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:
- Examine the thermal and environmental characteristics of three types of fuels burned in two quantities contained within a metal lavatory.
- Determine the hazard experienced in opening the door of a lavatory containing a developed fire.
- Select the most severe source fuel for use in a baseline test.
- 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 O₂, CO₂, CO, CH₄, 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.
LAVATORY INSTRUMENTATION

- WELDED T.C. ON OUTER SURFACE OF SHEET METAL LAV ON BASELINE TEST STAPLE AND COVER WITH EPOXY

- AIR TEMP TO FITTING

- EXPOSED FACE

- METAL LAVATORY

- BASELINE LAVATORY

- CLAMP

- CALORIMETER

- INSULATION

- CALORIMETER

- AIR TEMP TC

- WELDED TC

Dimensions:
- 0.032M (1-1/4 IN.)
- 1.956M (77 IN.)
- 1.016M (40 IN.)
- 0.762M (30 IN.)
- 0.508M (20 IN.)
- 0.254M (10 IN.)
- 0.381M (15 IN.)
# SECONDARY IGNITION SOURCES

<table>
<thead>
<tr>
<th>FUEL TYPE</th>
<th>COMPOSITION &amp; WEIGHT PER UNIT</th>
<th>TESTS</th>
<th>QUANTITY</th>
<th>CLOSED DOOR</th>
<th>OPENED DOOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredded Paper</td>
<td>Per Wire Basket 2.268 Kg (5 Pounds)</td>
<td>3</td>
<td>One Basket</td>
<td>SP( )AC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shredded Unused Newsprint</td>
<td>3</td>
<td>Two Baskets</td>
<td>SP( )BC</td>
<td>SP( )BO</td>
</tr>
<tr>
<td>Airline Trash</td>
<td>Per Trash Bag 0.907 Kg (2 Pounds)</td>
<td>3</td>
<td>Two Bags</td>
<td>AL( )AC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paper Towels 0.045 Kg (0.1 Pounds)</td>
<td>3</td>
<td>Two Bags</td>
<td>AL( )BC</td>
<td>AL( )BO</td>
</tr>
<tr>
<td></td>
<td>Paper Cups 0.181 Kg (0.4 Pounds)</td>
<td>3</td>
<td>Four Bags</td>
<td>AL( )AC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polystyrene Cups 0.064 Kg (0.14 Pounds)</td>
<td>3</td>
<td>Four Bags</td>
<td>AL( )BC</td>
<td></td>
</tr>
<tr>
<td>Arson Attempt</td>
<td>Per Trash Bag 0.212 Kg (0.47 Pounds)</td>
<td>3</td>
<td>Two Bags</td>
<td>AA( )AC</td>
<td></td>
</tr>
</tbody>
</table>
AIRLINE TRASH FUEL

AL( ) AC & AO

AL( ) BC & BO
SHREDDED PAPER FUEL

SP( )AC & O

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

CLOSED DOOR

DOOR OPENED AT 150 SECONDS
LAVATORY EXHAUST AND CABIN
GAS ANALYSIS SP ( ) BC & BO

CLOSED DOOR

DOOR OPENED AT 150 SECONDS
LIGHT TRANSMISSION AND CABIN PRESSURE

SHREDDED PAPER
10 POUNDS

AIRLINE TRASH
10 POUNDS
BASELINE FIRE EFFECTS

RESIDUAL FUEL REMAINING

EXTERIOR OF LAVATORY
0–100 SECONDS AVERAGE Q

ALBC

BASELINE
100–200 SECONDS AVERAGE Q

ALBC

BASELINE
200–300 SECONDS AVERAGE Q

AL ( ) BC

BASELINE
COMPARISON OF SOURCE FUEL AND BASELINE PRODUCTS OF COMBUSTION

AL ( ) BC

BASELINE
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:

<table>
<thead>
<tr>
<th>GAS</th>
<th>LAVATORY EXHAUST</th>
<th>CABIN CLOSED DOOR</th>
<th>CABIN OPENED DOOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF</td>
<td>3.74 (AA)</td>
<td>12.7 (SP)</td>
<td>5.56 (SP)</td>
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<tr>
<td>HCL</td>
<td>458 (AA)</td>
<td>125 (AL)</td>
<td>125 (AL)</td>
</tr>
<tr>
<td>HCN</td>
<td>1.0 (AL &amp; SP)</td>
<td>0.8 (AL &amp; SP)</td>
<td>0.35 (AL)</td>
</tr>
</tbody>
</table>

IN THE BASELINE TEST THE FOLLOWING DATA WAS OBTAINED

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