A Multi-Application, Multi-Industry Asbestos Exposure Assessment During Maintenance of Surfaces and Joints Sealed with Gaskets and Packing

- PO115 -

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F.W. Boelter, CIH, PE
C.E. Simmons, CIH
L. Berman, PhD

Boelter & Yates, Inc.
Park Ridge, IL
Gaskets & Packings (FSD)

- Thousands of products worldwide
  - prevent hazardous material leaks
  - protect us and the environment in our daily lives
- Control leaks at mated or machined surfaces
- Highly engineered
  - Specific applications
  - Temperature, pressure and the media
- Construction
  - Nitrile rubber to Teflon
  - Vegetable fibers to asbestos
  - Stainless steel to copper
Exposure Potential

- Fluid sealing devices (FSD)
  - Occasionally fail, need replacement
  - Undergo preventative maintenance change-out
  - Handled during construction activities

- FSDs containing asbestos were dismissed
  - Investigators did not see as health hazards
  - Exempted from labeling by regulation

- More recently, FSDs have been investigated
  - Assess their significance as a source of exposure
  - Degree of risk for the worker and bystander
  - Cause of asbestosis, lung cancer and mesothelioma?
Assessment Strategy

- Field observation
- Interview individuals
- Observe work practices
- Select representative activities
- Evaluate exposures
- Use validated protocols
- If conducting a chamber study
  - activities must be representative of
    - sequence
    - time and motion
- Data must be relevant, reproducible, and predictive
Approach

- Wide variety of situations
  - acidic and caustic environments
  - high and low pressure
  - high and low temperature
- Not possible to sample all applications, activities, and conditions or people
- IHs model based on worst case scenario
- IHs rely on observation and professional judgment (PJ)
- Where anecdotal information does not match PJ…
  - PJ is superior decision making basis (National Research Council, 1983)
Objectives

- Compile data from numerous studies
- Examine variability
  - Between highly engineered fluid sealing devices
  - Between media, temperature, and pressure
  - Related to use and/or level of aggressive technique applied to removing residue
- Compare with occupational exposure limits
FSD Sources

- Variety of sources
  - Industrial and maritime fittings
  - Commercial and industrial pumps
  - Automobile engines
  - Farm equipment
  - Heavy machinery
  - Heavy trucks
  - Faucets
  - Boiler pipe fittings
  - Boiler burner mounting seal
Sampling Strategies

- Both full-shift and short-term (excursion limit) personal monitoring
  - Work scenarios designated as “worst case” conditions
    - Minimal to no ventilation conditions
    - Field and isolation chamber sites
    - Dry removal practices
  - Full-shift monitoring ranged from 6.5 to 9 hours
  - 30 minutes short-term excursion limit (EL) monitoring
  - Time and motion based on actual service shop or field maintenance
Database

- Full-shift personal and area TWA samples
- Personal EL samples results
- Phase contrast microscopy (PCM) by NIOSH 7400
- Transmission electron microscopy (TEM) by NIOSH 7402
- Cleanliness by AHERA TEM
- 72 full-shift personal TWA
- 320 full-shift area TWA
- 307 EL samples
Study Settings

- **Field studies**
  - Actual workplaces
  - Professionals using their own tools and techniques
  - Quantified air volumes and/or exchange rates
  - Took space essentially “as is”
  - Background samples

- **Isolation chamber studies**
  - No ventilation - static environment
  - Rigorous cleaning prior to testing
  - Aggressive clearance procedures by AHERA protocol TEM
  - Professionals using their own tools and techniques
  - Focused evaluation based on field time and motion
Methods

- All personal and area samples
  - pumps calibrated at 2.0 liters per minute
  - 25-mm conductive cowl cassettes
  - 0.8 µm or 0.45 µm MCE filters
  - NIOSH Method 7400
  - Fibers > 5 µm, with L:W ratio ≥ 3:1
  - In most studies, fibers > LOQ by PCM method were analyzed by TEM in accordance with NIOSH Method 7402
    - Fraction of asbestos fibers were determined
    - PCM fiber count was then multiplied by this ratio
    - Determine the asbestos fiber concentration in air

- Independent accredited laboratories were used

- Laboratory and analysts were kept blind
Censored Data

- When PCM samples reported < LOQ, the PCM LOQ was substituted.
- For TEM results with a ratio of zero, PCM LOQ was assigned.
- Substitution of the LOQ as a sample value is recommended by USEPA when less than 15% of a data set is below limits of detection.
  - Other options included substitution of one-half the LOQ, some number between zero and the LOQ, or deletion of the values that are less than the LOQ (i.e. analyze detectable values only).
- Conservative estimate of the sample values.
Intact fittings
- Decommissioned power house
- Decommissioned U.S. Navy destroyers

Each fitting rigorously cleaned

Fittings had intact gaskets and packing

10 separate cycles in an isolation chamber

48 gaskets removed and 96 flange faces were cleaned

20 valve stem packing stuffing boxes

Flanges and valves weighed a few to several hundred lbs

Boelter, et al. (2002) published the methods and findings

The authors performed all work

20 personal and 80 area TWA samples

18 EL samples
Valve Fittings

- Four main shut-off valves
- Hot water supply and return piping for two commercial boilers
- 39 year old gaskets
- Pipe fitter performed activities
- Sharp edged chisel
- Half-round machinists file
- Powered wire brush
- 2 personal and 8 area TWA samples
- 2 EL samples
Industrial/Commercial Pumps

- 24 pumps were tested
- Variety of applications and conditions of use
- Size from several pounds to hundreds of pounds
- 17 low-RPM pumps - viscous fluids ie molasses or asphalt
- 1 process-specific plunger pump - precise volumes
- 2 centrifugal pumps - hot oil in a chemical or industrial setting
- 3 high-head water system pumps
- 2 helical pumps – process related
- Gaskets and/or packing were removed and replaced
- All testing in an isolation chamber
- Experienced mechanics performed the work
- 16 personal and 56 area TWA samples
- 69 EL samples
Automotive Engines

- 1966 Ford Mustang
- 1964 Chevy Impala with a 1963 engine
- Engine overhaul included removal and replacement of engine gaskets
- Intact original engines
- Replacement gaskets two different NOS kits
- Head gaskets, intake manifold gaskets, valve lifter cover gaskets, water pump gaskets, carburetor gaskets, and others
- Isolation chamber
- 2 professional automobile mechanics
- Own individual and different techniques
- 12 personal and 32 area TWA samples
- 30 EL samples
Farm Equipment

- 1941 and 1965 farm tractors
- One tractor/loader (1940’s through the 1960’s)
- Engine overhauls – original condition
- Work on farm tractors performed in an actual maintenance garage
- Work on tractor/loader performed in an isolation chamber
- Professional farmer/mechanic
- 9 personal and 24 area TWA samples
- 51 EL samples
Heavy Machinery

- Four pieces of heavy construction equipment
- Bulldozer, motor grader, wheel loader, and track loader
- Manufactured during 1930s thru 1970s
- Nine-day evaluation
- Four professional heavy equipment mechanics
- Engine overhauls (clutch and brake work)
- Actual repair facility
- Majority of selected data relates specifically to gasket work
- Fiber release during simultaneous friction work activities would only make the gasket samples more conservative
- 21 personal and 41 area TWA samples
- 42 EL samples
Heavy Trucks

- Three diesel engine trucks
- 1960’s through 1970’s vintage
- Both turbo charged and non-turbo designs
- Range of use and abuse
- 1 high mileage truck
- 1 poorly maintained overheated concrete truck
- 1 heavy duty construction truck
- Varying maintenance timelines and difficulty in removing gaskets and their residues
- Slight differences between the engines necessitated making kit gaskets to fit
- 15 personal and 64 area TWA samples
- 95 EL samples
Three vintage faucets
- four-inch wall mount mop sink faucet
- eight-inch wall mount kitchen faucet
- four-inch under-mount laundry faucet

Packed with asbestos-containing packing prior to testing

Mechanical actuators to replicate a swing spout faucet in constant use

A licensed plumber performed the activities

Once each hour, over eight hours

Performed in an isolation chamber

2 personal and 8 area TWA samples

4 EL samples
Commercial Boiler

- A commercial boiler
- Burner mounting plate gasket
- Intact flange assembly was removed with an oxy-acetylene torch
- Installed on a mock-up faceplate
- Isolation chamber
- Removal of burner flange gasket
- A non-trade professional performed the work
- 2 personal and 8 area TWA samples
Pipe Fittings

- Eight flange faces
- Hot water supply and return piping
- 39 year old gaskets
- Licensed trade pipe fitter performed activities
- Flat scraper
- High speed grinder
- 6 personal and 16 area TWA samples
- 14 EL samples
Use of Aggressive Techniques

- Individuals used their own tools and techniques
- Individuals used aggressive techniques
  - Grinding
  - Hammering
  - Dry removal
- Activities performed with minimal to no ventilation
- Activities included
  - Forcefully scraping adhered gasket material
  - Hand wire or power wire brushing
  - Digging to remove packing
  - Pounding material
  - Using compressed air to clean surfaces
- Perceived level of aggression was recorded
Analysis Objectives

- Determine the distribution of the six separate data subsets for selection of normal or non-parametric analysis methods;
- Compare personal and area TWA samples by each analysis applied: PCM, TEM, or both, to determine whether or not these data are significantly different;
- Validate the application of substitution of the PCM LOQ for PCM results below detection and zero TEM values, by verifying that samples by PCM and TEM are statistically significantly different;
- Compare personal and area TWA samples to the OSHA 8-hr PEL of 0.1 f/cc; and
- Compare personal EL samples to the OSHA 30-min EL of 1 f/cc.
Bulks

- Every study involved at least some gaskets and packing that contained asbestos.
- Not all gaskets and packing are manufactured with asbestos.
- All removed gasket and packings, if they contained asbestos, were up to 90% chrysotile.
  - One exception - a set of removed packing rings which contained 80% crocidolite.
- Replacement gaskets, if they contained asbestos, contained chrysotile in ranges from 10% to 90%.
  - One exception - a replacement gasket which contained 20% amosite.
- Replacement packing materials contained from 20 to 45% chrysotile.
- No other asbestiform fiber type was detected in any bulk sample.
Studies of Gaskets and Packings

Total Fibers f/cc
(NIOSH 7400)

8hr TWA

Asbestos Fibers f/cc
(NIOSH 7402)
Studies of Gaskets and Packings

Total
Fibers
f/cc
(NIOSH 7400)

Asbestos
Fibers
f/cc
(NIOSH 7402)

30min EL
### Condensed Results

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Personal TWA by 7400 Avg Data</th>
<th>Area TWA by 7400 Avg Data</th>
<th>Personal TWA by 7402 Avg Data</th>
<th>Area TWA by 7402 Avg Data</th>
<th>Personal EL by 7400</th>
<th>Personal EL by 7402</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (f/cc)</td>
<td>0.025</td>
<td>0.023</td>
<td>0.009</td>
<td>0.009</td>
<td>0.086</td>
<td>0.057</td>
</tr>
<tr>
<td>Minimum (f/cc)</td>
<td>0.004</td>
<td>0.002</td>
<td>0.003</td>
<td>0.003</td>
<td>0.041</td>
<td>0.041</td>
</tr>
<tr>
<td>Maximum (f/cc)</td>
<td>0.084</td>
<td>0.079</td>
<td>0.024</td>
<td>0.028</td>
<td>0.940</td>
<td>0.940</td>
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<tr>
<td>Standard Deviation</td>
<td>0.016</td>
<td>0.015</td>
<td>0.005</td>
<td>0.006</td>
<td>0.085</td>
<td>0.064</td>
</tr>
</tbody>
</table>

**Note:** 72 full shift 8-hr TWA samples
307 30-minute Excursion Limit samples
Conclusions

- Regardless of the technique used and/or level of aggressive cleaning technique applied, the levels of asbestos fibers observed exhibited small variability, in addition to being below relevant occupational exposure limits.

- All studies were conducted under worst-case scenarios, including minimal to no ventilation and dry removal practices.

- High level of confidence that highly engineered fluid sealing devices used in a wide variety of gaskets or packing applications and conditions are relatively similar in terms of low asbestos fiber release potential and resulting low exposures.

- Airborne fiber type was only chrysotile.
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Fred W. Boelter, CIH, PE
Boelter & Yates, Inc.
Park Ridge, Illinois
847/692-4700
fboelter@boelter-yates.com