EXPOSURE OF CUSTODIAL EMPLOYEES TO AIRBORNE ASBESTOS

A Technical Report by

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ABSTRACT

The objective of this study was to evaluate the occupational exposure of custodians to airborne asbestos during routine activities. The sample population included eight custodians working in six public buildings in Missouri. Forty-seven personal samples and 91 area samples were collected and analyzed by transmission electron microscopy using direct preparation techniques. Personal samples resulted in an arithmetic mean of 0.0009 structures/cubic centimeter (s/cc) and area samples resulted in an arithmetic mean of 0.0003 s/cc. The highest personal sample concentration was 0.0255 s/cc, or 26% of the OSHA action level of 0.1f/cc.

INTRODUCTION

The goal of this study was to assess the exposure of custodians to airborne asbestos fibers as they conduct routine custodial activities in buildings where asbestos containing materials (ACM) are present. The study was designed to provide quantitative exposure data in the range of the current OSHA action level, 0.1 fiber/cubic centimeter (f/cc). Exposures did not involve the intentional disruption of ACM, as might occur with maintenance personnel, plumbers, electricians, and asbestos abatement workers. As studied here, custodial exposure was incidental and unintentional, often involving the redispersal of asbestos dust which had accumulated on surfaces after previously being released from its original source material. The study related exposure levels to the type of custodial activity involved, such as vacuuming, dust mopping, and stripping of vinyl asbestos tiles.

METHODS

STUDY DESIGN. Samples were collected for three consecutive days on each of two visits to six selected sites. Forty-seven personal samples were collected from the eight custodians involved in the study. These samples represented full shift exposures, and were computed as an eight hour time weighted average (8 hr. TWA). In addition to the personal samples, area samples were taken when a custodian was involved in a specific task. Six categories of custodial activities were monitored during area sampling: stripping vinyl asbestos tile (VAT), buffing VAT, vacuuming, dust mopping, dry broom sweeping, and hand dusting. These area samples provided information on the concentration of asbestos rendered airborne by the particular custodial activity. The area samples also gave information regarding the tasks during the day which contributed to the 8 hr. TWA exposure recorded on the custodian's personal sample. Custodians were instructed to perform their work routinely but in as much as possible to schedule their work so that the six relevant tasks would be performed at some time during the three day sampling periods.

SITE SELECTION. A list of potential sites for this study was generated from the records of the Missouri Department of Health. The Department maintains records of asbestos inspections for approximately 2900 public buildings in Missouri, inspected since 1988 under state law 701.122, RSMo 1991. The criteria used to determine potential building sites was the presence of accessible, friable, and

extensive ACM which was damaged to some degree. Managers of these buildings were contacted to determine the nature of custodial services in the building. Buildings were identified in which custodians worked routinely in the presence of ACM. Visits were made to each of the sites, with the result that six sites and eight custodians meeting the exposure criteria of the study were chosen. These sites are listed below:

Student Union, Missouri Western State College, St. Joseph (MWSC). This site had 10,000 square feet of asbestos sprayed onto the underside of roof and metal trusses on two floors. Custodial and maintenance areas of the building were directly exposed to this insulation. The space between the suspended ceiling and the metal trusses served as the return air plenum on both floors. Some damaged areas were visible in the sprayed on insulation. This material was friable and subjected to airstream abrasion. Two janitors worked here full time.

Dallas County Courthouse, Buffalo (Dallas CC). This building had approximately 20,000 square feet of ceiling area throughout that contained asbestos. About 90% of this ceiling had been painted with latex paint rendering it non-friable. The remaining 10% of ceiling area was not painted and was friable. Isolated areas of ceiling were damaged to the point of releasing fibers. Hallways in the building served as the return air plenum, which created a continuous flow of air over this ACM. Floors throughout the building were vinyl asbestos tile. Two half-time janitors were employed here.

Independence Power and Light Generating Station, Independence (IP&L). An extensive amount of TSI was present on the steam pipes of this coal fired electrical power plant, some in significantly damaged condition. A definitive quantity of TSI was not determined, but amount was estimated as hundreds of linear feet. A program of asbestos removal and/or abatement by outside contractors occurred periodically at the plant, but not during the period of this study. Approximately 75% of asbestos had been removed from the plant. Remaining TSI is subjected to strong air currents and vibration from operations of the plant. Floors in office areas contained vinyl asbestos floor tiles. Two janitors worked here spending time both in the generating plant and in the office areas.

Franklin County Courthouse, Union (Franklin CC). This building had 2700 square feet of hidden spline ceiling tile throughout which contained asbestos. Approximately 5% of the ceiling was damaged and friable.

Five hundred linear feet of hot water pipes in the basement were wrapped with TSI, some of which was in damaged condition. Two full-time and two part-time custodians worked in the building.

Western Missouri Medical Center, Warrensburg (WMMC). This building had 36,000 square feet of ceiling containing asbestos. The ceiling had been painted and was not friable. Approximately 25% of ceiling area had been cut to allow access for equipment, lights, mirrors, etc. Isolated spots in the ceiling showed damage. In some damaged areas, there was expected fiber release from the many openings into the ceiling. Approximately 7,200 square feet of flooring was VAT. The building also had approximately 150 thermal system joints packed with asbestos, of which 15 were damaged. Four full-time janitors were employed.

Hall of Waters (City Hall), Excelsior Springs (Ex Spr). This building served as the city's municipal building. Prior to the 1960's it had also been used as a center for therapeutic mineral bath treatments. The building had an extensive system of hot water pipes insulated with asbestos throughout. The total amount of TSI could not be determined accurately, but was estimated at several thousand linear feet. Varying degrees of damage existed in this material. Air chases in certain areas of the building were built around these insulated pipes, which created the possibility of widespread dispersal of asbestos fibers. One full time custodian worked here.

MATERIALS Materials were selected in accordance with the NIOSH Method 7402 protocols for asbestos fiber collection. All samples were collected on Millipore 0.045 micron mixed cellulose ester filters using open faced 25 mm preloaded cassettes. Personal sampling pumps were SKC Model 224-PCXR3 which were calibrated on site to a flow range between 2.0 and 2.5 liters per minute. Area samples were collected using Gilian Aircon 520 high volume samplers, calibrated to 10 liters per minute. Calibration of the air samplers was performed using a Gilian Gilibrator electronic flow meter with a representative filter in line. Pumps were calibrated at the beginning and end of each sample collected.

SAMPLE ANALYSIS Analysis of the samples was performed by transmission electron microscopy using direct transfer methods. Analysis was conducted according to the non-mandatory protocols of the Asbestos Hazard Emergency Response Act (AHERA) method, as described in 40 CFR 763, Appendix A, Subpart E. QuanTEM Laboratory,

Oklahoma City, Oklahoma, served as the principal analytical laboratory. QuanTEM's role involved the analysis of 156 samples and the repreparation of 7 samples. Included in the laboratory report were the following factors: structure type (free fibers, bundles, clusters, or matrices), species of asbestos (chrysotile/amphibole), the count of fibers less than or greater than 5 microns, and the length and diameter of all structures identified as asbestos. Quality control analysis was performed by Professional Service Industries (PSI) at their Pittsburg, Pennsylvania facility. All analysis was performed at or below a level of sensitivity of 0.005 s/cc.

QUALITY ASSURANCE/QUALITY CONTROL. In order to define the background contamination of the filters in the production lots, two lot blanks were selected at random from each of the 2 production lots. They were submitted for analysis without opening the cassettes. One field blank was selected for each day of sampling. Field blanks were handled in the same fashion as field samples, including removal of the cover in the field and connection to the pump tubing. This was a control for contamination occurring in the field but not resulting from air sampling. Nineteen duplicate area samples were collected side by side. The duplicate samples were sent to an external laboratory, PSI, for analysis. Results from the external laboratory were compared to results from the primary analytical laboratory. The degree of agreement between the two was used to define the overall precision of the sampling and analytical techniques. In order to test intra-laboratory analyst reliability, repreparations were done on seven (7) samples at the primary laboratory.

RESULTS

A total of 138 samples were collected, of which 47 (34%) were personal samples and 91 (66%) were area samples. Collection volumes averaged 1309 liters (SD +/- 302 L). Average analytical sensitivity was 0.0044 s/cc (SD +/- 0.0007s/cc). Seventeen samples (12.3%) were rejected as too dirty to count (TDTC) using the AHERA counting rules for TEM analysis by direct preparation. The remaining 121 samples were divided between 38 personal samples and 83 area samples. No asbestos structures were counted in 99 (81.8%) of the samples. Detectable asbestos structures were found in 22 (18.2%) of samples, with total concentrations ranging from 0.0029 s/cc to 0.1247 s/cc. When a level of interest was established at total concentrations of 0.005 s/cc or greater, detectable asbestos structures were reported in 12 (9.9%) samples.

ARITHMETIC MEAN VALUES. Table 1 gives the arithmetic mean values for personal and area samples. These are reported first for all samples, and then for samples from each of the sites. The mean 8 hr-TWA for all personal samples was 0.0009 s/cc (SD +/- 0.0043). The mean total concentration value for all area samples was 0.0033 s/cc (SD +/- 0.0147). Standard deviations were calculated based on total concentration for area samples, and on 8 hr-TWA's for personal samples.

Table 1: Arithmetic means, as structures/cubic centimeter, of personal and area samples.

	Total Conc.	8Hr TWA	< 5 µ	≥5 µ	Sample Size	SD
All Sites						
Personal	0.0064	0.0009	0.0054	0.0010	38	0.0043
Area	0.0033		0.0030	0.0003	83	0.0147
Dallas CC						
Personal	0.0472	0.0099	0.0364	0.0108	3	0.0136
Area	0.0176		0.0160	0.0016	14	0.0329
Exc. Spr.						
Personal		0.0202	0.0008	0.0192	0.0010	5
0.0019						
Area		0.0011		0.0009	0.0003	16
0.0020						
WMMC						
Personal		0	0	0	0	6 0
Area		0.0009	0	0.0009	0	15
0.0018						
MWSC						
Personal	0	0	0	0	12	0
Area	0	0	0	0	14	0
IP&L						
Personal	0	0	0	0	8	0
Area	0	0	0	0	11	0
Franklin CC						
Personal		0	0	0	0	8 0
Area	0	0	0	0	13	0

1. The category of total concentration is composed of structures <5µ and ≥5µ .

2. Standard deviations (SD) were calculated from total concentrations for area samplesand from 8Hr-TWA concentrations for personal samples.

As indicated in Table 1, sample results are skewed based on the building in which sampling occurred. Three buildings accounted for all reported asbestos structures. Two buildings, Dallas County Courthouse and Excelsior Springs City Hall, accounted for all values reported at a total concentration level of 0.005 s/cc or greater. Figure 1 graphically depicts this skewed distribution with respect to the personal samples. Eight hour TWA's in Figure 1 were based on asbestos structures greater than 5μ in length.

Figure 1: Arithmetic mean concentrations of fiber lengths<5μ, ≥5μ, and of 8Hr-TWA's for personal samples grouped by building collection site.

1. **Calculations of 8 Hr-TWA's were based on the concentration of asbestos structures ≥5μ.**

PERSONAL SAMPLES. Detectable asbestos structures were found in 6 (15.8%) of the analyzed personal samples. Listed in Table 2 are the personal samples with total concentrations ≥ 0.005 s/cc. Eight hour TWA's were calculated using asbestos structures greater than 5µ, following the OSHA definition of fiber length. Sample #79, from Dallas County Courthouse, was the only personal sample which met the criteria for both concentration (≥0.005s/cc) and fiber length (≥5µ).

Table 2: Results of personal samples with total concentrations ≥0.005s/cc.

ID #	Site	<5µ	≥5µ	Concentration	Total 8Hr-TWA
79	Dallas CC	0.0598	0.0276	0.0874	0.0255
120	Ex Spr	0.0098	0.0049	0.0147	0.0042
74	Dallas CC	0.0495	0.0000	0.0495	0.0000
176	Ex Spr	0.0450	0.0000	0.0450	0.0000
112	Ex Spr	0.0414	0.0000	0.0414	0.0000

Sample #79. The composition of custodial work during this personal sample was as follows: Sweeping (7%), dust mopping (7%), dusting (7%), miscellaneous activities (45%), and stripping VAT (34%). The miscellaneous category included activities such as wet mopping, emptying trash, and glass cleaning. The custodian was also involved in sweeping and dusting in a small store room that contained approximately 12 square feet of a friable asbestos ceiling. Although this sweeping and dusting were of short duration (five minutes), the activity was very dusty. Area sampling (sample #81) in this room during the cleanup did not confirm the presence of airborne asbestos. The custodian also stripped wax from approximately 300 square feet of vinyl asbestos floor tiles for a period of one hour using a rotary stripper and stripping solution. Area sampling of this operation recorded levels of airborne asbestos concentrations of 0.0043 s/cc (structure size ≥5µ). From observations of custodial work during the day, the elevated concentration of this personal sample is most likely attributable to the dusting and sweeping of the store room, despite the negative results of sample #81.

Sample # 120. The composition of custodial work during this personal sample was as follows: Sweeping (11%), dust mopping (22%),

miscellaneous (60%), vacuuming (7%). The custodian cleaned a seldom used storage room during this sampling period. Asbestos containing materials in this area included significantly damaged thermal system insulation located above the storage area. Approximately 15 minutes was spent sweeping the area with a dry broom. This area had a large accumulation of dust and was seldom cleaned. The majority of other work on this day involved little generation of dust.

DISTRIBUTION OF CUSTODIAL TIME. Custodial activities were monitored during each personal sampling period. Time spent on each activity has been averaged for all personal samples. Figure 2 gives the distribution of time, by percentage, spent on each of the listed job classes.

Figure 2: Average percentage distribution of an 8 hour workday on each task during personal sampling.

The distribution of work time, indicated in Figure 2 gives an approximation of the actual job exposure of custodians on an average day. A job such as dry broom sweeping, "sweep," which is high in exposure potential, occupies only about 4% of the work day. Thus the contribution of dry broom sweeping to daily exposure is low.

AREA SAMPLES. Area samples were collected in seven categories of custodial work. The numbers of samples distributed among these categories were as follows: Sweeping (5); buffing (8); dust mopping (32); dusting (8); stripping vinyl asbestos floor tile (5); vacuuming (12); and miscellaneous (13). Detectable asbestos structures were found in 16

(19.3%) of the analyzed area samples. Figure 3 gives the mean concentrations of area samples categorized by building location.

Figure 3: Arithmetic mean (<5μ, ≥5μ, and total) concentrations of area samples listed by collection site.

The means for area samples given here follow the trend established for personal samples in Figure 1. That is, Dallas County Courthouse shows the highest airborne concentration and the length of fibers is primarily <5μ.

Figure 4 gives the arithmetic mean of area samples categorized by job class. Three means are given for each job class (<5μ, ≥5μ, and total structure count). Of these three means, the mean for structures ≥5μ is the most relevant for comparison to occupational standards. As seen in previous figures, airborne asbestos fibers are primarily <5μ in length.

Figure 4: Arithmetic mean concentrations for area samples, categorized by job class. Calculations are made for means of structures <5μ, ≥5μ, and for total structure counts.

Listed in Table 3 are the 7 area samples with concentrations at or above 0.005 s/cc. Because these samples are intended to represent ambient concentrations, as compared to personal exposures, TWA's have not been calculated. Six of the seven of these samples were collected at the Dallas County Courthouse.

Table 3. Results of area samples with total concentrations at or above 0.005

ID #	<5µ	≥5µ	Total Conc.	Site	Job note
78	0.1118	0.0129	0.1247	Dallas CC	Sweeping in furncace room with in room.
80	0.0258	0.0043	0.0301	Dallas CC	Stripping VAT down to exposed tile.
26	0.0300	0.0000	.0.0300	Dallas CC	Vacuum beneath paint encapsulated ACM surfaced ceiling.
27	0.0240	0.0048	0.0288	Dallas CC	Dry buffing on VAT with poor wax seal.
25	0.0096	0.0000	0.0096	Dallas CC	Dust mop beneath paint encapsulated ACM surfaced ceiling.
75	0.0096	0.0000	0.0096	Dallas CC	Dustmop on VAT with poor wax coat.
113	0.0050	0.0000	0.0050	Ex Spr	45 minutes vacuuming, 187 minutes background.

Sample # 78. Area sample #78 was collected during the cleaning of a mechanical and air handling room. The concrete ceiling of this room was identified as having a surface coating of friable asbestos in the Department of Health's 1988 inspection. This surfacing had been removed at the time this study was conducted. Remnants of the original surface have been covered with paint. Debris on the floor and other horizontal surfaces of the room appeared to contain remnants of asbestos surfacing. The custodian worked in this room for approximately 90 minutes. Area sample #78 was collected concurrently with personal sample #74. Personal sample #74 which does not indicate a high personal exposure, had an 8 hr-TWA of 0.0000 s/cc.

Sample # 80. Area sample #80 was collected during the stripping of approximately 300 square feet of VAT floor. Stripping was done by applying a chemical stripper solution to the old floor wax, followed by removal using a rotary stripper/buffer machine. The stripper/buffer

machine was operated for one hour, resulting in the complete removal of wax and some direct abrasion of the VAT. This sample was collected as an area sample associated with the personal sample #79, which had an 8 hr-TWA of 0.0255 s/cc.

Sample # 27. Area sample #27 was collected during the dry buffing of 1000 square feet of VAT. This floor was not frequently buffed and was poorly coated with wax at the time of sampling. The procedure for buffing the floor consisted of an initial cleaning with an oil impregnated dust mop. This was followed by rotary buffing using a nylon pad. The operation required one hour. The area sample was collected in association with personal sample #24, which was rejected from analysis as too dirty to count.

REJECTED SAMPLES. Samples that were too dirty to count represented 12.3% of the samples collected (19. 1% of personal samples and 8.8% of area samples). These samples are listed in Table 4.

Table 4: Samples too dirty to count (TDTC) by AHERA counting rules for TEM, by probable source of overexposure.

ID #	Type	Site	Probable Source of Overexposure
17	Personal	Dallas CC	No identified probable source of overexposure
19	Personal	Dallas CC	Very dusty mechanical/furance room cleanup
23	Area	Dallas CC	Very dusty mechanical/furnace room cleanup
24	Personal	Dallas CC	Very dusty mechanical/furnace room cleanup
28	Area	Dallas CC	Very dusty mechanical/furnace room cleanup
178	Area	Ex Spr	Very dusty store room, with TSI on pipes above area
42	Personal	Franklin CC	Very dusty basement hallway cleanup
44	Area	Franklin CC	Very dusty basement hallway cleanup
46	Personal	Franklin CC	Includes dusting venetian blinds
91	Area	Franklin CC	Includes non-routine sweeping back stairs and dusting
94	Area	Franklin CC	Vicinity of old ACM ceiling tile, seldom cleaned
5	Personal	IP&L	Extremely dusty, fly ash at coal power plant
6	Personal	IP&L	Extremely dusty, fly ash at coal power plant
7	Area	IP&L	Dusting rails in area of coal fired boiler
129	Personal	IP&L	Mostly dustmopping, ongoing construction on boilers
131	Area	IP&L	Includes dustmopping in construction area
134	Personal	IP&L	replace VAT and dustmop in construction area

ASBESTOS STRUCTURE LENGTH AND WIDTH. Length and width measurements of 115 structures identified as asbestos were made. Arithmetic mean value for length of all structures was 2.45μ (SD +/-1.94 s/cc). The range of length data was 0.5μ to 9.5μ. Nine structures were measured at ≥5μ length. Arithmetic mean width was 0.14μ (SD +/- 0.18 s/cc). The range of width data was 0.1μ to 1.75μ. Lengths and widths were compared for asbestos structures collected at Dallas County Courthouse and Excelsior Springs City Hall, the two primary sites at which recordable asbestos structures were collected. No significant differences were found in length or width of structures coming from these two sites (p=0.05). Asbestos structures were proportionately divided in the following categories: Bundles, 7%; fibers, 15%; matrices, 78%.

QUALITY CONTROL SAMPLES. Nineteen samples were collected side-by-side for duplicate analysis at PSI. No significant difference was found between the original samples and the duplicates (p=0.05). Repreparations were done on seven samples. No significant difference was found between the original sample and the reprepared sample (p=0.05). One asbestos structure was found on a field blank, which gave a total concentration of 0.0045 s/cc. No explanation for this occurrence

was made. No other asbestos structures were found on field blanks or production lot blanks.

DISCUSSION

As an occupational group, custodial exposure to asbestos has not received the same attention which has been focused on persons whose work directly disturbs ACM in buildings. This paucity of research data has recently been noted in the comprehensive review of asbestos exposure research undertaken by the Health Effects Institute - Asbestos Research (HEI-AR,1991). From the limited data currently available, estimates of the occupational exposure of custodians to asbestos vary greatly. Sawyer (1977) measured levels of airborne asbestos resulting from custodial dusting of book shelves beneath a friable 20% chrysotile ceiling in a Yale University building. Concentration levels, as counted by polarized light microscopy, ranged from 1.6 fibers/cubic centimeter (f/cc) for dry sweeping to 4.0 f/cc for dry dusting. These concentrations would indicate a significant health hazard if they were representative of normal custodial exposures. By contrast, one of the mean values of ambient concentration recorded in EPA's Public Buildings Study (1988) was 0.00073 structures/cubic centimeter (s/cc). The samples that contributed to this mean were collected in areas of public buildings with significantly damaged ACM. Samples were subsequently analyzed by transmission electron microscopy (TEM). If predictions of custodial exposure were made based on the deposition and resuspension of asbestos dust, as measured in the Public Buildings Study, it would be reasonable to estimate that exposures would be quite low, well below the OSHA action level.

Concern has been expressed that routine custodial exposure may be a significant health hazard (HEI-AR, 1991; Indoor Air Review, 1991; Bricher, 1990). Catherine Oliver's review (1991) of the pulmonary radiographs and lung functions of custodians has focused attention on this issue. In Oliver's study, pulmonary radiographs and spirometric measurements were reviewed from a cohort of custodial employees who had been occupationally exposed to asbestos in the Boston Public Schools. The prevalence of pleural plaques and pulmonary restrictions, in excess of background rates, was attributed to custodial occupational exposure to asbestos. Pleural plaques are considered diagnostic traits of asbestos exposure. Advocates of custodial employees have called for more stringent controls of ACM in buildings to ensure occupational health protection.

The OSHA asbestos standard was used in this study for comparison to the obtained analytical results, with the acknowledgment that OSHA uses phase contrast microscopy (PCM) for analysis rather than TEM. The OSHA/PCM standard was used in the absence of a comparable TEM standard. In this study the arithmetic mean for all personal samples with fibers longer than 5 microns, is 0.0009 s/cc, 8 hour TWA. This mean is below the OSHA action level of 0.1 f/cc (95% Upper Confidence Level of 0.029 s/cc). In the case of the highest exposure building, Dallas County Courthouse, the building mean for personal exposure was 0.0099 s/cc, from Table 1. The 95% Upper Confidence Level for this mean is 0.032 s/cc, or 32% of the action level. The personal sample with the highest measured concentration, also from Dallas County Courthouse, was 0.0255 s/cc, Table 2, or 26% of the OSHA action level.

Mean values for all area samples was 0.0033 s/cc, with the mean for the area samples from Dallas County Courthouse at 0.0176 s/cc. These means included fibers of all lengths. Among individual area sample results, the highest concentration, 0.1247 s/cc, came from a sample collected during the dry broom sweeping of a furnace room at the Dallas County Courthouse. The ceiling of this room was originally coated with a friable asbestos surfacing material. This surfacing had been scraped off within the last five years and replaced with decorative paint. Debris and dust in the room were evident and cleanup of the room was rarely done, occurring less than once per year. Five additional area samples at Dallas County Courthouse also registered concentrations exceeding 0.005 s/cc. The custodial activities conducted during each of these sampling periods are described in the Job Notes, Table 3.

Included in the miscellaneous category of Figure 5 are two instances of small scale replacement of VAT flooring and the replacement of three damaged suspended ceiling tiles beneath a sprayed-on asbestos fireproofing. The miscellaneous category also included a high proportion of activities, such as wet mopping and moving equipment, when custodial exposure could not reasonably be expected to be higher than that of general building occupants.

REJECTED SAMPLES. The use of direct preparation TEM analysis presented difficulties in the assessment of custodial exposure to asbestos. In the custodial occupational environment, small concentrations of asbestos fibers were suspended in higher background concentrations of non-asbestos building dusts. In order to detect low concentrations of asbestos efficiently, it was necessary to draw a minimum volume (approximately 1000L) of air through the filter. In dusty environments, this volume of air caused the excessive buildup of dust on the filter. When 25% of the filter's grid area was obscured, the concentration of asbestos was considered too dirty to count (TDTC) by AHERA counting rules.

This problem was apparent in the attempts made in this study to collect peak custodial exposures. An example of this was the cleanup of the mechanical room at Dallas County Courthouse. The cleanup of this room, which reportedly had not been cleaned in the last three years, was not part of the custodian's routine duty. However, in an effort to define a "worst case scenario" for custodial exposure, the custodian was requested to clean this room during the study. A total of 7 samples (4 area, 3 personal) were collected. Of these 7 samples, 2 personal samples and 2 area samples were rejected as too dirty to count. The highest concentration for the samples which could be counted was 0.0874 s/cc, 8 hr-TWA.

Other samples that were TDTC are described in Table 4. From the right column of Table 4, it can be seen that overexposed samples generally occurred in association with the clean up of areas in buildings described as having a large amount of background dust. With the exception of Independence Power and Light, these areas of the buildings were excessively dusty because they were seldom, if ever, cleaned. These exposures have been considered episodic, or non-routine, rather than routine. Independence Power and Light was an exception to this, because excessive dust in the plant was due to the operation of the coal fired boilers, rather than to long periods between custodial services. This is a type of exposure which is routine, but applicable to only limited industrial populations.

LIMITATIONS OF DATA In discussing the results of this study, a distinction should be made between the two classes of samples collected. Personal samples, which are taken in the breathing zone of the custodian for an 8 hour work shift, represented actual occupational exposure. Area samples represented a potential exposure to building occupants who are in the vicinity of custodial activity for a time duration of approximately two hours. Area samples do not represent occupational exposure and can not be related to occupational standards. They did however, give an indication of the concentrations of airborne asbestos fibers generated during custodial work.

The present data can be used to assessed custodial exposure during tasks which were routinely performed on a daily, weekly, or monthly cycle. The data can not be used to make a valid assessment of tasks which fall under the general duties of custodians, but which are done on a non-routine basis. Routine exposures to custodians were reported to fall at or below the values obtained at Dallas County Courthouse, 0.0099 s/cc. The evaluation of custodial exposure levels for non-routine tasks can not be made from this data.

STUDY BIAS. A bias was established in this study which emphasized the occupational exposure of custodians to ACM. Work regimes were scheduled so that air sampling would predominately include activities which had the potential to dislodge or resuspend asbestos fibers. The buildings themselves were selected with a bias toward those buildings with damaged, friable ACM. The study did not attempt to define the "average" exposure of custodians. The rationale for the study's bias was to focus attention on those routine custodial activities which directly involved ACM and to document the resultant level of custodial exposure.

CONCLUSION

This study determined that custodians who performed routine activities in buildings which contained friable, asbestos materials were not exposed to levels of airborne asbestos which approached the OSHA action level of 0.1 f/cc. The arithmetic mean value for 38 personal samples, analyzed by TEM, was 0.0009 s/cc, 8 hr-TWA for structure lengths ≥5μ. The study attempted to bias sampling in order to maximize the number of occurrences in which custodians worked with asbestos containing materials. Even with this bias, resulting exposure levels were well below the OSHA action level.

A proportion of samples (12.3%) were rejected from analysis as too dirty to count. These samples predominantly reflect collections made under non-routine conditions. Hypothetically, the rejected samples contain higher asbestos content than the analyzed samples. The conclusion remains firm, however, that during routine activities the exposure of custodians is very low and does not pose a significant risk for the development of asbestos related diseases.

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