NATIONAL TRANSPORTATION SAFETY BOARD

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

August 21, 2015

MATERIALS LABORATORY FACTUAL REPORT Report No. 15-085

1. ACCIDENT

Place	:	Marco Island, Florida
Date	:	March 1, 2015
Vehicle	:	Canadair CL-600-2A12, N600NP
NTSB No.	:	ERA15LA140
Investigator	:	Tim Monville, AS-ERA

2. COMPONENTS EXAMINED

Pieces of power brake spring

3. DETAILS OF THE EXAMINATION

On March 1, 2015, about 1615 eastern standard time, a Bombardier CL-600-2A12, registered to and operated by Six Hundred NP, LLC, experienced a landing overrun and subsequent collapse of the nose landing gear at the Marco Island Airport (MKY), Marco Island, Florida. The airplane sustained substantial damage. According to the pilot, when the nose landing gear contacted the runway, he applied "moderate" brakes but there was no deceleration. The pilot attempted to deploy the thrust reversers but was unable to do so. Unable to stop the airplane, he added right rudder input causing the airplane to veer to the right. The airplane went off the end of the runway into sand causing the nose landing gear to collapse.

During the on-scene investigation, one of the brake springs was found fractured. This part, along with a fluid sample, was sent to the NTSB Materials Laboratory. Figure 1 and Figure 2 show the fractured power brake spring, as received. The spring had fractured at the fourth turn (from the left side, as depicted in Figure 1). The orientation of the fracture surface was generally angled parallel to the spring longitudinal direction, as opposed to a transverse orientation akin to a cross-section (the spring compression direction). For the purposes of this report, the mating fracture halves were identified as belonging to the shorter or longer spring fragment.

The mating fracture surfaces of the spring are highlighted in Figures 3 through 6. The fracture surface generally exhibited a curved, angled morphology that rotated around the spring (see Figure 4). The fracture surface generally was rough in appearance, with a dull, non-reflective luster.

There was a portion of the fracture surface that was generally smoother and flatter, positioned on the inside surface of the spring. This portion of the fracture surface was most evident in Figure 6. Both mating halves of the fracture surface contained this flatter, reflective region.

The fracture surfaces of both mating halves of the spring were examined in a scanning electron microscope (SEM). The portions of the fracture surface that were visually rougher and duller contained dimple rupture features consistent with tensile overstress (see Figure 7). These ruptured dimples were generally rounded and equiaxed in shape, indicative of little to no shear or torsional component.

Extensive examination of the flatter regions of the fracture surface revealed long sharp streaks consistent with smearing damage. As this was present on both mating fracture faces, the smearing was deemed consistent with post-fracture rubbing between the two spring fragments. Within these smeared regions, some isolated areas were found with relatively less damage; one of these regions exhibited features consistent with dimple rupture.

The inner surface of the spring exhibited a flat smoother area, suggestive of a witness mark from contact with an adjacent component (Figure 5). This inner witness mark was collocated along the flatter smeared portions of the mating fracture surfaces (Figure 4). There was also a similar but less pronounced mark on the outside surface of the spring (Figure 3).

The larger spring fragment was sectioned adjacent to the fracture surface. This cross-sectioned portion was mounted in a direction normal to the running direction of the spring, and the sample was polished and etched. A representative portion of the spring microstructure is illustrated in Figure 8. This microstructure was consistent with tempered martensite, with isolated second-phase precipitates.

The chemical composition was inspected using energy dispersive x-ray spectroscopy (EDS). The spring composition was consistent with a 17-7 precipitation-hardened stainless steel, the prescribed material for the spring. The microstructure of spring was consistent with one typical for this material.

Microindentation hardness measurements were taken across the mounted spring cross-section to determine if there was a change in internal hardness. The microindentation hardness was performed per ASTM E384.[1] No appreciable change in hardness was found in different areas examined in the spring cross-section. The hardness averaged 55 HRC (605 HV_{500}). There was no prescribed hardness requirement on the part drawing.

Erik Mueller
Materials Research Engineer

[1] ASTM E384 – *Standard Test Method for Knoop and Vickers Hardness of Materials*. ASTM International, West Conshohocken, PA

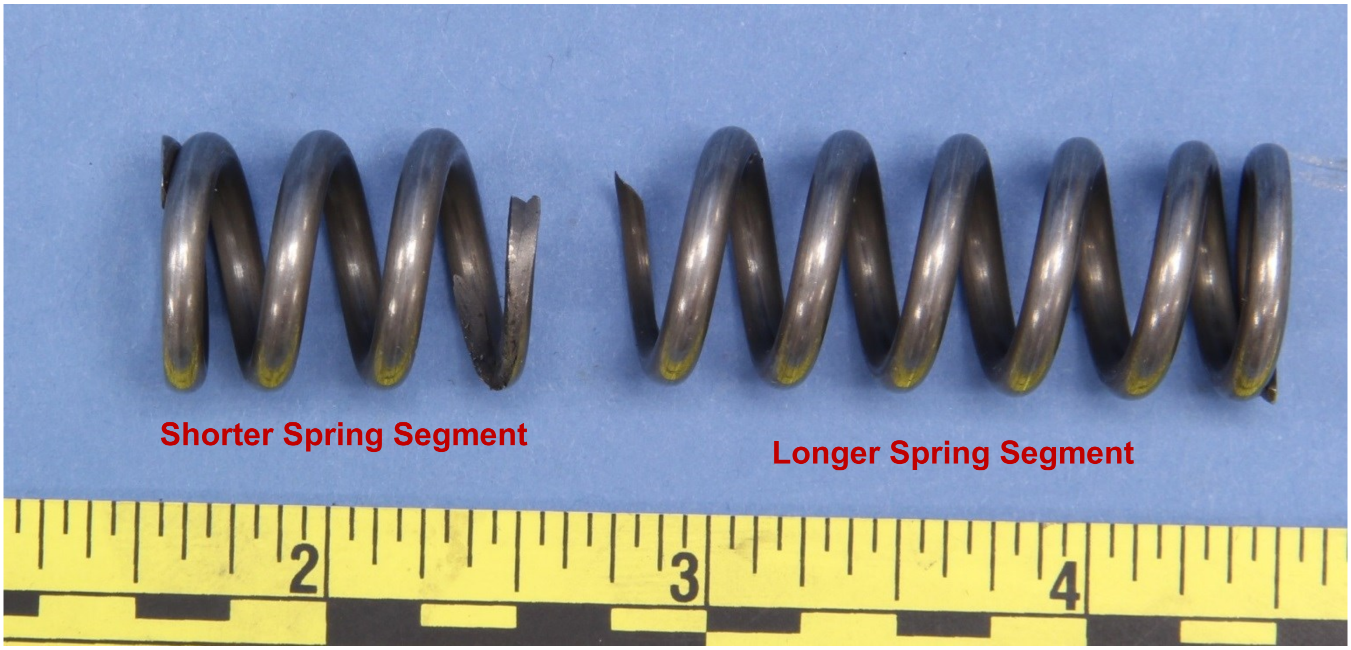

Figure 1 – The fractured power brake spring, as received.

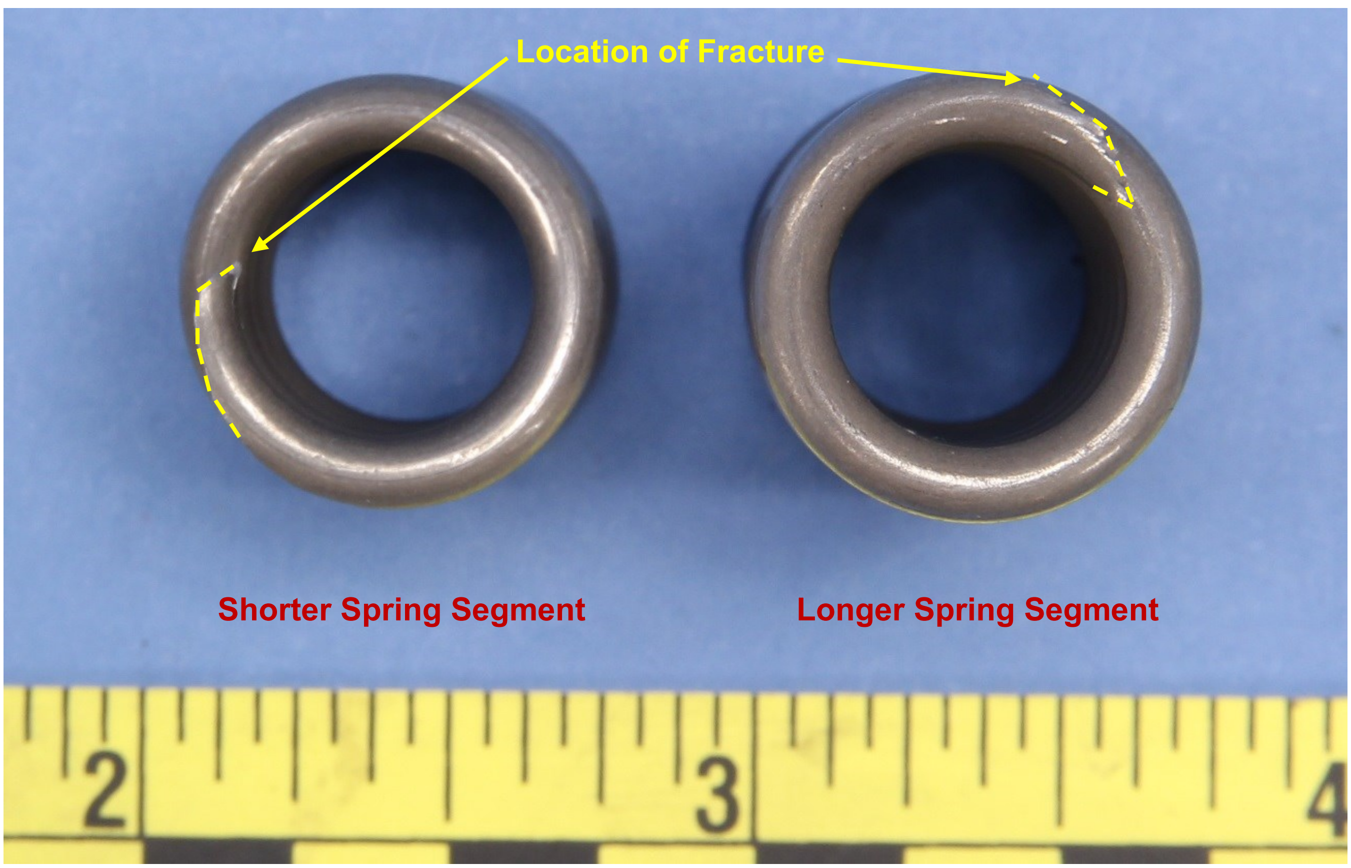

Figure 2 – The fractured power brake spring, as viewed from the fractured sides.

Figure 3 – The shorter spring fragment, showing the fracture surface, towards the right.

Figure 4 – Closer view of the shorter spring fragment fracture surface.

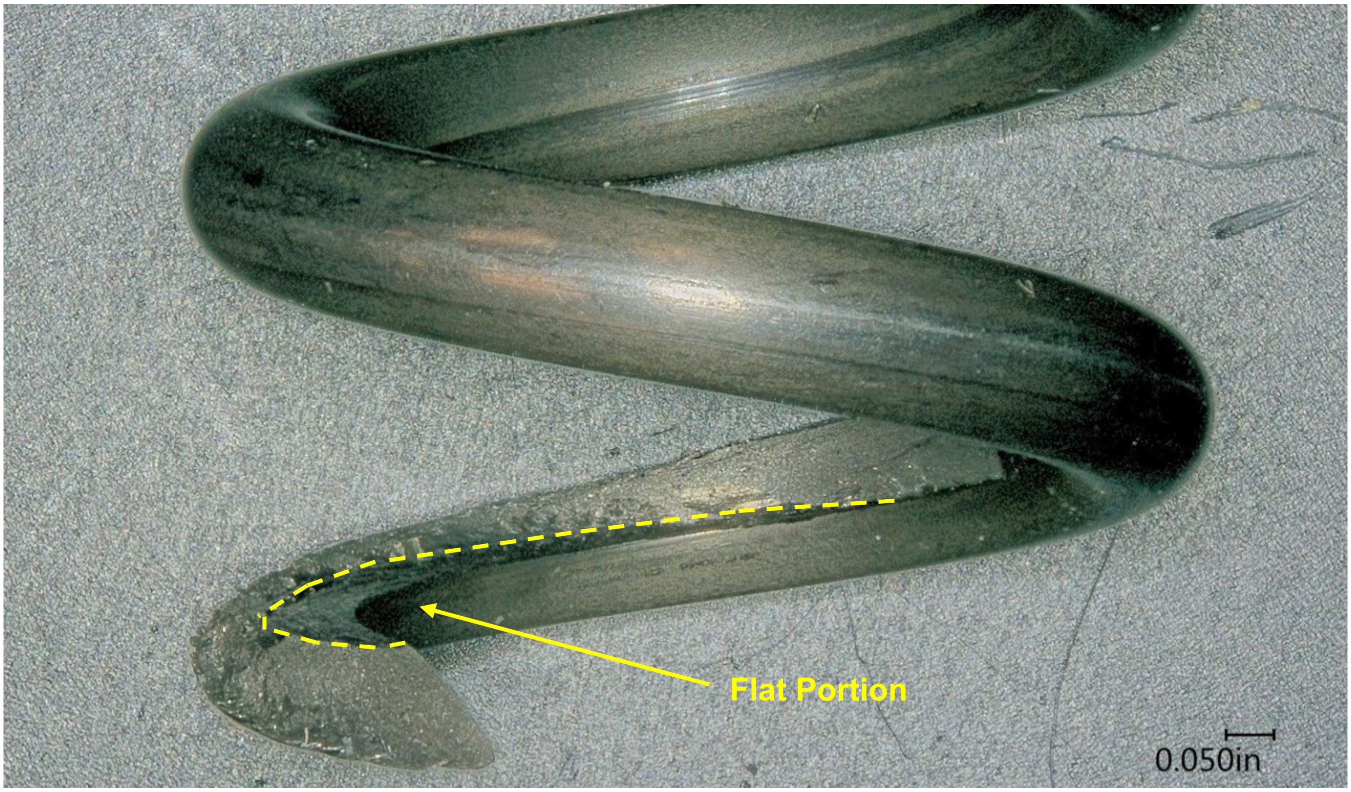

Figure 5 – The fracture surface of the longer spring fragment.

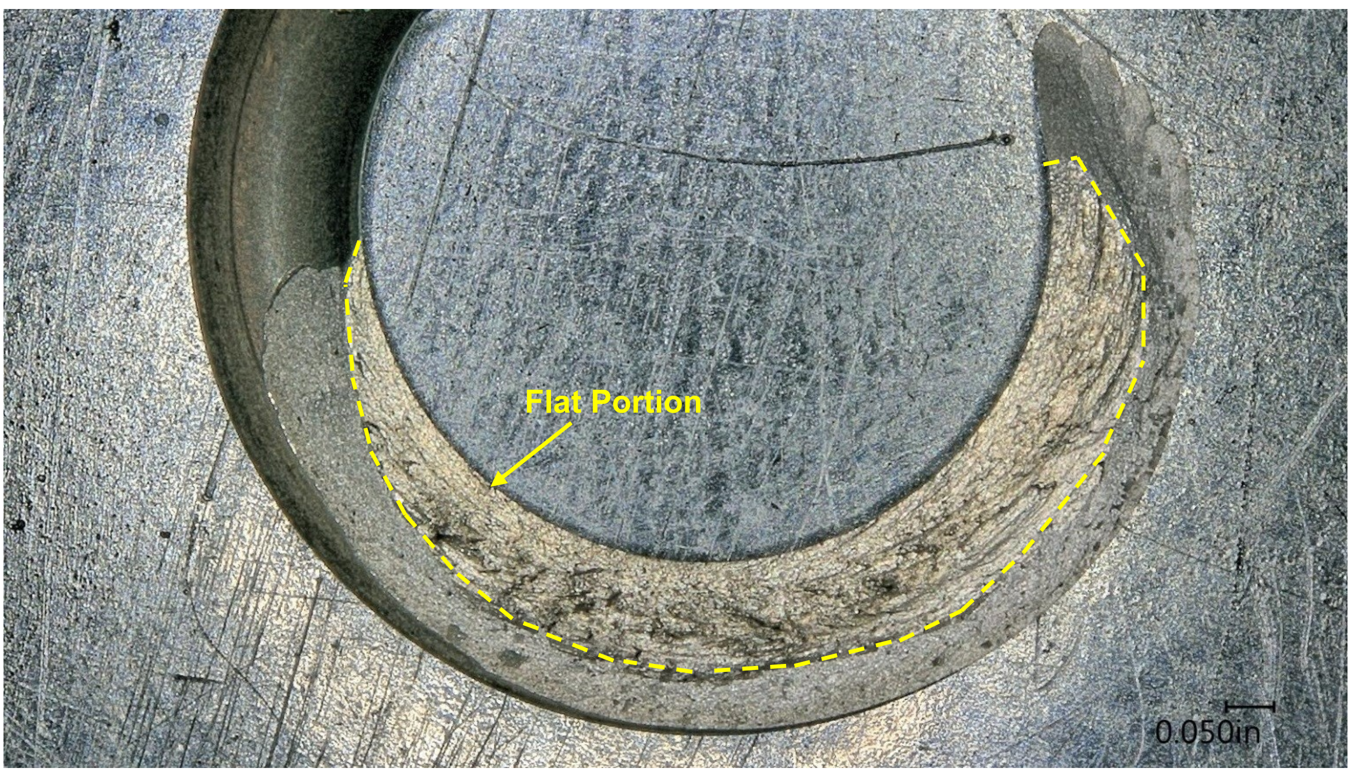

Figure 6 – The longer spring fragment fracture surface, after sectioning from the rest of the spring fragment.

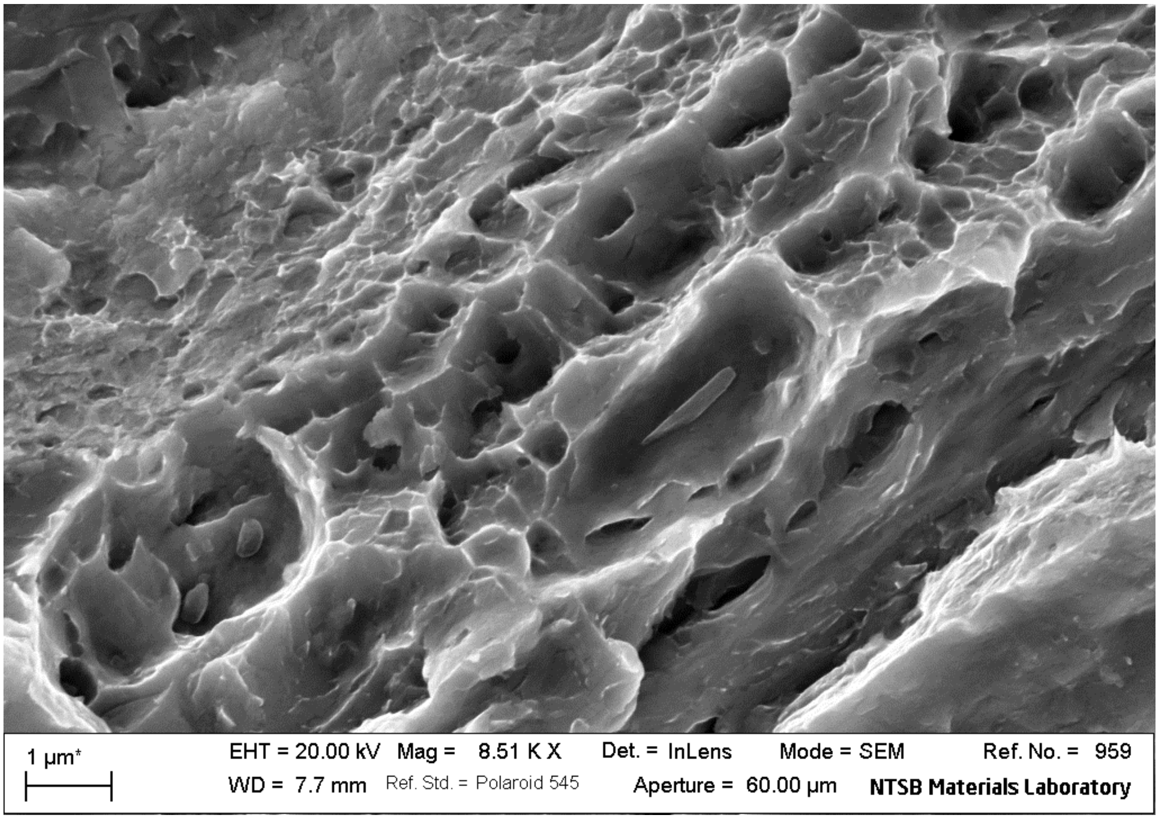

Figure 7 – Secondary electron (SE) micrograph of an undamaged region of the longer segment fracture surface, showing dimple rupture indicative of tensile overstress.

Figure 8 – Optical metallograph of the transverse microstructure of the spring near the fracture surface, consistent with tempered martensite (~500X, etched with Fry's Reagent).