National Transportation Safety Board
Office of Aviation Safety
Washington, DC 20594

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STRUCTURES

Structures Group Chair's Factual Report - Addendum

December 8, 2023

A ACCIDENT

Location: Hurricane, Utah
Date: December 10, 2015
Time: 1347 Mountain Standard Time (MST)
2047 Coordinated Universal Time (UTC)
Airplane: Van's Aircraft, Inc. RV-7

B STRUCTURES GROUP

Group Chair Clinton R. Crookshanks
National Transportation Safety Board
Aurora, Colorado

C DETAILS OF THE INVESTIGATION

The following paragraph supplements the information contained in the original Structure's Group Chairman's Factual Report in the public docket, Section D, 1.1. The information was developed by examining photos from the on-scene investigation.

The vertical stabilizer separated from the airplane during the accident sequence and had the upper portion of the rudder attached (Figure 1). The vertical stabilizer was mostly intact with little damage. The composite tip cap remained partially attached to the upper end. The forward spar was fractured just above its attachment to the horizontal stabilizer front spar. The rear spar was fractured and twisted just above the stabilizer shelf consistent with the vertical stabilizer separating leading edge left. Most of the upper half of the rudder remained attached at the upper and center hinge points. The rudder trailing edge was splayed open, and the trailing edge strip remained attached to the left rudder skin. There was evidence of sealant between the rudder skins and trailing edge strip. The rudder was fractured spanwise just below the center hinge. The rudder counterweight was separated from the upper end of the rudder just above the upper skin stiffeners (Figure 2). The lower half of the rudder remained attached to the empennage and both rudder cables were attached. The trailing edge was splayed open, the trailing edge strip remained attached to the left rudder skin, and there was evidence of sealant between the rudder skins and trailing edge strip.

Figure 1. Separated vertical stabilizer and upper rudder (NTSB photo)


Figure 2. Separated rudder counterweight (NTSB photo)

The following two sections should be added to the original Structure's Group Chairman's Factual Report, Section D.

2.0 Van's Flutter Analysis

Van's contracted with an outside company to have a flutter analysis performed for the RV-8 airplane. The analysis was completed in October 1998. The company performed a ground vibration test (GVT) on a RV-8 airplane at the Van's factory in the zero fuel and full fuel configurations to establish the natural modes of vibration for the airplane. This information was used to perform a flutter analysis at a simulated altitude of 10,000 ft up to V_d of 256 mph or 220 kts. The results of the analysis showed the RV-8 airplane to be free from flutter above the design envelope with the control surface balance weights provided by Van's.

Since the RV-7 airplane is a derivative of the RV-8 with a wider cabin, the results of the RV-8 flutter analysis were used for the RV-7. The RV-7 flutter analysis was completed by the same company in April 2001. A GVT was performed on the RV-7 airplane with zero fuel to evaluate the changes in vibration modes. The GVT showed that the wing vibration modes differed enough to require a flutter analysis while the tail modes were essentially the same. The analysis concluded that the RV-7 wing was free of flutter to speeds well above the dive speed of the airplane. The tail flutter analysis results from the RV-8 were applicable to the RV-7.

According to Van's, the rudder used on the RV-7 airplane was sized to meet the spin recovery requirements in the Part 23 regulations. The GVT conducted for the RV-7 airplane shows the first flutter mode that manifests itself with increasing airspeed is a fuselage side bending vibration mode that couples with a rudder flutter mode. The rudder damping for this mode is dependent on the density of the air flowing over the rudder and thus is dependent on the true airspeed of the airplane. The tests took into account changes in the rudder counterbalance mass. The tests showed the existing rudder counterbalance mass was sufficient to account for variations in paint and the addition of a taillight to the rudder. The GVTs and flutter analyses performed showed that the airplanes are free of flutter beyond the design never exceed speed. Van's also showed the airplanes to be free of flutter up to the design demonstrated dive speed for each of the models. Van's noted that the rudders analyzed and tested were built according to the design and did not incorporate any additions such as servo controlled trim tabs.

Also according to Van's, the GVTs showed that at even higher airspeeds flutter modes involving wing symmetric bending, aileron rotation, and horizontal stabilizer bending and torsion manifest themselves. The tests took into account changes in the fuel load on the airplane. The analysis indicated that these modes may interact with each other to exacerbate the response. Based on flight testing, GVT results, and flutter analyses, Van's concluded that the airplanes meet the requirements in Part 23 regulations and are free from flutter as designed and built when operated within the prescribed flight envelope.

3.0 Flutter

Flutter is an aeroelastic phenomenon that can occur when an airplane’s natural mode of structural vibration couples with the aerodynamic forces to produce a rapid periodic motion, oscillation, or vibration. Flutter can be somewhat stable if the natural damping of the structure prevents an increase in the forces and motions. Flutter can become dynamically unstable if the damping is not adequate or speed is increased, resulting in increasing self-excited destructive forces being applied to the structure. Flutter can range from an annoying buzz of a flight control or aerodynamic surface to a violent destructive failure of the structure in a very short period of time. Due to the high frequency of oscillation, even when flutter is on the verge of becoming catastrophic, it can still be very hard to detect. Aircraft speed, structural stiffness, and mass distribution are three inputs that govern flutter. An increase in airspeed, a reduction in structural stiffness, or a change in mass distribution can increase the susceptibility to flutter.

Submitted by:

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