Designation: D7390 – 18

Standard Guide for Evaluating Asbestos in Dust on Surfaces by Comparison Between Two Environments[1]

This standard is issued under the fixed designation D7390; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 There are multiple purposes for determining the loading of asbestos in dust on surfaces. Each particular purpose may require unique sampling strategies, analytical methods, and procedures for data interpretation. Procedures are provided to facilitate application of available methods for determining asbestos surface loadings and/or asbestos loadings in surface dust for comparison between two environments. At present, this guide addresses one application of the ASTM surface dust methods. It is anticipated that additional areas will be added in the future. It is not intended that the discussion of one application should limit use of the methods in other areas.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see 5.7.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D5755 Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading

D6480 Test Method for Wipe Sampling of Surfaces, Indirect Preparation, and Analysis for Asbestos Structure Number Surface Loading by Transmission Electron Microscopy

E456 Terminology Relating to Quality and Statistics

E2356 Practice for Comprehensive Building Asbestos Surveys

3. Terminology

3.1 *Definitions*—Unless otherwise noted all statistical terms are as defined in Terminology E456.

3.1.1 *activity generated aerosol, n*—a dispersion of particles in air that have become airborne due to physical disturbances such as human activity, sweeping, airflow, etc.

3.1.2 *background samples, n*—samples taken from surfaces that are considered to have concentrations of asbestos in surface dust that are representative of conditions that exist in an environment that is affected by only prevailing conditions and has not experienced events, disturbances or activities unusual for the environment.

3.1.3 *control, n*—an area that is used as the basis for a comparison.

3.1.3.1 *Discussion*—This could be an area where the dust has been previously characterized, an area thought to be suitable for occupancy, an area that has not experienced a disturbance of asbestos-containing materials, or that is for some other reason deemed to be suitable as the basis for a comparison.

3.1.4 *control samples, n*—samples collected for comparison to the study samples.

3.1.4.1 *Discussion*—These differ from background samples in that they are collected: either: in an area where the dust has been previously characterized, or in an area that has not experienced a disturbance of asbestos-containing materials, or in an area that is for some other reason deemed to be suitable as the basis for comparison.

3.1.5 *dust, n*—any material composed of particles in a size range of <1 mm.

3.1.6 *environment, n*—well defined three-dimensional area and everything that is in it.

[1] This guide is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.07 on Sampling and Analysis of Asbestos.

Current edition approved June 1, 2018. Published July 2018. Originally approved in 2007. Last previous edition approved in 2012 as D7390 – 07 (2012). DOI: 10.1520/D7390-18.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.7 *homogeneous samples, n*—group of samples that are collected from surfaces that are visually similar in texture, dust loading and environment.

3.1.8 *laboratory blank, n*—a cassette or wipe taken from laboratory stock that are not affected by field activities.

3.1.9 *loading, n*—quantity of asbestos in the dust found on a surface as measured by the ASTM standard methods for evaluating asbestos in dust on surfaces.

3.1.10 *open field blank, n*—cassette or wipe opened in the field as if for sample collection and then immediately closed that is analyzed in the same manner as a regular sample.

3.1.11 *power, n*—power of the test is the probability, expressed as a decimal fraction, that a specified difference between asbestos surface loadings in two environments will be detected by the test.

3.1.12 *replicates, n*—samples collected from an area that is visually identified as homogeneous.

3.1.13 *sampling set, n*—samples collected on the same day on surfaces in an area for the purpose of characterizing the asbestos loading in the dust of the samples surfaces in that area.

3.1.14 *sealed field blank, n*—cassette or wipe taken to the field but remaining closed at all times.

3.1.15 *study samples, n*—samples collected in an area believed to have experienced events, disturbances or activities affecting asbestos-containing materials.

3.1.15.1 *Discussion*—The area in which these samples are taken is called the study area. Study samples are compared to background samples or control samples.

4. Summary of Guide

4.1 The guidance contained in this document was developed for applications of Test Methods D5755 and D6480. The application addressed in this document is sampling to test for differences in surface loading in two or more environments including comparison to environments that may be considered to be "background."

4.2 Factors affecting the selection of sampling sites and types of samples to be collected are described in Appendix X1. These factors include:

4.2.1 Uniformity and distribution of dust within a building,
4.2.2 The nature of dust found within buildings,
4.2.3 The nature of the surface from which samples are to be collected,
4.2.4 Past disturbances of asbestos-containing materials,
4.2.5 Environmental conditions,
4.2.6 Ventilation,
4.2.7 Building history,
4.2.8 Occupation and activity of occupants, and
4.2.9 Outdoor sampling.

4.3 This guide describes statistical procedures to be used for:

4.3.1 Defining sampling needs including the size, number and location of samples required to address a particular application; and

4.3.2 Interpreting analytical results—estimating loadings or loadings from single or multiple-sample results, establishing confidence intervals for such estimates, and comparing between such estimates.

5. Significance and Use

5.1 This guide describes factors to be considered by an investigator designing a sampling program to compare the asbestos dust loadings in two environments and presents statistical methods for making the comparison. Each user is responsible for the design of an investigation and the interpretation of data collected when using dust data.

5.2 This guide does not deal with situations where dusts of different compositions or from different surfaces are to be evaluated.

5.3 This guide describes methods for interpreting the results of sampling and analysis performed in accordance with Test Methods D5755 and D6480. It may be appropriate to use the procedures in this guide with other dust collection and analysis methods, but it is the responsibility of the user to make this determination.

5.4 The methods described in this guide are not intended to be used alone. They are intended to be used along with various evaluation methods that may include consideration of building use, activities within the building, air sampling, asbestos surveys (refer to Practice E2356), evaluation of building history and study of building ventilation systems.

5.5 This guide describes methods for comparing environments and does not draw any conclusions relating asbestos surface loadings to the potential safety or habitability of buildings.

5.6 This guide does not address risk assessments or the use of dust sampling in risk assessment. Health based risk assessments are beyond the scope of this guide.

5.7 **Warning—**Asbestos fibers are acknowledged carcinogens. Breathing asbestos fibers can result in disease of the lungs including asbestosis, lung cancer, and mesothelioma. Precautions should be taken to avoid creating and breathing airborne asbestos particles when sampling and analyzing materials suspected of containing asbestos. Regulatory requirements addressing asbestos are defined by USEPA[3,4] and OSHA.[5]

6. Comparison Between Environments

6.1 One use of dust sampling is to compare the asbestos dust loadings on surfaces in two environments. This guide describes several ways in which such a comparison might be made. The user should consider these and other site-specific factors in Appendix X1, Factors Affecting Sample Collection, that may affect the interpretation of results and the need to proceed beyond the Baseline Calculations in Section 7.

6.1.1 *Comparison to Background Samples*—If one environment is considered to represent conditions that are typical of a building this could be used as the source of background

[3] USEPA, 40 CFR Part 61, Subpart M.
[4] USEPA, 40 CFR Part 763, Subpart E.
[5] OSHA, 29 CFR Parts 1910, 1915, and 1926.

samples against which study samples from areas in questions could be compared. Areas may be in question due to disturbance of an asbestos-containing material, damage to the building materials, change in occupancy or any other occurrence that could change the asbestos loading in dust.

6.2 *Sample Collection Requirements:*

6.2.1 *Homogeneous Dust*—A visual determination should be made about the homogeneity of the dust and site to be sampled. Samples should be collected from homogeneous locations within each area—study and background. A location is considered to be homogeneous if:

6.2.1.1 The sample sites have visually similar depositions of dust on their surfaces, including the absence of visible dust.

6.2.1.2 The surfaces to be sampled have the same type of surface texture based upon a visual determination.

6.2.2 The efficiency of dust collection on a given surface is likely to be different for wipe and microvacuum methods (see Crankshaw et al. (**1**)[6]). As such, the same sample collection method should be used for samples that are to be compared.

6.3 *Selection of Sampling Locations:*

6.3.1 *Representative Locations*—Samples should be collected from locations and surfaces that are representative of the environments to be tested. In the study area proximity to sources of asbestos fiber release may be a consideration.

6.3.2 Depending on the configuration of the sampling site and surfaces to be sampled, it may be possible to randomize the selection of sampling locations with a random number table or other means. Accessibility of sites for sampling may be limited by safety, security, or other considerations.

6.4 *Number of Samples:*

6.4.1 A sufficient number of samples should be collected to be able to discern differences that may exist between the study area and background area. For the examples of Baseline Calculations in Section 7 this number is defined as five study samples and, where taken, five background samples. Cost and accessibility being factors that affect the number of samples taken, this combination of sample sets is seen as the minimum from which a reasonable comparison of results may be made. If the user cannot do so, additional samples or statistical tests as described in Appendix X2 may be considered.

6.5 *Sampling and Analytical Requirements:*

6.5.1 Collect and analyze samples as described in Test Methods D5755 and D6480.

6.5.2 *Quality Control Requirements*—The following blanks should be collected as part of the sampling:

6.5.2.1 A sealed field blank per lot of cassettes or wipes.

6.5.2.2 One open field blank for each set of five study samples and one open field blank for each set of five background samples, if taken.

6.5.2.3 Blanks should be sent to the laboratory for analysis in the same manner as a regular sample. Blanks need not be analyzed if no asbestos is found in the study samples or background samples. If asbestos is found the "Open Field Blanks" should be analyzed. If asbestos is found on the "Open Field Blanks," then the "Sealed Field Blanks" should be analyzed. If no asbestos is found on the "Open Field Blank" there is no need to analyze the sealed blanks. If any blank is found to contain more than the limit set forth in the section on blanks in the appropriate method then the sampling may be considered to be suspect. Do not adjust the sample results with the results of the blank filter analyses.

6.6 *Data Interpretation:*

6.6.1 For each sample set the Analytical Parameters tabulated for the examples in Section 7 should be extracted from the laboratory report. For each sample the number of asbestos structures counted, analytical sensitivity of the analysis, and surface loading should be entered in the tables for the study samples and background samples. Where both study samples and background samples are taken, the upper and lower 95 % confidence limits (95 % combined upper confidence limit (95 % UCL) and 95 % combined lower confidence limit (95 % LCL)) can be calculated for the background samples and study samples, respectively, using the procedures in Section 7. The example most descriptive of the user's investigation should be used as a guide.

6.6.2 For each sample set the Combined Measurements tables in Section 7 should be completed according to the instructions provided. Where both study samples and background samples are taken, if the 95 % LCL of the study samples is less than the 95 % UCL of the background samples the distributions overlap, indicating no statistical difference.

6.6.3 Where no background samples are taken, Section 7 presents appropriate comparisons from which the user may also draw reasonable inferences. After reviewing the results of the study sample analyses and, in consultation with the laboratory, the user may want to dispense with analysis of the background samples if the information from them would not justify the cost or time required.

6.6.4 If the overlap or separation of the confidence intervals is small the Baseline Calculations in Section 7 may be augmented with other statistical tests described in Appendix X2 to confirm the conclusion.

6.7 *Asbestos Structure Types and Sizes:*

6.7.1 The mineral form(s) of the asbestos found during analysis of dust samples should be considered. If the mineral form of the asbestos within or between sample sets (study and background) differs, the user shall consider the impact on the interpretation of the data and the decisions derived therefrom.

6.7.2 If the size or type of asbestos structures differs between the study samples and background samples this also may indicate a difference in the dust loadings at each site. For example, if one set of samples consists of small fibers and the other set has large matrices, then these areas would appear to be different. As such, additional investigation may be necessary in such an instance, even if statistical analysis of the number or mass of particles finds no difference between the sites.

6.8 *Reporting:*

6.8.1 The user's report should contain sufficient information to allow the reader to locate the sampling sites, and repeat the sampling if conditions permit.

6.8.2 The complete data set should be reported, including results of blanks and background samples.

[6] The boldface numbers in parentheses refer to a list of references at the end of this standard.

6.8.2.1 For each sample the number of asbestos structures, analytical sensitivity, asbestos loading and upper and lower 95 % confidence limits on the asbestos loading should be tabulated according to the examples and procedures in Section 7.

6.8.2.2 For each Combined Set of samples the total asbestos structures counted, sum of sensitivity weights, and estimate of asbestos loading for the environment along with upper and lower 95 % confidence limits on this estimate should be tabulated according to the examples and procedures in 7.

6.8.2.3 If statistical tests other than those in Section 7 are used, the type of statistical comparisons and results of these comparisons should be given.

6.8.3 Laboratory reports should be included as an appendix to the report.

7. Examples of Baseline Calculations

7.1 Each of the eight examples in this section illustrates the calculation procedures to compare study samples to background samples or other criteria. The examples describe typical scenarios encountered in settled dust sampling and analysis for asbestos, and have the following attributes.

7.1.1 All examples are based on five study samples and, where applicable, five background samples.

7.1.2 The tables in each example illustrate separately calculations for the individual study samples and, where applicable, the individual background samples, followed by calculations for the combined study samples and, where applicable, the combined background samples, then comparing the distributions of the combined sample sets.

7.1.3 The combined sample sets are compared by calculating the 95 % Lower Confidence Limit (95 % LCL) of the study samples to the 95 % Upper Confidence Limit (95 % UCL) of the background samples. If the confidence limits overlap the user can reasonably conclude that there is no significant statistical difference at the 95 % confidence level.

7.1.4 Test Method D5755 directs the analyst to "stop on grid opening No. 10 or the grid opening which contains the 100th asbestos structure, whichever comes first." It is not uncommon for the analyst to identify 100 asbestos structures before counting ten grid openings. If that happens with one or more of the study samples the 95 % LCL will far exceed the 95 % UCL of background samples taken in an uncontaminated background environment. The user may conclude that there is a statistical difference between surface loadings in the study and uncontaminated background areas, and dispense with the collection or analysis of background samples. No calculations are needed to support this decision.

7.2 These calculations may suffice for the user to make a decision based on the results or may be considered an initial screening to be followed by additional sampling and analysis, or the application of further statistical tests as described in Appendix X2.

7.3 The 95 % LCL and 95 % UCL are determined from the Poisson distribution in Table 1. For each number of structures, N, the 95 % LCL and 95 % UCL in Table 1 have been calculated by the following formulas: (IF(N>0, (CHIINV(0.975,2·N)/2),0)) for the 95% LCL and (IF(N>0, (CHIINV(0.025,2·(N+1))/2),(CHIINV(0.05,2)/2))) for the 95% UCL.

7.3.1 The 95 % LCL and 95 % UCL in Table 1 refer to the number of structures at these limits, not the surface loading, which is calculated from the analytical parameters as shown in the examples.

7.3.2 The following terms are used in the tables in the examples. All of the Analytical Parameters should be in the laboratory report or available from the laboratory. (See also 3.1, Definitions.)

7.3.2.1 Effective filter area is the area of the filter on which the rinse solution aliquot is deposited for TEM analysis. It is not the area of the filter in the sample collection cassette, which is not analyzed.

7.3.2.2 Sample area is the area of the surface sampled by the user and is assumed to be 100 cm² unless the user specifies otherwise. It may vary for different samples.

7.3.2.3 Volume filtered is the volume of the rinse solution aliquot deposited on the filter for TEM analysis. It may vary for different samples.

7.3.2.4 Analytical Sensitivity is the surface loading calculated on the basis of finding one structure in the sample and is a function of the analytical parameters. It may vary for different samples.

7.3.2.5 Number of Structures is the total number counted in all grid openings for the sample according to the counting rules of the analytical method.

7.3.2.6 Sensitivity Weight is the reciprocal of the Analytical Sensitivity for each sample.

7.3.2.7 Structures 95 % LCL is the lower 95 % confidence limit of the study samples and Structures 95 % UCL is the upper 95 % confidence limit of the background samples, based on the Poisson distribution in Table 1. (See 7.3.)

7.4 *Example 1 — Study Samples Exceed Background Sample but No Statistical Difference* (Tables 2-6):

7.4.1 Example 1 illustrates a hypothetical situation where a contractor scraped off small sections of asbestos-containing fireproofing on one floor of an office building. The work was done at several locations and when the error was discovered the area was cleaned up using a high efficiency particulate air filtered vacuum cleaner and wet wiping of all surfaces. The building owner demanded the air and surfaces in the affected area be at least as clean as other parts of the building not affected. To answer the surface cleanliness question five samples were collected from non-porous surfaces in the affected area and five samples from another floor on a different ventilation system (unaffected or background area). The results and analysis of the data are described in Tables 2-6.

7.4.2 This example uses the analytical parameters in Table 2 that are taken from the laboratory report.

7.4.3 The analytical parameters are used to calculate the study area results in Table 3 and Table 4.

7.4.4 In Table 3:

(1) The number of structures and analytical sensitivity are taken from the laboratory report.

(2) The Estimated Loading is the product of the Number of Structures and the Analytical Sensitivity.

TABLE 1 Upper and Lower 95 % Confidence Limits for the Poisson Distribution

N = Number of Structures			N = Number of Structures			N = Number of Structures			N = Number of Structures		
N	95 % LCL	95 % UCL	N	95 % LCL	95 % UCL	N	95 % LCL	95 % UCL	N	95 % LCL	95 % UCL
0	0.000	3.0	50	37.1	65.9	100	81.4	122	150	127	176
1	0.025	5.6	51	38.0	67.1	101	82.3	123	151	128	177
2	0.24	7.2	52	38.8	68.2	102	82.3	124	152	129	178
3	0.62	8.8	53	39.7	69.3	103	84.1	125	153	130	179
4	1.1	10.2	54	40.6	70.5	104	85.0	126	154	131	180
5	1.6	11.7	55	41.4	71.6	105	85.9	127	155	132	181
6	2.2	13.1	56	42.3	72.7	106	86.8	128	156	132	182
7	2.8	14.4	57	43.2	73.9	107	87.7	129	157	133	184
8	3.5	15.8	58	44.0	75.0	108	88.6	130	158	134	185
9	4.1	17.1	59	44.9	76.1	109	89.5	131	159	135	186
10	4.8	18.4	60	45.8	77.2	110	90.4	133	160	136	187
11	5.5	19.7	61	46.7	78.4	111	91.3	134	161	137	188
12	6.2	21.0	62	47.5	79.5	112	92.2	135	162	138	189
13	6.9	22.2	63	48.4	80.6	113	93.1	136	163	139	190
14	7.7	23.5	64	49.3	81.7	114	94.0	137	164	140	191
15	8.4	24.7	65	50.2	82.8	115	94.9	138	165	141	192
16	9.1	26.0	66	51.0	84.0	116	95.9	139	166	142	193
17	9.9	27.2	67	51.9	85.1	117	96.8	140	167	143	194
18	10.7	28.4	68	52.8	86.2	118	97.7	141	168	144	195
19	11.4	29.7	69	53.7	87.3	119	98.6	142	169	144	196
20	12.2	30.9	70	54.6	88.4	120	99.5	143	170	145	198
21	13.0	32.1	71	55.5	89.6	121	100	145	171	146	199
22	13.8	33.3	72	56.3	90.7	122	101	146	172	147	200
23	14.6	34.5	73	57.2	91.8	123	102	147	173	148	201
24	15.4	35.7	74	58.1	92.9	124	103	148	174	149	202
25	16.2	36.9	75	59.0	94.0	125	104	149	175	150	203
26	17.0	38.1	76	59.9	95.1	126	105	150	176	151	204
27	17.8	39.3	77	60.8	96.2	127	106	151	177	152	205
28	18.6	40.5	78	61.7	97.3	128	107	152	178	153	206
29	19.4	41.6	79	62.5	98.5	129	108	153	179	154	207
30	20.2	42.8	80	63.4	99.6	130	109	154	180	155	208
31	21.1	44.0	81	64.3	101	131	110	155	181	156	209
32	21.9	45.2	82	65.2	102	132	110	157	182	157	210
33	22.7	46.3	83	66.1	103	133	111	158	183	157	212
34	23.5	47.5	84	67.0	104	134	112	159	184	158	213
35	24.4	48.7	85	67.9	105	135	113	160	185	159	214
36	25.2	49.8	86	68.8	106	136	114	161	186	160	215
37	26.1	51.0	87	69.7	107	137	115	162	187	161	216
38	26.9	52.2	88	70.6	108	138	116	163	188	162	217
39	27.7	53.3	89	71.5	110	139	117	164	189	163	218
40	28.6	54.5	90	72.4	111	140	118	165	190	164	219
41	29.4	55.6	91	73.3	112	141	119	166	191	165	220
42	30.3	56.8	92	74.2	113	142	120	167	192	166	221
43	31.1	57.9	93	75.1	114	143	121	168	193	167	222
44	32.0	59.1	94	76.0	115	144	121	170	194	168	223
45	32.8	60.2	95	76.9	116	145	122	171	195	169	224
46	33.7	61.4	96	77.8	117	146	123	172	196	170	225
47	34.5	62.5	97	78.7	118	147	124	173	197	170	227
48	35.4	63.6	98	79.6	119	148	125	174	198	171	228
49	36.3	64.8	99	80.5	121	149	126	175	199	172	229

TABLE 2 Analytical Parameters for Example 1

Effective filter area	923 mm^2
Number of grid openings examined	10
Average grid opening area	0.009 mm^2
Sample area	100 cm^2
Total volume	100 mL
Volume filtered	50 mL
Analytical sensitivity	205 s/cm^2

(3) Structures 95 % LCL is read from Table 1.

(4) Loading 95 % LCL is the product of the Structures 95 % LCL and the Analytical Sensitivity.

7.4.5 In Table 4:

(1) Total Structures is the sum of the Number of Structures in Table 3.

(2) The Sum of Sensitivity Weights is the sum of Sensitivity Weights in Table 3.

(3) The Weighted Analytical Sensitivity is the reciprocal of the Sum of Sensitivity Weights.

(4) The Estimated Loading is the product of the Total Structures and the Weighted Analytical Sensitivity.

TABLE 3 Study Samples for Example 1

Sample Number	Number of Structures	Analytical Sensitivity (s/cm^2)	Sensitivity Weight	Estimated Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)
S1	10	205	0.0049	2050	4.8	984
S2	4	205	0.0049	820	1.1	226
S3	13	205	0.0049	2665	6.9	1415
S4	4	205	0.0049	820	1.1	226
S5	6	205	0.0049	1230	2.2	451

TABLE 4 Combined Measurements of Study Samples for Example 1

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	95 % LCL	
				Structures (Table 1)	Loading (s/cm^2)
37	0.024	41.0	1517	26.1	1070

TABLE 5 Background Samples for Example 1

Sample Number	Number of Structures	Analytical Sensitivity (s/cm^2)	Sensitivity Weights	Loading (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
B1	3	205	0.0049	615	8.8	1804
B2	4	205	0.0049	820	10.2	2091
B3	3	205	0.0049	615	8.8	1804
B4	4	205	0.0049	820	10.2	2091
B5	6	205	0.0049	1230	13.1	2686

TABLE 6 Combined Measurements of Background Samples for Example 1

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	95 % UCL	
				Structures (Table 1)	Loading (s/cm^2)
20	0.024	41.0	820	30.9	1267

(5) 95 % LCL Structures is read from Table 1.

(6) Loading is the product of 95 % LCL Structures and Weighted Analytical Sensitivity.

7.4.6 The same analytical parameters are used to calculate the background area results in Table 5 and Table 6.

7.4.7 The calculation procedures for the background samples in Table 5 and Table 6 are the same as for the study samples in Table 3 and Table 4. For example, Table 5 shows that a structure count of 3 for sample B1 has a 95 % UCL of 8.8 structures, giving a 95 % UCL loading of 1804 s/cm^2. In Table 6 Total Structures is the sum of the structures in Table 5.

7.4.8 The 95 % LCL for the combined set of study samples in Table 4 — 1070 s/cm^2 — is less than the 95 % UCL for the background samples — 1267 s/cm^2 — in Table 6 . Since the distributions for the two sample sets overlap, there is no statistical difference at the 95 % confidence level.

7.5 *Example 2 — Clear Statistical Difference Between Study and Background Samples* (Tables 7-11):

7.5.1 Example 2 illustrates a hypothetical situation where a contractor scraped off small sections of asbestos-containing fireproofing on one floor of an office building. The work was done at several locations and when the error was discovered the area was cleaned up using a high efficiency particulate air filtered vacuum cleaner only. The building owner demanded the air and surfaces in the affected area be at least as clean as other parts of the building not affected. To answer the surface cleanliness question five samples were collected from non-porous surfaces in the affected area and five samples from another floor on a different ventilation system (unaffected or background area). The results and analysis of the data are described in Tables 7-11.

7.5.2 This example uses the analytical parameters in Table 7 that are taken from the laboratory report.

7.5.3 The analytical parameters are used to calculate the study area results in Table 8 and Table 9.

TABLE 7 Analytical Parameters for Example 2

Effective filter area	923 mm^2
Number of grid openings examined	10
Average grid opening area	0.009 mm^2
Sample area	100 cm^2
Total volume	100 mL
Volume filtered	50 mL
Analytical sensitivity	205 s/cm^2

TABLE 8 Study Area Samples for Example 2

Sample Number	Number of Structures	Analytical Sensitivity (s/cm^2)	Sensitivity Weight	Estimated Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)
S1	41	205	0.0049	8405	29.4	6027
S2	27	205	0.0049	5535	17.8	3649
S3	57	205	0.0049	11685	43.2	8856
S4	22	205	0.0049	4510	13.8	2829
S5	46	205	0.0049	9430	33.7	6908

TABLE 9 Combined Measurements of Study Samples for Example 2

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	95 % LCL	
				Structures (Table 1)	Loading (s/cm^2)
193	0.024	41.0	7913	167	6847

TABLE 10 Background Area Samples for Example 2

Sample Number	Number of Structures	Analytical Sensitivity (s/cm^2)	Sensitivity Weights	Loading (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
B1	3	205	0.0049	615	8.8	1804
B2	4	205	0.0049	820	10.2	2091
B3	3	205	0.0049	615	8.8	1804
B4	4	205	0.0049	820	10.2	2091
B5	6	205	0.0049	1230	13.1	2686

TABLE 11 Combined Measurements of Background Samples for Example 2

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	95 % UCL	
				Structures (Table 1)	Loading (s/cm^2)
20	0.024	41.0	820	30.9	1267

7.5.4 In Table 8:

(1) The number of structures and analytical sensitivity are taken from the laboratory report.

(2) The Estimated Loading is the product of the Number of Structures and the Analytical Sensitivity.

(3) 95 % LCL is read from Table 1.

(4) Loading 95 % LCL is the product of the Structures 95 % LCL and the Analytical Sensitivity.

7.5.5 In Table 9:

(1) Total Structures is the sum of the Number of Structures in Table 8.

(2) The Sum of Sensitivity Weights is the sum of Sensitivity Weights in Table 8.

(3) The Weighted Analytical Sensitivity is the reciprocal of the Sum of Sensitivity Weights.

(4) The Estimated Loading is the product of the Total Structures and the Weighted Analytical Sensitivity.

(5) 95 % LCL Structures is read from Table 1.

(6) Loading is the product of 95 % LCL Structures and Weighted Analytical Sensitivity.

7.5.6 The same analytical parameters are used to calculate the background area results in Table 10 and Table 11.

7.5.7 The calculation procedures for the background samples in Table 10 and Table 11 are the same as for the study samples in Table 8 and Table 9. For example, Table 10 shows that a structure count of 3 for sample B1 has a 95 % UCL of 8.8 structures, giving a 95 % UCL loading of 1804 s/cm^2. In Table 11 Total Structures is the sum of the structures in Table 10.

7.5.8 The 95 % LCL for the combined set of study samples in Table 9 — 6847 s/cm^2 — is more than the 95 % UCL for the background samples — 1267 s/cm^2 — in Table 11. Since the distributions for the two sample sets do not overlap, the study samples are statistically higher at the 95 % confidence level. The surfaces are therefore not clean enough.

TABLE 12 Analytical Parameters for Example 3

Effective filter area			923	mm^2
Number of grid openings examined			10	
Average grid opening area			0.009	mm^2
Sample area			100	cm^2
Total volume			100	mL
Volume filtered	25	10	5	mL
Analytical sensitivity	410	1025	2050	s/cm^2

7.6 *Example 3 — Calculation with Different Analytical Parameters (Volume Filtered)* (Tables 12-16):

7.6.1 Example 3 illustrates a hypothetical situation where there was a fire on three floors of an office building. The top floor had asbestos-containing structural fireproofing applied to the steel beams. There was a concern raised that there might be asbestos on the surfaces of the top floor due to the fire. The decision was made to collect surface dust samples from the top floor and the lowest floor to look for asbestos in the dust. In this example the surfaces were covered with smoke particulate, ash, and other dusts. It was necessary for the laboratory to make dilutions of the samples due to this dust. This resulted in the analytical sensitivity of the samples to be different depending on the amount of sample filtered. The results and analysis of the data are described in Tables 12-16.

7.6.2 This example uses the analytical parameters in Table 12 that are taken from the laboratory report.

7.6.3 The analytical parameters are used to calculate the study area results in Table 13 and Table 14.

7.6.4 In Table 13:

(1) The number of structures and analytical sensitivity are taken from the laboratory report. The analytical sensitivity corresponds to the volume filtered. For example, if only 5 mL was filtered then the analytical sensitivity was 2050 s/cm^2 in this example.

(2) The Estimated Loading is the product of the Number of Structures and the Analytical Sensitivity.

(3) Structures 95 % LCL is read from Table 1.

(4) Loading 95 % LCL is the product of the Structures 95 % LCL and the Analytical Sensitivity.

7.6.5 In Table 14:

(1) Total Structures is the sum of the Number of Structures in Table 13.

(2) The Sum of Sensitivity Weights is the sum of Sensitivity Weights in Table 13.

(3) The Weighted Analytical Sensitivity is the reciprocal of the Sum of Sensitivity Weights.

(4) The Estimated Loading is the product of the Total Structures and the Weighted Analytical Sensitivity.

(5) 95 % LCL Structures is read from Table 1.

(6) Loading is the product of 95 % LCL Structures and Weighted Analytical Sensitivity.

7.6.6 The same analytical parameters are used to calculate the background area results in Table 15 and Table 16.

7.6.7 The calculation procedures for the background samples in Table 15 and Table 16 are the same as for the study samples in Table 13 and Table 14. For example, Table 13 shows that a structure count of three for sample B1 has a 95 % UCL of 8.8 structures, giving a 95 % UCL loading of 3608 s/cm^2. In Table 16 Total Structures is the sum of the structures in Table 13.

7.6.8 The 95 % LCL for the combined set of study samples in Table 14 — 24124 s/cm^2 — is more than the 95 % UCL for the background samples — 4488 s/cm^2 — in Table 16. Since the distributions for the two sample sets do not overlap, the study samples are statistically higher at the 95 % confidence level. The surfaces on the top floor will need to be cleaned to get them at least as clean as the lowest floor.

7.7 *Example 4 — Background Sample Set with a Zero Structure Count* (Tables 17-21):

7.7.1 One or more zero structure counts can be expected in background samples if the area is free of known sources of asbestos-containing materials. In this example, the study samples and background samples are repeated from Example 1, except that for background sample B3 the laboratory reported "NSD" for "No Structures detected."

7.7.2 This example uses the analytical parameters in Table 17 that are taken from the laboratory report.

7.7.3 The analytical parameters are used to calculate the study area results in Table 18 and Table 19.

7.7.4 In Table 18:

(1) The number of structures and analytical sensitivity are taken from the laboratory report.

(2) The Estimated Loading is the product of the Number of Structures and the Analytical Sensitivity.

(3) Structures 95 % LCL is read from Table 1.

(4) Loading 95 % LCL is the product of the Structures 95 % LCL and the Analytical Sensitivity.

7.7.5 In Table 19:

(1) Total Structures is the sum of the Number of Structures in Table 18.

(2) The Sum of Sensitivity Weights is the sum of Sensitivity Weights in Table 18.

(3) The Weighted Analytical Sensitivity is the reciprocal of the Sum of Sensitivity Weights.

(4) The Estimated Loading is the product of the Total Structures and the Weighted Analytical Sensitivity.

(5) 95 % LCL Structures is read from Table 1.

(6) Loading is the product of 95 % LCL Structures and Weighted Analytical Sensitivity.

7.7.6 The same analytical parameters are used to calculate the background area results in Table 20 and Table 21.

7.7.7 The calculation procedures for the background samples in Table 20 and Table 21 are the same as for the study samples in Table 18 and Table 19. Table 1 shows that a zero

TABLE 13 Study Samples for Example 3

Sample Number	Number of Structures	Volume Filtered (mL)	Analytical Sensitivity Loading (s/cm^2)	Sensitivity Weights	Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)
S1	16	10	1 025	0.00098	16400	9.1	9328
S2	12	5	2 050	0.00049	24600	6.2	12710
S3	32	5	2 050	0.00049	65600	21.9	44895
S4	18	5	2 050	0.00049	36900	10.7	21935
S5	10	5	2 050	0.00049	20500	4.8	9840

TABLE 14 Combined Measurements of Study Samples for Example 3

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	95 % LCL	
				Structures (Table 1)	Loading (s/cm^2)
88	0.0029	341.7	30070	70.6	24124

TABLE 15 Background Samples for Example 3

Sample Number	Number of Structures	Volume Filtered (mL)	Analytical Sensitivity (s/cm^2)	Sensitivity Weights	Loading (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
B1	3	25	410	0.00244	1230	8.8	3680
B2	3	10	2050	0.00049	6150	8.8	18040
B3	2	10	2050	0.00049	4100	7.2	14760
B4	1	10	2050	0.00049	2050	5.6	11480
B5	2	10	2050	0.00049	4100	7.2	14760

TABLE 16 Combined Measurements of Background Samples for Example 3

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	95 % UCL	
				Structures (Table 1)	Loading (s/cm^2)
11	0.004	227.8	2506	19.7	4488

TABLE 17 Analytical Parameters for Example 4

Effective filter area	923 mm^2
Number of grid openings examined	10
Average grid opening area	0.009 mm^2
Sample area	100 cm^2
Total volume	100 mL
Volume filtered	50 mL
Analytical sensitivity	205 s/cm^2

TABLE 18 Study Samples for Example 4

Sample Number	Number of Structures	Analytical Sensitivity (s/cm^2)	Sensitivity Weight	Estimated Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)
S1	10	205	0.00049	2050	4.8	984
S2	4	205	0.00049	820	1.1	226
S3	13	205	0.00049	2665	6.9	1415
S4	4	205	0.00049	820	1.1	226
S5	6	205	0.00049	1230	2.2	451

TABLE 19 Combined Measurements of Study Samples for Example 4

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)
37	0.024	41.0	1517	26.1	1070

structure count has a 95 % UCL of 3 structures, giving a 95 % UCL loading of 615 s/cm^2 for sample B3 in Table 20.

7.7.8 The 95 % LCL for the combined set of study samples in Table 19 — 1,070 s/cm^2 — is less than the 95 % UCL for the background samples — 1.115 s/cm^2 — in Table 21. Although no structures were found in sample B3, indicating a zero surface loading for that sample, the variability of the sample affects the combined measurements and the sample cannot be disregarded. Because of the slight overlap of the distributions for the two sample sets showing no statistical difference at the 95 % confidence level, the user may decide to consider other factors in deciding whether or not to re-clean the study area.

7.8 *Example 5 — Study Samples Only — No Background Samples* (Tables 22-24):

7.8.1 Background samples are often not taken because the user is unable to define a suitable location for background samples with characteristics that are comparable to the study area, or cost, schedule, accessibility or other factors preclude taking and analyzing background samples. The user may only wants to know the variability in the study samples and a comparison to background samples is not important for his purposes. This example describes a set of study samples that enabled the investigator to prioritize cleaning requirements based on the results and confidence limits of the individual samples and the combined sample set.

TABLE 20 Background Samples for Example 4

Sample Number	Number of Structures	Analytical Sensitivity (s/cm^2)	Sensitivity Weights	Loading (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
B1	3	205	0.0049	615	8.8	1804
B2	4	205	0.0049	820	10.2	2091
B3	0	205	0.0049	0	3	615
B4	4	205	0.0049	820	10.2	2091
B5	6	205	0.0049	1230	13.1	2686

TABLE 21 Combined Measurements of Background Samples for Example 4

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
17	0.024	41.0	697	27.2	1115

TABLE 22 Analytical Parameters for Example 5

Effective filter area	962 mm^2
Number of grid openings examined	10
Average grid opening area	0.012 mm^2
Sample area	100 cm^2
Total volume	100 mL
Volume filtered	5 mL
Analytical sensitivity	1603 s/cm^2

TABLE 23 Study Area Samples for Example 5

Sample Number	Number of Structures	Volume Filtered (mL)	Analytical Sensitivity (s/cm^2)	Sensitivity Weights	Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
S1	3	5.0	1603	0.00062	4809	0.62	994	8.8	14106
S2	25	5.0	1603	0.00062	40075	16.0	25648	36.9	59151
S3	4	5.0	1603	0.00062	6412	1.1	1763	10.2	16351
S4	4	5.0	1603	0.00062	6412	1.1	1763	10.2	16351
S5	15	5.0	1603	0.00062	24045	8.4	13465	24.7	39594

TABLE 24 Combined Measurements of Study Samples for Example 5

Total Structures	Sum of Sensitivity Weights	Weighted Analytical Sensitivity (s/cm^2)	Estimated Loading (s/cm^2)	Structures 95 % LCL (Table 1)	Loading 95 % LCL (s/cm^2)	Structures 95 % UCL (Table 1)	Loading 95 % UCL (s/cm^2)
51	0.00312	321	16351	38	12183	67.1	21512

7.8.2 This example uses the analytical parameters in Table 22 that are taken from the laboratory report.

7.8.3 The analytical parameters are used to calculate the study area results in Table 23 and Table 24.

7.8.4 In Table 23:

(1) The number of structures and analytical sensitivity are taken from the laboratory report.

(2) The Loading is the product of the Number of Structures and the Analytical Sensitivity.

(3) Structures 95 % LCL and Structures 95 % UCL are read from Table 1.

(4) Loading 95 % LCL is the product of the Structures 95 % LCL and the Analytical Sensitivity.

(5) Loading 95 % UCL is the product of the Structures 95 % UCL and the Analytical Sensitivity.

7.8.5 In Table Table 24:

(1) Total Structures is the sum of the Number of Structures in Table 23.

(2) The Sum of Sensitivity Weights is the sum of Sensitivity Weights in Table 23.

(3) The Weighted Analytical Sensitivity is the reciprocal of the Sum of Sensitivity Weights.

(4) The Estimated Loading is the product of the Total Structures and the Weighted Analytical Sensitivity.

(5) 95 % LCL Structures is read from Table 1.

(6) Loading is the product of 95 % LCL Structures and Weighted Analytical Sensitivity.

7.8.6 The 95 % LCLs and 95 % UCLs are both calculated for each sample and the entire sample set. This information allows the user to compare individual sample confidence limits as well as the confidence limits of the combined samples and to make inferences about the cleanliness of individual locations as well as the overall study area.