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Aircraft Brake Dust Dispersion (Airwash) Testing

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Abstract

Prior industrial hygiene research involving wheel brake changing on a light general aviation aircraft has shown negligible potential for asbestos fiber exposure to mechanics that perform such work. This is despite the use of organic-style brake friction pads that contained asbestos. It has been otherwise established that chrysotile asbestos is largely degraded to a non-crystalline, amorphous substance by the heat and mechanical shear forces inherent to the braking process. However, trace (<1.0%) quantities of chrysotile have been found in brake wear dust. Disc-style brakes, the types used on aircraft, are of open design, such that wear dust is typically dispersed into the ambient air during and after brake application. For fixed-gear aircraft, the brake assemblies are also subject to substantial air velocities while the aircraft is in flight. This research was undertaken to measure and characterize the airflows experienced by aircraft wheel assemblies during takeoff, cruise, and landing maneuvers. No wear (brake) dust was observed at any point during the study.

Keywords

Aircraft, Brakes, Asbestos, Airwash

1. Introduction

Asbestos-containing materials have been used in a variety of components in small aircraft and, in the past, were commonly a part of friction brake systems. The presence of asbestos in the workplace and the potential for fibers to be liberated during the servicing of vehicles have given rise to allegations of increased rates of asbestos-related diseases among mechanics [1] [2]. Despite these concerns, epidemiological studies attempting to characterize the risk of lung cancer

and mesothelioma within automobile mechanics report no increased risk of asbestos-related diseases [3]-[9]. However, the debate continues regarding the deleterious effects of exposure to asbestos fibers in automotive mechanics and other occupations that perform maintenance on asbestos-containing materials, such as aircraft mechanics.

Currently, there is only one article that characterizes the airborne asbestos fiber levels that mechanics may encounter while performing maintenance activities on the various asbestos-containing parts found within small aircraft. Due to the relatively high asbestos content in some aircraft brake pads and the frequency with which brake pads need replacement, aircraft brake repair has been a primary concern for asbestos exposure. The chrysotile asbestos content of these brakes typically ranges from 16% to 23% by weight, used as an aggregate for the phenolic binders. Several exposure assessments performed during automobile brake maintenance report asbestos concentrations that do not exceed the current Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL) of 0.1 fibers per cubic centimeter (f/cc) [10] [11] [12] [13] [14]. Research published by Blake *et al.* in 2009 [15] has shown an absence of measurable asbestos fiber exposure to an aircraft mechanic while servicing organic-style brakes on a light, general aviation aircraft.

This research focuses on aircraft brake operation and the blowout effects that occur during flight operations. Specific measurements were made of airspeed and direction of airflows impinging on the brake assemblies. Also, video records were made of brake assemblies during all phases of aircraft flight.

2. Materials and Methods

2.1. Test Aircraft

For this research, a 1998 Cessna, model 172R was outfitted with video cameras that recorded multiple views of the aircraft's right main wheel brake assembly (**Figure 1**), along with the right-seat passenger's view (**Figure 2**).

Instrumentation and telltales were installed that measured and recorded aircraft attitude and airspeed around the brake assemblies, along with relative wind directions (**Figure 3**).

Applied brake force was also measured and recorded (**Figure 4**), and Global Positioning System (GPS) data were utilized to record the aircraft's flight path (**Figure 5**).

A ground-based video camera was used to record aircraft operations, with primary focus on landings (**Figure 6**).

Given the various modifications made to the aircraft for test purposes, the aircraft was classified as experimental and operated under temporary license obtained from the Federal Aviation Administration (FAA) (**Figure 7**).

2.2. Flight Tests

Flight tests took place on June 27, 2019, at the Meadow Lake Airport (KFLY),

Figure 1. Right main wheel brake assembly.

Figure 2. Right seat passenger's view.

Figure 3. Instrumentation and telltale's record attitude and airspeed.

Figure 4. Brake force measured and recorded.

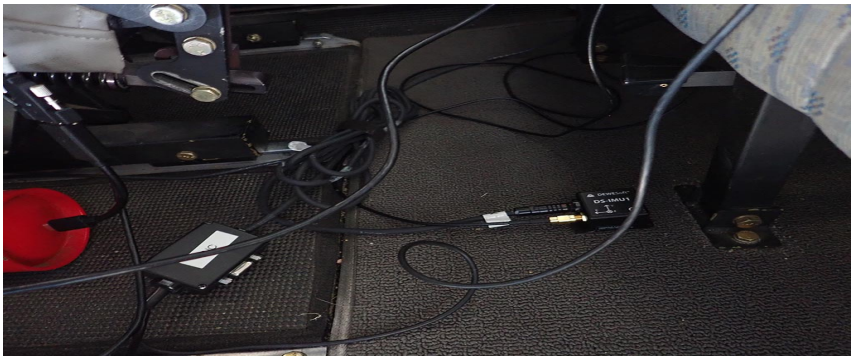

Figure 5. GPS utilized to record flight path.

Figure 6. Video recording aircraft operations and landing.

Figure 7. FAA classification as experimental aircraft.

located 14 miles northeast of Colorado Springs, Colorado. During the testing period, which lasted 44 minutes, four separate takeoffs and full-stop landings were made. While in cruise configuration, the aircraft reached airspeeds of 110 miles per hour (mph). The aircraft crew consisted of one pilot and one instrument technician. Weather conditions throughout the period of testing were sky clear, winds out of 182 degrees at 15 to 17 mph, gusting to 30 mph.

Observations made during the testing program include turbulent airflow at and around the aircraft's main wheel and brake assembly. This airflow began after engine start and continued until final engine shutdown, having been initially caused by "propwash" from the nose-mounted engine. As the aircraft accelerated through climb and cruise speeds, the turbulence increased. Airspeeds at the aircraft's wheels reached 120 mph during cruise/descent.

At no time was any visible dust observed emanating from the right brake caliper. Also, post-flight brake inspection showed no dust accumulation either on the top or bottom surfaces of the brake caliper. Any wear dust generated during the braking process was released into the turbulent airstream and did not accumulate on the brake assembly or its component parts.

3. Discussion

This testing program has demonstrated the existence of turbulent, high-speed airflows directly impinging on an aircraft's brake assemblies. The effects of these airflows are two-fold: first, dust produced by brake operation is readily swept away by ambient airflows existent at the time generated, and second, respirable-sized chrysotile fibers that survive the braking process and accumulate on brake assembly surfaces will be dislodged by the high-speed, turbulent airflows experienced during both ground operation and flight.

Organic-style aircraft brake friction pads, at times in the past, had chrysotile asbestos as part of their formulations [16]. Recent research on exposures during

the maintenance of the brakes on heavy equipment shows chrysotile exposures below the OSHA Permissible Exposure Limit (PEL) [17].

The individual chrysotile asbestos fibers, known as fibrils, have diameters roughly 2500 times less than human hair [18]. Of concern to industrial hygienists and other health professionals are those airborne particles that can be inhaled, reaching the gas exchange region of the human lungs. Such particles are classified as being of respirable size. For fibers, diameter is the factor controlling respirability [19].

Owing to their microscopically small size, respirable chrysotile fibers, once settled onto surfaces, set up weak covalent bonds and become adhered to those surfaces, residing in the boundary layer where the velocity of passing airflow approaches zero. For these reasons, relatively high ambient airflows are required to cause even movement of respirable fibers, much less re-entrainment into a person's breathing zone.

4. Conclusion

The results of this research confirm previous reports. Brake dust is typically dispersed into the ambient air during and after brake application. Asbestos fiber exposure to mechanics that perform work on light general aviation aircraft is de minimis.

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Conflicts of Interest

CB and RH have testified in matters involving asbestos-containing brakes.

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