Boeing Commercial Airplane Group
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July 19, 1995
B-U01B-15315-AS1

BY FACSIMILE: (202) 382-6576

Mr. Thomas Haueter, AS-10
National Transportation Safety Board
490 L'Enfant Plaza SW
Washington D.C. 20594

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Subject: Wake Vortex Effect on Vertical Fin - USAir 737-300 N513AU Accident Near Pittsburgh - September 8, 1994

Reference: Your letter to Rick Howes, May 9, 1995

Dear Mr. Haueter:

In the reference letter you asked for Boeing's analysis of the tangential velocities needed in a wake vortex to cause structural damage to the vertical fin and rudder to support the subject investigation.

The analysis of an assumed theoretical "worst case" wake vortex impingement from the Delta 727 on a 737-300 vertical tail has been completed by Boeing. In this analysis the assumption is made that the 737 is flying parallel to the centerline of the vortex, at an airplane speed of 190 knots, with the vertical tail projecting through the vortex centerline. The anaylsis assumes the worst case wake vortex definition, with the centerline of the vortex positioned at the most critical spanwise location on the vertical tail. The results of this analysis in comparison with the ultimate design loads of the 737-300 vertical tail are shown in Figure 1, enclosed. In this figure, Vy is the lateral shear, Mx is the lateral bending moment, and Mz is the torsion about the vertical tail. Eta is the distance from the base of the vertical tail divided by the height of the vertical tail. The equivalent tangential velocity at the most critical spanwise location is 191 ft/sec, with a vortex circulation of 2400 ft^2/sec, and a vortex radius of 2 feet. As a result, the tangential velocity that would be needed to cause damage to the vertical tail would be significantly higher than what the worst case wake vortex could produce.

You also asked for the maximum forces on the fin that would be produced by a full rudder input at an airspeed of 190 knots. At the moment the rudder reaches blowdown, the vertical tail load is 75 percent of the limit load. If the rudder is held until the airplane reaches maximum overyaw angle (overshoot beyond steady-state side slip), the vertical tail loads reaches approximately 100 percent of limit load which is a load that would cause permanent set or yeilding in the structure. Boeing designs structure to break at a minimum of 1.5 times the limit load which is equivalent to the ultimate load.

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If you have any questions, please contact me.

Very truly yours,

FLIGHT TEST

[redacted]

John W. Purvis
Director, Air Safety Investigation
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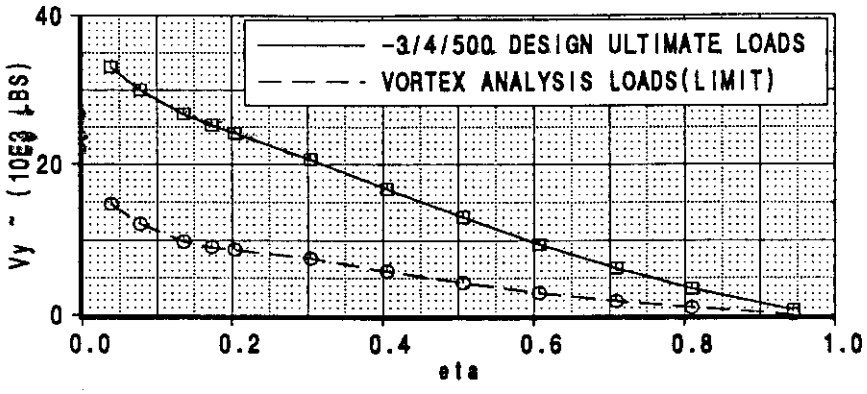
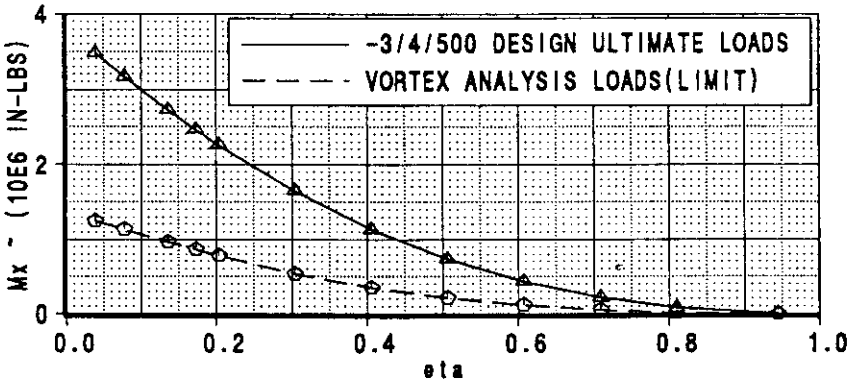
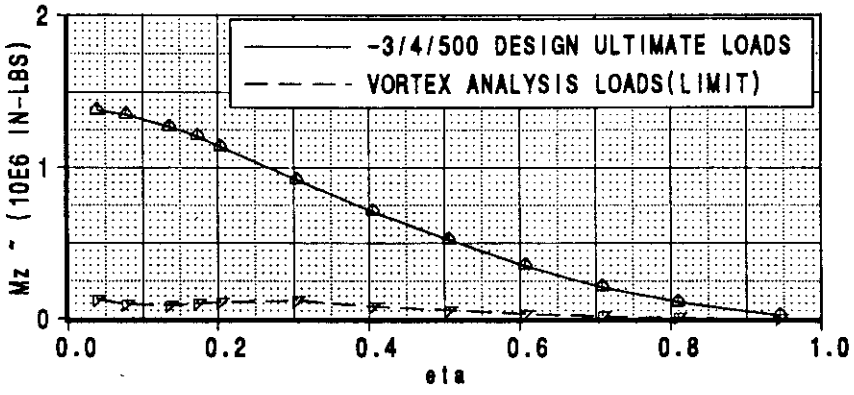
[redacted]

Enclosure: Boeing load charts, *Vortex Impingement on 737-300 Vertical Tail,* July 13, 1995







BASED ON WORST CASE POTENTIAL VORTEX VELOCITY PROFILE AT MOST CRITICAL LOCATION ON THE VERTICAL TAIL.
WORST CASE: Γ = 2400 FT^2/SEC
r_c = 2 FT.

CALC	NEIL PARKER	13Jul95	REVISED	DATE	VORTEX IMPINGEMENT ON 737-300 VERTICAL TAIL	
CHECK						FIGURE 1.0
APPD.						
APPD.					BOEING	PAGE