SEM ASBESTOS FIBRE COUNTING PT SCHEME
REPORT FOR ROUND 1

BACKGROUND
This is report for the first round of the SEM asbestos fibre counting PT scheme. The scheme is operated by HSL, in collaboration with APC, Germany and TNO, Netherlands.

INTRODUCTION
In total 29 laboratories registered to participate in Round 1 of this scheme and 27 laboratories submitted results.
The participating laboratories represented a number of European countries: Germany (13), Netherlands (4), Switzerland (4), Italy (3), United Kingdom (2), France (1), Finland (1) and Czech Republic (1).

SAMPLES
Four samples were circulated representing a range of different fibre densities and fibre types. All samples were produced at HSL using the modified sputnik multi-port sampling instrument.

The samples were as follows:

1SEM1XX – Very low fibre density (0-10 fibres/mm^2)

1SEM2XX – Mainly amphibole - low-medium fibre density (15-25 fibres/mm^2)

1SEM3XX – Mainly amphibole – medium fibre density (20-40 fibres/mm^2)

1SEM4XX – Chrysotile – very high density – (1500 fibres/mm^2)

Note on sample 1SEM4XX – it was decided by the scheme steering committee that this sample was not suitable for inclusion in the PT scheme, especially for the first round. The main reasons being that the fibre density was too high, therefore representing or even exceeding the upper limit of the useful range of ISO 14966.
This sample shows a large number of very fine chrysotile fibres ($\leq$0,2 μm) and is therefore especially useful for calibration purposes of both the visibility (at 2000 magnification) and the analytical performance of the instrument.

INFORMATION SUBMITTED BY LABORATORIES
For each sample laboratories were asked to supply the numbers of fibres counted (total, amphibole, chrysotile and other inorganic), the number of areas searched, the area of the field of view and the magnification used. Laboratories were also asked to calculate the fibre density (in fibres/mm^2) for each fibre type identified.

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LABORATORY ASSESSMENT

RESULTS

General Points

Screen area – three laboratories incorrectly calculated their SEM screen area which consequently produced anomalous results for all of their samples. In all cases the submitted values were questioned by HSL and the laboratories proposed revised screen area/fibre densities. These were accepted in all cases. However, in future HSL may not provide the option for laboratories to correct errors after the closing date of the round.

Magnification – Five of the laboratories used an operating magnification outside the range defined in ISO 14966 (or VDI 3492) i.e. between 2000 – 2500x. Of these five, one used a magnification of 6000x, one used 3750x and the other three all used magnifications of around 1000x.

The laboratory that used 6000x magnification found more fibres on each sample than any other laboratory (in some cases almost twice as many).

One of the laboratories using 1000x found slightly few fibres on all samples but was especially low on sample 4 – fine chrysotile. The results for the remaining 2 laboratories using 1000x magnification and the one using 3750x were not significantly different from the other laboratories.

Analysis of fibre type has not been undertaken at this stage.

Data Analysis
Data analysis is based upon the calculated total asbestos (amphibole & chrysotile) fibre densities derived from fibre numbers counted and the area of the filter searched. The distribution of fibres on a filter derived from airborne sampling is normally described as being Poisson-distributed. For Poisson-distributed counts, the variance (standard deviation squared) is equal to the mean. However, in practice the variation may be larger due to differences in sample production, laboratories and individual microscopists. A comparison of the observed standard deviations with the expected standard deviations (expected under Poisson distribution) show that the observed variation is larger than that expected, and it is difficult to quantify how much of this may be due to differences in sample production, and how much is due to differences between labs/microscopists.

For each sample, it has been assumed that there are no production differences between samples, and that the fibre densities are Poisson distributed with mean lambda (lambda is unknown but is estimated from the mean fibre counts). An estimate of lambda is the observed mean density count across all participating labs; 95% confidence limits for lambda can also be calculated from this observed mean. For a Poisson random variable

with mean lambda, the variance is equal to the mean, i.e. if fibre counts truly follow a Poisson distribution with mean lambda, the variance should also equal lambda.

Calculating Confidence Limits for a Poisson Mean

The fibre densities are assumed to follow a Poisson distribution with unknown mean λ. The maximum likelihood estimate of λ, (which we denote as s) is the mean of the observed fibre densities across all laboratories, i.e.

$$s = \frac{\sum_{i=1}^{N} x_i}{N}$$

Where x_i is the observed fibre densities and N is the number of observations. The 95% confidence interval for the Poisson mean is

$$\left[\frac{\chi^2_{2s,0.025}}{2}, \frac{\chi^2_{2s+2,0.975}}{2} \right]$$

Where $\chi^2_{2s,0.025}$ (lower limit of the confidence interval for the Poisson mean) and $\chi^2_{2s+2,0.975}$ (upper limit of the confidence interval for the Poisson mean) are calculated as the chi-square quantiles with lower tail probabilities 0.025 and 0.975 on 2s and 2s+2 degrees of freedom respectively.

Laboratory results have been compared against the 95% confidence intervals as follows:

1. Where the total asbestos fibre density falls within the 95% confidence intervals, the result is classified as "A"

2. Where the total asbestos fibre density falls outside the 95% confidence intervals, the result is classified as "B"

Results for total asbestos fibre densities for each laboratory are summarised in Appendix 1.

Appendix 2 summarises the total fibre, total asbestos, amphibole, chrysotile and other inorganic fibre densities for all samples.

FUTURE ROUNDS
As more data is gathered for each laboratory, the data will be analysed to determine the best ways to assess overall performance of laboratories, differences between samples for individual laboratories and differences in fibre types identified.

APPENDIX 1

Sample 1

Lab No	Sample No	Total Asbestos Density (f/mm^2)	Score (based on 95% Confidence Interval for mean density)
7	1SEM1-03	0.0	A
300	1SEM1-25	0.0	A
807	1SEM1-17	0.0	A
818	1SEM1-29	4.0	A
1187	1SEM1-07	0.0	A
1267	1SEM1-33	0.8	A
1562	1SEM1-19	2.1	A
1575	1SEM1-23	0.9	A
1582	1SEM1-10	1.0	A
1620	1SEM1-08	0.0	A
1628	1SEM1-20	0.8	A
1638	1SEM1-27	0.0	A
1639	1SEM1-11	1.0	A
1640	1SEM1-18	2.4	A
1658	1SEM1-13	2.0	A
1669	1SEM1-12	0.0	A
1675	1SEM1-04	1.5	A
1684	1SEM1-16	0.0	A
1686	1SEM1-09	1.0	A
1687	1SEM1-26	0.0	A
1714	1SEM1-01	0.9	A
1715	1SEM1-02	0.0	A
1716	1SEM1-05	3.5	A
1717	1SEM1-06	0.9	A
1718	1SEM1-21	1.5	A
1719	1SEM1-24	0.0	A
1720	1SEM1-27	0.0	A
1722	1SEM1-37	0.0	A
1723	1SEM1-38	5.0	A
APC	1SEM1-30	4.0	A

Observed mean	1.11
Observed median	0.84
Observed SD	1.41
Max, likelihood estimate of Poisson mean	1.11
Poisson lower limit of CI for mean (rounded down to nearest integer)	0
Poisson upper limit for mean (rounded up nearest integer)	6
SD of Poisson	1.05

APPENDIX 1

Sample 2

Lab No	Sample No	Total Asbestos	Score (based on 95% Confidence Interval for mean density)
7	1SEM2-03	5.4	A
300	1SEM2-25	3.0	B
807	1SEM2-17	7.1	A
818	1SEM2-29	32.0	B
1187	1SEM2-07	4.1	A
1267	1SEM2-33	2.8	B
1562	1SEM2-19	12.2	A
1575	1SEM2-23	11.2	A
1582	1SEM2-10	10.0	A
1620	1SEM2-08	11.0	A
1628	1SEM2-20	5.7	A
1638	1SEM2-27	11.0	A
1639	1SEM2-11	10.0	A
1640	1SEM2-18	9.8	A
1658	1SEM2-13	13.0	A
1669	1SEM2-12	7.5	A
1675	1SEM2-04	9.5	A
1684	1SEM2-16	4.9	A
1686	1SEM2-09	16.3	A
1687	1SEM2-26	4.9	A
1714	1SEM2-01	7.4	A
1715	1SEM2-02	13.9	A
1716	1SEM2-05	17.5	A
1717	1SEM2-06	5.3	A
1718	1SEM2-21	7.9	A
1719	1SEM2-24	7.0	A
1720	1SEM2-27	4.5	A
1722	1SEM2-37	5.4	A
1723	1SEM2-38	12.0	A
APC	1SEM2-30	14.0	A

Observed mean	9.5	
Observed median	8.7	
Observed SD	5.8	
Max. Likelihood estimate of Poisson mean	9.54	
Poisson lower limit of CI for mean (rounded down to nearest integer)	4	
Poisson upper limit for mean (rounded up nearest integer)	18	
SD of Poisson	3.09	

APPENDIX 1

Sample 3

Lab No	Sample No	Total Asbestos	Score (based on 95% Confidence Interval for mean density)
7	1SEM3-03	19.7	A
300	1SEM3-25	4.1	B
807	1SEM3-17	18.6	A
818	1SEM3-29	85.9	B
1187	1SEM3-07	14.1	B
1267	1SEM3-33	18.4	A
1562	1SEM3-19	37.3	A
1575	1SEM3-23	24.2	A
1582	1SEM3-10	13.0	B
1620	1SEM3-08	25.0	A
1628	1SEM3-20	16.9	A
1638	1SEM3-27	37.9	A
1639	1SEM3-11	25.1	A
1640	1SEM3-18	24.9	A
1658	1SEM3-13	26.0	A
1669	1SEM3-12	22.5	A
1675	1SEM3-04	11.0	B
1684	1SEM3-16	18.7	A
1686	1SEM3-09	44.2	B
1687	1SEM3-26	24.7	A
1714	1SEM3-01	25.1	A
1715	1SEM3-02	21.8	A
1716	1SEM3-05	54.0	B
1717	1SEM3-06	16.9	A
1718	1SEM3-21	26.6	A
1719	1SEM3-24	17.0	A
1720	1SEM3-27	23.5	A
1722	1SEM3-37	23.5	A
1723	1SEM3-38	28.0	A
APC	1SEM3-30	26.0	A

Observed mean	25.8
Observed median	23.9
Observed SD	15.0
Max. Likelihood estimate of Poisson mean	25.82
Poisson lower limit of CI for mean (rounded down to nearest integer)	16
Poisson upper limit for mean (rounded up nearest integer)	38
SD of Poisson	4.89

HSL SEM PT Round 1

APPENDIX 2

Sample 1 (1SEM1-XX)

FIBRE DENSITIES (f/mm^2)

HSL PT Laboratory No	Sample No	Total Fibres	Total Asbestos	Amph Fibres	Chrys Fibres	Inorg Fibres
7	1SEM1-03	0.0	0.0	0.0	0.0	0.0
300	1SEM1-25	0.0	0.0	0.0	0.0	0.0
807	1SEM1-17	0.0	0.0	0.0	0.0	0.0
818	1SEM1-29	4.0	4.0	2.0	2.0	0.0
1187	1SEM1-07	0.0	0.0	0.0	0.0	0.0
1267	1SEM1-33	0.8	0.8	0.0	0.8	0.0
1562	1SEM1-19	2.1	2.1	0.0	2.1	0.0
1575	1SEM1-23	0.9	0.9	0.0	0.9	0.0
1582	1SEM1-10	1.0	1.0	1.0	0.0	0.0
1620	1SEM1-08	0.0	0.0	0.0	0.0	0.0
1628	1SEM1-20	0.8	0.8	0.0	0.8	0.0
1638	1SEM1-27	0.0	0.0	0.0	0.0	0.0
1639	1SEM1-11	1.0	1.0	0.0	1.0	0.0
1640	1SEM1-18	2.9	2.4	1.0	1.5	0.5
1658	1SEM1-13	3.0	2.0	1.0	1.0	1.0
1669	1SEM1-12	0.0	0.0	0.0	0.0	0.0
1675	1SEM1-04	1.5	1.5	0.5	1.0	0.0
1684	1SEM1-16	0.0	0.0	0.0	0.0	0.0
1686	1SEM1-09	1.0	1.0	0.0	1.0	0.0
1687	1SEM1-26	0.0	0.0	0.0	0.0	0.0
1714	1SEM1-01	0.9	0.9	0.9	0.0	0.0
1715	1SEM1-02	0.0	0.0	0.0	0.0	0.0
1716	1SEM1-05	3.5	3.5	0.0	3.5	0.0
1717	1SEM1-06	1.8	0.9	0.9	0.0	0.9
1718	1SEM1-21	1.5	1.5	0.0	1.5	0.0
1719	1SEM1-24	1.0	0.0	0.0	0.0	1.0
1720	1SEM1-27	0.0	0.0	0.0	0.0	0.0
1722	1SEM1-37	0.0	0.0	0.0	0.0	0.0
1723	1SEM1-38	5.0	5.0	4.0	1.0	0.0
APC	1SEM1-30	5.0	4.0	1.0	3.0	1.0
	MEAN	1.3	1.1	0.4	0.7	0.1
	MEDIAN	0.9	0.8	0.0	0.0	0.0
	SD	1.5	1.4	0.8	1.0	0.3
	MIN	0.0	0.0	0.0	0.0	0.0
	MAX	5.0	5.0	4.0	3.5	1.0

Sample 2 (1SEM2-XX)

FIBRE DENSITIES (f/mm^2)

HSL PT Laboratory No	Sample No	Total Fibres	Total Asbestos	Amph Fibres	Chrys Fibres	Inorg Fibres
7	1SEM2-03	6.4	5.4	4.9	0.5	1.0
300	1SEM2-25	4.1	3.0	3.0	0.0	0.0
807	1SEM2-17	10.9	7.1	4.4	2.7	3.8
818	1SEM2-29	34.0	32.0	16.0	16.0	2.0
1187	1SEM2-07	4.1	4.1	3.5	0.6	0.0
1267	1SEM2-33	3.6	2.8	1.6	1.2	0.8
1562	1SEM2-19	15.8	12.2	5.2	7.0	3.6
1575	1SEM2-23	14.0	11.2	9.3	1.9	2.8
1582	1SEM2-10	10.0	10.0	8.0	2.0	0.0
1620	1SEM2-08	22.0	11.0	8.0	3.0	11.0
1628	1SEM2-20	5.7	5.7	4.4	1.3	0.0
1638	1SEM2-27	16.0	11.0	6.0	5.0	0.0
1639	1SEM2-11	10.0	10.0	8.0	2.0	0.0
1640	1SEM2-18	13.2	9.8	6.8	2.9	3.4
1658	1SEM2-13	15.0	13.0	9.5	3.5	2.0
1669	1SEM2-12	8.5	7.5	5.5	2.0	1.0
1675	1SEM2-04	14.0	9.5	5.5	4.0	4.5
1684	1SEM2-16	4.9	4.9	3.0	2.0	0.0
1686	1SEM2-09	16.3	16.3	6.7	9.6	0.0
1687	1SEM2-26	12.8	4.9	3.5	1.5	7.9
1714	1SEM2-01	9.1	7.4	3.5	3.9	1.7
1715	1SEM2-02	19.8	13.9	7.9	5.9	5.9
1716	1SEM2-05	25.0	17.5	9.0	8.5	7.5
1717	1SEM2-06	7.1	5.3	3.6	1.8	1.8
1718	1SEM2-21	13.8	7.9	4.4	3.5	5.9
1719	1SEM2-24	7.0	7.0	6.0	1.0	0.0
1720	1SEM2-27	6.5	4.5	4.5	0.0	2.0
1722	1SEM2-37	6.2	5.4	3.6	1.8	0.9
1723	1SEM2-38	12.0	12.0	10.0	2.0	0.0
APC	1SEM2-31	14.0	11.0	7.0	4.0	3.0
APC	1SEM2-30	25.0	14.0	8.0	6.0	11.0
	MEAN	12.5	9.6	6.1	3.5	2.7
	MEDIAN	12.0	9.5	5.5	2.0	1.8
	SD	7.1	5.7	2.9	3.3	3.2
	MIN	3.6	2.8	1.6	0.0	0.0
	MAX	34.0	32.0	16.0	16.0	11.0

APPENDIX 2

Sample 3 (1SEM3-XX)

FIBRE DENSITIES (f/mm^2)

HSL PT Laboratory No	Sample No	Total Fibres	Total Asbestos	Amph Fibres	Chrys Fibres	Inorg Fibres
7	1SEM3-03	22.6	19.7	17.2	2.5	2.9
300	1SEM3-25	5.1	4.1	0.0	4.1	0.0
807	1SEM3-17	22.9	18.6	14.8	3.8	4.4
818	1SEM3-29	88.9	85.9	67.9	18.0	3.0
1187	1SEM3-07	14.1	14.1	13.5	0.6	0.0
1267	1SEM3-33	22.4	18.4	14.9	3.4	4.0
1562	1SEM3-19	45.3	37.3	21.8	15.5	8.0
1575	1SEM3-23	27.0	24.2	20.5	3.7	2.8
1582	1SEM3-10	15.0	13.0	10.0	3.0	2.0
1620	1SEM3-08	48.0	25.0	19.0	6.0	23.0
1628	1SEM3-20	16.9	16.9	15.3	1.6	0.0
1638	1SEM3-27	59.3	37.9	25.1	12.8	21.4
1639	1SEM3-11	25.1	25.1	22.1	3.0	0.0
1640	1SEM3-18	31.2	24.9	17.1	7.8	6.3
1658	1SEM3-13	31.0	26.0	22.0	4.0	5.0
1669	1SEM3-12	22.5	22.5	17.5	5.0	0.0
1675	1SEM3-04	17.0	11.0	7.5	3.5	6.0
1684	1SEM3-16	21.7	18.7	16.7	2.0	3.0
1686	1SEM3-09	48.1	44.2	34.6	9.6	3.8
1687	1SEM3-26	34.6	24.7	15.8	8.9	9.9
1714	1SEM3-01	32.0	25.1	10.4	14.7	6.9
1715	1SEM3-02	25.7	21.8	20.8	1.0	4.0
1716	1SEM3-05	64.5	54.0	36.0	18.0	10.5
1717	1SEM3-06	18.7	16.9	15.1	1.8	1.8
1718	1SEM3-21	27.6	26.6	21.7	4.9	1.0
1719	1SEM3-24	23.0	17.0	16.0	1.0	6.0
1720	1SEM3-27	23.5	23.5	19.5	4.0	2.5
1722	1SEM3-37	28.2	23.5	15.1	8.5	4.7
1723	1SEM3-38	28.0	28.0	28.0	0.0	0.0
APC	1SEM3-30	42.0	26.0	18.0	8.0	16.0
APC	1SEM3-31	36.0	26.0	14.0	12.0	10.0
	MEAN	31.2	25.8	19.6	6.2	5.4
	MEDIAN	27.0	24.2	13.2	4.0	4.0
	SD	16.9	14.7	11.4	5.2	5.8
	MIN	5.1	4.1	0.0	0.0	0.0
	MAX	88.9	85.9	67.9	18.0	23.0

APPENDIX 2

Sample 4 (1SEM4-XX)

FIBRE DENSITIES (f/mm^2)

HSL PT Laboratory No	Sample No	Total Fibres	Total Asbestos	Amph Fibres	Chrys Fibres	Inorg Fibres
7	1SEM4-03	1000.5	995.6	4.9	990.7	4.9
300	1SEM4-25	13.2	11.2	0.0	11.2	0.0
807	1SEM4-17	1673.0	1625.2	0.0	1625.2	47.8
818	1SEM4-29	2911.6	2911.6	27.2	2884.4	0.0
1187	1SEM4-07	56.5	56.5	0.0	56.5	0.0
1267	1SEM4-33	906.9	906.9	0.0	906.9	0.0
1562	1SEM4-19	1067.4	1067.4	10.4	1057.0	0.0
1575	1SEM4-23	931.2	912.6	9.3	903.3	18.6
1582	1SEM4-10	662.9	662.9	18.9	643.9	0.0
1620	1SEM4-08	1825.2	1741.5	0.0	1741.5	83.7
1628	1SEM4-20	467.2	467.2	0.0	467.2	0.0
1638	1SEM4-27	1208.1	1111.0	21.6	1089.4	97.1
1639	1SEM4-11	2456.1	2456.1	0.0	2456.1	0.0
1640	1SEM4-18	1660.3	1645.4	14.9	1630.6	14.9
1658	1SEM4-13	753.2	753.2	7.5	745.7	0.0
1669	1SEM4-12	956.3	956.3	11.3	945.0	0.0
1675	1SEM4-04	986.4	954.5	9.1	945.5	31.8
1684	1SEM4-16	486.1	486.1	0.0	486.1	0.0
1686	1SEM4-09	1634.6	1506.4	32.1	1474.4	64.1
1687	1SEM4-26	756.9	749.3	3.8	745.5	7.6
1714	1SEM4-01	1360.5	1360.5	0.0	1360.5	0.0
1715	1SEM4-02	460.6	456.3	4.3	452.0	4.3
1716	1SEM4-05	2210.9	2188.9	22.0	2166.9	22.0
1717	1SEM4-06	1143.4	1143.4	33.3	1110.1	0.0
1718	1SEM4-21	1339.7	1339.7	12.8	1326.9	0.0
1719	1SEM4-24	1657.1	1585.7	28.6	1557.1	71.4
1720	1SEM4-27	369.4	362.0	0.0	362.0	7.4
1722	1SEM4-37	685.8	691.0	31.1	659.9	0.0
1723	1SEM4-38	2525.3	2525.3	202.0	2323.2	0.0
APC	1SEM4-30	1457.1	1457.1	0.0	1457.1	0.0
	MEAN	1187.4	1169.6	16.8	1152.7	15.9
	MEDIAN	1033.9	1031.5	8.3	1023.8	0.0
	SD	716.5	708.9	36.8	693.5	27.9
	MIN	13.2	11.2	0.0	11.2	0.0
	MAX	2911.6	2911.6	202.0	2884.4	97.1