DEVELOPMENT OF AIRCRAFT LAVATORY COMPARTMENTS WITH IMPROVED FIRE RESISTANCE CHARACTERISTICS

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By

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ABSTRACT

This presentation describes Boeing's participation in a NASA-funded program (FIREMEN) to develop materials for use as lavatory wall panels, sidewall panels, and ceiling panels possessing flammability, smoke, and toxicity (FS&T) characteristics superior to current materials of construction (i.e., epoxy resin, polyvinylfluoride film, and acrylic ink). The objective of the program was to develop a sandwich panel system (viz., impregnating resin, honeycomb core, decorative film, and printing ink) that possessed both improved FS&T characteristics and acceptable cost, processing requirements, aesthetic qualities, abrasion resistance, stain resistance, scuff resistance, and washability.

Development of an impregnating resin (viz., modified phenolic) has been completed, development of a decorative film is in progress, and screen printing ink development has just begun. The effort began in 1975 and is scheduled for completion in 1979.

All tests performed under this program were on a laboratory scale. Consequently, final verification of FS&T improvements will ultimately require full-scale testing.

PRESENTATION

Slide 1 - Title

A program to evaluate baseline and candidate materials for aircraft lavatory applications and funded by NASA-ARC began in 1975.

Slide 2 - Objectives

Overall objectives of the whole program.

Slide 3 - Materials Development Program

Whole program broken into four phases.

Slide 4 - Baseline Lavatory Burn

A burn test was conducted on a 747 lavatory in 1975. The results have been reported.

Slide 5 - Sandwich Panel Resin System Development

Slide 6 - Objectives

Objectives of the resin system development program.

Slide 7 - Sandwich Panel Development Program

Resin system development program broken down into five tasks.

Slide 8 - Resin System Program Schedule

Slide 9 - Task 1

Screening of phenolic prepregs resulted in peel strength failure of all candidates.

Slide 10 - Task 2

Laboratory testing of four resin systems.

Slide 11 - Materials Matrix - Task 2

Slide 12 - Assessment of Test Results

Slide 13 - Ranking Procedure

Slide 14 - Ranking Procedure

Slide 15 - Sandwich Panel Ranking

The ranking shown resulted from both arithmetic and geometric procedures.

Slide 16 - Fire Containment Considerations

Four foams evaluated to improve burn through characteristics.

Slide 17 - Foam Evaluation

Foam and core with no face sheets were tested. The weight distribution of each of the tests is shown on the slide.

Slide 18 - Foam Ranking

Equations similar to those on Slide 14 were utilized.

Slide 19 - Tasks 3 and 4

Results showed polycarbonate (Lexan) to be the only promising film. Unfortunately, embrittlement problems precluded its incorporation into Task 5.

Slide 20 - Materials Matrix - Task 5

Slide 21 - Limiting Oxygen Index Apparatus

Slide 22 - Propensity to Burn

Slide 23 - NASA Animal Exposure Chamber

Slide 24 - Panel Weight

Slide 25 - OSU Heat Release Apparatus

Slide 26 - Smoke Emission - OSU Chamber - Flaming

Slide 27 - Smoke Emission - OSU Chamber - Flaming

Slide 28 - Total Heat Release - OSU Apparatus - Flaming Vertical

Specimens with no decorative film and thin core were utilized to minimize their contribution to the heat release values.

Slide 29 - Total Heat Release - OSU Apparatus - Flaming Vertical

Specimens included decorative film and thick core.

Slide 30 - Heat Release Rate - OSU Apparatus - Flaming Vertical

Specimens with no decorative film and thin core were utilized to minimize their contribution to the heat release values.

Slide 31 - Heat Release Rate - OSU Apparatus - Flaming Vertical

Specimens included decorative film and thick core.

Slide 32 - Boeing Burn Through Apparatus

Slide 33 - Boeing Burn Through

Slide 34 - Mechanical Strength - 0.25 Inch Core

A value of 10 in-lb/3 in width is acceptable.

Slide 35 - Mechanical Strength

A value of 150 lb/in^2 is acceptable.

Slide 36 - FS&T Imrpovements

Slide 37 - Decorative Film Development

Slide 38 - Objectives

Objectives of the decorative film development program.

Slide 39 - Film Development Program

Program involved three tasks.

Slide 40 - Decorative Film Program Schedule

Slide 41 - Test Plan

Decorative film development test plan.

Slide 42 - Test Plan

Continuation of the decorative film development test plan.

Slide 43 - Task 1-A Films

List of candidate films.

Slide 44 - Task 1-A Films

Continuation of the candidate film list.

Slide 45 - Propensity to Burn

Limiting oxygen index.

Slide 46 - Propensity to Burn

Limiting oxygen index.

Slide 47 - Smoke Emission - NBS Chamber

Tests on unsupported films.

Slide 48 - Smoke Emission - NBS Chamber

Tests on unsupported films.

Slide 49 - Toxic Gas Emission - NBS Chamber

Slide 50 - Toxic Gas Data - NBS Chamber

Slide 51 - Toxic Gas Data - NBS Chamber

Slide 52 - Tensile Properties - Room Temperature

Test Method ASTM D882.

Slide 53 - Tensile Properties - Room Temperature

Test Method ASTM D882.

Slide 54 - Tensile Properties - Room Temperature

Test Method ASTM D882.

Slide 55 - Tensile Properties - Room Temperature

Test Method ASTM D882.

Slide 56 - Tensile Properties - Room Temperature

Test Method ASTM D882.

Slide 57 - Tensile Properties - Room Temperature

Test Method ASTM D882.

Slide 58 - Mechanical Test

Test set up to be used in conjunction with a Thermomechanical Analyzer for the determination of tensile properties of the candidate films at elevated temperatures.

Slide 59 - Materials Evaluation - Task 2

New resin system from France under evaluation.

Slide 60 - Problems

There are problems with the resin system from France including the four listed.

Slide 61 - Future Work

Tentative films for Task 1B - Testing.

Slide 62 - Future Work

Testing for the tentative films shown on Slide 61.

Slide 63 - Decorative Laminate Configurations

Various material configurations to be investigated.

Slide 64 - FS&T Specimens

Specimen configuration to be used for the four tests indicated.

Slide 65 - Screen Printing Ink Development

Slide 66 - Objectives

Objectives of the screen printing ink development.

Slide 67 - Screen Printing Ink Development Program

Program involved three tasks.

Slide 68 - Screen Printing Ink Program Schedule

Slide 69 - Test Plan

Screen printing ink development test plan.

Slide 70 - Test Plan

Continuation of the screen printing ink development test plan.

Slide 71 - Material Requirements - Task 1

Screening test requirements.

Slide 72 - Resin Systems

Potential candidate materials for consideration.

Slide 73 - Tasks 2 and 3

Five different panels will be made during ink evaluation studies. Testing will include those tests shown.

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R.A. ANDERSON AND G.A. JOHNSON
BOEING COMMERCIAL AIRPLANE COMPANY
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OBJECTIVES

- SIDEWALL, CEILING, AND PARTITION PANEL DEVELOPMENT
  - RESIN SYSTEM
  - DECORATIVE FILM
  - DECORATIVE INK
- LOW SMOKE, FLAMMABILITY, AND TOXICITY
- AESTHETIC AND MECHANICAL PROPERTY RETENTION
- END ITEM DELIVERIES TO NASA-ARC

MATERIALS DEVELOPMENT PROGRAM

- BASELINE LAVATORY BURN
- RESIN SYSTEM DEVELOPMENT
- DECORATIVE FILM DEVELOPMENT
- DECORATIVE INK DEVELOPMENT

BASELINE LAVATORY BURN

PHASE I

NAS2-8700

SANDWICH PANEL RESIN SYSTEM DEVELOPMENT

PHASE II

NAS2-8700

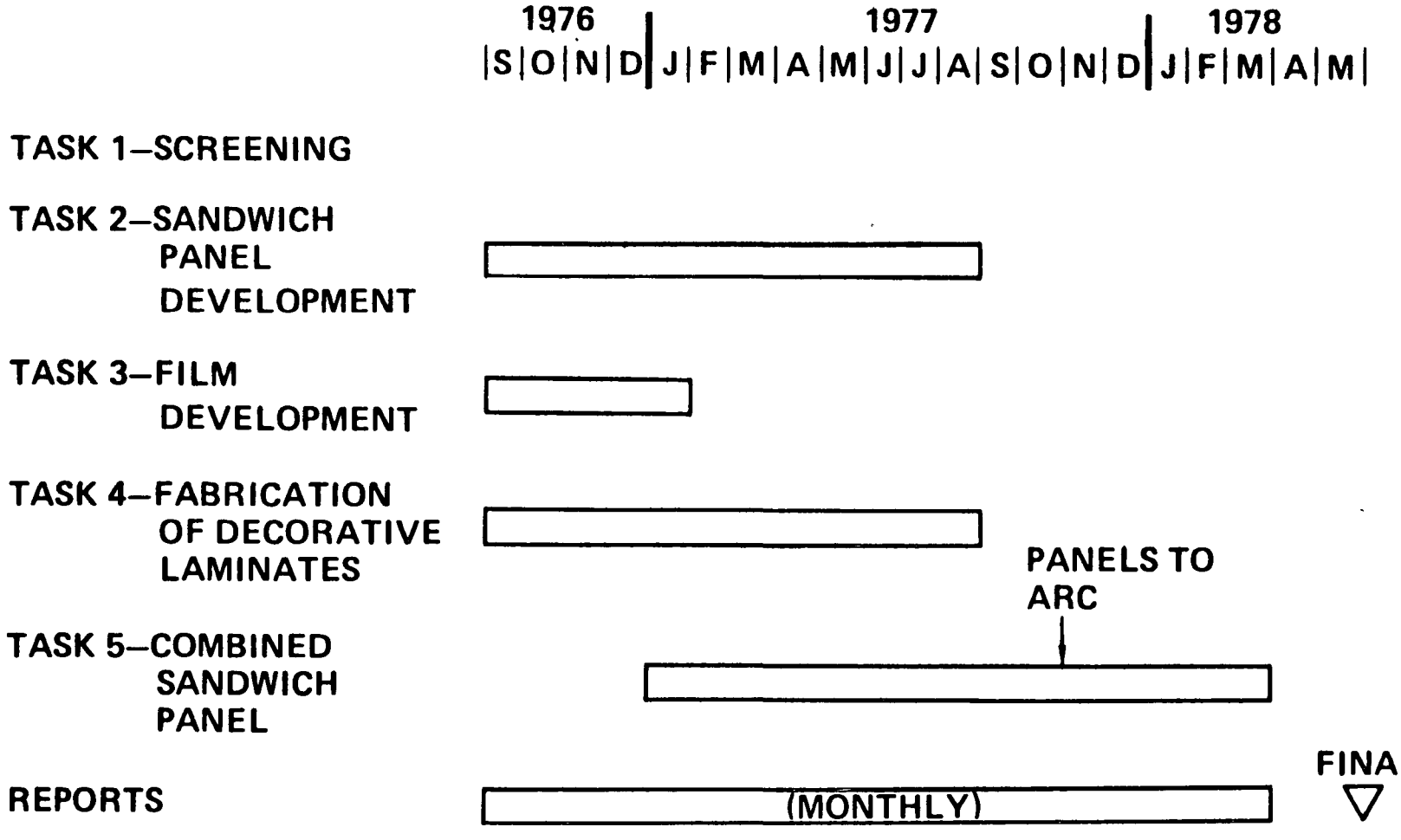
OBJECTIVES

- SIDEWALL, CEILING, AND PARTITION PANEL DEVELOPMENT
- RESIN AND DECORATIVE FILM DEVELOPMENT
- LOW SMOKE AND TOXIC GAS EMISSION
- RESISTANT TO HIGH HEAT FLUX
- PROCESS ASSESSMENT
- RANKING SYSTEM
- END ITEM DELIVERY TO NASA-ARC

SANDWICH PANEL DEVELOPMENT PROGRAM

- TASK 1—SCREENING
- TASK 2—SANDWICH PANEL DEVELOPMENT
- TASK 3—FILM EVALUATION
- TASK 4—FABRICATION OF DECORATIVE LAMINATES
- TASK 5—COMBINED SANDWICH PANEL

RESIN SYSTEM PROGRAM SCHEDULE



TASK 1

- PHENOLIC PREPREG SCREENING
  - FIBERITE
  - NARMCO
  - DUPONT
  - CIBA-GEIGY
- MECHANICAL STRENGTH PROBLEM
  - PHENOLIC–7.7 MAXIMUM
  - EPOXY–15 MAXIMUM
- NEW MATERIALS FOR TASK 2

TASK 2

- RESIN SYSTEM DEVELOPMENT
  - EPOXY (BASELINE)–FIBERITE
  - BISMALEIMIDE–HEXCEL AND HITCO
  - POLYIMIDE–DUPONT
  - PHENOLIC–NARMCO, FIBERITE, AND CIBA-GEIGY
- LABORATORY TESTING
  - FLAMMABILITY
  - SMOKE EMISSION
  - TOXIC GAS EMISSION
  - TOXICOLOGY (USF–DR. CARLOS HILADO)
  - HEAT RELEASE
  - MECHANICAL PROPERTIES
  - DURABILITY

MATERIALS MATRIX–TASK 2

SYST. NO.	FACESHEET	BOND PLY AND BACK SKIN	ADHESIVE	HONEYCOMB CORE	FOAM
1	EPOXY FIBERITE MXB-7203	EPOXY FIBERITE MXB-7251	NONE	PHENOLIC/ POLYAMIDE 3 PCF NOMEX	NONE
2	PHENOLIC NARMCO 8250	PHENOLIC NARMCO 9251	NONE	PHENOLIC/ POLYAMIDE 3 PCF NOMEX	NONE
3	BISMALEIMIDE HEXCEL 531	BISMALEIMIDE HEXCEL 532	NONE	PHENOLIC/ POLYAMIDE 3 PCF NOMEX	NONE
4	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE AM.CYANAMID BR-34	POLYIMIDE/ FIBERGLASS 4.5 PCF	NONE
5	PHENOLIC NARMCO 8250	PHENOLIC NARMCO 9251	NONE	PHENOLIC/ POLYAMIDE 3 PCF NOMEX	ICU 2 PCF
6	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE AM.CYANIMID BR-34	POLYIMIDE/ FIBERGLASS 4.5 PCF	PI/PU 2 PCF
7	BISMALEIMIDE RHODIA KERIMID 601	BISMALEIMIDE RHODIA KERIMID 601	POLYIMIDE AM.CYANAMID FM-34	PHENOLIC/ POLYAMIDE 1.8 PCF NOMEX	PQ 2 PCF
8	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE AM CYANAMID BR-34	POLYIMIDE/ POLYAMIDE 3.0 PCF PI-NOMEX	NONE
9	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE DUPONT PYRALIN 3002	POLYIMIDE AM. CYANAMID BR-34	POLYIMIDE/ POLYAMIDE 3.0 PCF PI-NOMEX	PI/PU 2 PCF
10	PHENOLIC CIBA-GEIGY FIBREDUX 917G	PHENOLIC CIBA-GEIGY FIBREDUX 917G	NONE	PHENOLIC/ POLYAMIDE 3.0 PCF NOMEX	NONE
11	PHENOLIC FIBERITE MXB-6070	PHENOLIC FIBERITE MXB-7255	NONE	PHENOLIC/ POLYAMIDE 3.0 PCF NOMEX	ICU 2 PCF
12	PHENOLIC FIBERITE MXB-6070	PHENOLIC FIBERITE MXB-7255	NONE	PHENOLIC/ POLYAMIDE 3.0 PCF NOMEX	NONE
13	BISMALEIMIDE RHODIA KERIMID 601	BISMALEIMIDE RHODIA KERIMID 601	POLYIMIDE AM.CYANAMID FM-34	PHENOLIC/ POLYAMIDE 1.8 PCF NOMEX	ICU 2 PCF (PYROLYZED)

ASSESSMENT OF TEST RESULTS

- VISUAL EXAMINATION

- RANKING PROCEDURE

RANKING PROCEDURE

- LABORATORY TESTS–WEIGHT DISTRIBUTION
  - FLAMMABILITY–10%
  - SMOKE EMISSION–20%
  - TOXIC GAS EMISSION–10%
  - HEAT RELEASE–20%
  - HEAT RELEASE RATE–20%
  - THERMAL CONDUCTIVITY–4%
  - MECHANICAL STRENGTH–6%
  - DENSITY–10%

- MATERIAL AND FABRICATION
  - 15%
  - LABORATORY TESTS–85%

RANKING PROCEDURE

- METHOD 1—ARITHMETIC
  - $A_T = 0.85\ A_{LT} + 0.15\ A_{MF}$
  - $A_{LT} = 0.1\ (FLA) + 0.2\ (SMO) + 0.1\ (TOX) + 0.2\ (HEA) + 0.2\ (HER) + 0.04\ (BFT) + 0.06\ (MEC) + 0.1\ (DEN)$
- METHOD 2—GEOMETRIC
  - $G_T = (G_{LT})^{0.85}\ (G_{MF})^{0.15}$
  - $G_{LT} = (FLA)^{0.1}\ (SMO)^{0.2}\ (TOX)^{0.1}\ (HEA)^{0.2}(HER)^{0.2}\ (BFT)^{0.04}\ (MEC)^{0.06}\ (DEN)^{0.1}$

SANDWICH PANEL RANKING

1. CIBA-GEIGY FIBREDUX 917G/917G/NOMEX CORE

2. FIBERITE MXB 6070/MXB 7255/NOMEX CORE

3. NARMCO 8250/9251/NOMEX CORE

FIRE CONTAINMENT CONSIDERATIONS

- BACKFACE TEMPERATURE
- BURN-THROUGH
- FOAM IN CORE
  - POLYQUINOXALINE–HITCO
  - POLYIMIDE/POLYURETHANE–GENERAL PLASTICS
  - PYROLYZED POLYISOCYANURATE–HITCO
  - PHENOLIC–CIBA GEIGY

FOAM EVALUATION

- CORE + FOAM ONLY
- OSU APPARATUS (5.0 W/cm^2)
  - SMOKE EMISSION–10%
  - HEAT RELEASE–10%
  - HEAT RELEASE RATE–10%
- BOEING BURN-THROUGH
  - HEAT RELEASE–10%
  - HEAT RELEASE RATE–10%
  - THERMAL CONDUCTIVITY–50%
- MATERIAL
  - 7.5%
  - LABORATORY TESTS–92.5%

FOAM RANKING

- PROCEDURE
  - ARITHMETIC
  - GEOMETRIC

- RESULTS
  1. PHENOLIC
  2. PQ
  3. PYROLYZED ICU
  4. PI/PU

TASKS 3 AND 4

- DECORATIVE FILM EVALUATION
  - POLYVINYLFLUORIDE–DUPONT
  - FM POLYVINYLFLUORIDE–DUPONT
  - POLYVINYLIDENE FLUORIDE–REXHAM
  - POLYCARBONATE–GENERAL ELECTRIC
  - POLYETHERSULFONE–ICI AMERICAS
- RESULTS AND CONCLUSIONS
  - POLYCARBONATE
  - POLYVINYLFLUORIDE–FINAL TASK
  - FILM NEEDED–IMPROVED FS & T
  - FILM DEVELOPMENT PROGRAM

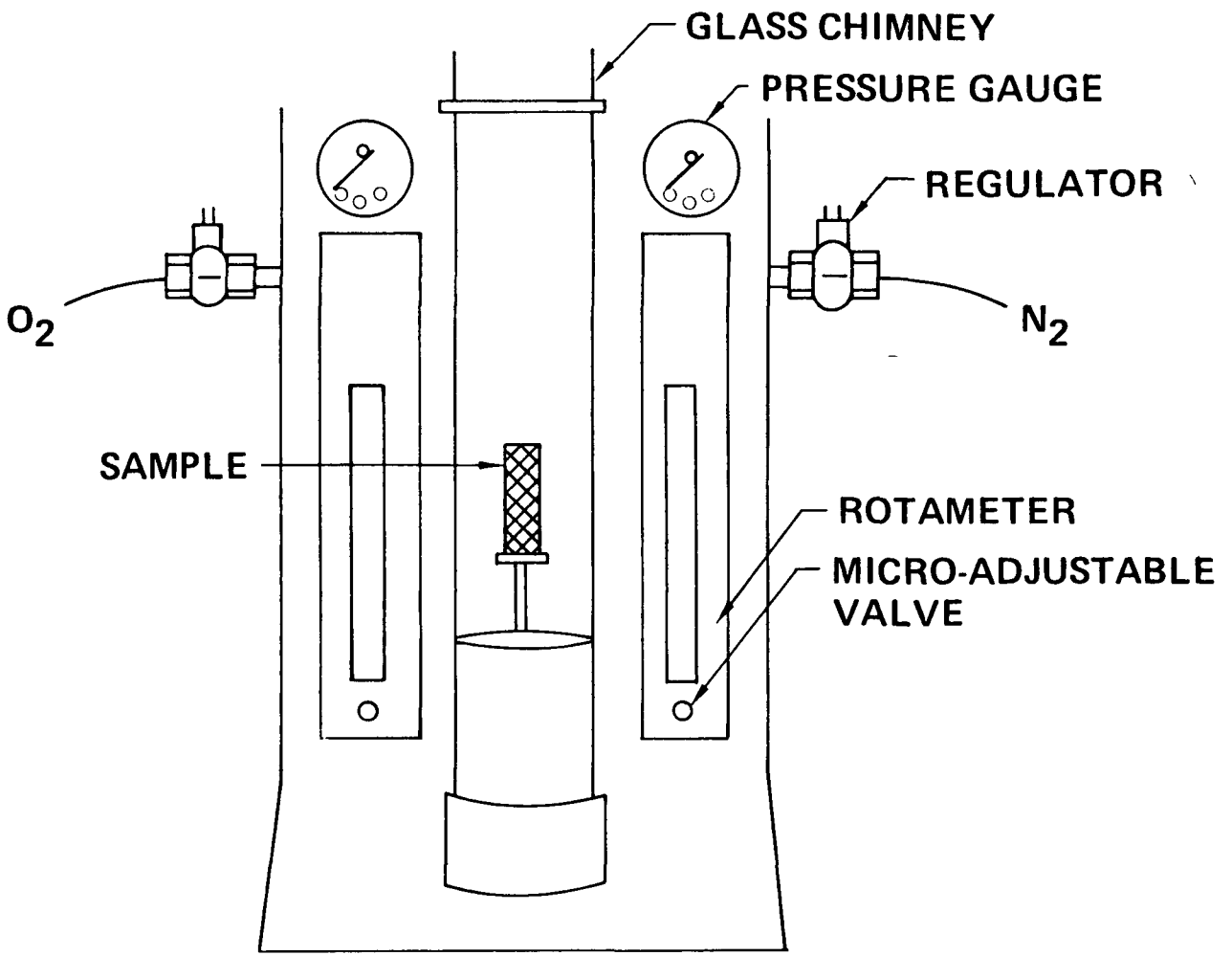
MATERIALS MATRIX–TASK 5

PANEL NO	DECORATIVE FILM	FACESHEET		BOND PLY		HONEYCOMB CORE		FOAM	
1	PVF*/ACRYLIC INK/PVF**	EPOXY	FIBERITE MXB-7203	EPOXY	FIBERITE MXB-7251	PHENOLIC/ POLYAMIDE	3 PCF NOMEX	NONE	
2	PVF*/ACRYLIC INK/PVF**	PHENOLIC	CIBA-GEIGY FIBREDUX 917G	PHENOLIC	CIBA-GEIGY FIBREDUX 917G	PHENOLIC/ POLYAMIDE	3 PCF NOMEX	NONE	
3	PVF*/ACRYLIC INK/PVF**	PHENOLIC	CIBA-GEIGY FIBREDUX 917G	PHENOLIC	CIBA-GEIGY FIBREDUX 917G	PHENOLIC/ POLYAMIDE	3 PCF NOMEX	PHENOLIC	2 5 PCF

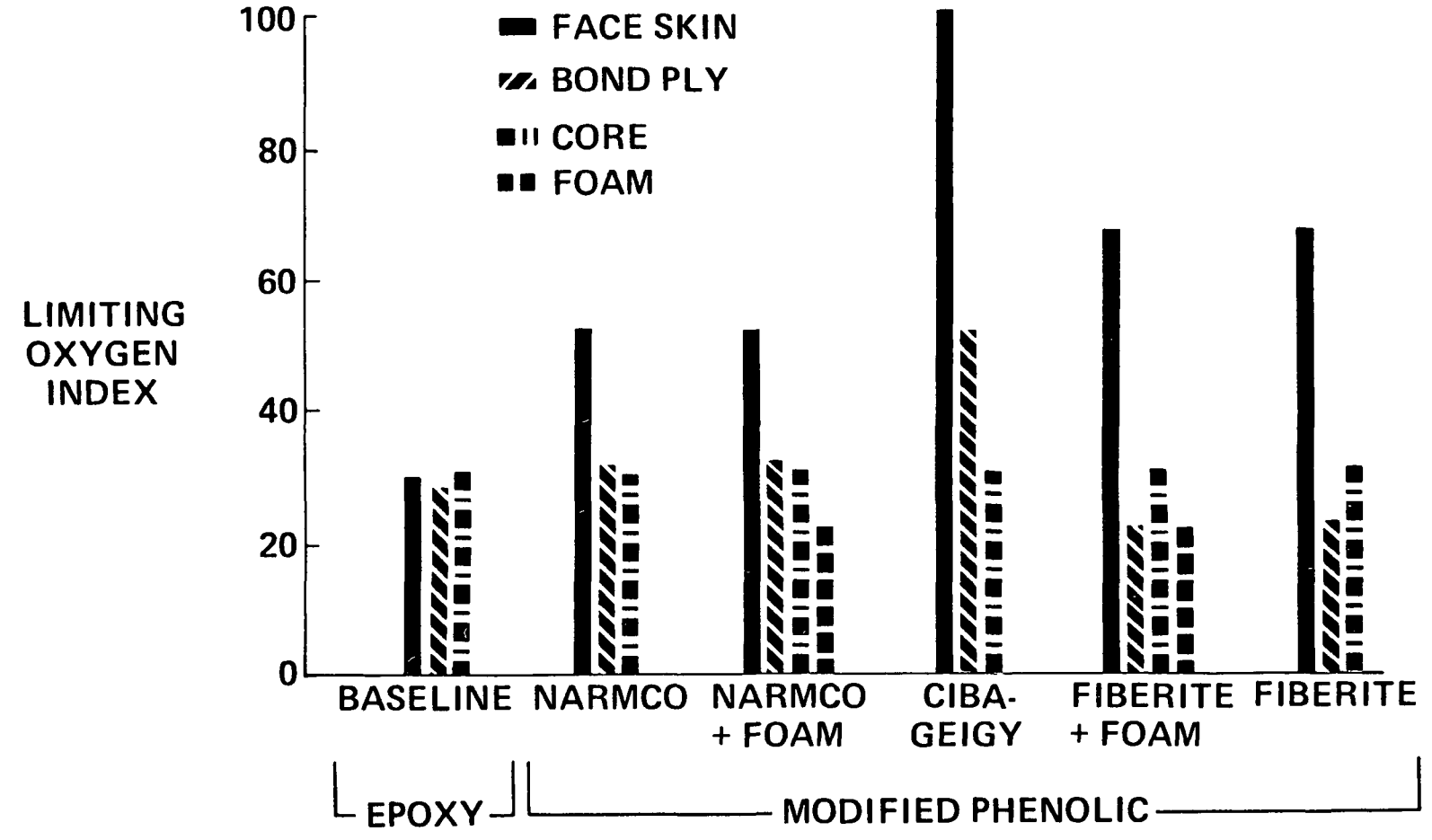
*0 025 mm (0 001 in) PVF TOP FILM

**0.051 mm (0 002 in.) PVF SUBSTRATE FILM

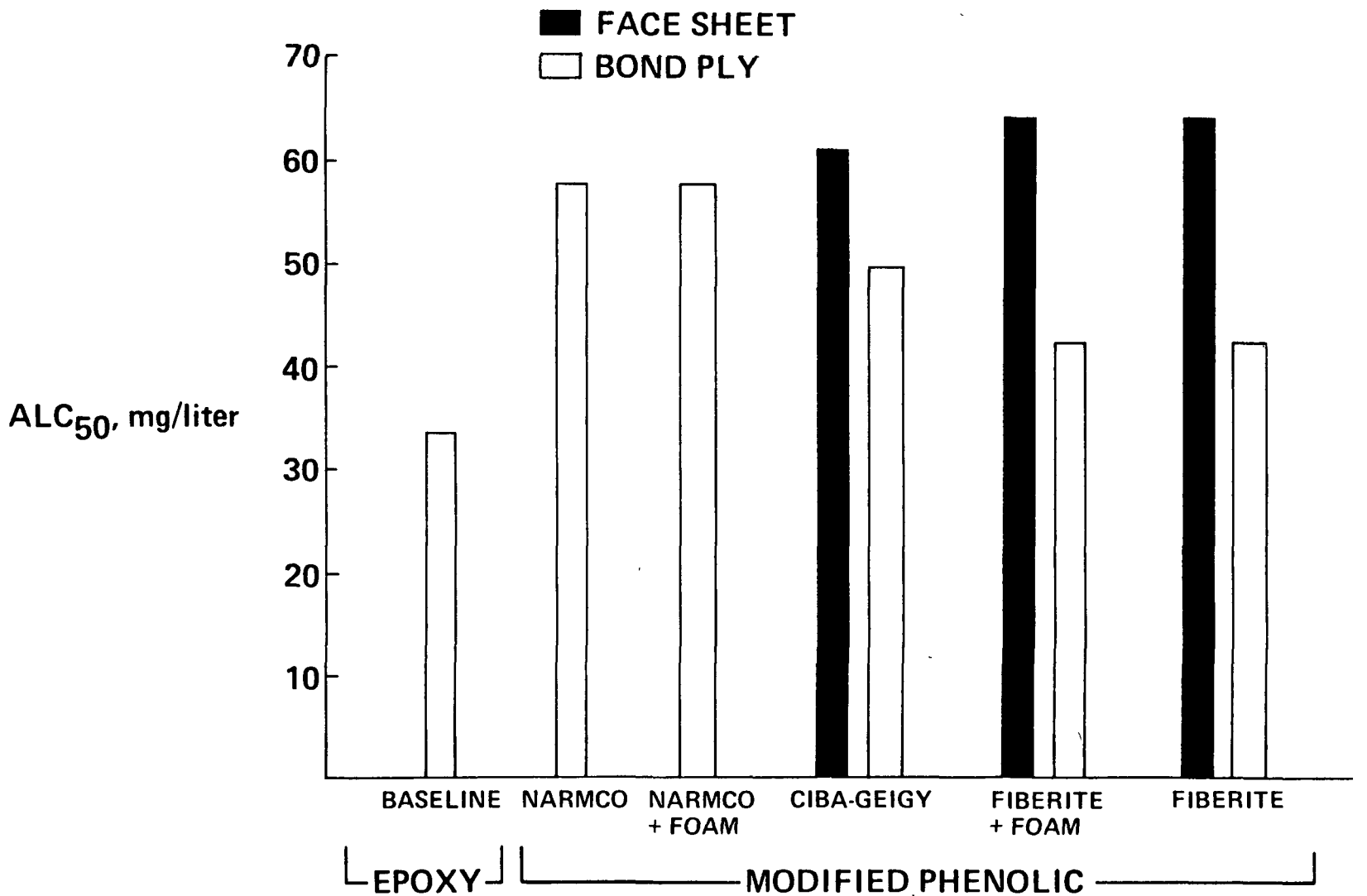
LIMITING OXYGEN INDEX APPARATUS



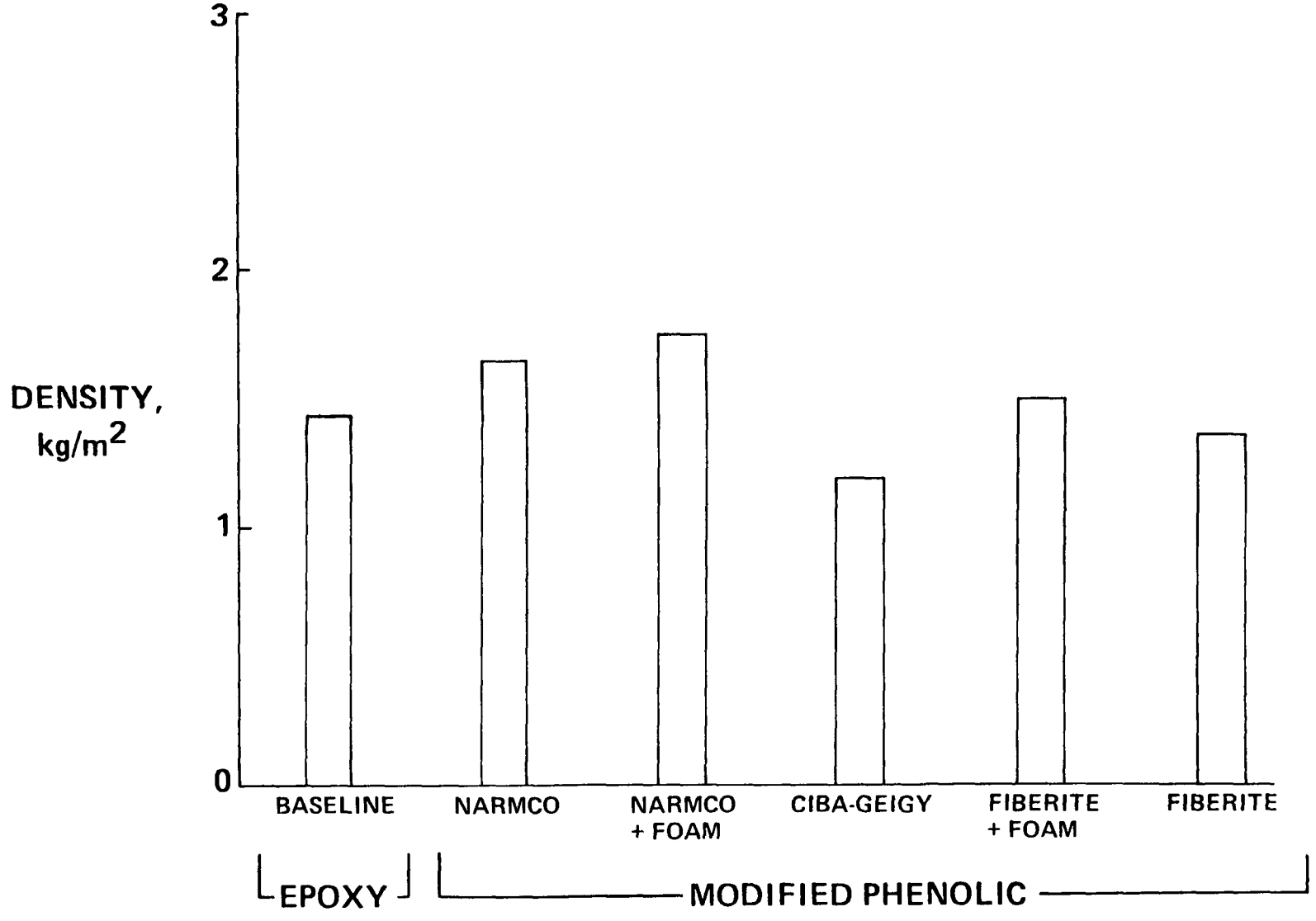
PROPENSITY TO BURN



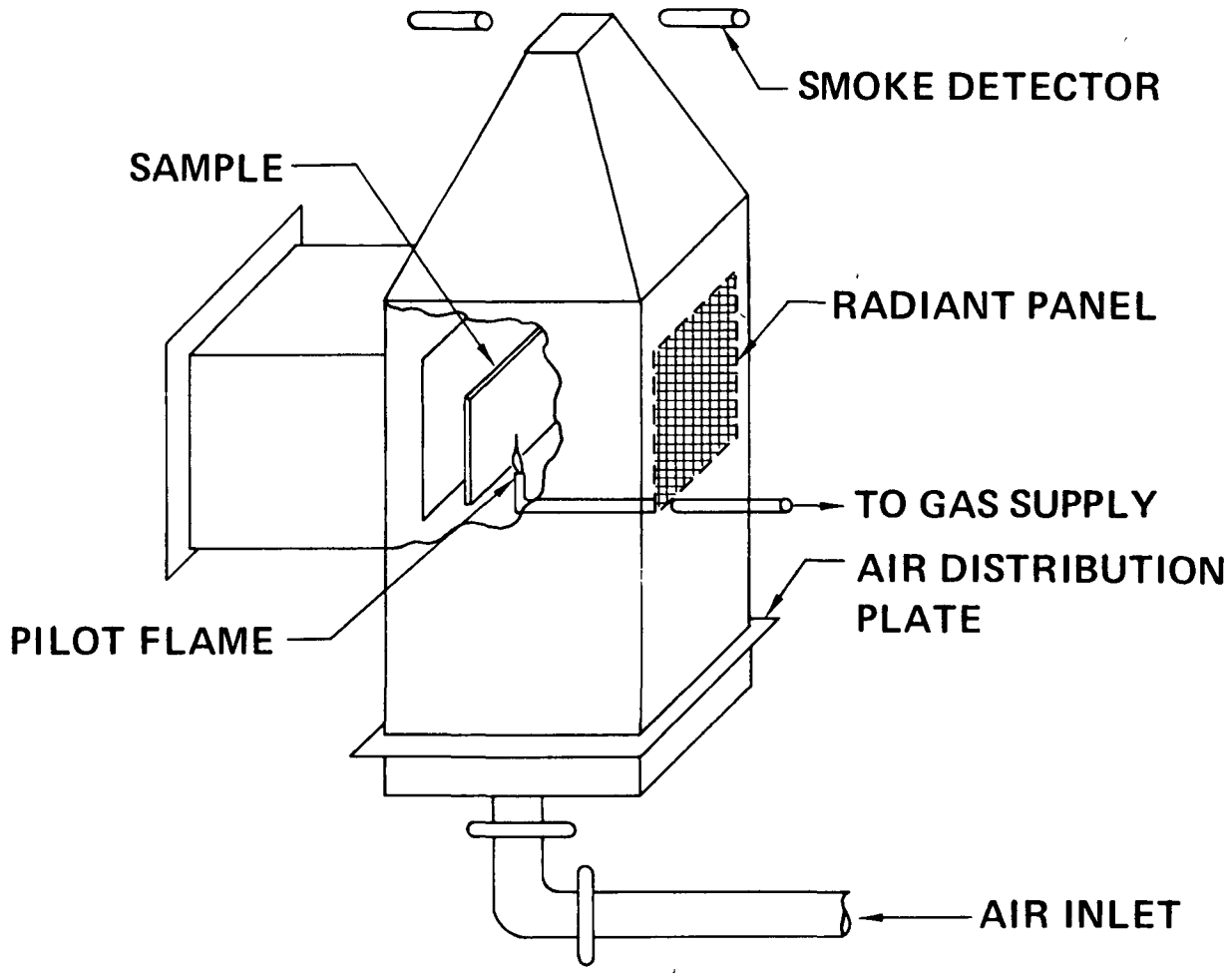
NASA ANIMAL EXPOSURE CHAMBER



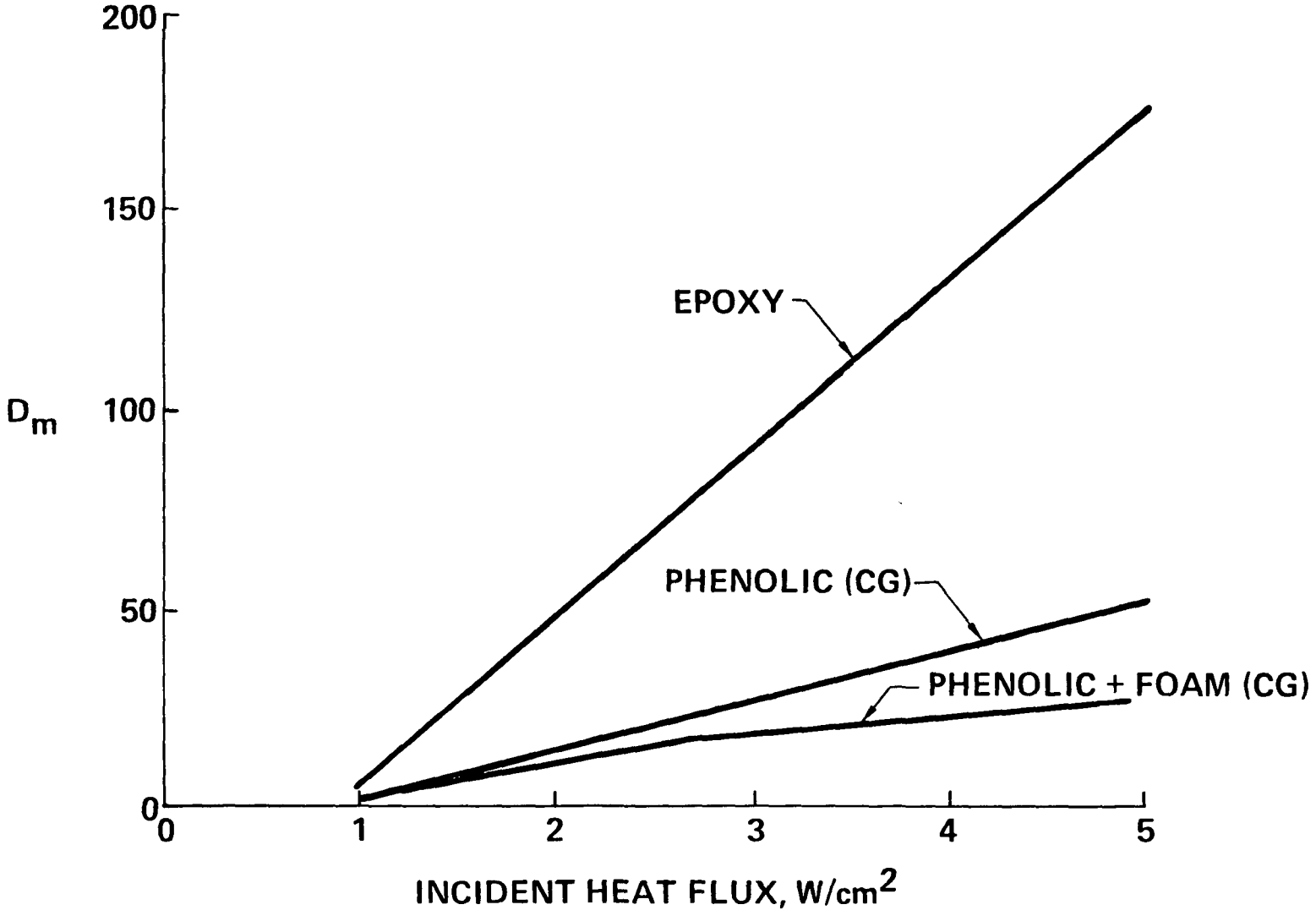
PANEL WEIGHT



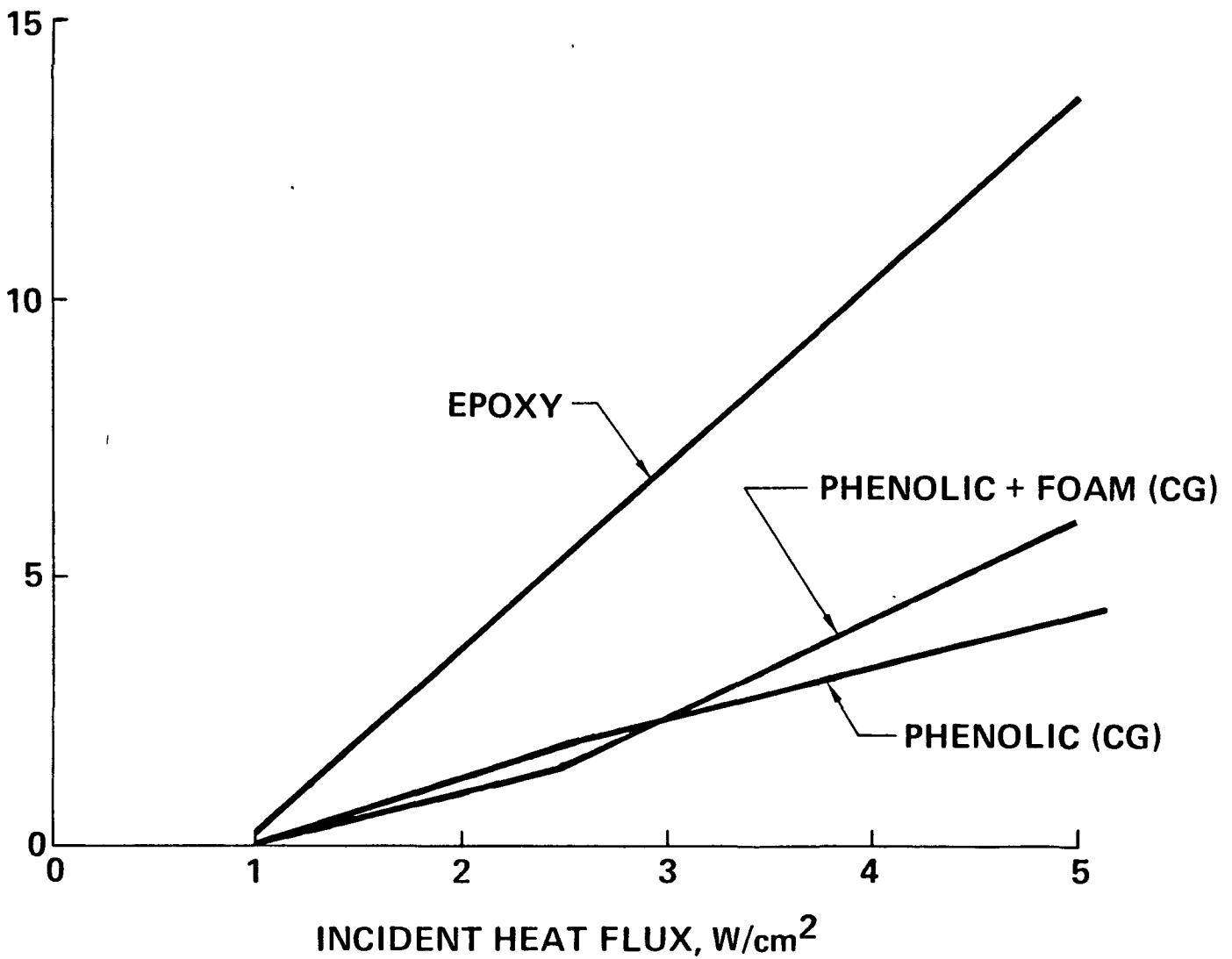
OSU HEAT RELEASE APPARATUS



SMOKE EMISSION–OSU CHAMBER–FLAMING

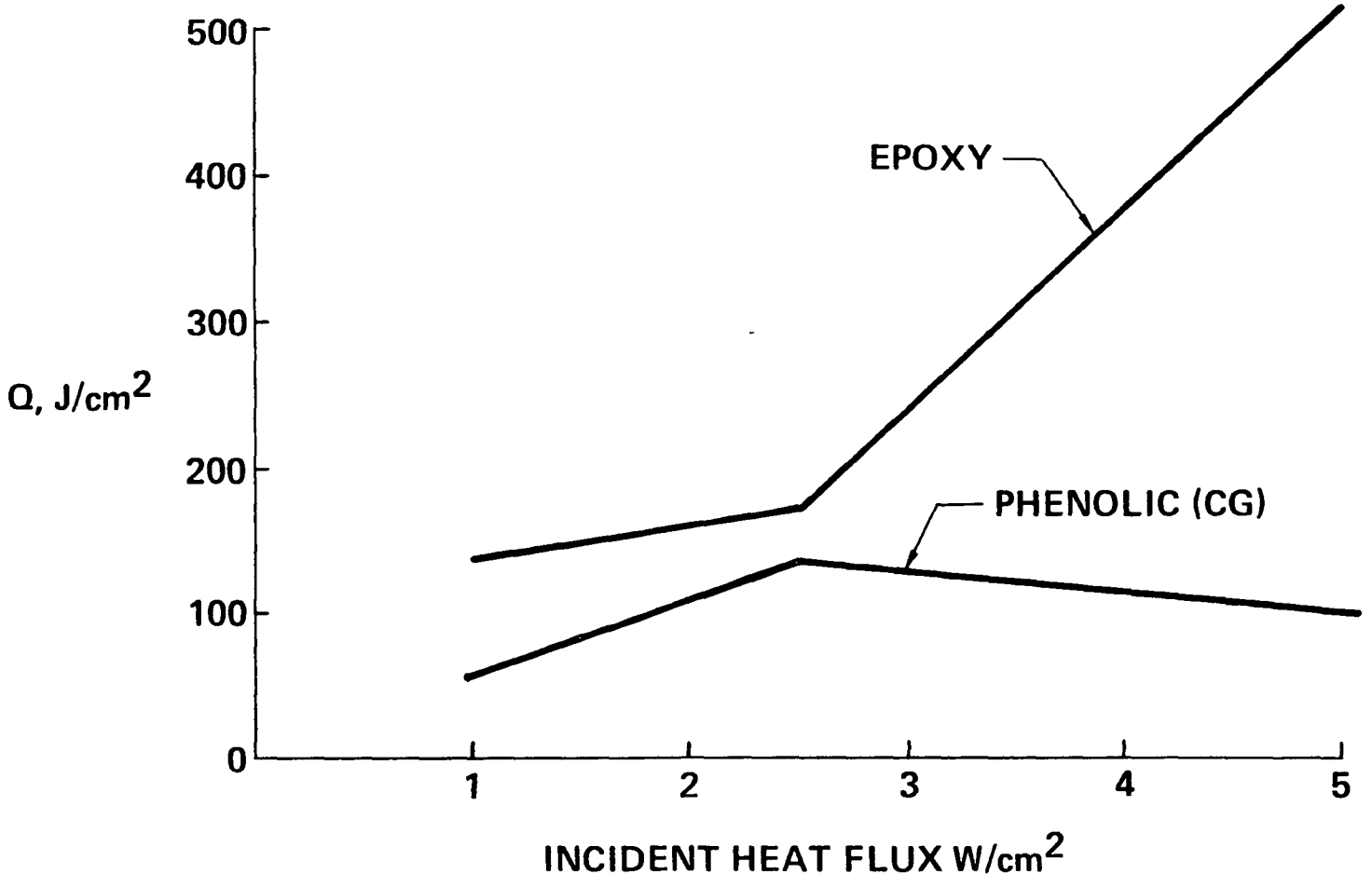


SMOKE EMISSION–OSU CHAMBER–FLAMING



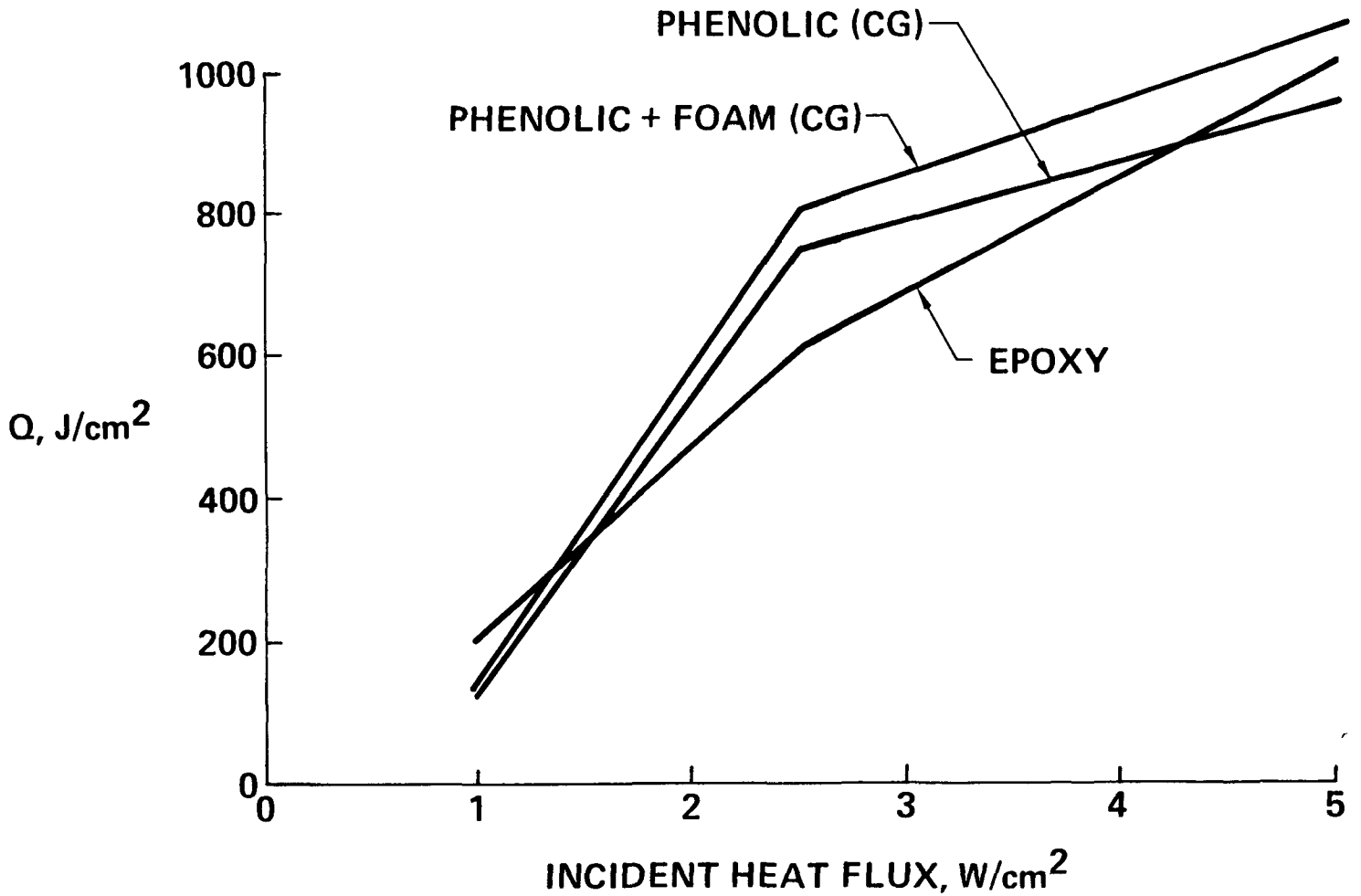
TOTAL HEAT RELEASE–OSU APPARATUS–FLAMING VERTICAL

0.25 INCH CORE

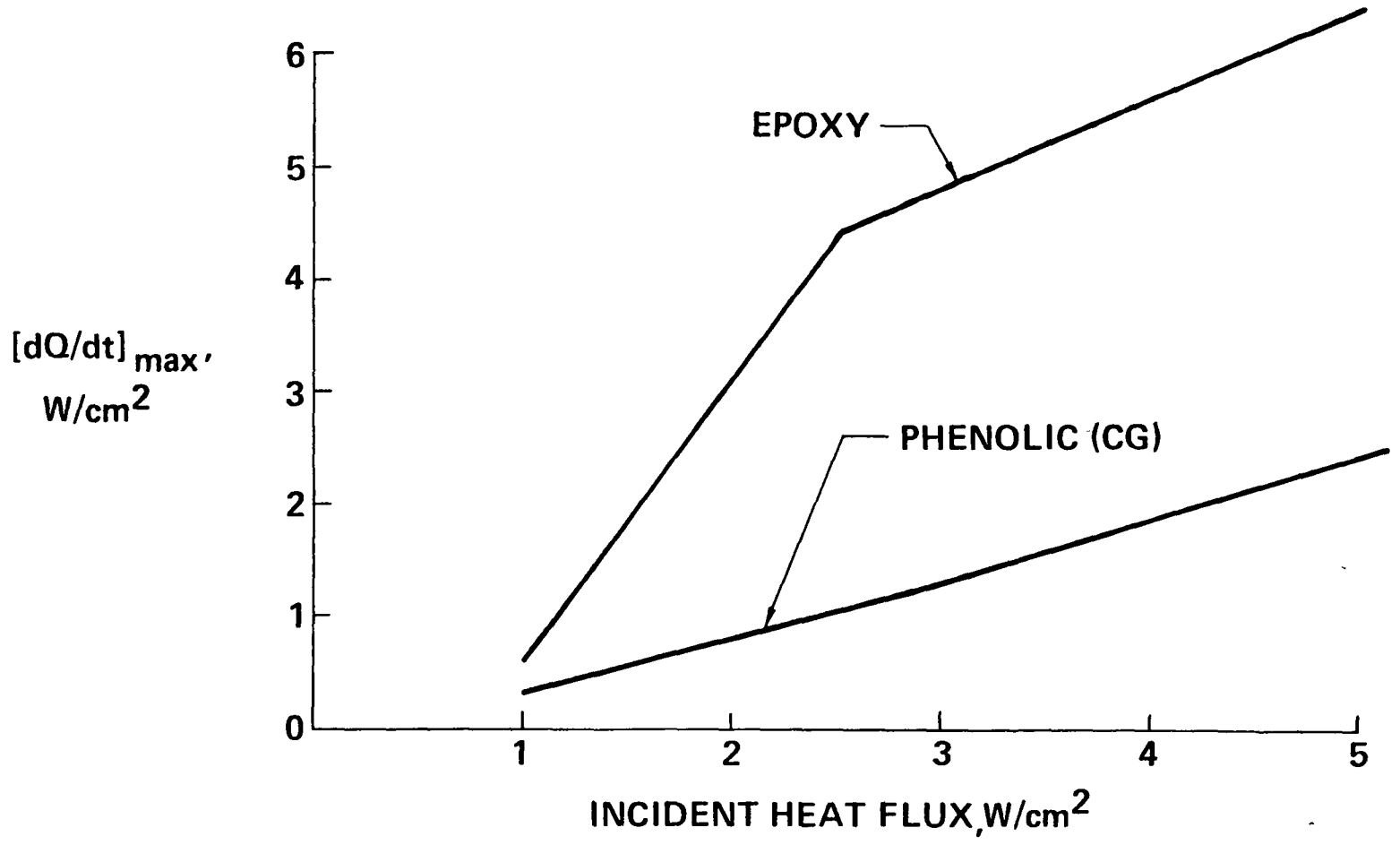


TOTAL HEAT RELEASE–OSU APPARATUS–FLAMING VERTICAL

0.95 INCH CORE

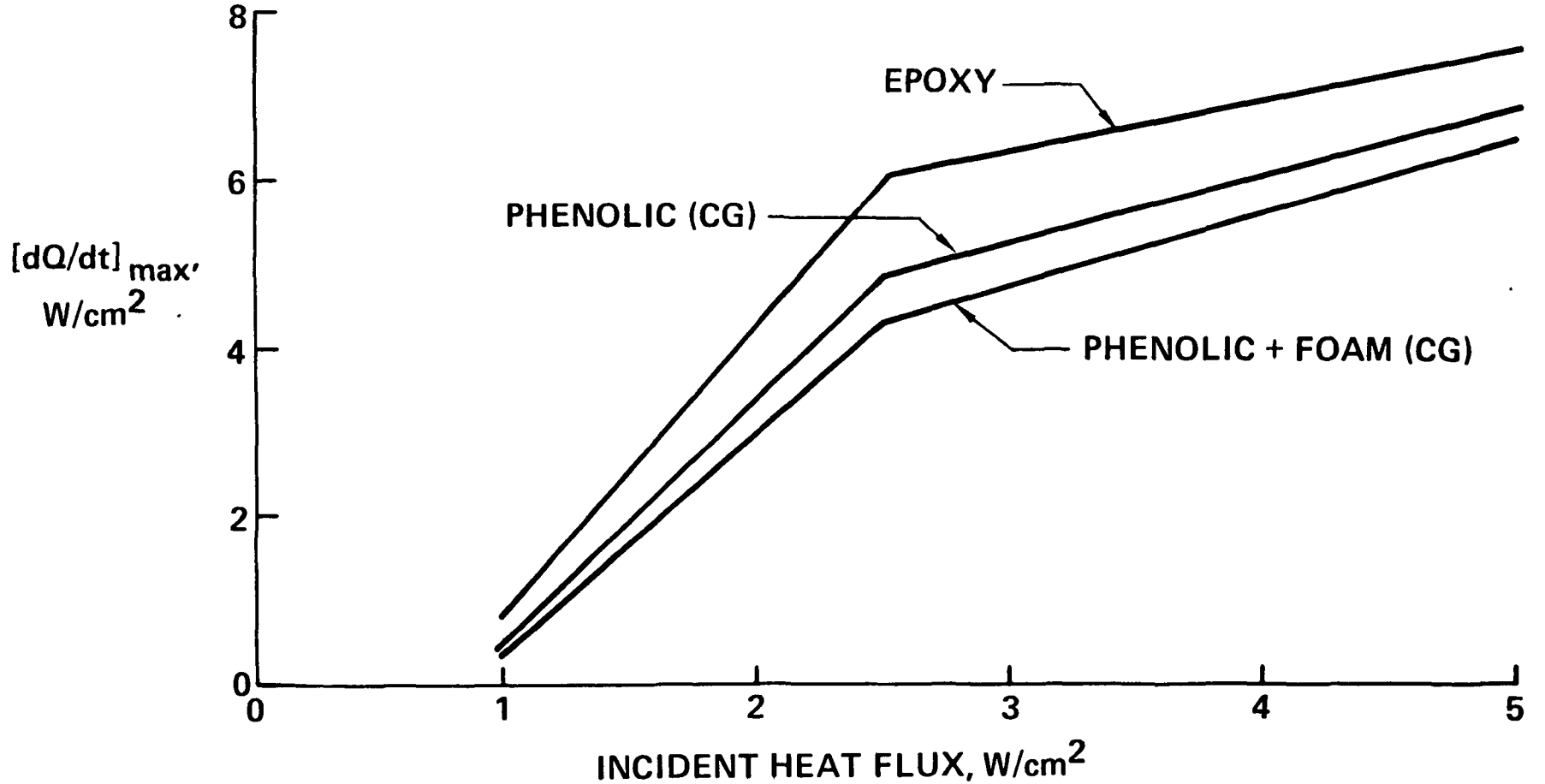


HEAT RELEASE RATE–OSU APPARATUS–FLAMING VERTICAL
0.25 INCH CORE

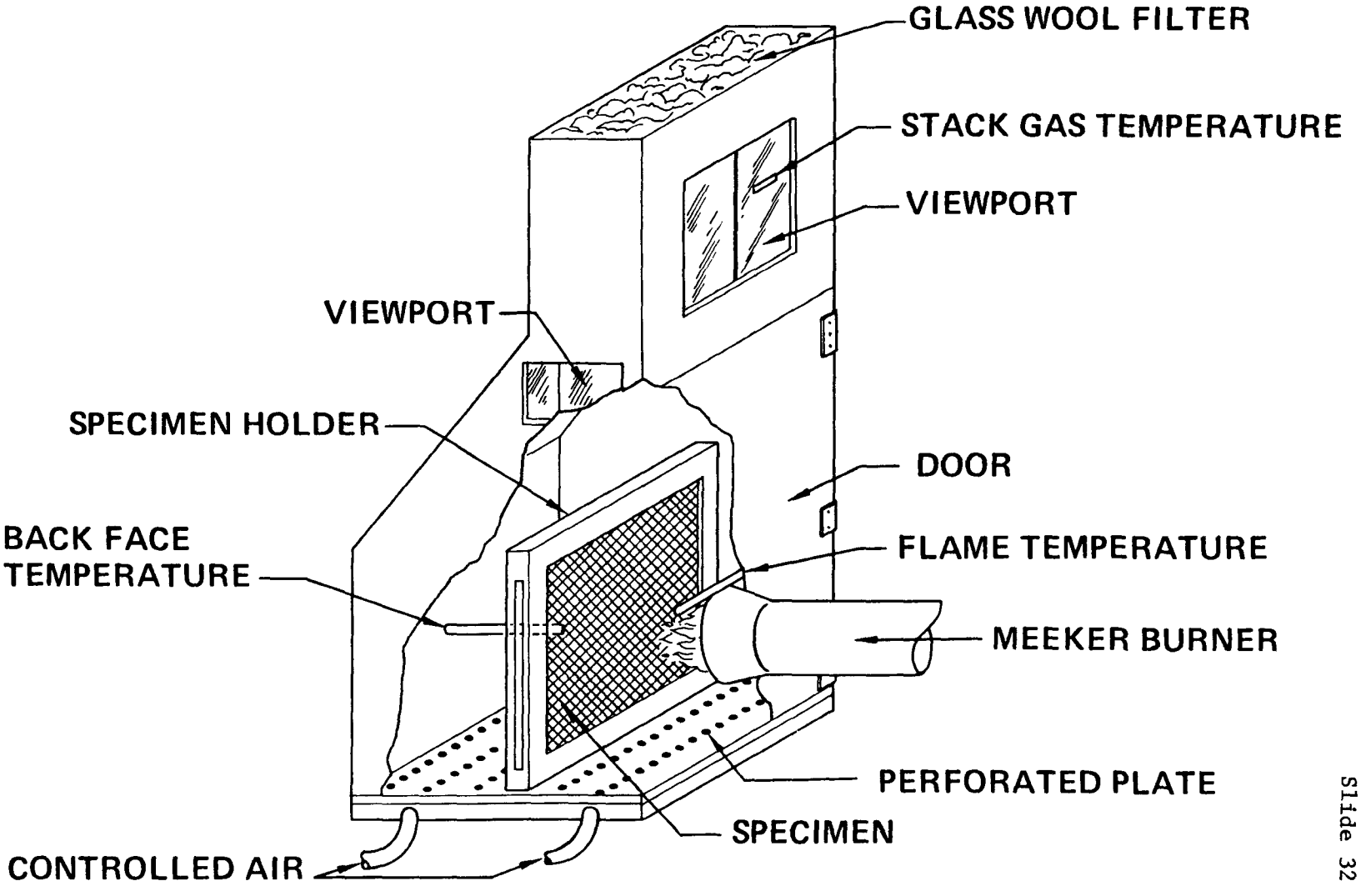


HEAT RELEASE RATE–OSU APPARATUS–FLAMING VERTICAL

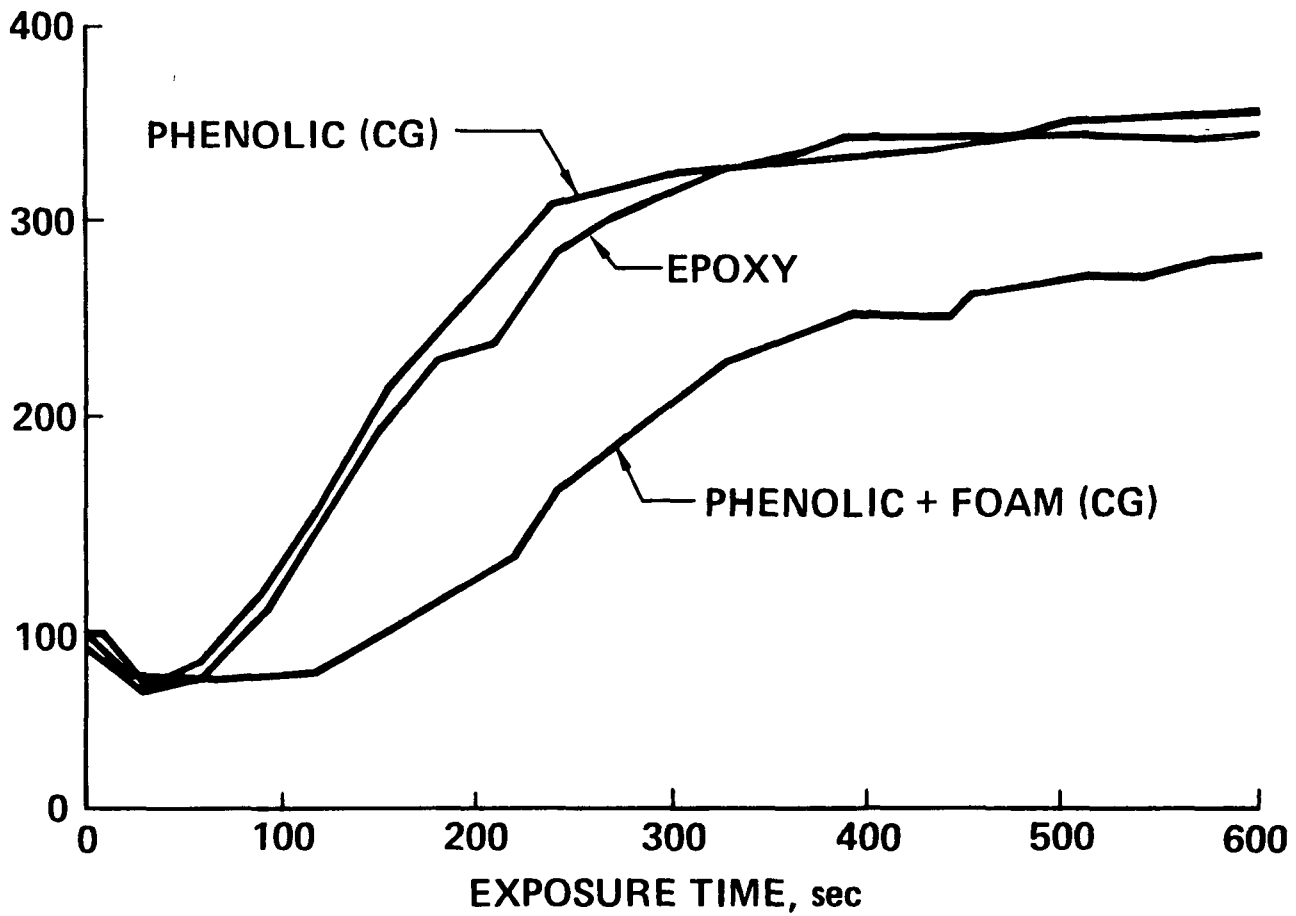
0.95 INCH CORE



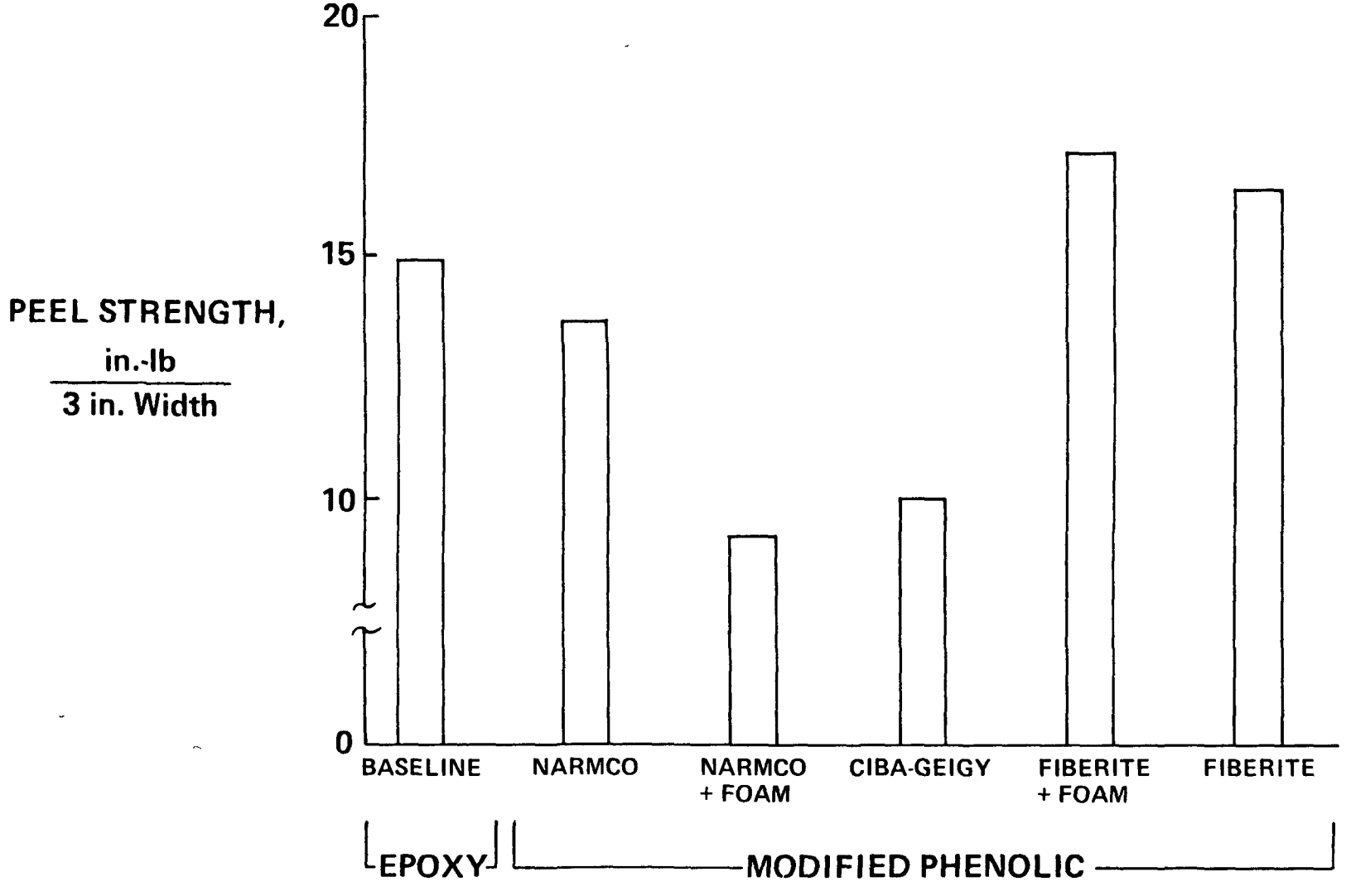
BOEING BURN-THROUGH APPARATUS



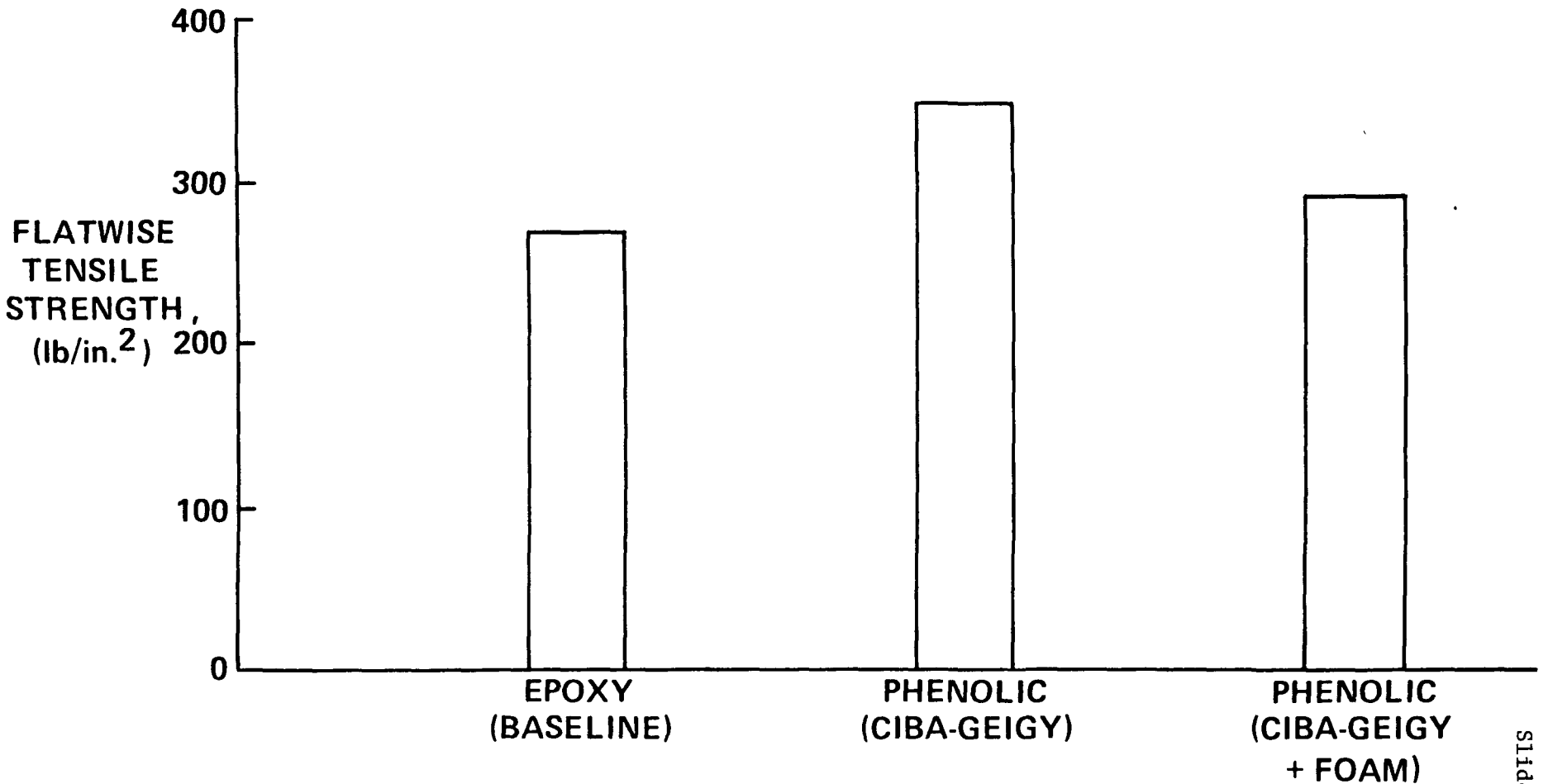
BOEING BURN-THROUGH



MECHANICAL STRENGTH–0.25 INCH CORE



MECHANICAL STRENGTH



FS & T IMPROVEMENTS

	BASELINE EPOXY	CIBA-GEIGY PHENOLIC
• PROPENSITY TO BURN (LOI)		
• FACE SHEET	29.0	100^{+}
• BOND PLY	27.7	53.5
• SMOKE EMISSION (D_s @ 4 min) NBS		
• 2.5 W/ cm^2	62.8	2.5
• 5.0 W/ cm^2	96.5	8.4
• HEAT RELEASE (J/cm^2) OSU		
• 2.5 W/ cm^2	177.2	126.0
• 5.0 W/ cm^2	512.4	96.3
• ALC_{50} (mg/liter) NASA CHAMBER		
• FACE SHEET	–	61.2
• BOND PLY	33.6	49.7

DECORATIVE FILM DEVELOPMENT

PHASE III

NAS2-8700

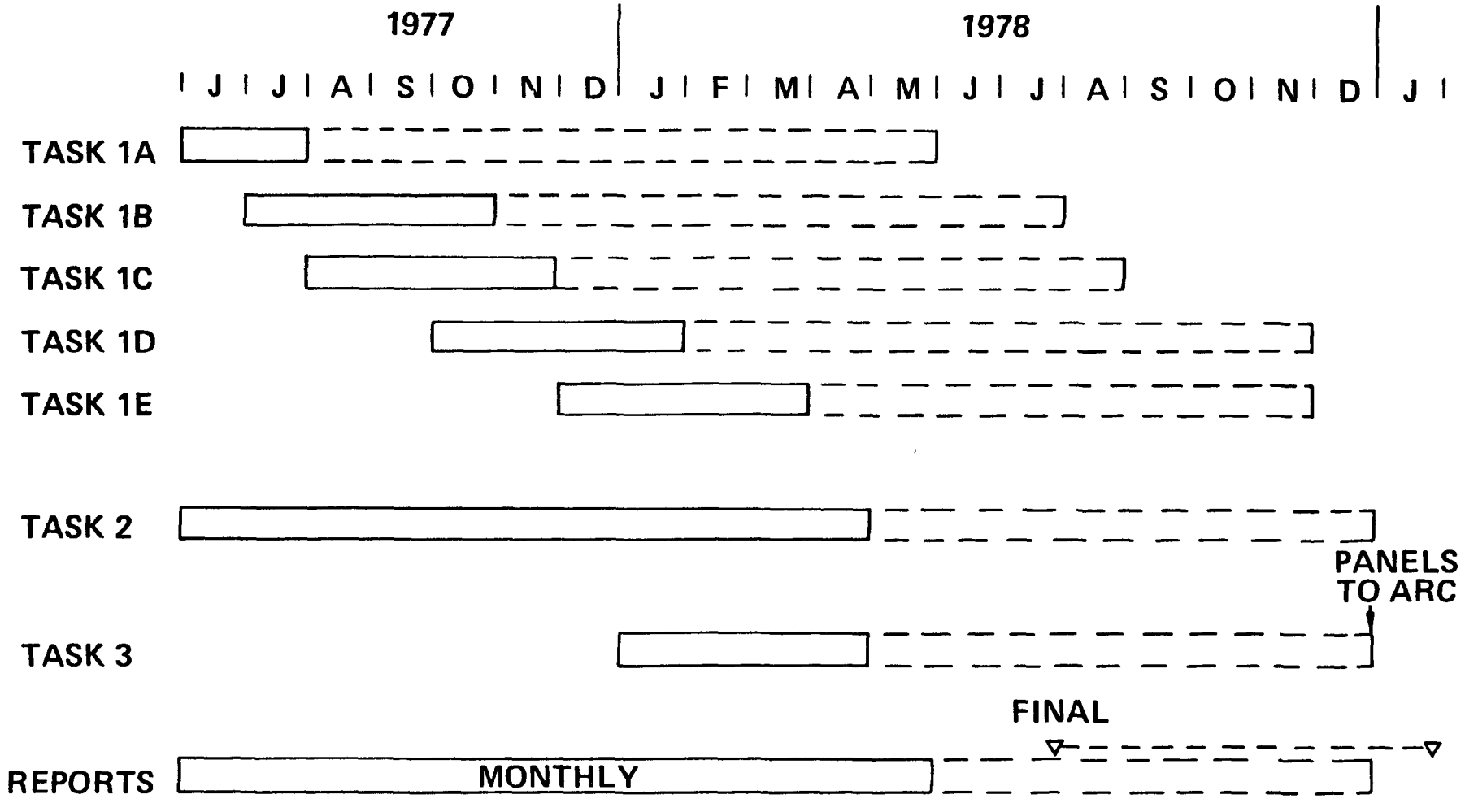
OBJECTIVES

- SIDEWALL, CEILING, AND PARTITION PANEL DEVELOPMENT
- DECORATIVE FILM DEVELOPMENT
- LOW SMOKE AND TOXIC GAS EMISSION
- RESISTANT TO HIGH HEAT FLUX
- PROCESS ASSESSMENT
- RANKING SYSTEM
- END ITEM DELIVERY TO NASA/ARC

FILM DEVELOPMENT PROGRAM

- TASK 1–DECORATIVE FILM DEVELOPMENT
  - TASK 1A–FILM SELECTION
  - TASK 1B–FILM SCREENING
  - TASK 1C–FILM PRINTABILITY
  - TASK 1D–COMPOSITE FILM TESTING
  - TASK 1E–FABRICATION OF DECORATIVE LAMINATES
- TASK 2–RESIN SYSTEM DEVELOPMENT
- TASK 3–COMBINED SANDWICH PANEL

DECORATIVE FILM PROGRAM SCHEDULE



TEST PLAN

	TASK					
	1-A	1-B	1-C	1-D	1-E	3
• FLAMMABILITY						
LOI (ASTM D2863)	X			X		
SMOKE (NBS CHAMBER)	X	X		X		X
TOXICITY (NBS CHAMBER)	X	X		X		X
HEAT RELEASE (OSU CHAMBER)		X				X
FLAME SPREAD (ASTM E-162)		X				
VERTICAL, 60 SECOND (FAR 25-32)				X		
BURN-THROUGH (BOEING)						X
T-3 THERMAL ENDURANCE (NASA)						X
TOXICITY (NASA)						X
• THERMOPHYSICAL						
TGA/DTA		X				
PYROLYSIS–600°C		X		X		

TEST PLAN

	TASK					
	1-A	1-B	1-C	1-D	1-E	3
• MECHANICAL						
TENSILE STRENGTH		X				
MODULUS		X				
ELONGATION		X		X		
SHRINKAGE		X				
HEAT DISTORTION TEMPERATURE		X				
PEEL STRENGTH				X	X	X
ABRASION RESISTANCE					X	X
BEAM FLEXURE						X
FLATWISE TENSION						X
IMPACT						X
• OTHER						
PRINTABILITY			X			
UV STABILITY				X		
STAIN RESISTANCE				X		
DECORATIVE CAPABILITY					X	
DENSITY						X

TASK 1-A FILMS

POLYVINYLFLUORIDE (PVF)

1. .002" WHITE TEDLAR (DUPONT)
2. .001" CLEAR DEGLOSSED TEDLAR + 6880 (DUPONT)
3. .002" WHITE FM TEDLAR (DUPONT)
4. .001" CLEAR TEDLAR + 6880 (DUPONT)

POLYVINYLIDENE FLUORIDE (PVF_2)

1. .003" WHITE FLUOREX H (REXHAM)
2. .002" CLEAR FLUOREX H (REXHAM)

POLYOLEFIN

1. .002" CLEAR BICOR 240B, POLYPROPYLENE (MOBIL)
2. .001" CLEAR BICOR 360B, POLYPROPYLENE (MOBIL)
3. .020" CLEAR TPX, POLYMETHYLPENTENE (MITSUI)
4. .008" WHITE APPLETON 61079, POLYETHYLENE (APPLETON)
5. .002" CLEAR WITCO, POLYBUTYLENE (WITCO)
6. .001" WHITE WITCO, POLYBUTYLENE (WITCO)

POLYIMIDE/POLYAMIDE

1. .001" BROWN KAPTON (DUPONT)
2. .002" BROWN KAPTON (DUPONT)
3. .002" CLEAR YELLOW DAPI-BTDA (CIBA-GEIGY)
4. .002" WHITE NOMEX PAPER (DUPONT)
5. .002" CLEAR ARAMID (DUPONT)

POLYPHENYLSULPHONE

1. .001" CREAM RADEL R-5010 (UNION CARBIDE)

POLYSULPHONE

1. .001" CLEAR UDEL (UNION CARBIDE)

POLYETHERSULPHONE

1. .001" POLYETHERSULPHONE 300P (ICI)

TASK 1-A FILMS

POLYESTER

1. .001" ISO-BPE AROMATIC (ISOVOLTA)
2. .002" WHITE MELINEX 334 (ICI-US)
3. .002" CLEAR MELINEX 442 (ICI-US)
4. .006" WHITE PERMACARE II HC (APPLETON)
5. .007" WHITE FR REEMAY (APPLETON)
6. .017" WHITE HY-PERMACARE-6 (APPLETON)
7. .008" WHITE PERMACARE IV (APPLETON)
8. .007" WHITE PERMALESCENT (APPLETON)
9. .006" COLORED PERMACARE (APPLETON)

POLYBENZIMIDAZOLE

1. .002" POLYBENZIMIDAZOLE 23856-30 #1 (CELANESE RESEARCH)

ACRYLIC

1. .002" CLEAR KORAD A-CU (KORAD)
2. .002" WHITE KORAD 63000 (KORAD)

POLYCARBONATE

1. .002" CLEAR LEXAN (GENERAL ELECTRIC)

POLYPARABANIC ACID

1. .002" CLEAR YELLOW TRADLON (EXXON)
2. .002" OPAQUE YELLOW TRADLON (EXXON)

IONOMER

1. .001" SURLYN 1652 (DUPONT)
2. .001" SURLYN 1601 (DUPONT)

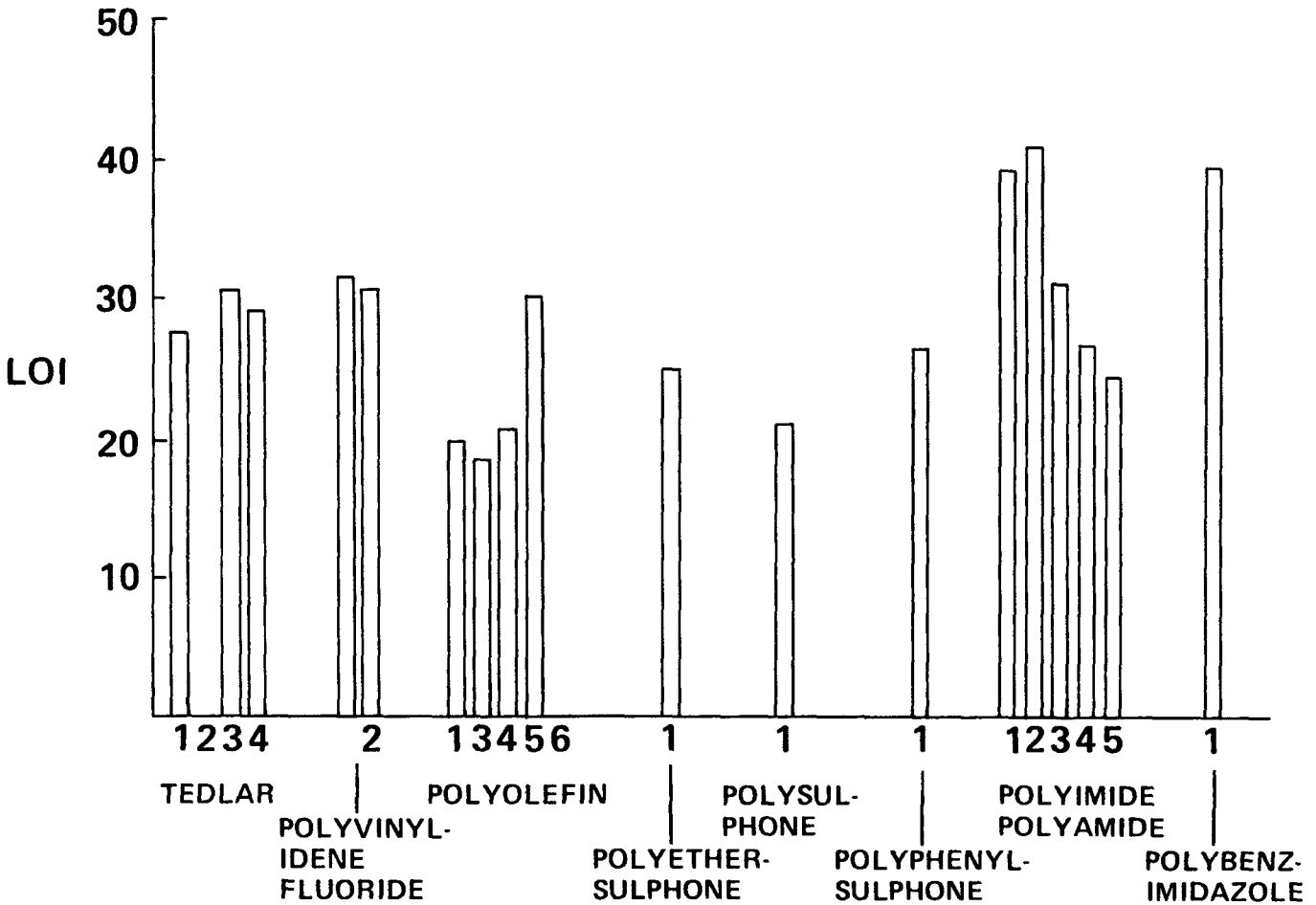
NYLON 6,6

1. .002" CLEAR BLUE WRIGHTON 8400 (INTERNATIONAL PLASTICS PRODUCTS)

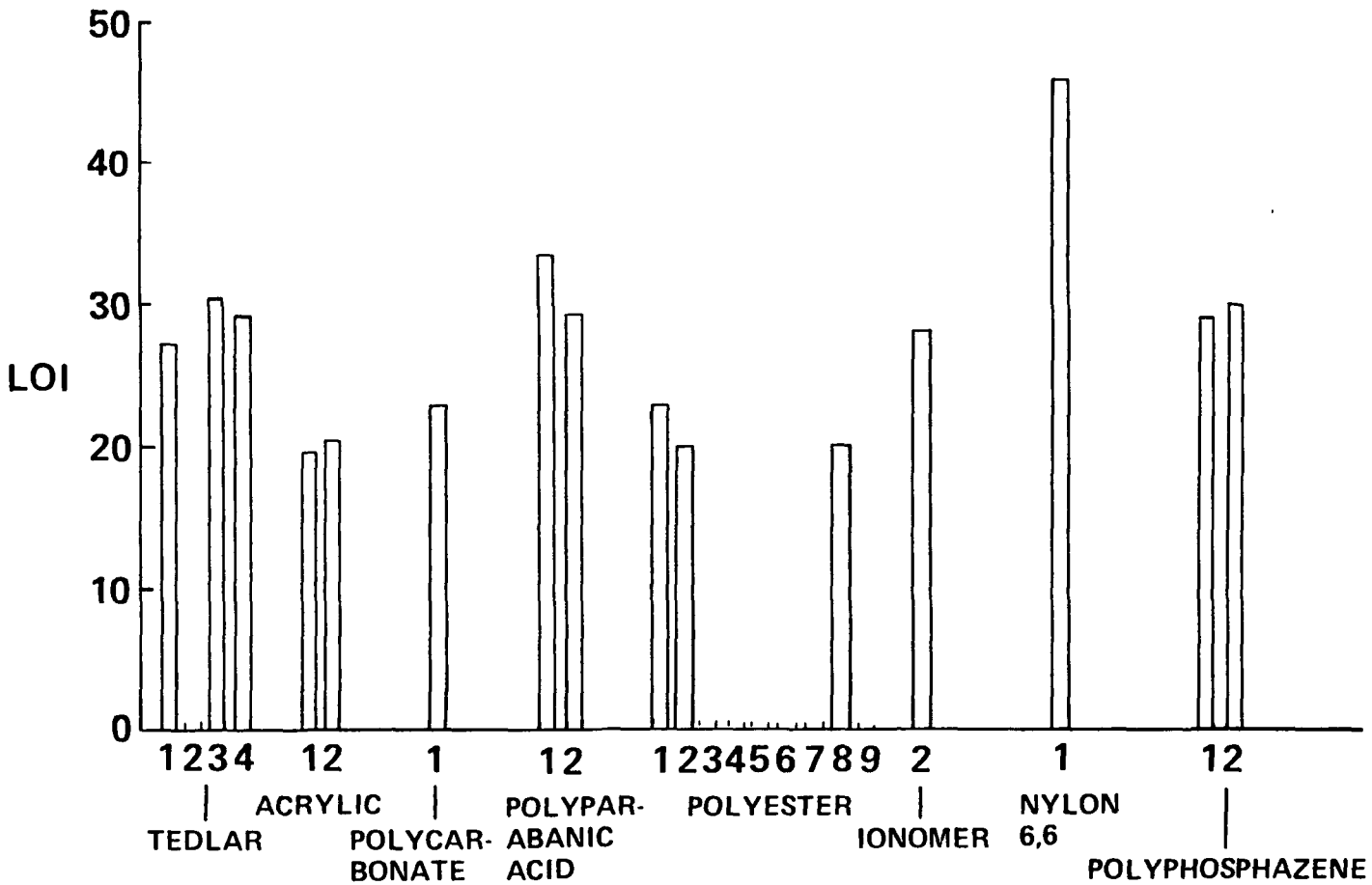
POLYPHOSPHAZENE

1. .007" HORIZONS 1443-24-2 (HORIZONS)
2. .007" HORIZONS 1443-24-1 (HORIZONS)

PROPENSITY TO BURN

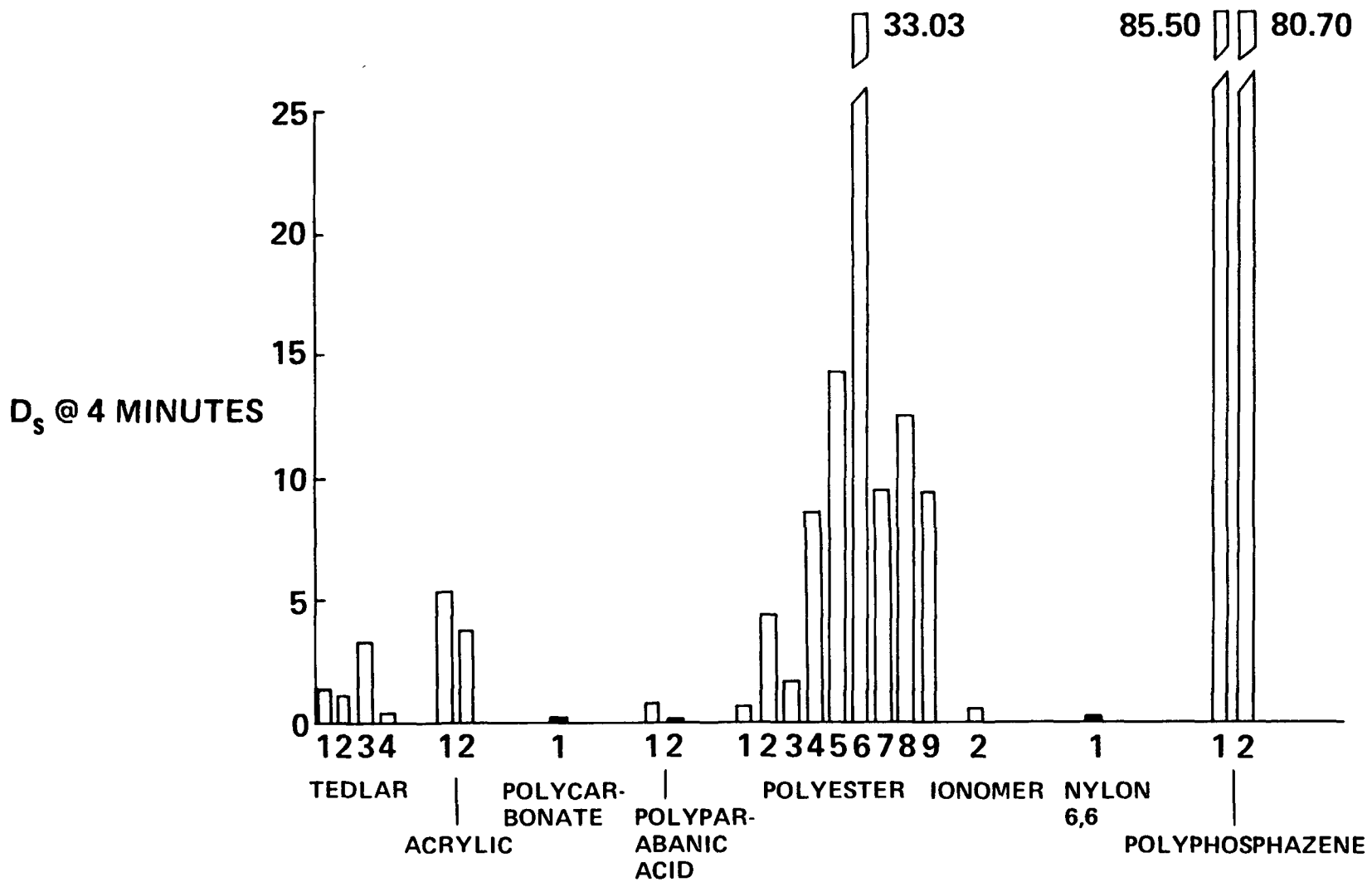


PROPENSITY TO BURN



SMOKE EMISSION—NBS CHAMBER

2.5 W/cm^2



SMOKE EMISSION–NBS CHAMBER

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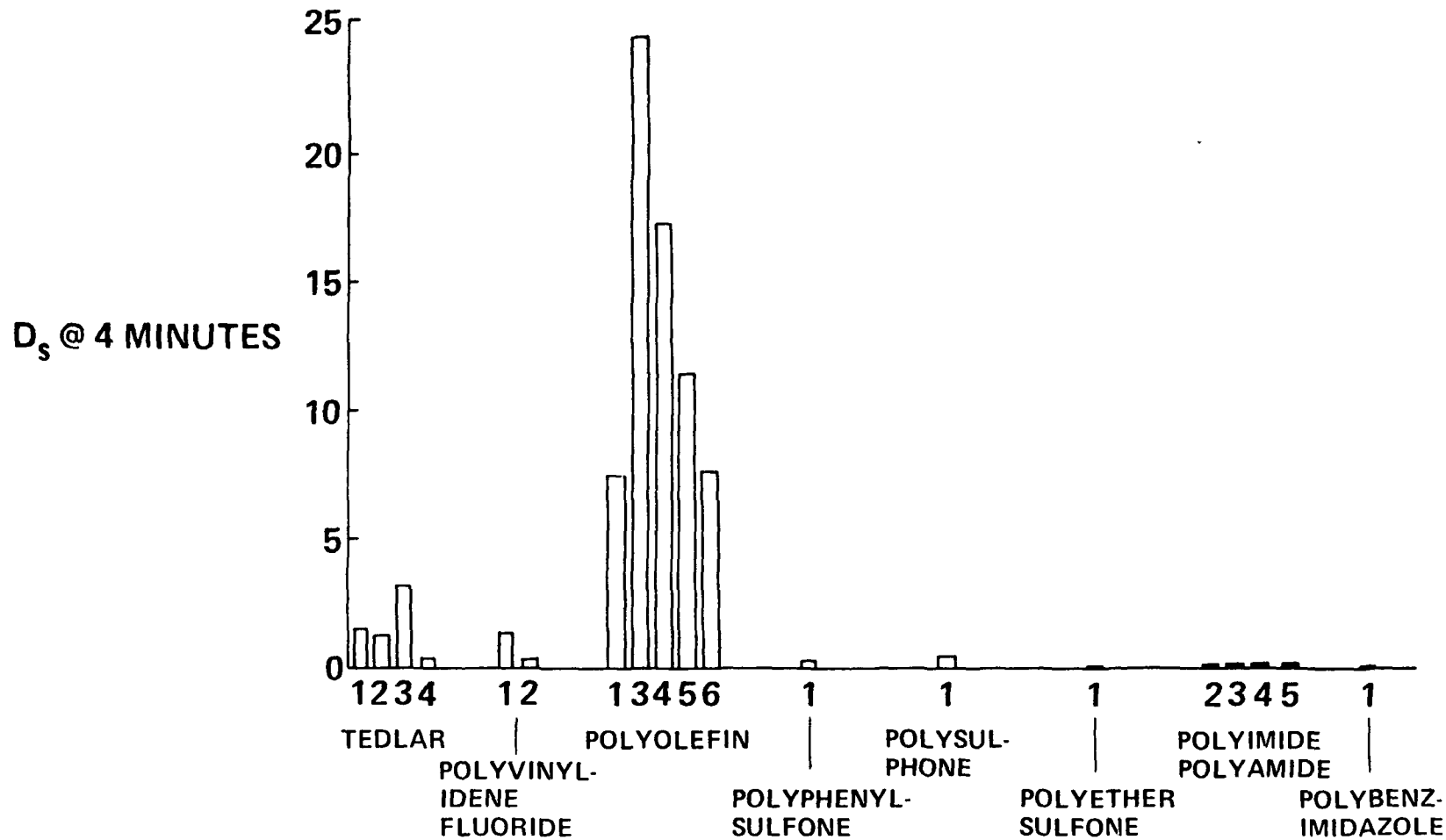
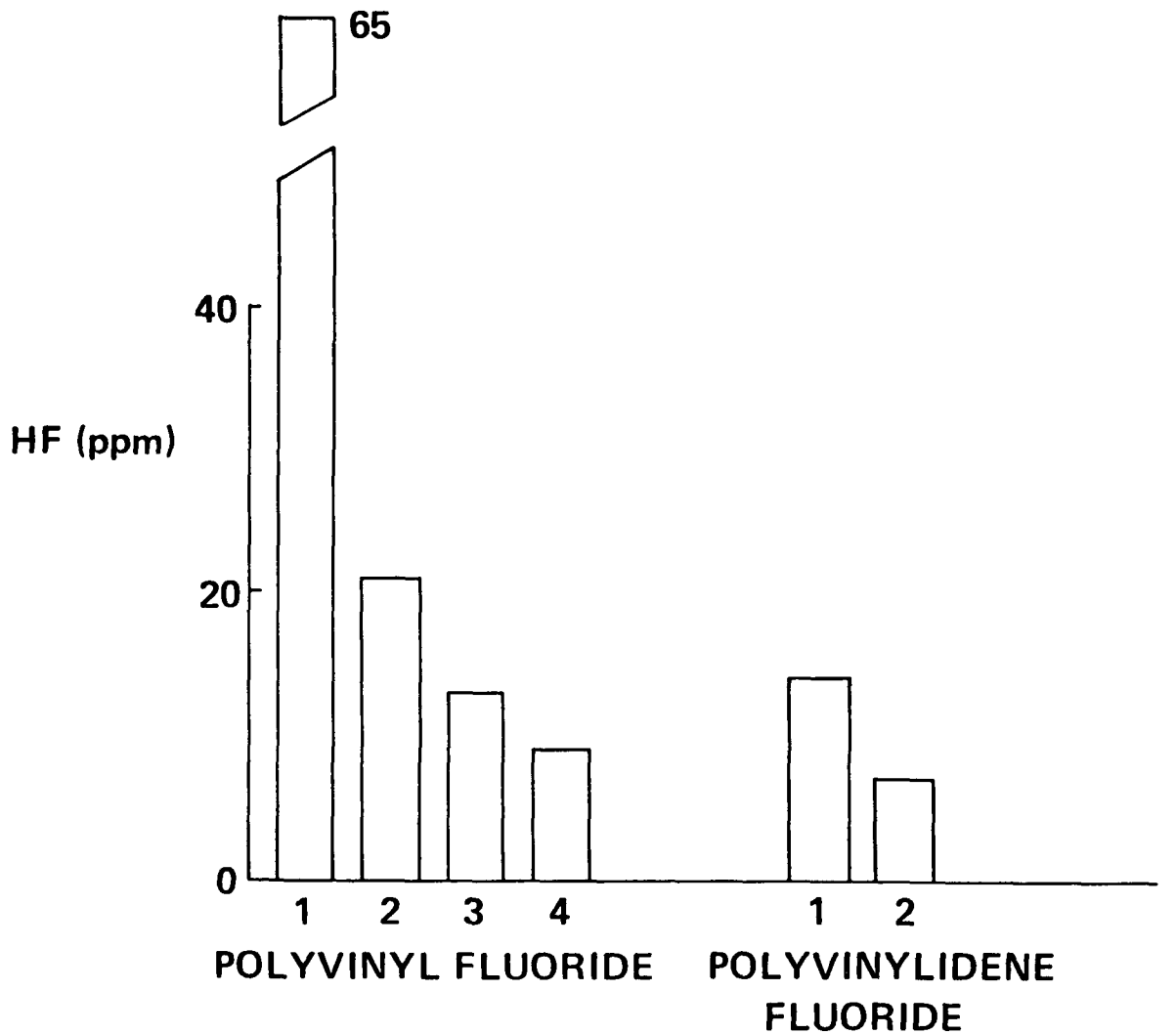


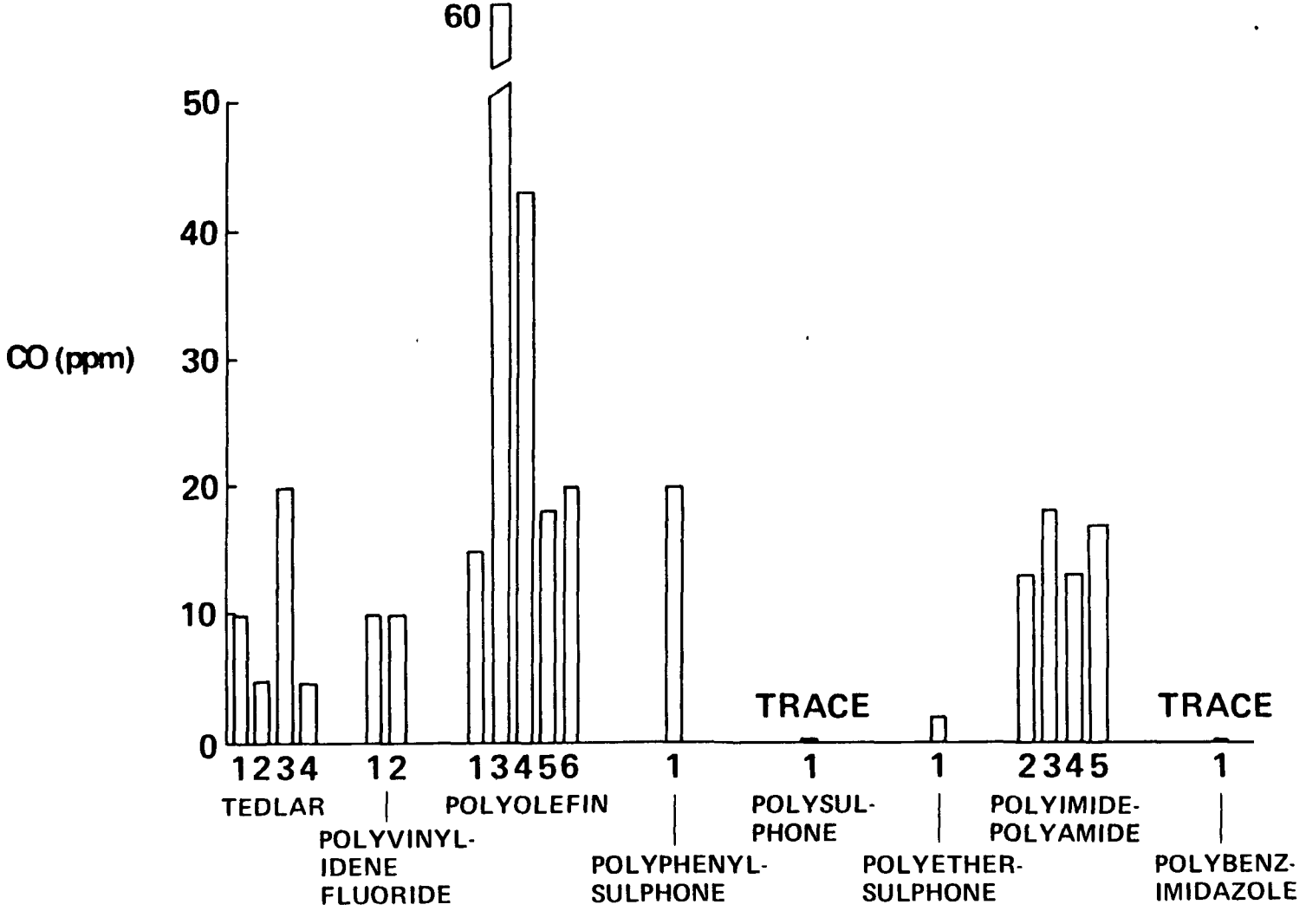
TOXIC GAS EMISSION–NBS CHAMBER

2.5 WATTS/cm^2 –4 MINUTES



TOXIC GAS DATA–NBS CHAMBER

2.5 WATTS/cm^2 –4 MINUTES



TOXIC GAS DATA–NBS CHAMBER

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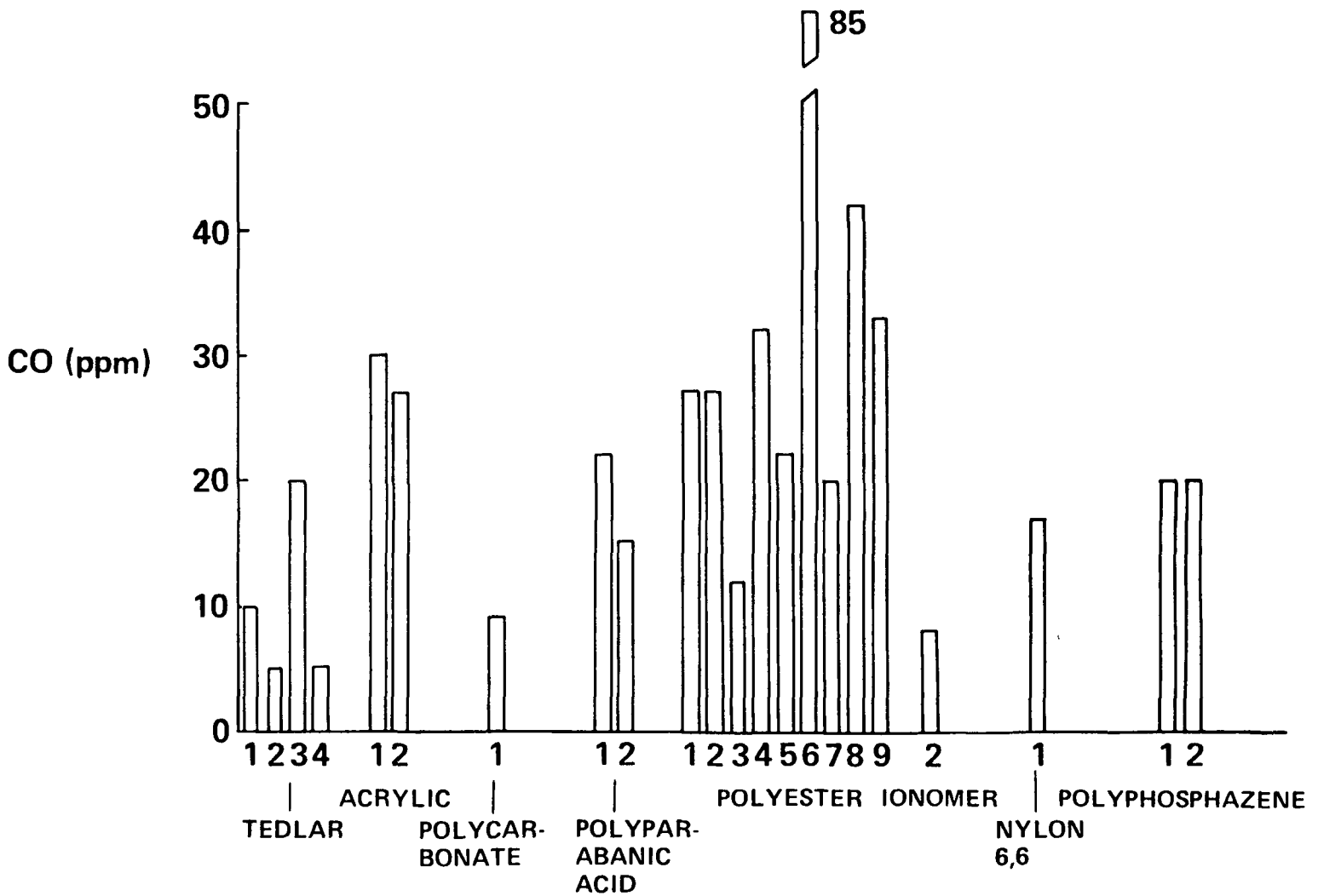
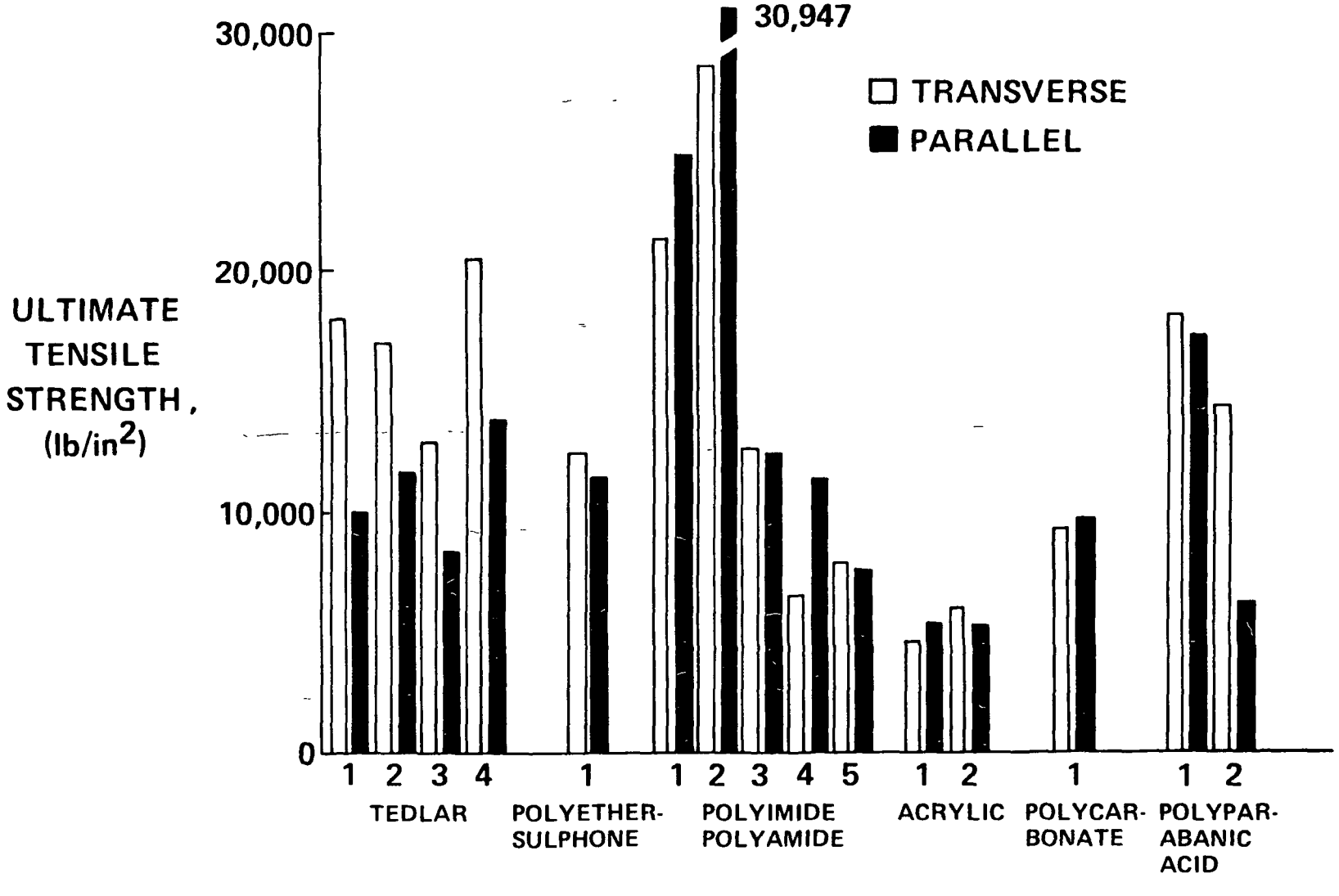
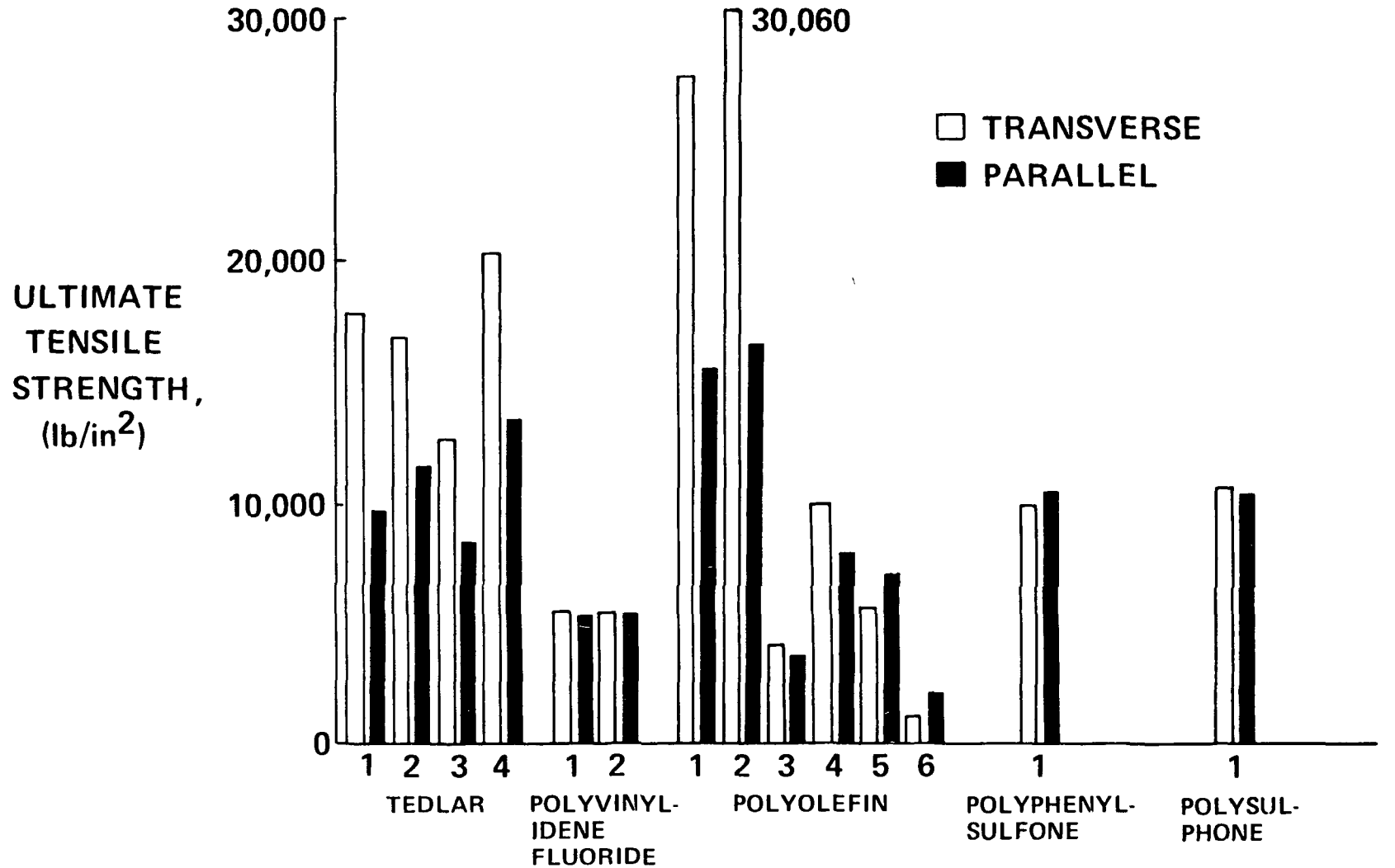


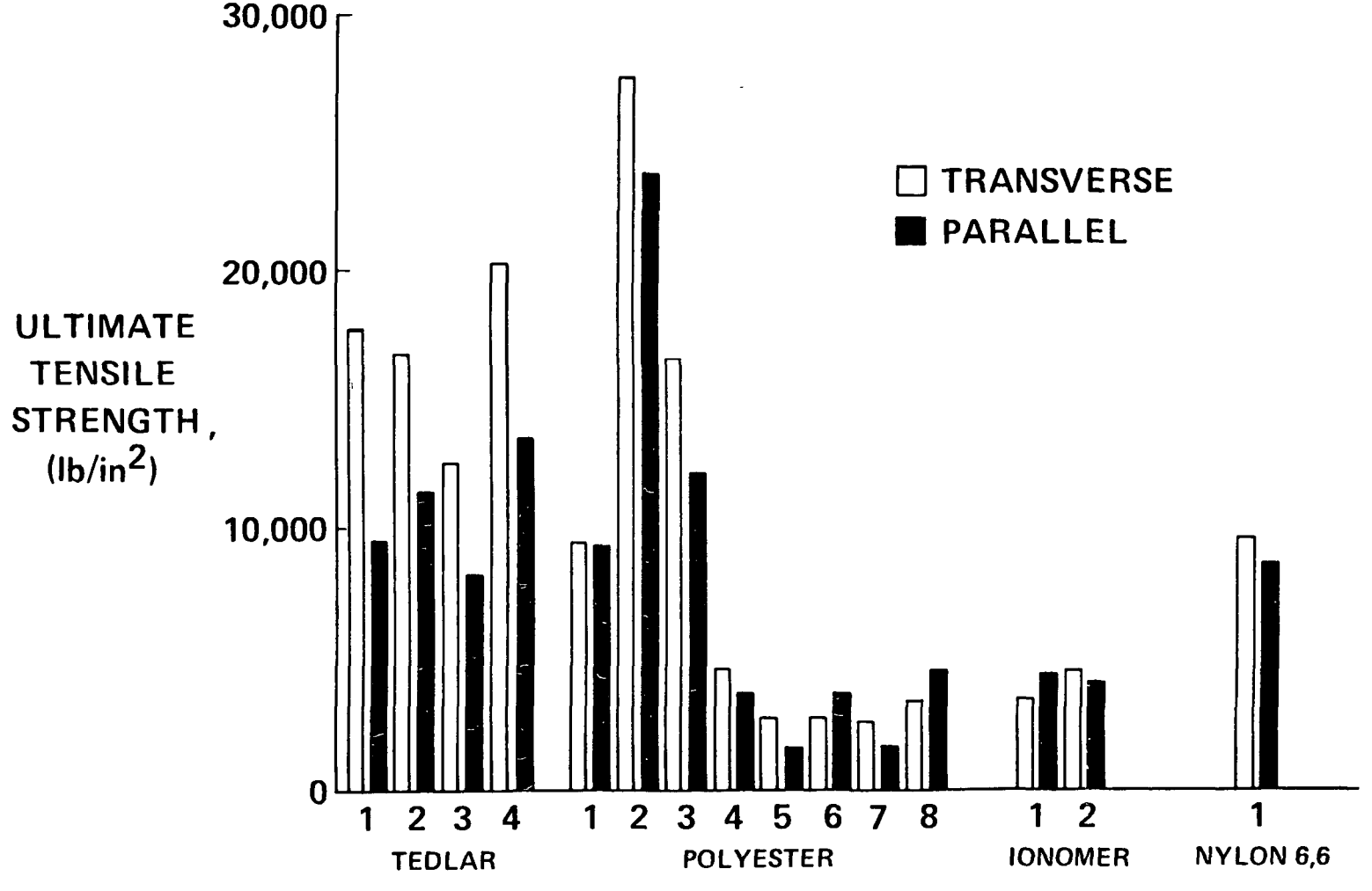
TENSILE PROPERTIES–ROOM TEMPERATURE



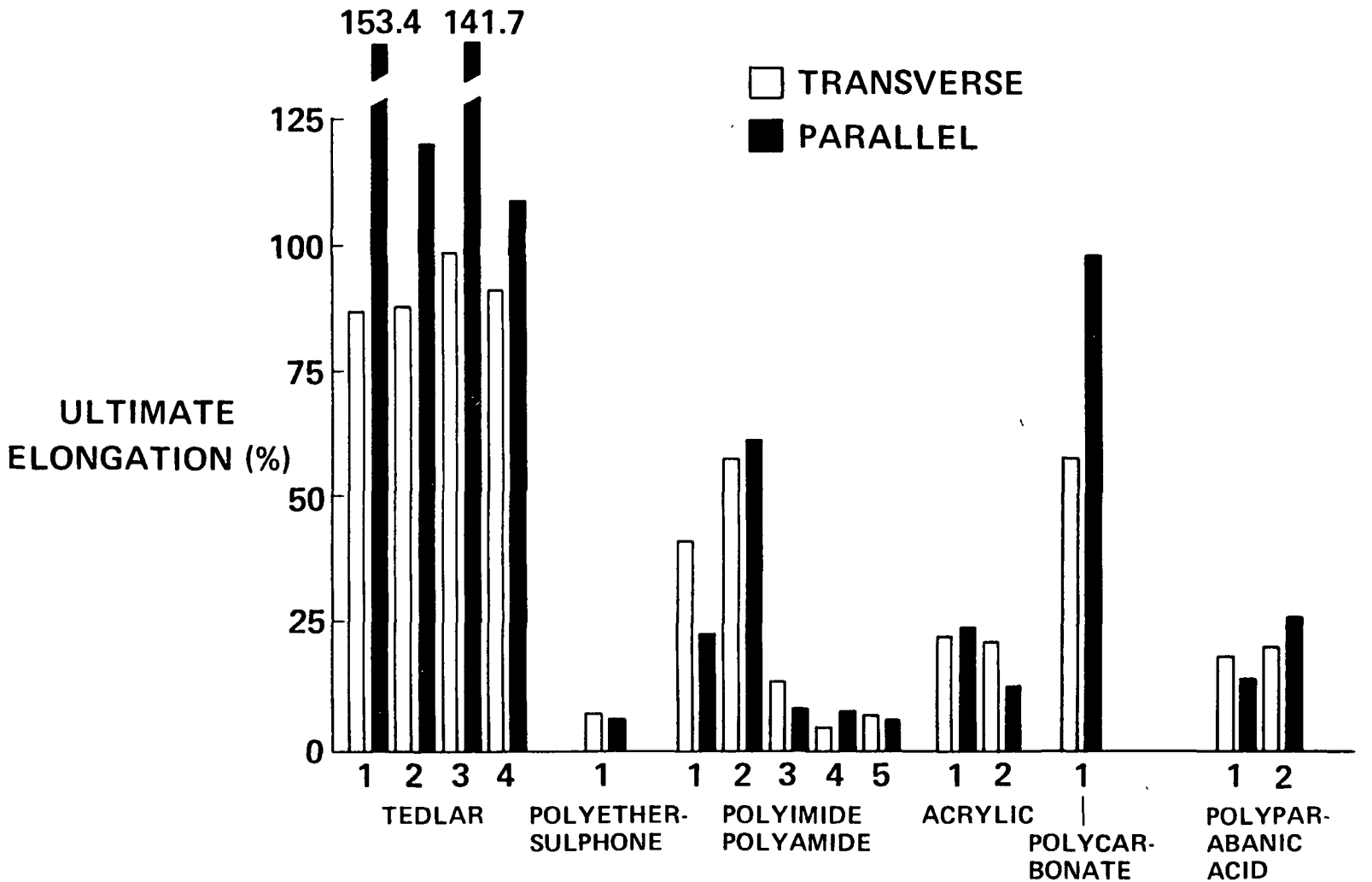
TENSILE PROPERTIES–ROOM TEMPERATURE



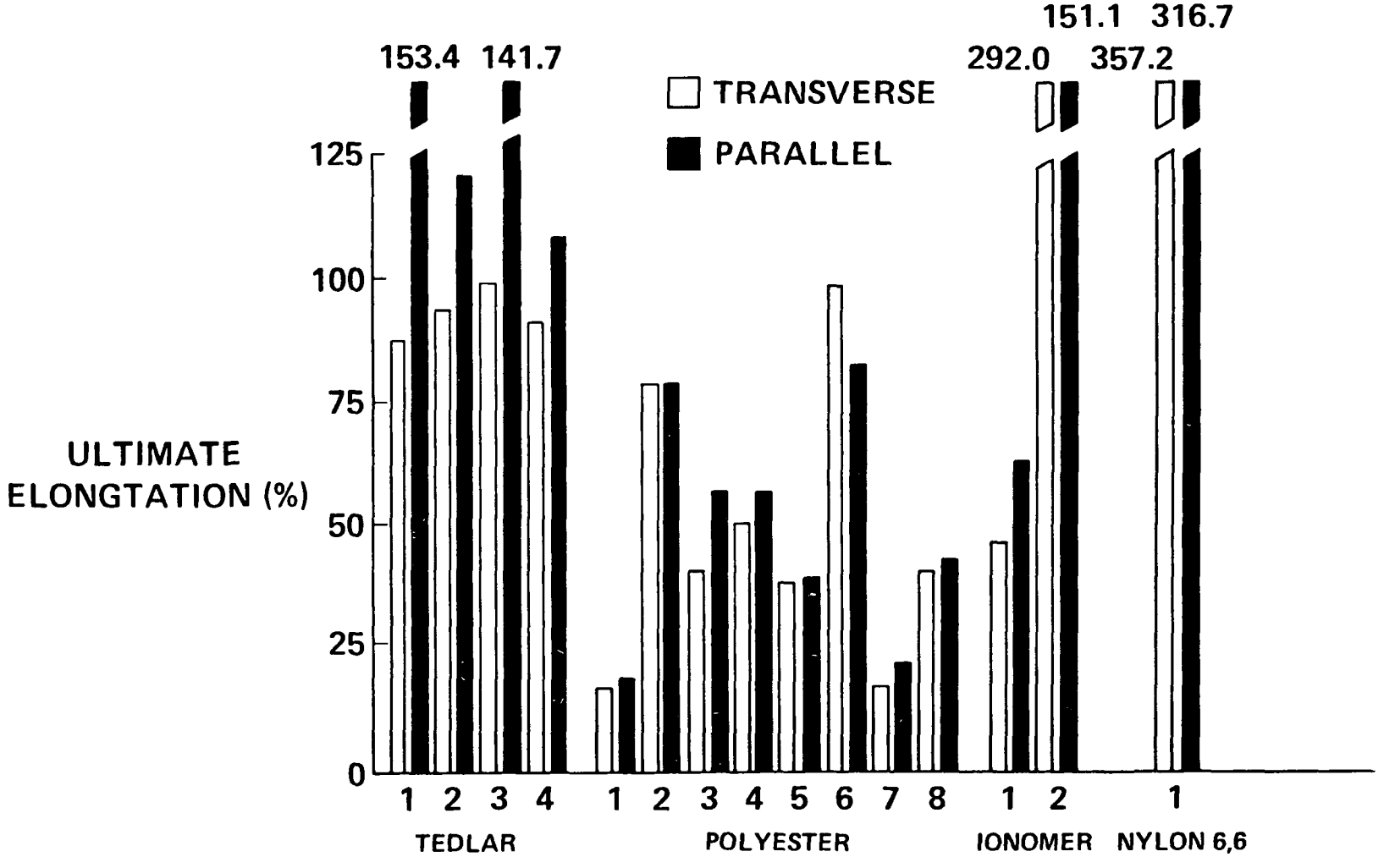
TENSILE PROPERTIES–ROOM TEMPERATURE



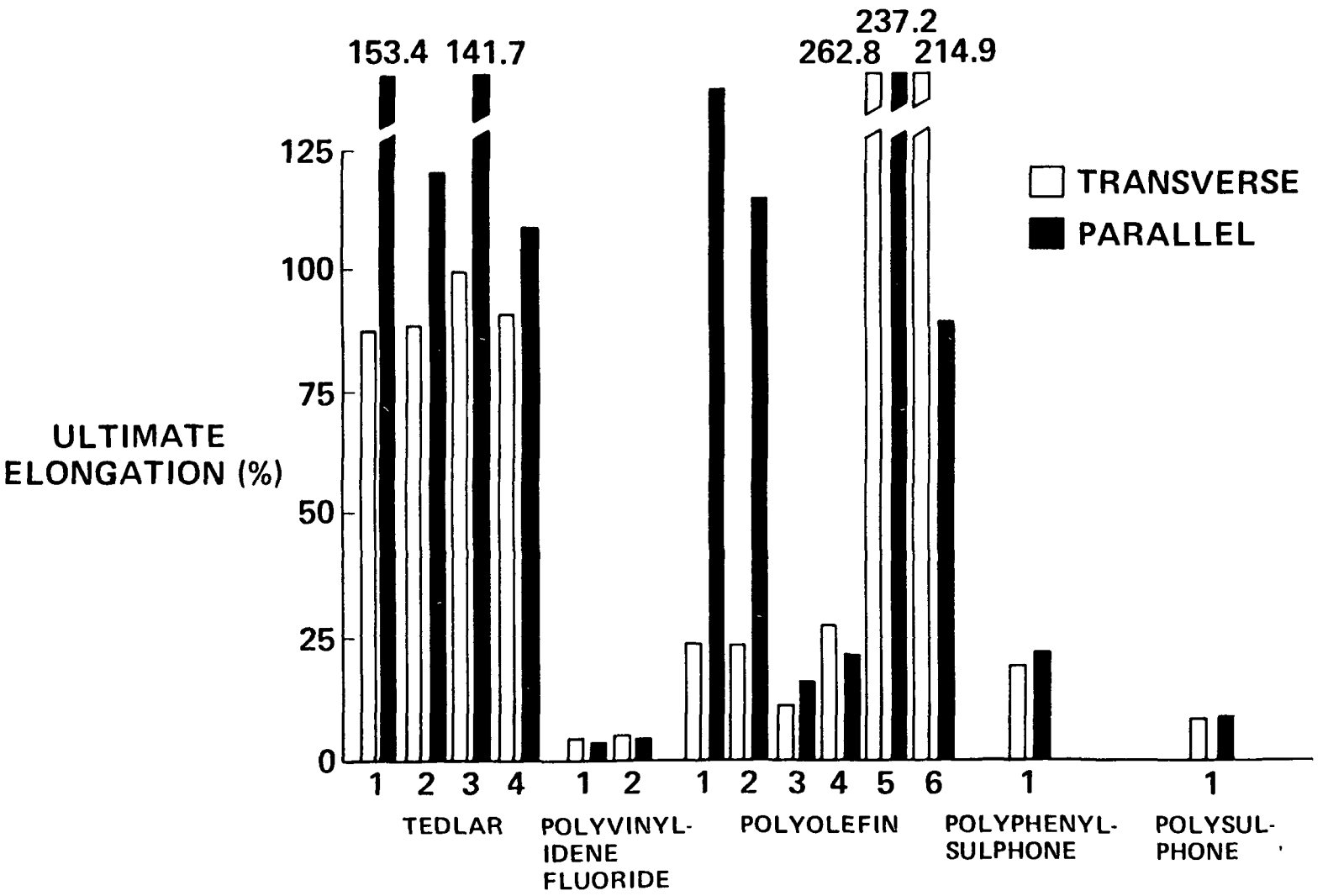
TENSILE PROPERTIES–ROOM TEMPERATURE



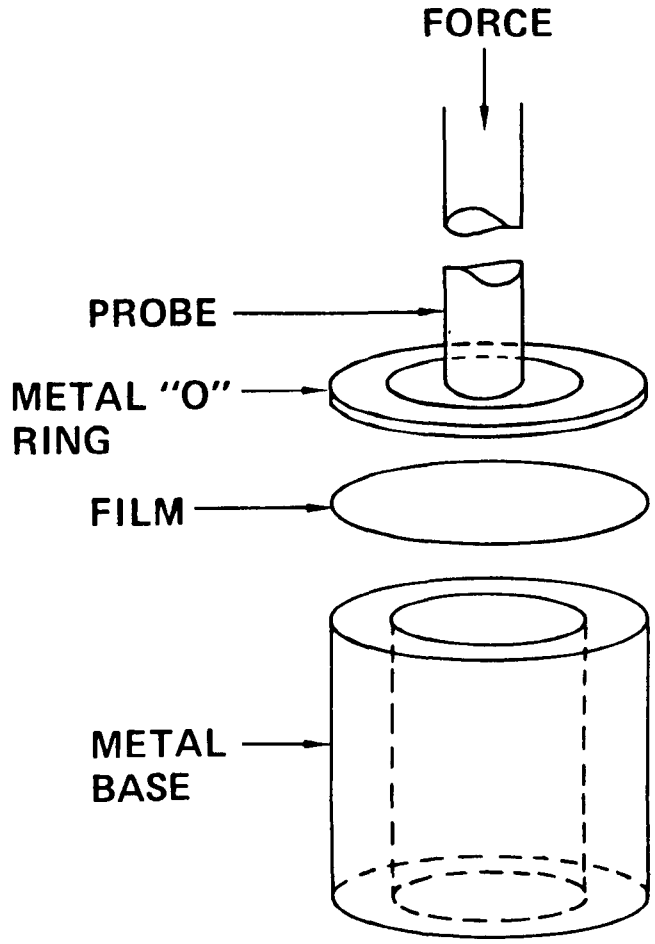
TENSILE PROPERTIES–ROOM TEMPERATURE

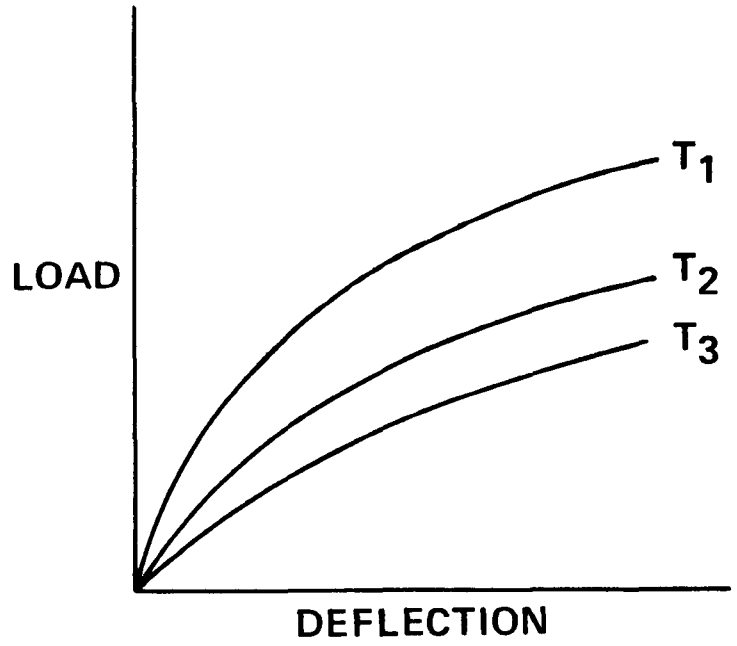


TENSILE PROPERTIES–ROOM TEMPERATURE



MECHANICAL TEST





MATERIALS EVALUATION–TASK 2

- POLYSTYRYLPYRIDINE
  - SOCIETE NATIONALE DES POUDRES ET EXPLOSIFS
- CURE CYCLE
  - 200°C–0 kg/cm^2–1 HOUR
  - 200°C–10 kg/cm^2–3 HOURS
  - 225°C–10 kg/cm^2–2 HOURS
- POSTCURE
  - 4 HOURS–300°C OR
  - 12 HOURS–250°C

PROBLEMS

- CURE CYCLE
- COST
- HANDLING
- AVAILABILITY

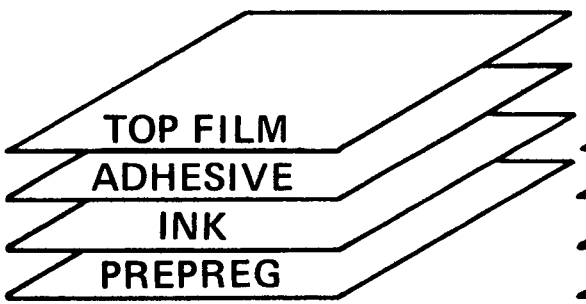
FUTURE WORK

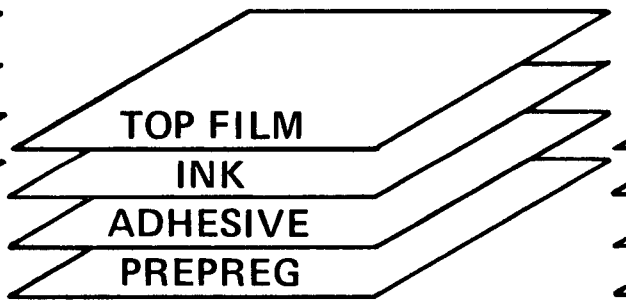
- CANDIDATE FILMS–TASK 1B
  - AROMATIC POLYAMIDE
  - AROMATIC POLYESTER
  - POLYBENZIMIDAZOLE
  - POLYETHERSULFONE
  - POLYIMIDE
  - POLYPARABANIC ACID
  - POLYVINYLIDENE FLUORIDE
  - POLYVINYLFLUORIDE
  - POLYCARBONATE

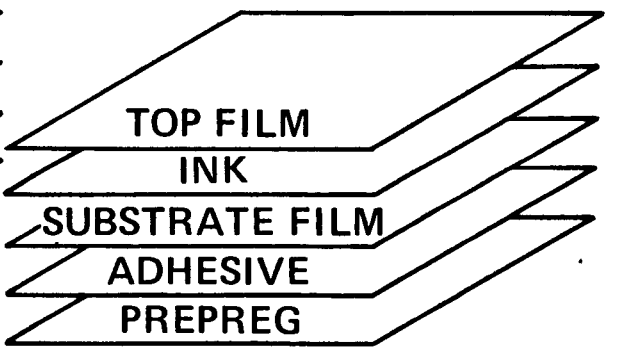
FUTURE WORK

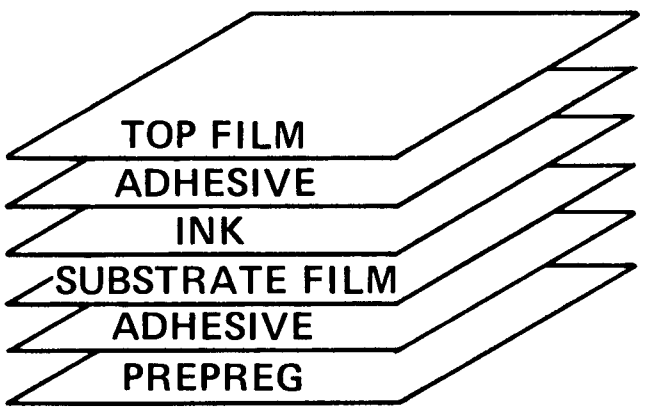
- SUBSTRATE AND TOP FILM EVALUATION
  - PRINTABILITY
  - DECORATIVE CAPABILITY
  - MAINTAINABILITY
- CONTINUED FS & T EVALUATION

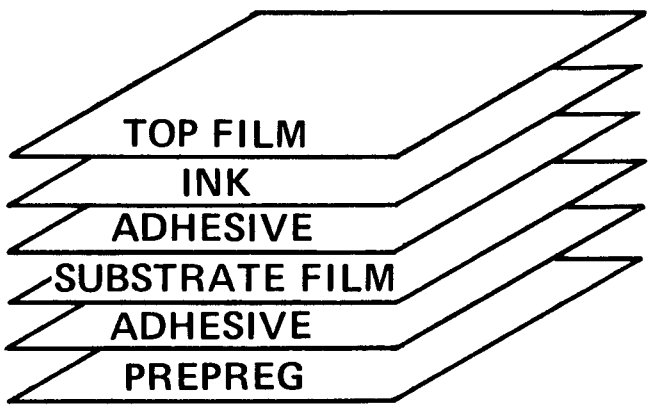
DECORATIVE LAMINATE CONFIGURATIONS



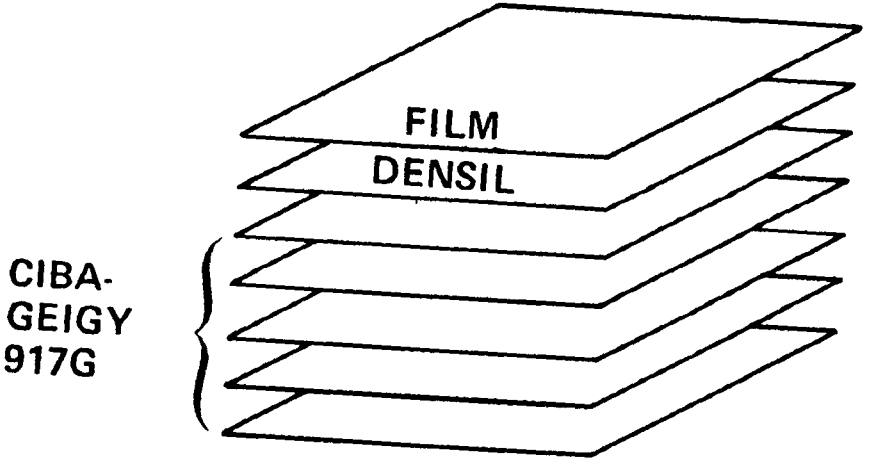








FS & T SPECIMENS



- FLAME SPREAD (ASTM E-162)
- SMOKE EMISSION (NBS)
- TOXIC GAS EMISSION (NBS)
- HEAT RELEASE (OSU)

SCREEN PRINTING INK DEVELOPMENT

PHASE IV

NAS2-9864

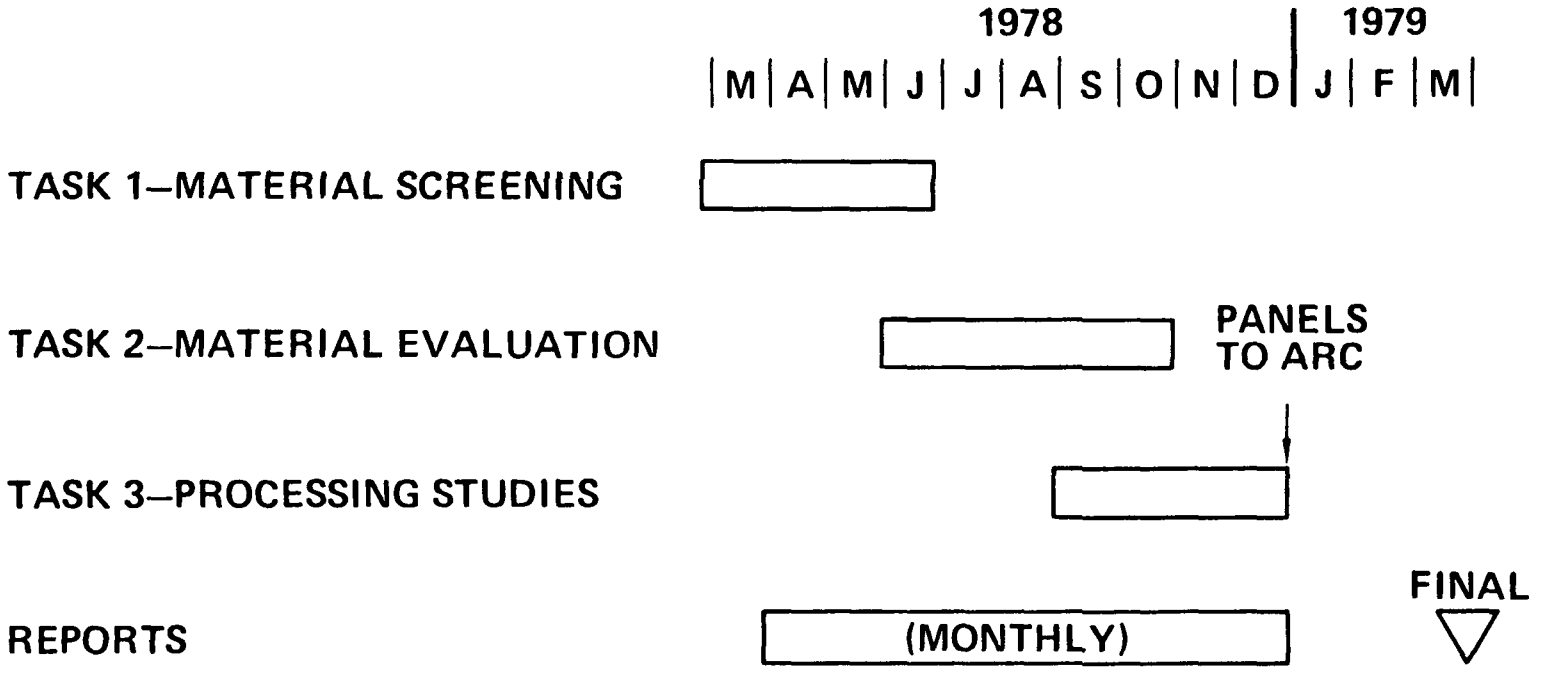
OBJECTIVES

- SIDEWALL, CEILING, AND PARTITION PANEL DEVELOPMENT
- SCREEN PRINTING INK DEVELOPMENT
- LOW SMOKE AND TOXIC GAS EMISSION
- THERMAL STABILITY
- FIRE RESISTANCE
- PROCESS ASSESSMENT
- END ITEM DELIVERY TO NASA-ARC

SCREEN PRINTING INK DEVELOPMENT PROGRAM

- TASK 1—MATERIAL SCREENING
- TASK 2—MATERIAL EVALUATION
- TASK 3—PROCESSING STUDIES

SCREEN PRINTING INK PROGRAM SCHEDULE



TEST PLAN

	TASK		
	1	2	3
• FLAMMABILITY			
PYROLYSIS TUBE–600°C		X	
LIMITING OXYGEN INDEX (LOI)	X	X	
SMOKE & TOXIC GAS EMISSION (NBS)	X	X	X
HEAT RELEASE (OSU)		X	X
TOXICITY (NASA)	X	X	X
• THERMOPHYSICAL			
TGA/DTA	X	X	
• MECHANICAL			
PEEL STRENGTH		X	X
IMPACT STRENGTH			X

TEST PLAN

	TASK		
• OTHER	1	2	3
UV STABILITY		X	X
DENSITY		X	
ODOR AND TOXICITY		X	
CONDITION IN CONTAINER		X	
STORAGE STABILITY		X	
NON-VOLATILE CONTENT		X	
THIXOTROPIC INDEX		X	
WORKING PROPERTIES		X	
FINENESS OF GRIND		X	
COLOR		X	
DRY TIME		X	
HIGH TEMPERATURE AND PRESSURE RESISTANCE		X	

MATERIAL REQUIREMENTS–TASK 1

- LOI $\geqslant$ 35
- DS @ 4 MINUTES $\leqslant$ 20
- TGA IN N_2 (RT $\rightarrow$ 250°C)

RESIN SYSTEMS

- PHOSPHAZENE SUBSTITUTED EPOXY
- PHOSPHORUS SUBSTITUTED EPOXY
- AROMATIC ORGANOSILICONE
- OTHERS TO BE DETERMINED

TASKS 2 and 3

- PANEL TYPES
  - CLASS A–0.002" PVF + INK
  - CLASS B–CLASS A + 0.001" PVF + EPOXY PREPREG
  - CLASS C–NEW FILM + INK
  - CLASS D–CLASS A + 0.001" PVF + PHENOLIC PREPREG
  - CLASS E–CLASS C + NEW FILM + PHENOLIC PREPREG
- TESTING
  - HEAT RELEASE
  - SMOKE RELEASE
  - TOXICITY
  - MECHANICAL PROPERTIES