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Asbestos Exposure during Gasket Removal from Aircraft Engine

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Abstract

We have previously evaluated asbestos exposure associated with various maintenance procedures on light aircraft. The purpose of this study was to evaluate asbestos exposure during engine maintenance on light aircraft. This test was designed to evaluate the potential for asbestos exposure to mechanics and others who remove asbestos-containing engine gaskets from reciprocating style aircraft engines. Utilized in this test was an air cooled, horizontally opposed, aviation gasoline burning engine, assembled during 1986 and operated intermittently up into 2015, having accumulated 1680 hours run time. Nearly 75% of the asbestos-containing gaskets installed during 1986 were still in place at the time of testing. Chrysotile asbestos contents of such gaskets ranged from 55% to 60% by area, for those of sheet style and 5% by area, for the spiral wound metal/asbestos style. Despite the levels of effort required to effect gasket removals, the professional aircraft mechanic was not exposed to airborne asbestos fibers at the lower limits of sampling and analytical detection achieved; all of which were substantially less than the current Occupational Safety and Health Administration Permissible Exposure Limits for asbestos. The results of this testing indicate an absence of gasket related asbestos exposure risk to mechanics who work with light aircraft engines, including those having asbestos-containing gaskets. These results are consistent with the findings of Mlyarek and Van Orden who studied the asbestos exposure risk occasioned during overhaul of larger radial style reciprocating aircraft engines [1].

Keywords

Asbestos Exposure, Gaskets, Aircraft Engine, Friction Materials

1. Introduction

We previously reported asbestos exposure assessments associated with various light aircraft maintenance procedures [2] [3]. Others have published similar results [1]. Some studies have also investigated health risks associated with asbestos exposure among aircraft mechanics [4] [5] [6]. Asbestos exposure associated with other engine gaskets have been reported [7] [8].

At times prior to the late 1980's, manufacturers of reciprocating style aircraft engines utilized chrysotile asbestos-containing, compressed sheet style gaskets to seal mating surfaces between metal engine components. Aircraft engine mechanics may have encountered such gaskets during certain engine maintenance procedures up to and including complete engine teardowns. This study involved an air cooled, horizontally opposed, piston engine of a type used on several light aircraft popular during the mid to late 20th century. Certain asbestos-containing gaskets, originally installed during a June 1986 factory overhaul, were still in place when the engine was taken out of service (in May 2015) having accumulated 1680 hours of operation.

As part of this study, the subject aircraft engine was torn down to the extent that all existing components having gaskets were removed, as also were the gaskets. The engine teardown was performed by an FAA licensed airframe and powerplant mechanic who at one time had been employed by an engine repair facility.

Throughout the engine teardown process, industrial hygiene personal and area air sampling was conducted for the mechanic and the room within which the activity took place. Collected air samples were analyzed for the presence of airborne fibers and asbestos fibers meeting the criteria of published National Institute for Occupational Safety and Health (NIOSH) sampling and analytical methodology.

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2. Materials and Methods

2.1. Pretest Preparations

Prior to the conduct of engine teardown and associated air sampling, the aircraft engine was moved into the test facility being mounted in a nose-down orientation, supported by a stand which was bolted to the crankshaft flange. The test room had been cleared of any visible dust with all surfaces being vacuumed and wet wiped. The forced air ventilation system serving the test room was sealed off. Pretest background air samples were collected from the test room, which remained closed and sealed off, from the completion of cleaning until the end of engine teardown and testing.

2.2. Test Facility

All test sessions were conducted inside a closed room part of the office/ shop/galley/restroom complex physically situated within a metal building aircraft hangar. The test room measures 3.05 × 4.01 meters with a ceiling height of 2.44 meters. Walls and ceiling are painted gypsum board with wood panel wainscoting. The floor is covered by a 30.5 × 30.5 cm vinyl composition tiles. A forced air heating, ventilating, and air conditioning (HVAC) unit serves this and the associated rooms through ceiling mounted supply and return registers. During all tests the HVAC system was shut down and the ceiling mounted registers were sealed using tape secured polyethylene films.

The aircraft hangar which houses the test room is physically located on the Cartersville-Bartow County Airport (KVPC) on Georgia Highway 61, west of Cartersville, Georgia. Throughout all test sessions the test room remained closed-off from the encompassing hangar. All outside doorways to the hangar also remained closed.

Prior to conduct of the test session, the room was cleaned of any visible dust and debris using a combination of vacuum cleaning and wet wiping. The work bench, tools and materials were cleaned using a wet sponge. After completion of all preliminary cleaning, the test room and hangar were closed, and pretest background sampling conducted to assure the absence of any background airborne asbestos fiber contamination.

2.3. Tools, Supplies and Methods

The mechanic utilized standard hand tools for the engine teardown and gasket removal procedures. These consisted of wrenches both fixed and socket style, screwdrivers, diagonal cutters, hammers, brass drifts, a plastic wedge, a battery powered nut driver and a flashlight. Gasket removal was accomplished by either prying the gaskets free or scraping gaskets and gasket remnants using a blade style gasket removal tool. In one instance involving the vacuum pump gasket, a wood chisel was used to remove gasket residue. The mechanic wore a cotton polyester work shirt and pants (Dickies). These clothes were purchased new for this testing and were laundered prior to being worn during the test. Protective type equipment consisted of safety glasses and earplugs. A single roll of household paper towels was used for hand and surface wiping. No solvents, water or other liquids were utilized for gasket removals or other purposes, during the test period. All engine teardown and gasket removal works were done in a manner consistent with guidance provided in Teledyne Industries, FAA approved, IO-470 Overhaul Manual, Part Number X30588A.

2.4. Air Sampling

Industrial hygiene air sampling was done throughout the approximately 3.5 hour test duration. This sampling included collection of duplicates, test duration, personal breathing zone air samples, along with short term personal samples collected during periods of greatest work-related fiber release potential. Stationary test-duration area air samples were collected inside the test room (n = 2) and outside the test room but within the hangar (n = 2). All air sampling done for this research followed recognized standard measurement procedures, as set forth by NIOSH [8] [9] and required by Occupational Safety and Health Administration (OSHA) in its published standards for asbestos [10].

Airborne Fiber Sampling and Analysis

Several published methods are available regarding sampling of workplace and other atmospheres for airborne fibers. These methods also specify the types of analyses to be used to determine the presence and quantities of airborne fibers and asbestos fibers. For the sampling phase, most modern methods specify use of membrane filters housed in plastic cassettes. Air is drawn through membrane filter media at calibrated airflow rates and airborne particles become trapped on the outer filter surface. Available airborne fiber sampling methods typically vary with respect to; membrane filter pore sizes and the sampling air flow rates.

For this project, the NIOSH 7400/7402 sampling methodology was utilized which incorporates use of 0.8 µm pore size mixed cellulose ester membrane filters, housed inside 25 µm diameter electrically conductive, extended cowl cassettes. For personal samples, MSA Model Flo-lite® battery operated portable air pumps were utilized, with airflow rates set in the 2.2 to 2.3 liter-per-minute (LPM) range. Three air sampling cassettes were drawn from within the mechanic's breathing zone being on his shoulders. Two of these samples ran for the full period of the engine teardown which lasted approximately 3.5 hours. The third personal sample which was worn on the mechanic's right shoulder, was exchanged at 161 minutes run time, then again at 191 minutes, thus yielding three separate air samples. The short-term samples were used for assessment of excursion level airborne fiber concentrations.

For area air samples, Gast model (1531-1075-0288X) line operated vacuum pumps drew air through cassette mounted 0.8 µm pore sized membrane filters at flowrates nominally set in the 8 - 9.3 LPM range. The sample cassettes were suspended at breathing zone heights (5-ft above floor) using metal stands. The open inlet ports of these cassettes were oriented in a downward facing attitude.

Air sampling flowrates were measured and recorded before commencement, and after completion of each testing session. These airflow measurements were performed using a primary standard, airflow calibrator, Bios International Model DC Lite.

Once collected, all air samples were sealed, then hand transported for analysis to Bureau Veritas North America's (BVNA's) American Industrial Hygiene Association (AIHA) and National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory, in Kennesaw, Georgia.

The choice of analytical methodologies for airborne fiber samples is largely governed by the intended use of the air sampling data. To determine compliance with OSHA standards for asbestos, a phase contract microscopy (PCM) analysis must be utilized, as detailed in the NIOSH 7400 [9] or OSHA ID-160 methods [10]. Where questions exist regarding the composition of any airborne fibers found using PCM, the NIOSH 7402 [11] methodology is indicated. Sample analysis by Transmission Electron Microscopy (TEM) following NIOSH 7402 will identify non-asbestos (those longer than 5 μm and wider than 0.25 μm) fibers, when such appear in air samples. Airborne fiber exposure data derived using PCM analysis, and refined using TEM determined asbestos vs. non-asbestos fiber ratios, yield asbestos adjusted PCM data which are suitable for comparison against OSHA PEL's and published health risk assessment databases.

All air samples collected during the engine teardown were submitted for analysis using PCM, according to NIOSH 7400. Those samples showing the presence of fibers above the lower limits of detection were also submitted for analysis using TEM, following the NIOSH 7402 methodology, through which asbestos adjusted airborne fiber concentrations were determined.

2.5. Aircraft Engine

The aircraft engine subject of this testing was a Continental Motors, Inc., model IO-470L which had served as the starboard (right) engine on a Beechcraft Baron model 95-B55. This engine was purchased from Continental during 1986 as a zero-time, factory remanufactured unit, then installed on the specified aircraft. Since that date, the engine had seen service in the Caribbean, Texas, and Massachusetts. In May 2015, at 1680 hours running time, it was taken out of service having accumulated 23 hours of operation since its last oil change in November 2014. This subject testing took place on August 28, 2015. Over its period of service, the magnetos, propeller governor and all cylinder assemblies had been reworked or exchanged. The fuel pump, starter/alternator drive, tachometer generator, oil pump, vacuum pump and oil sump remained in place with all associated sealing gaskets. Prior to start of testing, the engine was drained of lubricating oil and the engine exterior was cleaned of oil residue using solvent spray. In addition, the magnetos and associated ignition harnesses were removed, as also were those fuel injection system components not having sealing gaskets.

Work Procedures

The mechanic started engine teardown by removing the exhaust headers and engine mount. During this procedure he removed one spiral wound, exhaust flange gasket from each of the engine's six cylinders. From this point onwards he removed the intake manifolds and all engine accessory items, cleaning each item as removed, of gaskets and gasket residue. Gaskets, gasket fragments and debris were placed into separate, plastic, zip-seal style bags, each labeled per their associated engine component.

All the asbestos-containing gaskets encountered during engine teardown, remained adhered to at least one of the engine/component mating surfaces. Varying degrees of scraping/prying were required in every instance to free gaskets or gasket fragments.

3. Results

3.1. Analysis of Gaskets Removed

A total of twelve separate gasket samples were submitted for analysis using polarized light microscopy (PLM). These included gaskets used for the; tachometer generator, oil pump, oil cooler, propeller governor one intake manifold, vacuum pump, oil pump suction tube, fuel pump, accessory drive cover, starter/alternator adapter, one exhaust flange and the oil sump. Of these 12 gaskets, nine were found positive for chrysotile asbestos, in concentrations ranging from 5% for the metal/asbestos exhaust gasket to 55% and 60% by area for the balance (**Table 1**). Those gaskets found not to contain asbestos included those removed from the propeller governor, oil cooler and the intake manifolds. Not tested were any rocker cover gaskets, all of which had been changed during cylinder removals and appeared visually different from those known to have contained asbestos.

3.2. Air Sampling Results

3.2.1. Work Area Air Samples

Two area air samples were collected from inside the test room. One sample was in the southwest corner near the worktable used for parts storage and gaskets removals. The second area sample was in the northeast corner near the mechanic's tool chest. Both area samples ran for total test duration of 215 minutes, drawing 1958 and 1954 liters of air respectively. Analysis using PCM indicated the presence of fibers in concentrations ranging from 0.006 to 0.0098. The higher concentration was found near the parts table. Follow-up analysis using TEM found no asbestos present. All but one of the fibers found by TEM was identified as being organic. The single remaining fiber was identified as aluminum silicate.

3.2.2. Personal Air Samples

The results of analysis for personal air samples are summarized in **Table 2**. The mechanic wore a total of three samplers, two of which ran for full test duration while the third sampler was changed twice in series consisting of a 161-minute segment and two successive excursion level segments totaling 215 minutes.

When analyzed using PCM all but one of the excursion level samples showed the presence of airborne fibers at low concentration levels. Indicated airborne fiber concentrations ranged from 0.007 to 0.023 f/ml for the longer-term samples with the excursion level samples showing <0.028 and 0.053 f/ml. Assuming no airborne fiber exposure beyond the test period, calculated 8-hr TWA concentrations ranged from ≤0.003 to 0.01 f/ml. Those air samples showing the presence of fibers, when analyzed using TEM showed no asbestos present at concentrations ranging from <0.0010 to <0.0089 f/ml.

Table 1. Bulk sample analysis.

Sample	Asbestos	Other Fibers
Gasket: tachometer generator	Chrysotile 55%	ND
Gasket: oil pump	Chrysotile 60%	ND
Gasket: oil cooler	NAD	Cellulose 50% fibrous glass 50%
Gasket: propeller governor	NAD	Cellulose 50%
Gasket: intake manifold	NAD	Cellulose 35%
Gasket: vacuum pump	Chrysotile 60%	ND
Gasket: oil pump suction tube	Chrysotile 60%	ND
Gasket: fuel pump	Chrysotile 55%	ND
Gasket: accessory drive cover	Chrysotile 60%	ND
Gasket: starter/alternator adapter	Chrysotile 60%	ND
Gasket: exhaust manifold	Chrysotile 5%	ND
Gasket: oil sump	Chrysotile 55%	ND

NAD: No Asbestos Detected, ND: None Detected.

Table 2. Personal airborne fiber test data.

Sample Position	Sample Collection		PCM Analysis		TEM Analysis	Asbestos Adjusted PCM	
	Time (min)	Volume (L)	f/ml[a]	TWA[b] (f/ml)	Fiber Ratio	(f/ml)	TWA[b] (f/ml)
Right Shoulder	215	481	0.012	0.005	0	0	0
Left Shoulder	215	481	0.023	0.01	0	0	0
Right Shoulder	161	363	0.007		0	0	
Excursion Level	30	68	<0.028	N/A	-	-	
Excursion Level	24	54	0.053	N/A	0	0	
	215	485	≤0.02	≤0.003	0	0	0

PCM and TEM analyses were completed according to NIOSH Method 7400 and 7402, respectively. a: Average fiber concentration over test duration. b: TWA is 8-hr Time Weighted Average assuming no exposure other than test.

4. Discussion and Conclusion

This test was designed to evaluate the potential for asbestos exposure to mechanics and others who remove asbestos-containing engine gaskets from reciprocating style aircraft engines. Utilized in this test was an air cooled, horizontally opposed, aviation gasoline burning engine, assembled during 1986 and operated intermittently up into 2015, having accumulated 1680 hours run time. Nearly 75% of the asbestos-containing gaskets installed during 1986 were still in place at the time of testing. Chrysotile asbestos contents of such gaskets ranged from 55% to 60% by area, for those of sheet style and 5% by area, for the spiral wound metal/asbestos style.

All the asbestos-containing sheet style gaskets encountered during this testing were found adhered to at least one of the metal mating surfaces involved and required manual prying and/or scraping to effect removal. Some of the gasket materials were reduced to debris during the removal process. All gasket removals were done dry, without use of solvents or water.

Despite the levels of effort required to effect gasket removals, the professional aircraft mechanic was not exposed to airborne asbestos fibers at the lower limits of sampling and analytical detection achieved; all of which were substantially less than the current Occupational Safety and Health Administration Permissible Exposure Limits for asbestos. The results of this testing indicate an absence of gasket related asbestos exposure risk to mechanics who work with light aircraft engines, including those having asbestos-containing gaskets. These results are consistent with the findings of Mlyarek and Van Orden who studied the asbestos exposure risk occasioned during overhaul of larger radial style reciprocating aircraft engines.

Declaration

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

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Mlynarek, S. and Van Orden, A. (2012) Asbestos Exposure from Overhaul of a Pratt & Whitney R2800 Engine. *Regulatory Toxicology and Pharmacology*, **64**, 189-194. https://doi.org/10.1016/j.yrtph.2012.07.004

[2] Blake, C.L., Johnson, G.T. and Harbison, R.D. (2009) Airborne Asbestos Exposure during Light Aircraft Brake Replacement. *Regulatory Toxicology and Pharmacology*, **54**, 242-246. https://doi.org/10.1016/j.yrtph.2009.04.007

[3] Blake, C.L., Harbison, S.C., Johnson, G.T. and Harbison, R.D. (2011) Airborne Asbestos Exposures Associated with Work on Asbestos Fire Sleeve Materials. *Regulatory Toxicology and Pharmacology*, **61**, 236-242. https://doi.org/10.1016/j.yrtph.2011.08.003

[4] Garabrant, D., Held, J., Langholz, B. and Bernstein, L. (1988) Mortality of Aircraft Manufacturing Workers in Southern California. *American Journal of Industrial Medicine*, **13**, 683-693. https://doi.org/10.1002/ajim.4700130607

[5] Bianchi, C. and Bianchi, T. (2010) Aircraft Maintenance and Mesothelioma. *India Journal of Occupational and Environmental Medicine*, **14**, 24-35. https://doi.org/10.4103/0019-5278.64613

[6] Bianchi, C. and Bianchi, T. (2011) Mesothelioma and Aircraft Industry. *American Journal of Industrial Medicine*, **54**, 494-511. https://doi.org/10.1002/ajim.20949

[7] Liukonen, L. and Weir, F. (2005) Asbestos Exposure from Gaskets during Disassembly of a Medium Duty Diesel Engine. *Regulatory Toxicology and Pharmacology*, **4**, 113-121. https://doi.org/10.1016/j.yrtph.2004.10.003

[8] Blake, C.L., Scott Dotson, G. and Harbison, R.D. (2006) Assessment of Airborne

Asbestos Exposure during the Servicing and Handling of Automobile Asbestos-Containing Gaskets. *Regulatory Toxicology and Pharmacology*, **45**, 214-222. https://doi.org/10.1016/j.yrtph.2006.04.007

[9] (1977) NIOSH Asbestos and Other Fibers by PCM, Method 7400 NIOSH Manual of Analytical Methods. 4th Edition.

[10] (1977) Occupational Safety and Health Administration (OSHA) Regulation (Standards-29 CFR). Air Contaminants-1910.1000.

[11] (1984) NIOSH, Asbestos by TEM, Method 7402 NIOSH Manual of Analytical Methods. 4th Edition.