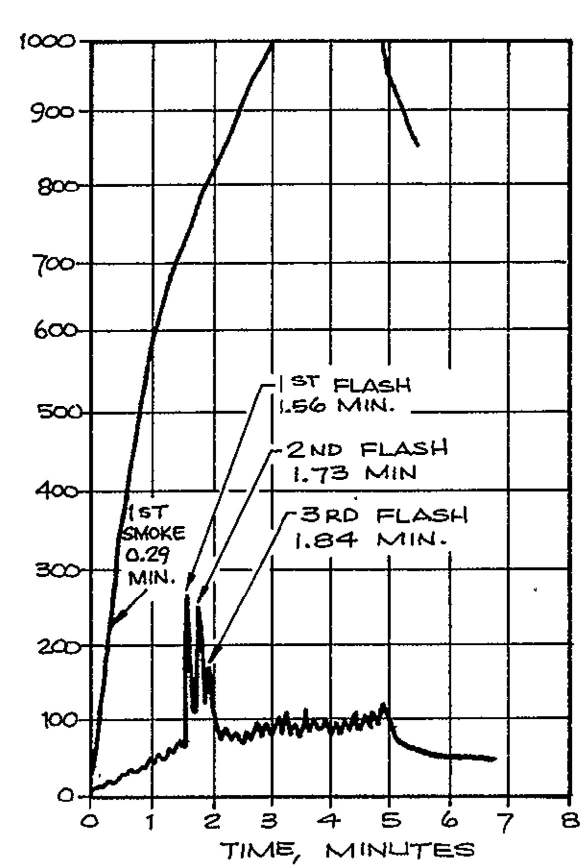


FIGURE 9. FLASH FIRE TC TRACE - (104)

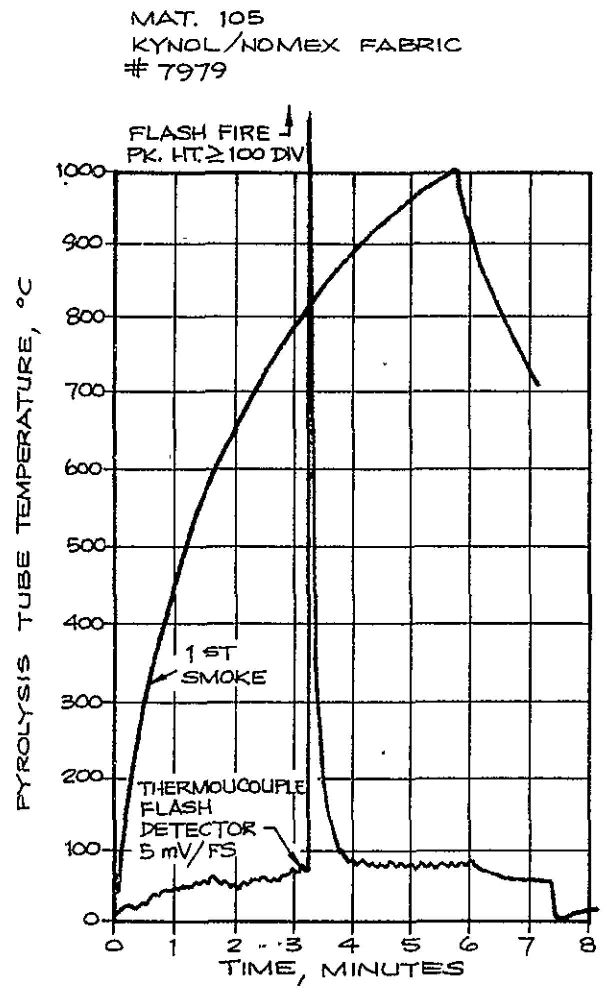


FIGURE 10. FLASH FIRE TC TRACE -(105)

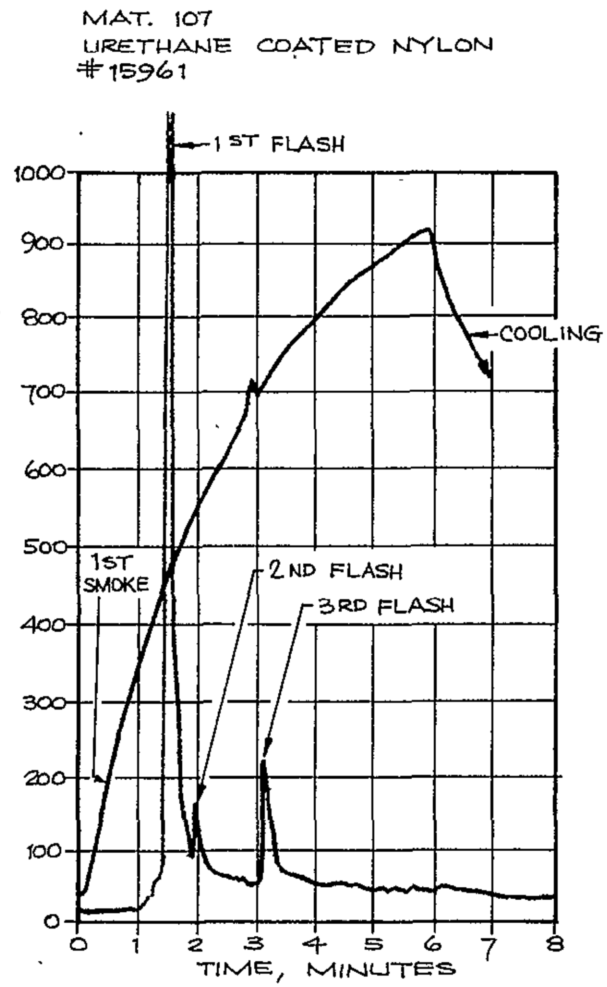


FIGURE 11. FLASH FIRE TC TRACE - (107)

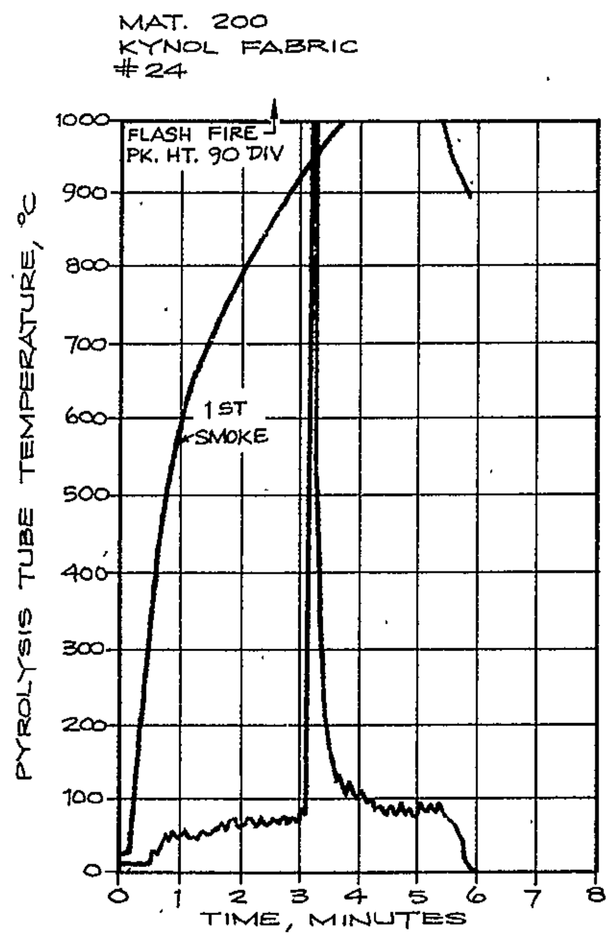


FIGURE 12. FLASH FIRE TC TRACE - (200)

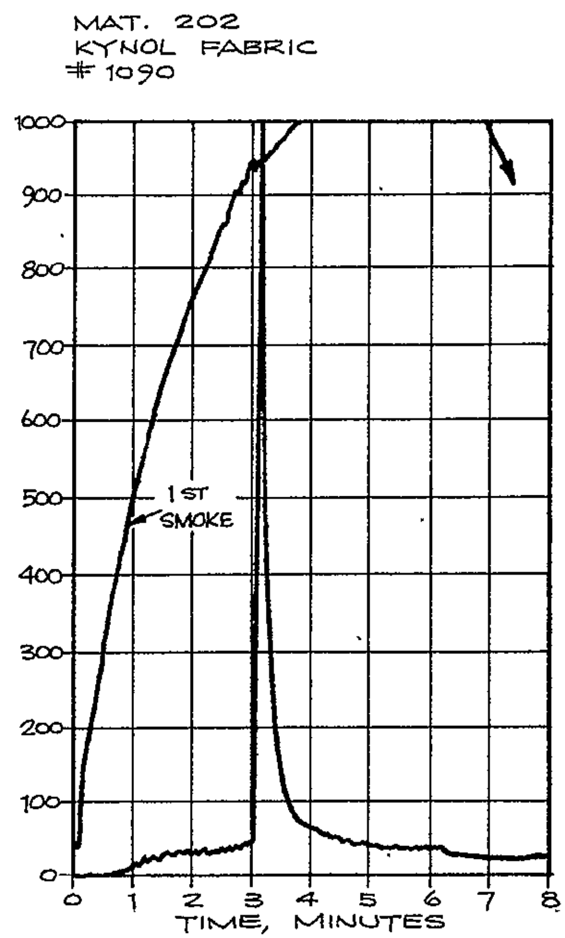


FIGURE 13. FLASH FIRE TC TRACE -(202)

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OF POOR QUALITY

MAT. 203
KYNOL BATTING
B-104S

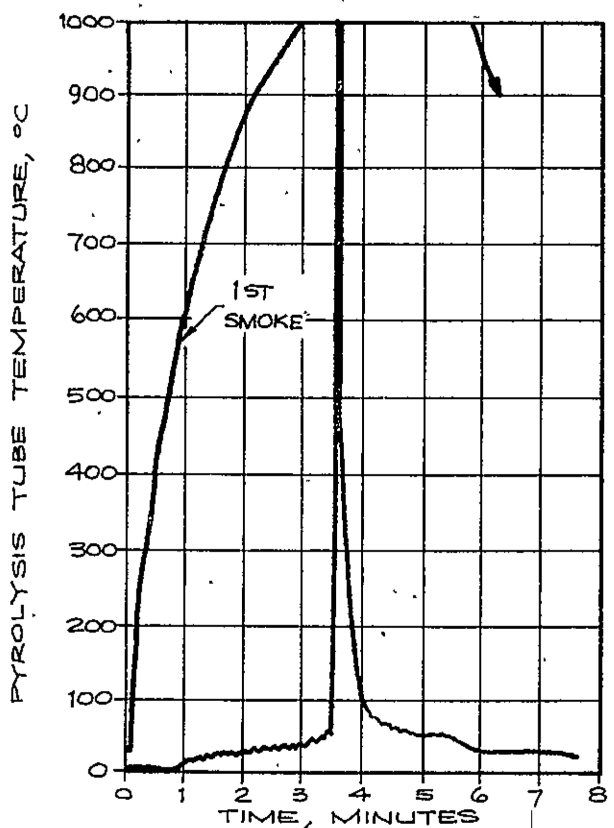


FIGURE 14. FLASH FIRE TC TRACE -(203)

MAT. 204
PBI TWILL FABRIC
#40-7010-1

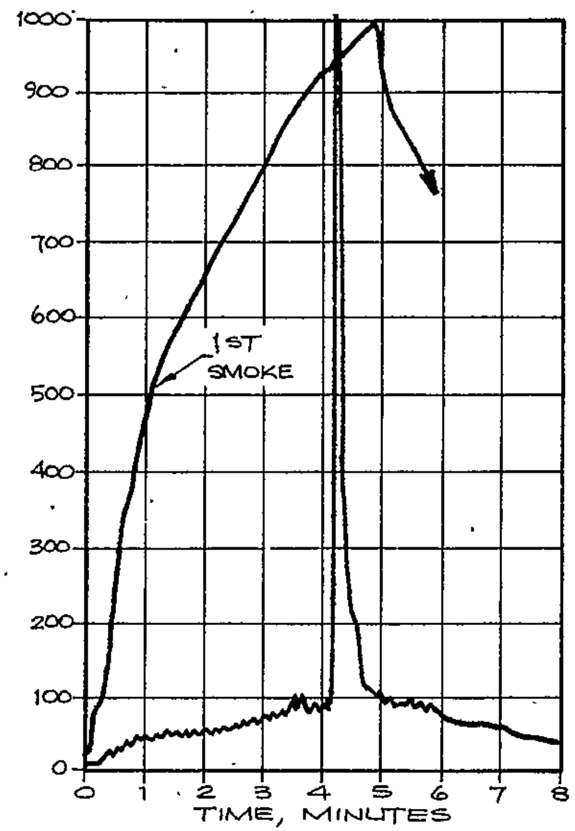


FIGURE 15. FLASH FIRE TC TRACE -(204)

MAT. 205
PBI BATTING
40-4010-1

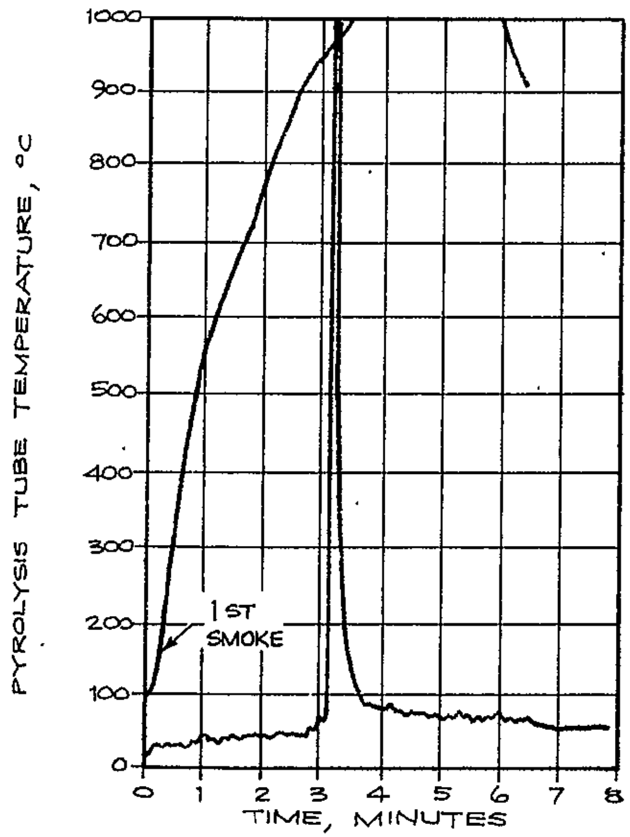


FIGURE 16. FLASH FIRE TC TRACE - (205)

MAT. 206
BLACK BATTING
35-4020-1

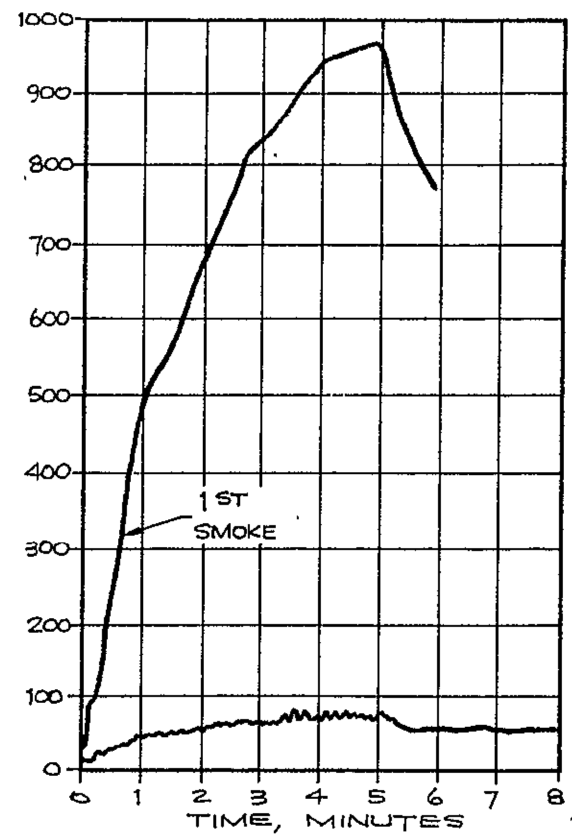


FIGURE 17. FLASH FIRE TC TRACE - (206)

MAT. 207
KYNOL W/POLYESTER
SCRIM NEEDLE PUNCH

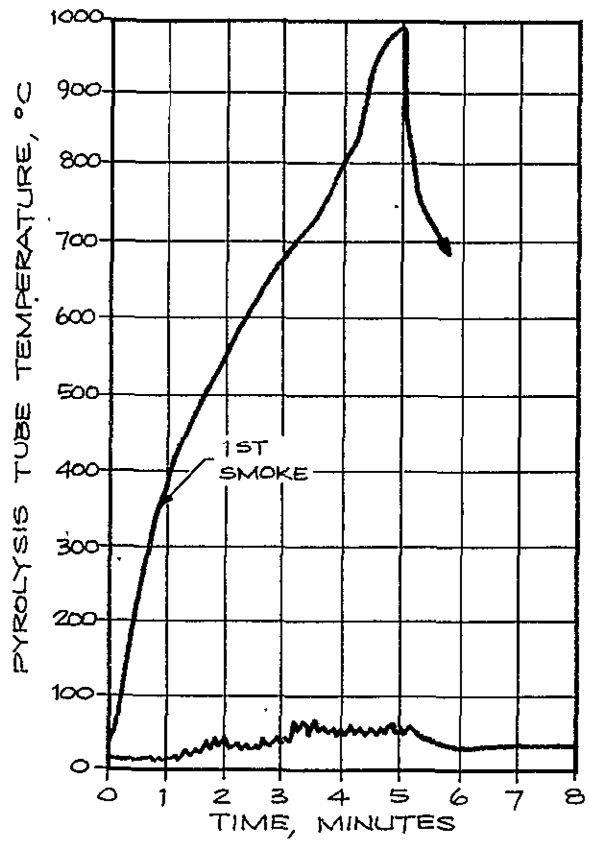


FIGURE 18. FLASH FIRE TC TRACE - (207)

MAT. 208
VONAR 1
NEOPRENE FOAM W/SCRIM

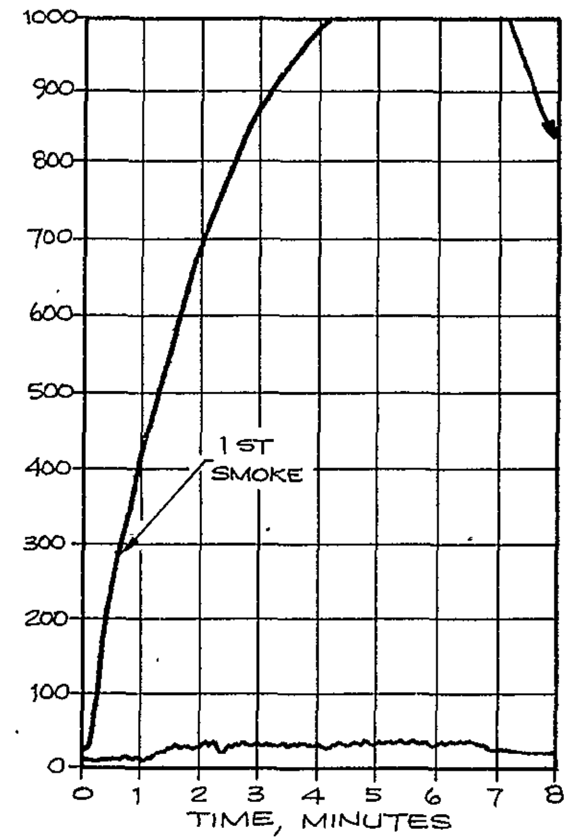


FIGURE 19. FLASH FIRE TC TRACE - (208)

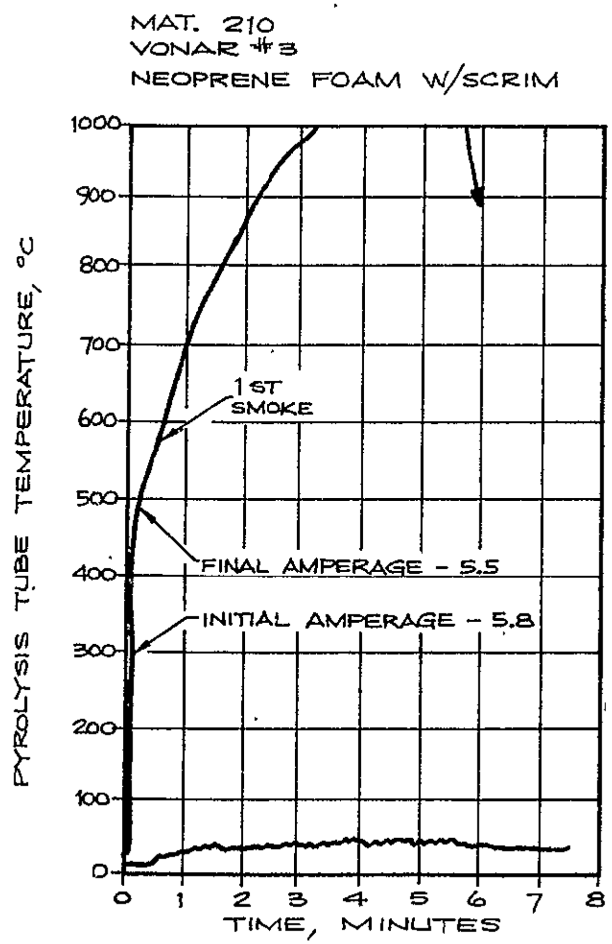


FIGURE 20. FLASH FIRE TC TRACE -(210)

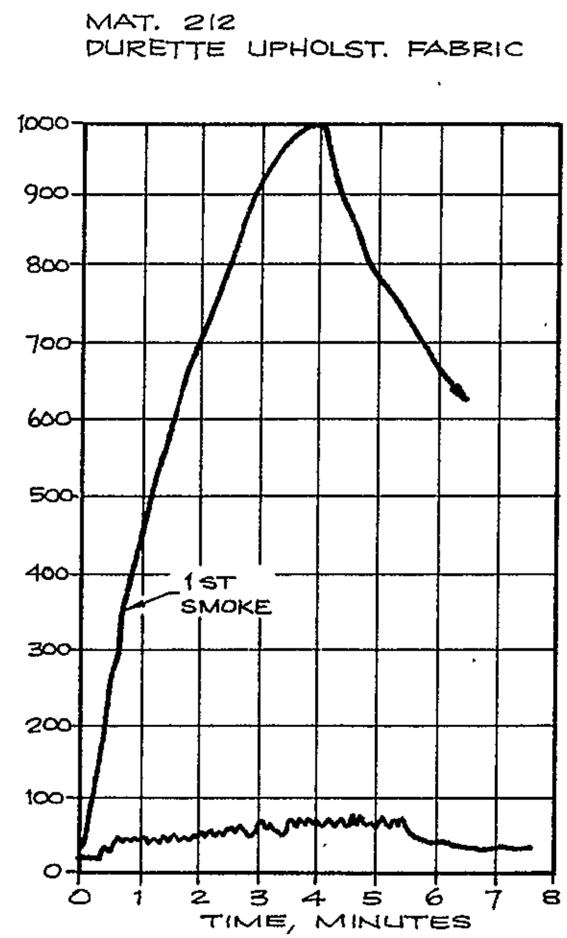


FIGURE 21. FLASH FIRE TC TRACE -(212)

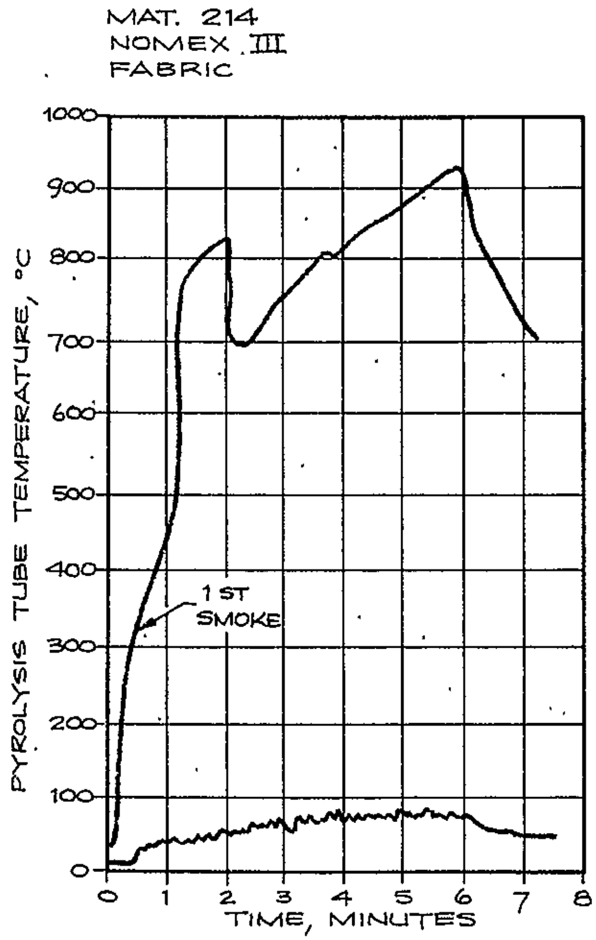


FIGURE 22. FLASH FIRE TC TRACE – (214)

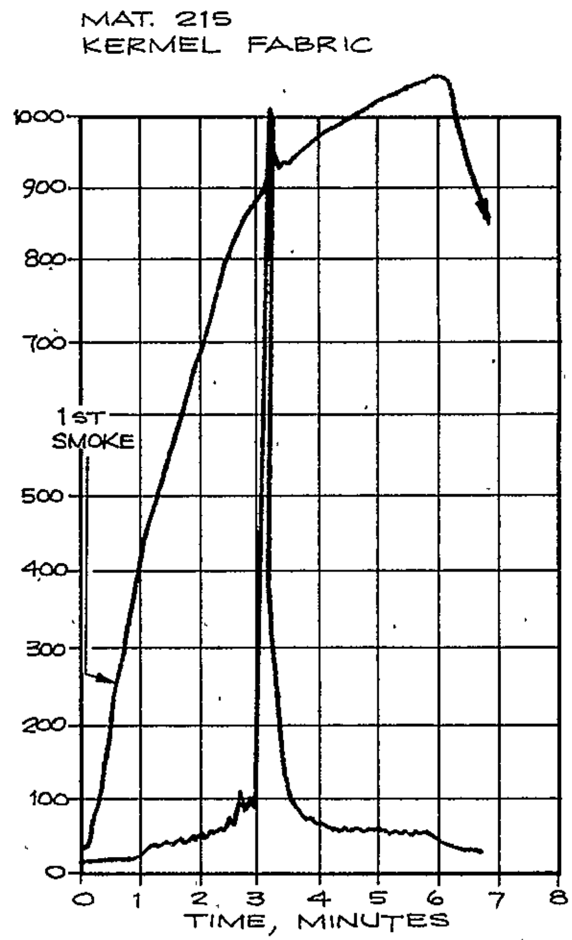


FIGURE 23. FLASH FIRE TC TRACE – (215)

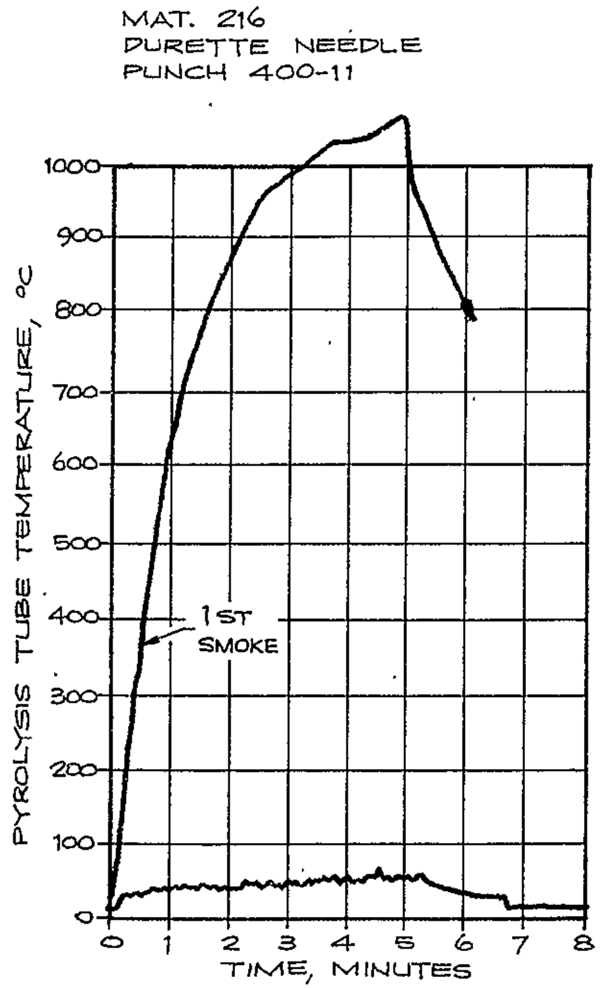


FIGURE 24. FLASH FIRE TC TRACE -(216)

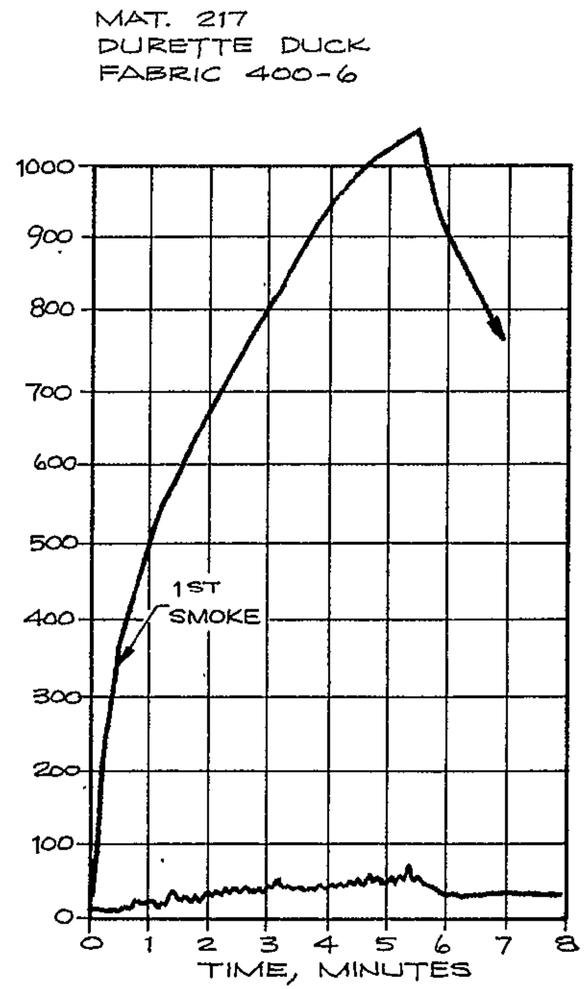


FIGURE 25. FLASH FIRE TC TRACE -(217)

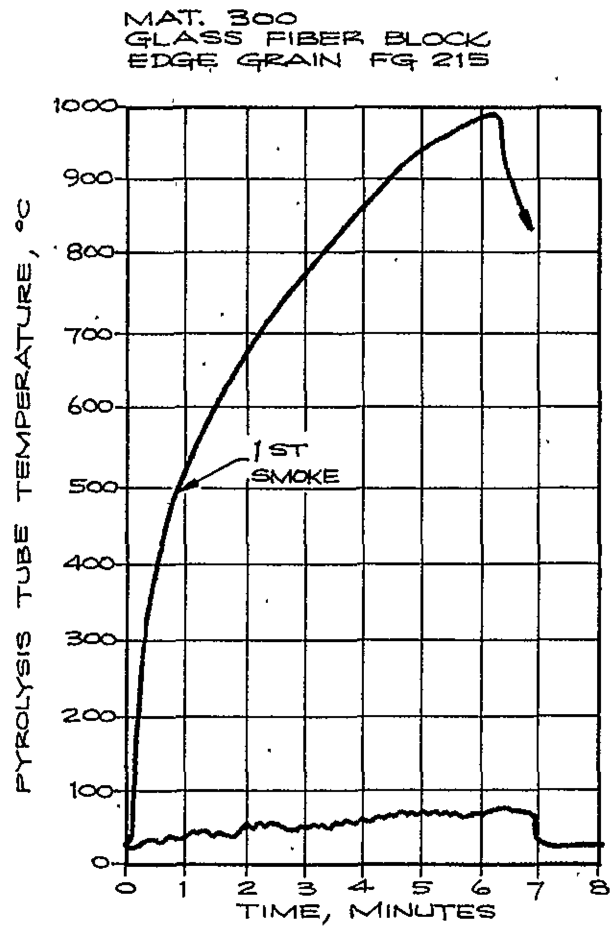


FIGURE 26. FLASH FIRE TC TRACE - (300)

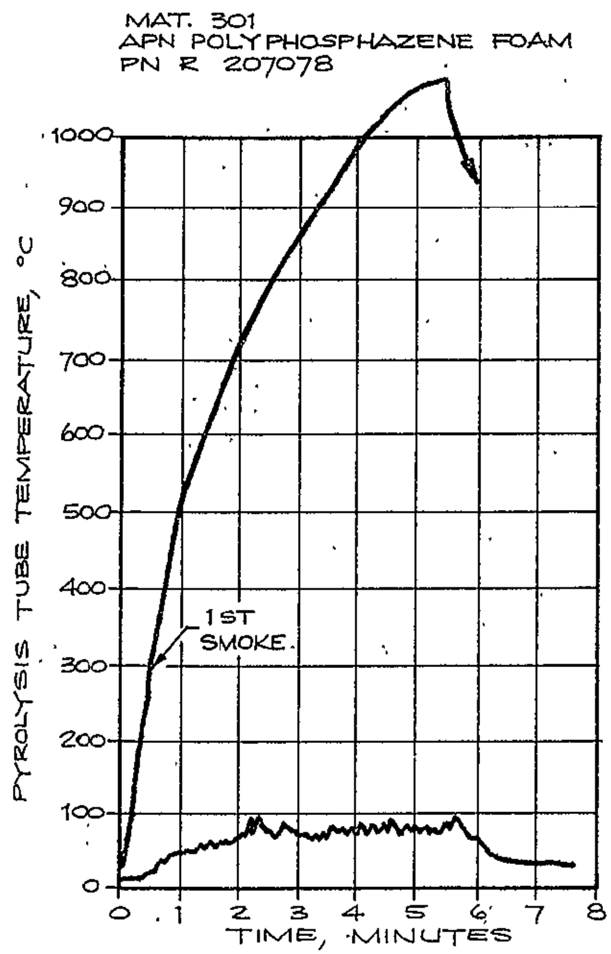


FIGURE 27. FLASH FIRE TC TRACE - (301)

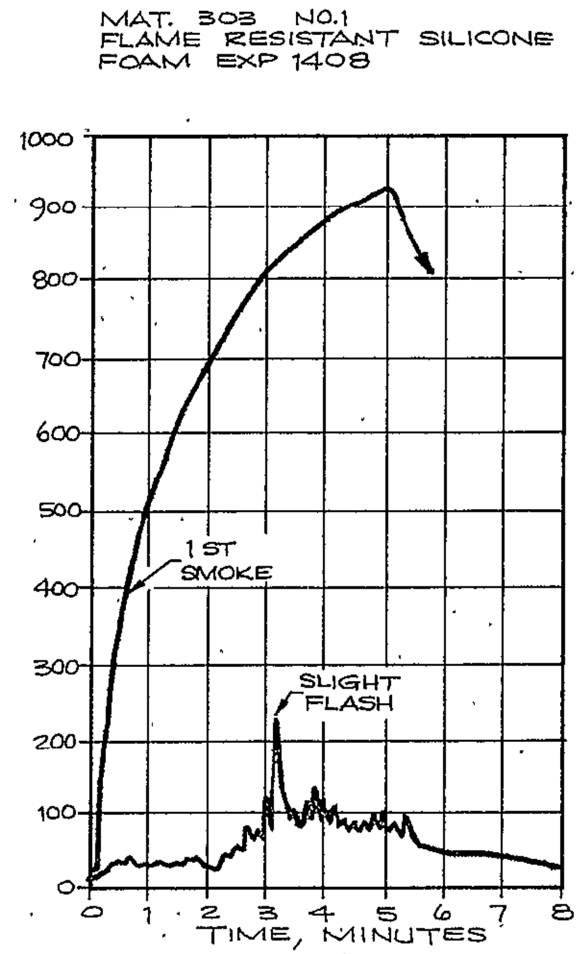


FIGURE 28. FLASH FIRE TC TRACE -(303) NO. 1

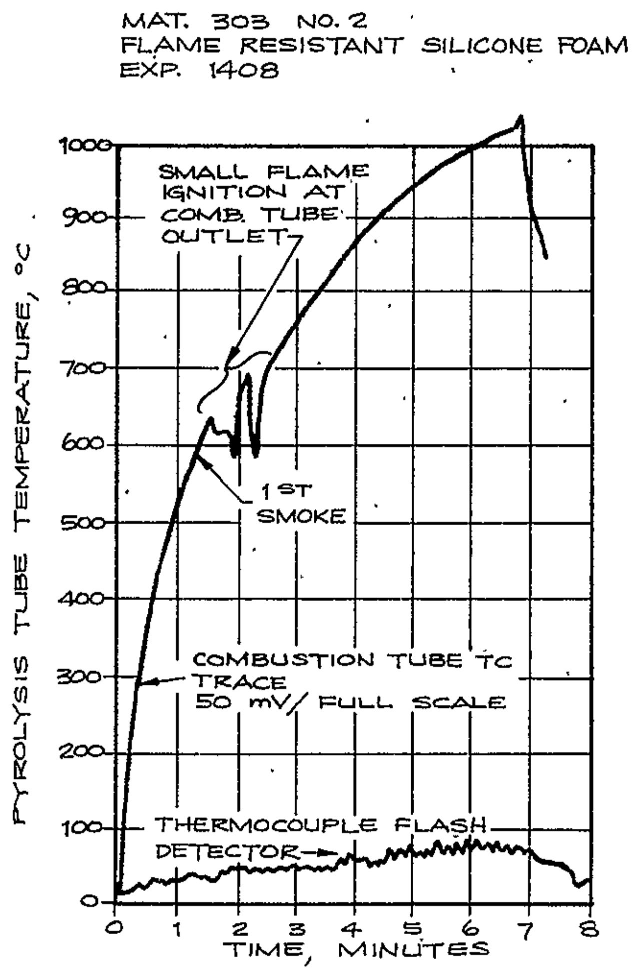


FIGURE 29. FLASH FIRE TC TRACE -(303) NO. 2

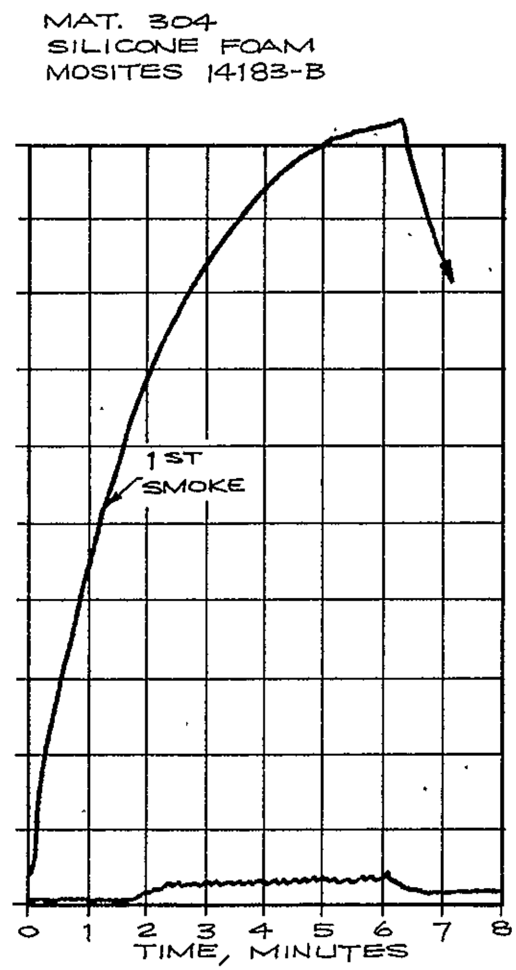


FIGURE 30. FLASH FIRE TC TRACE -(304)

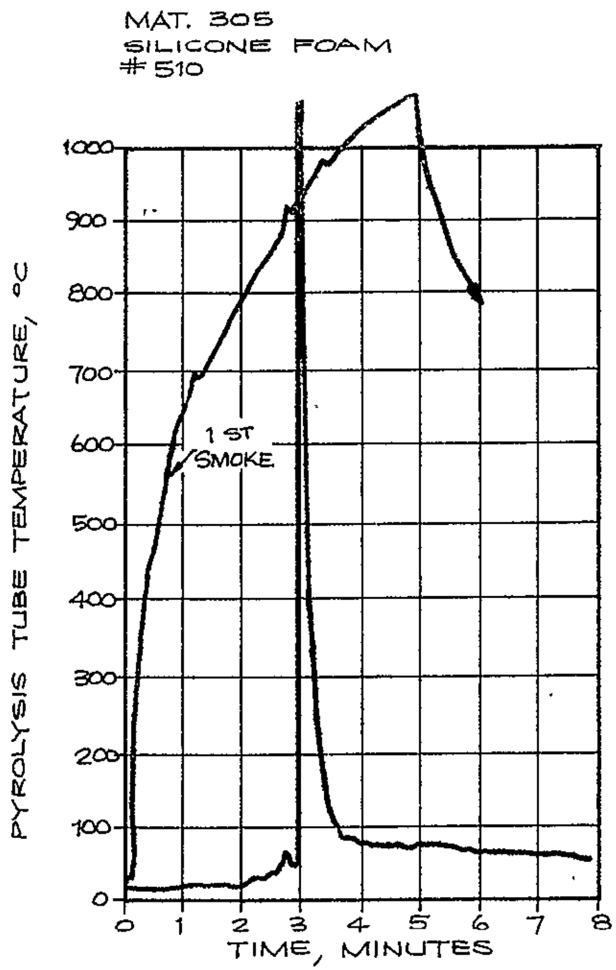


FIGURE 31. FLASH FIRE TC TRACE - (305)

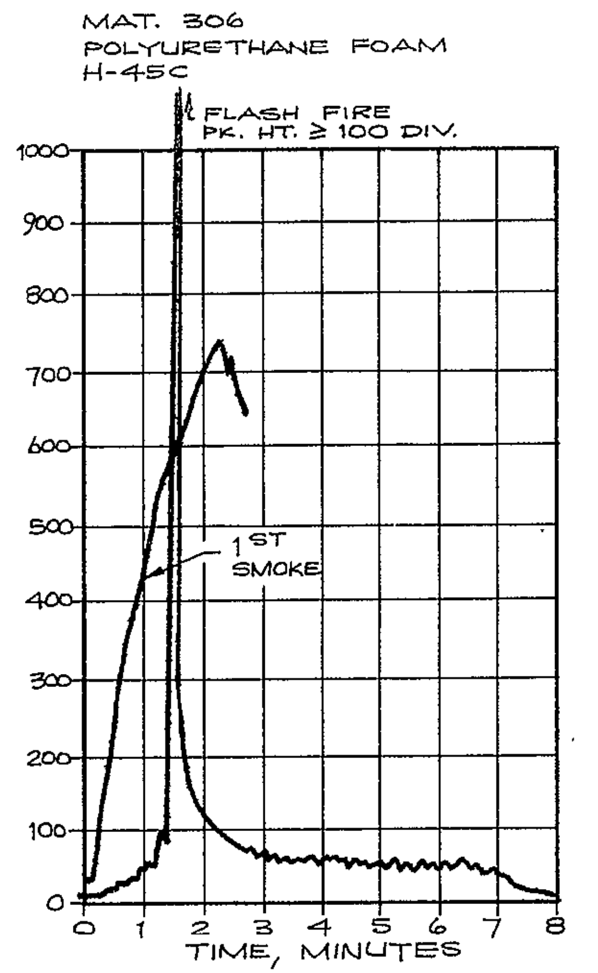


FIGURE 32. FLASH FIRE TC TRACE - (306)

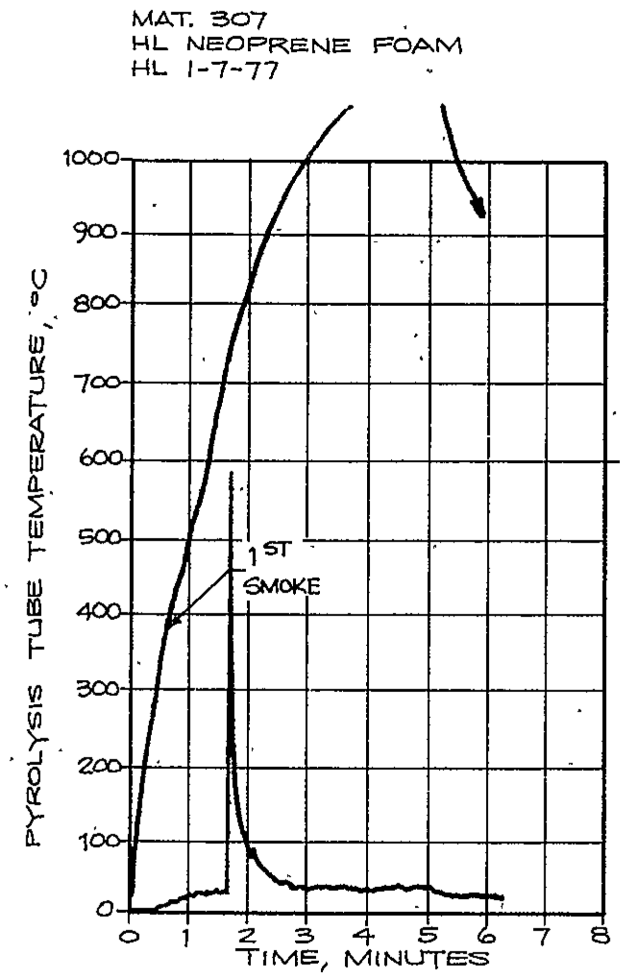


FIGURE 33. FLASH FIRE TC TRACE -(307)

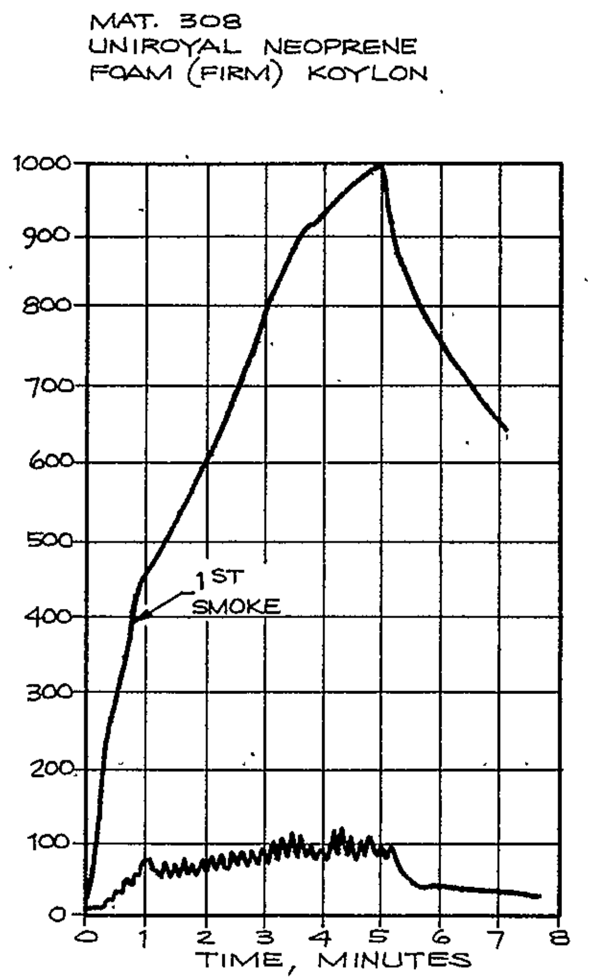


FIGURE 34. FLASH FIRE TC TRACE -(308)

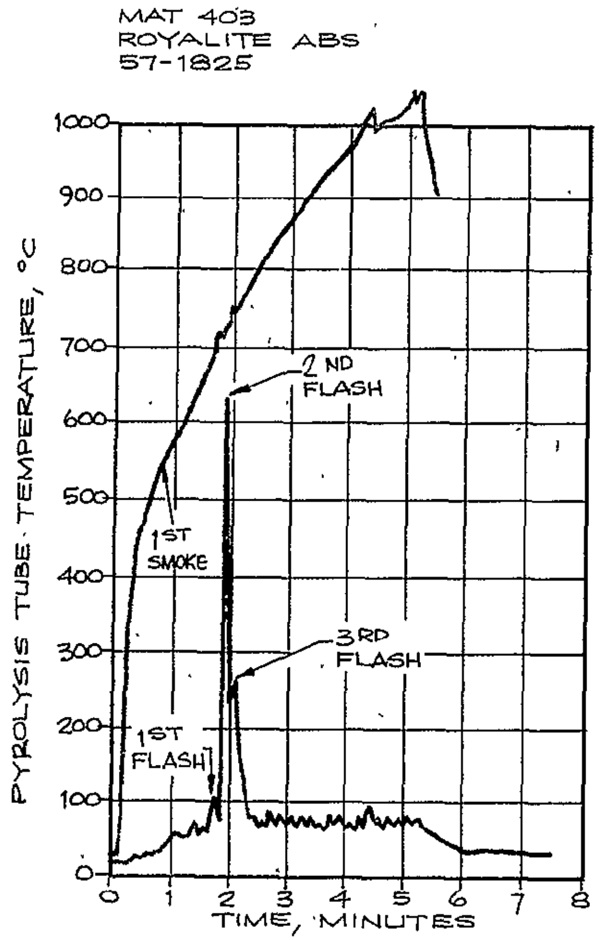


FIGURE 35. FLASH FIRE TC TRACE -(403)

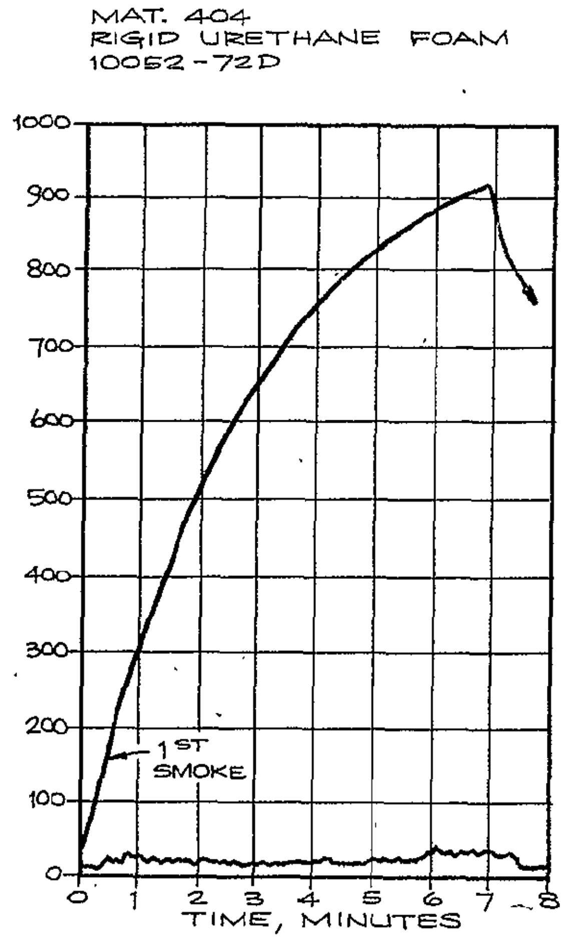


FIGURE 36. FLASH FIRE TC TRACE -(404)

MATERIAL		TIME TO 1ST SMOKE MIN.	SAMPLE PYROLYSIS TEMP. AT 1ST SMOKE °C	FLASH RESPONSE				OBSERVATIONS
NO.	IDENTIFICATION & WT.			NO.	TIME MIN.	THERMAL PULSE HT.-DIVNS.	SPLE.PYRO TEMP. °C	
100	Airgard Nylon ST 7193-29 0.5g	0.8	380	1st. 2nd. 3-6	1.2 3.28 4.5-4.8	100 85 8-12	570 910 1000	Medium light & sound Low light & sound Very low level
101	Kermel/Wool Fabric 2028T 0.5g	0.44	290	No Flash				Heavy yellow smoke
103	Nomex Fabric Off-White 69-40T 0.5g	0.72	378	No Flash				Heavy yellow smoke
104	Dress Cover Sun Eclipse Blue Fab. 90% Wool/10% Nylon ST7427-112 0.5g	0.29	229	1st. 2nd. 3rd.	1.56 1.73 1.84	17 15 9	275 264 175	Low noise & light Heavy gray smoke
105	Kynol/Nomex Fabric 7979 0.5g	0.53	319	1st.	3.28	95	810	Medium sound Low light emission Dense lt. yellow smoke
107	Urethane Coated Nylon 15691 0.5g	0.50	184	1st. 2nd. 3rd.	1.36 1.88 3.10	100 5 14	450 550 700	Multiple explosions w/med. light emission Low light & sound Low light & sound
200	Kynol Fabric #24 0.5g	0.60	350	1st.	1.60	100	850	Fast detonation wave w/med. sound and low light emission
201	Kynol Fabric #1110 0.5g	0.80	480	1st.	1.72	100	750	Fast detonation wave w/low level sound and light

FLASH FIRE PROPENSITY TEST DATA SUMMARY

TABLE 12

MATERIAL		TIME TO 1ST SMOKE MIN.	SAMPLE PYROLYSIS TEMP. AT 1ST SMOKE °C	FLASH RESPONSE				OBSERVATIONS
NO.	IDENTIFICATION & WT.			NO.	TIME MIN.	THERMAL PULSE HT.-DIVNS.	SPLE. PYRO. TEMP. °C	
202	Kynol Fabric #1090 0.5g	0.71	463	1st.	3.1	100	940	Rapid flash front low light & sound
203	Kynol Batting Needle Punch B-104S 0.5g	1.08	600	1st.	3.56	100	1040	Low light & sound
204	PBI Twill Fabric 40-9010-1 0.5g	1.00	510	1st.	4.18	83	940	Very low light & sound Rapid flame front travel
205	PBI Batting 40-4010-1 0.5g	0.24	150	1st.	3.10	100	960	Light white smoke Rapid flame front & Medium light emission sound
206	Black Batting 35-4010-1 0.5g	0.44	305	No Flash				Very low smoke
207	Kynol "Flameout" Not Run	-	-	Not Run				-
208	Vonar #1 Neoprene Foam W/Scrim 0.5g	0.48	263	No Flash				Light smoke
209	Vonar #2 Neoprene Foam W/Scrim	-	-	Not Run				-

FLASH FIRE PROPENSITY TEST DATA SUMMARY

TABLE 12 (Cont'd)

MATERIAL		TIME TO 1ST SMOKE MIN.	SAMPLE PYROLYSIS TEMP. AT 1ST SMOKE °C	FLASH RESPONSE				OBSERVATIONS
NO.	IDENTIFICATION & WT.			NO.	TIME MIN.	THERMAL PULSE HT.-DIVNS.	SPLE. PYRO TEMP. °C	
210	Vonar #3 Neoprene Foam W/Scrim 0.5g	0.54	580	No Flash				Light smoke
212	Durette Upholstery Fabric 0.5g	0.67	331	No Flash				Med. quantity of smoke Brown color Density air Odor - phthalate (ester)
214	Nomex III 0.5g	0.35	319	No Flash				Temp. perturbations in pyrolysis tube Yellowish smoke Density air
215	Kermel Fabric 0.5g	0.28	233	1st.	2.86	>100	910	Rapid flash Low light emission & sound
216	Durette Batting Needle Punch 400-11 0.5g	0.40	370	No Flash				Med. quantity of smoke Brown color Density air
217	Durette Duck Fabric 400-6 0.5g	0.40	343	No Flash				Medium quantity of smoke Brown color Density air
300	Glass Fiber Block Edge Grain FG-215 0.5g	0.83	485	No Flash				Very low quant. smoke Phenolic odor
301	APN Phosphazene Foam #R-207080 0.5g	0.17	295	No Flash				High quant. of smoke Density air White color

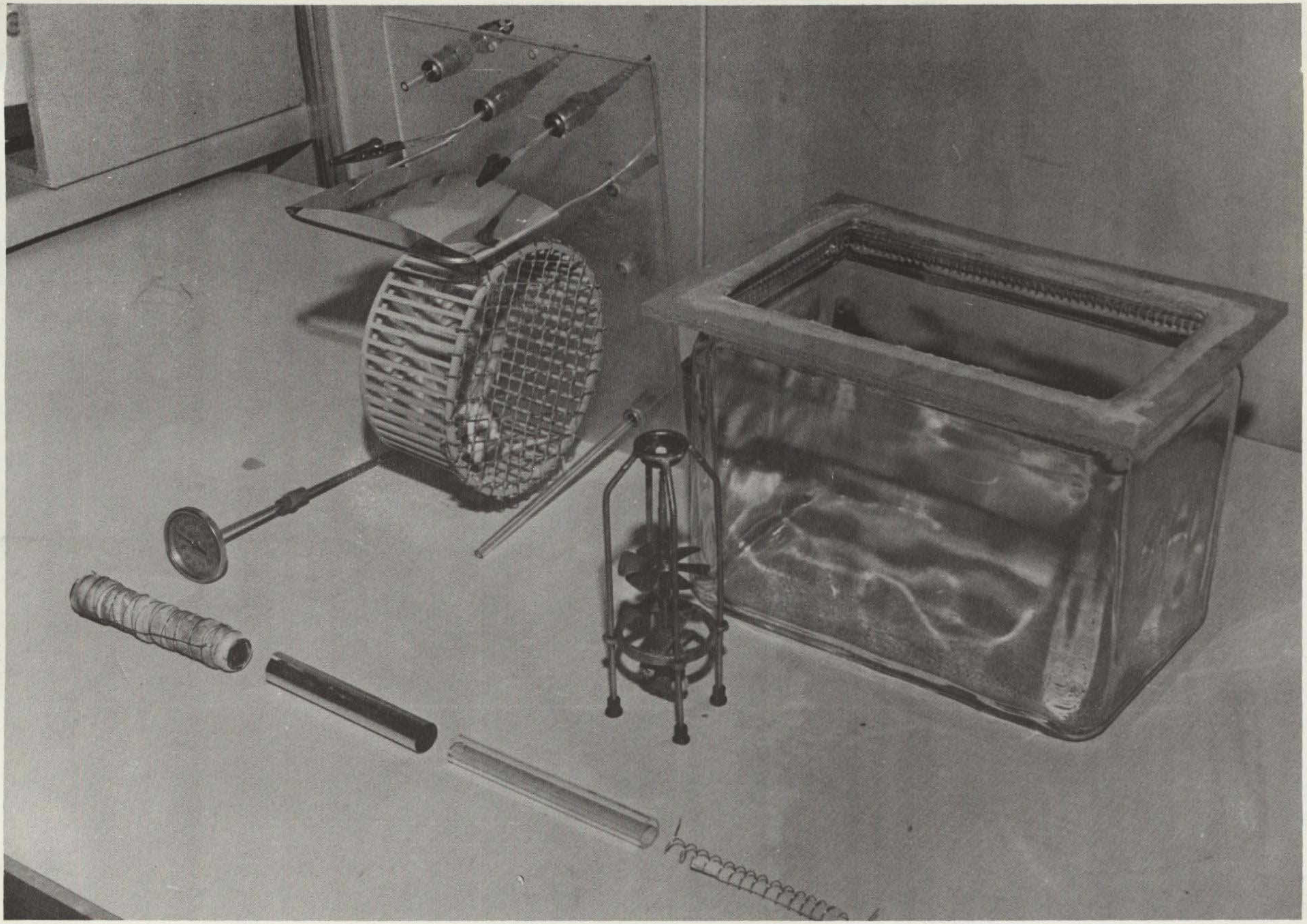
FLASH FIRE PROPENSITY TEST DATA SUMMARY

TABLE 12 (Cont'd)

MATERIAL		TIME TO 1ST SMOKE MIN.	SAMPLE PYROLYSIS TEMP. AT 1ST SMOKE °C	FLASH RESPONSE				OBSERVATIONS
NO.	IDENTIFICATION & WT.			NO.	TIME MIN.	THERMAL PULSE HT.-DIVNS.	SPLE. PYRO. TEMP. °C	
303	Flame Resistant Silicone Foam Exp. 1408 0.5g	0.50	391	1st.	3.00	12	825	Large quant. white smoke Very low flash
304	Silicone Foam Mosites 14183-B 0.5g	1.20	520	No Flash				-

FLASH FIRE PROPENSITY TEST DATA SUMMARY

TABLE 12 (Cont'd)



NEG. J413017

FIGURE 37. ANIMAL TEST HOUSING DISASSEMBLED

Each test subject was held in place inside the exercise wheel with a transparent plexiglas disc. This modification was found to be necessary since the test subject tended to ride the hardware screen lid previously used in the free turning wheel tests (as shown in Figure 37).

The final assembly is shown in Figure 38. Power leads from a 110 vac variac transformer wired in series with an AC ammeter and in parallel with a volt meter were connected to the external leads on the chamber lid. A variable speed controlled electric motor drive was attached to the exercise wheel vertical friction drive just prior to beginning a test.

Swiss albino male mice of the Webster strain weighing from 25-37 grams were used for most of the tests. Several initial tests were conducted with mice of mixed breed and unknown strain.

Samples were weighed to ±0.0001 gram in the range of 0.1-2 gram for those materials found to be most toxic to those least toxic, respectively. The tare weight of the heating coil and pyrolysis tube was recorded for each run so that the quantity of material pyrolyzed into the 5.3 liter free volume of the chamber was calculated after the conclusion of each test run, to determine the efficiency and repeatability of the pyrolysis.

The toxic endpoints selected for these tests were time to incapacitation Ti and time to death T_D. Ti was determined, with rare exceptions, to a precision of approximately one revolution of the exercise wheel (10 seconds). T_D was determined on the basis of time to cessation of breathing.

Measurements of internal temperature and oxygen residual associated with thermal decomposition of the samples indicated maximum temperatures of 30-40°C (86-104°F) and oxygen levels above 15%. Therefore, hyperthermia and anoxia were not significant factors in animal mortality, but probably contributed marginally to the Ti determination. Pryor, et al (Reference 6) reported 4 hour lethal temperatures of 49°C (120°F) and an oxygen concentration of 7.5% for mice. Swiss albino male mice, however, have shown less resistance to temperature averaging 77 minutes survival time at 40°C (104°F) as reported by Maul, et al (Reference 7).

The test was terminated at the end of a 30-minute test period if the animal subject survived. These animals were not used in additional testing. Detailed post test observations and pathological examinations were not made on surviving animals. Within the scope of the 30-minute acute exposure procedure, the recorded data was limited to the Ti and Td determination as measures of short term survivability, rather than a determination of LC_{50} or LD_{50}, which require more testing.

Each animal was acclimated to the powered wheel for a short period (2 min.) with air circulating through the chamber prior to a run. The air supply was shut down, and an electronic timer started at the same time the power was applied to the pyrolysis tube heating coil. Input energy was adjusted to 5.3 amperes which provided a heating profile of approximately 300-400°C per minute inside the pyrolysis tube, depending upon the quantity and packing density of sample, sample thermal conductivity, decomposition temperature, heat capacity and orientation. The pyrolysis phase was limited to 200 seconds; temperature inside the pyrolysis tube exceeded 800°C at that time.

NEG. J413019

FIGURE 38. ANIMAL TEST HOUSING

Examination of sample residues and weight measurements indicated practically complete decomposition occurred in the 200-second heating interval for most materials, as shown by the char yield. Toxicity test data is reported in Tables 13 thru 15 and shown graphically in Figures 39 thru 41.

3.5.3 Heat Release Rate Testing

The candidate materials were tested in the Ohio State University version of the heat release rate calorimeter (HRR), Reference 8. This calorimeter was used to evaluate the heat released from 15 x 15 cm samples cut from each material under varying thermal heat fluxes representative of various fire environments. Quantitative measures of heat released in terms of kilowatt (kw) or BTU/minute were calculated per square meter (m^2) of original surface areas exposed as a function of time.

Figure 42 shows the Douglas (modified) HRR chamber and auxiliary pen recorder and gas monitoring instrumentation employed to evaluate the fire response of nonmetallic materials. The principal value of testing the seat materials in the HRR calorimeter was to provide an insight into the dynamic response of each material in a fire environment, and the potential contribution of the material to the propagation of fire. These characteristics are applicable to the identification and selection of the best materials for seat construction in each use category as discussed later in the report.

Table 16 lists the physical characteristics of the samples and the HRR calorimeter operational modes and parameter settings.

For screening purposes of the program the samples were not conditioned per the method outlined in Reference 9. Samples were stored in a laboratory atmosphere varying from 38-45% relative humidity.

A special modified, lightweight, stainless steel sample holder and refractory backing board of low thermal capacitance was used for all tests to reduce heat absorption by the holder immediately following injection of the mounted sample into the HRR chamber.

The electrically powered Glowbar^R radient panel heating source was adjusted to the required thermal flux using a Hycal Radiometer-Calorimeter and allowed to equilibrate to a constant level with air flowing through the chamber. In most tests baseline recorded temperature variations (noise) differentially recorded between the air input temperature and the exit stack of the HRR were observed to hold within ±0.5 division of chart (equivalent to approximately ±1 kw/m^2 heat release).

The recorded curves of heat (temperature) were read out and calculated against calibrations obtained at the same airflow setting as the test materials using natural gas of known heat content. Heat release rate data are summarized in Tables 17 through 19. Typical types of heat release curves are shown in Figures 43 through 47. Approximate black body temperatures for the heat fluxes used were 2.5 w/cm^2 - 532°c (990°F), 3.5 w/cm^2 - 616°c (1140°F), and 5 w/cm^2 - 693°c (1280°F).

MATERIAL NO. & NAME	MATERIAL WEIGHT GRAMS	ANIMAL WEIGHT GRAMS	OBSERVED Ti MIN.	OBSERVED Td MIN.	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Ti	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Td	APPARENT MATERIAL PYROLYZED MG	APPARENT PYROLYZED MAT'L CONC. IN CHAMBER MG	NOTES
100	0.5	28	6.47	7.88	2.89	3.52	500	94	
Airgard Nylon	0.5	28.9	8.83	10.83	3.82	4.68	492	93	Av. % Char
Fabric	0.5	30.2	4.75	9.17	1.97	3.80	401	76	<1
ST7193-29 Av	0.5	29.0	6.68	9.29	$\bar{X}$=2.89 ±0.93	$\bar{X}$=4.00 ±0.61	$\bar{X}$ = 464	$\bar{X}$ = 88	
101	0.5	25.8*	3.33	4.67	1.61	2.26	316	60	*Unknown breed
Kermel/Wool	0.5	31.8	4.08	14.42	1.60	5.67	308	58	Av. % char
Fabric	0.5	31.9	2.50	3.75	0.98	1.47	315	59	37 ± 0.6
20787 Av	0.5	29.8	3.30	7.61	$\bar{X}$=1.40 ±0.36	$\bar{X}$=3.13 ±2.23	$\bar{X}$ = 313	$\bar{X}$ = 59	
103	1.0	24.5	4.28	6.25	4.37	6.38	520	98	
Nomex Fabric	1.0	33.6	2.83	3.58	2.11	2.66	484	91	Av. % Char
Off White	0.5	35.3	2.58	4.42	0.91	1.57	262	49	49 ± 3
69-407	0.25	33.0	4.43	15.58	0.84	2.95	122	23	
	0.25	32.0	3.67	15.80	0.72	3.09	121	23	
Av	0.33	33.4	3.56	11.93	$\bar{X}$=0.82 ±0.10	$\bar{X}$=2.54 ±0.84	168	32	
104	0.5	28.7	2.27	3.15	1.00	1.37	360	68	
90% Wool/10% Nylon	0.25	25.5	2.83	4.27	0.70	1.05	199	38	Av. % Char
Fabric	0.25	24.3	3.75	17.50	0.97	4.50	178	34	26 ± 4
ST7427-112	0.25	33.6	3.42	18.55	0.64	3.45	183	35	
Av	0.25	27.8	3.33	13.44	$\bar{X}$=0.83 ±0.18	$\bar{X}$=2.59 ±1.66	187	36	
105	0.25	30.4	8.58	24.17	1.76	4.97	118	22	
Kynol/Nomex	0.50	33.4	3.00	16.25	1.12	6.08	224	42	Av. % Char
Fabric	0.50	36.5	5.00	21.50	1.71	7.36	209	39	55 ± 1.7
7979	0.50	34.5	6.58	10.17	2.38	3.69	234	44	
Av	0.50	34.8	4.86	15.97	$\bar{X}$=1.74 ±0.51	$\bar{X}$=5.53 ±1.57	222	42	
107	0.25	35.5	5.66	13.17	1.00	2.32	230	43	
Urethane Coated	0.25	32.5	11.67	14.67	2.24	2.82	214	40	Av. % Char
Nylon Fabric	0.25	30.0	8.67	23.87	1.81	4.96	205	39	13 ± 4
15691	0.25	34.0	12.42	20.00	2.28	3.68	221	42	
Av	0.25	33.0	9.61	17.92	$\bar{X}$=1.83 ±0.59	$\bar{X}$=3.45 ±1.16	$\bar{X}$ = 218	$\bar{X}$ = 41	

SUMMARY - DECORATIVE FABRICS ACUTE RELATIVE TOXICITY TEST DATA
(Swiss Albino Mice - Webster Strain)

TABLE 13

MATERIAL NO. & NAME	MATERIAL WEIGHT GRAMS	ANIMAL WEIGHT GRAMS	OBSERVED Ti MIN.	OBSERVED Td MIN.	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Ti	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Td	APPARENT MATERIAL PYROLYZED MG	APPARENT PYROLYZED MAT'L. CONC. IN CHAMBER MG	NOTES
200	1.00	28.4*	3.90	5.10	3.43	4.49	450	85	*Unknown breed
Kynol Fabric	0.5	27.1*	6.25	15.75	2.88	7.26	235	44	of mouse
#24	0.5	24.3	6.67	8.83	3.43	4.54	211	40	Av. % Char
	0.5	28.5	6.00	11.92	2.63	5.23	211	40	57 ± 2
Av.	0.62	27.1	5.65	10.40	$\bar{X}$=3.09 ±0.40	$\bar{X}$=5.38 ±1.3	277	52	
201	0.5	29.1*	7.33	11.58	3.15	4.97	289	55	*Unknown breed
Kynol/Nomex	0.25	36.9	4.33	5.92	1.47	2.01	118	22	Av. % Char
Fabric 1110 Av.	0.36	33.0	5.83	8.75	$\bar{X}$=2.31 ±1.19	$\bar{X}$=3.49 ±2.1	204	39	55 ± 4
202	1.0	28.3*	5.0	5.83	4.42	5.15	460	87	*Unknown breed
Kynol/Nomex	0.5	27.2	6.25	10.83	2.87	4.98	211	40	Av. % Char
Fabric 1090	0.5	29.4	6.98	9.33	2.97	3.97	211	40	57 ± 2
Av.	0.7	28.3	6.08	8.66	$\bar{X}$=3.42 ±0.87	$\bar{X}$=4.7 ±0.64	294	56	
203	0.5	23.5	8.00	10.25	4.26	5.45	216	41	Av. % Char
Kynol Batt.	0.5	26.8	7.40	10.00	3.45	4.66	244	46	53 ± 4
w/Scrim B-104S	0.5	27.4	6.00	7.77	2.74	3.54	251	47	
Av.	0.5	18.1	7.13	9.34	$\bar{X}$=3.48 ±0.76	$\bar{X}$=4.55 ±0.94	$\bar{X}$ = 237	$\bar{X}$ = 45	
204	0.5	34.7	1.58	2.33	0.57	0.84	153	29	Av. % Char
PBI Fabric	0.25	33.1	3.00	4.33	0.57	0.82	60	11	72 ± 4
40-9010-1	0.15	30.5	3.17	Lived	0.39	-	43	8	
Av.	0.30	32.8	2.58	3.33	$\bar{X}$=0.51 ±0.10	$\bar{X}$=0.83 ±0.01	85	16	
206	0.5	30.7	1.58	2.42	0.62	0.99	163	31	
Black Batt.	0.25	24.3	1.58	3.08	0.41	0.79	95	18	Av. % Char
	0.15	29.0	1.83	3.00	0.24	0.39	55	10	64 ± 2
35-4020-1	0.10	33.5	2.00	3.12	0.15	0.23	37	7	
	0.10	33.5	N.D.	Lived	N.D.	Lived	37	7	
	0.10	33.0	2.58	Lived	0.20	Lived	37	7	
Av.	0.20	30.7	1.91	2.91	$\bar{X}$=0.2 ±0.05	$\bar{X}$=0.31 ±0.11	77	13	

SUMMARY - FIRE BLOCKING LAYERS ACUTE RELATIVE TOXICITY TEST DATA

TABLE 14

MATERIAL NO. & NAME	MATERIAL WEIGHT GRAMS	ANIMAL WEIGHT GRAMS	OBSERVED Ti MIN.	OBSERVED Td MIN.	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Ti	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Td	APPARENT MATERIAL PYROLYZED MG	APPARENT PYROLYZED MAT'L. CONC IN CHAMBER MG	NOTES
207	0.5	30.0	6.67	10.00	2.78	4.17	243	46	Av. % Char
Kynol Batt.	0.5	29.0	6.83	13.00	2.94	5.60	243	46	52 ± 1
w/Polyester scrim	0.5	36.5	6.00	10.00	2.06	3.43	234	44	
"Flameout" Av.	0.5	31.8	6.50	11.00	$\bar{X}$ =2.59 ±0.47	$\bar{X}$=4.4 ±1.10	$\bar{X}$ = 240	45	
208	0.5	24.7	ND	Lived	-	-	243	46	
Vonar #1	1.0	29.9	ND	Lived	-	-	490	93	Av. % Char
	2.0	32.2	5.50	12.83	8.54	19.92	927	175	52 ± 1
	2.0	31.6	7.92	14.00	12.53	22.15	960	181	
Av.	1.4	29.6	6.71	13.42	$\bar{X}$ = 10.54	$\bar{X}$ = 21.05	655	124	
205	0.5	30.9	3.00	4.17	1.21	1.69	143	27	Av. % Char
PBI Batt.	0.25	26.8	3.17	4.58	0.74	1.07	66	13	72 ± 1
40-4010-1	0.15	32.7	3.83	24.33	0.44	2.79	46	9	
Av.	0.30	30.1	3.33	12.42	$\bar{X}$ =0.8 ±0.39	$\bar{X}$=1.85 ±0.87	85	16	
210	0.5	28.0*	20.3	Lived	9.06	Lived	242	46	*Unknown breed
Vonar #3	1.0	24.9	N.D.	Lived	-	Lived	477	90	Av. % Char
	1.5	25.7	7.5	Lived	10.90	Lived	710	134	
	2.0	36.5	9.5	Lived	13.00	Lived	946	178	53 ± 0.7
Av.	1.3	28.8	12.4		$\bar{X}$ =10.99±1.97		593	112	
212	0.5	30.0	2.83	4.00	1.18	1.67	198	37	Av. % Char
Durette	0.25	32.8	2.83	4.58	0.58	0.87	99	19	58 ± 3
Upholstery Fabric	0.15	36.8	4.00	Lived	0.41	-	67	13	
Av.	0.30	33.2	3.22	4.29	$\bar{X}$ =0.71 ±0.41	$\bar{X}$=1.27 ±0.57	121	23	
214	0.5	30.8	2.83	4.67	1.38	2.28	238	45	
Nomex III	0.25	33.0	5.17	14.50	0.98	2.75	110	21	Av. % Char
Fabric	0.25	32.5	3.05	14.90	0.59	2.86	121	23	55 ± 3
Av.	0.33	32.1	3.68	11.36	$\bar{X}$ =0.98 ±0.40	$\bar{X}$=2.63 ±0.31	156	30	

SUMMARY - FIRE BLOCKING LAYERS ACUTE RELATIVE TOXICITY TEST DATA

TABLE 14 (Cont'd)

MATERIAL NO. & NAME	MATERIAL WEIGHT GRAMS	ANIMAL WEIGHT GRAMS	OBSERVED Ti MIN.	OBSERVED Td MIN.	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Ti	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Td	APPARENT MATERIAL PYROLYZED MG	APPARENT PYROLYZED MAT'L. CONC IN CHAMBER MG	NOTES
215 Kermel Fab.	0.5	23.4	3.80	5.83	2.03	3.11	236	45	Av. % Char 54 ± 2
	0.5	29.5	3.25	4.83	1.38	2.05	240	45	
	0.5	35.4	3.08	4.83	1.09	1.71	235	44	
Av.	0.5	29.4	3.38	$\bar{X}$ 5.16	=1.5 ±0.48	$\bar{X}$=2.29 ±0.73	$\bar{X}$= 237	44.7	
217 Durette Duck 400-6	0.5	31.7	3.00	4.50	1.18	1.81	189	36	Av. % Char 66 ± 8
	0.25	33.9	3.25	4.83	0.60	0.89	94	18	
	0.15	33.3	4.25	22.67	0.48	2.55	68	13	
Av.	0.30	32.0	3.50	10.67 $\bar{X}$	=0.75 ±0.37	$\bar{X}$=1.75 ±0.83	117	22	
216 Durette Batt. 400-11	0.5	30.0	2.00	3.00	0.83	1.25	269	51	Av. % Char 57 ± 11
	0.25	30.9	5.30	11.63	1.07	2.35	79	15	
	0.25	38.7	3.17	4.82	0.51	0.78	109	21	
Av.	0.33	33.2	3.49	6.48 $\bar{X}$	=0.80 ±0.28	$\bar{X}$=1.46 ±0.81	152	29	

SUMMARY - FIRE BLOCKING LAYERS ACUTE RELATIVE
TOXICITY TEST DATA

TABLE 14 (Cont'd)

MATERIAL NO. & NAME	MATERIAL WEIGHT GRAMS	ANIMAL WEIGHT GRAMS	OBSERVED Ti MIN.	OBSERVED Td MIN.	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Ti	NORMALIZED DATA PER GM MAT'L 25 GM MOUSE Td	APPARENT MATERIAL PYROLYZED MG	APPARENT PYROLYZED MAT'L. CONC IN CHAMBER MG	NOTES
301	0.5	30.4	ND	Lived	-	-	215	41	
APN Polyphosphazene	1.0	35.9	13.3?	Lived	9.26?	-	442	83	Ti doubtful
Foam PN R207078	2.0	29.6	2.0	15.0	3.38	25.34	862	163	Av. % Char
	2.0	34.5	1.67	19.2	2.42	27.83	861	163	57 ± 0.5
Av.	1.4	32.6	5.66	17.1	$\bar{X}$=2.9 ±0.68	$\bar{X}$=26.6 ±1.76	595	113	
303	0.5	29.0	13.33	Lived	5.75	-	212	40	
Silicone Sponge	1.0	31.5	15.00	Lived	11.90	-	407	77	Av. % Char
Exp. 1408	1.0	32.5	4.83	9.16	3.72	7.05	288	54	62 ± 6
	1.0	32.5	7.25	10.83	5.58	8.33	414	78	
Av.	.9	31.4	10.10	10.00	$\bar{X}$=6.74 ±3.56	$\bar{X}$=7.69 ±0.91	330	62	
304	0.5	25.0	18.00	20.83	9.00	10.47	206	39	Av. % Char
Mosites Silicone	0.5	28.9	14.00	15.87	6.41	6.86	230	43	54 ± 5
Sponge 14183-B	0.5	29.1	11.67	18.00	5.01	7.73	252	48	
Av.	0.5	27.7	11.56	18.23	$\bar{X}$=6.81 ±2.02	$\bar{X}$=8.34 ±1.86	229	43	
306	0.5	25.3	5.27	5.67	2.60	2.80	375	71	
Polyurethane	0.25	26.5	7.07	7.92	1.67	1.87	189	36	Av. % Char
Foam	0.25	35.5	7.93	10.17	1.40	1.79	163	31	26 ± 6
H-45C	0.25	23.6	4.67	5.92	1.24	1.57	206	39	
	0.5	30.0	6.25	9.67	2.60	4.03	364	69	
	0.25	29.6	10.33	33.33	2.18	7.04	183	35	
Av.	0.33	28.4	6.92	12.11	$\bar{X}$=1.95 ±0.60	$\bar{X}$=3.18 ±2.1	247	47	
307	1.0	23.7	5.25	Lived	5.54	-	440	83	
Neoprene	0.5	24.9	ND	Lived	-	-	230	43	Av. % Char
Foam HL	1.5	30.3	10.00	17.83	12.38	22.07	718	136	53 ± 2
	1.5	30.8	5.17	20.00	6.29	24.35	711	134	
	1.5	33.5	10.50	Lived	11.75	-	731	138	
	1.5	32.0	11.33	28.00	13.20	32.8	709	134	
Av.	1.25	29.2	8.45	21.94	$\bar{X}$=10.71 ±3.13	$\bar{X}$=23.2 ±1.61	590	111	

SUMMARY - CUSHIONING LAYERS ACUTE RELATIVE TOXICITY TEST DATA

TABLE 15

MATERIAL NO. & NAME	MATERIAL WEIGHT GRAMS	ANIMAL WEIGHT GRAMS	OBSERVED		NORMALIZED DATA PER GM MAT'L 25 GM MOUSE		APPARENT MATERIAL PYROLYZED MG	APPARENT PYROLYZED MAT'L. CONC. IN CHAMBER MG	NOTES
			Ti MIN.	Td MIN.	Ti	Td			
308	0.5	25.8	ND	Lived	-	-	322	61	No effects - 1 week
Neoprene	1.0	28.5	2.87	12.17	3.03	12.83	434	82	Av. % Char
Uniroyal	1.0	31.5	2.67	6.67	2.12	5.29	438	83	56 ± 2
Foam Firm Av.			-		$\bar{X}$=2.58 ±0.64	$\bar{X}$=9.06 ±5.3			
Baseline	0.25	26.6	2.0	12.30	0.47	2.89	177	33	Av. % Char
Royalite 57	0.25	33.3	2.1	12.06	0.39	2.26	195	37	26 ± 5
ABS R60268 Av.					$\bar{X}$=0.43 ±0.06	$\bar{X}$=2.58 ±0.45	186	35	
305	0.5	35.0	8.00	10.33	2.86	3.69	265	50	Av. % Char
Silicone Sponge	0.5	35.0	14.17	19.08	5.06	6.81	265	50	51 ± 5
#510	0.5	37.0	18.92	22.17	6.39	7.49	275	52	
Av.					$\bar{X}$=4.77 ±1.8	$\bar{X}$=6.0 ±2.0	268	51	

SUMMARY - CUSHIONING LAYERS ACUTE RELATIVE TOXICITY TEST DATA

TABLE 15

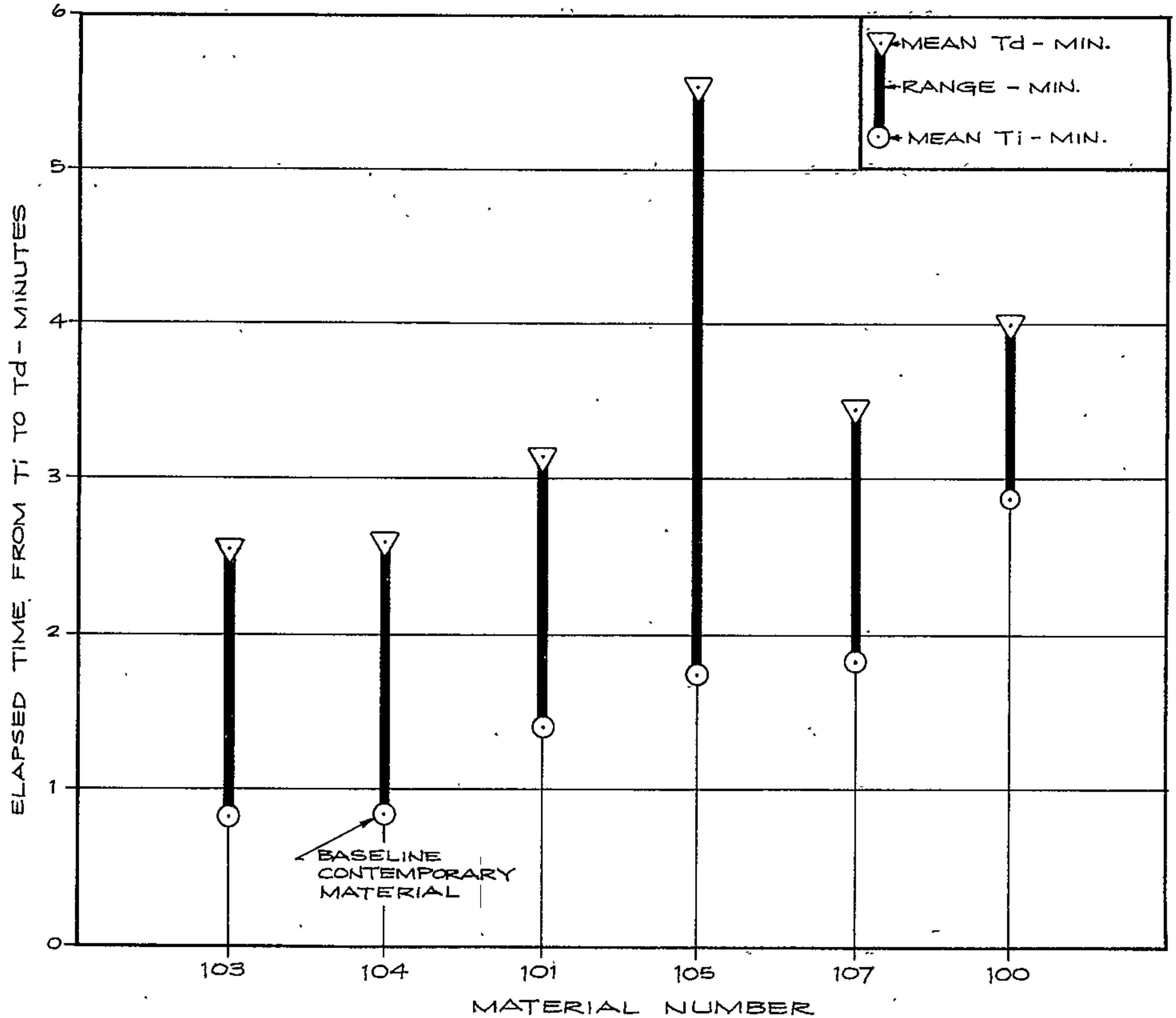


FIGURE 39. RELATIVE ACUTE TOXICITY OF CANDIDATE DECORATIVE FABRICS (DATA NORMALIZED PER GRAM OF MATERIAL & 25 g MOUSE)

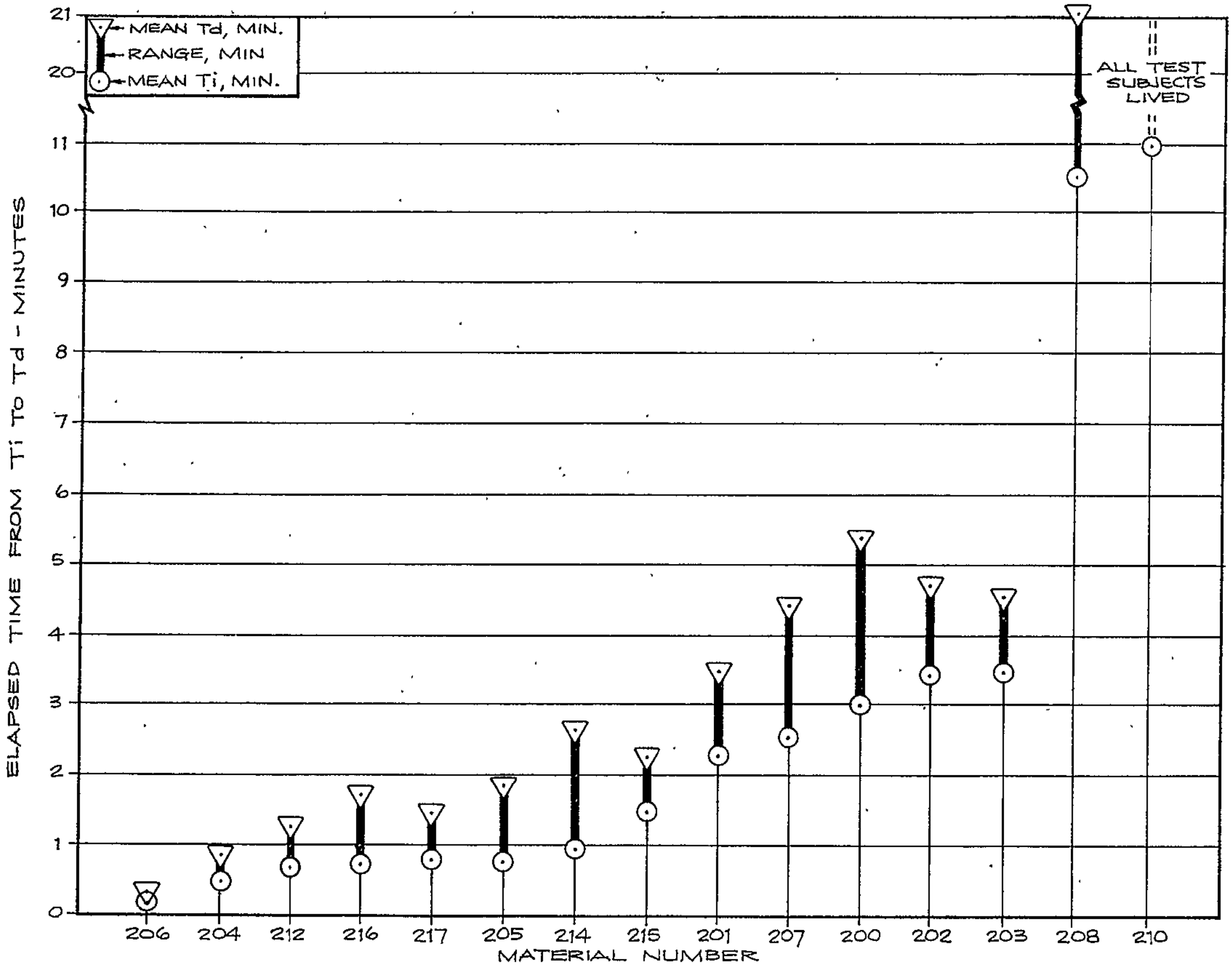


FIGURE 40. RELATIVE ACUTE TOXICITY OF CANDIDATE FIRE BLOCKING MATERIALS (NORMALIZED PER GRAM OF MATERIAL & 25g MOUSE)

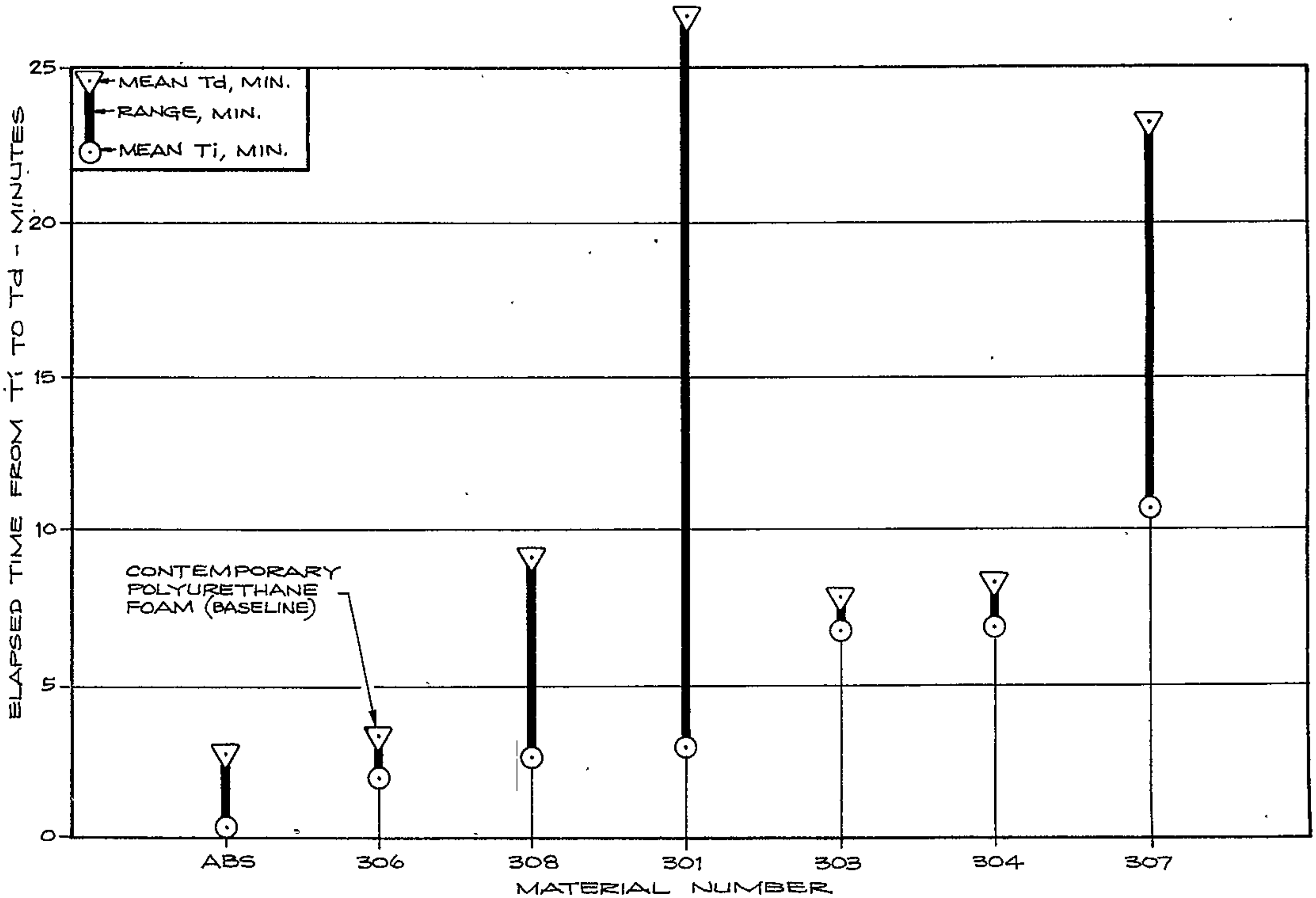


FIGURE 41. RELATIVE ACUTE TOXICITY OF CANDIDATE CUSHIONING MATERIALS (NORMALIZED PER GRAM OF MATERIAL & 25 g MOUSE)

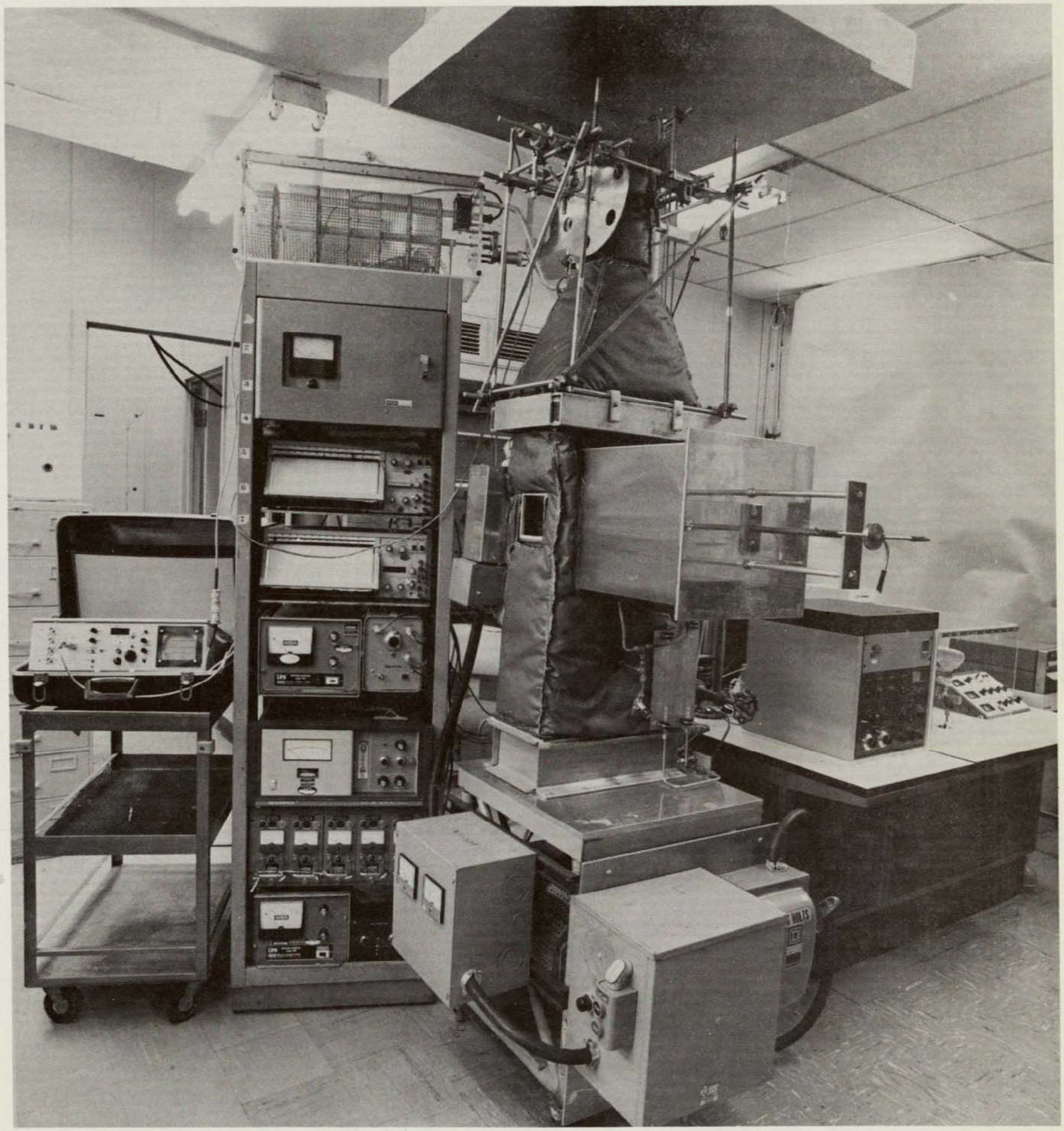


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FIGURE 42. DAC MODIFIED HEAT RELEASE RATE CHAMBER

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ITEM	PARAMETER	DATA UNITS
SAMPLE		
Identification	Material No. & Name	
Size	Length X Width X Thickness	15 x 15 cm (6 x 6 inch) thickness mm (inch)
Thermal Exposure	Area	225 cm^2 (36 in^2)
Mass	Weight, Pre and Post Test	Grams
Response	Shrinkage	Percent
Orientation	Vertical	
HRR CALORIMETER		
Airflow (set)	Cubic Feet/Minute	60
Thermal Flux (set)	Watt/$Centimeter^2$ (w/cm^2)	2, 2.5, 3.5, 5.0
Test Time (set)	Sample Exposure Time	5 - 15 minutes
Visual Ignition	Time to Ignition	Seconds
Visual Flaming	Flame Travel Rate (FTR)	mm/sec
Ignition Test Mode	Point Pilot Flame	10 cm from Sample, bottom center
Heat Release	Max Heat Release Rate/Area Heat Release vs. Time/Area	KW/m^2 at sec KW/m^2, 1.5, 3, 5, 10 minute
Effective Heat of Combustion	Total Heat/Area (Integrated)	KW/m^2 at min
Smoke Release	Max. Smoke Release Rate/Area Smoke Release vs. Time/Area	SRR; 1 unit = 10% T Reduction/ meter Path SRR $3/m^2$, 1.5, 3, 5, 10 min.
Total Smoke	SRR X Time (Integrated)	SRR/m^2 at min.

Table 16. Sample and HRR Calorimeter Operational Data

△P≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m2	HEAT RELEASE AFTER - 90 sec. kW/m2	3 min. kW/m2	5 min. kW/m2	10 min. kW/m2	TOTAL kW/m2	SAMPLE WT. g & CHAR YIELD %	REMARKS
100 AIRGARD NYLON FABRIC										
2.5 W/cm^2	Flashes 22	2.7	78.5 @ 57 sec.	51.6	120.5	164.4	-	199 7.5 min	9.27 g < 2 %	Burns completely Melts, flaming Drips - drips extinguish
3.5 W/cm^2	Flashes 5	10	70 @ 42 sec.	62.5	143.1	165.2	180	180 10 min	9.00 g < 2 %	Flameout - 155 sec. Melted drips burn in catch pan
5.0 W/cm^2	Flashes 5	N.D. melt-ing	117.4 @ 80 sec.	87.4	155.0	181.3	-	181	9.41 g < 1 %	Flameout - 103 sec. Burns in drip pan
101 Kermel/wool										
2.5 W/cm^2	Flashes 5	12	65.5 @ 26 sec.	36.0	42.1	49.4	65.2	>65.2	6.82 g 36.7 %	Burns rapidly Shrinkage - 56% Char cracks
3.5 W/cm^2	Flashes 5	7	44.3 @ 22 sec.	32.6	41.0	43.6	-	>49 10 min.	6.70 g 23.1 %	Burst into flame 70% shrinkage Flameout - 33 sec.
5.0 W/cm^2	Flashes 5	9	59.1 @ 17 sec.	50.3	72.9	102.3	-	130 7 min.	6.76 g 40.8 %	Flameout - 53 sec. 5 surface flashes 66% shrinkage

HEAT RELEASE DATA - DECORATIVE FABRIC COVERING

TABLE 17

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m^2	HEAT RELEASE AFTER - 90 sec. kW/m^2	3 min. kW/m^2	5 min. kW/m^2	10 min. kW/m^2	TOTAL kW/m^2	SAMPLE WT. g & CHAR YIELD %	REMARKS
103 Nomex (Off White) 69-407										
2.5 W/cm^2	Flashes None	None	5.5 @ 100 sec.	2.9	7.6	11.2	22.8	22.8	7 g 67.6 %	No flame Shrinkage 66% Blue flame surface flashes
3.5 W/cm^2	Flashes 5	> 6	13.4 @ 45 sec.	15.1	20	25.9	49.3	49.3	7.2 g 23.6 %	Spalls off Flashes Shrinkage 70%
5.0 W/cm^2	Flashes < 6	> 6	31.9 @ 27 sec.	26.4	42.1	52.7	-	52.7	6.9 g 26 %	Spalls off as white powder 77% shrinkage
5.0 W/cm^2	Flashes < 6	>6	31.5 @ 25 sec.	28.6	48.7	64.2	-	64.2	-	Spalls off as white powder 77% shrinkage
104 90% Wool/10% Nylon ST7427-112										
2.5 W/cm^2	Flashes < 5	3	125.8 @ 32 sec.	91.8	115.4	132.5	162.8	163	10.63 g < 1 %	Burns rapidly 50% shrinkage Smolders & spalls off
3.5 W/cm^2	Flashes < 5	>6	114.3 @ 30 sec.	88.8	115.6	130.9	158.9	159	10.40 g < 1 %	Flameout - 80 sec.
5.0 W/cm^2	Flashes < 5	6.7	133.8 @ 25 sec.	85.6	112	132	160	160	10.63 g < 1 %	Flameout - 78 sec. 50% shrinkage Smolders to fine white ash

HEAT RELEASE DATA - DECORATIVE FABRIC COVERING

TABLE 17

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m²	HEAT RELEASE AFTER – 90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²	SAMPLE WT. g & CHAR YIELD %	REMARKS
105 Kynol/Nomex Fabric #7979										
2.5 W/cm²	Flashes 10	3.8	30.9 @ 41 sec.	22.0	36.5	52.7	101.9	101.9	7.2 g –	Flashes occasionally Smolders for 15 min.
3.5 W/cm²	Flashes < 5	5.5	49.6 @ 35 sec.	26.9	39.3	52.1	76.7	76.7	7.5 g 6 %	Flameout – 49.6 sec. Smolders
5.0 W/cm²	Flashes < 5	3	37 @ 20 sec.	27.3	45.1	62.5	–	86.5 8.3 min	7.18 g < 1 %	Flameout – 38 sec. and Smolders to 7.5 min. 20% shrinkage
107 Urethane Coated Nylon										
2.5 W/cm²	Flashes < 5	>6	86.3 @ 37 sec.	64	90.1	107.2	–	107.2 & 103.7	6.6 g < 1 %	Flameout – 100 sec. Melts and drips
3.5 W/cm²	Flashes < 5	>6	62 @ 23 sec.	64.7	90.1	–	–	>90.1 3 min.	6.88 g < 1 %	Flameout – 77 sec. Melts and drips 95% shrinkage
5.0 W/cm²	Flashes < 5	>6	80.5 @ 20 sec.	62.9	83.2	–	–	>83.2 3 min.	6.80 g < 1 %	Flameout – 95 sec. Melts and drips

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HEAT RELEASE DATA – DECORATIVE FABRIC COVERING

TABLE 17

$\Delta P \cong 2$; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m²	HEAT RELEASE AFTER – 90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²	SAMPLE WT. g & CHAR YIELD %	REMARKS
200 Kynol Fabric #24										
2.5 W/cm²	Flashes 6	Flash	14 @ 34 sec.	11.8	23.5	43.1	66	66 10 min	5.7 g 22.9 %	Flameout 40 sec. Flashes & smoldering
3.5 W/cm²	Flashes 5	Flash	20.6 @ 28 sec.	17.3	34.6	52.7	–	62 7 min	5.3 g <1 %	Flickering fl. over surface Flash & smoldering 95% shrinkage
5.0 W/cm²	Flashes <2	Flash	36.0 @ 22 sec.	22.5	44	63.8	–	63.8 5 min	5.6 g <1 %	Flickering flameout 290 sec. Smoldering & glow embers
201 Kynol Fabric #1110										
2.5 W/cm²	Flashes <5	Repeat Flashes	7.5 @ 230 sec	4.3	14.4	29.3	51.3	51.3 10 min	4.6 g 10.9 %	Sporadic flashes & smolder 75% shrinkage
3.5 W/cm²	Flashes <5	>6	29.4 @ 25 sec	19.5	36.7	52.3	84.8	84.8 10 min	3.9 g 4.9 %	Sporadic flashes to 360 sec. Smoldering 75% shrinkage
5.0 W/cm²	Flashes <5	>6	41.2 @ 16 sec	28.3	51.6	70	–	70.0 10 min	4.8 g <1 %	Flickering flameout 290 sec. Smoldering for 5 min. Lt ash remains

HEAT RELEASE DATA – FIRE BLOCKING LAYERS

TABLE 18

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m^2	HEAT RELEASE AFTER – 90 sec. kW/m^2	3 min. kW/m^2	5 min. kW/m^2	10 min. kW/m^2	TOTAL kW/m^2	SAMPLE WT. g & CHAR YIELD %	REMARKS
202 Kynol Fabric #1090										
2.5 W/cm^2	Flashes None	None	6.3 @ 324 sec.	5.3	13.2	23.8	43.6	43.6	3.8 g 15.3 %	Sporadic flashes Near 300 sec.
3.5 W/cm^2	Flashes < 5	8.6	24.1 @ 25 sec.	15.8	26.7	34.8	-	34.8	3.9 g < 5 %	Sporadic flashes Flashes Smolders
5.0 W/cm^2	Flashes < 2	>6	26.4 @ 16 sec.	22.5	43.4	57.7	-	57.7	3.6 g < 1 %	Shrinks & cracks Thin flickering flame Following smoky flame
203 (B-104S) Kynol Needle Punch Bat.										
2.5 W/cm^2	Flashes 25 sec.	3.6	16.1 @ 40 sec.	12.1	24.8	41.9	74.7	74.7	4.8 g < 2 %	Flameout - 34 sec. Flashing sporadically w/ smoldering over 6'
3.5 W/cm^2	Flashes < 5	7	20.8 @ 19 sec.	13.6	28.1	39.6	47.9	47.9	3.8 g < 1 %	Flashes Smoldering 10% shrinkage
5.0 W/cm^2	Flashes < 1	8.6	25.3 @ 16 sec.	24.2	45.8	65.5	-	65.5	5.0 g < 1 %	Flickering blue-white flames over surface Smoldering - burns out sample to ash in 6 min. 25 sec.

HEAT RELEASE DATA - FIRE BLOCKING LAYERS

TABLE 18

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m2	HEAT RELEASE AFTER - 90 sec. kW/m2	3 min. kW/m2	5 min. kW/m2	10 min. kW/m2	TOTAL kW/m2	SAMPLE WT. g & CHAR YIELD %	REMARKS
204 PBI Fabric 40-9010-1										
$2.5\ W/cm^2$	Flashes None	None	None	2.2	6.6	11.7	31.6	31.6 10 min.	4.0 g 74 %	No flame 55% shrinkage Char flexible
$3.5\ W/cm^2$	Flashes None	None	None	2.3	8.4	15.4	43.1	43.1 10 min.	3.9 g 25.6 %	Smoldering with flickering flames
$5.0\ W/cm^2$	Flashes None	None	None	5.7	19.0	34	67.9	95.7 13 min.	4.0 g <1 %	Smolder w/ flickering flames at 60 sec. 50% shrinkage (initial)
205 PBI Batting 40-4010-1										
$2.5\ W/cm^2$	Flashes None	None	None	1.2	4.6	13.9	-	13.9	2.28 g 74 %	No flames
$3.5\ W/cm^2$	Flashes None	None	None	3.0	5.9	7.4	-	7.4	2.2 g 77 %	No flames 80% shrinkage
$5.0\ W/cm^2$	Flashes None	None	None	0.7	6.4	12.9	-	12.9	1.9 g <1 %	Shrank away from pilot lt. Blue flickering flames Smoldering ends in 9 min. 89% shrinkage (initial)

HEAT RELEASE DATA - FIRE BLOCKING LAYERS

TABLE 18

$\Delta P \cong 2$; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m^2	HEAT RELEASE AFTER – 90 sec. kW/m^2	3 min. kW/m^2	5 min. kW/m^2	10 min. kW/m^2	TOTAL kW/m^2	SAMPLE WT. g & CHAR YIELD %	REMARKS
206 Black Batting										
2.5 W/cm^2	Flashes	–	19.1 @ 10 sec.	12.8	20.3	28.5	–	28.5	3.1 g 65.8 %	No fire - multiple flashes over surface
3.5 W/cm^2	Flashes	–	15 @ 12 sec.	10.5	20.0	23.3	28.2	28.2	3.95g <2 %	No fire - multiple flashes over surface Shrinkage - 8.3%
5.0 W/cm^2	Flash only	N.D.	7.6 @ 10 sec.	7.7	16.2	26	29	29	3.2 g <2 %	No fire - flash only
207 Kynol Bat/polyest. scrim			RECEIVED TOO LATE - NOT RUN							
2.5 W/cm^2										
3.5 W/cm^2										
5.0 W/cm^2										

HEAT RELEASE DATA - FIRE BLOCKING LAYERS

TABLE 18

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE						SAMPLE WT. g & CHAR YIELD %	REMARKS
			RATE	HEAT RELEASE AFTER –						
			Max@ s kW/m²	90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²		
208 Vonar #1 Neoprene										
2.5 W/cm²	Flashes <10 slight	None	9.8 @ 43 sec.	9.1	22.3	37.7	58.9	58.9	10.4 g <5 %	Flames briefly around pilot lt. – some smoldering Shrinkage – 30% Spalls off
3.5 W/cm²	Flashes <10	Flash vert.	15.0 @ 55 sec.	13.0	23.6	30.0	–	>51.4 8 min.	10.6 g <5 %	Flashed across top edge Smoldering – spalling
5.0 W/cm²	Flashes <6	Flash vert.	0.4 @ 30 sec.	17.2	–	–	–	17.2	10.3 g <5%	Flameout – 68 sec. Spalls off – 92 sec.
210 Vonar #3										
2.5 W/cm²	Flashes None	None	11.3 @ 500 sec.	8.8	19.5	33.3	82.7	82.7	22.7 g < 5 %	Friable char No smoldering Shrinks 16.6% Spalls off
3.5 W/cm²	Flashes < 7	.6	9.3 @ 96 sec.	11.5	24.0	40.3	76.7	76.7	21.0 g < 5 %	Flameout 96 sec. Spalls off
5.0 W/cm²	Flashes < 7	0.9	52.9 @ 85 sec.	25.6	52.7	74.8	–	74.8	23.5 g < 5 %	Flameout in 100 sec. Sporadic flashes Spalls off

HEAT RELEASE DATA – FIRE BLOCKING LAYERS

TABLE 18

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE						SAMPLE WT. g & CHAR YIELD %	REMARKS
			RATE	HEAT RELEASE AFTER -						
			Max@ s kW/m2	90 sec. kW/m2	3 min. kW/m2	5 min. kW/m2	10 min. kW/m2	TOTAL kW/m2		
212 Durette Fabric										
2.5 W/cm2	Flashes None	None	7.0 @ 80 sec.	7	15.9	27.5	70.7	70.7	7.8 g 44.6 %	No flame propagation 95% shrinkage
3.5 W/cm2	Flashes None	None		3.1	14.3	21.3	44.4	44.4	7.8 g N.D.	No flame propagation 95% shrinkage
5.0 W/cm2	Flashes < 5	4	31.3 @ 32 sec.	≃26.2	≃ 57.9	≃104.3	≃217	-	7.5 g N.D.	HRR values high due to baseline shift Strong smoldering
214 Nomex III										
2.0 W/cm2	-	-	-	4.0	6.3	10.3	-	>10.3		
2.5 W/cm2	Flashes < 5	>6	12.3 @ 25 sec.	7.2	11.8	15.4	21.3	>21.3	5.8 g 57 %	Flameout 33 sec. Shrinkage - 10% No smoldering
3.5 W/cm2	Flashes < 5	>6	46.3 @ 25 sec.	25.7	37.7	49.6	71.6	71.6	6.25 g 4 %	Flameout - 45 sec. Shrinkage - 95%
5.0 W/cm2	Flashes <2	>6	39.5 @ 16 sec.	34.1	55.4	73.3	-	73.3 7.6 min	6.1 g <2 %	Flameout @ 62 sec. and smoldering begins 75 sec. Shrinkage - 50%

HEAT RELEASE DATA - FIRE BLOCKING LAYERS

TABLE 18

$\Delta P \cong 2$; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@_s kW/m2	HEAT RELEASE AFTER – 90 sec. kW/m2	3 min. kW/m2	5 min. kW/m2	10 min. kW/m2	TOTAL kW/m2	SAMPLE WT. g & CHAR YIELD %	REMARKS
215 Kermel Fabric										
2.5 W/cm²	Flashes 17	4	23.6 @ 45 sec.	16.0	23.8	33.7	60.2	>60.2	6.2 g 29 %	Shrinkage – 50% Burns irregularly
3.5 W/cm²	Flashes 8	>6	34.4 @ 35 sec.	25.5	33.9	51.8	60.6	>60.6	6.15g 25.2%	Charred to white residue Flameout 45 sec. Shrinkage 95%
5.0 W/cm²	Flashes 3	>6	71.2 @ 25 sec.	32.4	48.9	63.8	66.95	>66.95	6.2 g <1 %	Totally charred out – white residue Flameout at 46 sec. Shrinkage 95%
216 Durette Batting 400-11										
2.5 W/cm²	Flashes None	None	None	7.3	16.7	28	71.7	71.7	8.8 g N.D.	33% shrinkage
3.5 W/cm²	Flashes None	None	None	1.6	6.3	13.7	36.9	36.9	7.8 g N.D.	50% shrinkage After 5 min – flash flames
5.0 W/cm²	Flash @ 40 sec.	None	None	8.8	28.4	47.4	–	77.4 9 min.	7.8 g N.D.	3 blue flashes @ upper center of specimen Smolders – 40 sec. – 6 min 28" 10% shrinkage

HEAT RELEASE DATA – FIRE BLOCKING LAYERS

TABLE 18

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE						SAMPLE WT. g & CHAR YIELD %	REMARKS
			RATE	HEAT RELEASE AFTER -						
			Max@ _ s kW/m²	90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²		
217 Durette Duck 400-6										
2.5 W/cm²	Flashes <5	None	None	7.0	13.8	17.7	19.6	>19.6	3.76 g N.D.	Minimum shrinkage Flashes rapidly over surface Some smoldering
3.5 W/cm²	Flashes <5	6	9.9 @ 20 sec.	9.3 @ 20 sec.	18.5	27.6	38.6	38.6	3.45 g 14.5 %	Flameout - 34 sec.
5.0 W/cm²	Flashes <2	Flash 7.5	24.7 @ 18 sec.	17.7	36.5	-	-	36.5	3.78 g N.D.	Flameout - 18 sec. Flickering flame Smoldering ends 3 min. 15 sec. Minimum shrinkage

HEAT RELEASE DATA - FIRE BLOCKING LAYERS

TABLE 18

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE						SAMPLE WT. g & CHAR YIELD %	REMARKS
			RATE	HEAT RELEASE AFTER –						
			Max@ s kW/m^2	90 sec. kW/m^2	3 min. kW/m^2	5 min. kW/m^2	10 min. kW/m^2	TOTAL kW/m^2		
300 Glass Fiber Block										
2.5 W/cm^2	Flashes None	None	None	6	11.8	23.2	35.1	35.1	24.4 g 83.2 %	Adhesive side exposed No flame Charred 50% through
3.5 W/cm^2	Flashes None	None	None	3.2	9.1	13.6	24.6	24.6	17.84 g 85.2 %	No flame
5.0 W/cm^2				INSUFFICIENT SAMPLE – NOT RUN						
301 APN Polyphosphazene Foam										
2.5 W/cm^2	Flashes 10	1.4	55.0 @ 63 sec	63.8	119.9	167.5	226.2	226	63.4 g 58.3 %	
3.5 W/cm^2	Flashes <5	3	58.3 @ 335 sec	44.2	131	232.5	368.6	492.9 @ 14.5 min	N.D.	Flameout 370 sec. Burns steadily No shrinkage
5.0 W/cm^2	Flashes <5	5	59.9 @ 300 sec	66.1	146.7	248.8	384.1	412 @ 13.5 min	65 g 52 %	Flameout - 512 sec. Burns steadily 5 min. Swells - white char

HEAT RELEASE DATA - CUSHIONING LAYERS

TABLE 19

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNI-TION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m²	HEAT RELEASE AFTER – 90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²	SAMPLE WT. g & CHAR YIELD %	REMARKS
303 Silicone Sponge Exp 1408										
2.5 W/cm²	Flashes 8	2.3	62.4 @ 290 sec.	29.3	78.8	148.8	274	306 @ 15 min	63.6 g 54.1 %	Flameout – 760 sec.
3.5 W/cm²	Flashes 4	10	63 @ 230 sec.	44.8	113.6	229	365.3	530 @ 13.5 min	65.7 g 73 %	Flameout – 620 sec. Loss due to spalling White char layer 1/8 – 3/16"
5.0 W/cm²	Flashes <2	20	71.2 @ 256 sec	65.7	154.6	315.3	485.6	473 @ 14' 17"	Spalls off	Flameout @ 450 sec.
304 Mosites Foam 14183-B										
2.5 W/cm²	Flashes <10	5.5	62.4 @ 37 sec.	67.4	151	258.7	466.7	519.5	80.5 g 60.5 %	Flameout – 865 sec. Charred white Spalls off
3.5 W/cm²	Flashes <5	>6	60.5 @ 52 sec.	72.8	159.5	252.4	393.6	468.5 16 min	66.6 g 70 %	Flameout – 820 sec. Spalls off
5.0 W/cm²	Flashes <5	>6	97 @ 271 sec	94.9	226.7	411.6	594.3	596.7 12 min	83.4 g 61.1 %	Flameout – 505 sec. Spalls off

HEAT RELEASE DATA – CUSHIONING LAYERS

TABLE 19

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE						SAMPLE WT. g & CHAR YIELD %	REMARKS
			RATE	HEAT RELEASE AFTER -						
			Max@ s kW/m²	90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²		
305 Silicone Sponge #510										
2.5 W/cm²	Flashes 9	1.9	56.4 @ 282 sec	59.2	142.9	269.2	483	525 16 min	66.5 g 76 %	Spalls off Sample char lost
3.5 W/cm²	Flashes 5	3.1	69.6 @ 287 sec	61	150.6	283.6	529	531 14 min	71.7 g 67 %	Flameout - 685 sec. Spalls off
5.0 W/cm²	Flashes <5	3.8	118.8 @ 252 sec	92.1	212	431	664	671 13.3 min	70.0 g 53 %	Flameout - 495 sec.
306 Polyurethane Foam H-45C										
2.5 W/cm²	Flashes <5	3	141.3 @ 46 sec.	188.8	213.8	-	-	213.8	9.0 g <1 %	Burns very rapidly Melts Flaming drips
3.5 W/cm²	Flashes <5	Melts N.D.	138.8 @ 34 sec.	100.0	130.0	144	159.8	>159.8	9.2 g <1 %	
5.0 W/cm²	Flashes <5	>6	108.1 @ 18 sec.	76.8	100.4	110.7	115.9	115.9	9.1 g <1 %	Flameout - 75 sec.

HEAT RELEASE DATA - CUSHIONING LAYERS

TABLE 19

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m²	HEAT RELEASE AFTER – 90 sec. kW/m²	3 min. kW/m²	5 min. kW/m²	10 min. kW/m²	TOTAL kW/m²	SAMPLE WT. g & CHAR YIELD %	REMARKS
307 Neoprene Foam HL-1-7-77										
2.5 W/cm²	Flashes None	None	None	7.9	21.6	38.4	97.2	97.2	37.3 g N.D.	Burns only near pilot lt Swells & spalls off after 11 min.
3.5 W/cm²	Flashes <5	Flash None	44.9 @ 33 sec.	22.3	45.3	142.6	–	142.6 5 min.	38.7 g 17 %	Flameout – 52 sec. Spalls off
5.0 W/cm²	Flashes <2	>6	48.8 @ 107 sec.	56.1	112.8	138.6	–	138.6 5 min.	35.5 g 27.8 %	Flameout – 165 sec. Chars to white Spalls off
308 Koylon Neoprene Foam (Firm)										
2.5 W/cm²	Flashes 4.8	>6	24.2 @ 120 sec.	25.2	75.1	100.4	162.8	188.2 840 sec.	36.9 g 26.6 %	Flameout – 167 sec. Flashes across surface Stand-off flames observed
3.5 W/cm²	Flashes <5	>6	49 @ 95 sec.	68.2	87.0	106.7	147.8	202	36.4 g N.D.	Flameout – 158 sec. Spalled off
5.0 W/cm²	Flashes <5	>6	68.4 @ 57 sec.	75	106.9	125.9	–	141 398 sec.	39.2 g N.D.	Flameout – 111 sec. Spalls off

HEAT RELEASE DATA – CUSHIONING LAYERS

TABLE 19

ΔP≅2; FLUX AS SHOWN MATERIAL NO. AND HEAT FLUX	TIME TO IGNITION sec.	FLAME TRAVEL RATE mm/sec	HEAT RELEASE RATE Max@ s kW/m^2	HEAT RELEASE AFTER - 90 sec. kW/m^2	3 min. kW/m^2	5 min. kW/m^2	10 min. kW/m^2	TOTAL kW/m^2	SAMPLE WT. g & CHAR YIELD %	REMARKS
ABS Royalite 57										
2.5 W/cm^2	Flashes <10	1.3	68.6 @ 188 sec	42.7	180.8	314.5	-	327.2 8 min.	39.0 g N.D.	Flameout - 570 sec.
3.5 W/cm^2	Flashes <5	3.1	132 @ 138 sec	83.6	242.9	300	344	344 10 min.	38.0 g 10 %	Flameout - 160 sec.
5.0 W/cm^2	Flashes 7	N.D. Melts	113 @ 99 sec.	102.4	224.6	270.4	-	293 8 min.	39.6 g N.D.	Flameout - 179 sec.

HEAT RELEASE DATA - CUSHIONING LAYERS

TABLE 19

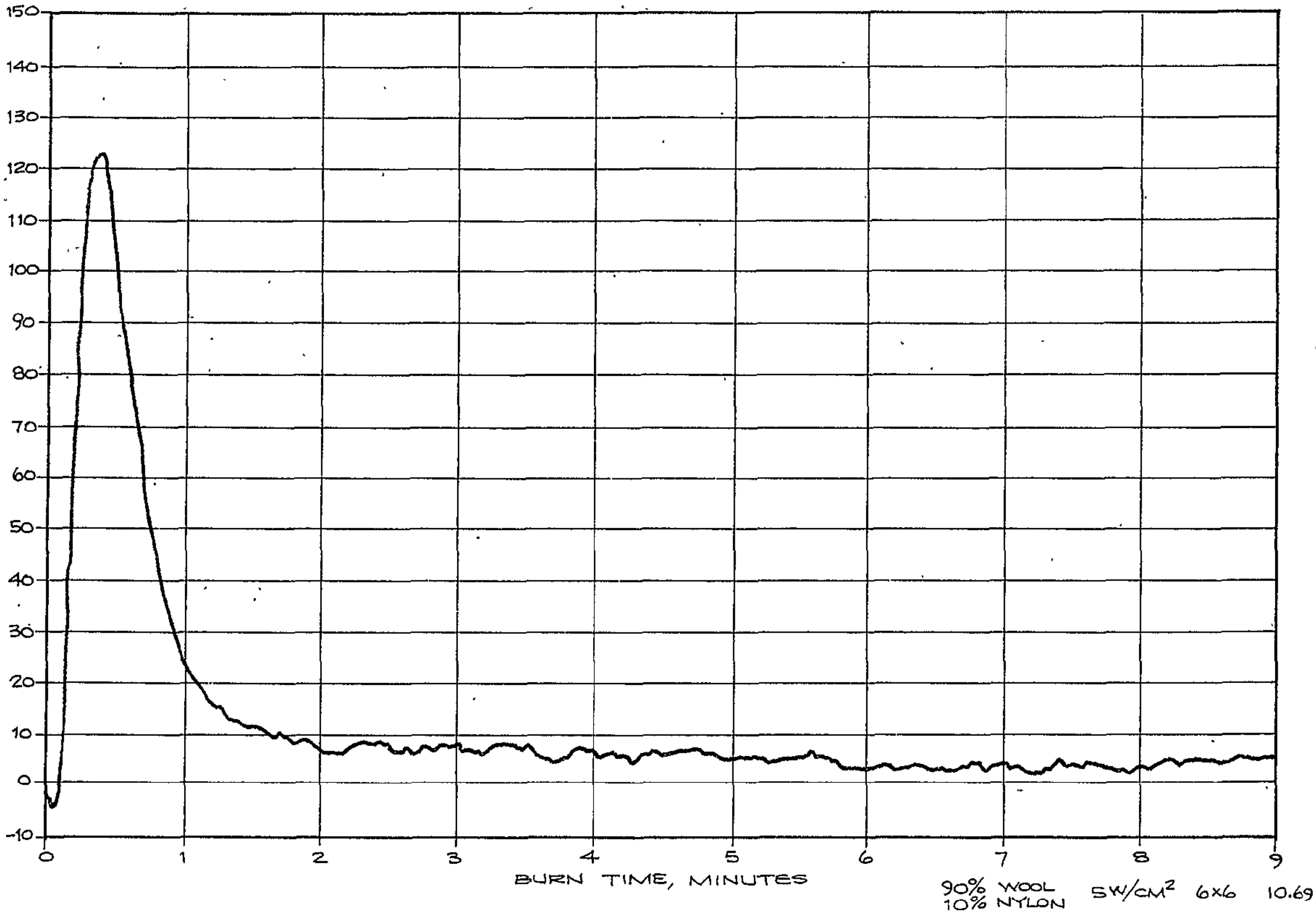

FIGURE 43. HEAT RELEASE RATE MATERIAL NO. 104

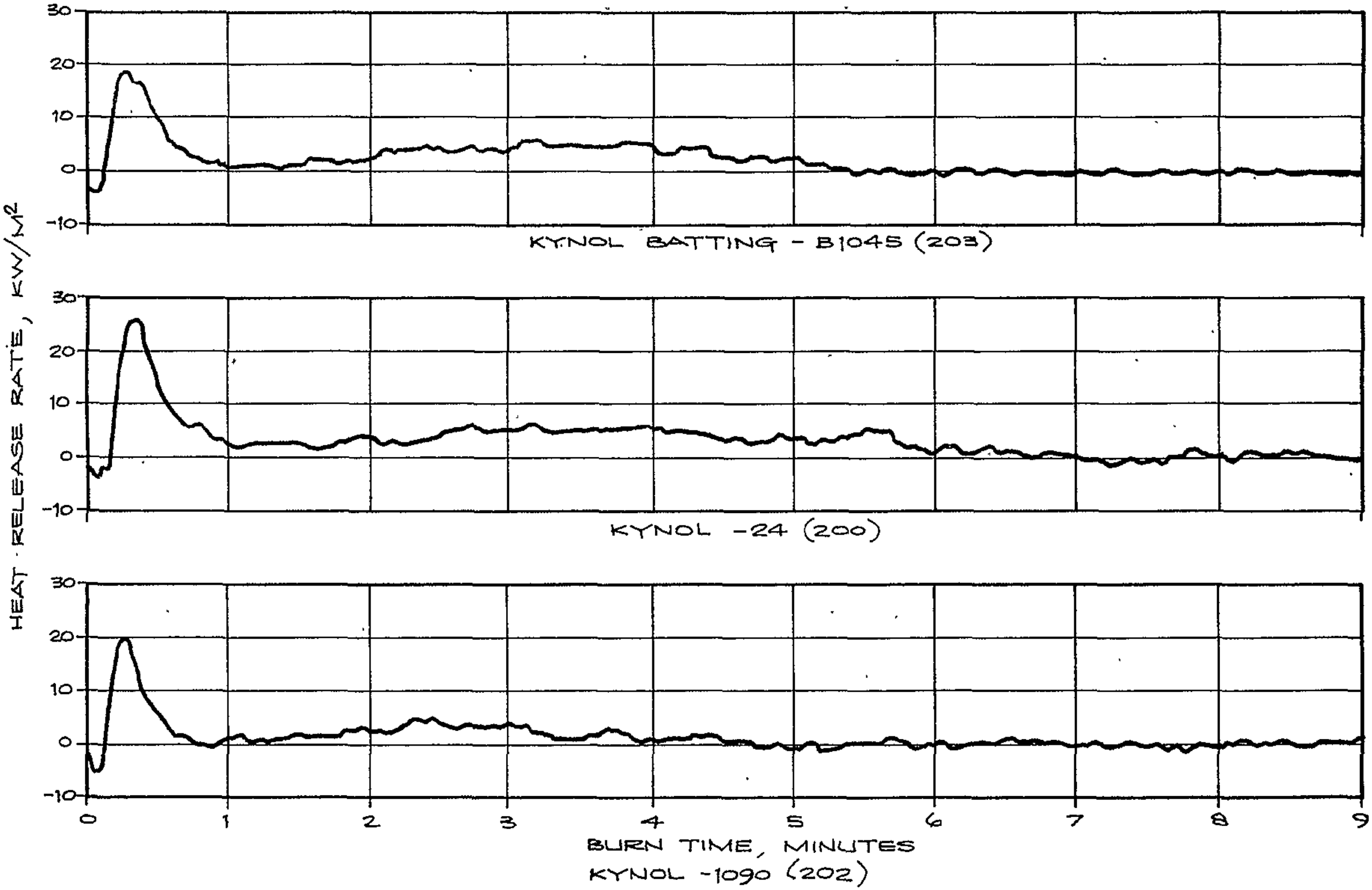

FIGURE 44. HEAT RELEASE RATE MATERIAL NO'S. 200, 202, 203

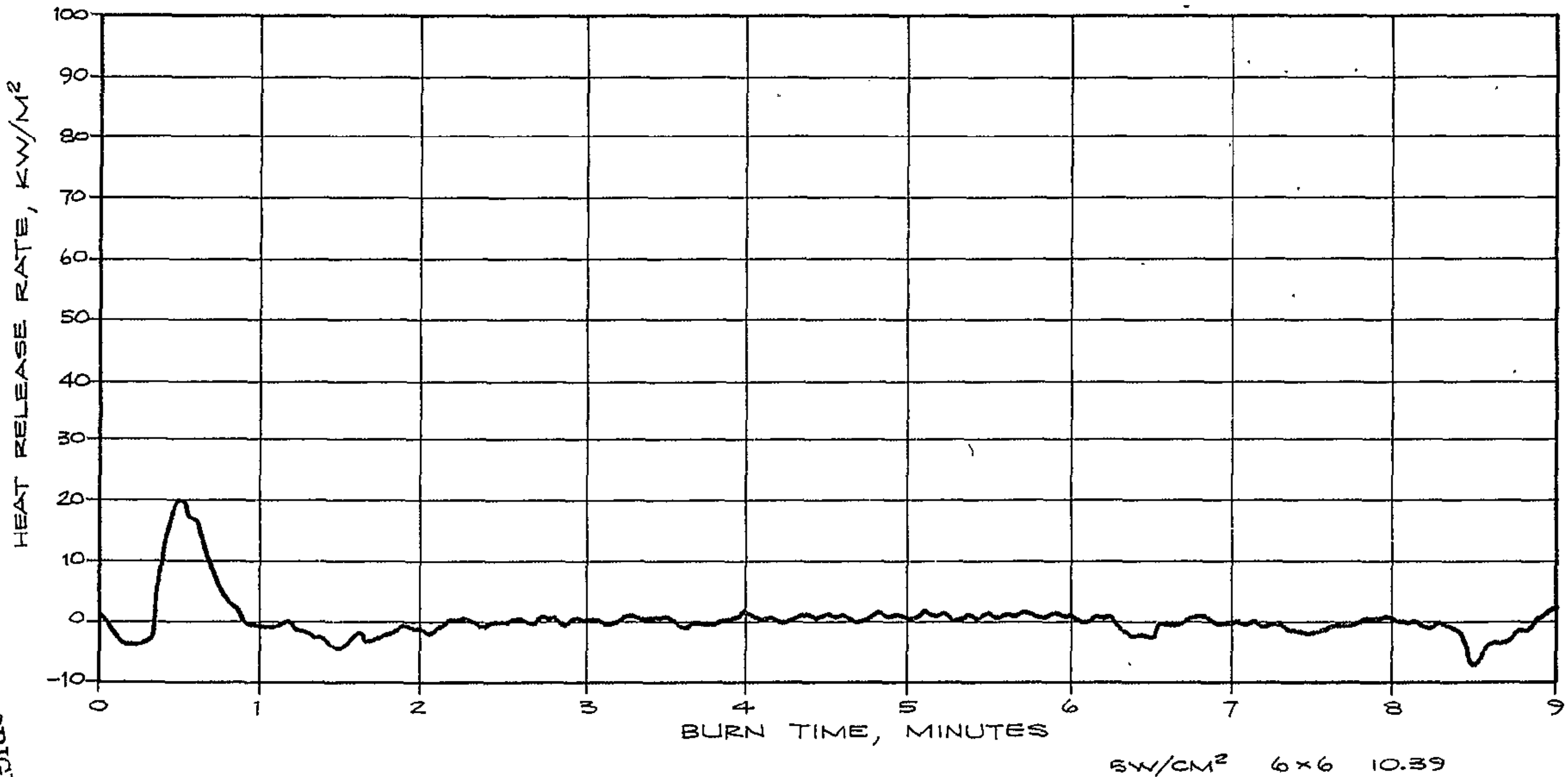

FIGURE 45. HEAT RELEASE RATE MATERIAL NO. 208

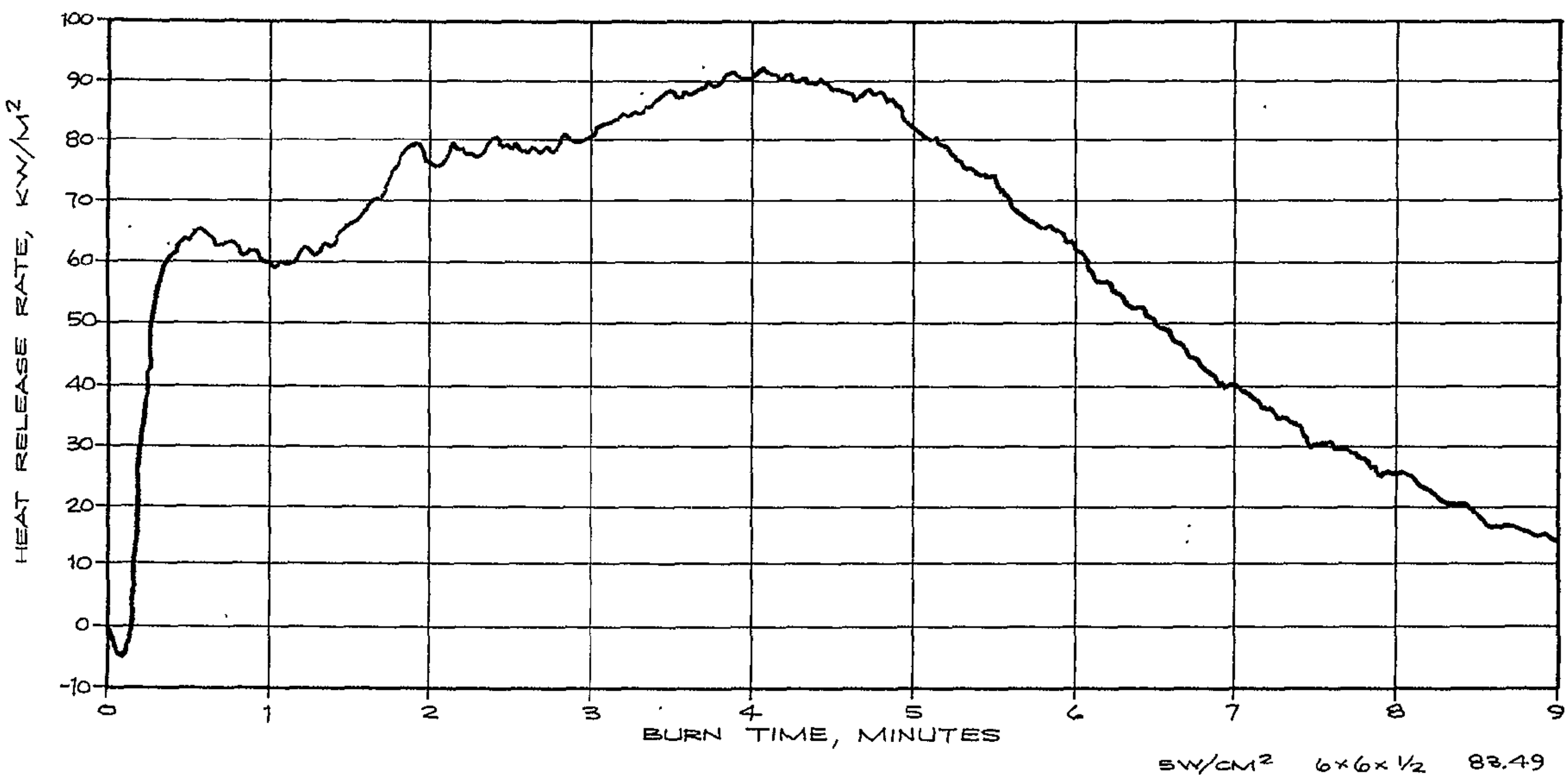

FIGURE 46. HEAT RELEASE RATE MATERIAL NO. 304

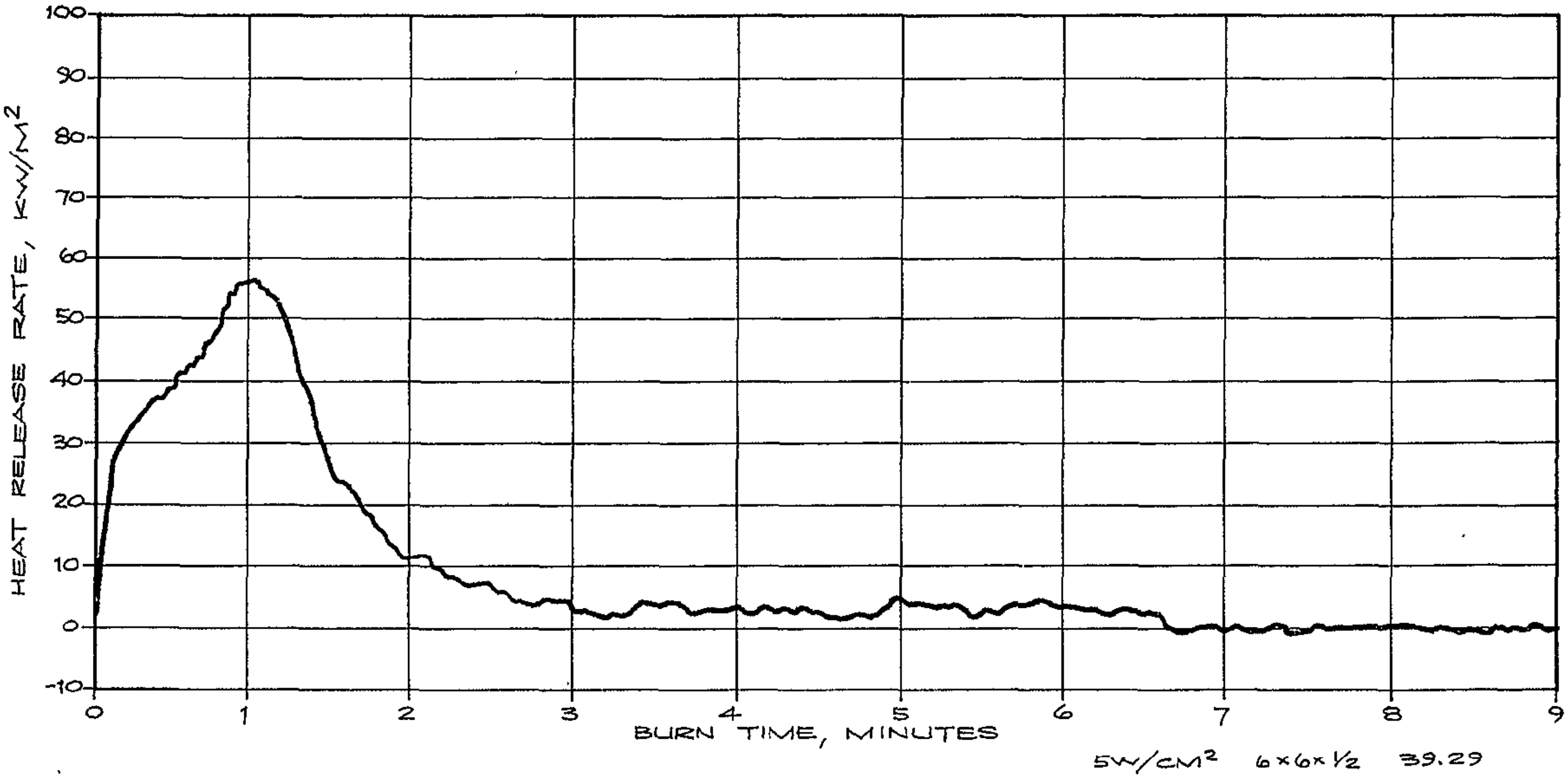

FIGURE 47. HEAT RELEASE RATE MATERIAL NO. 308

4.0 MATERIALS EVALUATION

4.1 Decorative Fabric Cover

Decorative fabrics used for seat covers must meet various aesthetic, thermal and mechanical requirements. In order to aid in comparing the candidate materials in this program, a table was developed with requirements in order of importance. The mandatory requirements were colorfastness, color availability, FAA required burn test and FAA recommended smoke density. Heat release was not considered as first level importance due to the small mass of fabric in the seat and its distribution. The fabric's resistance to ignition and the rate of burning were considered second level of importance. (See Table 20.)

On the basis of the stated requirements OL618 (102), 69-407 (103) and 7979 (105) were eliminated for consideration due to fading. The OL618 (102) also showed poor abrasion resistance. Nylon material backed with Vonar #3 was discontinued for development by the supplier but would have been eliminated by burn requirements. The 15691 coated nylon (107) was not available in sufficient colors and, in addition, had a low tear strength and therefore questionnable serviceability. The remaining materials were the baseline fabric (104), ST7793-29 (100) nylon and 20787 fabric (101), a Kermel blend. These materials are candidate materials for Phase II testing. The toxicity of these materials on a comparative basis under the test conditions was lower than the baseline material, and the smoke density was significantly improved over baseline material. These candidate materials are currently in service as upholstery materials in aircraft seating, and therefore are expected to be satisfactory from a mechanical performance standpoint when considered as an individual material.

The decorative fabrics that were evaluated for the Phase I program were those that were available in a suitable fabric form and met the schedule constraints of the nine month program. Some of the new advanced polymers have reached a development stage where further evaluation of new fabric blends incorporating these fibers would be appropriate. Kynol was recommended for use as fire blocking layers only, by the supplier, due to poor abrasion and colorfastness in the required blend ratios. PBI fiber is not colorfast and shrinks drastically under thermal load. A blend with PBI (natural) cannot be ruled out as a possibility. Nomex fabric (103) was not colorfast but is in airline use today, and further investigation of blends may be warranted. It is anticipated that some of the more immediate fabric developments might be incorporated in the Phase II program if other availability constraints are met.

REQUIREMENT	TEST METHOD	MATERIALS							
		ST-7427-112 (104) Baseline Fabric		ST-7193-29 Fabric (100)		20787 Kermel Blend (101)		15691 Coated Nylon (107)	
COLOR:	Availability Wide Range	Yes		Yes		Yes		Yes	
Colorfastness - Light	FTMS No. 191 *Method 5660	20SFH Exc	40SFH Exc	20SHF Exc	40SHF Exc	20SFH Exc	40SFH Good	20SFH Fair	40SFH Fair
- Crocking	*Method 5651(B)	-	-	-	-	-	-	-	-
NBS SMOKE: (Aged and nonaged specimens)	NBS TECH NOTE 708 Nonflaming, D_m 90 sec. 4 min.	28 73		4 12		21 38		40 41	
	Flaming, D_m 90 sec. 4 min.	64 127		10 33		21 37		8 13	
FLAMMABILITY: Burn Test FAR 25.853(b)	Burn Time Burn Length Drip	1 2.3 ND	1 2.6 ND	3 2.8 1	6 2.8 1	0 4.5 ND	0 5.0 ND	0 4.5 ND	
WEAR: Abrasion	*Method 5306 ASTM 1175 #8 cotton duck abrader	-		-		-		Poor 750cy 1000g CS-10 wheel	
Tear	*Method 5132 Kg lbs	>6.4	4.8	>6.4	>6.4	4.0	3.1	>6.4	>6.4
IGNITION: Pill Test	ASTM D 2859	No burn char in area of pill on foam.		Slight burning of fabric 3/4 in/dia on foam.		No burn char in area of pill on foam.		-	
TOXICITY: Normalized Data per Gram of Material; 25-gram Mouse	Av Ti Min Av Td Min	0.83 2.59		2.89 4.00		1.40 3.13		-	

DECORATIVE FABRIC COVER - COMPARISONS

TABLE 20

REQUIREMENT	TEST METHOD	MATERIALS: 69-407 Nomex (103)	7979 "No Burn" (105)	15691 Coated Nylon (107)	Nylon Gold Vonarbacked (106)
COLOR:	Availability Wide Range	No	Yes	No	Discontinued
Colorfastness - Light	FTMS No. 191 *Method 5660	20SFH Poor; 40SFH Poor	20SFH Poor; 40SFH Poor	20SFH Good; 40SFH Good	20SFH Good; 40SFH Good
- Crocking	*Method 5651(B)	- -	- -	- -	- -
NBS SMOKE: (Aged and nonaged specimens)	NBS TECH NOTE 708 Nonflaming, D_m 90 sec. / 4 min.	2 / 3	2 / 6	12 / 43	- / -
	Flaming, D_m 90 sec. / 4 min.	6 / 12	11 / 19	30 / 46	- / -
FLAMMABILITY: Burn Test FAR 25.853(b)	Burn Time / Burn Length / Drip	0 / 2.8 / ND; 0 / 2.6 / ND	0 / 2.3 / ND; 0 / 2.5 / ND	0 / 4.9 / 1; 0 / 4.6 / 0	282** / 10.3** / ND
WEAR: Abrasion	*Method 5306 #8 cotton ASTM 1175 duck abrader	-	-	-	-
Tear	*Method 5132 Kg lbs	>6.4 >6.4	22 k cycles; >6.4 >6.4	2.5 3.2	>6.4 >6.4
IGNITION: Pill Test	ASTM D 2859	No burn char in area of pill on foam.	No burn char in area of pill 1/2" dia. on foam.	No burn char in area of pill 1 in. on foam	-
TOXICITY: Normalized Data per Gram of Material; 25-gram Mouse	Av Ti Min / Av Td Min	0.82 / 2.54	1.74 / 5.54	1.83 / 3.45	-

**Failed Requirements

DECORATIVE FABRIC COVER - COMPARISONS

TABLE 20 (Cont'd)

4.2 Fire Blocking Layers

The use of a fire blacking layer(s) under the decorative cover is a new aircraft seat design concept. These layers can perform a number of potential functions that include the following:

1. Substitutes for cushion topper (muslin over cushion that provides a slippery surface for decorative cover application and removal and foam reinforcement).
2. Insulates to delay involvement of the cushion mass in a fire.
3. Contributes to the tactile comfort.
4. Absorbs some of the toxic gases produced by the decorative fabric and cushion material.
5. Reinforces mechanically the tear strength of the cushioning layer.

The fire blocking layer is not intended to compensate for a cushion material that does not meet a high level of fire resistance as an individual material.

Table 21 was developed to improve visibility for the purpose of comparing blocking layer materials. Requirements are listed in order of importance.

Due to the complexity of the heat release flash fire propensity, and toxicity data, the comparison table was used with the individual data tables to make selective judgments.

All materials tested met the required FAA burn and recommended smoke requirements. In addition, all materials passed the pill ignition test showing good resistance to flame spread at that thermal exposure. PBI materials (204)(205) and proprietary black batting (206) showed indications of serious shrinkage problems and high toxicity compared to other materials and were dropped as Phase II candidates. These PBI materials were not stabilized. Stabilized material will be available by the end of the year and should be evaluated then. Of the Kynol materials, the B104S showed best all around performance. Smoke generation was at a higher temperature, and the material required a longer time to flash. The heat release was higher than other Kynols. The toxicity rating (Ti) was one of the longest for textile materials. This material is recommended for Phase II testing. The Durette duck 400-6 (217) showed very low heat release. Toxicity was not favorable, but further evaluation should be performed. This Durette (217) showed less shrinkage than (216) or (212). The (212) material showed serious shrinkage problems. The Durette (217) was recommended for Phase II testing. Nomex III performed in the same general range as Durette and in flash fire propensity tests did not flash. The small weight loss supports the low prepensity to flash. Nomex III (214) was recommended for Phase II testing. The Kermel fabric (215) showed significant shrinkage problems. The possibility of stabilizing the material should be investigated. This Kermel fabric will not be included in Phase II testing unless further testing can justify inclusion. Vonar #3 a foam material showed a significantly lower toxicity rating than any of the other blocking materials. In addition, it did not flash. Vonar #3 (210) was recommended for Phase II testing.

REQUIREMENT	TEST METHOD	MATERIALS #24 Kynol (200)	 #1110 Kynol Blend (201)	 #1090 Kynol Blend (202)	 B-104S Needle Punch (203)	 40-9010-1 PBI Fabric (204)	 40-4010-1 PBI Batting (205)
IGNITION	Pill Test ASTM D 2559	No burn char in pill area on foam	No burn char in pill area on foam	No burn char in pill area on foam	No burn char in pill area on foam	Material charred & shrunk on foam	-
BURN TEST	FAR 25.853(b) Burn Time Burn Length Drip	 1 1 2.3 2.3 ND ND	 0 0 3.1 2.9 ND ND	 0 0 2.9 2.9 ND ND	 0 0 2.5 2.4 ND ND	 0 0 1.2 1.2 ND ND	 0 0 1.4 1.2 ND ND
NBS SMOKE (Aged and nonaged specimens)	NBS NOTE 708 Nonflaming, D_m 90 sec. 4 min.	 0 1	 0 1	 2 2	 4 8	 1 2	 1 2
	Flaming, D_m 90 sec. 4 min.	0 1	3 6	4 6	11 16	0 1	0 1
TGA Based on wt loss/m^2	Paragraph 3.3	244g	196g	156g	210.9g	-	-
HEAT RELEASE TOTAL	Paragraph 3.5.3 2.5 w/cm^2 3.5 w/cm^2 5.0 w/cm^2	66.0 62.0 63.8	51.3 84.8 70.0	43.6 34.8 57.7	74.7 47.9 65.5	31.6 43.1 95.7	13.9 7.4 12.9
FLAME SPREAD @ 5.0 w/cm^2	Paragraph 3.5.3 mm/sec	Flash	6	6	8.6	None	None
FLASH FIRE PROPENSITY	Paragraph 3.5.1 Smoke °C Flash, min No. of Flash Pyro Temp °C	350 1.6 1 850	480 1.72 1 750	463 3.1 1 940	600 3.56 1 1040	510 4.18 1 940	150 3.10 1 960
TOXICITY Normalized Data per Gram & 25g Mouse	Paragraph 3.5.2 Av Ti min Av Td min	3.09 5.38	2.31 3.49	3.42 4.70	3.48 4.55	0.51 0.83	0.8 1.85
WEAR Tear	FTMS No. 191 Kg Method 5132 lbs	3.18 7	3.18 1.85 7 4.07	2.76 3.18 6.07 7	3.14 3.18 6.92 7	-	1.01 .91 2.24 2.01

Fabric Baseline (104)
Foam Baseline (306)

FIRE BLOCKING LAYERS - COMPARISONS

TABLE 21

REQUIREMENT	TEST METHOD	MATERIALS: 35-4020-1 Black Batting (206)	"Flameout" Kynol on Remay (207)	Vonar #1 Neoprene Foam (208)	Vonar #2 Neoprene Foam (209)	Vonar #3 Neoprene Foam (210)	Durette Upholstery (212)
IGNITION	Pill Test ASTM D 2559	0.8 in char area around pill on foam	No burn char in area of pill	–	–	No burn char in pill area	No burn 4 in/dia char
BURN TEST	FAR 25.853(b) Burn Time Burn Length Drip	0 0 1.7 1.9 ND ND	0 0 2.3 2.3 ND ND	0 0 2.6 2.2 ND ND	0 0 2.0 1.6 ND ND	0 0 1.7 1.6 ND ND	0 0 1.3 1.3 ND ND
NBS SMOKE (Aged and nonaged specimens)	NBS NOTE 708 Nonflaming, D_m 90 sec. 4 min.	0 2	2 8	22 34	30 57	40 98	0 3
	Flaming, D_m 90 sec. 4 min.	1 0	3 3	30 43	45 78	70 136	8 15
TGA Based on wt loss/m^2	Paragraph 3.3	139g	95g	–	–	591.5g	148.1g
HEAT RELEASE TOTAL	Paragraph 3.5.3 2.5 w/cm^2 3.5 w/cm^2 5.0 w/cm^2	28.5 28.2 29.0	– – –	58.9 51.4 17.2	– – –	82.7 76.7 74.8	70.7 44.4 –
FLAME SPREAD @ 5.0 w/cm^2	Paragraph 3.5.3 mm/sec	ND	–	Flash Vert	–	0.9	4
FLASH FIRE PROPENSITY	Paragraph 3.5.1 Smoke °C Flash, min No. of Flash Pyro Temp °C	305 No Flash – –	– – – –	263 No Flash – –	– – – –	580 No Flash – –	331 No Flash – –
TOXICITY Normalized Data per Gram & 25g Mouse	Paragraph 3.5.2 Av Ti min Av Td min	0.20 0.31	2.59 4.40	10.54 21.05	– –	10.99 Lived	0.71 1.27
WEAR Tear	FTMS No. 191 Method 5132 Kg lbs	1.01 .91 2.24 2.01	1.19 1.09 2.61 2.41	–	–	–	>6.4 >6.4

Fabric Baseline (104)
Foam Baseline (306)

FIRE BLOCKING LAYERS – COMPARISON

TABLE 21 (Cont'd)

REQUIREMENT	TEST METHOD	MATERIALS: SE-5559 Silicone Elastomer (213)	Nomex III (214)	Kermel Fabric (215)	Durette Batting 400-11 (216)	Durette Duck 400-6 (217)	
IGNITION	Pill Test ASTM D 2559	No burn char in area of pill	No burn 16 in/dia char in area of pill	-	-	-	
BURN TEST	FAR 25.853(b) Burn Time Burn Length Drip	0 0 0.1 0.1 ND ND	2 0 2.7 2.7 ND ND	1 2 2.2 2.4 ND ND	0 0 .6 .7 ND ND	-	
NBS SMOKE (Aged and nonaged specimens)	NBS NOTE 708 Nonflaming, D_m 90 sec. 4 min.	0 11	1 5	3 10	0 1	-	
	Flaming, D_m 90 sec. 4 min.	7 26	8 16	6 16	6 11	-	
TGA Based on wt loss/m^2	Paragraph 3.3	377.4g	68.6g				
HEAT RELEASE TOTAL	Paragraph 3.5.3 2.5 w/cm^2 3.5 w/cm^2 5.0 w/cm^2	- - -	21.3 71.6 73.3	60.2 60.6 67.0	71.7 36.9 77.4	19.6 38.6 36.5	
FLAME SPREAD @ 5.0 w/cm^2	Paragraph 3.5.3 mm/sec	-	> 6	> 6	None	Flash 7.5	
FLASH FIRE PROPENSITY	Paragraph 3.5.1 Smoke °C Flash, min No. of Flash Pyro Temp °C	- - - -	319 No Flash	233 2.86 1 910	-	-	
TOXICITY Normalized Data per Gram & 25g Mouse	Paragraph 3.5.2 Av Ti min Av Td min	- -	0.98 2.63	1.5 2.29	0.80 1.46	0.75 1.75	
WEAR Tear	FTMS No. 191 Kg Method 5132 lbs		5.4 3.3 11.8 7.2	4.4 6.2	-	-	

Fabric Baseline (104)
Foam Baseline (306)

FIRE BLOCKING LAYERS - COMPARISONS

TABLE 21 (Cont'd)

There was no baseline material with which to compare the fire blocking material candidates. The materials selected for Phase II testing appeared to have a balance of critical properties that was suitable for a range of designs. The further evaluation of modified forms of these fibers should be conducted during Phase II as well as investigation of any new material developments meeting program constraints. During Phase II, further testing will be performed to identify the contribution of the fire blocking layers to flame penetration and thermal insulative protection of the cushioning layers.

4.3 Cushioning Layers

Table 22 was developed to aid in comparing candidate materials and was used together with detailed advanced test tables. In this group of materials, ease of ignition was considered most important. Heat release rate was considered a primary requirement due to the mass of material available. Flash fire and toxicity were also of prime importance for the same reason. It was assumed that the thermal threat would be high to penetrate the decorative and blocking layers to reach the cushioning layers.

Three materials and the baseline in this category were logically grouped together as deep foams or materials known to be available in thicknesses of 7.62 cm (3 in.) to 10.16 cm (4 in.). They were the FG215 glass fiberblock (300) the HL neoprene foam (307) and Koylon neoprene foam (308). The Koylon foam (308) was dropped from the program due to significant smoke generation over the FAA recommended requirements. The FG 215 glass fiber block (300) exceeded the baseline foam in all categories for which it was tested and had the lowest heat release of the materials tested. The HL neoprene foam (307) had the next best performance in total heat released. The 307 foam also was significantly better in toxicity than the baseline material and all other foam. Both the (300) and (307) materials were recommended for Phase II testing. The remaining foams were available in lesser thicknesses that might be built up to greater thicknesses by plying or might be used as one of the layers of a multilayer cushion.

The R-207080 (301) foam was lower in heat release than the other foams and did not flash but showed a high toxicity interms of Ti. Further, the development sizes available did not permit mechanical testing. Visual examination indicated a relatively weak foam. New developments for an open cell foam of this type are expected to proceed more rapidly, and it was recommended that this foam be dropped until the new APN phosphazene becomes available for evaluation and then be included in the Phase II program. Of the remaining foams, the (303) and (304) had relatively low heat release and were reasonably equivalent in other properties. The (305) foam was slightly inferior in performance but offered a mechanically tougher material in terms of tear and a different range of properties.

All three foams were recommended for evaluation in the Phase II program in order to provide sufficient design flexibility.

4.4 Economic Analysis

Commercial seating outside of the transportation field is under significant material cost pressures due to the competitive structure of the market. Passenger seating in the aircraft field is not under these cost pressures. It has been estimated that a ten fold increase in material costs would only increase the total aircraft seat price by 10-15%.

REQUIREMENT	TEST METHOD	MATERIAL H-45C Urethane Baseline (306)	FG215 Glass Fiber Block (300)	R-207080 APN Phosphazene (301)	9907-13 Hypol Foam (302)	Exp 1408 Silicone Foam (303)
HEAT RELEASE	Total KW/m^2 2.5w/cm^2 3.5w/cm^2 5.0w/cm^2 Par. 3.5.3	 213.8 159.8 115.9	 35.1 24.6 -	 226 492.9 412.	-	 306 530 473
	Flame Spread @ 5w/cm^2 Par. 3.5.3 mm/sec.	>6	None	5	-	20
FLASH FIRE	Pyro Temp at 1st Smoke °C Flash Time in min Number of Flashes Sample Pyro Temp @ Flash °C	433 1.36 1 600	485 No flash	295 No flash	- - - -	391 3.0 1 825
BURN TEST Warp	**FAR 25.853b Burn Time Burn Length Drip Burn Time	 1 2.8 ND	 0 0.1 ND	 0 0.8 ND	-	 3 0.9 ND
Fill	Burn Time Burn Length Drip Burn Time	-	-	-	-	-
NBS SMOKE	NBS Tech. Note 708 Flaming 90 sec 4 min Nonflaming 90 sec 4 min	 27 37 51 134	 4 6 5 8	 43 89 14 113	-	 31 67 47 163
TGA	based on wt. loss per .028m^3 (1ft^3)	1.68kg	0.20kg-0.41kg	2.30kg	-	1.83kg
TOXICITY	Animal Toxicity per 3.5.2 Av T_i min Av T_d min	 1.95 3.18	 - -	 2.9 26.6	 - -	 6.74 7.69
INDENTATION LOAD DEFLECTION (ILD)	ASTM 1564 Method A Sect 19-26 25% 65%	10.2cm(4.0in) 195.7-222.4N (44-50 lbs)	12.1cm(4.75in) 41.9N(9.41 lbs) 252.6N(56.81bs)	-	 155.7N(35 lbs) 889.6N(200 lbs)	-
COMPRESSION SET	ASTM 1564 Sect 12-18	@80% = 5% @90% = 10%		-	32%	-

CUSHIONING LAYERS - COMPARISONS

TABLE 22

REQUIREMENT	TEST METHOD	MATERIAL #14183-B Silicone Foam (304)	#510 Silicone Foam (305)	HL 1-7-77 Neoprene Foam (307)	Koylon Firm Foam (308)	
HEAT RELEASE	Total KW/m^2 $2.5w/cm^2$ $3.5w/cm^2$ $5.0w/cm^2$ Par. 3.5.3	 519.5 468.5 596.7	 525 531 671	 97.2 142.6 138.6	 188.2 202 141	
	Flame Spread @ $5w/cm^2$ Par. 3.5.3 mm/sec.	> 6	< 5	> 6	>6	
FLASH FIRE	Pyro Temp at 1st Smoke °C Flash Time in min Number of Flashes Sample Pyro Temp @ Flash °C	520 No flash	555 2.96 1 930	375 1.6 1 740	396 No flash	
BURN TEST Warp	**FAR 25.853b Burn Time Burn Length Drip Burn Time	 0 1.5 ND	 89 0.8 ND	 0 1.0 ND	 0 1.2 ND	
Fill	Burn Time Burn Length Drip Burn Time	-	-	-	0 1.4 ND	
NBS SMOKE	NBS Tech. Note 708 Flaming 90 sec 4 min Nonflaming 90 sec 4 min	 51 115 42 118	 54 100 2 17	 84 165 45 115	 122 231* 107 222*	
TGA	based on wt. loss per $.028m^3$ ($1ft^3$)	2.69kg	3.12kg	2.04kg	-	
TOXICITY	Animal Toxicity per 3.5.2 Av T_i min Av T_d min	6.81 8.34	4.77 6.0	3.13 1.61	2.58 9.06	
INDENTATION LOAD DEFLECT ION (ILD)	ASTM 1564 Method A Sect 19-26 25% 65%	1334.4N(300lb) 12232.0N (2750lbs)	1334.4N(300lb) 9563.2N (2150lbs)	6.4cm(2.5in) 164.6N(37lbs) 725.0N(163lbs)	-	
COMPRESSION SET	ASTM 1564 Sect 12-18	@50%-30%			-	

*Failed Requirement

CUSHIONING LAYERS - COMPARISONS

TABLE 22 (Cont'd)

The real driving force in aircraft seating is performance. Tables 23 through 25 show the comparative material price estimates for 1977 and projected prices for 1980. These prices are not hard cost projections. In general, the prices tend to cluster for similar types and forms of material, such as woven fabrics of upholstery weight, woven fabrics of nonupholstery weight, nonwoven textiles and forms of similar generic type.

It is anticipated that price can affect the early use of a material in the industry on a one-for-one substitution basis even though price is not the most important factor in this program. Price will also be reflected in an eventual cost/performance evaluation of full scale seats designed, built and tested in this program.

COST	MATERIAL							
	ST-7193-29 FABRIC (100) C & A	20787 KERMEL BLEND (101) H. LELIEVRE	OL618 COTTON KNIT (102) LANGENTHAL	69-407 NOMEX (103) C & A	ST-7427-112 WOOL/NYLON (104) C & A	7979 "NO BURN" "KYNOL BLEND (105) C & A	NYLON GOLD W/VONAR 3 BACKING (106) DUPONT	#15691 COATED NYLON (107) REEVES BROS.
1977 Cost $/m2 @418 sq.m	8.31	11.47	7.61	13.49	13.72	-	-	-
Cost $/yd2 @500 sq/yd.	6.95	7.35	6.36	11.28	11.47	-	-	-
Cost $/m2 @1672 sq.m	8.31	11.47	7.11	13.49	13.72	-		
Cost $/yd2 @2000 sq/yd.	6.95	7.35	5.94	11.28	11.47	-	-	-
1980 Cost $/m2 @418 sq.m	14.39	-	8.37	26.99	22.49	-	-	-
Cost $/yd2 @500 sq.yd.	12.03	-	7.00	22.56	18.80	-	-	-
Cost $/m2 @1672 sq.m	14.39	-	7.83	26.99	22.49	-	-	-
Cost $/yd2 @2000 sq/yd.	12.03	-	6.55	22.56	18.80	-	-	-

MATERIAL COST - DECORATIVE FABRIC COVER

TABLE 23

COST	MATERIAL							
	SE-5559 SILICONE ELASTOMER (213) GE	NOMEX III FABRIC (214) DUPONT	KERMEL FABRIC (215) RHODIA	VONAR 2 NEOPRENE FOAM (209) DUPONT				
1977 Cost $/m^2$ @418 sq.m	-	6.48	7.89	1.47				
Cost $/yd^2$ @500 sq/yd.	-	5.42	-	1.23				
Cost $/m^2$ @1672 sq.m	-	6.48	7.89	1.47				
Cost $/yd^2$ @2000 sq/yd.	-	5.42	-	1.23				
1980 Cost $/m^2$ @418 sq.m	-	7.78*	-	2.19				
Cost $/yd^2$ @500 sq/yd.	-	6.50*	-	1.83				
Cost $/m^2$ @1672 sq.m	-	7.78*	-	2.19				
Cost $/yd^2$ @2000 sq/yd.	-	6.50*	-	1.83				

*DAC Projection

MATERIAL COST - FIRE BLOCKING LAYERS (Cont'd)

TABLE 23

COST	MATERIAL							
	#24 Kynol (200) AKI	#1110 Kynol Blend (201) AKI	#1090 Kynol Blend (202) AKI	B-104S Kynol Needle Punch (203) AKI	40-9010-1 PBI Fabric (204) Celanese	40-4010-1 PBI Batting (205) Celanese	35-4020-1 Black Batting (206) Celanese	"Flameout" Kynol Needled Remay (207) Dan River
<u>1977</u> Cost $/m^2$ @ 418 sq.m	7.21	6.08	4.89	2.72	- (1)	- (1)	- (1)	3.59
Cost $/yd^2$ @ 500 sq.yd.	6.03	5.08	4.09	2.27	- (1)	- (1)	- (1)	3.00
Cost $/m^2$ @ 1672 sq.m	7.07	5.98	4.81	2.60	-	-	-	3.59
Cost $/yd^2$ @ 2000 sq/yd.	5.91	5.00	4.02	2.17	- (1)	- (1)	- (1)	3.00
<u>1980</u> Cost $/m^2$ @ 418 sq/m	6.08	5.02	3.59	2.15	13.16	9.27	1.95-2.09	2.99
Cost $/yd^2$ @ 500 sq.yd.	5.08	4.20	3.00	1.80	11.00	7.75	1.63-1.75	2.50
Cost $/m^2$ @ 1672 sq/m	5.53	4.81	3.35	1.91	13.16	9.27	1.95-2.09	2.99
Cost $/yd^2$ @ 2000 sq/yd.	4.62	4.02	2.80	1.60	11.00	7.75	1.63-1.75	2.50

(1) Development material.

MATERIAL COST - FIRE BLOCKING LAYERS

TABLE 24

COST	MATERIAL							
	Vonar #3 Neoprene Foam (210) DuPont	SE-5559 Silicone Elastomer (213) G.E.	Nomex III Fabric (214) DuPont	Kermel Fabric (215) Rhodia	Vonar #2 Neoprene Foam (209) DuPont	400-11 Durette (216) Firesafe Prod		
1977 Cost $/m2 @ 418 sq.m	1.99	-	6.48	7.89	1.47	14.65		
Cost $/yd2 @ 500 sq/yd.	1.66	-	5.42		1.23	12.25		
Cost $/m2 @ 1672 sq.m	1.99	-	6.48	7.89	1.47	13.16		
Cost $/yd2 @ 2000 sq/yd.	1.66	-	5.42		1.23	11.00		
1980 Cost $/m2 @ 418 sq/m	2.60	-	7.78*	-	2.19	-		
Cost $/yd2 @ 500 sq/yd.	217	-	6.50*	-	1.83	-		
Cost $/m2 @ 1672 sq.m	2.60	-	7.78*	-	2.19	-		
Cost $/yd2 @ 2000 sq/yd.	2.17	-	6.50*	-	1.83	-		

*Dac Projection.

MATERIAL COST - FIRE BLOCKING LAYERS - Cont'd

TABLE 24

COST	MATERIAL							
	FG215 Glass Fiber Block (300) Expanded Rubber	R-207080 APN Phosphazene Foam (301) Firestone	9907-13 Hypol Foam (302) W.R. Grace	Expl408 Silicone Foam (303) Kirkhill	14183-B Silicone Foam (304) Mosites	#510 Silicone Foam (305) Silicone Eng.	H-45C Urethane Foam (306) E.R.Carpenter	HL 1-7-77 Neoprene Foam (307) Toyad
<u>1977</u> $\$/m^3$ @ 454 kg qty	3535.7	-	-	39714.29	69000	53571.42	78.41	198.23
$\$/ft^3$ @ 1000 lb.qty	9.90	-	-	111.20	193.20	150.00	2.22	5.61
$\$/m^3$ @ 2270 kg.qty	3392.86	-	-	39714.29	69000	49957.14	78.41	198.23
$\$/ft^3$ @ 5000 lb.qty	9.50	-	-	111.20	193.20	139.88	2.22	5.61
<u>1980</u> $\$/m^3$ @ 454 kg.qty	3964.29	-	-	49242.85	91800.00	71307.142	-	264.66
$\$/ft^3$ @ 1000 lb.qty	11.10	17.47 to 87.36	-	137.88	257.04	199.66	-	7.34
$\$/m^3$ @ 2270 kg.qty.	3803.57		-	49242.85	91800.00	66496.43	-	264.66
$\$/ft^3$ @ 5000 lb.qty	10.65	17.47 to 87.36	-	137.88	257.04	186.19	-	7.34

MATERIAL COST - CUSHIONING LAYERS

TABLE 25

COST	MATERIAL							
	Koylon Neoprene Foam (308) Uniroyal							
<u>1977</u> $/m³ @ 454 kg.qty	5678.57							
$/ft³ @ 1000 lb.	15.90							
$/m³ @ 2270 kg.qty	5678.57							
$/ft³ @ 5000 lb.qty	15.90							
<u>1980</u> $/m³ @ 454 kg.qty.	6532.14							
$/ft³ @ 1000 lb.qty.	18.29							
$/m³ @ 2270 kg.qty.	6532.14							
$/ft³ @ 5000 lb.qty.	18.29							

MATERIAL COST - CUSHIONING LAYERS

TABLE 25 (Cont'd)

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A data base has been established for a wide range of condidate fire resistant seat materials, and selections are made for incorporation in Phase II testing.

The new modified burn test for materials that melt and the pill test for foam represent a higher seat material standard than in current use when tested to the limits of current FAA requirements. The baseline fabric and foam, in current use, were totally consumed when subjected to the modified burn test. It is believed that the modified burn test more closely represents a combined material "as used" and is therefore a more practical test than isolated individual testing.

The difficulty of obtaining mechanical test data from suppliers focused on the test methods used in various building and transportation industries to identify material performance for application and development purposes.

The emphasis in the Phase I program was fire oriented, and missing data needed for specific design applications is expected to be accumulated as necessary to meet Phase II program requirements. Flash fire and toxicity testing were done at probable high flux levels, and a variety of thermal fluxes were used for heat release rate determinations.

Many of the materials tested are still in a development state and can be significantly improved by minor development modifications that will be forthcoming in the near future. Candidate materials were retained from each grouping where this could be justified. In some areas, the few materials available required retention of materials in order to provide the designer with sufficient options.

Several material developments had not progressed at the anticipated rate and were not available in a suitable form to meet the July 1 cutoff date for Phase I. Phosphazene foam (Firestone), polyimide foam (Solar Industries), and stabilized PBI (Firestone) were in this group.

5.2 Recommendations

It is recommended that the following materials be incorporated in the Phase II program multilayer construction evaluations:

1. Decorative Fabric Coverings
   a. ST7793-29 (100) Nylon
   b. 20787 (101) Kermel Blend
2. Fire Blocking Layers
   a. B104-S (203) Kynol (Needlepunch)
   b. 400-6 (217) Durette Duck Fabric
   c. Nomex III (214) Fabric
   d. Vonar 3 (210) Foam Interliner
3. Cushioning Layers
   a. FG215 (300) Glass Fiber Blocking
   b. H.L. Neoprene Foam (307)

c. EXP 1408 (303) Silicone Foam

d. 14183-B (304) Silicone Foam

e. #510 (305) Silicone Foam

Physical configuration selections, such as the coring of foams and blending of fibers for selected candidates, can be pursued in order to further enhance the utility and performance of these materials.

New materials should continue to be evaluated on an on-going basis to take advantage of the considerable momentum this program has contributed toward new material development. Some materials could very well meet the time requirements of being available in sufficient quantity for Phase II and in commercial production by 1980.

6.0 REFERENCES

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