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Mr. J. Wildey, RE-30
National Transportation Safety Board
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Subject: Sequence Report Analysis, TWA 747-100 N93119, Accident off Long Island, NY – 17 July 1996

Reference: Metallurgy/Structures Sequencing Report No 97-38, dated April 8,1997 in support of TWA Flight 800 accident investigation.

Dear Mr. Wildey:

In your recent telecon with the Boeing Sequence Group team members, you noted that Appendix E to the Sequence Report states that Boeing was continuing to analyze various aspects of the sequence team findings. You requested a report on that analysis.

Background

As described in Appendix E: Boeing Supporting Data of the reference report, "Both concurrent with and subsequent to the determinations of the Sequence Group, Boeing conducted separate analyses in the Seattle area to address various steps of the documented breakup sequence. This work was done with the intent of providing assurance that the sequence, as determined from the wreckage evaluation on site, would in fact be rational from the perspective of a much more rigorous analytical assessment of airplane loads, stresses, and predicted structural behavior." The Appendix went on to state "The analysis work is still ongoing and further tasks may possibly be defined as a result of the latest efforts by the Group". And later in the Appendix it was stated, "Examples of areas of ongoing analysis are the forward keel beam separation and fracture propagation in the fuselage lower lobe".

The purpose of this transmittal is to address the Boeing analysis performed in direct support of the Sequence Group findings, and conducted subsequent to release of the reference report. Therefore, the specific Boeing analyses already discussed in Appendix E will not be addressed again. It is important to note that subsequent Boeing analysis did not change any of the analysis

conclusions summarized in Appendix E in April 1997 when the report was released.

Discussion

The Boeing computer analysis, described in the Appendix and performed in direct support of the Sequence Group findings, was essentially completed by mid 1997. Two discrete aspects of the documented breakup sequence were the primary focus of these activities; failure propagation in the fuselage lower lobe, and failure of the keel beam. Additional analysis was done to understand the damage observed in the middle part of SWB 2 as it could possibly relate to keel beam separation. In each analysis case the computer model was configured and loaded to replicate the conditions of the documented breakup sequence just preceding the failure event under investigation. Then an attempt was made to determine if the model would predict the latter failure event.

With regard to the failure propagation in the fuselage lower lobe, the analysis was inconclusive in terms of being able to fully predict a failure replicating the documented event, which resulted in the separation of fuselage lower lobe structure, primarily piece LF6A and directly associated pieces. As stated in Appendix E, a failure of the lower lobe skin at either LBL 66 or RBL 66 would be predicted following the documented failure of the front spar bulkhead. From either of those locations (RBL 66 as documented), lower lobe failure propagation forward and then inward (towards the access hole at B.L. 0) at approximately a 30 degree angle would be expected, consistent with the predicted orientation of principal stress in the skin panel. The calculated critical cabin pressure differential for crack propagation was 7.4 psi. The latter would equate to approximately 3.4 psi required overpressure in addition to the basic 4 psi assumed to be representative of the altitude of Flight 800 at the time of the event. Boeing methods are not suited to predicting the actual complete dynamic crack propagation path (i.e. basically completing the failure on the left side of LF6A to link up with the front spar bulkhead at LBL 66).

To evaluate the keel beam failure, the model was configured to replicate the preceding failure of SWB 3, the Front Spar bulkhead, and the fuselage lower lobe. The model was loaded with the assumed 25 psi overpressure in the CWT area and 4 psi differential cabin pressure on the fuselage lower lobe piece which includes keel beam extensions. The above pressure loadings were previously discussed in Appendix E. The analysis predicted an initial bending failure of the keel beam between the midspar and SWB 1 consistent with the documented failure location. Subsequent to such a failure, the forward keel beam along with attached lower lobe (LF6A and associated pieces) would have moved downward projecting into the airstream. Analysis then indicated that a failure of the keel beam extension joint just ahead of the

front spar bulkhead would be a rational next occurrence (resulting in the complete separation of LF6A and associated pieces).

Subsequent analysis also focused on the expected effects of keel beam separation on the keel beam interface with SWB 2 and the failures observed in the middle portion of SWB 2 which contributed to the relatively early separation of the manufacturing access door. In Section 4.9 of the reference document, these failures were discussed in detail and described as consistent with "either a large downward load imparted by the keel beam tension bolts or overpressure acting approximately in equal amounts in the bays ahead of and behind SWB 2". Analysis of the latter hypothesized overpressure scenario was unable to predict the observed failure modes within SWB 2 and at the keel beam attachments. However, the analysis of keel beam separation and expected effects on SWB 2, indicated that this was the most likely cause of the damage to the middle portion of the beam, including the SWB 2 web attachments to the inboard and lower sides of the manufacturing access door.

Conclusions

When the reference document was released, the Summary of Appendix E stated "As of the time of inclusion of this appendix (April 8, 1997) the analysis has uncovered nothing to refute the basic findings of the Sequence Group." The Boeing analyses conducted subsequent to April 1997 did not change the earlier observation.

If you have any questions, please do not hesitate to call.

Very truly yours,

for

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