



Scanning Electron Microscopy Scheme

BACKGROUND

This report covers Round 12C of the SEMS asbestos fibre counting PT scheme. The scheme is operated by HSE, in collaboration with APC, Germany and TNO, Netherlands.

SAMPLES

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

INTRODUCTION

A total of 38 laboratories participated in this round (including the validating laboratories). Laboratories were able to submit up to three results per sample and many laboratories took advantage of this with a total of 259 results submitted.

The samples were as follows:

12CSEM1 – Medium density (17.1 fibres mm^{-2}) - chrysotile fibres

12CSEM2 – Low density (13.6 fibres mm^{-2}) - amosite fibres

12CSEM3 – High density (95.0 fibres mm^{-2}) – amosite fibres

12CSEM4 – No asbestos (0 fibres mm^{-2}) – MMMF fibres

INFORMATION SUBMITTED BY LABORATORIES

Laboratories were asked to supply the following information:

- Number of fibres $>5\mu\text{m}$ in length counted (amphibole, chrysotile & other inorganic)
- The number of fields of view searched
- The area of the field of view
- The magnification and the method used

Laboratories were asked to calculate the fibre density (in fibres/ mm^2) for each fibre type identified. There was also an option to include the number of fibres $\leq 5\mu\text{m}$ in length.

LABORATORY ASSESSMENT

RESULTS

Calculations – No errors were identified in this round.

Screen area – The fibre densities submitted by laboratories have not been recalculated and the density calculation and therefore screen area has not been verified.

Magnification – As was the case in earlier rounds, some laboratories used an operating magnification outside the range defined in ISO 14966 (or VDI 3492).

Magnifications ranging from 900x – 6000x were recorded.

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

Data Analysis

Data analysis is based upon the total asbestos fibre densities (amphibole & chrysotile) 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 this report, the data have been compared against the criteria used in the UK phase contrast fibre counting proficiency testing scheme RICE. Details of the analysis used can be found in Appendix 2.

Round 12C Overview

Summary statistics from this round of results are displayed in Table 1. Below this, Figure 1 displays the percentage of participants in each scoring band (as per the RICE scoring system). Figures 2 and 3 show the band scored by participants divided according to magnification and method used respectively.

Table 1: Summary statistics for results received in SEMS Round 12C.

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|--|----------|----------|----------|----------|
| Number of results | 65 | 65 | 65 | 64 |
| Median (fibres/mm²) | 17.1 | 13.6 | 95.0 | 0.0 |
| 25th percentile (fibres/mm²) | 11.4 | 11.0 | 69.1 | 0.0 |
| 75th percentile (fibres/mm²) | 26.6 | 17.5 | 113.9 | 0.0 |
| Interquartile range (fibres/mm²) | 15.2 | 6.5 | 44.9 | 0.0 |
| Mean (fibres/mm²) | 19.2 | 15.0 | 95.4 | 3.0 |
| Standard deviation (fibres/mm²) | 10.1 | 7.6 | 40.0 | 12.8 |
| Relative standard deviation (%) | 52.5 | 50.8 | 41.9 | 428.0 |

Note: The relative standard deviation (RSD) is calculated by $(\text{standard deviation}/\text{mean}) \times 100\%$. This statistic illustrates the variation relative to the size of the mean value. For very low values of the mean (e.g. Sample 4), the value of the RSD can be considered largely meaningless.

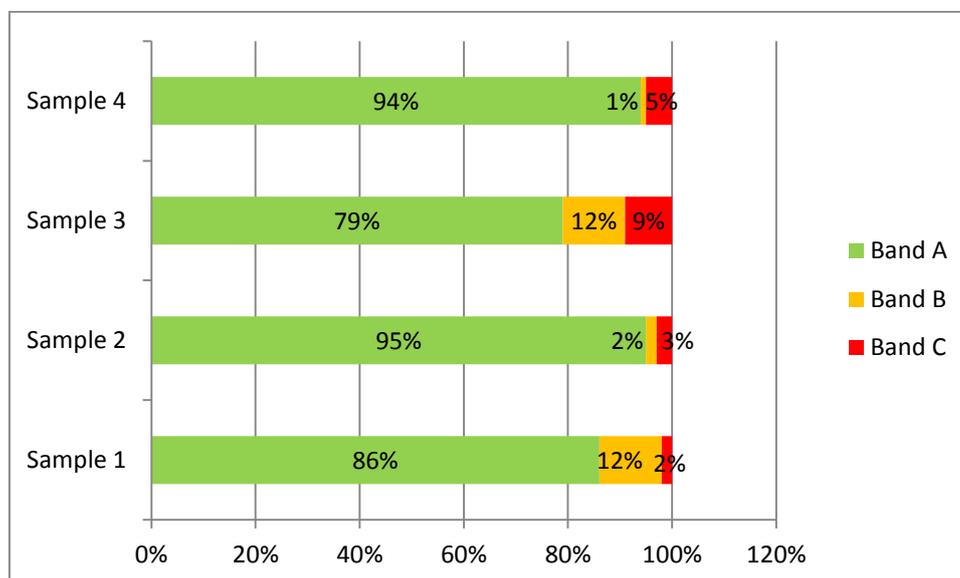


Figure 1: Banded scores for participants in SEMS Round 12C (categorised as per RICE scoring system - see Appendix 2)

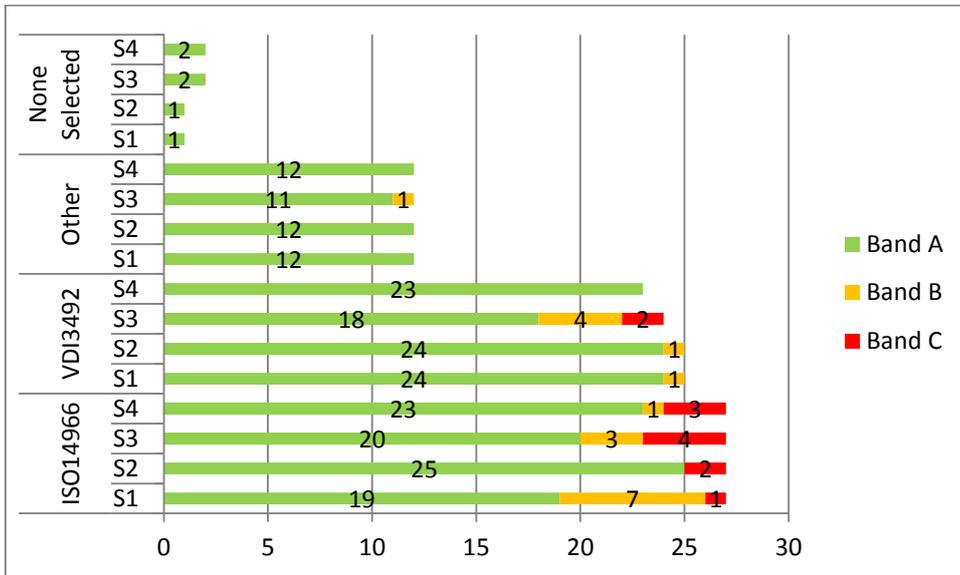


Figure 2: Banded scores for participants in SEMS Round 12C divided according to method used

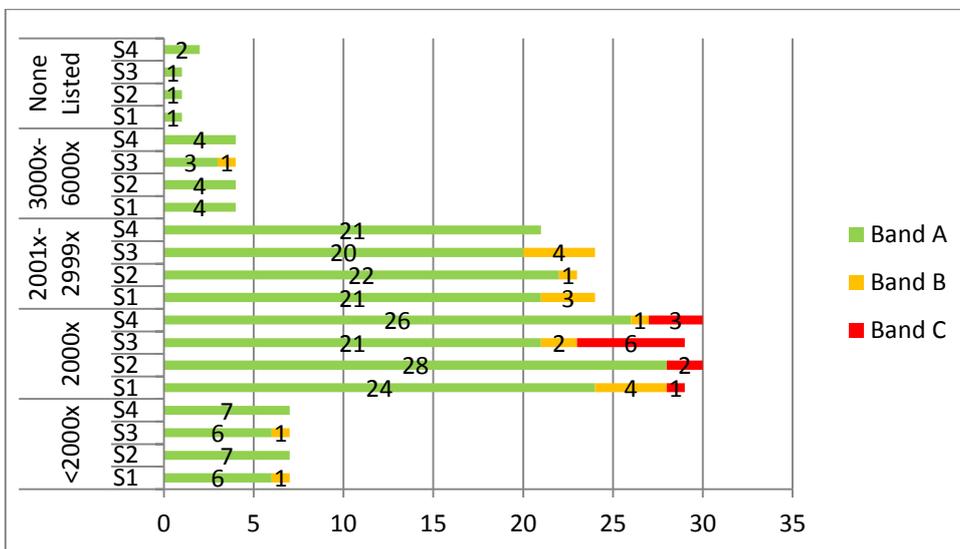


Figure 3: Banded scores for participants in SEMS Round 12C divided according to magnification use

APPENDIX 1

Sample 1 (12CSEM1) - Medium density (17.1 fibres/mm²) - chrysotile fibres

| LAB NUMBER | TOTAL ASBESTOS | BAND (RICE) |
|------------|----------------|-------------|
| 300 | 25 | A |
| 807 | 26.61 | A |
| 807 | 27.31 | A |
| 818 | 22.44 | A |
| 818 | 32.41 | A |
| 1181 | 29.79 | A |
| 1445 | 0 | C |
| 1510 | 14.5 | A |
| 1569 | 7 | A |
| 1576 | 11.43 | A |
| 1576 | 17.14 | A |
| 1620 | 10 | A |
| 1620 | 15.5 | A |
| 1620 | 8 | A |
| 1649 | 12.7 | A |
| 1658 | 12 | A |
| 1658 | 17 | A |
| 1684 | 26.2 | A |
| 1687 | 27 | A |
| 1718 | 28 | A |
| 1718 | 22 | A |
| 1734 | 12 | A |
| 1734 | 11 | A |
| 1759 | 5.1 | B |
| 1759 | 5.5 | B |
| 1759 | 4.2 | B |
| 1768 | 11.84 | A |
| 1768 | 9.87 | A |
| 1768 | 25.22 | A |
| 1776 | 14 | A |
| 1817 | 31.5 | A |
| 1884 | 7 | A |
| 1884 | 18 | A |
| 1922 | 25 | A |
| 1922 | 47.1 | B |
| 1937 | 14.3 | A |
| 1937 | 17.1 | A |
| 1948 | 10 | A |
| 1977 | 20.4 | A |
| 1992 | 16.06 | A |

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|------|-------|---|
| 1992 | 15.06 | A |
| 1993 | 25 | A |
| 1993 | 39 | B |
| 1993 | 42 | B |
| 2020 | 29.17 | A |
| 2020 | 34.38 | A |
| 2020 | 28.13 | A |
| 2076 | 28 | A |
| 2076 | 21 | A |
| 2116 | 14 | A |
| 2125 | 21.3 | A |
| 2125 | 26.8 | A |
| 2188 | 35.47 | A |
| 2188 | 25 | A |
| 2189 | 24 | A |
| 2191 | 23.56 | A |
| 2194 | 32.1 | A |
| 2207 | 4.5 | B |
| 2226 | 9.29 | A |
| 2226 | 10.9 | A |
| 2226 | 5.1 | B |
| 2288 | 13.33 | A |
| 2295 | 15.91 | A |
| 2295 | 10.23 | A |
| 2295 | 18.18 | A |

| | |
|---------------|------|
| Mean | 19.2 |
| Median | |
| (Ref) | 17.1 |
| STDev | 10.1 |
| Min | 0.0 |
| Max | 47.1 |

| RICE A (Lower) | RICE A (Upper) | RICE B (Lower) | RICE B (Upper) | RICE C (Lower) | RICE C (Upper) |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 6.6 | 37.2 | 3.2 | 55.3 | <3.2 | >55.3 |

APPENDIX 1

Sample 2 (12CSEM2) - Low density (13.6 fibres/mm²) - amosite fibres

| LAB NUMBER | TOTAL ASBESTOS | BAND (RICE) |
|------------|----------------|-------------|
| 300 | 11 | A |
| 807 | 9.1 | A |
| 807 | 8.4 | A |
| 818 | 9.97 | A |
| 818 | 16.45 | A |
| 1181 | 14.4 | A |
| 1445 | 0 | C |
| 1510 | 19.5 | A |
| 1569 | 11 | A |
| 1576 | 26.67 | A |
| 1576 | 14.76 | A |
| 1620 | 13.5 | A |
| 1620 | 11.5 | A |
| 1620 | 18 | A |
| 1649 | 14.6 | A |
| 1658 | 13 | A |
| 1658 | 12 | A |
| 1684 | 13.6 | A |
| 1687 | 10.2 | A |
| 1718 | 17.5 | A |
| 1718 | 20 | A |
| 1734 | 20 | A |
| 1734 | 32.5 | B |
| 1759 | 13.6 | A |
| 1759 | 7.6 | A |
| 1759 | 12.3 | A |
| 1768 | 11.84 | A |
| 1768 | 9.43 | A |
| 1768 | 16.45 | A |
| 1776 | 14 | A |
| 1817 | 31.5 | A |
| 1884 | 18 | A |
| 1884 | 13 | A |
| 1922 | 20.1 | A |
| 1922 | 20.1 | A |
| 1937 | 9.5 | A |
| 1937 | 11.4 | A |
| 1948 | 9 | A |
| 1977 | 12.93 | A |
| 1992 | 20.08 | A |
| 1992 | 13.05 | A |

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|------|--------|---|
| 1993 | 16 | A |
| 1993 | 18 | A |
| 1993 | 13 | A |
| 2020 | 12 | A |
| 2020 | 12.5 | A |
| 2020 | 15.63 | A |
| 2076 | 19 | A |
| 2076 | 17 | A |
| 2116 | 16 | A |
| 2125 | 14.4 | A |
| 2125 | 21.3 | A |
| 2188 | 16.86 | A |
| 2188 | 20.35 | A |
| 2189 | 15.7 | A |
| 2191 | 13.746 | A |
| 2194 | 57.5 | C |
| 2207 | 11 | A |
| 2226 | 9.71 | A |
| 2226 | 10.1 | A |
| 2226 | 6.3 | A |
| 2288 | 15.83 | A |
| 2295 | 6.82 | A |
| 2295 | 7.95 | A |
| 2295 | 9.09 | A |

| | |
|---------------------|------|
| Mean | 15.0 |
| Median (Ref) | 13.6 |
| STDev | 7.6 |
| Min | 0.0 |
| Max | 57.5 |

| RICE A (Lower) | RICE A (Upper) | RICE B (Lower) | RICE B (Upper) | RICE C (Lower) | RICE C (Upper) |
|----------------|----------------|----------------|----------------|----------------|----------------|
| 4.5 | 31.9 | 1.8 | 48.8 | <1.8 | >48.8 |

Sample 3 (12CSEM3) - High density (95.0 fibres/mm²) - amosite fibres

| LAB NUMBER | TOTAL ASBESTOS | BAND (RICE) |
|------------|----------------|-------------|
| 300 | 138 | A |
| 807 | 86.82 | A |
| 807 | 93.82 | A |
| 818 | 86.26 | A |
| 818 | 50.36 | B |
| 1181 | 113.94 | A |
| 1445 | 0 | C |
| 1510 | 97 | A |
| 1569 | 113 | A |
| 1576 | 76.19 | A |
| 1576 | 116.67 | A |
| 1620 | 81.5 | A |
| 1620 | 81 | A |
| 1620 | 159.5 | B |
| 1649 | 75.6 | A |
| 1658 | 84.5 | A |
| 1658 | 64 | A |
| 1684 | 68.5 | A |
| 1687 | 125 | A |
| 1718 | 226 | C |
| 1718 | 232 | C |
| 1734 | 133.5 | A |
| 1734 | 117 | A |
| 1759 | 85.2 | A |
| 1759 | 72.5 | A |
| 1759 | 102.1 | A |
| 1768 | 69.08 | A |
| 1768 | 106.8 | A |
| 1768 | 127.41 | A |
| 1776 | 67 | A |
| 1817 | 100.5 | A |
| 1884 | 65 | A |
| 1884 | 68 | A |
| 1922 | 122.7 | A |
| 1922 | 157.1 | B |
| 1937 | 80 | A |
| 1937 | 65.7 | A |
| 1948 | 84 | A |
| 1977 | 53.7 | B |
| 1992 | 99.9 | A |
| 1992 | 97.39 | A |

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|------|--------|---|
| 1993 | 96 | A |
| 1993 | 96 | A |
| 1993 | 93 | A |
| 2020 | 106.25 | A |
| 2020 | 115.63 | A |
| 2020 | 110.42 | A |
| 2076 | 95 | A |
| 2076 | 98 | A |
| 2116 | 96.5 | A |
| 2125 | 136.2 | A |
| 2125 | 165.3 | B |
| 2188 | 125 | A |
| 2188 | 81.98 | A |
| 2189 | 102.9 | A |
| 2191 | 108.99 | A |
| 2194 | 0 | C |
| 2207 | 91.5 | A |
| 2226 | 68.4 | A |
| 2226 | 59.9 | B |
| 2226 | 52.4 | B |
| 2288 | 124.16 | A |
| 2295 | 53.41 | B |
| 2295 | 37.5 | C |
| 2295 | 45.45 | C |

| | |
|---------------|-------|
| Mean | 95.4 |
| Median | |
| (Ref) | 95.0 |
| STDev | 40.0 |
| Min | 0.0 |
| Max | 232.0 |

| RICE A (Lower) | RICE A (Upper) | RICE B (Lower) | RICE B (Upper) | RICE C (Lower) | RICE C (Upper) |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 61.8 | 147.3 | 47.5 | 190 | <47.5 | >190 |

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Sample 4 (12CSEM4) - No Asbestos (0 fibres/mm²) - MMMF fibres

| LAB NUMBER | TOTAL ASBESTOS | BAND (RICE) |
|------------|----------------|-------------|
| 300 | 0 | A |
| 807 | 0 | A |
| 807 | 0 | A |
| 818 | 0 | A |
| 818 | 0 | A |
| 1181 | 0 | A |
| 1445 | 0 | A |
| 1510 | 0 | A |
| 1569 | 0 | A |
| 1576 | 0 | A |
| 1576 | 0 | A |
| 1620 | 0 | A |
| 1620 | 0 | A |
| 1620 | 0 | A |
| 1649 | 0 | A |
| 1658 | 0 | A |
| 1658 | 0 | A |
| 1684 | 0 | A |
| 1687 | 2.5 | A |
| 1718 | 0 | A |
| 1718 | 0 | A |
| 1734 | 0 | A |
| 1734 | 0 | A |
| 1759 | 0 | A |
| 1759 | 0 | A |
| 1759 | 0 | A |
| 1768 | 0.44 | A |
| 1768 | 0 | A |
| 1768 | 0 | A |
| 1776 | 0 | A |
| 1817 | 0 | A |
| 1884 | 0 | A |
| 1884 | 0 | A |
| 1922 | 0 | A |
| 1922 | 0 | A |
| 1937 | 0 | A |
| 1937 | 0 | A |
| 1948 | 0 | A |
| 1977 | 0 | A |
| 1992 | 0 | A |
| 1992 | 0 | A |

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|------|-------|---|
| 1993 | 0 | A |
| 1993 | 0 | A |
| 1993 | 0 | A |
| 2020 | 0 | A |
| 2020 | 0 | A |
| 2020 | 0 | A |
| 2076 | 0 | A |
| 2076 | 0 | A |
| 2116 | 0 | A |
| 2125 | 0 | A |
| 2125 | 0 | A |
| 2188 | 0 | A |
| 2188 | 0 | A |
| 2189 | 0 | A |
| 2191 | 0 | A |
| 2194 | 10.1 | B |
| 2207 | 0 | A |
| 2226 | 0 | A |
| 2226 | 0 | A |
| 2288 | 0 | A |
| 2295 | 48.86 | C |
| 2295 | 62.5 | C |
| 2295 | 67.05 | C |

Mean 3.0
Median
(Ref) 0.0
 STDev 12.8
 Min 0.0
 Max 67.1

| RICE A (Lower) | RICE A (Upper) | RICE B (Lower) | RICE B (Upper) | RICE C (Lower) | RICE C (Upper) |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 0 | 3.8 | | 10.9 | | >10.9 |

APPENDIX 2

DATA ANALYSIS

Regular Inter-laboratory Counting Exchange (RICE) Criteria

Where R is the reference value – in this case the Median value.

High density samples ($R > 63.7$ fibres. mm^{-2})

Target band A: $> 0.65R$ to $< 1.55R$

Target band B: $> 0.50R$ to $0.65R$ [band -B] and $> 1.55R$ to $2.00R$ [band +B]

Target band C: $< 0.50R$ [band -C] and $> 2.00R$ [band +C]

Low density samples ($R \leq 63.7$ fibres. mm^{-2})*

Target band A: $(\sqrt{R-1.57})^2$ to $(\sqrt{R+1.96})^2$ [band A]

Target band B: $< (\sqrt{R-2.34})^2$ to $(\sqrt{R-1.57})^2$ [band -B]
 $> (\sqrt{R+1.96})^2$ to $(\sqrt{R+3.30})^2$ [band +B]

Target band C: $< (\sqrt{R-2.34})^2$ [band -C]
 $> (\sqrt{R+3.30})^2$ [band +C]

* For samples less than 5.5 fibres. mm^{-2} the lower limit is set to zero when the component within the brackets $(\sqrt{R-n})$ is less than zero.

The plot below shows the positions of the performance limits in relation to the reference counts up to reference density 500 fibres per mm^2 .

