# Response to Aircraft Ducting Working Group Members' Questions

Federal Aviation Administration

Presented to: IAMFTWG

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Location: Atlantic City, NJ

# Background

## RECEIVED LETTERS:

✓ The FAA received two letters commenting on FAA's report number DOT/FAA/AR-08/4, "Development on an Improved Fire Test Method for Aircraft Ducting Materials":

- Boeing Letter 6-20P4-08-0297
- International Coordinating Council of Aerospace Industries Associations Letter ICCAIA/AC/029

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES

1. BCA: "*Sample dimensions were not kept constant (variable thermal conductivity parameters).*"

   FAA:

   - Draft Test Plan called for a standard size duct: 6" in dia. by 96" long
   - Suppliers (TG members) could not provide one size/geometry without retooling their plants
   - Ducts provided included: 4", 6", 6.75", 7", 8.5", and 12" (round, square, oval)
   - The upper surface of the tested ducts was placed 6 inches below the attic ceiling to expose them to the same thermal conditions.
   - The ignition source was laterally placed 1/8" from the sample in every test.

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

2. BCA: "*The study evaluated too few material thicknesses and only a small variety of duct diameters.*"

FAA:

- For this study, we relied on the support of our working group members.
- 10 manufacturers supplied test samples
- 23 different types of materials and configurations (Full Test Matrix)
- Diameters included: 4", 6", 6.75", 7", 8.5", and 12"
- Material samples included rigid and flexible ducts, thermoplastics and thermosetting, and insulated.
- Thicknesses ranged from 0.02" to 0.5"
- We tested what was supplied to us.

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

3. BCA: "*The degree of variation in flame temperature and heat flux is unknown.*"

FAA:

- We conducted eight baseline tests:
  - Avg. Peak Temperature: 1449 °F (std dev = 181 °F)
  - Avg. Peak Heat Flux: 6.4 BTU/ft$^2$-sec (std dev = 2.1 BTU/ft2-sec)

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

4. BCA: "*The thermal conductivity of the intermediate scale test structure (ceiling panels, insulation blankets, supporting steel structure) all contribute to the outcome of the test and need to be precisely defined and standardized.*"

FAA:

- We concur and it was reported in final report.
- Thermal-acoustic insulation: polyimide film (Facile Insulfab film 200C) and a double layer of 1-inch fiberglass blanket (Johns Manville Microlite AA Blanket 0.34 PCF fiberglass). Blankets: 8' long x 30" wide. Caps were 8' long by 6" wide.
- Ceiling panels: 0.25" composite panel made with Nomex honeycomb core and fiberglass/phenolic faces. Tedlar decorative face (cabin side).
- The attic frame was 1/8" thick/1-inch wide steel angle.

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

5. BCA: "*Airflow through the test apparatus is a key parameter, providing oxidizer and convective transport for flame propagation, yet this was not defined or discussed*."

FAA:

- We concur with statement.
- SOP: we test inside a test cell with no external wind flowing over or through test apparatus
- Building exhaust fans are off during test.

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

6. BCA: "*The difference in the size of the attic space above the ceiling panels in wide body versus narrow bodies and the impact upon airflow needs to be clearly defined. This is a key parameter affecting heat flow during the burn event*."

FAA:

- The attic dimensions of the test apparatus were based on the dimensions of our B-737 aircraft (narrow-body) and B-747 aircraft (wide-body) dimensions and duct placement.
- No external airflow affected the experiment
- Fire hot gases interact differently in these two configurations
- Selected narrow-body configuration because it provided worse case scenario (conservative approach). Conductive/Convective/Radiant heat

# Boeing Letter



# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

7. BCA: "*Ambient temperature and humidity should be recorded. Preferably, this test should be done in a controlled environment.*"

FAA:

- This ambient data was recorded, but not published.
- We concur that a control environment is preferable over a non-control one, but in a full-scale facility is difficult and expensive to achieve.
- In very cold days, we used controlled-heaters to maintain standard temperature.
- In our small-scale test labs, we do have controlled environments.

# Boeing Letter

## INTERMEDIATE-SCALE FIRE TEST ISSUES (CONT.)

8. BCA: "*Without a good understanding of the different variables (duct size, duct mass, crown volume, etc.) it is difficult to establish confidence in the resulting correlation. In fact, some of the limited burn area and after-burn times may not represent a non-fire-worthy material except in the specific configuration evaluated.*"

FAA:

- Significant effort was put in the test protocol to maintain consistency between tests.
- In addition, conducted ASTM D 7309-07 tests, micro-scale tests, to determine the flammability properties of the samples
- The ASTM results correlated very well with the intermediate-scale fire test results, which provided confidence

# Boeing Letter

## MICROSCALE TESTING

9. BCA: "*Results from the MSCC testing are useful to characterize the different materials. It would also be useful to have the heats of gasification for each material reported since this can provide an estimate of the burn rate for a solid at a specific heat flux.*"

FAA:

- We concur with this statement; we have in our chem-lab a differential scanning calorimetry equipment.
- During the project planning phase, the TG members did not recommend performing this activity.

# Boeing Letter

## SMOKE EVALUATION

10. BCA: "*In section 2.4, there is an analysis of the NBS smoke density results using the FAR 25.853 test method. All specimens passed, yet no correlation to the intermediate scale test results was provided.*"

FAA:

- No comments were provided on the quantity of smoke emitted by the sample ducts because there was no objective way of quantifying it during the ISF test and the polyurethane foam block smoke also contributed to the increase in smoke density.
- But subjectively, the sample ducts having high specific optical density values ($D_s$ = 199) produced significantly more smoke than the ones with low values ($D_s$ = 0.1).
- If industry feels that the FAA should revisit the smoke issue, please let us know.

# Boeing Letter

## DUCT JOINTS

11. BCA: "*The report does not include any documentation showing test results on duct joints and it is not appropriate to include duct joints in the conclusion.*"

FAA:

- One of the ducting manufacturers provided us with ducting joint material (similar to Duct Material X without the helix). So, we were able to test it. Point taken; we should not generalize on a subject with only one data point.

# Boeing Letter

## RECOMMENDED MODIFIED RADIANT PANEL TEST METHOD/REQUIREMENTS

12. BCA: "*The proposed radiant heat panel test method includes a 1-minute dwell time. Generally, this is not representative of typical in-service events involving electrical ignition sources. Although the dwell time appears to correlate to the ISF test results in this study, it only does so due to the specific duct and crown configurations used*"

FAA:

- We concur with these statements.
- We were not trying to imitate an electrical fire; our initial assumption was to have an established robust fire.
- We believe that the selected attic configuration provided a robust fire, when compared to other configurations (oxygen, fuel, heat).

# Boeing Letter

## SUMMARY

13. BCA: "*The ducting report does not clearly explain the reason for using this more stringent fire threat for evaluating ducting.*"

FAA:

- The report mentions that the same fire source used during the development of the thermo-acoustic was used in this project; a 9" x 4" x 4" polyurethane foam block spiked with 10 cc of heptane.
- The B737 attic configuration was used because this aircraft is the U.S. flying work horse.
- Yes, we agree that it is a bit more stringent since the volume is smaller than the larger structure used during the Swiss Air Flight 111 investigation/research work – *We Err On The Side Of Safety*.

# Boeing Letter

## SUMMARY (CONT.)

14. BCA: "*Without documenting the results in the wide-body configuration as well as the baseline foam block test, a full analysis cannot be completed.*"

FAA:

- The wide-body configuration evaluation was not continued, nor published, because it was recognized earlier during the project that the narrow-body attic configuration represented the worst case scenario.
- Material flammability data was also used during this project analysis phase.
- The foam block baseline data (ISF test) is available if anyone is interested in getting a copy of it.

# Boeing Letter

## SUMMARY (CONT.)

15. BCA: "*The report is deficient in detailed definition about the duct sizes and materials used for testing.*"

FAA:

- A confidentiality agreement was made between the FAA and some of the material suppliers, so a complete list, details, and photos of the materials tested could not be included in the report.

# ICCAIA Letter

## INSULATED DUCT

16. ICCAIA: "*Another aspect that needs further clarification is the case of air ducts covered with insulation material compliant with 14 CFR 25.856(a) and/or (b). All test data in the report came from tests done using air ducts without any insulation covering.*"

FAA:

- The second sentence is not correct. Duct Material AD is an insulated material and its performance was reported in the published document. There were other samples tested that were insulated, but because they were not fully tested (for 12VBB, smoke, OSU, etc.), we did not included them in the final report.
- If thermo-acoustic insulation is to be used as a fire-blocking jacket, it needs to meet 14 CFR 25.856(a) & (b) and this new test.

# ICCAIA Letter

# ICCAIA Letter

## INSULATED DUCT

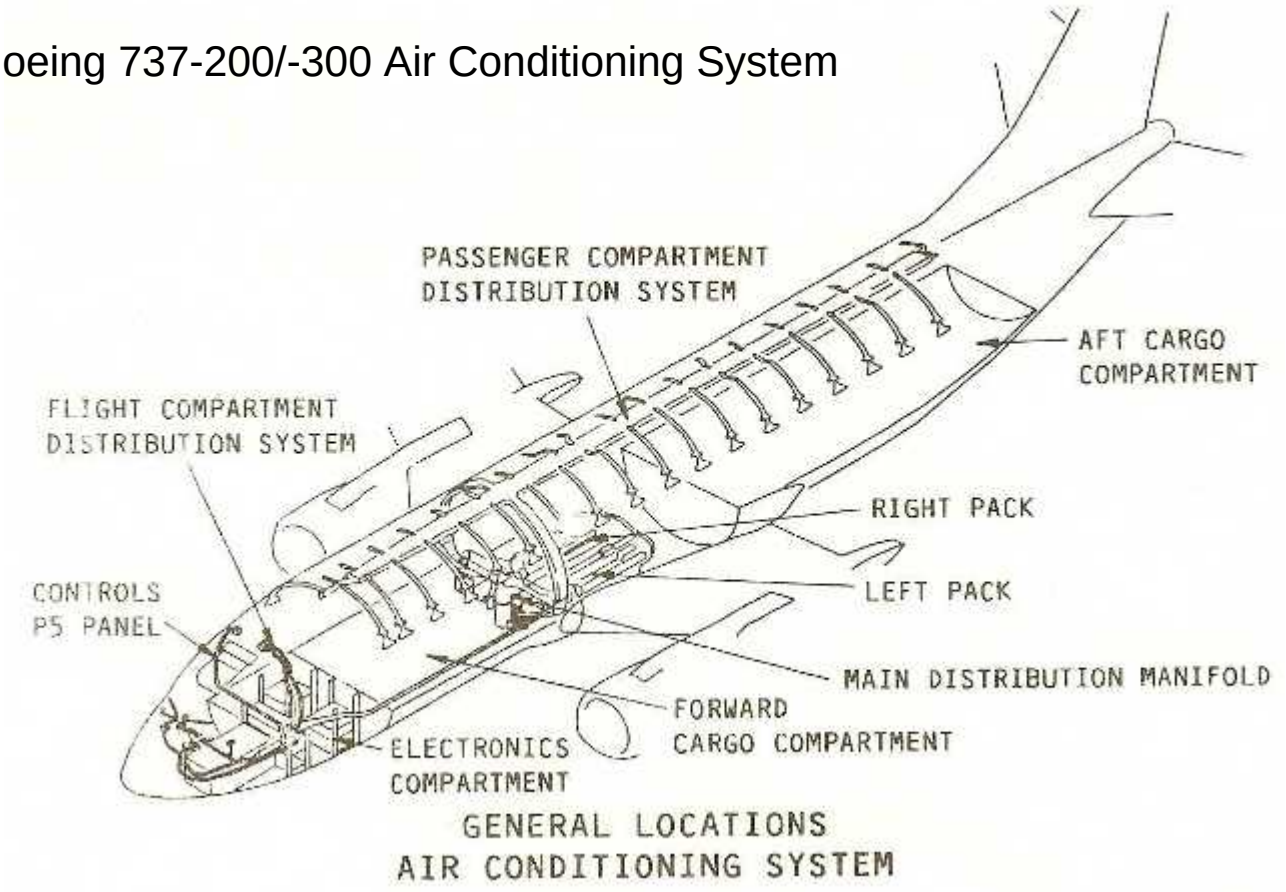
17. ICCAIA: "*Besides the scale variation observed when comparing narrow to wide-body fuselages, there are other locations where air ducts are installed, such as: risers behind sidewall panels, air ducts built into overhead stowage bins, gaspers ducts installed behind overhead stowage bins, air ducts under floor, etc. The identification of the predominant configurations/environments and their effect on fire .*"

FAA:

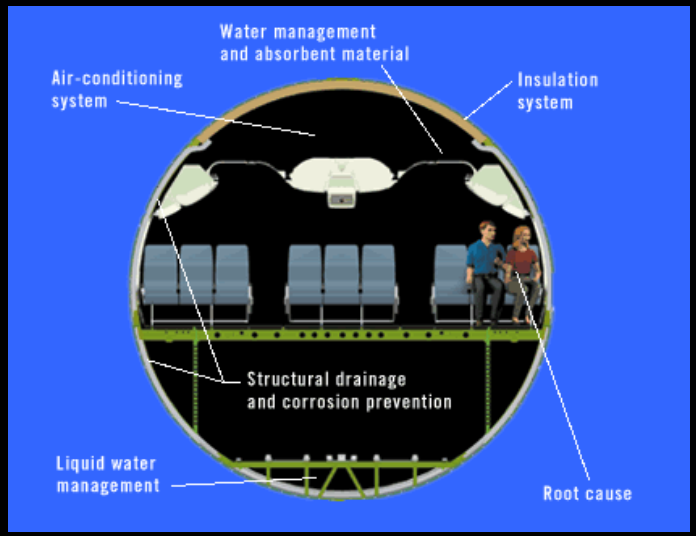
- During the planning phase of this project, we did an informal survey of our B737 and B747 aircraft to look at the air conditioning ducting installation. We selected the attic because it contained large HVAC components (plenty of fire fuel) and significant air volume to supply oxygen for the fire. The sidewalls volume were too tight and the HVAC components were smaller.

# ICCAIA Letter

Boeing 737-200/-300 Air Conditioning System



# ICCAIA Letter






# Final Comments

## FAA COMMENTS

Even though this safety improvement effort was not published with the degree of transparency and details desired by Boeing and the International Coordinating Council of Aerospace Industries Association, we are very confident that this developed test method for aircraft ducting provides a significant enhancement in aviation safety when compared to our currently used certification test method – the 12 seconds Vertical Bunsen Burner Test.


Fiberglass/Epoxy/Polyisocyanurate foam core