FIRE TESTING IN THE BOEING 707 CABIN SECTION

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E. A. TUSTIN

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ABSTRACT

The goal of a FIREMEN funded contract is the definition of a laboratory test method ranking airplane interior materials by probable performance in post-crash and in-flight fires. A major task is the relation of laboratory results to full scale data. A large scale test facility for testing materials to the thermal threat of fuel fed and interior fires has been developed with quartz lamps and a propane burner in a twenty foot fuselage section. A method has been developed to analyze full scale data for the apparent heat, smoke and toxicant release rates of the material tested.

PRESENTATION CONTENT | CHART

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FIRE TESTING IN THE BOEING 707 CABIN SECTION

NASA-JSC CONTRACT NAS9-15168

"DEVELOPMENT OF FIRE TEST METHODS FOR AIRPLANE INTERIOR MATERIALS"

BOEING IR&D PROJECT

"FIRE TEST METHODS DEVELOPMENT"

PROGRAM SUMMARY

	PHASE I DESIGN FIRE TESTS	PHASE II SIMULATED FIRE TESTS	PHASE III DATA CORRELATION
NAS 9-15168	CONDUCT TESTS WITH REAL FIRE SOURCES IN NASA 737 FUSELAGE	TEST TWO CURRENT AND TEN NEW MATERIALS TO SIMULATIONS OF DESIGN FIRES	LAB TEST NASA TWELVE MATERIALS AND RECOMMEND METHODS WITH RESULTS RELATING WELL TO FULL SCALE DATA
BOEING IRAD	DEVELOP FULL SCALE TEST CONCEPT TO STUDY DESIGN FIRE SOURCES.	DEVELOP 707 TEST SECTION TO TEST MATERIALS WITH FIRE SIMULATIONS AND DEVELOP ANALYSIS METHODS	DEVELOP DETAILED CORRELATION BETWEEN LAB AND FULL SCALE TEST RESULTS BASED ON EVALUATION OF EIGHT CURRENT MATERIALS

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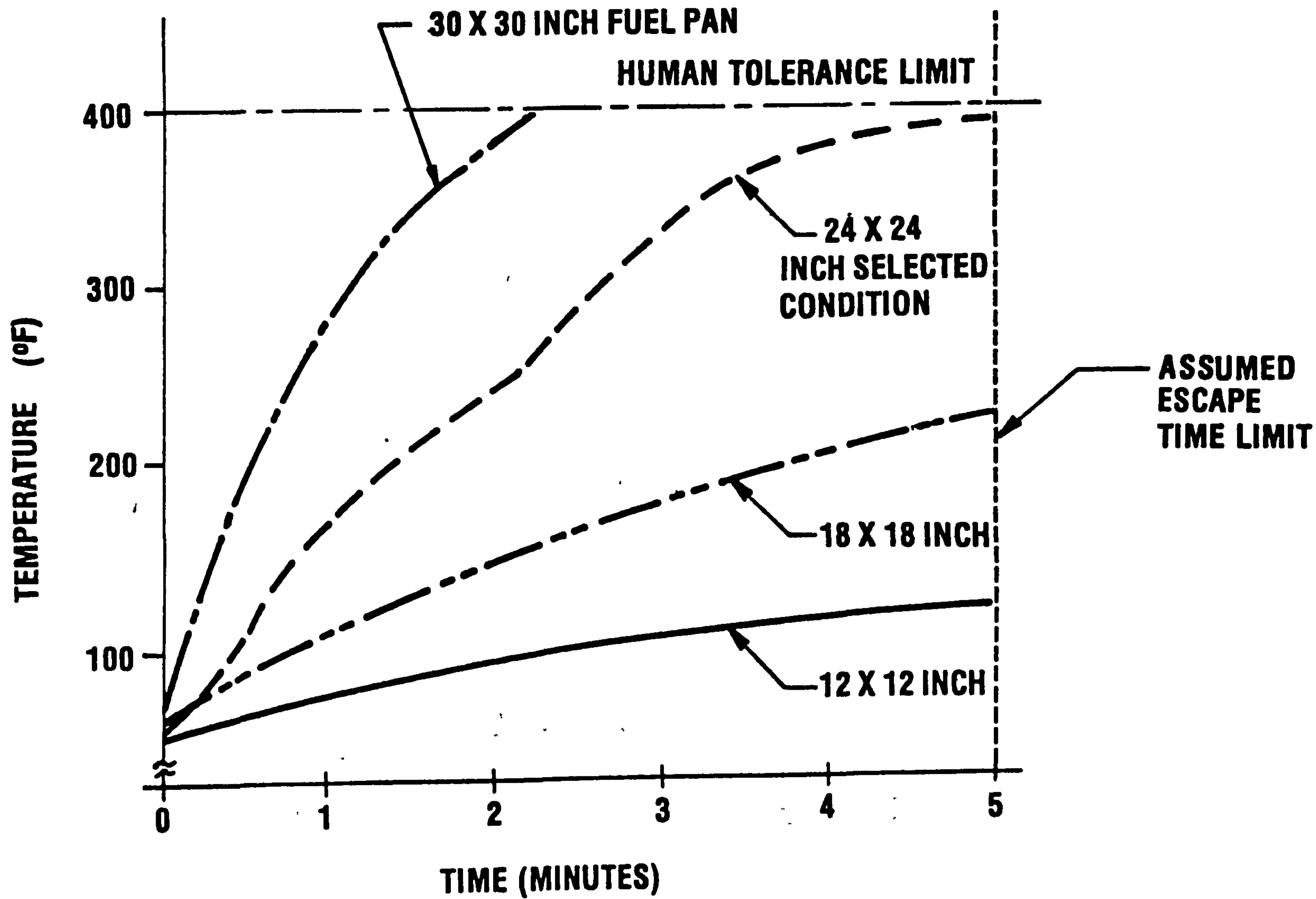
ESTABLISHING A POST CRASH DESIGN FIRE SOURCE

(56 FT. FUSELAGE)

AVERAGE CABIN CENTERLINE TEMPERATURE AT HEAD LEVEL



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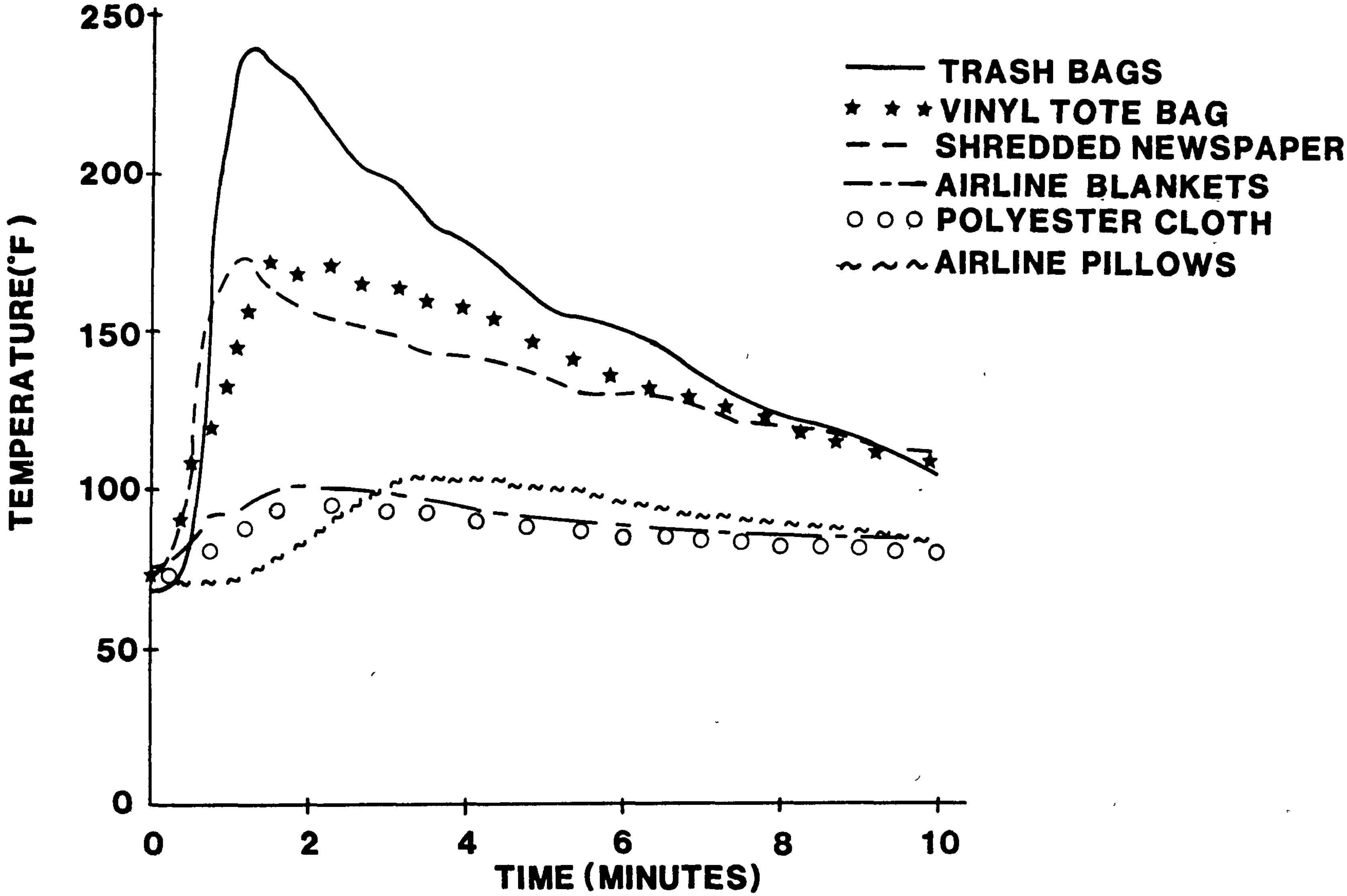
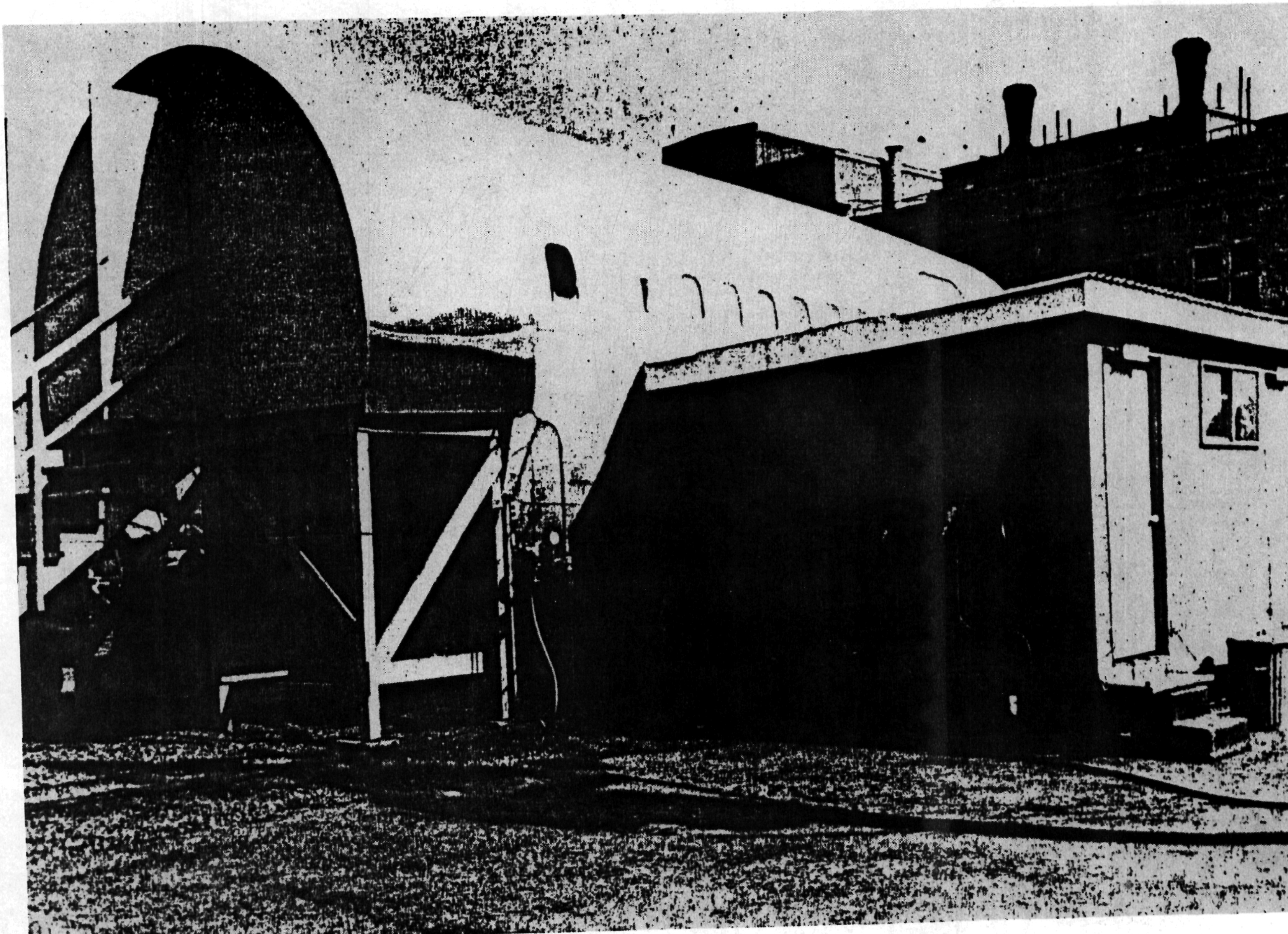
ESTABLISHING AN IN-FLIGHT DESIGN FIRE SOURCE

(56 FT. FUSELAGE)

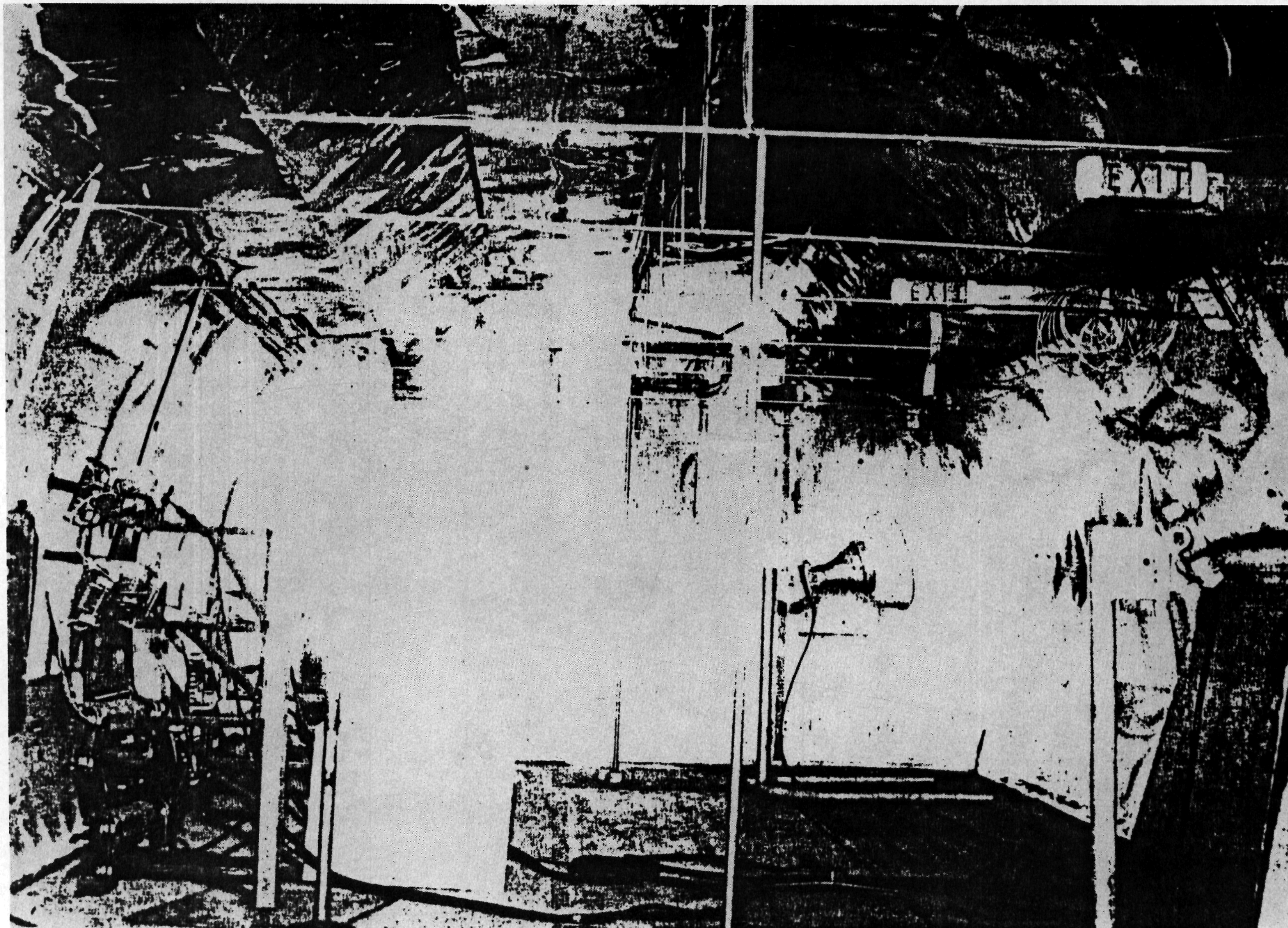
AVERAGE CABIN CENTERLINE AIR TEMPERATURE AT HEAD LEVEL



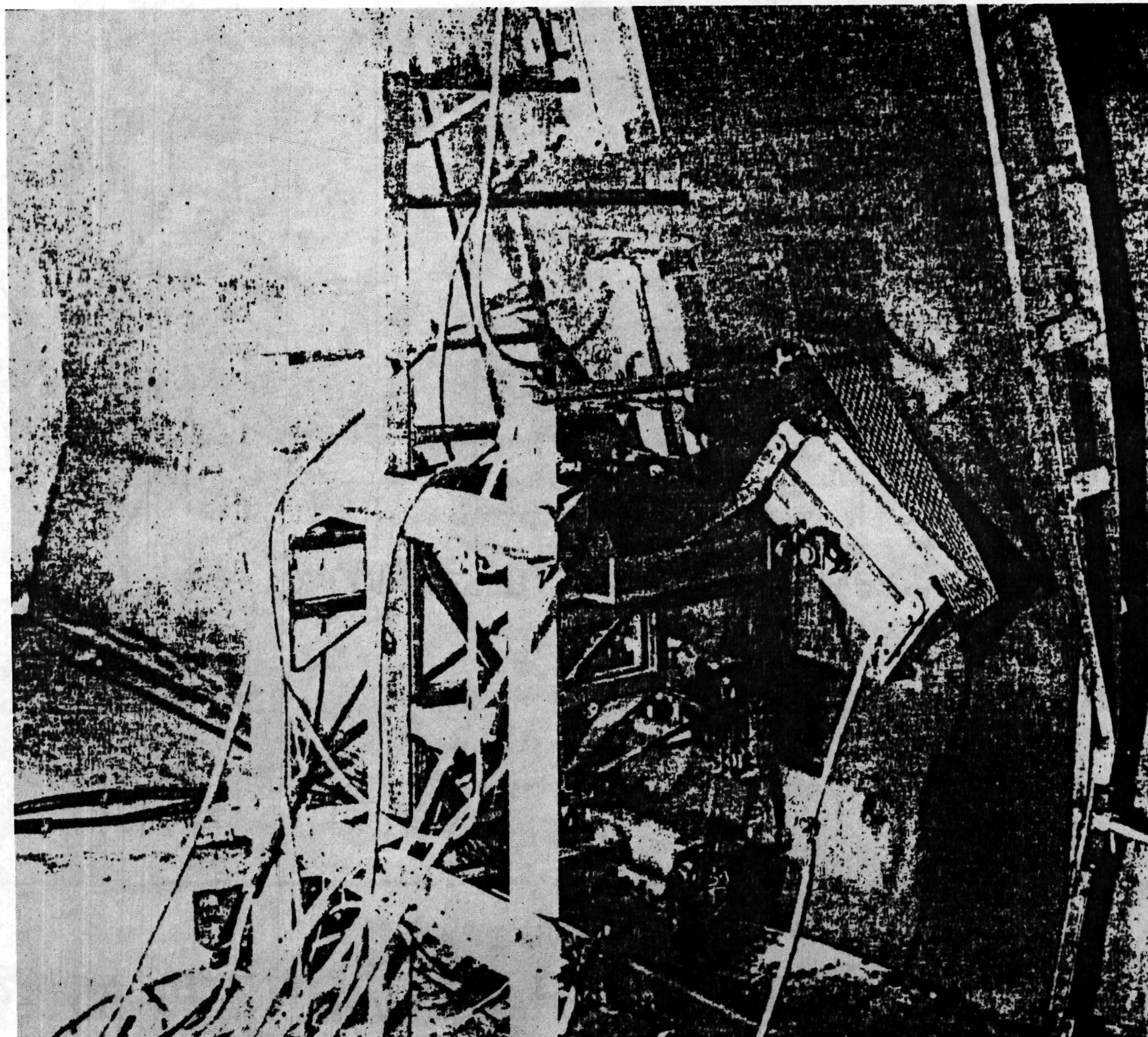
SIMULATED FIRE TEST FUSELAGE



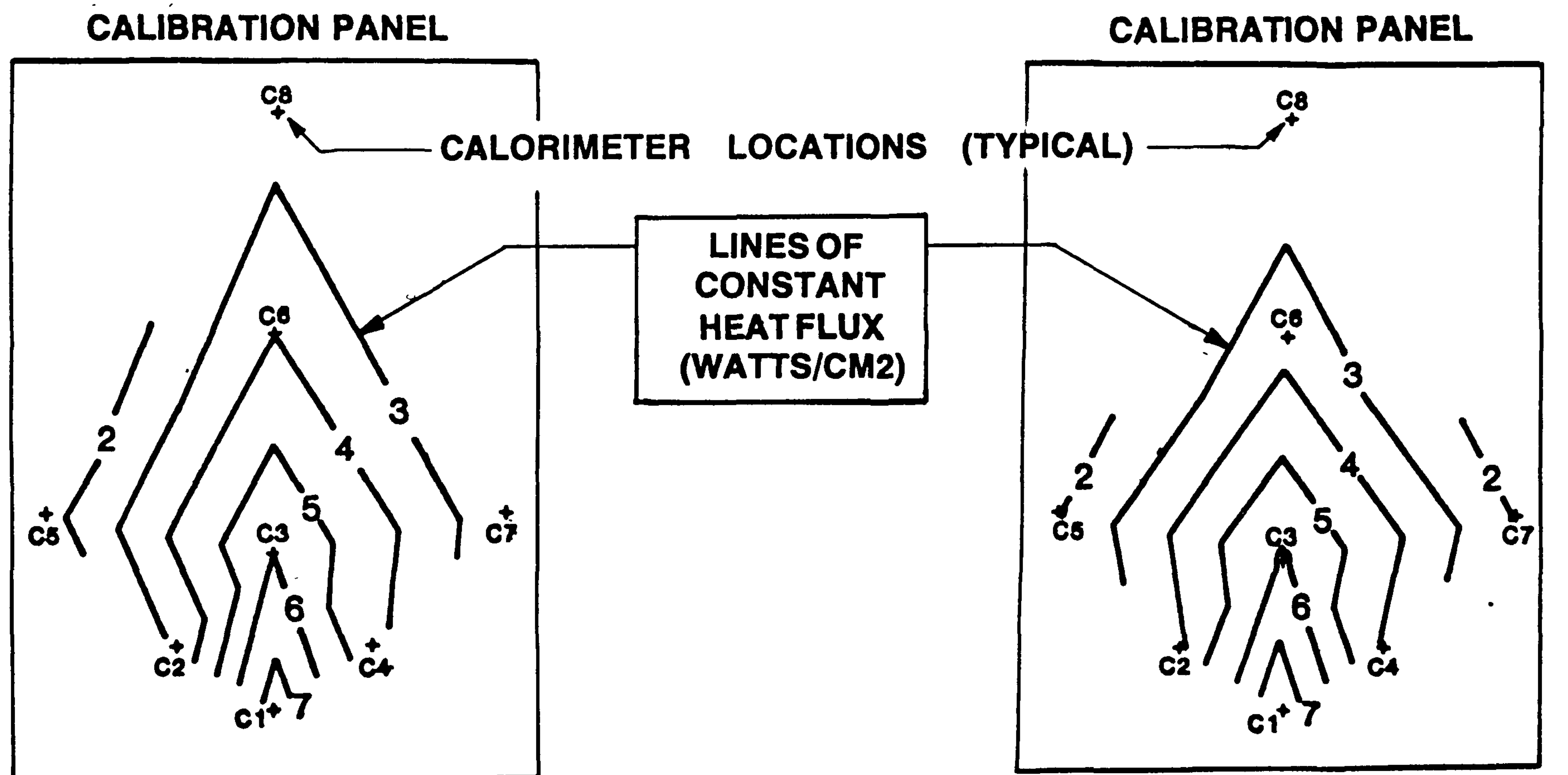
CABIN INSTRUMENTATION–SIMULATED FIRE



FIRE SIMULATING APPARATUS



EQUIVALENCY OF HEAT FLUX DISTRIBUTION



ORIGINAL DESIGN FUEL FIRE

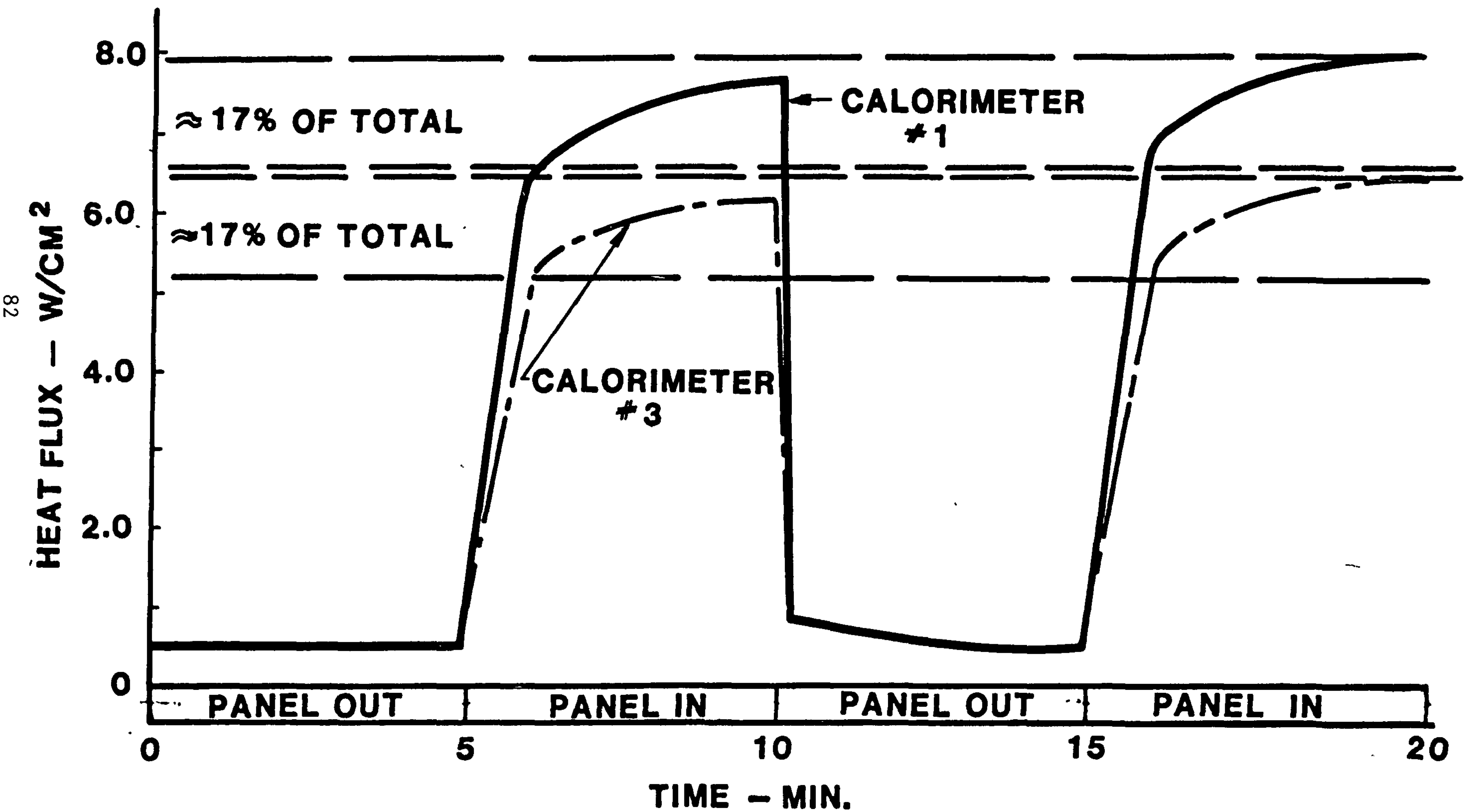
SIMULATED DESIGN FUEL FIRE

COMPARISON OF TEST RESULTS

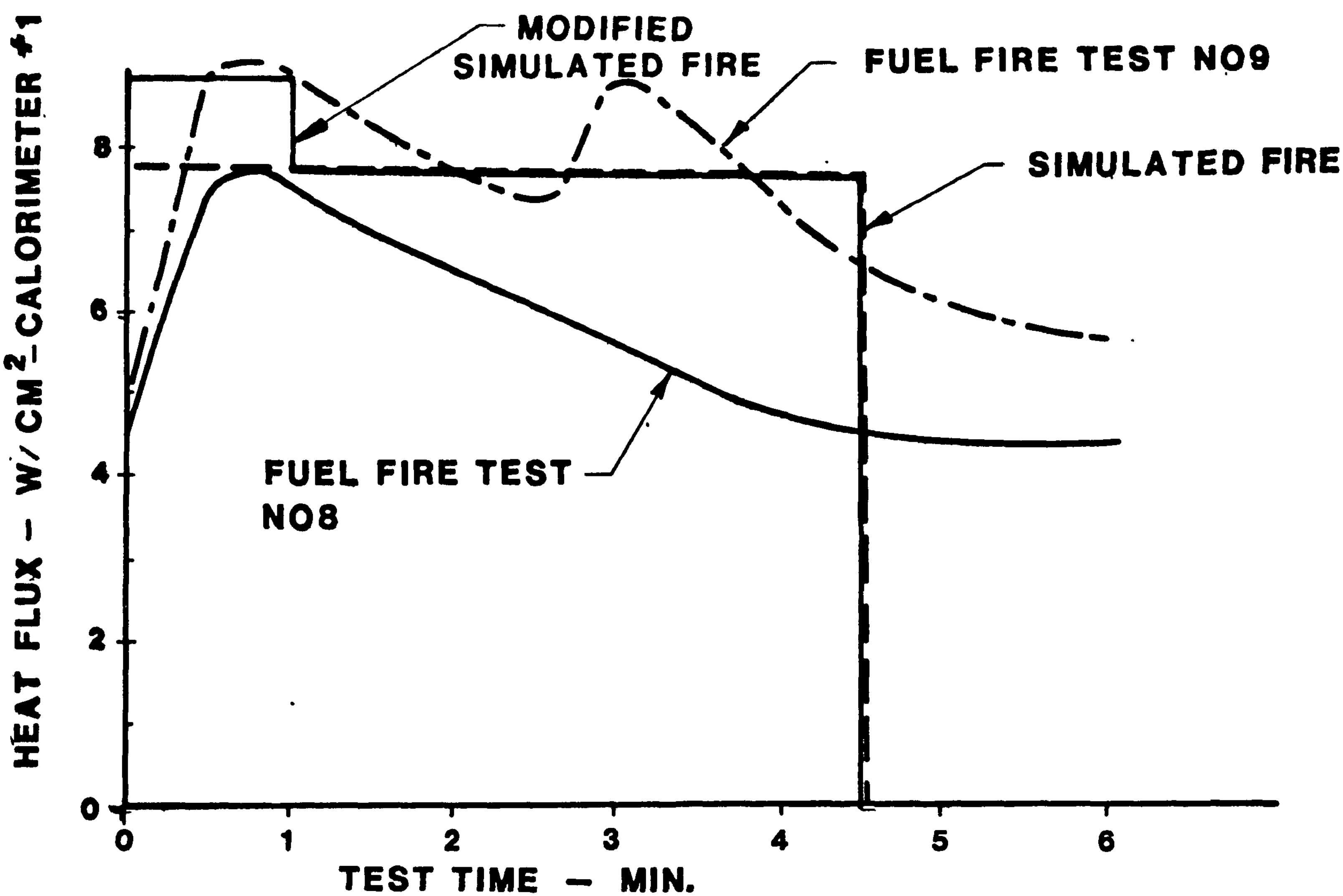
MATERIAL	FIRE DAMAGE %LOSS OF WT.		CALCULATED TOTAL TOXICANT RELEASE ~ 10^{-2} LBS.					
			HCL		HF		HCN	
	NASA FUEL FIRE	BCAC SIM. FIRE	NASA	BCAC	NASA	BCAC	NASA	BCAC
POLYURETHANE SEAT FOAM	≈ 100	≈ 100	2.7	11.6	TRACE	0	0.4	1.4
FABRIC - BACKED VINYL	≈ 100	≈ 100	8.9	94.5	0.2	0	0	0
PVF / PVC / ALUMINUM LAM.	*9-13	5-10	1.18	33.0	0.4	1.4	0	0
PVF/EPOXY/POLY AMIDE-PHENOLIC H.C. SAND	27-32	12-13	4.5	5.4	0.2	3.4	.7	0.2

* DOES NOT INCLUDE ALUMINUM WT. LOSS

INCREASED HEATING FROM RERADIATION



ADJUSTMENT FOR MAXIMUM HEAT FLUX



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COMPARISON OF TEST RESULTS

MATERIAL	FIRE DAMAGE %LOSS OF WT.		CALCULATED TOTAL TOXICANT RELEASE ~ 10^{-2} LBS.					
			HCL		HF		HCN	
	NASA FUEL FIRE	BCAC SIM. FIRE	NASA	BCAC	NASA	BCAC	NASA	BCAC
POLYURETHANE SEAT FOAM	≈ 100	≈ 100	2.7	11.6	TRACE	0	0.4	1.4
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PVF / PVC / ALUMINUM LAM.	*9-13	5-10	1.18	33.0	0.4	1.4	0	0
MODIFIED FIRE SIMULATION		8-14		11.0		1.3		0
PVF/EPOXY/POLY AMIDE-PHENOLIC H.C. SAND	27-32	12-13	4.5	5.4	0.2	3.4	.7	0.2
MODIFIED FIRE SIMULATION		18-19		15.0		4.4		TRACE

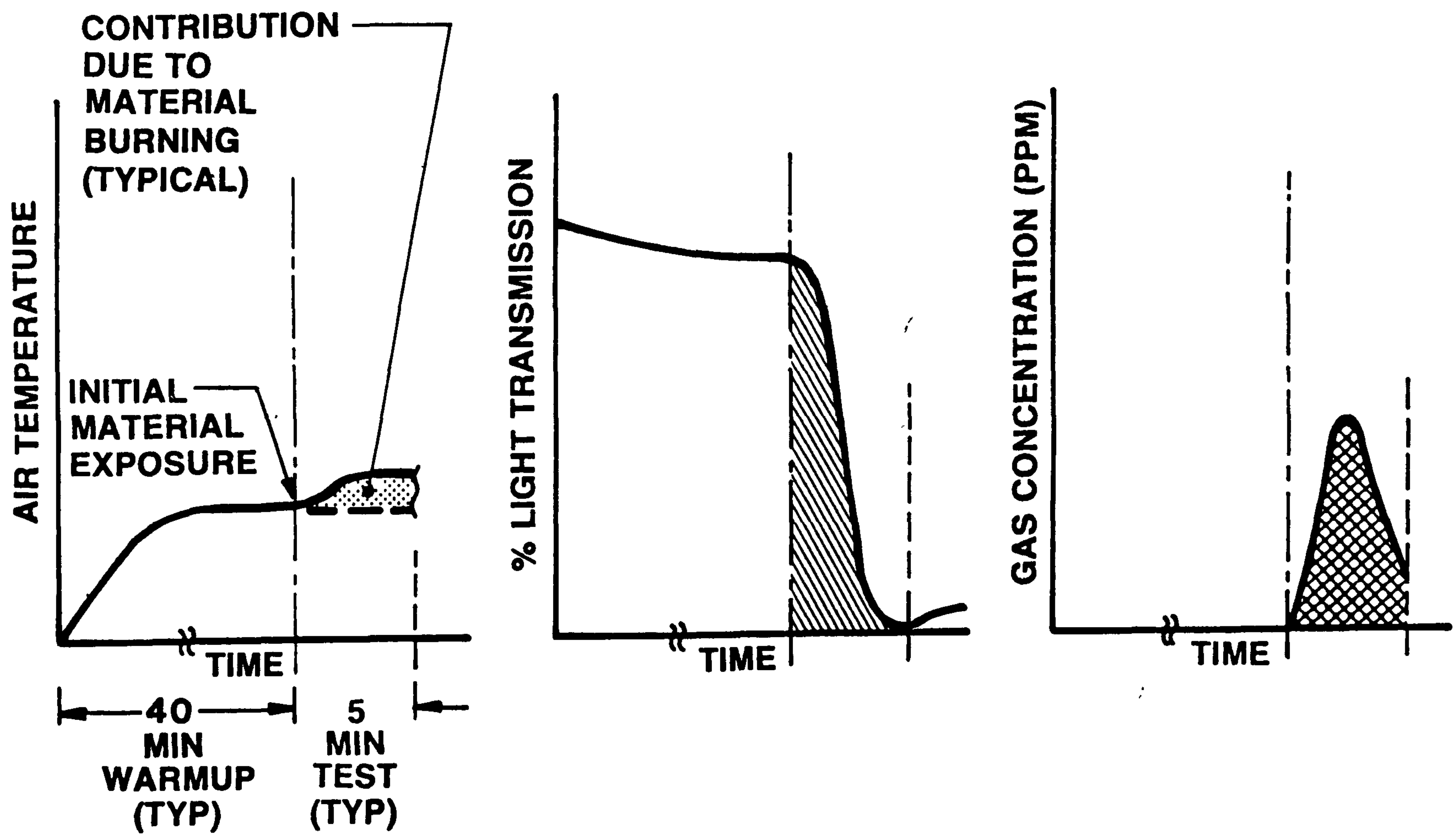
* DOES NOT INCLUDE ALUMINUM WT. LOSS

PROGRAM DIRECTION

- CONTINUE SIMULATION TESTING WITH NEW ADJUSTED HEAT
    - HEAT DAMAGE APPROACHING ACTUAL FROM PAN FIRES
    - TEST IS A VERY SEVERE FIRE EXPOSURE
    - TOXICANT RELEASE CORRELATION IS POOR , BUT SIMULATION WILL GIVE CONSERVATIVE MATERIAL SELECTION CRITERION
- INVESTIGATE TOXICANT RELEASE MEASUREMENT IN FUEL PAN FIRE IN BOEING 707 TEST SECTION

TYPICAL CABIN ENVIRONMENT DATA
SIMULATED DESIGN FIRES

POST CRASH FIRE SOURCE CONDITION



DATA ANALYSIS EQUATIONS

HEAT RELEASE RATE

$$\overline{R_h} = \frac{P_c V_c C_p}{R \Delta t}\left(\ln \frac{T_c}{T_{co}}\right) + C_p\left[m_l + \frac{P_c V_c}{R \Delta t}\left(\frac{T_c - T_{co}}{T_c T_{co}}\right)\right]\left[\frac{T_c + T_{co}}{2} - T_l\right]$$

SMOKE RELEASE RATE

$$\overline{R_s} = \frac{m_x}{\rho} \cdot \frac{1}{\alpha L}\left[\log \frac{100}{\%T}\left(e^{\frac{m_x \Delta t}{\rho V_c}}\right) - \log \frac{100}{\%T_o}\right] \div \left[\left(e^{\frac{m_x \Delta t}{\rho V_c}}\right) - 1\right]$$

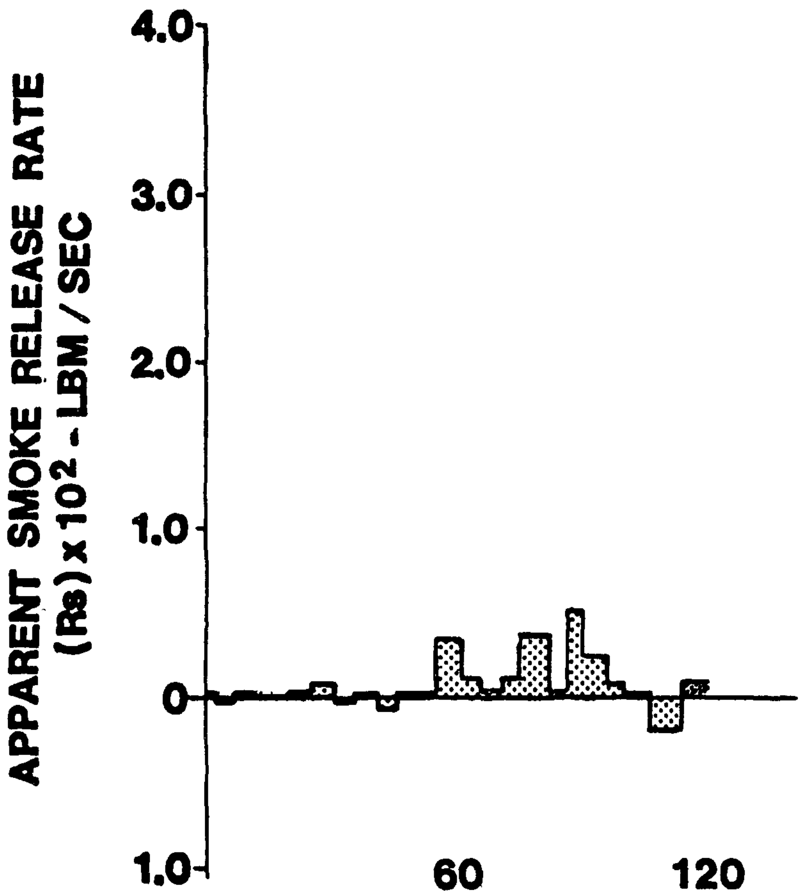
GAS RELEASE RATE

$$R_g = \frac{m_x}{\rho} \cdot \frac{1}{\gamma_g}\left[C_g\left(e^{\frac{m_x \Delta t}{\rho V_c}}\right) - C_{go}\right] \div \left[\left(e^{\frac{m_x \Delta t}{\rho V_c}}\right) - 1\right]$$

EQUATIONS BASED ON:

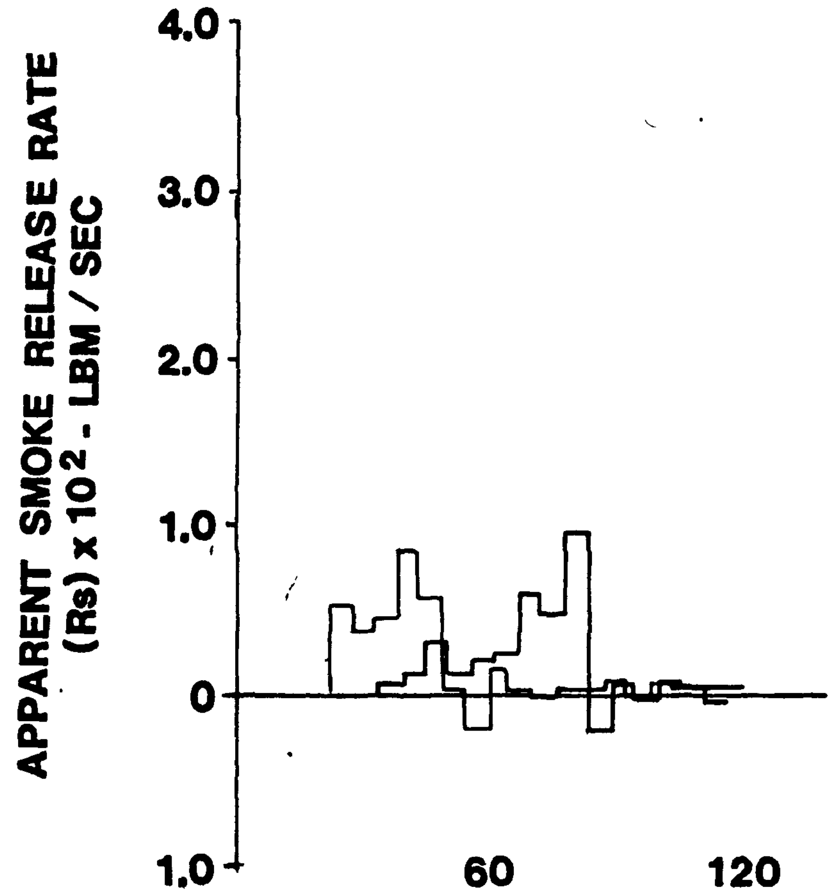
- **INSTANTANEOUS DISTRIBUTIONS; INSTRUMENTATION AT AVG POINTS.**
- **PERFECT GAS LAWS ; BASIC THERMODYNAMIC AND HEAT TRANSFER THEORY**
- **PAST STUDIES ON SMOKE PARTICLES W/R TRANSMISSION BY OTHER INDIVIDUALS AND ORGANIZATIONS**

SMOKE RELEASE RATES
FOR INFLIGHT FIRE SOURCES



TIME SECONDS
DESIGN INFLIGHT FIRE SOURCE

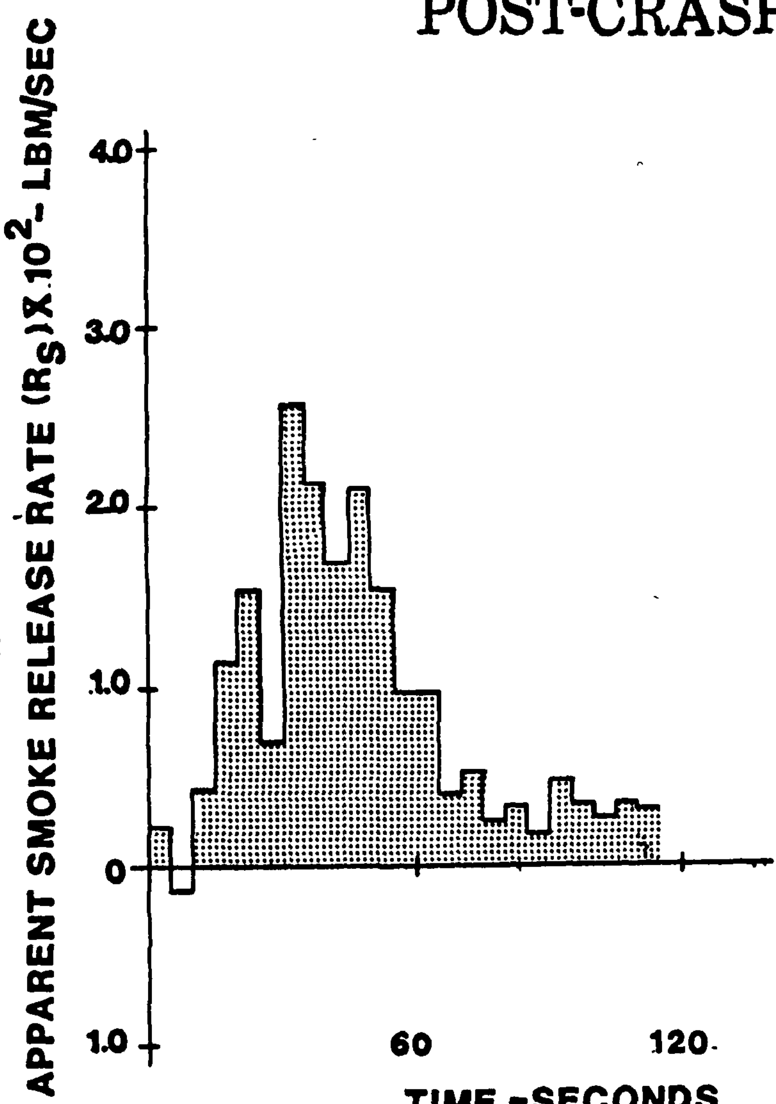
NOTE: VALUES $\leq +10^{-5}/-10^{-5} = 0$



TIME SECONDS

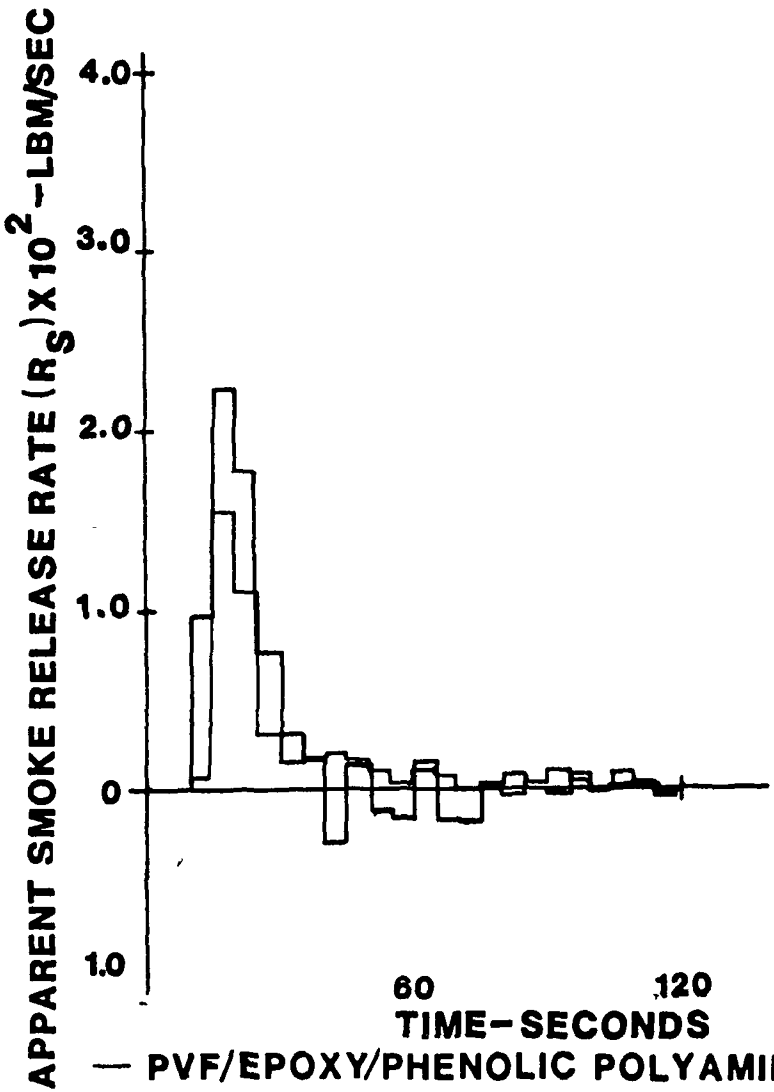
— PVF/EPOXY/PHENOLIC POLYAMIDE HONEYCOMB CORE
— PVF / PVC/ALUMINUM

SMOKE RELEASE RATES FOR POST-CRASH FIRE SOURCES



DESIGN POST - CRASH FIRE SOURCE

NOTE: VALUE $\leq +10^{-5} / -10^{-5} = 0$



— PVF/EPOXY/PHENOLIC POLYAMIDE HONEYCOMB CORE

— PVF/PVC/ALUMINUM

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ASSUMPTION FOR TRANSMISSION PREDICTIONS IN THE 737 FUSELAGE SECTION

PRESSURE = 2110.29 PSF.........THIS ASSUMES TEMP AMBIENT AND CABIN = 70° F (530° R) AT TIME = 0.

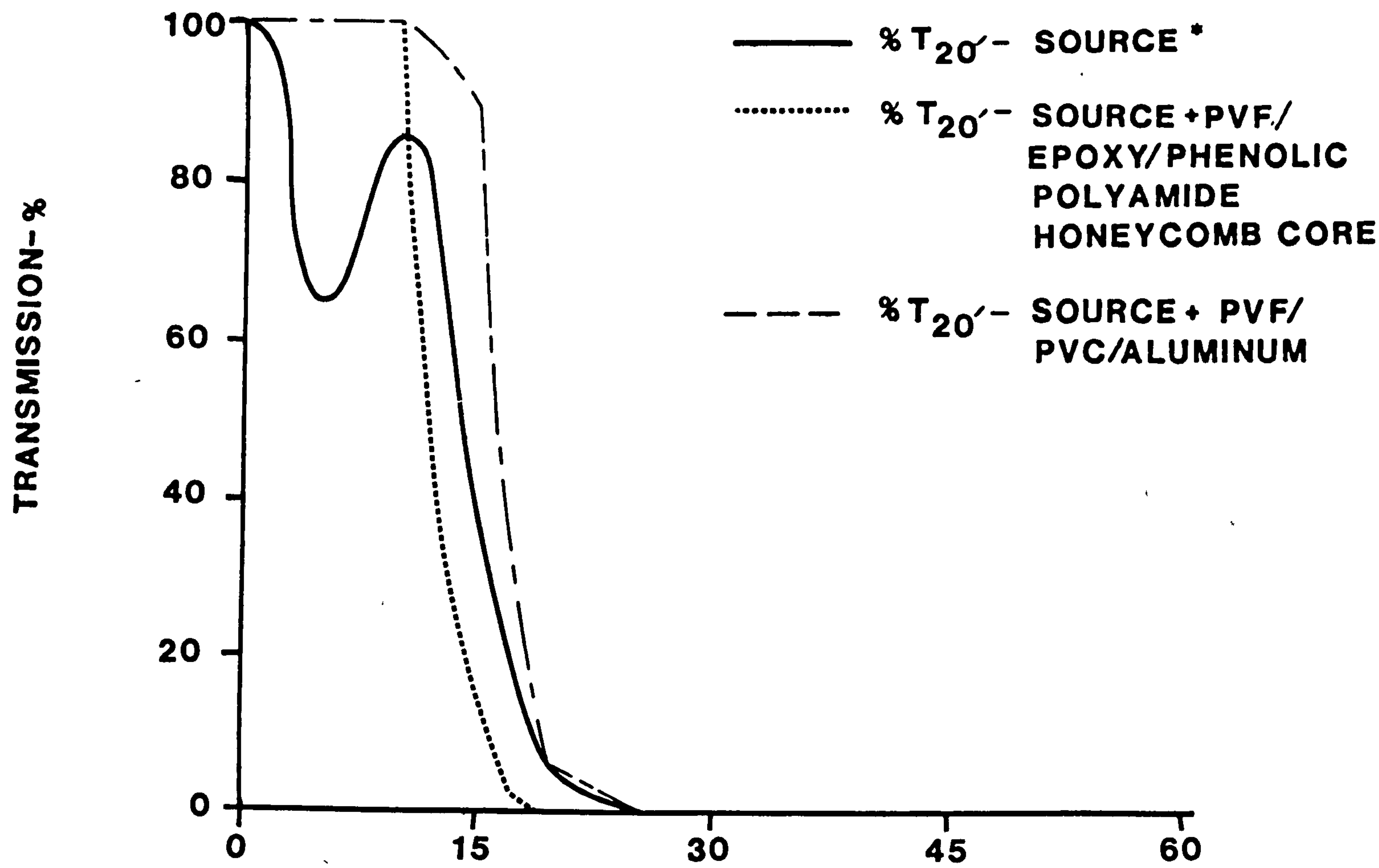
DESIGN TEMPERATURE =

1) **DESIGN FIRE SOURE: TEMPERATURE OF DESIGN FIRE SOURCE ALONE.**

2) **MATERIAL/MATERIAL + DESIGN FIRE SOURCE TEMPERATURE PRODUCED BY BURNING OF MATERIAL WITH DESIGN FIRE SOURCE.**

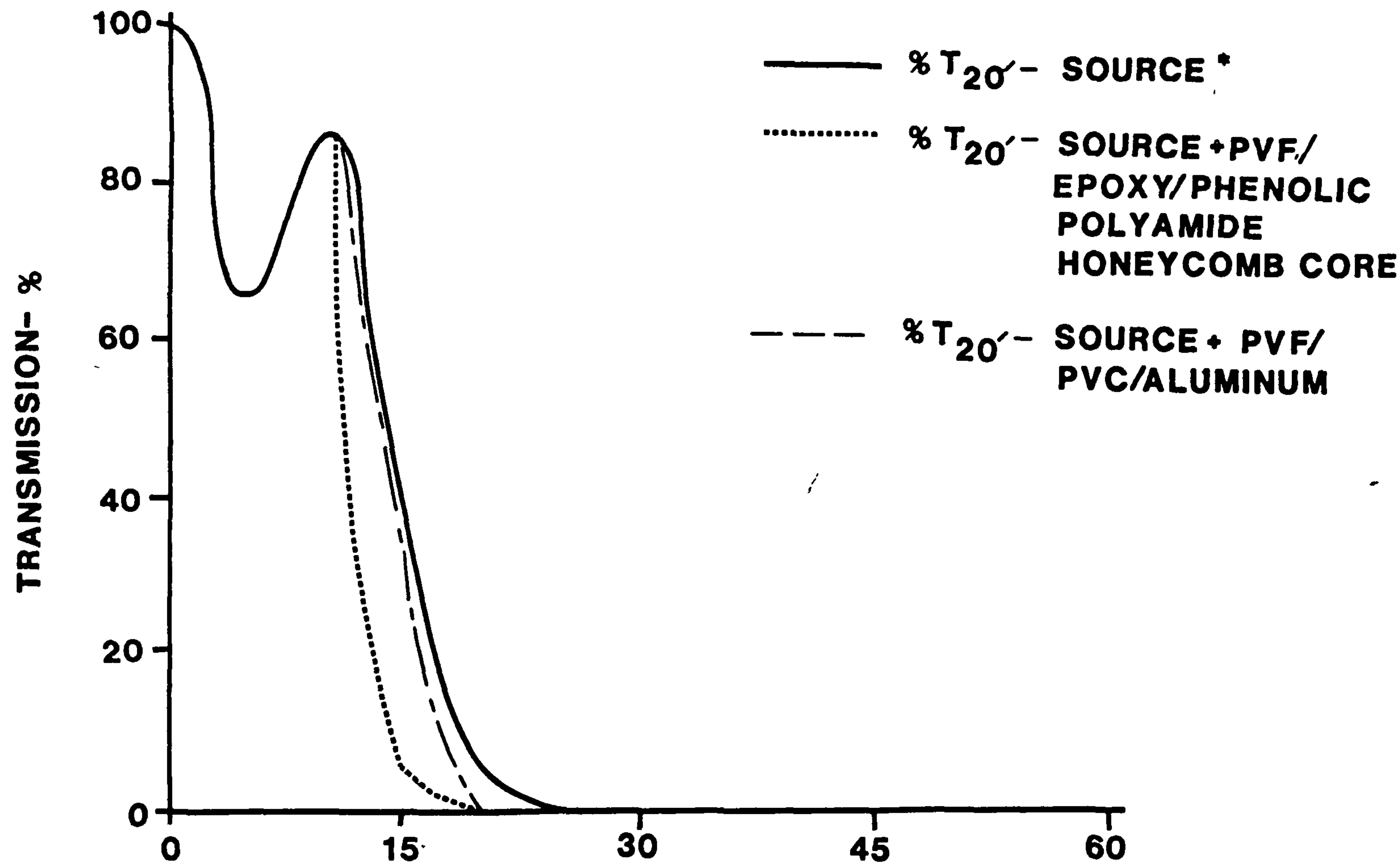
PREDICTED TRANSMISSION IN 737 SECTION

USING DESIGN POST-CRASH (FUEL) FIRE



* DESIGN POST CRASH (FUEL) FIRE

PREDICTED TRANSMISSION IN 737 SECTION
SUMMATION OF CONTRIBUTORS



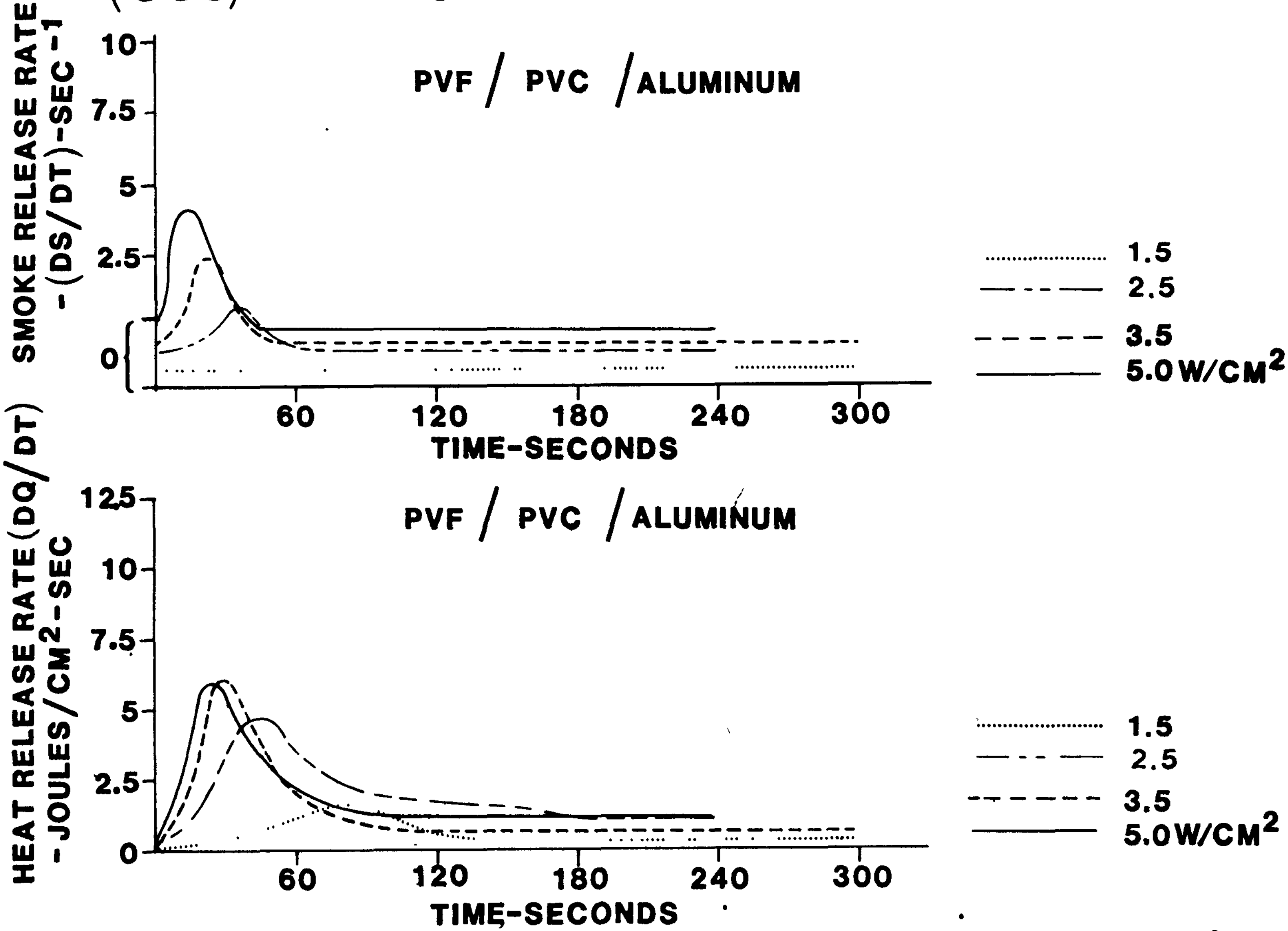
* DESIGN POST CRASH (FUEL) FIRE

LABORATORY FIRE TESTS CONDUCTED AND PLANNED

BOEING IRAD	OSU	NBS	ASTME 162-67	FAR 25.853	METTLER	LOI
8 BASELINE MATERIALS	all positions W/CM2 1.5 √ 2.5 √ 3.5 √ 5.0 √	W/CM2 2.5 Flm √ 2.5 Smol √ 5.0 Flm √	√	60Sec V √ 12Sec V √ 15Sec H √	√	√
4 NEW MATERIALS	2.5 ★ 5.0 ★	2.5 Flm ★ 5.0 Flm ★	★	Applicable test for in-service use ★	★	★
NAS 9-15168 2 BASELINE MATERIALS	all positions (W/CM2) 1.5 √ 2.5 √ 3.5 √ 5.0 √	W/CM2 2.5 Flm √ 2.5 Smol √ 5.0 Flm √	√	60 SecV √ 15 SecH √	√	√
10 NEW MATERIALS	2.5 √ 5.0 √	2.5 Flm √ 5.0 Flm √	√	Applicable test for in-service use √	√	√

√ = Test Complete ★ = Test Planned Smol = Smoldering Flm = FLAMMING

DATA EXAMPLES–OHIO STATE UNIVERSITY (OSU) RELEASE RATE APPARATUS

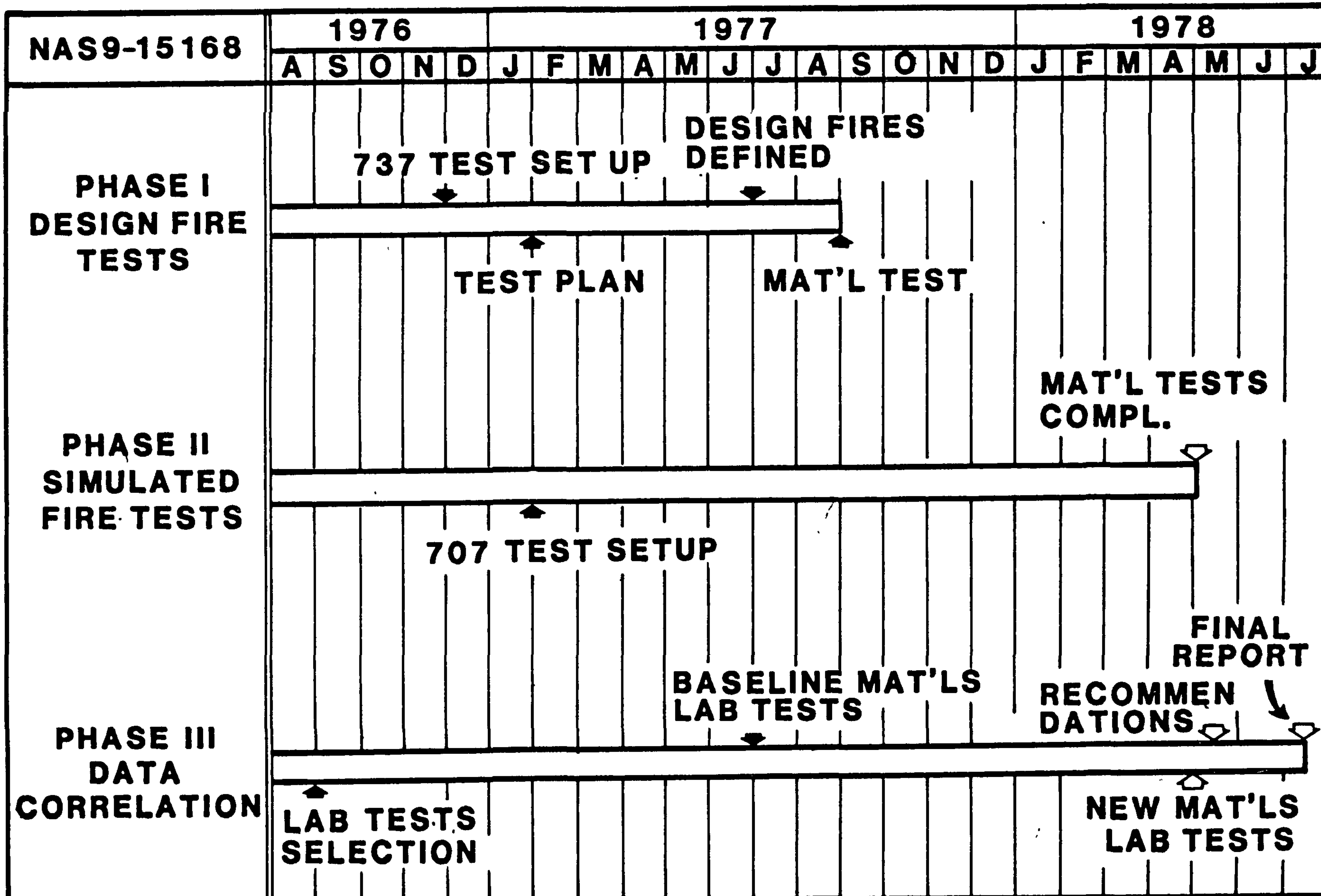


NAS 9-15168 TEST METHOD SELECTION

_____ TEST(S) @ _____ HEAT FLUX(ES) WILL GIVE RESULTS APPROXIMATELY RANKING MATERIALS IN THE SAME ORDER AS PERFORMANCE IN SIMULATED FUEL (INTERIOR FIRES)

__________ TEST(S) CAN EFFECTIVELY SCREEN OUT MATERIALS NOT WARRANTING EXTENSIVE TESTING (ABOVE)

PROGRAM SCHEDULE



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