

DOUGLAS AIRCRAFT CABIN FIRE TESTS

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(Abstract)

Industry and government have been independently active for many years in aircraft fire safety research and are currently joined in a mutual effort in the Firemen Program.

The fire safety research conducted at Douglas is a comprehensive multi-discipline program. A portion of this total program is in the area of full scale cabin fire simulation. The objectives of this phase of our work are to:

Establish the degree of hazard that may exist.

Develop solutions or improvements to the identified hazards and evaluate their effectiveness.

The scope of our IRAD work has included:

The development of a Cabin Fire Simulator.

Source fire studies.

Full cabin tests.

Module detection and extinguishment.

Module containment.

Burn-through resistance.

Effects of ventilation.

The past, current and planned research in support of the Firemen Program includes:

Ignition source tests and lavatory baseline test, 1977.

Passenger seat fire source tests, 1978.

Fire resistant lavatory panel tests (planned 1978).

Fire resistant seat tests (planned 1979).

The program summarized in this presentation was completed late in 1977 for Lyndon B. Johnson Space Center and consisted of 30 source fire tests and one baseline test.

The major objectives in this program were to:

- a. Examine the thermal and environmental characteristics of three types of fuels burned in two quantities contained within a metal lavatory.
- b. Determine the hazard experienced in opening the door of a lavatory containing a developed fire.
- c. Select the most severe source fuel for use in a baseline test.
- d. Evaluate the effect of the most severe source upon a lavatory constructed of contemporary materials. The results of this test will serve as a basis of comparison for future tests of new materials.

All tests in this program were conducted in the Douglas Cabin Fire Simulator (CFS) under typical in-flight ventilation conditions. Thirty tests were conducted of five fuel sources. In half of these tests, the door remained closed for the 30-minute test period. The door was opened 100 to 150 seconds after the fire had started in the remaining 15 tests. The fire in the baseline test was allowed to continue for a period of one hour. Data obtained during these tests included:

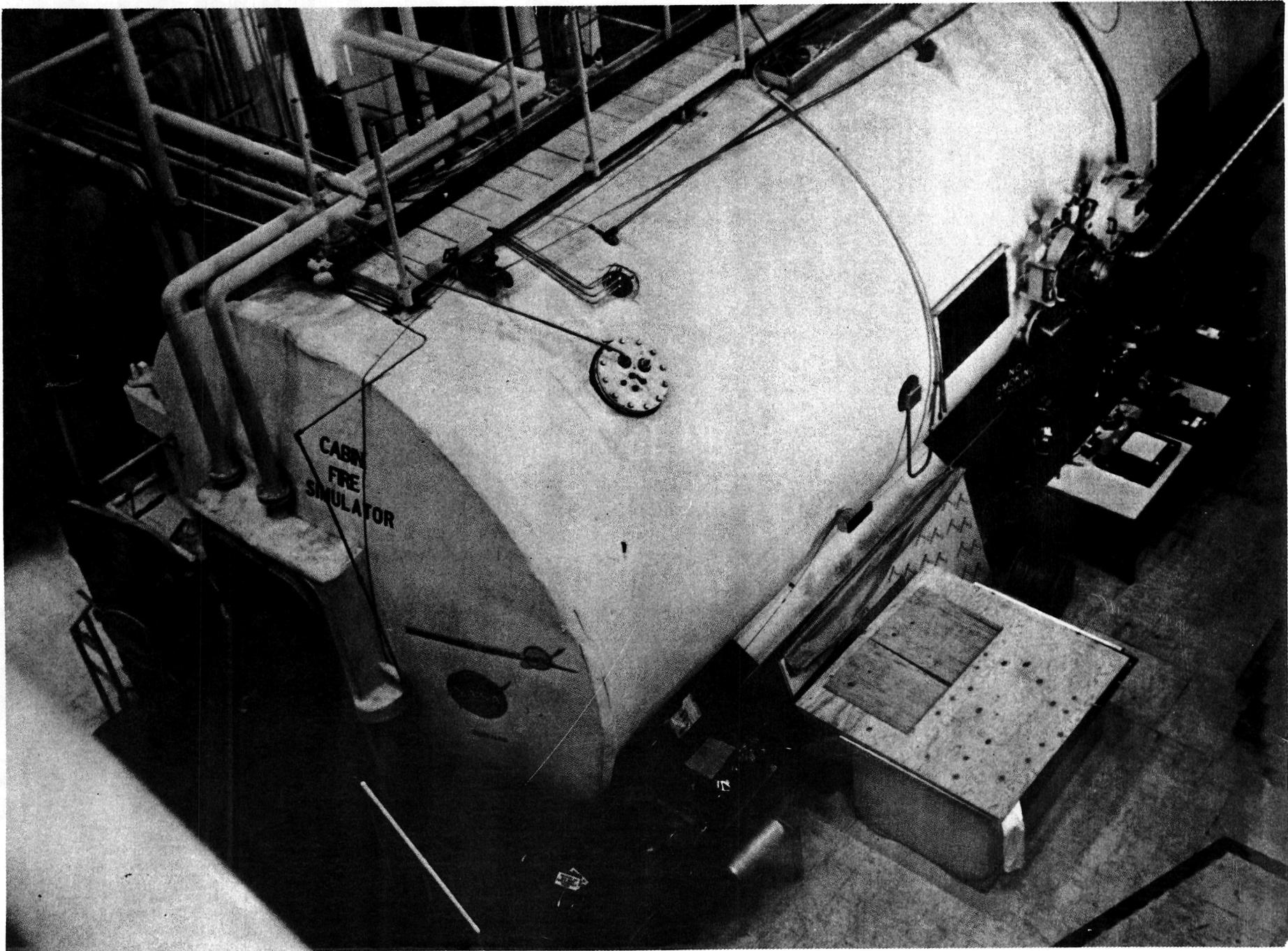
- a. Heat flux and temperature profiles of the lavatory at 10 locations.
- b. Cabin temperature variations.
- c. Gas analysis for O_2 , CO_2 , CO , CH_4 , HF , HCL and HCN .
- d. Respiration and electrocardiogram data on an instrumented rat subject exposed in the cabin.
- e. Color motion pictures were made of the baseline and ten opened door tests.

The conclusions reached on the program were:

- a. The maximum load of simulated airline trash resulted in the most severe fire threat.
- b. Opening the door of an involved module would be inadvisable.
- c. Contemporary materials exposed to the selected source provided remarkable protection; however, the improvement in fire resistance of specific materials is advisable.
- d. The baseline fire resulted in a survivable cabin condition; however, occupants of the cabin would have been subjected to severe discomfort from smoke.



DOUGLAS AIRCRAFT CABIN FIRE TESTS
IN SUPPORT OF
NASA FIREMAN PROGRAM
DOUGLAS IRAD PROGRAMS



FULL-SCALE CABIN INTERIOR TEST PROGRAMS

PROGRAMS IN SUPPORT OF NASA FIREMAN

IGNITION SOURCE AND LAVATORY BASELINE (JSC) 1977

PASSENGER SEAT SOURCE FIRE (ARC) 1978

FIRE RESISTANT LAVATORY PANELS (JSC) 1978

FIRE RESISTANT SEAT TESTS (ARC) 1978-1979

DOUGLAS IRAD PROGRAMS — 1975-1988

SOURCE FIRE STUDIES

FULL CABIN TESTS

DETECTION AND EXTINGUISHMENT

MODULE CONTAINMENT

BURN THROUGH RESISTANCE

VENTILATION EFFECTS

CHARACTERIZATION OF SECONDARY IGNITION SOURCES IN UNATTENDED COMPARTMENTS AND FULL-SCALE BASELINE TEST PROGRAM OBJECTIVES

SECONDARY IGNITION SOURCES

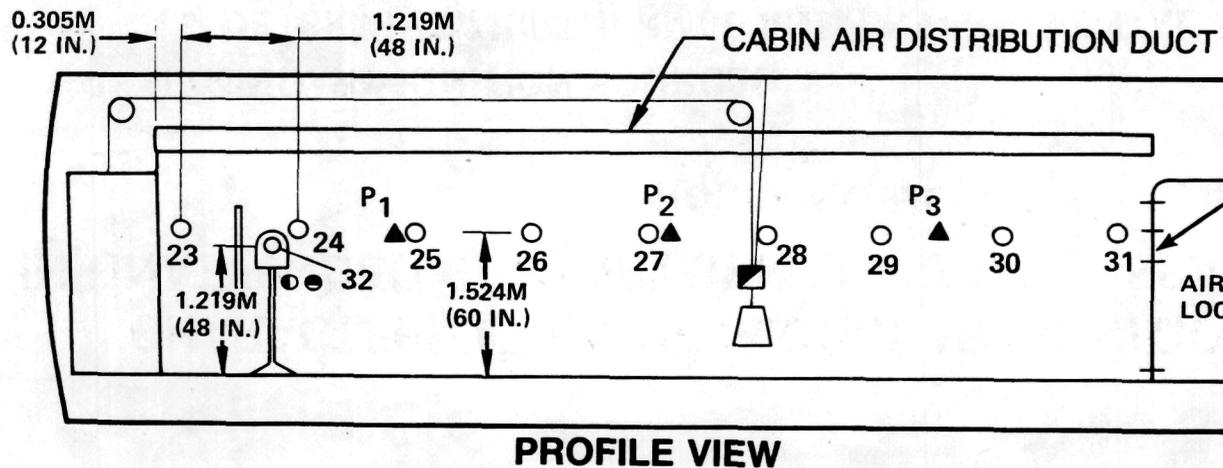
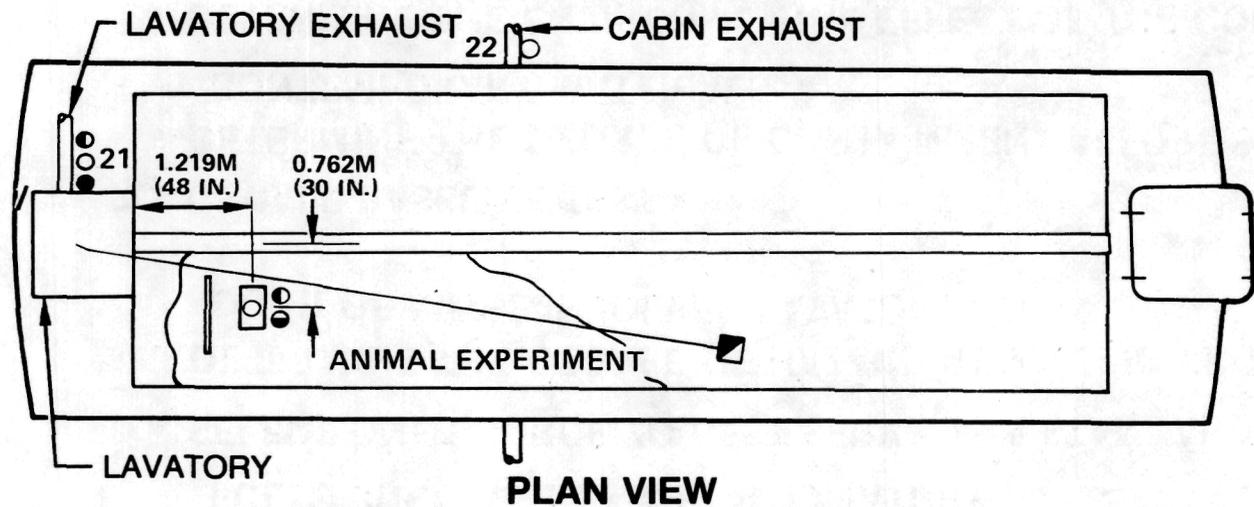
- **DETERMINE THE THERMAL AND ENVIRONMENTAL EFFECTS OF VARIOUS FUELS BURNING IN A METAL LAVATORY.**
- **SELECT ONE SOURCE TO BEST SERVE AS A STANDARD.**
- **DETERMINE THE DEGREE OF HAZARD RESULTING FROM OPENING THE DOOR OF A FIRE-INVOLVED LAVATORY .**

FULL-SCALE BASELINE TEST

- **DETERMINE THE DEGREE OF CONTAINMENT AFFORDED BY CONTEMPORARY MATERIALS.**
- **DETERMINE THE ENVIRONMENTAL EFFECT OF THE CONTAINED FIRE.**
- **PROVIDE A BASIS FOR MEASURING FUTURE IMPROVEMENTS.**

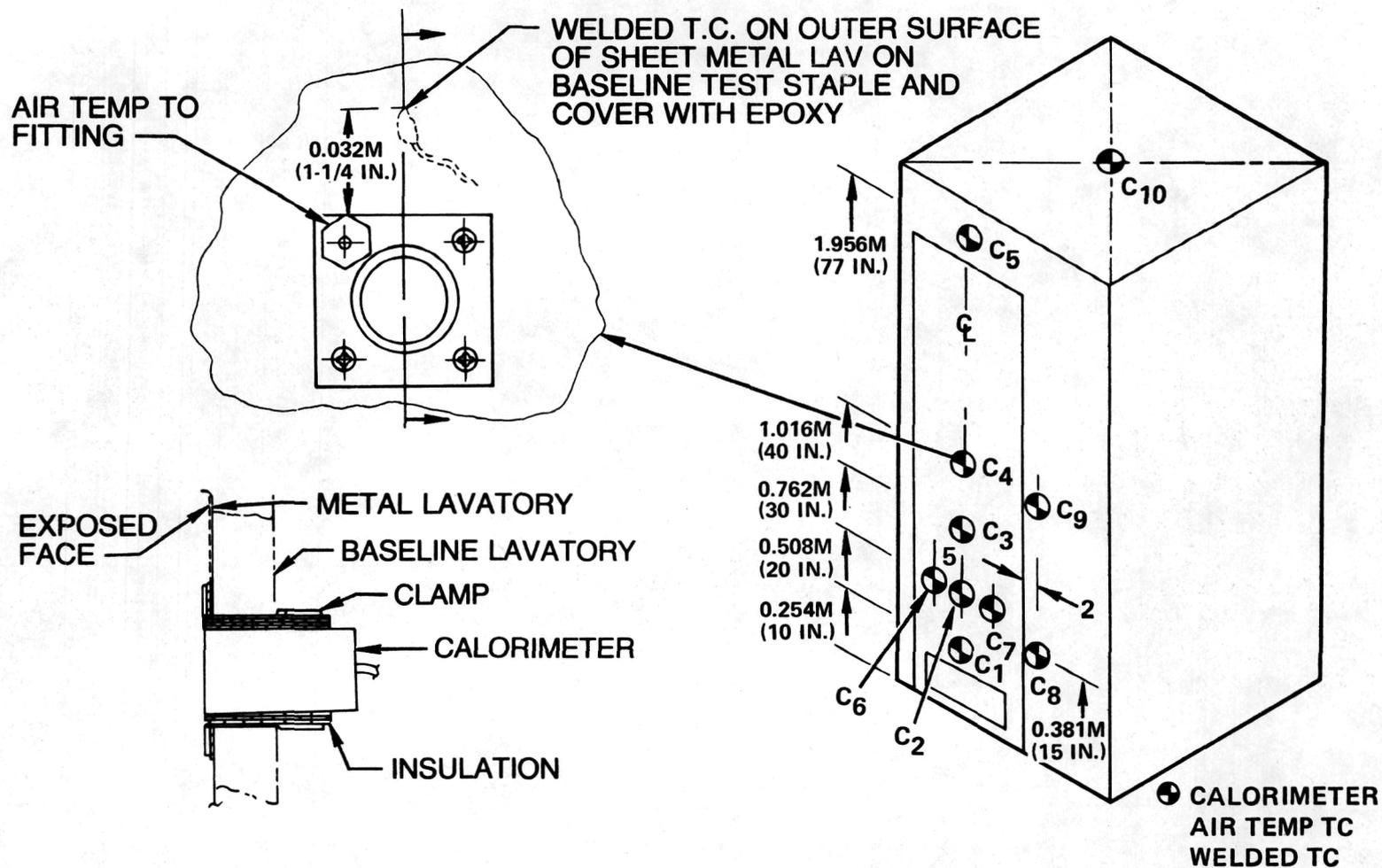
CABIN INSTRUMENTATION

94

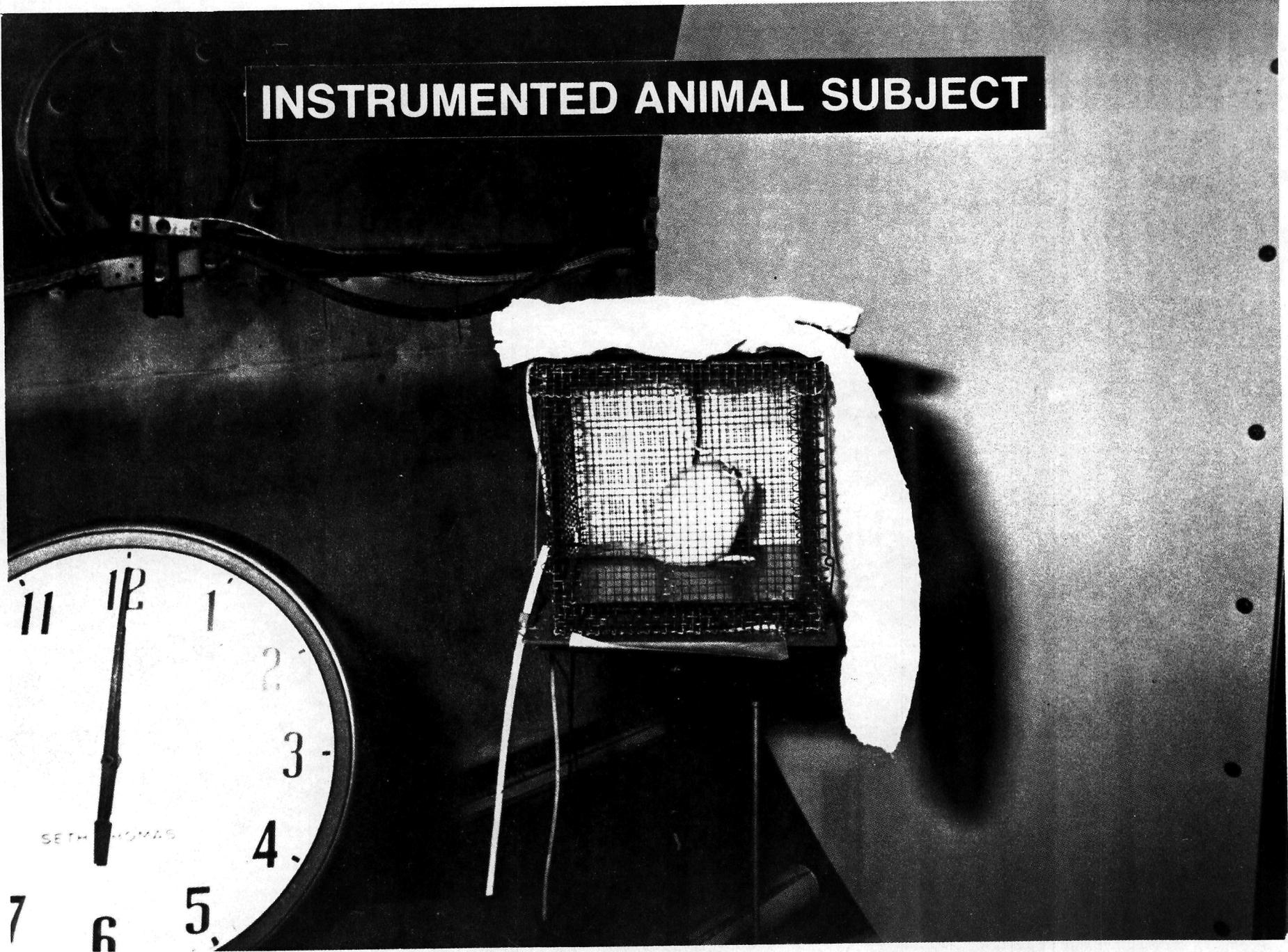


- THERMOCOUPLE
- REAL TIME CO₂, CO, O₂, CH₄
- ◐ REAL TIME CO₂, CO
- ◑ BUBBLER SAMPLING
- ▲ SMOKE DETECTOR
- ▣ LOAD TRANSDUCER

LAVATORY INSTRUMENTATION



INSTRUMENTED ANIMAL SUBJECT



SECONDARY IGNITION SOURCES

FUEL TYPE	COMPOSITION & WEIGHT PER UNIT	TESTS	QUANTITY	TEST CODE IDENTIFICATION	
				CLOSED DOOR	OPENED DOOR
SHREDDED PAPER	PER WIRE BASKET	3	ONE BASKET	SP()AC	
	2.268 Kg (5 POUNDS)	3	ONE BASKET		SP()AO
	SHREDDED UNUSED	3	TWO BASKETS	SP()BC	
	NEWSPRINT	3	TWO BASKETS		SP()BO
AIRLINE TRASH	PER TRASH BAG	3	TWO BAGS	AL()AC	
	PAPER TOWELS	3	TWO BAGS		AL()AO
	0.907 Kg (2 POUNDS)	3	FOUR BAGS	AL()BC	
	PAPER CUPS	3	FOUR BAGS		AL()BO
	0.045 Kg (0.1 POUNDS)				
	POLYSTYRENE CUPS				
	0.181 Kg (0.4 POUNDS)				
POLYETHYLENE TRASH BAG					
	0.064 Kg (0.14 POUNDS)				
ARSON ATTEMPT	PER TRASH BAG	3	TWO BAGS	AA()AC	
	AIRLINE TRASH AS ABOVE LIGHTER FLUID	3			AA()AO
	0.212 Kg (0.47 POUNDS)				

AIRLINE TRASH FUEL



AL() AC & AO



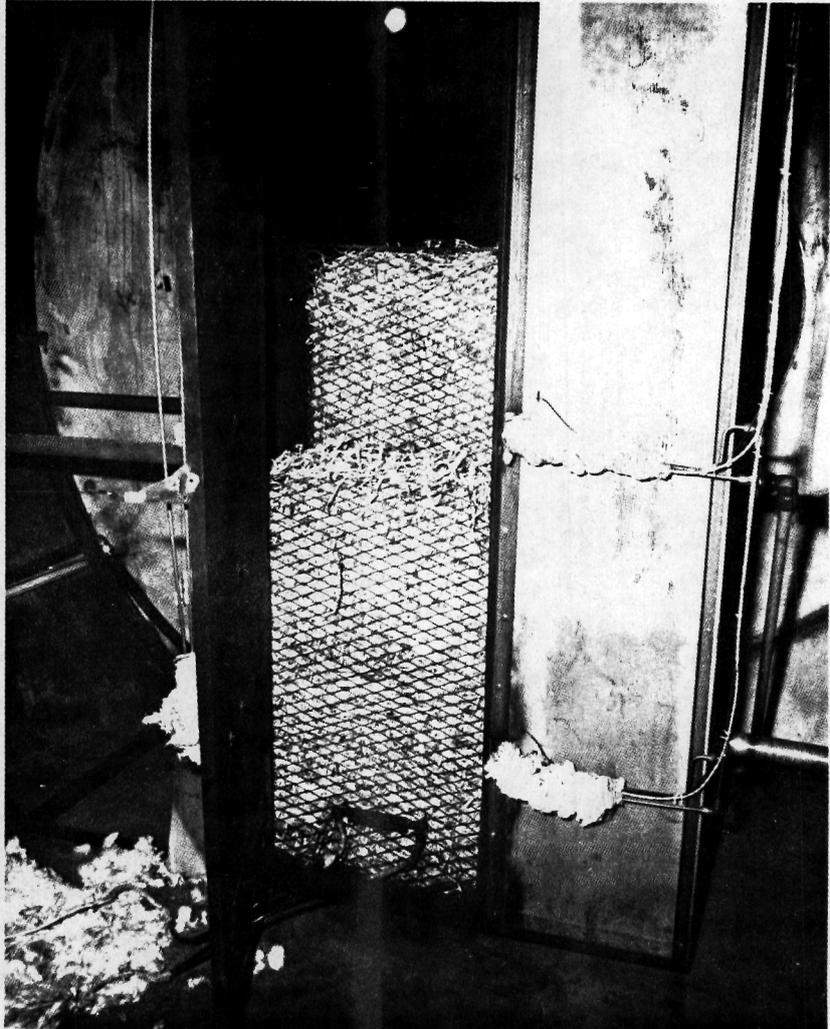
AL() BC & BO

SHREDDED PAPER FUEL

54

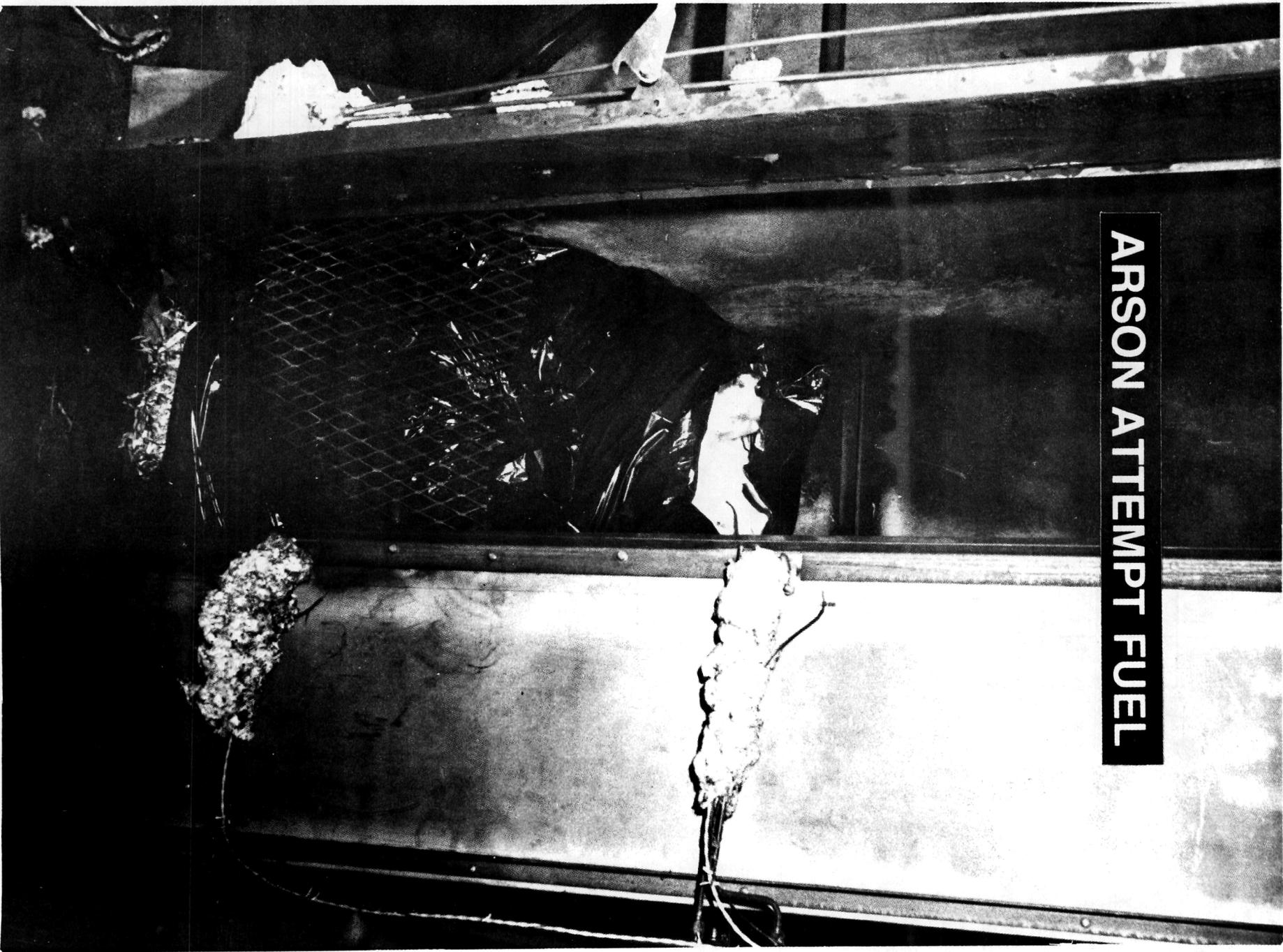


SP()AC&O



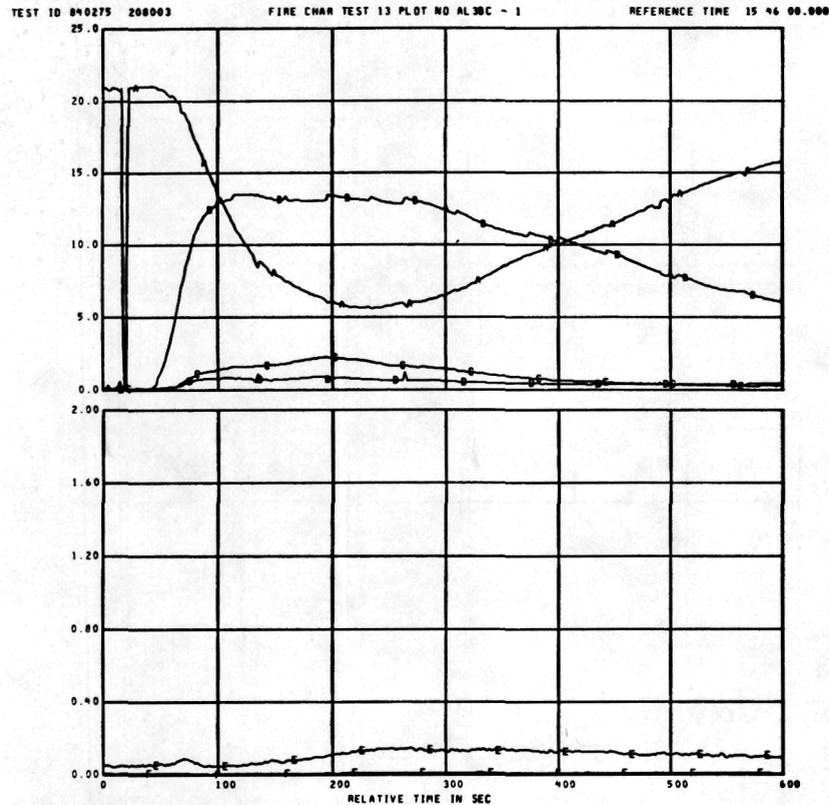
SP()BC&O

ARSON ATTEMPT FUEL



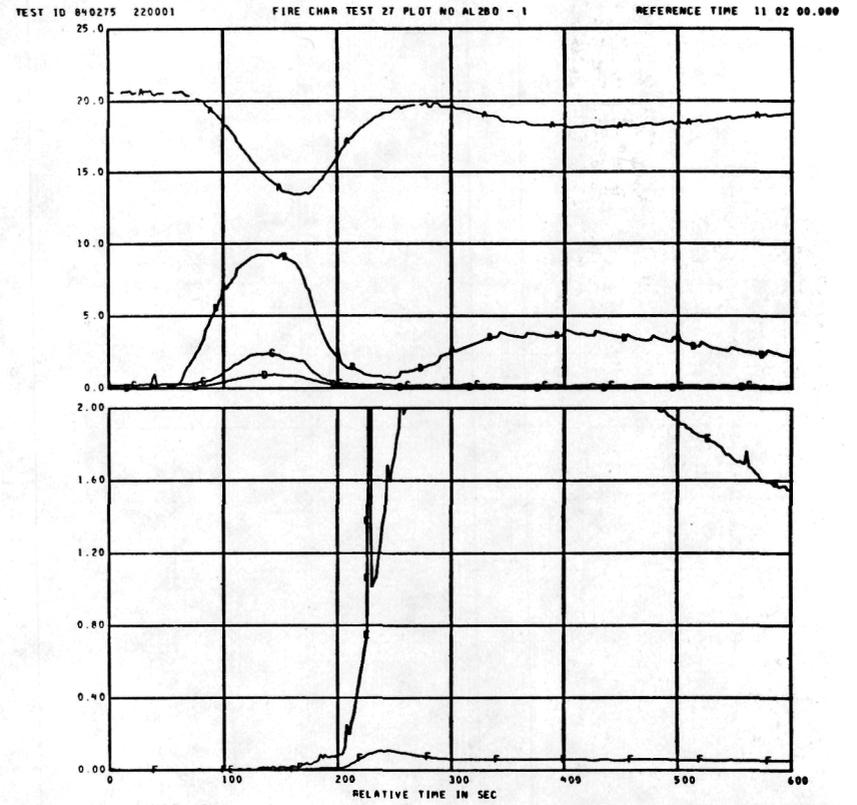
LAVATORY EXHAUST AND CABIN GAS ANALYSIS AL () BC & BO

56



PEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
02LAV	091	LAVATORY O2	0.0 TO 25.0	PCT	AB
CO2LV	093	LAVATORY CO2	0.0 TO 25.0	PCT	AB
COLAV	088	LAVATORY CO	0.0 TO 25.0	PCT	AC
CH4LV	085	LAVATORY CH4	0.0 TO 25.0	PCT	AB
CO2CB	090	CABIN CO2	0.00 TO 2.00	PCT	BE
COCAB	084	CABIN CO	0.00 TO 2.00	PCT	BF

CLOSED DOOR

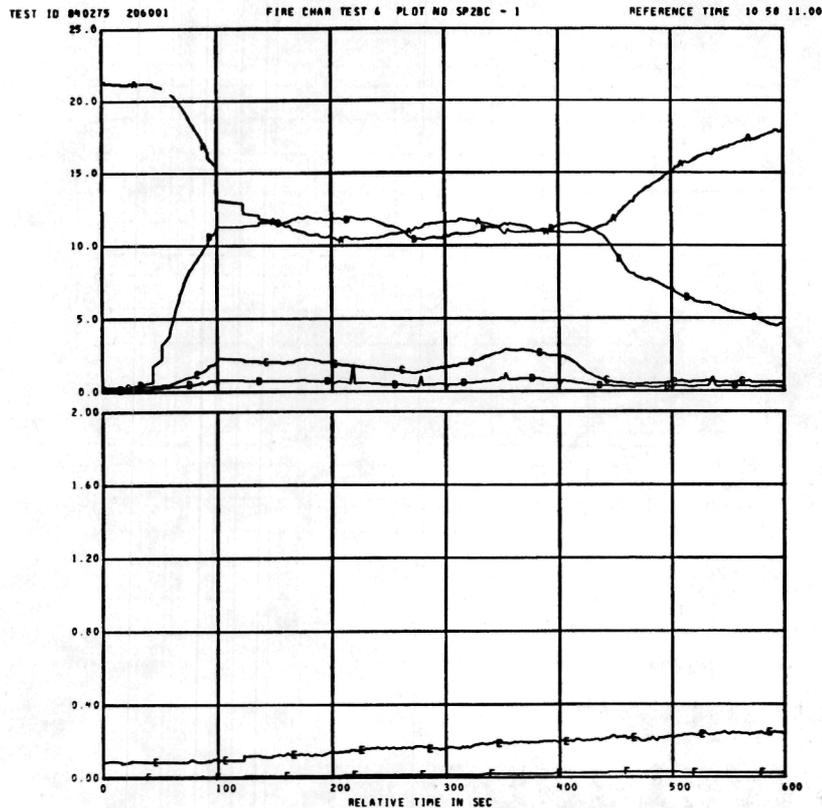


PEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
02LAV	091	LAVATORY O2	0.0 TO 25.0	PCT	AB
CO2LV	093	LAVATORY CO2	0.0 TO 25.0	PCT	AB
COLAV	088	LAVATORY CO	0.0 TO 25.0	PCT	AC
CH4LV	085	LAVATORY CH4	0.0 TO 25.0	PCT	AB
CO2CB	090	CABIN CO2	0.00 TO 2.00	PCT	BE
COCAB	084	CABIN CO	0.00 TO 2.00	PCT	BF

DOOR OPENED AT 150 SECONDS

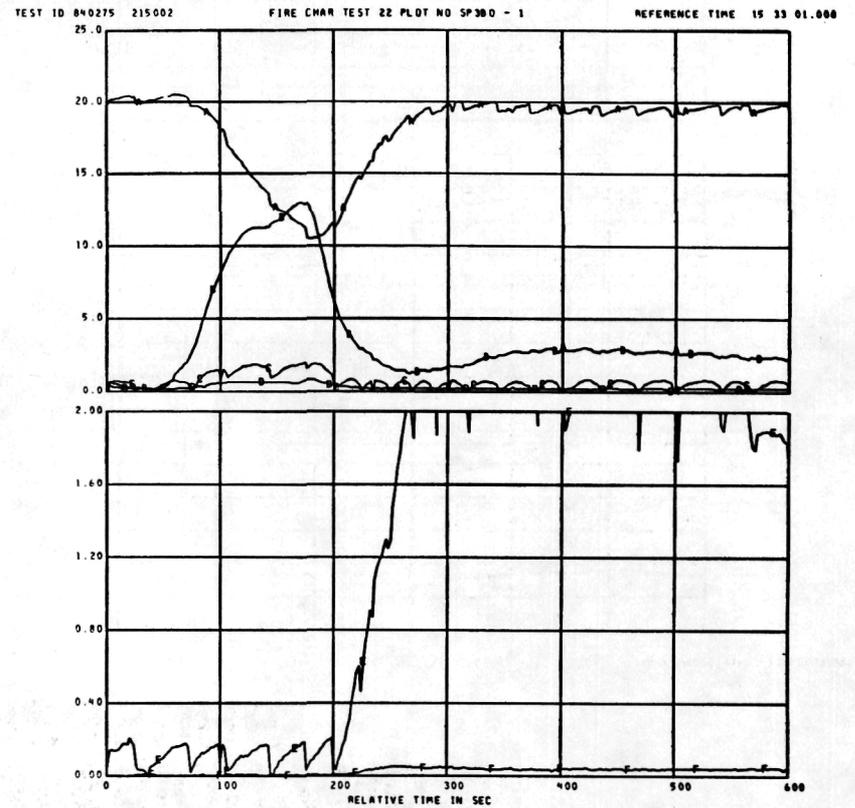
LAVATORY EXHAUST AND CABIN GAS ANALYSIS SP () BC & BO

57



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
02LAV	091	LAVATORY O2	0.0 TO 25.0	PCT	AA
CO2LV	093	LAVATORY CO2	0.0 TO 25.0	PCT	AB
COLAV	088	LAVATORY CO	0.0 TO 25.0	PCT	AC
CH4LV	085	LAVATORY CH4	0.0 TO 25.0	PCT	AD
CO2CB	090	CABIN CO2	0.00 TO 2.00	PCT	BE
COCAB	084	CABIN CO	0.00 TO 2.00	PCT	BF

CLOSED DOOR



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
02LAV	091	LAVATORY O2	0.0 TO 25.0	PCT	AA
CO2LV	093	LAVATORY CO2	0.0 TO 25.0	PCT	AB
COLAV	088	LAVATORY CO	0.0 TO 25.0	PCT	AC
CH4LV	085	LAVATORY CH4	0.0 TO 25.0	PCT	AD
CO2CB	090	CABIN CO2	0.00 TO 2.00	PCT	BE
COCAB	084	CABIN CO	0.00 TO 2.00	PCT	BF

DOOR OPENED AT 150 SECONDS

LIGHT TRANSMISSION AND CABIN PRESSURE

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TEST ID 840275 215002

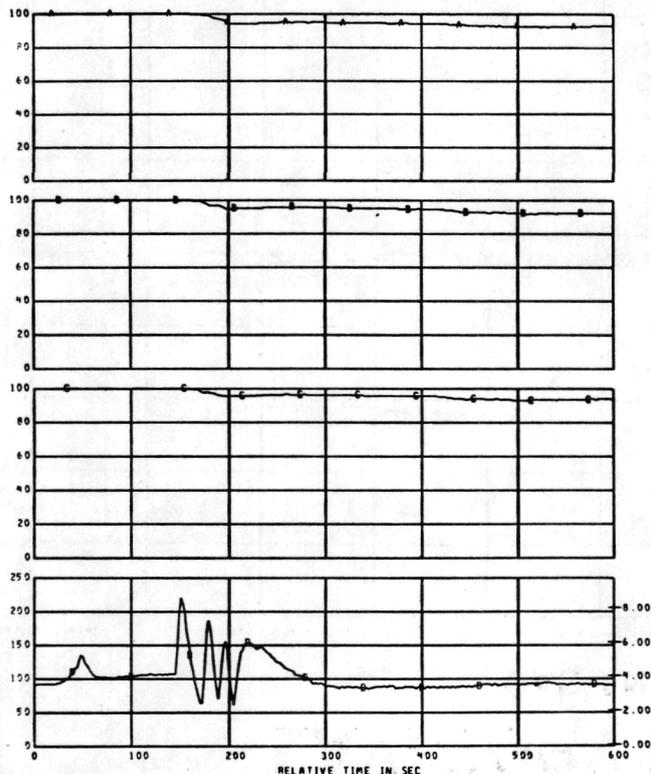
FIRE CHAR TEST 22 PLOT NO 5P380 - 1

REFERENCE TIME 15 33 01.000

TEST ID 840275 220002

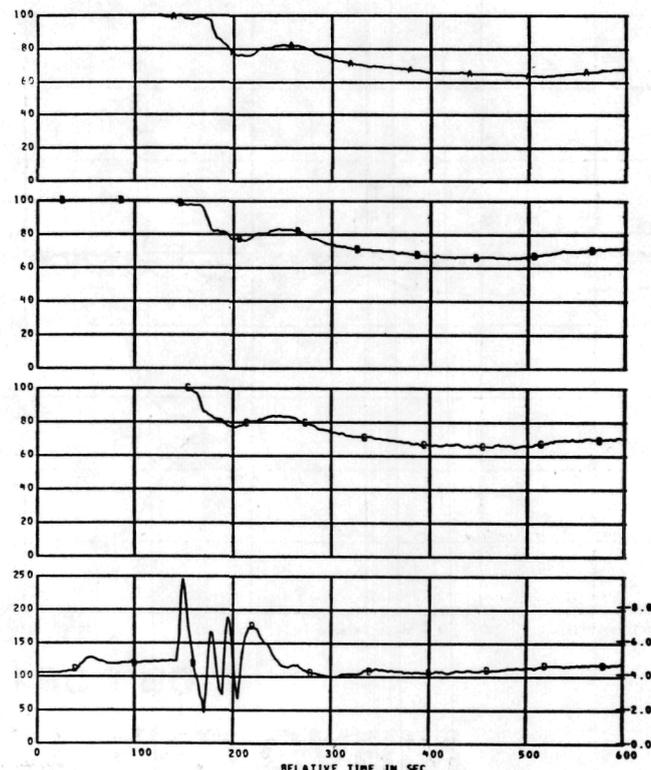
FIRE CHAR TEST 28 PLOT NO AL380 - 1

REFERENCE TIME 13 53 00.000



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
P1	160	LIGHT TRANSMISSION "MOST WEST"	0 TO 100	PCT	AA
P2	161	LIGHT TRANSMISSION "MIDDLE"	0 TO 100	PCT	BB
P3	162	LIGHT TRANSMISSION "MOST EAST"	0 TO 100	PCT	CC
Δ PRESS	098	CABIN DELTA PRESSURE	0 TO 250	MM H20	DD

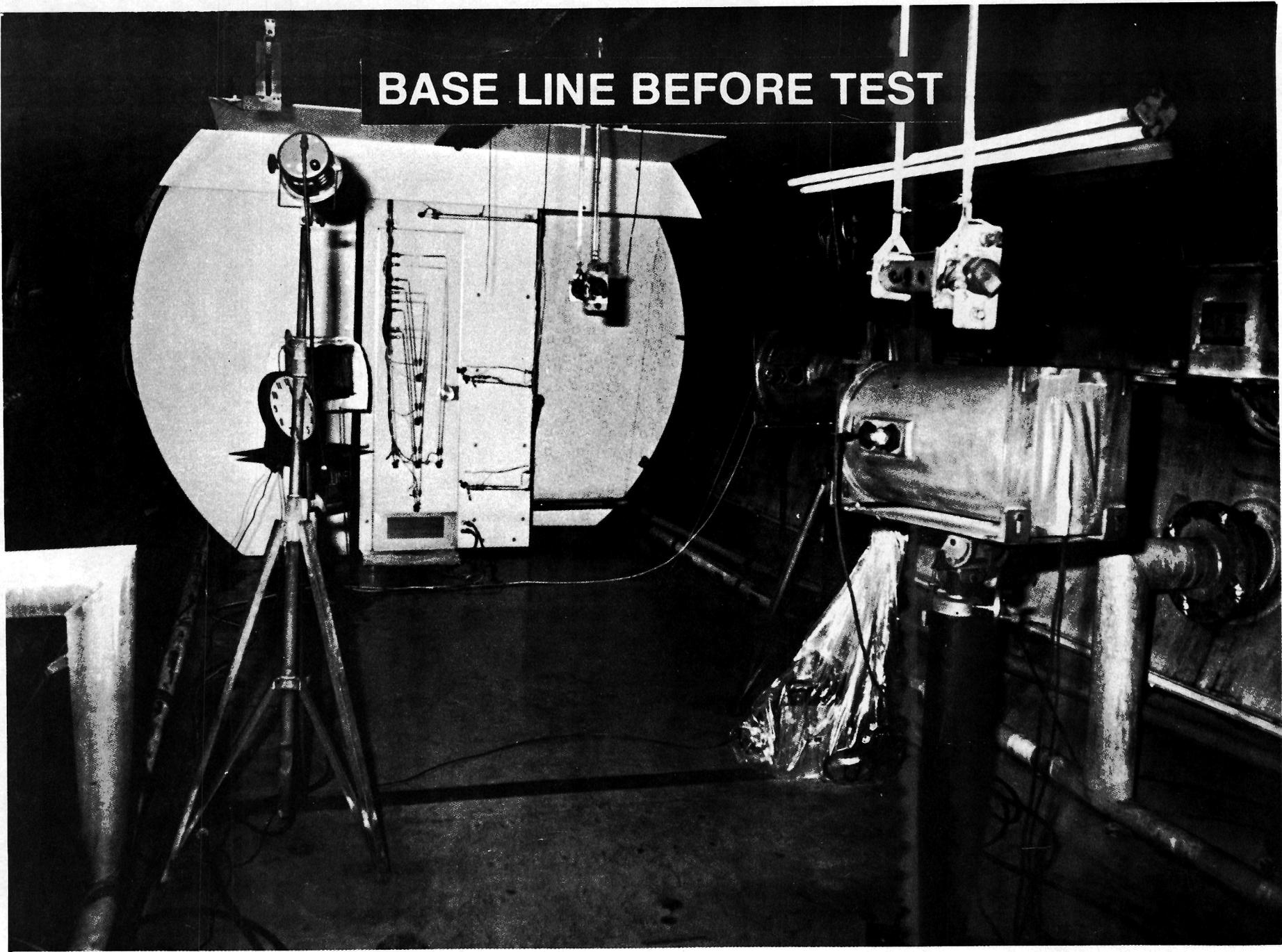
**SHREDDED PAPER
10 POUNDS**



MEAS. NUMBER	CHANNEL ASGN.	TITLE	RANGE	UNITS	GRID-SYM
P1	160	LIGHT TRANSMISSION "MOST WEST"	0 TO 100	PCT	AA
P2	161	LIGHT TRANSMISSION "MIDDLE"	0 TO 100	PCT	BB
P3	162	LIGHT TRANSMISSION "MOST EAST"	0 TO 100	PCT	CC
Δ PRESS	098	CABIN DELTA PRESSURE	0 TO 250	MM H20	DD

**AIRLINE TRASH
10 POUNDS**

BASE LINE BEFORE TEST

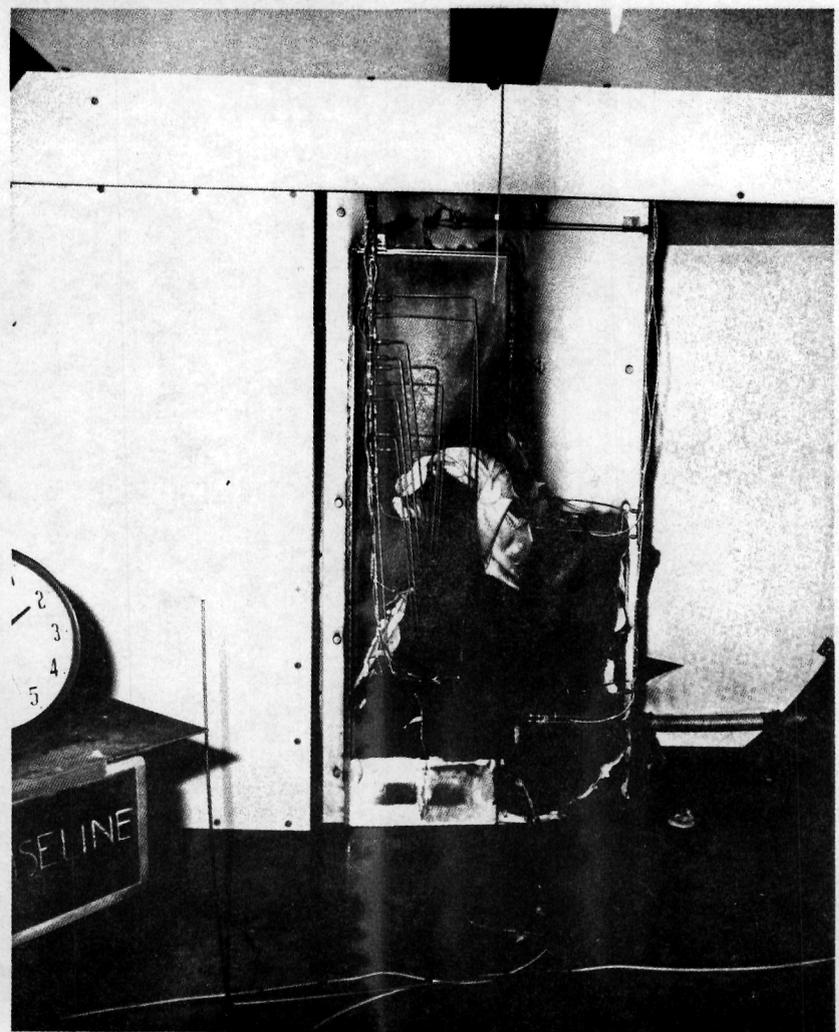


BASELINE FIRE EFFECTS

60



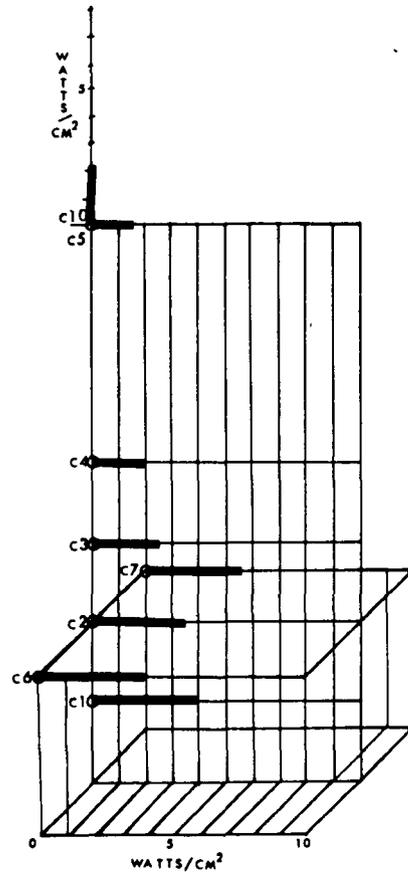
RESIDUAL FUEL REMAINING



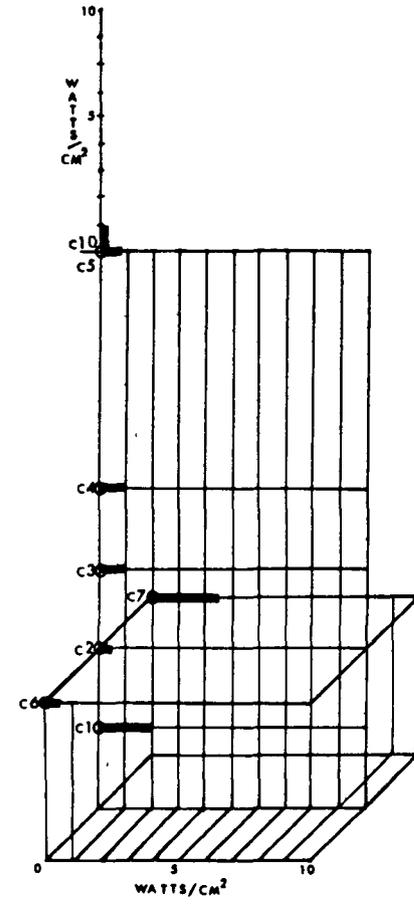
EXTERIOR OF LAVATARY

0-100 SECONDS AVERAGE Q

19



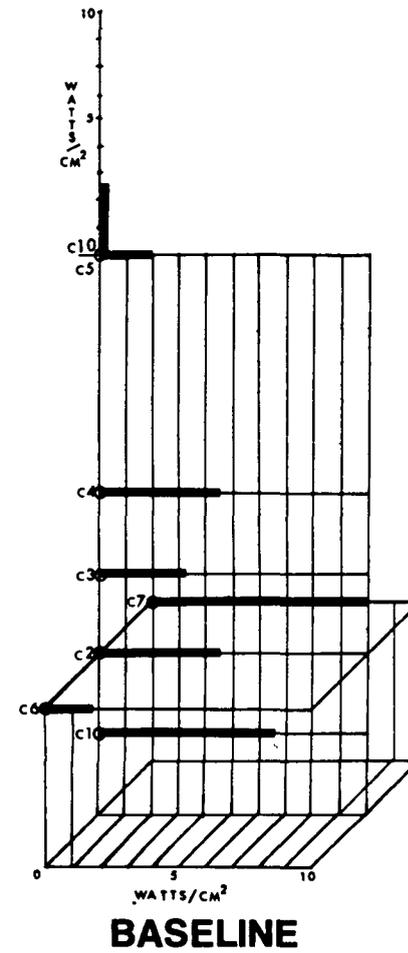
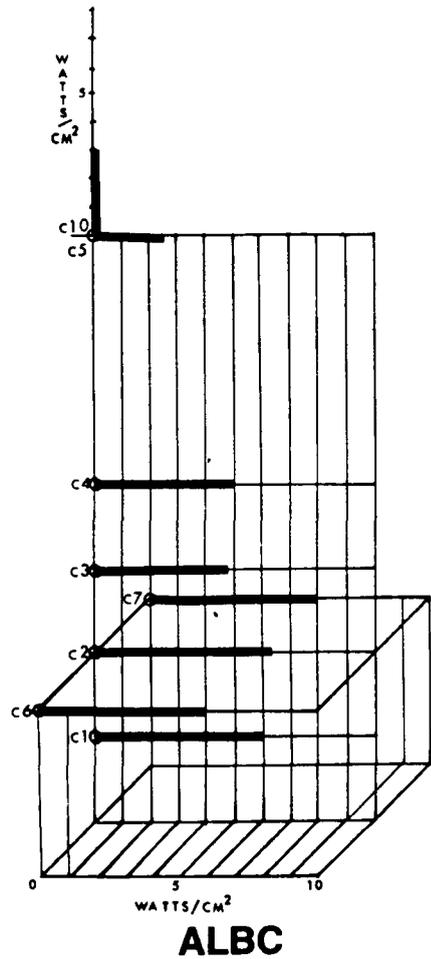
ALBC



BASELINE

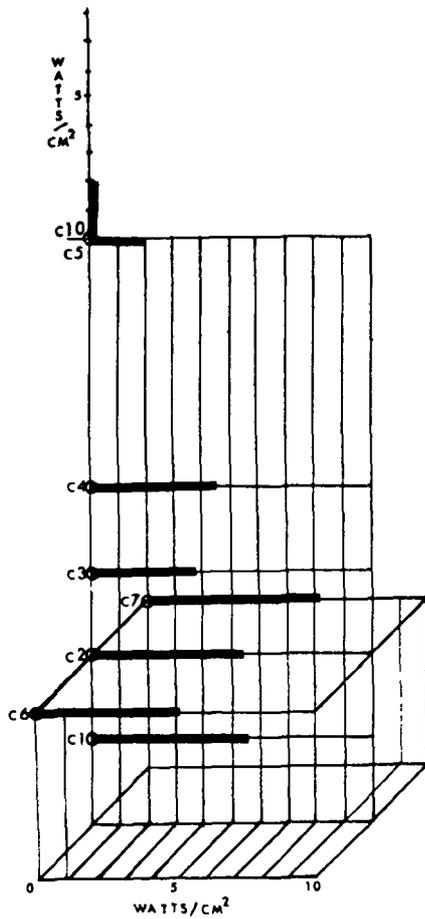
100-200 SECONDS AVERAGE Q

62

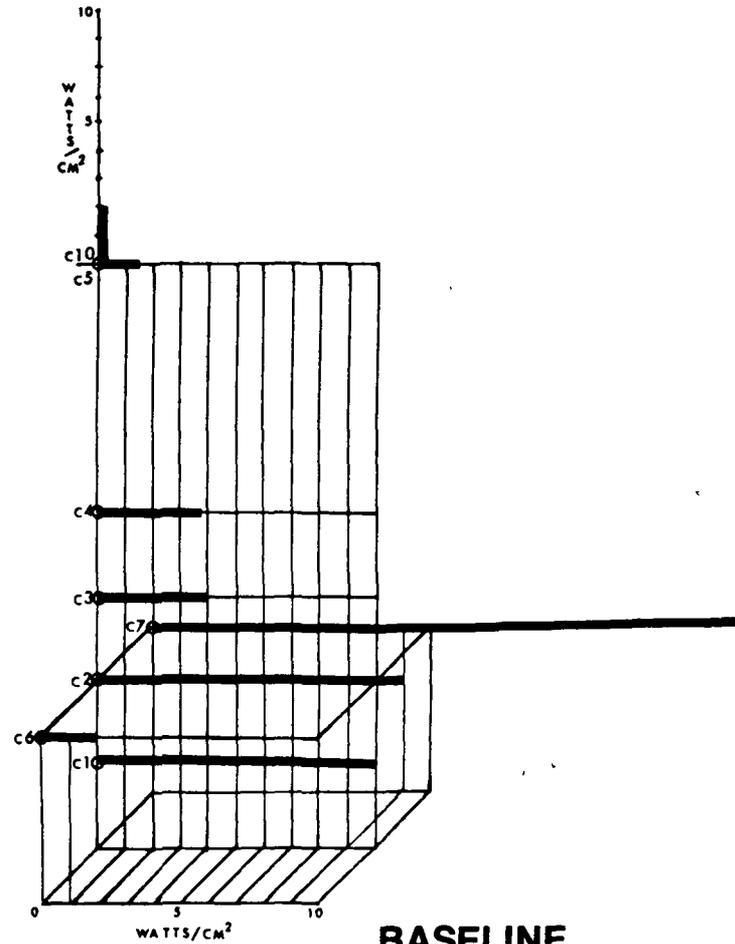


200-300 SECONDS AVERAGE Q

63



AL () BC

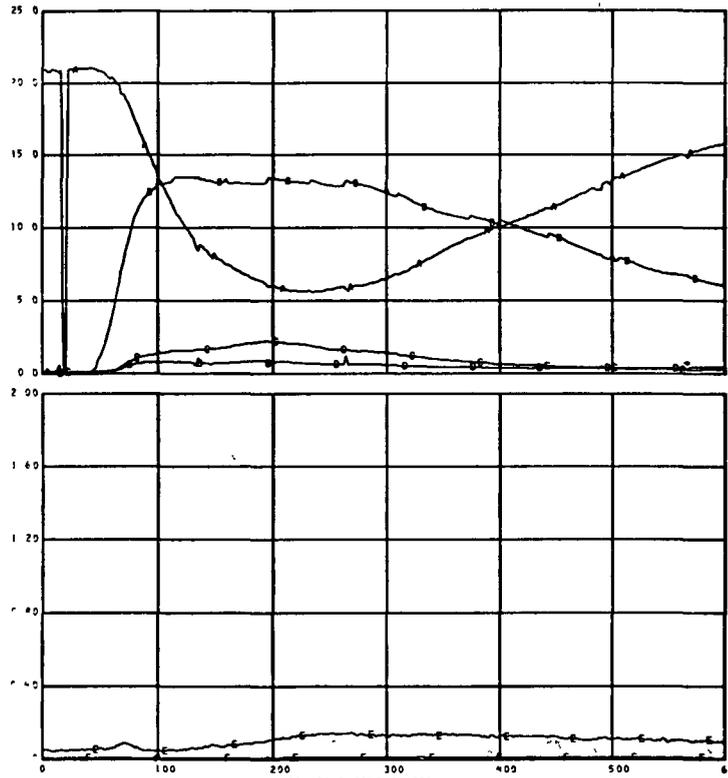


BASELINE

COMPARISON OF SOURCE FUEL AND BASELINE PRODUCTS OF COMBUSTION

64

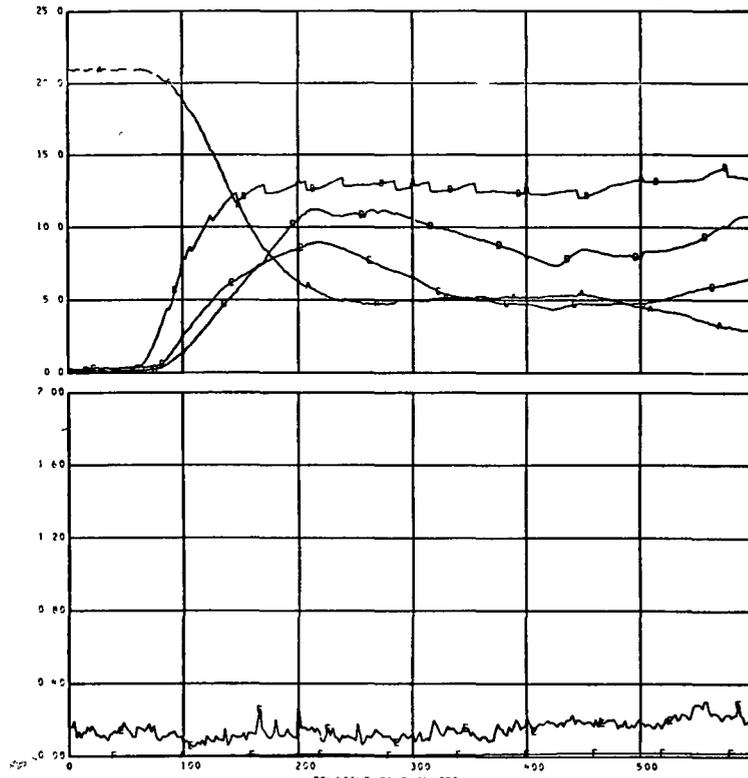
TEST ID 840275 208003 FIRE CHAR TEST 13 PLOT NO AL3BC - 1 REFERENCE TIME 15 46 00 000



PEAS NUMBER	CHANNEL ASGN	TITLE	RANGE	UNITS	GRID-SYM
OZLAV	091	LAVATORY O2	0 0 TO 25 0	PCT	AB
COZLV	093	LAVATORY CO2	0 0 TO 25 0	PCT	AB
COLAV	088	LAVATORY CO	0 0 TO 25 0	PCT	AC
CH4LV	085	LAVATORY CH4	0 0 TO 25 0	PCT	AD
COZCB	090	CABIN CO2	0 00 TO 2 00	PCT	BE
COCA8	084	CABIN CO	0 00 TO 2 00	PCT	BF

AL () BC

TEST ID 840275 224001 FIRE CHAR TEST BL PLOT NO BASE - 1 REFERENCE TIME 11 05 00 000



PEAS NUMBER	CHANNEL ASGN	TITLE	RANGE	UNITS	GRID-SYM
OZLAV	091	LAVATORY O2	0 0 TO 25 0	PCT	AB
COZLV	093	LAVATORY CO2	0 0 TO 25 0	PCT	AB
COLAV	088	LAVATORY CO	0 0 TO 25 0	PCT	AC
CH4LV	085	LAVATORY CH4	0 0 TO 25 0	PCT	AD
COZCB	090	CABIN CO2	0 00 TO 2 00	PCT	BE
COCA8	084	CABIN CO	0 00 TO 2 00	PCT	BF

BASELINE

BASE LINE SMOKE DENSITY

0-1200 SECONDS

TEST ID 040275 224001

FIRE CHAR TEST BL PLOT NO BASE - 1

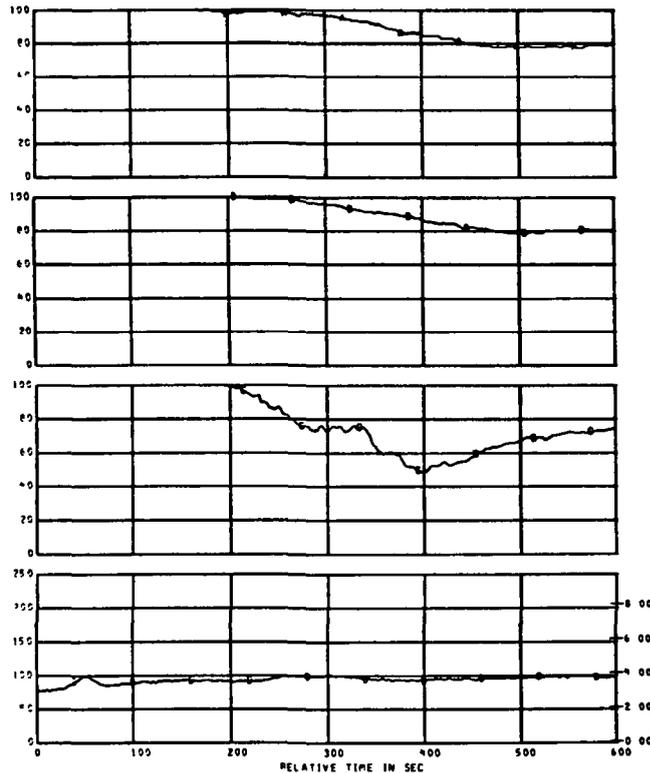
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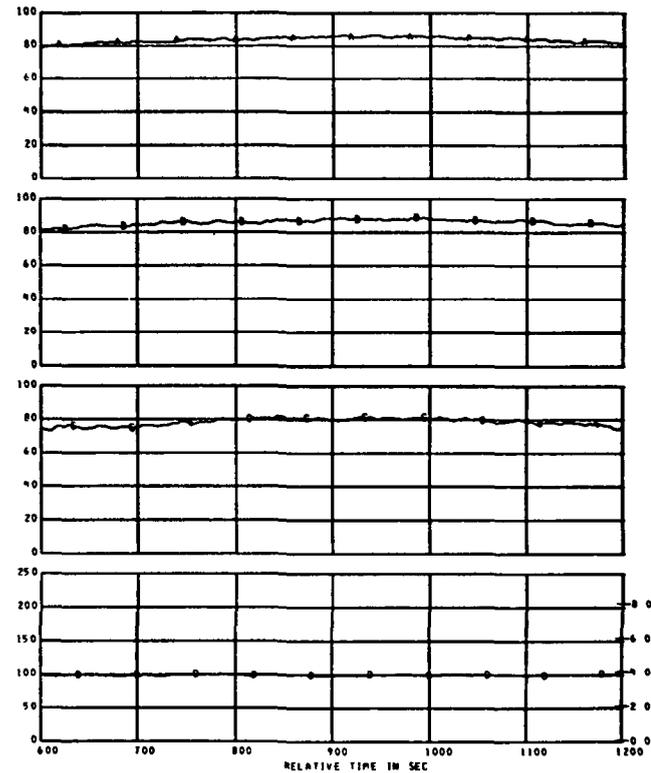
FIRE CHAR TEST BL PLOT NO BASE - 2

REFERENCE TIME 11 05 00 000

65



PEAS NUMBER	CHANNEL ASGN	TITLE	RANGE	UNITS	GRID-SYM
P1	160	LIGHT TRANSMISSION "MOST WEST"	0 TO 100	PCT	BB
P2	161	LIGHT TRANSMISSION "MIDDLE"	0 TO 100	PCT	BB
P3	162	LIGHT TRANSMISSION "MOST EAST"	0 TO 100	PCT	CC
Δ PRESS	098	CABIN DELTA PRESSURE	0 TO 250	MM H2O	DD



PEAS NUMBER	CHANNEL ASGN	TITLE	RANGE	UNITS	GRID-SYM
P1	160	LIGHT TRANSMISSION "MOST WEST"	0 TO 100	PCT	BB
P2	161	LIGHT TRANSMISSION "MIDDLE"	0 TO 100	PCT	BB
P3	162	LIGHT TRANSMISSION "MOST EAST"	0 TO 100	PCT	CC
Δ PRESS	098	CABIN DELTA PRESSURE	0 TO 250	MM H2O	DD

BUBBLER ANALYSIS FOR HCN, HCL AND HF

ANALYSIS OF THE CONTENT OF THE LAVATORY EXHAUST AND WITHIN THE CABIN WERE MADE OF 15 OF THE SOURCE FIRE SERIES AND THE BASELINE TEST USING A MINIATURE IMPINGER SYSTEM DEVELOPED AND FURNISHED BY NASA. SIX SAMPLES WERE TAKEN AT EACH LOCATION EACH FOR A PERIOD OF TWO MINUTES. IN THE SOURCE FIRE SERIES RANDOM RESULTS WERE OBTAINED. THE MAXIMUM QUANTITY DETECTED IN P.P. MILLION FOR THIS SERIES WERE:

GAS	LAVATORY EXHAUST	CABIN CLOSED DOOR	CABIN OPENED DOOR
HF	3.74 (AA)	12.7 (SP)	5.56 (SP)
HCL	458 (AA)	125 (AL)	125 (AL)
HCN	1.0 (AL & SP)	0.8 (AL & SP)	0.35 (AL)

IN THE BASELINE TEST THE FOLLOWING DATA WAS OBTAINED

PERIOD	HF		HCL		HCN	
	LAV.	CABIN	LAV.	CABIN	LAV.	CABIN
0-120	803	8.0	121	121	11	0
120-240	22	5.0	577	118	106	0
240-360	17	4.0	0	245	154	0
360-480	8	1.0	198	186	76	0
460-600	22	3.0	380	159	87	0
600-720	11	2.0	501	56	105	0

PROGRAM SUMMARY

IGNITION SOURCE CHARACTERIZATION TESTS

NO ADVERSE EFFECTS ON ANIMAL SUBJECTS

NO TOXIC GAS LEVELS DETECTED

MOST SEVERE FIRE PRODUCED BY AIRLINE TRASH

OPENING THE DOOR OF AN INVOLVED LAVATORY WOULD BE HAZARDOUS

BASELINE TEST

**ANIMAL SUBJECT SURVIVED WITHOUT ADVERSE SHORT- OR LONG-TERM
EFFECTS SUPPORTING THE NONTOXIC LEVELS OF GAS DETECTED**

LAVATORY STRUCTURE CONTAINED THE FIRE

AN EXTERNAL PROPAGATING FIRE DID NOT DEVELOP

WEIGHT LOSS OF LAVATORY STRUCTURE WAS 24.73 POUNDS

RESIDUAL SOURCE FUEL WEIGHED 1.14 POUNDS

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