ECON INCORPORATED

STUDY OF MATERIALS PERFORMANCE MODEL FOR AIRCRAFT INTERIORS

FINAL REPORT - August 31, 1980

Contract NAS2-10515

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-152378		

4. Title and Subtitle	5. Report Date
STUDY OF MATERIALS PERFORMANCE MODEL FOR AIRCRAFT INTERIORS	AUGUST 31, 1980
	6. Performing Organization Code: SC
7. Author(s): K. LEARY, J. SKRATT	8. Performing Organization Report No.
	10. Work Unit No.: 534-05-11
9. Performing Organization Name and Address: ECON, INC. 4020 MOORPARK AVE., SUITE 216 SAN JOSE, CA. 95117	11. Contract or Grant No.: NAS2-10515
	13. Type of Report and Period Covered: FINAL
12. Sponsoring Agency Name and Address: CHEMICAL RESEARCH PROJECTS OFFICE AMES RESEARCH CENTER, MOFFETT FIELD, CA. 94035	14. Sponsoring Agency Code: SC

15. Supplementary Notes

TECHNICAL MONITOR - D. KOURTIDES, CHEMICAL RESEARCH PROJECTS OFFICE, NASA - AMES RESEARCH CENTER, MOFFETT FIELD, CA.

16. Abstract

A demonstration version of an aircraft interior materials computer data library was developed to support the activities of the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee Technical Group on Compartment Interior Materials. The library contains information on selected materials applicable to aircraft seats and wall panels, including materials for the following:

- panel face sheets, bond plies, honeycomb, foam, decorative film systems,
- seat cushions, adhesives, cushion reinforcements, fire blocking layers, slip covers, decorative fabrics
- thermoplastic parts

The information obtained for each material pertains to the material's performance in a fire scenario, selected material properties and several measures of processability.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Materials, Aircraft Interiors	UNLIMITED

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
UNCLASSIFIED	UNCL	82	$19.950.

*For sale by the National Technical Information Service, Springfield, Virginia 22161

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FINAL REPORT

ECON, INC.

August 31, 1980

Prepared under Contract No. NAS2-10515 by

ECON, INC.

San Jose, California

for

AMES RESEARCH CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOREWORD

This final report has been prepared for the Chemical Research Projects Office at Ames Research Center of NASA, Moffett Field, California, under Contract No. NAS2-10515.

This report consists of documentation for the work performed under the three contract tasks in support of the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee Technical Group on Compartment Interior Materials.

I. AIRCRAFT INTERIOR MATERIALS LIBRARY PRESENTATION

II. DESCRIPTION AND DEFINITION OF MATERIAL PARAMETERS

III. DESCRIPTION AND EXAMPLE OUTPUT OF AIRCRAFT INTERIOR MATERIALS LIBRARY

IV. LISTING OF ALL MATERIALS AND THEIR CHARACTERISTICS DATA CURRENTLY INCLUDED IN LIBRARY

V. REVIEW OF BOEING'S LAVATORY PANEL STUDY

INTRODUCTION

The primary goal of ECON's work under this contract for the Chemical Research Projects Office at NASA-Ames was to support the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee Technical Group on Compartment Interior Materials by constructing a data base of selected materials that are currently or can potentially be used in aircraft seats and wall panels. An overview of the materials library has been presented by Mr. John Skratt, Vice-President of ECON, Inc., to members of the SAFER COMMITTEE. That presentation is included as the first section of this report.

As part of this contract ECON collected information regarding the specific material attributes and associated test procedures relating to aircraft fire performance safety from various SAFER Sub-Committee members. The second section of this report presents the resultant list and description of attributes for materials used in both aircraft seats and aircraft wall panels.

Based upon the recommendations of SAFER, ECON's screening model, recently developed in a demonstration version for NASA-Ames, was expanded to include a greater number of aircraft parts and was modified to accommodate more than 60 materials attributes for each material. The later modification was done to accommodate many of the material attributes that are required as input to the Composite Material Comparative Costs (CMCC) model. The materials library and the CMCC model can be utilized in conjunction with each other, providing that the scenarios being run use compatible data.

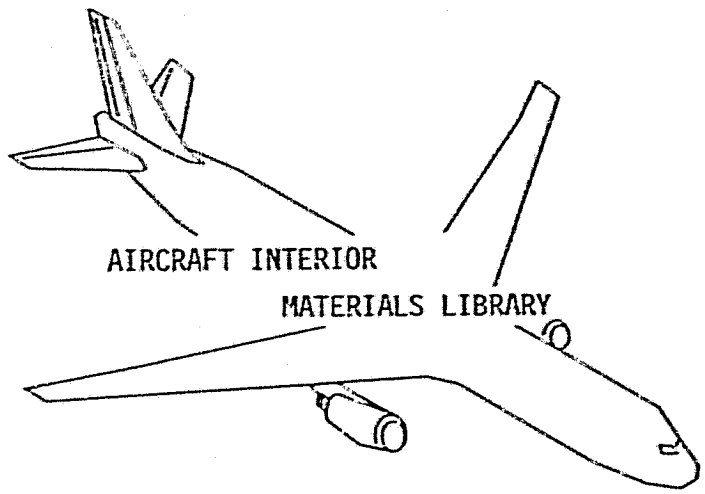
An example of the output from the materials library model is included as the third section of this report. The model was used to examine the inconsistencies between test data generation, including the number and kinds of tests run and the materials for which insufficient data is available.

I. AIRCRAFT INTERIOR MATERIALS LIBRARY PRESENTATION

The following section is a copy of the briefing charts used to present the concepts of the Aircraft Interior Materials Library to various members of the SAFER Sub-Committee on Materials/ Polymers. These charts were developed to introduce an initial version of this library constructed to include a select set of materials for aircraft interior seats and wall panels. This version of the library program was developed and is operational on the Ames in-house IBM 360/TSS computer system.

SPECIAL AVIATION FIRE AND EXPLOSION REDUCTION

ADVISORY COMMITTEE
TECHNICAL GROUP ON COMPARTMENT
INTERIOR MATERIALS



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AIRCRAFT INTERIOR MATERIALS LIBRARY

- INTRODUCTION -

- ECON PRESENTATION OF AIRCRAFT INTERIOR MATERIALS SCREENING/COST MODEL CONCEPT AT SAFER MATERIALS SUBGROUP MEETING

- SUBGROUP RECOMMENDATION -
  - VALUE IN CREATING COMPUTER BASED MATERIALS LIBRARY AS AN INITIAL STEP IN SCREENING MODEL
  - INCORPORATE SUBGROUPS INITIAL BASELINE AND ALTERNATIVE AIRCRAFT INTERIOR MATERIALS LISTING

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AIRCRAFT INTERIOR MATERIALS LIBRARY

- CONTENTS -

- MULTI-USER ACCESSIBLE COMPUTER BASED FORMAT WITH INTERACTIVE AND READABLE INPUT/OUTPUT
- DEMONSTRATION DATA
  - DECORATIVE WALL PANELS
    - DECORATIVE FILM
    - LAMINATED FACESHEETS
    - HONEYCOMB CORE
  - CONTEMPORARY SEATS
    - CUSHION
    - FABRIC
    - THERMOPLASTIC PARTS
  - DATA CHARACTERISTICS
    - DESCRIPTION OF AIRCRAFT INTERIOR PART ELEMENTS
    - GENERIC TRADE NAMES AND DESCRIPTION
    - MATERIAL CHARACTERISTICS

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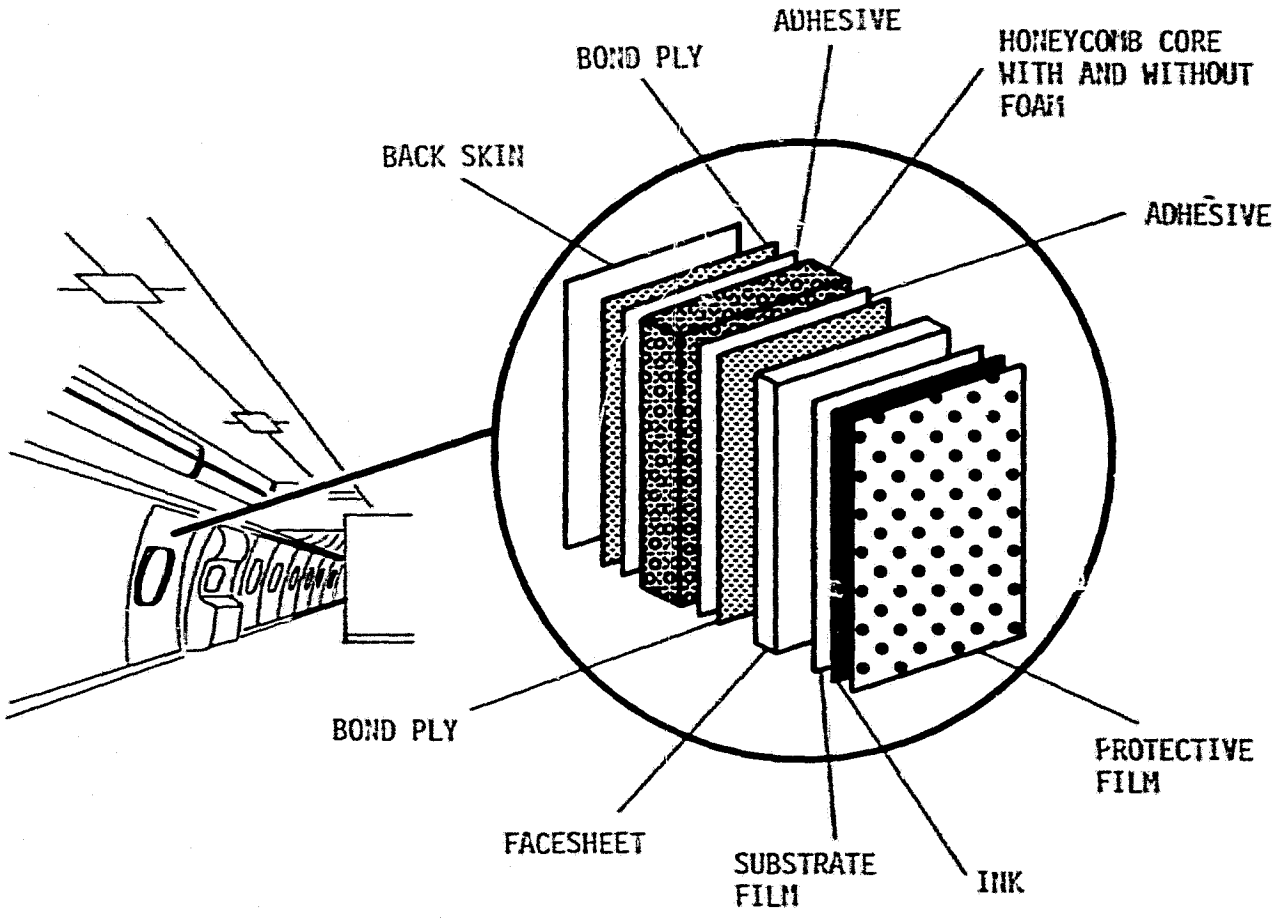
TYPICAL MULTIPLE LAYER PANEL COMPONENTS

THE MATERIAL DATA BANK FOR DECORATIVE WALL PANELS IN AIRCRAFT WILL INCLUDE BASELINE AND ALTERNATIVE MATERIALS FOR EACH OF THE PANEL COMPONENTS SHOWN



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MATERIAL IDENTIFIER LIBRARY

- PANELS -

FOR EACH COMPONENT WITH A USER SPECIFIED PANEL CONFIGURATION, THE FOLLOWING MATERIAL IDENTIFIERS STORED IN THE MATERIALS DATA BASE WILL BE PRINTED:

- MATERIAL CODE
- GENERIC NAME
- TRADE NAME

CODE	GENERIC NAME	TRADE NAME
FACE SHEET		
BASELINE:		
1012	PHENOLIC	FIBERITE MXB-6070
ALTERNATE:		
1011	PHENOLIC	CIBA-GEIGY FIBREDUX 917G
1010	PHENOLIC	NARMCO 8250
BOND PLY:		
BASELINE:		
2012	PHENOLIC	FIBERITE MXB-7255
ALTERNATE:		
2011	PHENOLIC	CIBA-GEIGY FIBREDUX 917G
ADHESIVE:		
⋮	⋮	⋮

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MATERIALS CHARACTERISTICS LIBRARY

- PANELS -

ALL MATERIAL CHARACTERISTICS DATA STORED IN THE DATA BANK WILL BE PRINTED FOR MATERIALS SPECIFICALLY IDENTIFIED BY THE USER, IN THE FOLLOWING FORMAT:

FIRE CHARACTERISTICS	B/L 1012	2012
LOI (% O_2)	65.8	.0
QDOT (W/CM^2)		
@ 1.0 W/CM^2	.071	.1
@ 2.5 W/CM^2	.071	.1
@ 5.0 W/CM^2	.594	.845
DELTA H ($W\text{-}SEC/CM^2$)		
@ 1.0 W/CM^2	13.2	18.76
@ 2.5 W/CM^2	24.71	35.12
@ 5.0 W/CM^2	43.17	61.29
CHAR YIELD (% WT. REM.)	80.9	64.4
SMOKE & TOXICITY		
DSUBS		
@ 1.0 W/CM^2	0.0	0.0
@ 2.5 W/CM^2	8.8	0.8
@ 5.0 W/CM^2	5.0	6.0
CO CONCENTRATION (PPM)		
@ 1.0 W/CM^2	7.8	7.8
@ 2.5 W/CM^2	16.4	16.4
@ 3.0 W/CM^2	51.1	51.1
ALC 50 (MG/LITER)	228.6	37.3

OTHERS	B/L 1012	2012
WEIGHT (KG)	.762	.762
RAW MATL $ (PER POUND)	ND	ND
EST. FAB $	ND	ND
PEEL	N/A	N/A
ELONGATION (%)	N/A	N/A
WEAR	ND	ND
MAINTENANCE	ND	ND
REGISTRATION	N/A	N/A
COMPATABILITY	ND	ND
REFERENCES	1.	1.

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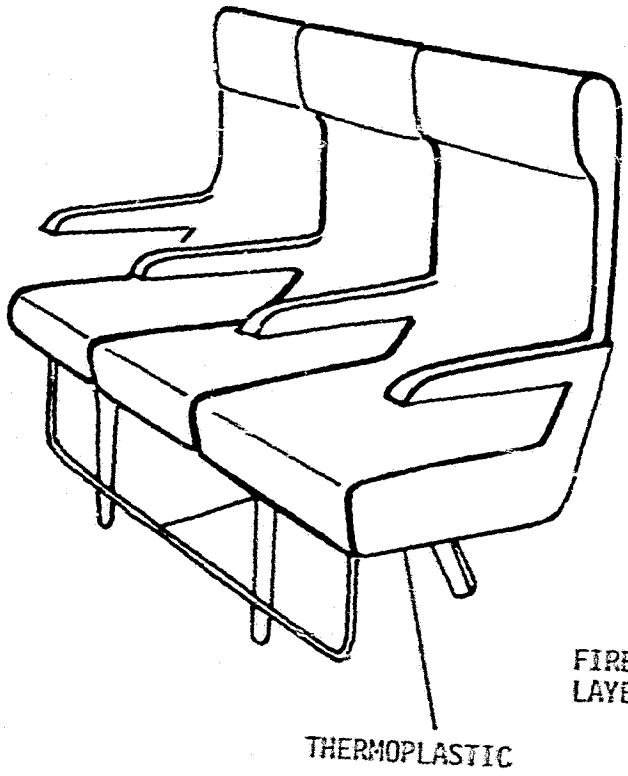
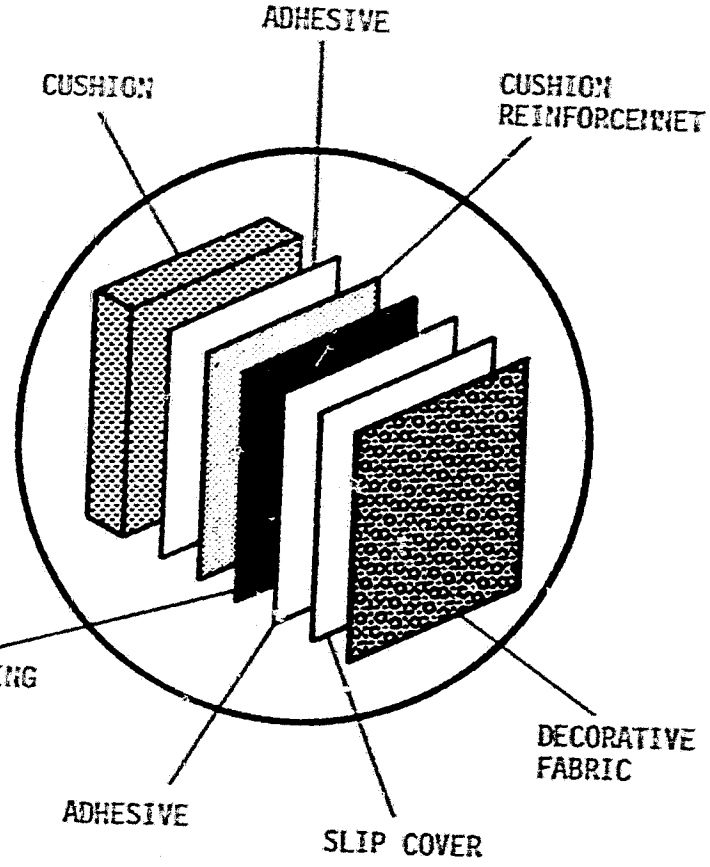
TYPICAL MULTIPLE LAYER SEAT COMPONENTS

THE MATERIAL DATA BANK FOR AIRCRAFT SEATS WILL INCLUDE BASELINE AND ALTERNATE MATERIALS FOR EACH OF THE SEAT COMPONENTS SHOWN.





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MATERIAL IDENTIFIER LIBRARY

- SEATS -

FOR EACH COMPONENT OF AIRCRAFT SEATS, THE FOLLOWING MATERIAL IDENTIFIERS STORED IN THE MATERIAL DATA BASE WILL BE PRINTED:

- MATERIAL CODE
- GENERIC NAME
- TRADE NAME
- SUPPLIER
- DESCRIPTION

CODE	GENERIC NAME	TRADE NAME	SUPPLIER	DESCRIPTION
DECORATIVE FABRIC				
ALTERNATE:				
1104	WOOL/AMIDE	SUN ECLIPSE S77427-112	COLLINS & AIKMAN	90% WOOL, 10% NYLON
BASELINE:				
1101	AMIDE-IMIDE/WOOL BLEND	20787	H. LELIEVRE	52.5% KERMEL, 47.5% WOOL
FIREBLOCKING LAYER				
3210	POLYCHLOROPRENE	VONAR #3		.475 CM NEOPRENE FOAM WITH COTTON SCRIM
⋮	⋮	⋮	⋮	⋮

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MATERIAL CHARACTERISTICS LIBRARY

- SEATS -

ALL MATERIAL CHARACTERISTICS DATA STORED IN THE DATA BANK WILL BE PRINTED MATERIALS SPECIFICALLY IDENTIFIED BY THE USER IN THE FOLLOWING FORMAT.

FIRE CHARACTERISTICS	B/L 1104	3210
PILL TEST (CM)	0.0	0.0
TIME TO IGNITION (SEC)	4.9	6.9
FLAME SPREAD (mm/SEC)		
@ 2.5 W/CM^2	3.0	0.0
@ 3.5 W/CM^2	6.0	0.6
@ 5.0 W/CM^2	6.7	0.9
FAR TEST - time (SEC)	1.0	0.0
length (CM)	2.3	1.7
drip (Y,N)	0.0	0.0
HEAT RELEASE - (KW/M^2)		
@ 2.5 W/CM^2	163.0	82.7
@ 3.5 W/CM^2	159.0	76.7
@ 5.0 W/CM^2	160.0	74.8
FLASH TEMP (^{o}C)	275.0	NO FLASH
SMOKE & TOXICITY		
NBS SMOKE - FLAME 90s	64.0	70.0
4m	127.0	136.0
NO FLAME 90s	28.0	40.0
4m	73.0	98.0
TIME TO INCAPACITATION (MIN)	.83	10.99
TIME TO DEATH (MIN)	2.59	LIVED
TIME TO 1ST SMOKE (MIN)	.3	.5
1ST SMOKE TEMP (^{o}C)	230.0	580.0
CHAR YIELD TGA (% WT REM.)	ND	4.9

OTHER	B/L 1104	3210
DENSITY (G/M^2, G/M^3)	457.	954.
SAMPLE WT (GR)	10.5	22.7
AVAIL OF COLORS	YES	N/A
COLORFAST	EXC	N/A
COMPRESSION (%)	N/A	N/A
ILD (CM)	N/A	N/A
ABRASION (# CYCLES)	750.	ND
TEAR (KG)	>6.4	ND
TENSILE STRENGTH (KG)	ND	ND
EST. FAB COST ($)	ND	ND
RAW MAT'L COST ($)	ND	ND
REFERENCES	2.	2.

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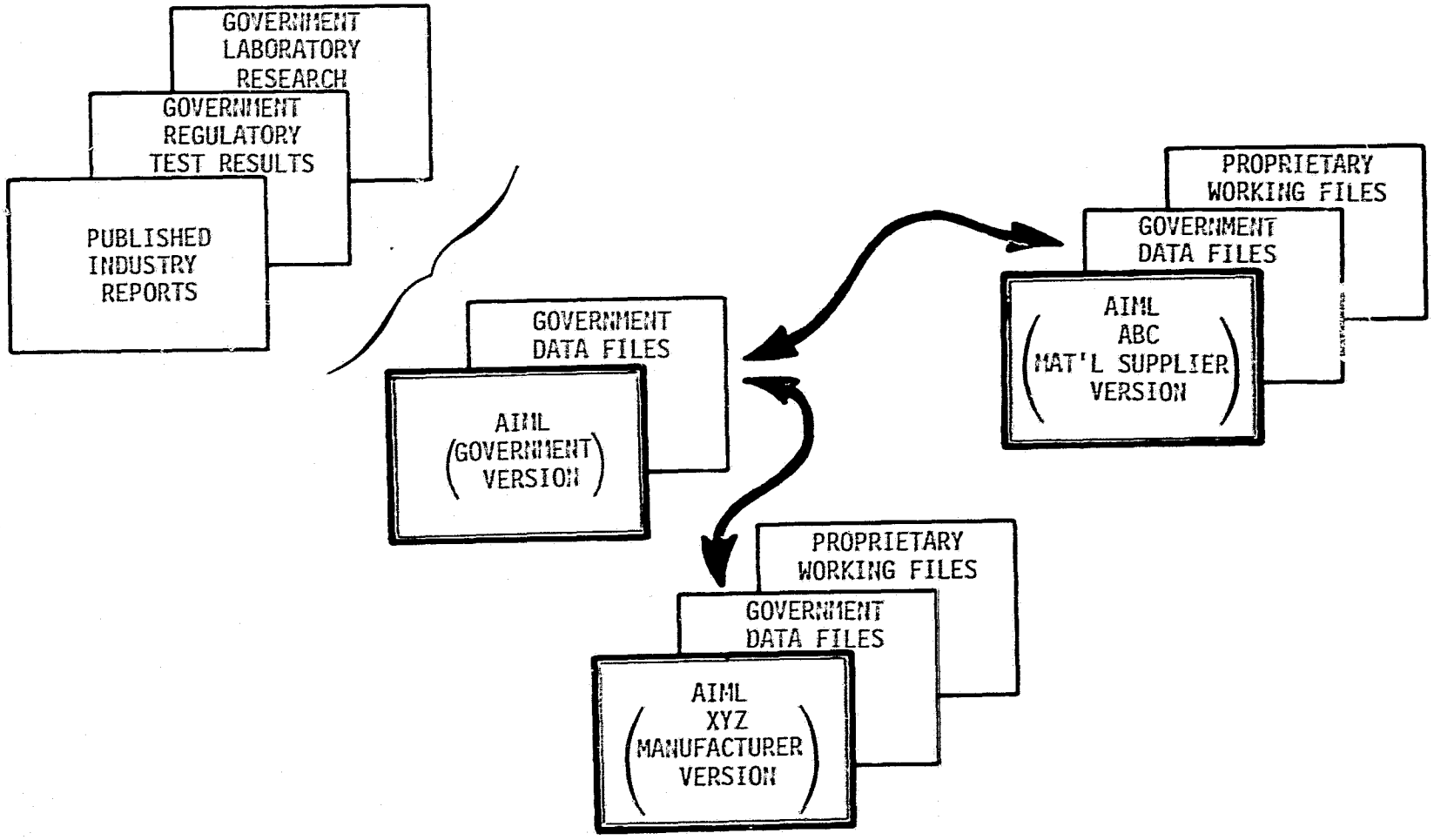
AIRCRAFT INTERIOR MATERIALS LIBRARY (AIML)

- GOVERNMENT/INDUSTRY PARTICIPATIONS -



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AIRCRAFT INTERIOR MATERIALS LIBRARY

- DATA FILES -

- USE OF FULLY OR PARTIALLY FILLED DATA FILES
  - POINTS OUT AREAS OF MISSING DATA
  - ALLOWS ASSESSMENT OF "IMPORTANCE" OF MISSING DATA
- GENERALLY AVAILABLE DATA FILE CAN BE HELD SEPARATE FROM SPECULATIVE OR WORKING FILES
  - WORKING FILES CAN BE PROPRIETARY DATA BASE FOR INDUSTRY
  - WORKING FILES SERVE AS PARAMETRIC ASSESSMENT OF NEW OR PROPOSED MATERIAL PERFORMANCE

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AIRCRAFT INTERIOR MATERIALS LIBRARY

- SUMMARY -

- SUCCESSFUL DEMONSTRATION OF COMPUTER BASED AIRCRAFT INTERIOR MATERIALS LIBRARY ROUTINE
- DEMONSTRATION ACCOMPLISHED WITH:
  - GOVERNMENT FUNDED INDUSTRY RESEARCH
  - GOVERNMENT RESEARCH
- LIBRARY FUNCTION WILL BE BASIS FOR SUBSEQUENT MATERIALS SCREENING LIFE CYCLE COST ESTIMATION ANALYSIS
  - ASSIST IN DIRECTING/MANAGING GOVERNMENT RESEARCH
- INTENT TO EXPAND DATA BASE BY WORKING WITH:
  - OTHER GOVERNMENT RESEARCH ORGANIZATION
  - REPRESENTATIVES OF MANUFACTURING INDUSTRIES
  - REPRESENTATIVES OF MATERIAL SUPPLIERS

II. DESCRIPTION AND DEFINITION OF MATERIAL PARAMETERS

A list of material attributes has been collected from persons recommended by members of the SAFER Advisory Committee Technical Group and is included as Section II of this report. These attributes represent the parameters or performance values of a specific material by which the material can be assessed in terms of its contribution to an aircraft fire scenario and applicability to a particular component. The attributes included on the list vary as a function of the component the material is utilized for because of the different performance criteria of the different components.

A description or explanation of the attribute is also provided. Each of these attributes has been incorporated into the Aircraft Interior Materials Library.

DESCRIPTION AND DEFINITION OF PARAMETERS UTILIZED IN CURRENT VERSION OF LIBRARY MODEL

PARAMETER	DESCRIPTION/DEFINITION/EXPLANATION

MATERIAL IDENTIFIER

CHEMICAL NAME	
TRADE NAME	
MATERIAL SUPPLIER	

THERMAL AND FIRE CHARACTERISTICS

IGNITION RESISTANCE	ASTM D-2859; "pill" is ignited and burn distance from "pill" is measured
TIME TO IGNITION (SEC)	The time in seconds until the sample ignites at a 3.5 W/M^2 heat flux
LOI	Limiting oxygen index; ASTM D-2863; percent oxygen required for ignition
FLAME RESISTANCE	Far 28.853 (a) Appendix F; 60 sec. vertical flame exposure to measure burn length, ignition time, self-extinguishing time and whether there is any drip from the sample; specimen thickness ~ .040 ± .005 in.
FLAME SPREAD (MM/S) AT 5 W/CM^2	Flame travel rate at the heat source specified. The flame spread is measured in millimeters per second
PYRO TEMP AT 1st FLASH (C)	This data entry provides the sample pyrolysis temperature in degrees Centigrade at the moment the flame flash occurs
HEAT RELEASE RATE ($\dot{Q}$)	Heat release rate usually expressed in W/CM^2 at heat flux rate specified
TOTAL HEAT RELEASE (Δ HEAT)	Total heat release usually expressed in W sec/cm^2 at heat flux rate specified

THERMAL AND FIRE CHARACTERISTICS (CONT'D)

PARAMETER	DESCRIPTION/DEFINITION/EXPLANATION
HEAT DEFLECTION	ASTM D 648, Method of test for deflection temperature of plastics under load; 264 psi and 1820 kPa load measurements
THERMAL STABILITY (TGA)	Thermogravemetric analysis at heating rate of 20° C/Min in air; °C
CHAR YIELD (% WT REMAINING)	Percent of material (char) remaining at 800°C
SMOKE DENSITY -Ds	FAA-NPRM-SMOKE Standard Docket No. 9611, Notice 73-5, Feb. 1975, Appendix F (1); measures flaming condition, smoke density at 6 min. for specimen thickness of .040 ± .005 in.
TIME TO 1st SMOKE (MIN)	The time in minutes until the specimen first emits smoke during testing
TIME TO INCAPACITATION (MIN)	The time for the start of the test until it appears that all laboratory animals in the test cannot function as a result of the toxic fumes released from the material being tested
TIME TO DEATH (MIN)	The time in minutes until all laboratory animals have died as a result of the toxic fumes from the specimen
ALC (50)	Apparent lethal concentration of toxic substances producing 50% incidence of death among laboratory animals during test at 700°C; MG/liter
CO CONCENTRATION	Carbon monoxide concentration at heat flux rate specified, expressed in parts per million

PARAMETER	DESCRIPTION/DEFINITION/EXPLANATION
PHYSICAL CHARACTERISTICS	
DENSITY (G/M^2 or G/M^3)	ASTM D-1564; the density of the material expressed either as grams per square meter or as grams per cubic meter, in the case of materials such as foams
WEIGHT	FTMS 191, Method 5041
SAMPLE WEIGHT (GRAMS)	The weight of the sample utilized in the tests, expressed in units of grams
SPECIFIC GRAVITY	FTMS 406, Method 5011
WATER ABSORPTION	FTMS 406, Method 7031 % water absorbed after 24 hours at $23^{\circ}C$
HARDNESS	FTMS 406, Method 1081 Rockwell, M scale
MECHANICAL CHARACTERISTICS	
FLEXURAL STRENGTH	FTMS 406, Method 1031, in 10^3 psi
FLEXURAL MODULUS	FTMS 406, Method 1031, in 10^6 psi
MOD OF ELASTICITY	FTMS 406, Method 1031, in psi
COMPRESSIVE STRENGTH	FTMS 406, Method 1031, in 10^3 psi
COMPRESSION	ASTM 1564, % of compression
INDENTATION/DEFLECTION	ASTM, Method A, in CM
TENSILE STRENGTH	FTMS 406, Method 1011 Number of kilograms required to reach limit of material's tensile strength, in 10^3 psi
ELONGATION	FTMS 406, Method 1011, Speed C & of original length which sample stretches under load at break
IMPACT	FTMS 406, Method 1071 . Ft. lb/in of notch . Ni m/m

PARAMETERS	DESCRIPTION/DEFINITION/EXPLANATION
SERVICE CHARACTERISTICS	
ABRASION	ASTM 1175 duck abrader; number of cycles which abrader completes before material is torn
TEAR	FTMS 191, Method 5132; amount of pressure needed to produce tear, in KG
COLORFASTNESS	FTMS 191, Method 5060; use of ultra-violet Fade-O-Meter, in hours
SOIL AND CLEANER RESISTANCE	Excellent, good, fair or poor
EASE OF MAINTENANCE INDEX	An indexed number relating to the maintenance complexity
PEEL STRENGTH	The amount of pull necessary to separate one layer from another in a panel, in centimeter kilograms
PROCESS CHARACTERISTICS	
AVAILABILITY OF COLORS	A "yes" or "no" indicating availability of a wide range of colors
RAW MATERIAL COST	Cost of raw material in $/LB
EST. FABRICATION COSTS	Estimated costs to fabricate one unit, in $
SURFACE BONDING ACCEPTANCE	180^{o} -Peel lb/in. -N/m

III. DESCRIPTION AND EXAMPLE OUTPUT OF AIRCRAFT INTERIOR MATERIALS LIBRARY

The following section includes an example interactive computer session utilizing the Aircraft Interior Materials Library. An explanation accompanies the example session. The library is capable of handling data for many different aircraft interior parts. At this time the library contains information on selected materials applicable to aircraft seats and wall panels. This includes materials for the following:

- panel face sheet
- panel bond ply
- panel honeycomb
- panel foam
- panel decorative film system
- seat cushion
- seat adhesive
- seat cushion reinforcement
- seat fire blocking layer
- seat slip cover
- seat decorative fabric
- seat thermoplastics

The library system was developed and is operational on the Ames in-house IBM 360/TSS computer system.

DESCRIPTION OF
AIRCRAFT INTERIOR MATERIALS LIBRARY
INTERACTIVE COMPUTER SESSION

The following describes to the reader each of the steps taken in the example session of the user-interactive Aircraft Interior Materials Library. User responses to program questions are underlined in the example to facilitate the reader's understanding. In addition, user responses are all followed by a carriage return symbolized in this example by an arrow (➲).

To initiate execution of the model the user types LIBRARY ➲ . After the program titles and credits have been printed, the program lists the aircraft interior parts for which data can be stored. The user is requested to specify the part he wants to analyze by keying in the number which corresponds to that part.

SPECIFY PART NUMBER FOR ANALYSIS: ? 5 ➲

When the user specifies part number 5 - decorative wall panels (for which data is stored), the library program indicates it is loading into its work space the data base of panel material characteristics.

READ DATA BASE OF PANEL MATERIAL CHARACTERISTICS.
SCDAK***.FAA.PANELMAT COPIED AS SCDAK***.TEMP.D.

The program now implements a subroutine specific to this part. There are two basic assemblies or sub-parts for wall panels, a sandwich made up of a core structure with bond plies, facesheets, adhesives and possibly foam, and a film system made up of protective and substrate films with inks and adhesives. For this version of the screening model, decorative panels can utilize one of four sandwich configurations. These options, along with their corresponding numbers, are printed and the user is asked to select the appropriate configuration:

SANDWICH CONFIGURATIONS FOR DECORATIVE PANELS

NO	NAME
1	EPOXY
2	PHENOLIC
3	BISMALEIMIDE
4	POLYIMIDE

SPECIFY SANDWICH CONFIGURATION FOR ANALYSIS: ? 1 ↵

The user response of "1" indicates that an epoxy sandwich configuration has been specified. This ensures that all potential components of the sandwich panel will be compatible with epoxy face sheets and bondplies.

At this point the user is shown a list of the potential decorative thermoplastic film configurations that may be combined with the sandwich configuration already selected. He is requested to specify one of the films as follows:

DECORATIVE THERMOPLASTIC FILM CONFIGURATIONS FOR WALL PANELS

NO	PROTECTIVE FILM	INK	SUBSTRATE FILM
1	CLEAR PVF TEDLAR	ACRYLIC	WHITE PVF TEDLAR
2	CLEAR PVF TEDLAR	ACRYLIC	FM-PVF FLAM MOD TEDLAR
3	CLEAR PVF2 FLUOREX H	ACRYLIC	WHITE PVF2 FLUOREX H
4	CLEAR PVF TEDLAR	ACRYLIC	WHITE PC
5	CLEAR PVF TEDLAR	ACRYLIC	CLEAR POLYETHERSULFONE

SPECIFY THERMOPLASTIC FILM CONFIGURATION FOR ANALYSIS: ? 1 ↵

In this instance, the user response of "1" designates that the decorative film configuration will consist of:

CLEAR PVF TEDLAR
ACRYLIC INK
WHITE PVF TEDLAR

The user is then asked if he wants a list of the material generic and trade names that can be used in the specified sandwich and film configurations.

PRINT LIBRARY OF MATERIAL NAMES (YES OR NO)? YES ↵

The "yes" response generates the list of generic and trade names with the associated, unique material code categorized by the appropriate elements in the decorative panel. The decorative panel may be comprised of up to eight sub-parts or elements. Figure 1 displays the organization of a hypothetical system for a decorative panel that utilizes all eight elements.

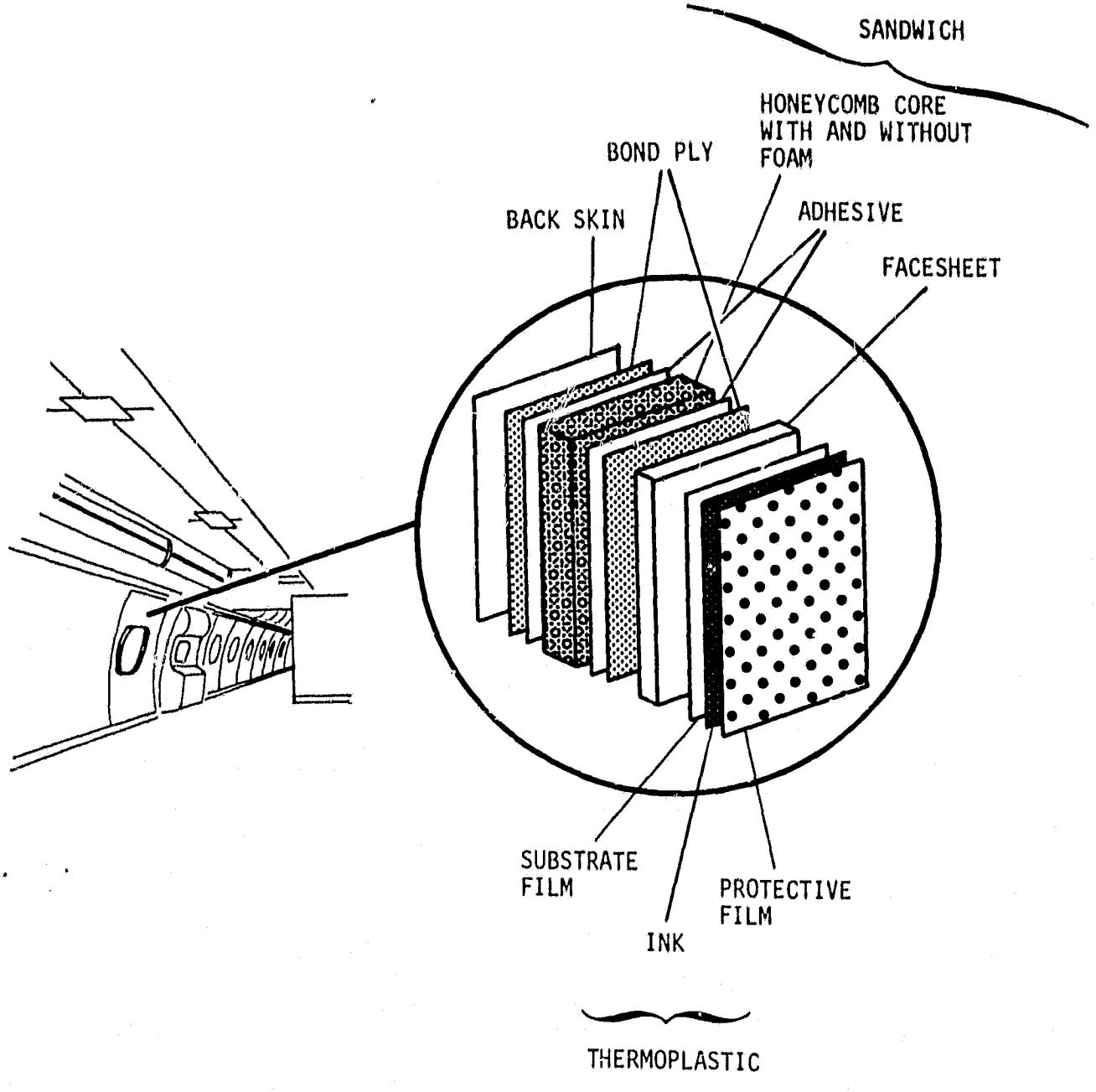


Figure 1 - MATERIAL ELEMENTS IN AN AIRCRAFT PANEL

As can be seen in Figure 1 on the preceding page, some elements may appear more than one time in the panel system. The configurations specified in the example computer session that follows utilize only six of the eight potential elements.

The user is then requested to specify whether he wants a list of the characteristics data for any of the materials named.

PRINT LIBRARY OF MATERIAL CHARACTERISTICS DATA? (YES OR NO)? YES ↵

When a "yes" response is made, as in the example, the user is asked to specify the particular materials the library of characteristics data is to be printed for. The materials are named using 4-digit codes which have been displayed in the library of material names.

SPECIFY MATERIAL CODES AS 4 DIGIT INTEGERS
(ZERO WILL TERMINATE REQUESTS)

MATERIAL CODE? 1000 ↵
MATERIAL CODE? etc

Only four material libraries can be displayed at one time due to the requirement to restrict the report output to the size of an 8½" width page. Therefore, if the user wants to display data on six materials, the first four will be specified and printed for one report and the fifth and sixth specified and printed in a second report. The example that follows illustrates this procedure. Data for material coded 1000, 2000, 4010 and 6400 are printed in the first report, and materials coded 7500 and 8400 in the second. The user indicates he is finished with requests for material characteristics data by entering at zero.

MATERIAL CODE? 0 ↵

The user's entry of "0" has indicated the termination of requests for materials characteristics to be displayed for materials within the previously specified configurations, (epoxy sandwich configuration and

thermoplastic film configuration #1). However, the library model continues to allow the user to specify requests for additional libraries as follows:

ANOTHER LIBRARY? (YES OR NO)?YES ↵

A "no" response indicates that no additional libraries are desired and will trigger a question about continuing with the screening model. A "yes" response will trigger a series of questions to prompt the user to specify the exact library desired. The first question is:

NEW CONFIGURATION ? (YES OR NO) ?NO ↵

A "yes" response will direct the program to the series of questions discussed earlier to specify the sandwich and thermoplastic film configurations. A "no" response will trigger a question to determine if the additional library desired is for a new part.

NEW PART ? (YES OR NO) ?YES ↵

In the example provided in the pages following this discussion, the user has indicated with a "yes" response that a new library is desired for a new part. Thus, the model is directed to return to the original set of questions prompting the selection of an aircraft interior part.

The remainder of the example session that follows traces the execution of the library model for two additional aircraft parts, seats and luminaires. The run is terminated when the user answers the questions "ANOTHER LIBRARY?" and "CONTINUE WITH SCREENING MODEL?" with a "no" response.

ANOTHER LIBRARY? (YES OR NO)?NO ↵

CONTINUE WITH SCREENING MODEL ? (YES OR NO)?NO ↵

E N D O F R U N

TERMINATED: STOP

EXAMPLE INTERACTIVE COMPUTER SESSION WITH

AIRCRAFT INTERIOR MATERIALS LIBRARY

```
LIBRARY

                AIRCRAFT INTERIOR MATERIALS MODEL
                DEMONSTRATION VERSION 8/80

        NASA-ARC                        ECON, INC.
        CRPO                            SAN JOSE, CA.
        J.A. PARKER                     J.P. SKRATT


EXISTING DATA BASE HAS INFORMATION ON THE FOLLOWING A/C INTERIOR PARTS

     NO     NAME
     --     ----
      1     CEILING PANELS
      2     LAVATORY PANELS
      3     CARGO LININGS
      4     STRUCTURAL FLOOR PANELS
      5     DECORATIVE WALL PANELS
      6     WINDOW REVEALS
      7     SEATS
      8     INSULATION
      9     PARTITIONS
     10     STORAGE BIN DOORS
     11     DUST COVERS
     12     CARPETS
     13     DRAPERY
     14     LUMINAIRES


SPECIFY PART NUMBER FOR ANALYSIS: ? 5


READ DATA BASE OF PANEL MATERIAL CHARACTERISTICS.
SCDAK***.FAA.PANELMAT COPIED AS SCDAK***.TEMP.D.
```

SANDWICH CONFIGURATIONS FOR DECORATIVE WALL PANELS

NO	NAME
1	EPOXY
2	PHENOLIC
3	BISMALEIMIDE
4	POLYIMIDE

SPECIFY SANDWICH CONFIGURATION FOR ANALYSIS: ?1

DECORATIVE THERMOPLASTIC FILM CONFIGURATIONS FOR DECORATIVE WALL PANELS

NO	PROTECTIVE FILM	INK	SUBSTRATE FILM
1	CLEAR PVF TEDLAR	ACRYLIC	WHITE PVF TEDLAR
2	CLEAR PVF TEDLAR	ACRYLIC	FM-PVF FLAM MOD TEDLAR
3	CLEAR PVF2 FLUOREX H	ACRYLIC	WHITE PVF2 FLUOREX H
4	CLEAR PVF TEDLAR	ACRYLIC	WHITE PC
5	CLEAR PVF TEDLAR	ACRYLIC	CLEAR POLYETHERSULFONE

SPECIFY THERMOPLASTIC FILM CONFIGURATION FOR ANALYSIS: ?1

PRINT LIBRARY OF MATERIAL NAMES? (YES OR NO)?YES

CODE NO.	GENERIC NAME	TRADE NAME
S A N D W I C H		
FACE SHEET		
BASELINE- 1000	EPOXY	FIBERITE MXB-7203
BOND PLY		
BASELINE= 2000	EPOXY	FIBERITE MXB-7251
HONEYCOMB		
BASELINE- 4010		NOMEX13PCF (0.125 IN CELL)
T H E R M O P L A S T I C F I L M		
PROTECTIVE FILM		
BASELINE- 6400		CLEAR PVF TEDLAR
DECORATIVE INK		
BASELINE- 7500		ACRYLIC INK
SUBSTRATE FILM		
BASELINE- 8400		WHITE PVF TEDLAR

PRINT LIBRARY OF MATERIAL CHARACTERISTICS DATA? (YES OR NO)?YES

SPECIFY MATERIAL CODES AS 4 DIGIT INTEGERS.
(ZERO WILL TERMINATE REQUESTS)

MATERIAL CODE?1000
MATERIAL CODE?2000
MATERIAL CODE?4010
MATERIAL CODE?6400

	CODE 1000 B/L	CODE 2000 B/L	CODE 4010 B/L	CODE 6400 B/L
FIRE CHARACTERISTICS				
LOI	29.000	27.700	30.900	46.000
Q(DOT) AT 5 W/CM2	0.108	0.154	0.129	0.240
Q(DOT) AT 2.5 W/CM2	0.790	1.122	0.343	0.780
Q(DOT) AT 1 W/CM2	1.030	1.466	1.072	0.108
DELTA H AT 5 W/CM2	14.660	17.500	22.410	42.060
DELTA H AT 2.5 W/CM2	18.920	22.590	109.930	217.500
DELTA H AT 1 W/CM2	56.310	67.270	254.360	297.300
CHAR YIELD (% WT REMAINING)	80.300	59.800	10.000	10.000
SMOKE & TOXICITY				
D(S) AT 5 W/CM2/	1.800	1.800	0.000	N/D
D(S) AT 2.5 W/CM2	12.200	2.200	0.220	N/D
D(S) AT 1 W/CM2	18.800	18.800	4.320	N/D
CO CONCENTRATION AT 1 W/CM2	16.900	16.900	9.570	N/D
CO CONCENTRATION AT 2.5 W/CM2	32.100	32.100	20.210	N/D
CO CONCENTRATION AT 5 W/CM2	83.800	83.800	62.760	N/D
ALC(50) (MG/LITER)	N/D	71.400	N/D	N/D
OTHER				
WEIGHT (KG)	0.822	0.822	0.936	0.069
RAW MATERIAL $/LB	10.000	10.000	40.000	N/D
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	17.200	N/A	N/A
ELONGATION (%)	N/A	N/A	N/A	48.600
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/A	N/A	N/D

SPECIFY MATERIAL CODES AS 4 DIGIT INTEGERS.
(ZERO WILL TERMINATE REQUESTS)

MATERIAL CODE?7500
MATERIAL CODE?8400
MATERIAL CODE?0

	CODE 7500 B/L	CODE 8400 B/L
FIRE CHARACTERISTICS		
LOI	15.000	30.000
Q(DOT) AT 5 W/CM2	0.040	0.120
Q(DOT) AT 2.5 W/CM2	0.130	0.390
Q(DOT) AT 1 W/CM2	0.180	0.540
DELTA H AT 5 W/CM2	7.010	21.030
DELTA H AT 2.5 W/CM2	36.300	108.750
DELTA H AT 1 W/CM2	49.600	148.650
CHAR YIELD (% WT REMAINING)	15.000	10.000
SMOKE & TOXICITY		
D(S) AT 5 W/CM2/	N/D	N/D
D(S) AT 2.5 W/CM2	N/D	N/D
D(S) AT 1 W/CM2	N/D	N/D
CO CONCENTRATION AT 1 W/CM2	N/D	N/D
CO CONCENTRATION AT 2.5 W/CM2	N/D	N/D
CO CONCENTRATION AT 5 W/CM2	N/D	N/D
ALC(50) (MG/LITER)	N/D	N/D
OTHER		
WEIGHT (KG)	0.139	0.139
RAW MATERIAL $/LB	10.000	3.000
EST. FABRICATION COSTS ($)	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	N/A
ELONGATION (%)	N/A	63.000
WEAR	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/D

```
ANOTHER LIBRARY? (YES OR NO)?YES

NEW CONFIGURATION ? (YES OR NO) ?NO

NEW PART ? (YES OR NO) ?YES


EXISTING DATA BASE HAS INFORMATION ON THE FOLLOWING A/C INTERIOR PARTS

     NO      NAME
     --      ----
      1      CEILING PANELS
      2      LAVATORY PANELS
      3      CARGO LININGS
      4      STRUCTURAL FLOOR PANELS
      5      DECORATIVE WALL PANELS
      6      WINDOW REVEALS
      7      SEATS
      8      INSULATION
      9      PARTITIONS
     10      STORAGE BIN DOORS
     11      DUST COVERS
     12      CARPETS
     13      DRAPERY
     14      LUMINAIRES


SPECIFY PART NUMBER FOR ANALYSIS:
                  (ZERO WILL TERMINATE PROGRAM.)   ?7


READ DATA BASE OF SEAT MATERIAL CHARACTERISTICS.
SCDAK***.FAA.SEATMAT COPIED OVER SCDAK***.TEMP.D.
```

PRINT LIBRARY OF MATERIAL NAMES? (YES OR NO)?YES

CODE NO.	GENERIC NAME	TRADE NAME	SUPPLIER
DECORATIVE FABRIC			
BASELINE-			
1104	WOOL/AMIDE 90% WOOL,10% NYLON	S77427-112	COLLINS&AIKMAN
ALTERNATES-			
1100	AMIDE		
1101	AMIDE-IMIDE/WOOL BLEND 52.5% KERMEL,47.5% WOOL	20787	H.LELIEVRE
1102	COTTON 100% COTTON DOUBLE KNIT		
1103	ARAMID 100% NOMEX DENSITY		
1105	NOVOLOID/ARAMID 50% KYNOL,50% NOMEX		
1106	AMIDE/CHLOROPRENE NYLON GOLD WITH VONAR#3 FOAM BACKING		
1107	URETHANE/AMIDE URETHANE ELASTOMER COATED ON NYLON FABRIC		
SLIP SHEET			
ALTERNATES-			
2214	ARAMID NOMEX III FABRIC		

FIRE BLOCKING LAYER

ALTERNATES-

3200 NOVOLOID
100% KYNOL (TWILL WEAVE)

3201 NOVOLOID/ARAMID
70% KYNOL,30% NOMEX(PERM PRESS FINISH) 200G/M2

3202 NOVOLOID/ARAMID
70% KYNOL,30% NOMEX (PERM PRESS FINISH) 159G/M2

3203 NOVOLOID
100% KYNOL BATTING ON POLYESTER SCRIM NEEDLE PUNCH

3204 IMIDAZOLE
PBI FABRIC & UNSTABILIZED TWILL

3205 IMIDAZOLE
PBI & BATTING NATURAL UNSTABILIZED FROM STAPLE

3206 IMIDAZOLE
BLACK COLORED BATTING

3207 NOVOLOID FIBER BATTING
REMAY SPUN BONDED POLYESTER FAB NEEDLED W/ 100% KYNOL

3208 POLYCHLOROPRENE VONAR NO.1
.156 CM NEOPRENE FOAM WITH COTTON SCRIM

3209 POLYCHLOROPRENE VONAR NO.2
.317CM NEOPRENE FOAM WITH COTTON SCRIM

3210 POLYCHLOROPRENE VONAR NO.3
.475CM NEOPRENE FOAM WITH COTTON SCRIM

3212 DURETTE UPHOLSTERY

3215 AMIDE-IMIDE
KERMEL FABRIC

3216 400-11 FIRE-SAFE PROD
10.4 OZ/YD2 DURETTE BATTING

REINFORCEMENT

ALTERNATES-

4213 SILICONE
SILICONE RUBBER

4214 ARAMID
NOMEX III FABRIC

4217 400-6 FIRE-SAFE PROD
4.4 OZ/YD2 DURETTE DUCK

CUSHIONING

BASELINE-

5302 URETHANE
POLYURETHANE FOAM,FLEXIBLE

ALTERNATES-

5300 GLASS FG 215 EXP RUBBER&PLAST
GLASS FIBER BLOCK CUSHION EDGE GRAIN BLOCKING

5301 POLYPHOSPHAZENE
APN PHOSPHAZENE OPEN CELL FOAM

5303 SILICONE
SILICONE RUBBER SPONGE

5304 SILICONE 14183-B MOSITES RUBBER
SILICONE RUBBER SPONGE 11.8 LB/F3

5305 SILICONE
SILICONE RUBBER SPONGE

5306 H-45C ER CARPENTER
URETHANE FOAM .036G/CC

5307 HL1-7-77 TOYAD
NEOPRENE FOAM,OPEN CELL

5309 9FR618B KIRKILL RUBBER
SILICONE SPONGE 9.4 LB/FT3

5310 LS FORMULA T TOYAD
NEOPRENE FOAM 7.5PCF

```
PRINT LIBRARY OF MATERIAL CHARACTERISTICS DATA? (YES OR NO)?YES


 SPECIFY MATERIAL CODES AS 4 DIGIT INTEGERS.
        (ZERO WILL TERMINATE REQUESTS)

MATERIAL CODE?1104
MATERIAL CODE?3203
MATERIAL CODE?5314
 5314MATERIAL CODE IS NOT CURRENTLY IN DATA BASE.
MATERIAL CODE?5304
MATERIAL CODE?0
```

	CODE 1104 B/L	CODE 3203 ALT	CODE 5304 ALT
FIRE CHARACTERISTICS			
PILL TEST (CM)	0.000	0.000	N/A
TIME TO IGNITION (SEC)	4.900	25.000	10.000
FLAME SPREAD(MM/S) AT 2.5 W/CM2	3.000	3.600	5.500
FLAME SPREAD(MM/S) AT 3.5 W/CM2	6.000	7.000	6.000
FLAME SPREAD(MM/S) AT 5 W/CM2	6.700	8.600	6.000
FAR 25.853(B) TIME (SEC)	1.000	0.000	0.000
FAR 25.853(B) LENGTH (CM)	2.300	2.500	1.500
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO
PYRO TEMP AT 1ST FLASH (C)	275.000	40.000	NO FLASH
HEAT RELEASE (KW/M2) 2.5 W/CM2	163.000	74.700	519.500
HEAT RELEASE (KW/M2) 3.5 W/CM2	159.000	47.900	468.500
HEAT RELEASE (KW/M2) 5 W/CM2	160.000	65.500	596.700
SMOKE & TOXICITY			
NBS - FLAMING 90 SEC	64.000	11.000	51.000
NBS - FLAMING 4 MIN	127.000	16.000	115.000
NBS - NON FLAMING 90 SEC	28.000	4.000	42.000
NBS - NON FLAMING 4 MIN	73.000	8.000	118.000
TIME TO INCAPACITATION (MIN)	0.830	3.480	6.810
TIME TO DEATH (MIN)	2.590	4.550	8.340
TIME TO 1ST SMOKE (MIN)	0.300	1.100	1.200
OTHER			
DENSITY (G/M2 OR G/M3)	457.000	213.000	0.190
SAMPLE WEIGHT (GRAMS)	10.500	4.700	80.500
AVAILIBILITY OF COLORS	YES	NO	NO
COLORFAST	EXCELLENT	N/A	N/A
COMPRESSION (%)	N/A	N/A	0.300
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/D
ABRASION (NO. OF CYCLES)	750.000	N/D	N/D
TEAR (KG)	6.400	3.140	N/D
TENSILE STRENGTH (KG)	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	1.000	N/D

```
ANOTHER LIBRARY? (YES OR NO)?YES

NEW PART ? (YES OR NO) ?YES


EXISTING DATA BASE HAS INFORMATION ON THE FOLLOWING A/C INTERIOR PARTS


     NO      NAME
     --      ----
      1      CEILING PANELS
      2      LAVATORY PANELS
      3      CARGO LININGS
      4      STRUCTURAL FLOOR PANELS
      5      DECORATIVE WALL PANELS
      6      WINDOW REVEALS
      7      SEATS
      8      INSULATION
      9      PARTITIONS
     10      STORAGE BIN DOORS
     11      DUST COVERS
     12      CARPETS
     13      DRAPERY
     14      LUMINAIRES


SPECIFY PART NUMBER FOR ANALYSIS:
                  (ZERO WILL TERMINATE PROGRAM.)   ?14


READ DATA BASE O  THERMOPLASTICS MATERIAL CHARACTERISTICS.
SCDAK***.FAA.THERMAL COPIED OVER SCDAK***.TEMP.D.

PRINT LIBRARY OF MATERIAL NAMES? (YES OR NO)?YES
         WHAT? (YES OR NO)YES


        CODE
         NO.  GENERIC NAME            TRADE NAME
        ----  ------------            ----------

THERMOPLASTICS
--------------

    BASELINE-
        6410 CHLORINATED-PVC

    ALTERNATES-
        6411 POLYCARBONATE            SL 1000
        6412 POLYETHERSULFONE         212 P
        6413 POLYPHENYLENE SULFIDE
```

PRINT LIBRARY OF MATERIAL CHARACTERISTICS DATA? (YES OR NO)?YES

SPECIFY MATERIAL CODES AS 4 DIGIT INTEGERS.
(ZERO WILL TERMINATE REQUESTS)

MATERIAL CODE?6410
MATERIAL CODE?6411
MATERIAL CODE?6412
MATERIAL CODE?6413

	CODE 6410 B/L	CODE 6411 ALT	CODE 6412 ALT	CODE 6413 ALT
THERMAL AND FIRE CHARACTERISTICS				
HEAT DEFLECTION TEMP @ 264 PSI	200.000	230.000	390.000	275.000
HEAT DEFLECTION TEMP @ 1820 KPA	84.000	110.000	199.000	135.000
SMOKE DENSITY FLAMING (6MIN)	140.000	300.000	20.000	100.000
TGA C	N/D	N/D	440.000	430.000
LIMITING OXYGEN INDEX	50.000	32.000	30.000	48.000
ALC50 AT 700 C MG/LITER	N/D	N/D	N/D	N/D
DELTA HEAT 1.0 W/CM2	N/D	N/D	N/D	N/D
2.5 W/CM2	N/D	N/D	N/D	N/D
5.0 W/CM2	N/D	N/D	N/D	N/D
CHAR YIELD	N/D	N/D	N/D	N/D
QDOT AT 1.0 W/CM2	N/D	N/D	N/D	N/D
2.5 W/CM2	N/D	N/D	N/D	N/D
5.0 W/CM2	N/D	N/D	N/D	N/D
FAR 25.853	N/D	N/D	N/D	N/D
CO AT 1.0 W/CM2	N/D	N/D	N/D	N/D
2.5 W/CM2	N/D	N/D	N/D	N/D
5.0 W/CM2	N/D	N/D	N/D	N/D
MECHANICAL & PHYSICAL				
TENSILE STRENGTH (PSI)	5400.000	8000.000	11000.000	9500.000
TENSILE STRENGTH (MPA)	37.200	55.200	75.800	65.400
ELONGATION % OF R.T.	40.000	30.000	N/D	1.500
FLEXURAL STRENGTH (PSI)	10000.000	12000.000	16000.000	13000.000
FLEXURAL STRENGTH (MPA)	68.900	82.700	113.000	88.600
SPECIFIC GRAVITY	1.570	1.230	1.370	1.300
IMPACT STRENGTH, NOTCHED IZOD	6.600	2.000	1.600	1.200
IMPACT STRENGTH, N M/M:	352.000	107.000	85.400	64.200
MOD OF ELASTICITY (K PSI)	300.000	300.000	350.000	500.000
MOD OF ELASTICITY (MPA)	2070.000	2070.000	2415.000	3550.000
COMPRESSIVE STRENGTH (PSI)	N/D	N/D	N/D	N/D
COMPRESSIVE STRENGTH (MPA)	N/D	N/D	N/D	N/D
WEIGHT	N/D	N/D	N/D	N/D
OTHER				
ULTRAVIOLET FADE-O-METER (1 HR)	60.000	60.000	50.000	50.000
SURFACE BONDING ACCEPTANCE 180	10.000	10.000	POOR	N/D
SURFACE BONDING ACCEPTANCE, N/M	1751.000	1751.000	N/D	N/D
SOIL & CLEANER RESISTANCE	EXCELLENT	FAIR	FAIR	EXCELLENT
COST RATING	1.300	1.000	4.000	2.500

```
 SPECIFY MATERIAL CODES AS 4 DIGIT INTEGERS.
        (ZERO WILL TERMINATE REQUESTS)

MATERIAL CODE?0

 ANOTHER LIBRARY? (YES OR NO)?NO

 CONTINUE WITH SCREENING MODEL ? (YES OR NO)?NO


E N D   O F    R U N
 TERMINATED: STOP
>
```

IV. LISTING OF ALL MATERIALS AND THEIR CHARACTERISTICS DATA CURRENTLY INCLUDED IN LIBRARY

This section contains computer output reports for all the materials entered into the library during this study. The section is divided into materials used in panels, materials used in seats, and thermoplastic materials used in window reveals and luminaires. The panel materials are further divided into configurations for the sandwich and decorative film. Each subsection is labeled to indicate the appropriate part and configuration.

Each subsection contains two kinds of output reports. The first set of output reports displays the name and corresponding code number for each material as well as the material trade name. The second set of reports shows the fire characteristics, smoke and toxicity and other miscellaneous data.

DECORATIVE PANEL MATERIALS

SANDWICH CONFIGURATION:	NO. 1	EPOXY
FILM CONFIGURATION:	NO. 1	CLEAR PVF TEDLAR
		ACRYLIC INK
		WHITE PVF TEDLAR

CODE NO.	GENERIC NAME	TRADE NAME
FACE SHEET		
BASELINE-2000	EPOXY	FIBERITE MXB-7203
BOND PLY		
BASELINE-2000	EPOXY	FIBERITE MXB-7251
HONEYCOMB		
BASELINE-4010		NOMEX13PCF (0.125 IN CELL)
PROTECTIVE FILM		
BASELINE-6400		CLEAR PVF TEDLAR
DECORATIVE INK		
BASELINE-7500		ACRYLIC INK
SUBSTRATE FILM		
BASELINE-8400		WHITE PVF TEDLAR

	CODE 1000 B/L	CODE 2000 B/L	CODE 4010 B/L	CODE 6400 B/L
FIRE CHARACTERISTICS				
LOI	29.000	27.700	30.900	46.000
Q(DOT) AT 5 W/CM2	0.108	0.154	0.129	0.240
Q(DOT) AT 2.5 W/CM2	0.790	1.122	0.343	0.780
Q(DOT) AT 1 W/CM2	1.030	1.466	1.072	0.108
DELTA H AT 5 W/CM2	14.660	17.500	22.410	42.060
DELTA H AT 2.5 W/CM2	18.920	22.590	109.930	217.500
DELTA H AT 1 W/CM2	56.310	67.270	254.300	297.300
CHAR YIELD (% WT REMAINING)	80.300	59.800	10.000	10.000
SMOKE & TOXICITY				
D(S) AT 5 W/CM2	1.800	1.800	0.000	N/D
D(S) AT 2.5 W/CM2	12.200	2.200	0.220	N/D
D(S) AT 1 W/CM2	18.800	18.800	4.320	N/D
CO CONCENTRATION AT 1 W/CM2	16.900	16.900	9.570	N/D
CO CONCENTRATION AT 2.5 W/CM2	32.100	32.100	20.210	N/D
CO CONCENTRATION AT 5 W/CM2	83.800	83.800	62.760	N/D
ALC(50) (MG/LITER)	N/D	71.400	N/D	N/D
OTHER				
WEIGHT (KG)	0.822	0.822	0.936	0.069
RAW MATERIAL $/LB	10.000	10.000	40.000	N/D
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	17.200	N/A	N/A
ELONGATION (%)	N/A	N/A	N/A	48.600
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/A	N/A	N/D

	CODE 7500 B/L	CODE 8400 B/L
FIRE CHARACTERISTICS		
LOI	15.000	30.000
Q(DOT) AT 5 W/CM2	0.040	0.120
Q(DOT) AT 2.5 W/CM2	0.130	0.390
Q(DOT) AT 1 W/CM2	0.180	0.540
DELTA H AT 5 W/CM2	7.010	21.030
DELTA H AT 2.5 W/CM2	36.300	108.750
DELTA H AT 1 W/CM2	49.600	148.650
CHAR YIELD (% WT REMAINING)	15.000	10.000
SMOKE & TOXICITY		
D(S) AT 5 W/CM2	N/D	N/D
D(S) AT 2.5 W/CM2	N/D	N/D
D(S) AT 1 W/CM2	N/D	N/D
CO CONCENTRATION AT 1 W/Cm2	N/D	N/D
CO CONCENTRATION AT 2.5 W/CM2	N/D	N/D
CO CONCENTRATION AT 5 W/CM2	N/D	N/D
ALC(50) (MG/LITER)	N/D	N/D
OTHER		
WEIGHT (KG)	0.139	0.139
RAW MATERIAL $/LB	10.000	3.000
EST. FABRICATION COSTS ($)	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	N/A
ELONGATION (%)	N/A	63.000
WEAR	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/D

DECORATIVE PANEL MATERIALS

SANDWICH CONFIGURATION:	NO. 2	PHENOLIC
FILM CONFIGURATION:	NO. 2	CLEAR PVF TEDLAR ACRYLIC INK FM-PVF FLAM MOD TEDLAR

CODE NO.	GENERIC NAME	TRADE NAME
FACE SHEET		
BASELINE-		
1012	PHENOLIC	FIBERITE MXB-6070
ALTERNATES-		
1011	PHENOLIC	CIBA-GEIGY FIBREDUX 917G
1010	PHENOLIC	NARMCO 8250
BOND PLY		
BASELINE-		
2012	PHENOLIC	FIBERITE MXB-7255
ALTERNATES-		
2011	PHENOLIC	CIBA-GEIGY FIBREDUX 917G
2010	PHENOLIC	NARMCO 9251
HONEYCOMB		
BASELINE-		
4010		NOMEX13PCF (0.125 IN CELL)
FOAM		
BASELINE-		
5100		ICU 2PCF
PROTECTIVE FILM		
BASELINE-		
6400		CLEAR PVF TEDLAR
DECORATIVE INK		
BASELINE-		
7500		ACRYLIC INK
SUBSTRATE FILM		
BASELINE-		
8402		FR-PVF FLAM MOD TEDLAR

	CODE 1012 B/L	CODE 1011 ALT	CODE 1010 ALT	CODE 2012 B/L
FIRE CHARACTERISTICS				
LOI	65.800	100.000	50.700	23.000
D(DOT) AT 5 W/CM2	0.071	0.032	0.090	0.100
D(DOT) AT 2.5 W/CM2	0.071	0.086	0.182	0.100
D(DOT) AT 1 W/CM2	0.594	0.268	0.746	0.845
DELTA H AT 5 W/CM2	13.200	5.690	27.840	18.760
DELTA H AT 2.5 W/CM2	24.710	27.900	34.290	35.120
DELTA H AT 1 W/CM2	43.170	64.550	53.350	61.290
CHAR YIELD (% WT REMAINING)	80.900	83.200	74.400	64.400
SMOKE & TOXICITY				
D(S) AT 5 W/CM2/	0.000	0.200	0.000	0.000
D(S) AT 2.5 W/CM2	8.800	0.500	0.400	0.800
D(S) AT 1 W/CM2	5.000	1.600	2.000	6.000
CO CONCENTRATION AT 1 W/CM2	7.800	8.300	17.100	7.800
CO CONCENTRATION AT 2.5 W/CM2	16.400	20.400	19.600	16.400
CO CONCENTRATION AT 5 W/CM2	51.100	82.800	72.300	51.100
ALC(50) (MG/LITER)	228.600	133.000	N/D	87.300
OTHER				
WEIGHT (KG)	0.762	0.725	0.970	0.762
RAW MATERIAL $/LB	N/D	15.000	N/D	N/D
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	N/A	N/A	19.500
ELONGATION (%)	N/A	N/A	N/A	N/A
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/D	N/A	N/A	N/A

	CODE 2011 ALT	CODE 2010 ALT	CODE 4010 B/L	CODE 5100 B/L
FIRE CHARACTERISTICS				
LOI	53.500	32.300	30.900	23.000
D(DOT) AT 5 W/CM2	0.047	0.127	0.129	0.200
D(DOT) AT 2.5 W/CM2	0.125	0.258	0.343	0.686
D(DOT) AT 1 W/CM2	0.392	1.060	1.072	1.600
DELTA H AT 5 W/CM2	8.300	39.550	22.410	14.100
DELTA H AT 2.5 W/CM2	40.720	48.730	109.930	69.190
DELTA H AT 1 W/CM2	94.210	77.490	254.360	160.100
CHAR YIELD (% WT REMAINING)	57.500	47.100	10.000	5.500
SMOKE & TOXICITY				
D(S) AT 5 W/CM2/	0.200	0.000	0.000	0.000
D(S) AT 2.5 W/CM2	0.500	0.400	0.220	0.400
D(S) AT 1 W/CM2	1.600	2.000	4.320	2.800
CO CONCENTRATION AT 1 W/CM2	8.300	17.100	9.570	3.600
CO CONCENTRATION AT 2.5 W/CM2	20.400	19.600	20.210	7.700
CO CONCENTRATION AT 5 W/CM2	82.800	72.300	62.760	23.900
ALC(50) (MG/LITER)	119.300	119.200	N/D	N/D
OTHER				
WEIGHT (KG)	0.735	0.970	0.936	0.357
RAW MATERIAL $/LB	15.000	N/D	40.000	N/D
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	11.500	15.700	N/A	N/A
ELONGATION (%)	N/A	N/A	N/A	N/A
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/A	N/A	N/A

	CODE 8402 B/L
FIRE CHARACTERISTICS	
LOI	67.800
D(DOT) AT 5 W/CM2	0.078
D(DOT) AT 2.5 W/CM2	0.254
D(DOT) AT 1 W/CM2	0.351
DELTA H AT 5 W/CM2	10.500
DELTA H AT 2.5 W/CM2	54.400
DELTA H AT 1 W/CM2	76.300
CHAR YIELD (% WT REMAINING)	20.000
SMOKE & TOXICITY	
D(S) AT 5 W/CM2/	N/D
D(S) AT 2.5 W/CM2	N/D
D(S) AT 1 W/CM2	N/D
CO CONCENTRATION AT 1 W/CM2	N/D
CO CONCENTRATION AT 2.5 W/CM2	N/D
CO CONCENTRATION AT 5 W/CM2	N/D
ALC(50) (MG/LITER)	N/D
OTHER	
WEIGHT (KG)	0.139
RAW MATERIAL $/LB	N/D
EST. FABRICATION COSTS ($)	0.000
PEEL STRENGTH (CM.KG)	N/A
ELONGATION (%)	37.800
WEAR	N/D
EASE OF MAINTENANANCE INDEX	N/D

DECORATIVE PANEL MATERIALS

SANDWICH CONFIGURATION:	NO. 3	BISMALEIMIDE
FILM CONFIGURATION:	NO. 3	CLEAR PVF2 FLOUREX H ACRYLIC INK WHITE PVF2 FLOUREX H

	CODE NO.	GENERIC NAME	TRADE NAME
FACE SHEET			
BASELINE-	1021	BISMALEIMIDE	RHODIA KERIMID 601
BOND PLY			
BASELINE-	2021	BISMALDEIMIDE	RHODIA KERIMID 601
ADHESIVE			
BASELINE-	3031	POLYMIDE	AMCYANAMID FM34
HONEYCOMB			
BASELINE-	4011	PHENOLIC/POLYAMINOMEX 3 1.8PCF	
FOAM			
BASELINE-	5300		PQ 2PCF
ALTERNATES-	5101		ICU 2PCF (PYROLYZED)
PROTECTIVE FILM			
BASELINE-	6401		CLEAR PVF2 FLUOREX H
DECORATIVE INK			
BASELINE-	7500		ACRYLIC INK
SUBSTRATE FILM			
BASELINE-	8401		WHITE PVF2 FLUOREX H

	CODE 1021 B/L	CODE 2021 B/L	CODE 3031 B/L	CODE 4011 B/L
FIRE CHARACTERISTICS				
LOI	56.000	52.600	58.900	30.900
D(DOT) AT 5 W/CM2	0.087	0.099	0.073	0.216
D(DOT) AT 2.5 W/CM2	0.299	0.343	0.253	0.742
D(DOT) AT 1 W/CM2	0.644	0.762	0.563	1.653
DELTA H AT 5 W/CM2	16.070	18.440	13.620	39.970
DELTA H AT 2.5 W/CM2	21.270	24.410	18.030	52.910
DELTA H AT 1 W/CM2	38.660	44.370	32.760	96.160
CHAR YIELD (% WT REMAINING)	63.900	61.300	72.700	10.000
SMOKE & TOXICITY				
D(S) AT 5 W/CM2/	0.200	0.200	0.100	0.300
D(S) AT 2.5 W/CM2	1.400	1.400	0.700	2.500
D(S) AT 1 W/CM2	2.000	2.000	1.000	3.500
CO CONCENTRATION AT 1 W/CM2	5.300	5.300	2.700	9.500
CO CONCENTRATION AT 2.5 W/CM2	12.400	12.400	6.200	22.200
CO CONCENTRATION AT 5 W/CM2	57.200	57.200	28.600	102.000
ALC(50) (MG/LITER)	N/D	N/D	N/D	N/D
OTHER				
WEIGHT (KG)	0.717	0.717	0.358	1.279
RAW MATERIAL $/LB	15.000	15.000	35.000	40.000
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	7.900	N/A	N/A
ELONGATION (%)	N/A	N/A	N/A	N/A
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/D	N/A	N/A	N/A

	CODE 5300 B/L	CODE 5101 ALT	CODE 6401 B/L	CODE 8401 B/L
FIRE CHARACTERISTICS				
LOI	N/D	63.500	25.900	59.700
Q(DOT) AT 5 W/CM2	0.152	0.152	0.060	0.060
Q(DOT) AT 2.5 W/CM2	0.525	0.525	0.195	0.195
Q(DOT) AT 1 W/CM2	1.169	1.069	0.270	0.270
DELTA H AT 5 W/CM2	28.270	29.230	10.520	13.680
DELTA H AT 2.5 W/CM2	37.420	38.690	54.380	70.690
DELTA H AT 1 W/CM2	68.010	70.310	74.330	96.630
CHAR YIELD (% WT REMAINING)	18.300	8.800	20.000	37.000
SMOKE & TOXICITY				
D(S) AT 5 W/CM2/	0.200	0.300	N/D	N/D
D(S) AT 2.5 W/CM2	1.800	1.800	N/D	N/D
D(S) AT 1 W/CM2	2.500	3.000	N/D	N/D
CO CONCENTRATION AT 1 W/CM2	6.800	7.200	N/D	N/D
CO CONCENTRATION AT 2.5 W/CM2	15.700	14.600	N/D	N/D
CO CONCENTRATION AT 5 W/CM2	72.200	70.600	N/D	N/D
ALC(50) (MG/LITER)	N/D	N/D	N/D	N/D
OTHER				
WEIGHT (KG)	0.905	0.905	0.105	0.070
RAW MATERIAL $/LB	N/D	N/D	7.000	7.000
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	N/A	N/A	N/A
ELONGATION (%)	N/A	N/A	7.000	14.200
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/A	N/D	N/D

DECORATIVE PANEL MATERIALS

SANDWICH CONFIGURATION:	NO. 4	POLYMIDE
FILM CONFIGURATION:	NO. 4	CLEAR PVF TEDLAR
		ACRYLIC INK
		WHITE PC

CODE NO.	GENERIC NAME	TRADE NAME
FACE SHEET		
BASELINE- 1030	POLYMIDE	DUPONT PYRALIN 3002
BOND PLY		
BASELINE- 2030	POLYMIDE	DUPONT PYRALIN 3002
ADHESIVE		
BASELINE- 3030	POLYIMIDE	AMCYANAMID BR34
HONEYCOMB		
BASELINE- 4031	POLYIMIDE/POLYAMNOMEX 4 3PCF(0.125 IN CELL)	
ALTERNATES- 4030	POLYIMIDE/FIBERG4.5PCF (0.1875 IN CELL)	
FOAM		
BASELINE- 5200		PI/PU 2PCF
PROTECTIVE FILM		
BASELINE- 6400		CLEAR PVF TEDLAR
DECORATIVE INK		
BASELINE- 7500		ACRYLIC INK
SUBSTRATE FILM		
BASELINE- 8600		WHITE PC

	CODE 1030 B/L	CODE 2030 B/L	CODE 3030 B/L	CODE 4031 B/L
FIRE CHARACTERISTICS				
LOI	100.000	71.400	49.800	35.200
Q(DOT) AT 5 W/CM2	0.043	0.068	0.076	0.270
Q(DOT) AT 2.5 W/Cm2	0.043	0.068	0.076	0.270
Q(DOT) AT 1 W/CM2	0.165	0.259	0.291	1.035
DELTA H AT 5 W/CM2	10.380	16.290	18.260	65.030
DELTA H AT 2.5 W/CM2	11.210	17.590	19.720	70.200
DELTA H AT 1 W/CM2	14.050	22.000	24.660	87.800
CHAR YIELD (% WT REMAINING)	86.900	75.900	73.000	10.000
SMOKE & TOXICITY				
D(S) AT 5 W/CM2/	0.000	0.000	0.000	0.000
D(S) AT 2.5 W/CM2	0.120	0.120	0.060	0.100
D(S) AT 1 W/CM2	0.930	0.930	0.460	0.900
CO CONCENTRATION AT 1 W/CM2	13.530	13.530	6.770	12.900
CO CONCENTRATION AT 2.5 W/CM2	17.390	17.370	8.690	16.500
CO CONCENTRATION AT 5 W/CM2	36.970	36.970	18.480	35.100
ALC(50) (MG/LITER)	N/D	N/D	N/D	N/D
OTHER				
WEIGHT (KG)	0.985	0.985	0.493	0.936
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	0.000	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	14.500	N/A	N/A
ELONGATION (%)	N/A	N/A	N/A	N/A
WEAR	N/D	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/D	N/A	N/A	N/A

	CODE 4030 ALT	CODE 5200 B/L	CODE 8600 B/L
FIRE CHARACTERISTICS			
LOI	58.900	27.700	30.000
Q(DOT) AT 5 W/CM2	0.270	0.200	0.050
Q(DOT) AT 2.5 W/CM2	0.270	1.699	0.293
Q(DOT) AT 1 W/CM2	0.435	2.837	0.405
DELTA H AT 5 W/CM2	65.030	85.000	15.770
DELTA H AT 2.5 W/CM2	70.200	139.070	81.560
DELTA H AT 1 W/CM2	87.800	395.330	111.490
CHAR YIELD (% WT REMAINING)	46.300	3.700	25.000
SMOKE & TOXICITY			
D(S) AT 5 W/CM2/	0.000	0.000	N/D
D(S) AT 2.5 W/CM2	0.100	5.800	N/D
D(S) AT 1 W/CM2	0.100	N/D	N/D
CO CONCENTRATION AT 1 W/CM2	9.800	0.000	N/D
CO CONCENTRATION AT 2.5 W/CM2	N/D	21.800	N/D
CO CONCENTRATION AT 5 W/CM2	14.200	93.000	N/D
ALC(50) (MG/LITER)	N/D	N/D	N/D
OTHER			
WEIGHT (KG)	0.667	1.902	0.346
RAW MATERIAL $/LB	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	0.000	0.000	0.000
PEEL STRENGTH (CM.KG)	N/A	N/A	N/A
ELONGATION (%)	N/A	N/A	14.000
WEAR	N/D	N/D	N/D
EASE OF MAINTENANANCE INDEX	N/A	N/A	N/D

SEATS:	DECORATIVE FABRIC
	SLIP SHEET
	FIRE BLOCKING LAYER
	REINFORCEMENT
	CUSHIONING

CODE NO.	GENERIC NAME	TRADE NAME	SUPPLIER

DECORATIVE FABRIC

BASELINE-

1104 WOOL/AMIDE — S77427-112 — COLLINS&AIKMAN
90% WOOL,10% NYLON

ALTERNATES-

1100 AMIDE

1101 AMIDE-IMIDE/WOOL BLEND — 20787 — H.LELIEVRE
52.5% KERMEL,47.5% WOOL

1102 COTTON
100% COTTON DOUBLE KNIT

1103 ARAMID
100% NOMEX DENSITY

1105 NOVOLOID/ARAMID
50% KYNOL,50% NOMEX

1106 AMIDE/CHLOROPRENE
NYLON GOLD WITH VONARH3 FOAM BACKING

1107 URETHANE/AMIDE
URETHANE ELASTOMER COATED ON NYLON FABRIC

SLIP SHEET

ALTERNATES-

2214 ARAMID
NOMEX III FABRIC

FIRE BLOCKING LAYER

ALTERNATES-

3200 NOVOLOID
100% KYNOL (TWILL WEAVE)

3201 NOVOLOID/ARAMID
70% KYNOL,30% NOMEX(PERM PRESS FINISH) 200G/M2

3202 NOVOLOID/ARAMID
70% KYNOL,30% NOMEX (PERM PRESS FINISH) 159G/M2

3203 NOVOLOID
100% KYNOL BATTING ON POLYESTER SCRIM NEEDLE PUNCH

3204 IMIDAZOLE
PBI FABRIC & UNSTABILIZED TWILL

3205 IMIDAZOLE
PBI & BATTING NATURAL UNSTABILIZED FROM STAPLE

3206 IMIDAZOLE
BLACK COLORED BATTING

3207 NOVOLOID FIBER BATTING
REMAY SPUN BONDED POLYESTER FAB NEEDLED W/ 100% KYNOL

3208 POLYCHLOROPRENE VONAR NO.1
.156 CM NEOPRENE FOAM WITH COTTON SCRIM

3209 POLYCHLOROPRENE VONAR NO.2
.317CM NEOPRENE FOAM WITH COTTON SCRIM

3210 POLYCHLOROPRENE VONAR NO.3
.475CM NEOPRENE FOAM WITH COTTON SCRIM

3212 DURETTE UPHOLSTERY

3215 AMIDE-IMIDE
KERMEL FABRIC

3216 400-11 FIRE-SAFE PROD
10.4 OZ/YD2 DURETTE BATTING

REINFORCEMENT

ALTERNATES-

4213 SILICONE
SILICONE RUBBER

4214 ARAMID
NOMEX III FABRIC

4217 400-6 FIRE-SAFE PROD
4.4 OZ/YD2 DURETTE DUCK

CUSHIONING

BASELINE-

5302 URETHANE
POLYURETHANE FOAM,FLEXIBLE

ALTERNATES-

5300 GLASS FG 215 EXP RUBBER&PLAST
GLASS FIBER BLOCK CUSHION EDGE GRAIN BLOCKING

5301 POLYPHOSPHAZENE
APN PHOSPHAZENE OPEN CELL FOAM

5303 SILICONE
SILICONE RUBBER SPONGE

5304 SILICONE 14183-B MOSITES RUBBER
SILICONE RUBBER SPONGE 11.8 LB/FT3

5305 SILICONE
SILICONE RUBBER SPONGE

5306 H-450 ER CARPENTER
URETHANE FOAM .036G/CC

5307 HL1-7-77 TOYAD
NEOPRENE FOAM,OPEN CELL

5309 9FR6188 KIRKILL RUBBER
SILICONE SPONGE 9.4 LB/FT3

5310 L5 FORMULA T TOYAD
NEOPRENE FOAM 7.5PCF

	CODE 1104 B/L	CODE 1100 ALT	CODE 1101 ALT	CODE 1102 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	0.000	1.900	0.000	N/D
TIME TO IGNITION (SEC)	4.900	22.000	5.000	N/D
FLAME SPREAD(MM/S) AT 2.5 W/CM2	3.000	2.700	12.000	N/D
FLAME SPREAD(MM/S) AT 3.5 W/CM2	6.000	10.000	7.000	N/D
FLAME SPREAD(MM/S) AT 5 W/CM2	6.700	GOOD	9.000	N/D
FAR 25.853(B) TIME (SEC)	1.000	3.000	0.000	0.000
FAR 25.853(B) LENGTH (CM)	2.300	2.800	4.500	4.500
FAR 25.853(B) DRIP (YES/NO)	NO	YES	NO	NO
PYRO TEMP AT 1ST FLASH (C)	275.000	570.000	NO FLASH	NO FLASH
HEAT RELEASE (KW/M2) 2.5 W/CM2	163.000	199.000	65.200	N/D
HEAT RELEASE (KW/M2) 3.5 W/CM2	159.000	180.000	49.000	N/D
HEAT RELEASE (KW/M2) 5 W/CM2	160.000	181.000	130.000	N/D
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	64.000	10.000	21.000	8.000
NBS - FLAMING 4 MIN	127.000	33.000	37.000	13.000
NBS - NON FLAMING 90 SEC	28.000	4.000	21.000	40.000
NBS - NON FLAMING 4 MIN	73.000	13.000	38.000	41.000
TIME TO INCAPACITATION (MIN)	0.830	2.890	1.400	N/D
TIME TO DEATH (MIN)	2.590	4.000	3.130	N/D
TIME TO 1ST SMOKE (MIN)	0.300	0.800	0.400	N/D
OTHER				
DENSITY (G/M2 OR G/M3)	457.000	389.000	290.000	335.000
SAMPLE WEIGHT (GRAMS)	10.500	9.250	6.760	N/D
AVAILIBILITY OF COLORS	YES	YES	YES	YES
COLORFAST	EXCELLENT	EXCELLENT	EXCELLENT	FAIR
COMPRESSION (%)	N/A	N/A	N/A	N/A
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/A	N/A
ABRASION (NO. OF CYCLES)	750.000	N/D	N/D	750.000
TEAR (KG)	6.400	6.400	4.000	6.400
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 1103 ALT	CODE 1105 ALT	CODE 1106 ALT	CODE 1107 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	0.000	1.270	N/D	2.540
TIME TO IGNITION (SEC)	5.000	10.000	N/D	4.900
FLAME SPREAD(MM/S) AT 2.5 W/CM2	0.000	3.800	N/D	6.000
FLAME SPREAD(MM/S) AT 3.5 W/CM2	6.000	5.500	N/D	6.000
FLAME SPREAD(MM/S) AT 5 W/CM2	6.000	3.000	N/D	6.000
FAR 25.853(B) TIME (SEC)	0.000	0.000	382.000	0.000
FAR 25.853(B) LENGTH (CM)	2.800	2.300	10.300	4.900
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	YES
PYRO TEMP AT 1ST FLASH (C)	NO FLASH	810.000	N/D	450.000
HEAT RELEASE (KW/M2) 2.5 W/CM2	22.800	101.900	N/D	107.200
HEAT RELEASE (KW/M2) 3.5 W/CM2	49.300	76.700	N/D	90.100
HEAT RELEASE (KW/M2) 5 W/CM2	52.700	86.500	N/D	0.200
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	6.000	11.000	N/D	30.000
NBS - FLAMING 4 MIN	12.000	19.000	N/D	46.000
NBS - NON FLAMING 90 SEC	2.000	2.000	N/D	17.000
NBS - NON FLAMING 4 MIN	3.000	6.000	N/D	43.000
TIME TO INCAPACITATION (MIN)	0.820	1.740	N/D	1.830
TIME TO DEATH (MIN)	3.540	5.540	N/D	3.450
TIME TO 1ST SMOKE (MIN)	0.700	0.500	N/D	0.500
OTHER				
DENSITY (G/M2 OR G/M3)	311.000	319.000	367.000	385.000
SAMPLE WEIGHT (GRAMS)	7.000	7.300	N/D	6.800
AVAILIBILITY OF COLORS	NO	YES	NO	NO
COLORFAST	POOR	POOR	GOOD	GOOD
COMPRESSION (%)	N/A	N/A	N/A	N/A
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/A	N/A
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	6.400	6.400	6.400	2.500
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 2214 ALT	CODE 3200 ALT	CODE 3201 ALT	CODE 3202 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	40.600	N/D	N/D	N/D
TIME TO IGNITION (SEC)	4.900	4.900	25.000	4.900
FLAME SPREAD(MM/S) AT 2.5 W/CM2	6.000	0.000	3.600	0.000
FLAME SPREAD(MM/S) AT 3.5 W/CM2	6.000	8.600	7.000	8.600
FLAME SPREAD(MM/S) AT 5 W/CM2	6.000	6.000	8.600	6.000
FAR 25.853(B) TIME (SEC)	2.000	N/D	N/D	N/D
FAR 25.853(B) LENGTH (CM)	2.700	N/D	N/D	N/D
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PYRO TEMP AT 1ST FLASH (C)	NO FLASH	850.000	750.000	940.000
HEAT RELEASE (KW/M2) 2.5 W/CM2	21.300	43.600	74.700	43.600
HEAT RELEASE (KW/M2) 3.5 W/CM2	71.600	34.800	47.900	34.800
HEAT RELEASE (KW/M2) 5 W/CM2	73.300	57.700	65.500	57.700
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	8.000	N/D	N/D	N/D
NBS - FLAMING 4 MIN	16.000	N/D	N/D	N/D
NBS - NON FLAMING 90 SEC	1.000	N/D	N/D	N/D
NBS - NON FLAMING 4 MIN	5.000	N/D	N/D	N/D
TIME TO INCAPACITATION (MIN)	0.980	N/D	N/A	N/D
TIME TO DEATH (MIN)	2.630	N/D	N/A	N/D
TIME TO 1ST SMOKE (MIN)	0.300	0.600	0.800	0.700
OTHER				
DENSITY (G/M2 OR G/M3)	254.000	244.000	200.000	159.000
SAMPLE WEIGHT (GRAMS)	6.100	3.800	4.900	3.800
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/A	N/A	N/A	N/A
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/A	N/A
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	5.400	3.180	3.180	2.760
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 3203 ALT	CODE 3204 ALT	CODE 3205 ALT	CODE 3206 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	0.000	N/D	N/D	0.800
TIME TO IGNITION (SEC)	25.000	NO FLAME	NO FLAME	N/D
FLAME SPREAD(MM/S) AT 2.5 W/CM2	3.600	0.000	0.000	N/D
FLAME SPREAD(MM/S) AT 3.5 W/CM2	7.000	0.000	0.000	N/D
FLAME SPREAD(MM/S) AT 5 W/CM2	8.600	0.000	0.000	N/D
FAR 25.853(B) TIME (SEC)	0.000	N/D	N/D	0.000
FAR 25.853(B) LENGTH (CM)	2.500	N/D	N/D	1.700
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PYRO TEMP AT 1ST FLASH (C)	40.000	940.000	960.000	N/D
HEAT RELEASE (KW/M2) 2.5 W/CM2	74.700	31.600	13.900	N/D
HEAT RELEASE (KW/M2) 3.5 W/CM2	47.900	43.100	7.400	N/D
HEAT RELEASE (KW/M2) 5 W/CM2	65.500	95.700	12.900	N/D
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	11.000	N/D	N/D	1.000
NBS - FLAMING 4 MIN	16.000	N/D	N/D	0.000
NBS - NON FLAMING 90 SEC	4.000	N/D	N/D	0.000
NBS - NON FLAMING 4 MIN	8.000	N/D	N/D	2.000
TIME TO INCAPACITATION (MIN)	3.480	N/D	N/D	0.200
TIME TO DEATH (MIN)	4.550	N/D	N/D	0.310
TIME TO 1ST SMOKE (MIN)	1.100	1.000	0.200	N/D
OTHER				
DENSITY (G/M2 OR G/M3)	213.000	273.000	118.700	142.400
SAMPLE WEIGHT (GRAMS)	4.700	4.000	2.230	8.900
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/A	N/A	N/A	N/A
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/A	N/A
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	3.140	N/D	1.460	1.010
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	1.000	N/D	N/D	N/D

	CODE 3207 ALT	CODE 3208 ALT	CODE 3209 ALT	CODE 3210 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	0.000	N/D	N/D	0.000
TIME TO IGNITION (SEC)	N/D	9.900	N/D	6.900
FLAME SPREAD(MM/S) AT 2.5 W/CM2	N/D	0.000	N/D	0.000
FLAME SPREAD(MM/S) AT 3.5 W/CM2	N/D	0.000	N/D	0.600
FLAME SPREAD(MM/S) AT 5 W/CM2	N/D	0.000	N/D	0.900
FAR 25.853(B) TIME (SEC)	0.000	0.000	0.000	0.000
FAR 25.853(B) LENGTH (CM)	2.300	2.600	2.000	1.700
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PIRO TEMP AT 1ST FLASH (C)	N/D	NO FLASH	N/D	N/D
HEAT RELEASE (KW/M2) 2.5 W/CM2	N/D	58.900	N/D	82.700
HEAT RELEASE (KW/M2) 3.5 W/CM2	N/D	51.400	N/D	76.700
HEAT RELEASE (KW/M2) 5 W/CM2	N/D	17.200	N/D	74.800
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	3.000	30.000	45.000	70.000
NBS - FLAMING 4 MIN	3.000	43.000	78.000	136.000
NBS - NON FLAMING 90 SEC	2.000	22.000	30.000	40.000
NBS - NON FLAMING 4 MIN	8.000	34.000	57.000	98.000
TIME TO INCAPACITATION (MIN)	2.590	10.540	N/D	10.990
TIME TO DEATH (MIN)	4.400	21.050	N/D	LIVED
TIME TO 1ST SMOKE (MIN)	N/D	0.500	N/D	0.500
OTHER				
DENSITY (G/M2 OR G/M3)	95.000	425.000	723.000	954.000
SAMPLE WEIGHT (GRAMS)	N/D	10.500	N/D	22.700
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/A	N/A	N/A	N/A
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/A	N/A
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	1.190	N/D	N/D	N/D
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 3212 ALT	CODE 3215 ALT	CODE 3216 ALT	CODE 4213 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	10.200	N/D	N/D	0.000
TIME TO IGNITION (SEC)	4.900	17.000	40.000	N/D
FLAME SPREAD(MM/S) AT 2.5 W/CM2	0.000	4.000	0.000	N/D
FLAME SPREAD(MM/S) AT 3.5 W/CM2	0.000	6.000	0.000	N/D
FLAME SPREAD(MM/S) AT 5 W/CM2	4.000	6.000	0.000	N/D
FAR 25.853(B) TIME (SEC)	0.000	1.000	0.000	0.000
FAR 25.853(B) LENGTH (CM)	1.300	2.200	0.600	0.100
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PYRO TEMP AT 1ST FLASH (C)	NO FLASH	910.000	NO FLASH	N/D
HEAT RELEASE (KW/M2) 2.5 W/CM2	70.700	60.200	71.700	N/D
HEAT RELEASE (KW/M2) 3.5 W/CM2	44.400	60.600	36.900	N/D
HEAT RELEASE (KW/M2) 5 W/CM2	N/D	66.950	77.400	N/D
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	8.000	6.000	6.000	7.000
NBS - FLAMING 4 MIN	15.000	16.000	11.000	26.000
NBS - NON FLAMING 90 SEC	0.000	3.000	0.000	0.000
NBS - NON FLAMING 4 MIN	3.000	10.000	1.000	11.000
TIME TO INCAPACITATION (MIN)	0.710	1.500	0.800	N/D
TIME TO DEATH (MIN)	1.270	2.290	1.460	N/D
TIME TO 1ST SMOKE (MIN)	0.700	0.300	0.400	N/D
OTHER				
DENSITY (G/M2 OR G/M3)	322.000	250.000	N/D	516.000
SAMPLE WEIGHT (GRAMS)	7.700	6.200	8.000	N/D
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/A	N/A	N/A	N/A
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/A	N/A
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	6.400	4.400	N/D	N/D
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 4214 ALT	CODE 4217 ALT	CODE 5302 B/L	CODE 5300 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	40.600	N/D	N/A	N/A
TIME TO IGNITION (SEC)	4.900	N/D	N/D	N/D
FLAME SPREAD(MM/S) AT 2.5 W/CM2	6.000	N/D	N/D	0.000
FLAME SPREAD(MM/S) AT 3.5 W/CM2	6.000	N/D	N/D	0.000
FLAME SPREAD(MM/S) AT 5 W/CM2	6.000	7.500	N/D	0.000
FAR 25.853(B) TIME (SEC)	2.000	N/D	N/D	0.000
FAR 25.853(B) LENGTH (CM)	2.700	N/D	N/D	0.100
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PYRO TEMP AT 1ST FLASH (C)	NO FLASH	N/D	N/D	NO FLASH
HEAT RELEASE (KW/M2) 2.5 W/CM2	21.300	19.600	N/D	35.100
HEAT RELEASE (KW/M2) 3.5 W/CM2	71.600	38.600	N/D	24.600
HEAT RELEASE (KW/M2) 5 W/CM2	73.300	36.500	N/D	N/D
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	8.000	N/D	N/D	4.000
NBS - FLAMING 4 MIN	16.000	N/D	N/D	6.000
NBS - NON FLAMING 90 SEC	1.000	N/D	N/D	5.000
NBS - NON FLAMING 4 MIN	5.000	N/D	N/D	8.000
TIME TO INCAPACITATION (MIN)	0.980	0.750	N/D	N/D
TIME TO DEATH (MIN)	2.630	1.750	N/D	N/D
TIME TO 1ST SMOKE (MIN)	0.300	N/D	N/D	0.800
OTHER				
DENSITY (G/M2 OR G/M3)	254.000	N/D	0.200	0.045
SAMPLE WEIGHT (GRAMS)	6.100	N/D	N/D	N/D
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/A	N/A	0.320	N/D
INDENTATION/DEFLECTION (CM)	N/A	N/A	N/D	12.100
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	5.400	N/D	N/D	N/D
TENSILE STRENGTH (KG)	N/D	N/D	3.600	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 5301 ALT	CODE 5303 ALT	CODE 5304 ALT	CODE 5305 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	N/A	N/A	N/A	N/A
TIME TO IGNITION (SEC)	10.000	8.000	10.000	9.000
FLAME SPREAD(MM/S) AT 2.5 W/CM2	1.400	2.300	5.500	1.900
FLAME SPREAD(MM/S) AT 3.5 W/CM2	3.000	10.000	6.000	3.100
FLAME SPREAD(MM/S) AT 5 W/CM2	5.000	20.000	6.000	3.800
FAR 25.853(B) TIME (SEC)	0.000	3.000	0.000	90.000
FAR 25.853(B) LENGTH (CM)	0.800	0.900	1.500	0.800
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PYRO TEMP AT 1ST FLASH (C)	NO FLASH	825.000	NO FLASH	930.000
HEAT RELEASE (KW/M2) 2.5 W/CM2	226.000	306.000	519.500	525.000
HEAT RELEASE (KW/M2) 3.5 W/CM2	492.900	530.000	468.500	531.000
HEAT RELEASE (KW/M2) 5 W/CM2	412.000	473.000	596.700	671.000
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	43.000	31.000	51.000	54.000
NBS - FLAMING 4 MIN	89.000	67.000	115.000	100.000
NBS - NON FLAMING 90 SEC	14.000	47.000	42.000	2.000
NBS - NON FLAMING 4 MIN	113.000	163.000	118.000	17.000
TIME TO INCAPACITATION (MIN)	2.900	6.740	6.810	4.770
TIME TO DEATH (MIN)	26.600	7.690	8.340	6.000
TIME TO 1ST SMOKE (MIN)	0.200	0.500	1.200	0.800
OTHER				
DENSITY (G/M2 OR G/M3)	0.140	0.150	0.190	0.210
SAMPLE WEIGHT (GRAMS)	64.000	64.500	80.500	70.000
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/D	0.196	0.300	N/D
INDENTATION/DEFLECTION (CM)	N/D	N/D	N/D	N/D
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	N/D	N/D	N/D	N/D
TENSILE STRENGTH (KG)	N/D	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

	CODE 5306 ALT	CODE 5307 ALT	CODE 5309 ALT	CODE 5310 ALT
FIRE CHARACTERISTICS				
PILL TEST (CM)	N/A	N/A	N/A	N/A
TIME TO IGNITION (SEC)	4.900	4.900	4.800	N/D
FLAME SPREAD(MM/S) AT 2.5 W/CM2	3.000	0.000	6.000	N/D
FLAME SPREAD(MM/S) AT 3.5 W/CM2	0.000	0.000	6.000	N/D
FLAME SPREAD(MM/S) AT 5 W/CM2	6.000	6.000	6.000	N/D
FAR 25.853(B) TIME (SEC)	1.000	0.000	0.000	N/D
FAR 25.853(B) LENGTH (CM)	2.800	1.000	1.200	N/D
FAR 25.853(B) DRIP (YES/NO)	NO	NO	NO	NO
PIRO TEMP AT 1ST FLASH (C)	600.000	715.000	NO FLASH	N/D
HEAT RELEASE (KW/M2) 2.5 W/CM2	213.800	97.200	188.200	N/D
HEAT RELEASE (KW/M2) 3.5 W/CM2	159.800	142.600	202.000	N/D
HEAT RELEASE (KW/M2) 5 W/CM2	115.900	138.600	141.000	N/D
SMOKE & TOXICITY				
NBS - FLAMING 90 SEC	27.000	84.000	122.000	N/D
NBS - FLAMING 4 MIN	37.000	165.000	231.000	N/D
NBS - NON FLAMING 90 SEC	51.000	45.000	107.000	N/D
NBS - NON FLAMING 4 MIN	134.000	115.000	222.000	N/D
TIME TO INCAPACITATION (MIN)	1.950	13.130	2.580	N/D
TIME TO DEATH (MIN)	3.180	23.610	9.060	N/D
TIME TO 1ST SMOKE (MIN)	1.000	0.600	0.800	N/D
OTHER				
DENSITY (G/M2 OR G/M3)	0.030	0.120	0.140	N/D
SAMPLE WEIGHT (GRAMS)	9.000	37.300	36.800	N/D
AVAILIBILITY OF COLORS	NO	NO	NO	NO
COLORFAST	N/A	N/A	N/A	N/A
COMPRESSION (%)	N/D	0.100	N/D	N/D
INDENTATION/DEFLECTION (CM)	10.200	6.400	N/D	N/D
ABRASION (NO. OF CYCLES)	N/D	N/D	N/D	N/D
TEAR (KG)	N/D	0.680	N/D	N/D
TENSILE STRENGTH (KG)	0.450	N/D	N/D	N/D
EST. FABRICATION COSTS ($)	N/D	N/D	N/D	N/D
RAW MATERIAL $/LB	N/D	N/D	N/D	N/D

LUMINAIRES: THERMOPLASTIC

CODE NO.	GENERIC NAME	TRADE NAME
THERMOPLASTICS		
BASELINE-		
6410	CHLORINATED-PVC	
ALTERNATES-		
6411	POLYCARBONATE	SL 1000
6412	POLYETHERSULFONE	212 P
6413	POLYPHENYLENE SULFIDE	

	CODE 6410 B/L	CODE 6411 ALT	CODE 6412 ALT	CODE 6413 ALT
THERMAL AND FIRE CHARACTERISTICS				
HEAT DEFLECTION TEMP @ 264 PSI	200.000	230.000	390.000	275.000
HEAT DEFLECTION TEMP @ 1820 KPA	84.000	110.000	199.000	135.000
SMOKE DENSITY FLAMING (6MIN)	140.000	300.000	20.000	100.000
TGA C	N/D	N/D	440.000	430.000
LIMITING OXYGEN INDEX	50.000	32.000	30.000	48.000
ALC50 AT 700 C MG/LITER	N/D	N/D	N/D	N/D
DELTA HEAT 1.0 W/CM2	N/D	N/D	N/D	N/D
2.5 W/CM2	N/D	N/D	N/D	N/D
5.0 W/CM2	N/D	N/D	N/D	N/D
CHAR YIELD	N/D	N/D	N/D	N/D
QDOT AT 1.0 W/CM2	N/D	N/D	N/D	N/D
2.5 W/CM2	N/D	N/D	N/D	N/D
5.0 W/CM2	N/D	N/D	N/D	N/D
FAR 25.853	N/D	N/D	N/D	N/D
CO AT 1.0 W/CM2	N/D	N/D	N/D	N/D
2.5 W/CM2	N/D	N/D	N/D	N/D
5.0 W/CM2	N/D	N/D	N/D	N/D
MECHANICAL & PHYSICAL				
TENSILE STRENGTH (PSI)	5400.000	8000.000	11000.000	9500.000
TENSILE STRENGTH (MPA)	37.200	55.200	75.800	65.400
ELONGATION % OF R.T.	40.000	30.000	N/D	1.500
FLEXURAL STRENGTH (PSI)	10000.000	12000.000	16000.000	13000.000
FLEXURAL STRENGTH (MPA)	68.900	82.700	113.000	88.600
SPECIFIC GRAVITY	1.570	1.230	1.370	1.300
IMPACT STRENGTH, NOTCHED IZOD	6.600	2.000	1.600	1.200
IMPACT STRENGTH, N M/M:	352.000	107.000	85.400	64.200
MOD OF ELASTICITY (K PSI)	300.000	300.000	350.000	500.000
MOD OF ELASTICITY (MPA)	2070.000	2070.000	2415.000	3550.000
COMPRESSIVE STRENGTH (PSI)	N/D	N/D	N/D	N/D
COMPRESSIVE STRENGTH (MPA)	N/D	N/D	N/D	N/D
WEIGHT	N/D	N/D	N/D	N/D
OTHER				
ULTRAVIOLET FADE-O-METER (1 HR)	60.000	60.000	50.000	50.000
SURFACE BONDING ACCEPTANCE 180	10.000	10.000	POOR	N/D
SURFACE BONDING ACCEPTANCE, N/M	1751.000	1751.000	N/D	N/D
SOIL & CLEANER RESISTANCE	EXCELLENT	FAIR	FAIR	EXCELLENT
COST RATING	1.300	1.000	4.000	2.500

V. REVIEW OF BOEING COMMERCIAL AIRPLANE COMPANY'S REPORT ENTITLED "DEVELOPMENT OF AIRCRAFT LAVATORY COMPARTMENTS WITH IMPROVED FIRE RESISTANCE CHARACTERISTICS - PHASE II SANDWICH PANEL RESIN SYSTEM DEVELOPMENT" (FEB 1979)

Included in this section is a discussion of the "weighted average" technique utilized in the Boeing report to relate individual material performance properties to the total panel system performance. A critique of this technique is provided and other models or techniques suggested that may be more appropriate to the situtation.

REVIEW OF BOEING COMMERCIAL AIRPLANE COMPANY'S REPORT ENTITLED "DEVELOPMENT OF AIRCRAFT LAVATORY COMPARTMENTS WITH IMPROVED FIRE RESISTANCE CHARACTERISTICS - PHASE II - SANDWICH PANEL RESIN SYSTEM DEVELOPMENT" (FEB 1979):

COMMENTS ON THE "WEIGHTED AVERAGE" TECHNIQUE USED TO RELATE INDIVIDUAL MATERIAL PERFORMANCE PROPERTIES TO THE TOTAL PANEL SYSTEM PERFORMANCE

The comments here refer to the procedure used to rank the benefits of various composite materials in Boeing's Lavatory Panel Study. The document (p. 23) suggests that the face sheet, adhesive ply, and honeycomb core materials were based on an ad hoc ranking procedure, which, it can be assumed was a "weighted average". A similar ranking procedure was used to select a foam-filled core. All rankings were based on test of individual constituents (e.g., face sheet, adhesive ply, honeycomb core, and foam). These rankings were used in the selection of the individual pieces that make up a composite material, and that 13 such composites (or systems) were ultimately formed and tested. Finally, these 13 systems were ranked using another "weighted average" technique, or linear additive utility model.

A linear additive utility model has the following form:

$$U(X_i) = \sum_{j}^{m} a_j x_{ij}$$

where,

- U = utility or benefit of a system with properties X
- X_i = particular attributes or properties of system i (an m-dimensional vector)
- a_j = the importance or contribution of attribute j to the utility of a system
- x_{ij} = quantitative amount of attribute j possessed by system i

The x_{ij}'s are usually normalized (although it is not required) be defining:

$$x_{ij} = \frac{P_{ij}}{\sum_i P_{ij}}$$

where,

P_{ij} = value of physical attribute j of system i

In the subject report it is assumed that the P_{ij}'s were obtained from tests performed in Task 5 and the a_j's were solicited from expert opinion.

I. CRITIQUE OF LINEAR ADDITIVE UTILITY MODEL

The Linear additive model (LAUM) is a simple form that most people can relate to and is cognitively pleasing. From the test data presented in the tables, however, there is no compelling reason to suppose that the test measures are related to each other by a linear transformation. All one should really hope to do is find a monotonic (i.e., non-decreasing or non-increasing) relationship between the controllable physical scale (test data) and the relevant psychological variable (the subjective value of a system having that test data). There are major assumptions which support the use of a LAUM and often the assumptions are not satisfied:

1. Factors are valuewise independent or that the utility of the whole equals the sum of utilities of its parts. Consider an example.

   Let $U(X_1) = 40$, $U(X_2) = 30$, $U(X_3) = 20$

   The expert or decision maker should perfer using system 1 to any combination of systems 2 and 3 in aircraft use. This is acutally a test of any utility model. But this becomes a particular problem with LAUM because its use may suggest:

   $$U(\text{smoke emission}) > U(\text{LOI}) + U(\text{toxicity})$$

   Some system may burn with little O_2 (it generates its own) and gives off cyanide gas but with no smoke. That is, unacceptable values of one or more attributes can be compensated by increases in the value of another. This should not be acceptable. Boeing, the author of the study, recognizes this limitation on p. 60.

2. The use of the LAUM requires consistent value judgments about the levels of any one factor when the levels of all other factors are held fixed and the judgments must not depend on the particular fixed levels of the other factors. For example, the noise level of an airport may be acceptable if the airport is far removed from a residential level. It may be unacceptable if it is adjacent to a residential area.

3. The attributes should be independent measures or contributors to utility. Looking at the data in Tables 81 and 82 suggest that attributes 2-4 are highly intercorrelated, so too with attributes 6-9 and 10-12. This will cause a hidden weighting factor to enter into the total utility. For example, even if the weighting were equal, one unit of smoke emission decrease would be 3 times as important as one unit of LOI decrease since smoke emission is essentially entered three times (attributes 2-4) and LOI is entered only once. If one were to construct a covariance matrix of the attribute data and then factor analyze it to determine independent (or nearly so) attributes, it could be shown that the same conclusions could be reached by measuring fewer parameters. For example, the data may show that smoke emission always occurs with heat release, say. If so, measure only one of these attributes especially the cheaper one.

II. OTHER MODELS OR APPROACHES

Ranking procedures ought to involve more subjective input. The LAUM ought to be modified to:

$$U(X_i) = \sum_j^m a_j y_{ij}$$

where,

$$y_{ij} = u_j\ (x_{ij})$$

and

y_{ij} = satisfaction with or utility of system i having value x_{ij}

u_j = utility or psychometric function

For example, it seems reasonable that LOI's from 50 on, say, are equally beneficial, or nearly so. But when an LOI of 21 is approched, the penalty ought to be asymptotic. It can be suggested that u(LOI) ought to be a hyperbola rather than a straight line. In any event, some experts ought to be polled (and there are numerous procedures for doing this) to

determine the utility (or disutility) of various values of an attribute. Furthermore, the experts ought to be pulled in for overall ranking of the composites. In this way better information can be obtained for the attribute weights (a_j's).

III. CONJUNCTIVE MODEL

A conjunctive model is one in which the utility is evaluated on the least relevant attribute. For example, an individual must have every vital organ functioning above a certain level for sustained life. Life or death depends upon one's worst vital organ. A parabolic conjunctive model is:

$$U(X) = \prod_j x_j^{aj}$$

The highest utility occurs when there are equal amounts of the attributes x_j. This model has the particular property that a low score on any attribute will severely penalize the utility evaluation. This model would be suited to ranking the composite systems, since one may have certain minimum standards on the value of attributes, less than which one is unwilling to accept. Furthermore, the cost of a false positive (Type II error) in this situation would be expected to be high, i.e., choosing a composite for aircraft use that turned out to be a fire safety hazard. As before the x_j's could be replaced by their subjective equivalent y_j's and the a_j's could be derived from an analysis of subjective rankings made of the composites by an expert.

IV. CONFIGURAL MODEL

When attributes interact and the utility of the value of one attribute depends upon the value of another, a configural model has often been used to successfully model such interactions. A common form of the model is:

$$U(X) = \sum_j a_j x_j + \sum_j \sum_{k>j} b_{jk} x_j x_k + \sum_j \sum_{k>j} \sum_{l>k} c_{jk} x_j x_k x_l + \ldots + e \prod_j x_j$$

which is a generalization of the LAUM. There are well-defined procedures for determining the a's, b's, c's, etc., which are interrelated. This technique was actually used to locate airports around Mexico City by a group of consultants from MIT. Again the x's could (and should) be replaced by y's.

CONJOINT ANALYSIS

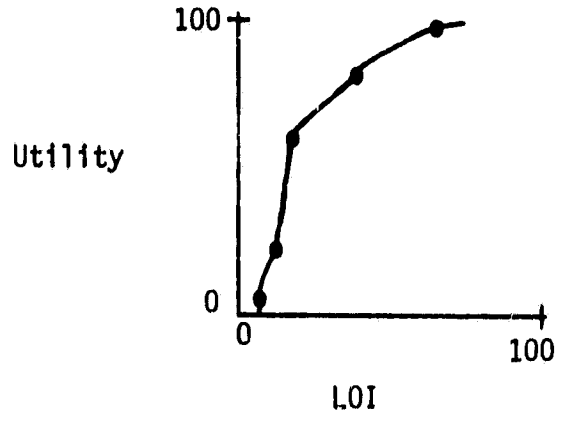
Conjoing analysis is a relatively new concept that has been used mostly in academia. But it is particularly well-suited to problems where the:

- response variable (utility) is often expressed in a judgmental form
- decision choices (stimuli) are multi-attribute in nature
- researcher is often ignorant of not only the partial contribution that each attribute level of the stimulus makes to the total psychological response (subjective utility) but also the appropriate "objective" scales by which the attributes themselves are to be measures (e.g., color of a composite)

Complex, judgmental responses to multi-attribute stimuli can sometimes be decomposed into partial contributions that are psychophysical (i.e., related to physical or other objective changes in a set of control variables. The technique is concerned with determining the separate psychological contributions of a set of independent variables to the ordering (ranking, or mere categorization) of a dependent variable. These partial contributions and the dependent variable (utility) can be conjointly (simultaneously) measured at the level of separate interval scales with common unit even though the responsible variable is (originally) non-numerical.

For example, the expert judge would be required to only rank the utility of composites $X_1, X_2, \ldots, X_n$ where each composite is represented by a set of m attributes with specific values $(x_{11}, x_{12}, \ldots, x_{1m})$. If x_{ij} is a continuous variable (e.g., LOI) then a set of discrete values would have to be chosen which was representative of the attribute range. The number of the discrete values should be small as well as the total number of attributes m. If every attribute had 2 possible values, there would be 2^m possible combinations of attributes or 2^m composites. For modest values of m the ranking task would become monumental. Even if the number of possible combinations is large, not every one need be presented to the judge; a Latin Square sampling design could be used to select a much smaller subset for ranking purposes without much loss of information. Any reasonable functional form can be used for the utility function U(X). The net result of a conjoint analysis would not only obtain numerical values for the U(X) which are consistent with the rankings given by the expert, but the psychophysical functions (partial utilities) are also

determined, i.e., the utility of each attribute taking on a specific



variable would also be determined. All of these great things could be accomplished by using only ranking data provided by an expert.

V. CONCLUDING OBSERVATIONS

The conjunctive model would be useful if the FAA wants to set a minimum standard for use of acceptable composites in aircraft. Of course it would be simpler if they would just set minimum acceptable levels of each important attribute.

The Boeing study determined the utility of composite materials using physical properties as attributes determined from actual testing. The testing of the composite constituents (e.g., face sheet, adhesive ply, etc.) was only to prepare data for use in selecting which constituents to join to form composites.

It might be beneficial to perform research to enable one to determine the physical properties of the composite by knowing the physical properties of the constituents.

There seem to be some crude attempts at this (e.g., A_1 on p. 48, A_8 and A_9 on p. 52), but no real logical approach. There would be tremendous merit to working and solving this problem: If there are m different face sheets, n adhesive plys, p honeycomb cores, and q core foams, the results from m + n + p + q tests could be used to predict the performance of m x n x p x q composites. If m = n = p = q = 3, 12 tests

would cover 81 composites. The savings would be tremendous in terms of testing time, money, personnel, opportunity cost for the testing apparatus, not to mention the cost to fabricate the composite samples.

Perhaps with a little thought on the functional form for a "utility function", e.g.,

LOI (composite) = f [LOI (face sheet), LOI (adhesive ply), LOI (honeycomb core), LOI (core foam)]

conjoint analysis could be used to work the problem. This technique would be especially beneficial since one would most likely not know the partial contributions of each of the constituents.