NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

September 12, 2012

MATERIALS LABORATORY FACTUAL REPORT Report No. 12-058

A. ACCIDENT INFORMATION

Place	:	Surprise, Arizona
Date	:	December 10, 2011
Vehicle	:	Vans RV7-A
NTSB No.	:	WPR12FA059
Investigator	:	Michael Huhn

B. COMPONENTS EXAMINED

Elevator trim actuator and control rod with clevis ends

C. DETAILS OF THE EXAMINATION

The elevator trim actuator and associated control rod from the accident aircraft was submitted to the Materials Laboratory to determine the cause of failure of a clevis at one end of the control rod and confirm if the failed clevis was fabricated from the specified material. An overall picture of the actuator and control rod can be seen in Figure 1.

The control rod had completely separated from the main body of actuator at the clevis as shown in Figure 2. The clevis was specified to be injected-molded, glass-filled polyamide. The fracture surfaces from both pieces of the clevis were visually examined using a 5x to 50x stereo zoom microscope and a scanning electron microscope (SEM). Under the stereomicroscope, the fracture surface exhibited hackle and river pattern as shown in Figure 3. SEM micrographs of the fracture surface of the polymer matrix showed fracture features with rough and uneven surfaces, isolated peaks and dimples as shown in Figure 4. The micrograph also exhibited “cup and cone” features on the ends of the fractured glass fibers. All of these fracture features are consistent with overstress. The fracture features are consistent with the fractured rod loaded in cantilever bending from the inside clevis slot toward the outside.

The failed clevis was x-rayed to determine the orientation of the glass fibers. The radiograph of the clevis is shown in Figure 5. The radiograph showed that the glass fibers uniformly distributed with proper orientation in the region of the fractured arm. No other anomalies such as porosity were noted in the radiograph.

To determine if the composition of the matrix polymer of the failed clevis was the specified material, a small shaving was removed from the failed clevis. The sample was

examined using a Fourier Transform Infrared (FTIR) micro-spectrometer with a germanium attenuated total reflectance (ATR) accessory[1] in accordance to ASTM E1252-98 and ASTM E334-01[2]. The spectrometer was used to collect and process infrared wavelength absorbance spectra of the sample[3]. The spectrum obtained from the sample suggested that the material was an organic amine. This was evidenced by the presence of strong characteristic carbon-hydrogen bonding peaks between ~3000 $cm^{-1}$and ~2800 cm^{-1} as well as a group of peaks between 1700 and 1300 $cm^{-1.}$ A small peak at ~3600 cm^{-1} and a strong peak at ~3300 cm^{-1} were indicative of an amine N-H bond present in the chemical structure of the material. Additionally, the scan contained strong peaks in the fingerprint region, below ~1400 cm^{-1}, particularly with a strong peak at ~1050 cm^{-1} indicative of strong carbon-nitrogen bonds. A search of spectral libraries of known substances found a very strong match to the spectrum for mineral-filled polyamide. A visual confirmation of the sample spectrum compared to the library spectrum was made. Therefore, it was determined that the material from the actuator arm attachment was a glass-filled polyamide as specified by the manufacturer.

Nancy B. McAtee
Chemist

[1] An IR spectrum is created when a molecule converts infrared radiation into molecular vibrations. There are two types of molecular vibrations: stretching and bending. These vibrational movements create bands in a spectrum that occur at specific wavelengths (cm^{-1}). Each wavelength is dependent on a number of factors including the mass of the atoms present, the force constants of the bonds present, and the geometry of the molecule present. Infrared spectra can help in identifying the chemical composition and/or bonding present in an unknown molecule. The spectrometer emits a broad band of infrared light through the specimen. Depending on the bonding present, the light will be absorbed, transmitted, or reflected at various wavelengths. From the spectrum produced, information about the bonding present is obtained from the location of group frequency peaks. Most spectra contain additional “fingerprint” peaks that are unique to a particular molecular structure. All molecules have a unique spectrum in IR.

[2] American Society for Testing Materials E1252-98: Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis and American Society for Testing Materials E334-01:Standard Practice for General Techniques for Infrared Microanalysis.

[3] The samples from this aircraft were analyzed using the reflective mode. In reflective mode, the infrared beam is passed through the sample and then reflected off of a reflective IR plate and passed back through the sample where it is detected and analyzed.

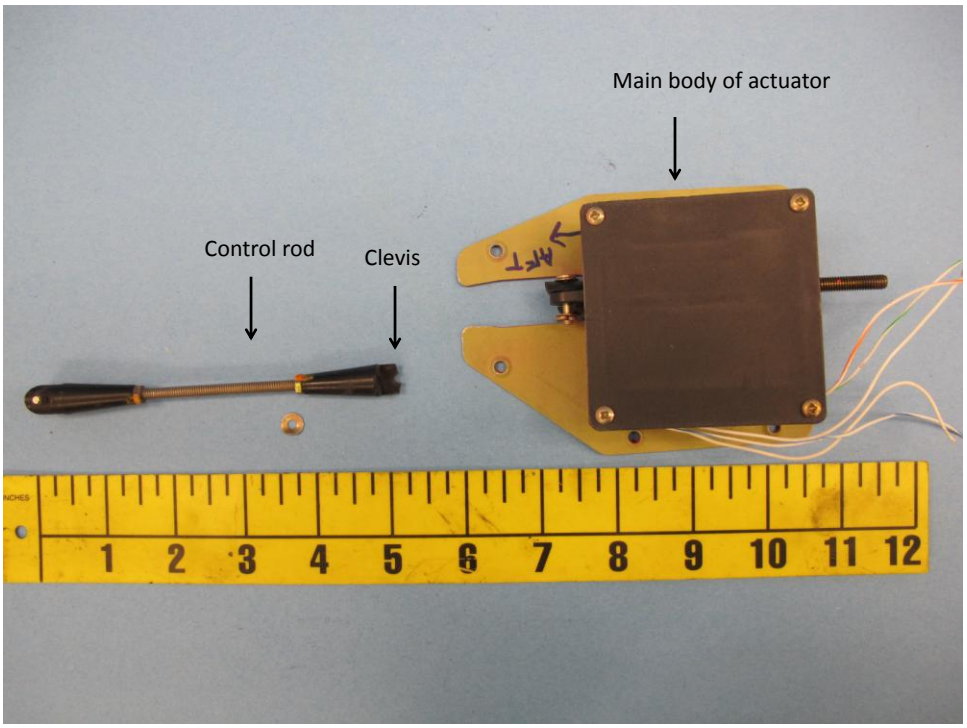

Figure 1. Overall photograph of elevator actuator.

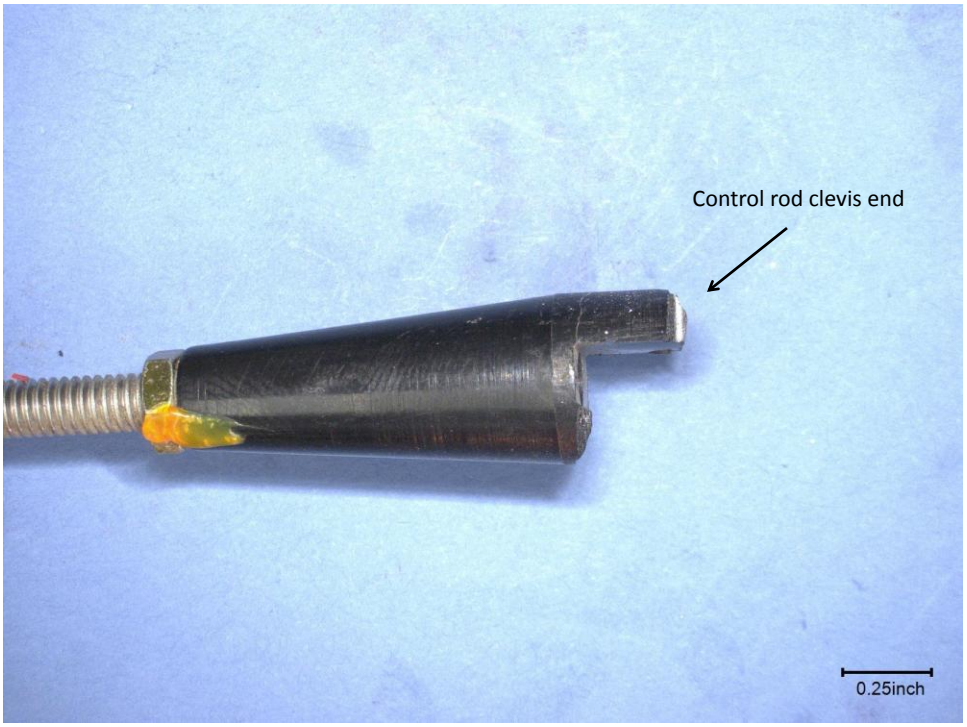

Figure 2. Close-up photograph of clevis.

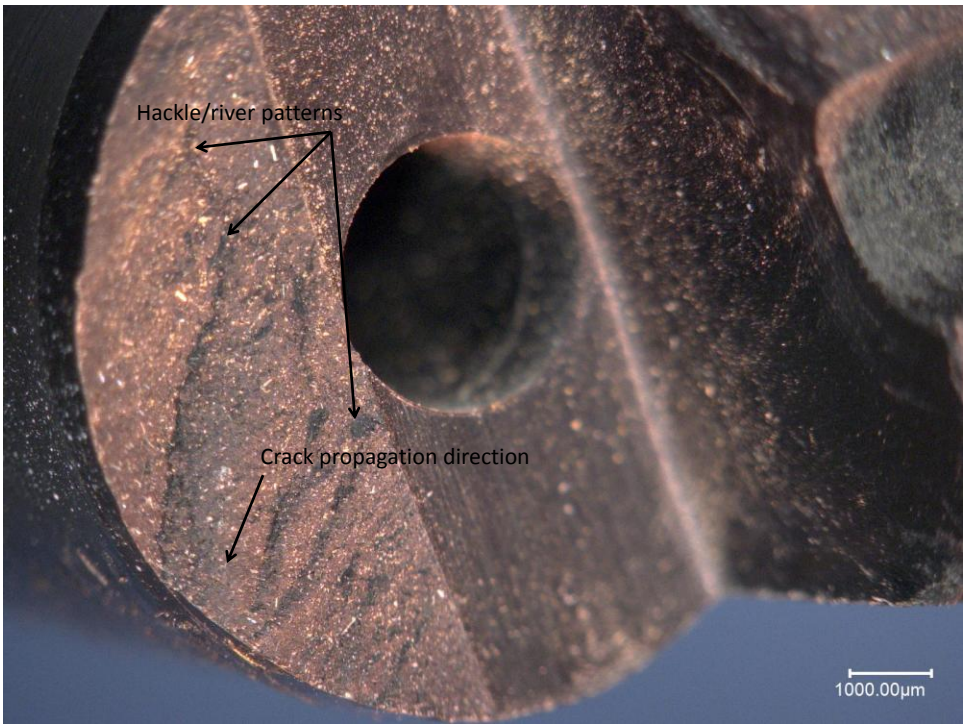

Figure 3. Overstress features on fracture surface.

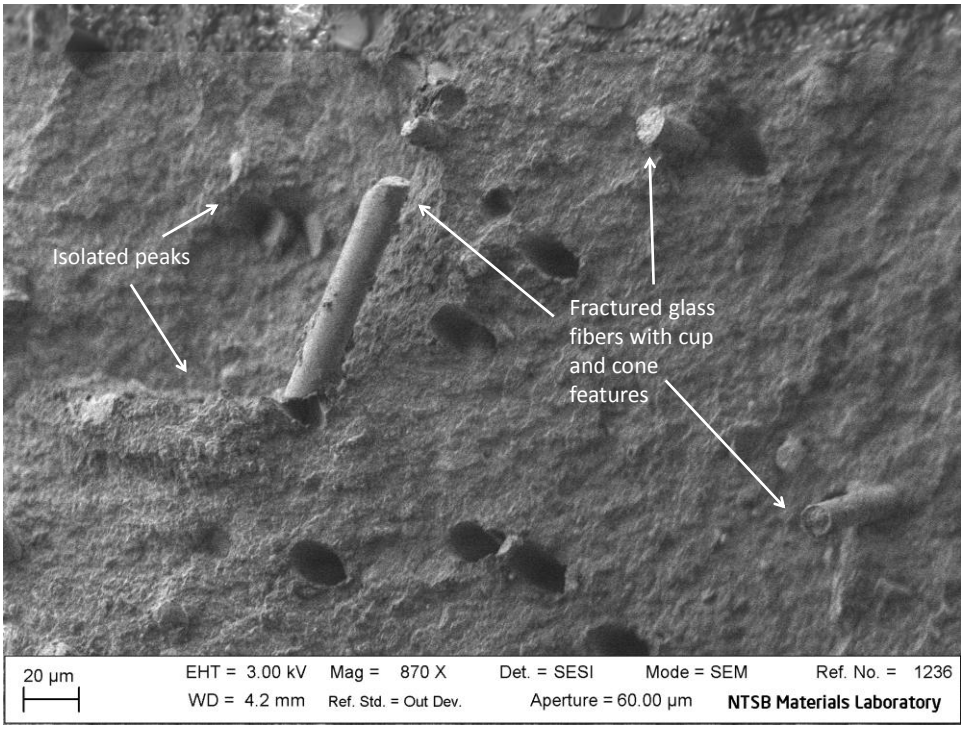

Figure 4. Micrograph of fracture surface exhibiting overstress related features.

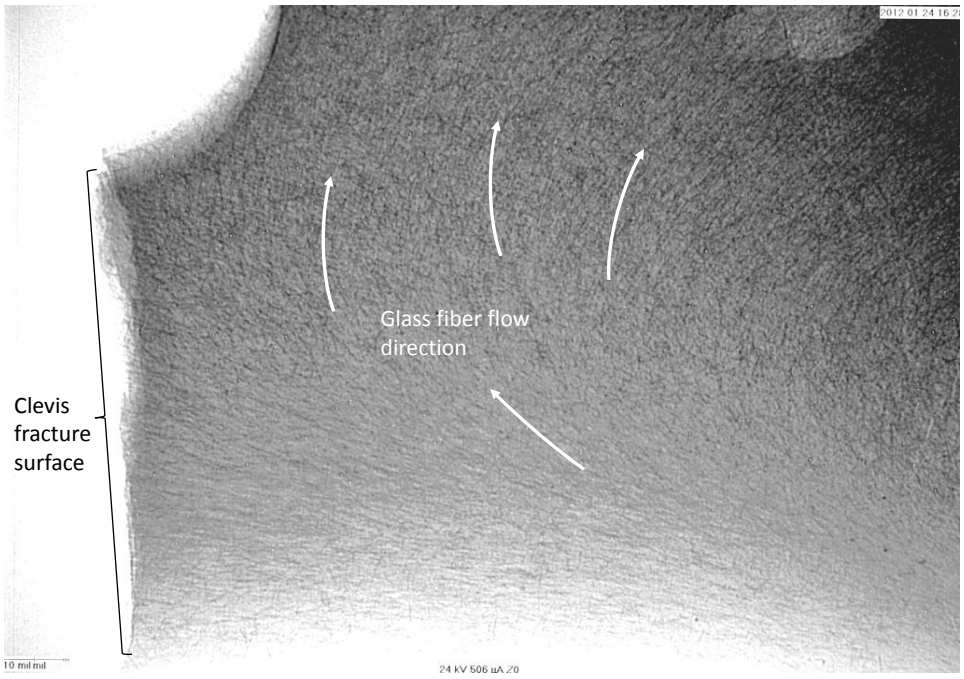

Figure 5. Radiograph of fractured clevis.