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Central Reference Scheme Steering Committee

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QUALITY CONTROL OF FIBRE COUNTING - THE WORK OF THE CENTRAL REFERENCE LABORATORY

by

Central Reference
Scheme Steering Committee

May 1989

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INSTITUTE OF OCCUPATIONAL MEDICINE

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by

Central Reference Scheme Steering Committee

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SUMMARY

The standard method used to measure airborne asbestos fibre concentrations involves drawing a known volume of dust-laden air through a membrane filter, clearing and mounting the filter on a glass slide and counting the fibres using a phase contrast optical microscope. However, application of this method can lead to large differences in results being produced by different operators.

In 1978, the UK Government's Advisory Committee on Asbestos recommended that laboratories using this method should accept the need for regular check counting within and between laboratories with the aim of minimising systematic and random errors. It was also recommended that a Central Reference Laboratory (CRL) be established to carry out such inter-comparisons. Consequently, the Health and Safety Executive and the Asbestosis Research Council jointly placed a contract with the Institute of Occupational Medicine to operate a Central Reference Scheme (CRS) and set up a Steering Committee to oversee the work.

The CRL's initial activities were directed towards quantifying the differences in counting levels that existed between five experienced member laboratories and establishing the causes of such differences. A review of methodology used in the five laboratories showed a number of differences in the detailed procedures used to evaluate samples. A slide exchange was conducted to determine the inter-laboratory variation arising from these 'in-house' methods. Up to 2.5 fold systematic differences in counts were observed between laboratories, with the ratio of highest to lowest count being up to 12:1 for individual slides. Special exercises were then conducted to identify possible causes of these differences, including methodological effects such as microscope specification, eyepiece graticule, mounting procedures and counting rules. The major contribution to the variation arose, however, from the subjectivity involved in the visual counting procedure. A reference method was formulated and, following a training course attended by all participating microscopists, further slide exchanges were carried out to assess the reproducibility of the CRS reference method. Not surprisingly, inter-laboratory variation was reduced; systematic differences were less than 2-fold, with the ratio of the highest to lowest counts not exceeding 3:1. Thus, the work of the CRL quantified not only the variation being achieved by experienced laboratories but also the achievable variations.

Despite the technical superiority of the CRS reference method, as indicated by the results of an international inter-laboratory comparison trial conducted by the Institute on behalf of the Commission of European Communities, the method published by the Asbestos International Association was adopted in 1983 as the European Reference Method.

The work of the CRS led to the Regular Inter-laboratory Counting Exchange (RICE) scheme being set up in 1982 to minimise inter- laboratory variations in counting nationally. This scheme makes use of reference counts produced by the Magiscan imatge analyser using software known as the Manchester Asbestos Program (MAP). RICE is a quality control scheme, with satisfactory performance criteria derived initially on the basis of the counting performance of the CRS group of laboratories using their own routine methodologies. More stringent criteria have recently been introduced. Present membership of RICE comprises some 320 laboratories. Participation in RICE and the achievement and maintenance of satisfactory performance are amongst the requirements of laboratory accreditation for asbestos fibre counting set out by the National Measurement Accreditation Service (NAMAS).

An international scheme, the Asbestos Fibre Regular Informal Counting Arrangement (AFRICA), similar to RICE was also established in 1984. Membership currently comprises 40 laboratories representing a total of 20 countries. Unlike RICE, AFRICA is simply a comparison scheme, with the RICE satisfactory performance criteria being used as guidelines only.

Some ideas on future developments in RICE and AFRICA are also presented in this report.

1. INTRODUCTION

The control of asbestos dust in the UK manufacturing industry has long been the subject of statutory requirements. The Asbestos Regulations (1931) covered only specific processes or scheduled areas and did not call for monitoring operations. In 1969 new more sophisticated regulations were introduced to cover manufacturing and user operations 'involving asbestos or any article composed wholly or partly of asbestos, except a process in connection with which asbestos dust cannot be given off'. The 1969 Regulations defined dust as 'dust consisting of or containing asbestos to such an extent as is liable to cause danger to the health of the employed persons' and this expression was interpreted in an accompanying Department of Employment Technical Data Note 13 (1971) which detailed action required to be taken at certain levels of airborne dust concentrations. The latter were presented both in gravimetric (mg/m^3) and fibre count (fibre/ml) units, a fibre being defined in terms of length and length:breadth ratio. The Technical Data Note also summarised a number of sampling methods and instruments in use at that time.

In 1976 the above Technical Data Note was replaced by the Health and Safety Executive Guidance Note EH10 (HSE, 1976) which gave revised criteria which the HSE was to adopt in determining whether in their opinion, the requirements of the Asbestos Regulations 1969 and Sections 2, 3 and 4 of the Health and Safety at Work etc. Act 1974 were being observed. The revised criteria, based on a Hygiene Standard for chrysotile asbestos dust derived by the British Occupational Hygiene Society (BOHS, 1968), were this time based solely in terms of fibre counts as given by a membrane filter sampling method. This (described in full detail later) involves drawing a known volume of dust laden air through a membrane filter by means of a pump, the collected fibres being subsequently examined and counted under a light microscope. The personal sampling method in which the membrane filter head was fixed to the worker's clothing within 300 mm of his/her nose was noted to give a more accurate indication of individual exposure although tests in the static mode (with samples fixed at head height) were considered to be satisfactory for continuous operations.

By 1976 the membrane filter method had become the standard method of monitoring in the UK, being used by both the HSE and Industry to assess dust concentrations from factory manufacturing operations and user processes. In 1978 a Working Group of the Government Advisory Committee on Asbestos (ACA) recommended that the membrane filter method be retained until better alternative methods could be assessed, proved and correlated (ACA, 1978). However the limitations and inaccuracies of the membrane filter method for comparing occupational exposure to airborne dust with current hygiene standards were recognised and further effort was deemed to be necessary to reduce variations which occurred in the evaluation of samples by this method. In consequence the ACA recommended that laboratories participating in such work should accept the need for regular check counting within and between laboratories, with the objective of minimising systematic and random errors. It was also recommended that a Central Reference Laboratory (CRL) be established to carry out such inter-comparisons and to publish the results of its findings.

2. CENTRAL REFERENCE LABORATORY

Arising from the above, in May 1978, the Health and Safety Executive (HSE) and the Asbestosis Research Council (ARC) an organisation funded by the asbestos industry, jointly placed a contract with the Institute of Occupational Medicine (IOM) in Edinburgh to operate a Central Reference Scheme (CRS) in connection with the measurement of airborne asbestos dust concentrations by the membrane filter method. The IOM is a charitable foundation associated with Edinburgh University and was set up by the then National Coal Board in 1969 to undertake research in occupational health. By 1978 it had already conducted comparative asbestos dust counting trials between laboratories in Britain and abroad and had developed considerable expertise in monitoring methodologies. It was therefore considered to be a most suitable centre to co-ordinate the scientific work of the Central Reference Laboratory.

The CRL was considered to have the following functions:

(i) To quantify the differences that existed between the main hygiene monitoring laboratories of the HSE and ARC.

(ii) To establish the causes of such differences.

(iii) To derive a standard Reference Method which would minimise both between and within laboratory variation in the UK.

(iv) To derive an accreditation scheme that could be used by all laboratories engaged in membrane filter evaluations so that a nationally recognised standard of counting would emerge.

This report summarises the work carried out by the CRL which was managed and operated by two Committees:

(a) A Steering Committee consisting of representatives from the HSE, the ARC and the IOM. (See Appendix 1 for constitution and terms of reference).

(b) A Technical Committee composed of scientists and hygienists from the IOM, HSE and ARC laboratories. This Committee, under the Chairmanship of a Senior IOM scientist, was charged with overseeing the various inter-laboratory evaluations and investigations.

3. THE WORK OF THE CRL - METHODOLOGY

As already indicated, the CRL's first activities were directed towards finding the principal causes of inter-laboratory variation in counting levels determined by its member laboratories. The latter were all experienced in asbestos monitoring and were designated 'master laboratories'. (In this report they are designated by the letters A-E). All five laboratories were routinely engaged in the evaluation of asbestos dust concentrations arising in occupational environments and adopted procedures based on the ARC method first published in 1968. However a critical review of the methodology used in the five laboratories showed a number of differences in the detailed procedures used to evaluate the exposed dust slides and the early work of the CRL was based on the hypothesis that a major source of variation was due to such differences; differences or errors in sampling methods were not investigated.

The first phase of the work therefore consisted of a series of slide exchanges, each slide or series of slides being counted in turn by one experienced counter at each master laboratory. Subsequently, additional counters were introduced for some slide exchanges and supplementary experimental studies were also carried out by a number of laboratories to investigate the effect of changing detailed experimental procedure. In later stages the scope of the CRL's activities was expanded to include the evaluation of slides by automated methods of counting.

The following is a summary of work carried out, the resultant findings and subsequent developments that have led to the establishment of United Kingdom quality assurance and laboratory accreditation schemes for asbestos fibre counting. The information given has been taken from various technical papers that have been produced by those directly responsible for the detailed investigations.

Reference is also made to developments that took place towards international agreement of methodology and the publication of a European Reference Method.

3.1 Initial Investigation

The initial investigation involved a slide exchange to determine the inter-laboratory variation arising from the 'in-house' methods used by the CRS Group laboratories for their routine evaluation of asbestos counts. The results shown in graphical form in Figure 1 (from tests carried out using chrysotile samples only) showed wide differences in the fibre densities recorded by the participating laboratories. Overall 90% of results lay within a band of ± 60% of the mean count; the ratio of highest to lowest being up to 12:1 on an individual slide basis. Systematic differences between laboratories were also apparent, one laboratory consistently producing results some 2.5 times those obtained from another laboratory. Such a degree of variation was considered to be unacceptable.

In consequence the above findings led to an in-depth consideration by the Technical Committee of the possible causes of such variation. In the first instance detailed attention was given to sources that could or might be ascribed to differences, however slight, in the detailed methodology applied by the various laboratories. Possible improvements in the visual evaluation of membrane filters by the optical microscope method were therefore considered and investigated under the following headings:

3.1.1 Microscope Specification

It was noted that although all the master laboratories used high quality phase contrast microscopes generally in accordance with the specification detailed in the 1978 revision of the Asbestosis Research Council Technical Note No. 1, these differed in some detail. However a scrutiny of the results obtained from the slide exchanges showed such differences to be relatively unimportant in terms of inter-laboratory variation. In some instances laboratories had widely different counts from identical microscopes and other laboratories had reached close agreement with different makes of equipment. Nevertheless the chance of error arising from the employment of poor quality or maladjusted microscopes was recognised. A detection limit test slide was therefore developed by the HSE (LE GUEN *et al*, 1984) and is now in widespread use internationally.

3.1.2 Eye-piece Graticule

This is a device placed in the eye-piece of the microscope to define the area within which fibres are counted. It also has a dimensional scale against which fibres can be assessed for size and conformity with the required length:diameter ratio (aspect ratio).

It had been known for some considerable time that a 'graticule count' is generally higher than a full-field (i.e. non-graticule) count (BECKETT, 1976) and the work of the CRL confirmed this finding, an inverse linear relationship being observed for routine counts between observed fibre density and the square root of the graticule area (CHERRIE, 1984). In consequence for the purposes of standardisation it was agreed to adopt the Walton-Beckett graticule referred to in Appendix 2.

3.1.3 Choice of Mountant

In the course of this work the CRL evaluated three different permanent mountants used to render the membrane filter transparent so that the fibres trapped on the filter could be examined by transmitted light. All three mountants gave an acceptably clear background and a sharp contrast for fibres but produced slightly different results in term of fibre counts (e.g. chrysotile textile samples being approximately 12% higher when mounted in acetone/euparal cf DMF/euparal). In the interest of standardisation and to ensure long term permanency, the CRL adopted the acetone/euparal medium for the CRS Reference Method (see later).

3.1.4 Counting Rules

In order to determine a numerical fibre count by the membrane filter method it is necessary to define a 'fibre' as seen through the light microscope. All the master laboratories had previously adopted the original Asbestosis Research Council definition of a fibre object of length greater than 5 μm, diameter less than 3 μm with a length to diameter ratio (aspect ratio) greater than 3:1, and this definition was retained. However it was noted that some laboratories had qualified this definition by only counting fibres judged to be asbestos by their morphology. Not surprisingly it was found that the results from such laboratories were invariably lower, in some instances half those from laboratories that did not discriminate in this manner. Other differences in laboratory counting rules also emerged due to ambiguities in the interpretation of split fibres, grouped fibres and fibres in contact with particles. Supportive scanning electron microscope studies were therefore undertaken at higher magnification to validate or otherwise the various criteria that had been adopted by the master laboratories. This work showed:

(a) that when fibres were examined by phase contrast optical microscopy alone, discrimination against non-asbestos fibres on morphological grounds was unreliable.

(b) it was not possible to detect with certainty whether or not split fibres, grouped fibres or fibres appearing to be in contact with particles were in fact attached or simply superimposed by chance.

3.2 CRS Reference Method

In view of the above differences in laboratory techniques and interpretation, a more precisely defined Reference Method was drawn up with the following objectives in mind:

(a) to produce a method which would improve the reproducibility between counters.

(b) to produce a method against which other methods could be compared and perhaps receive wider consideration as a national or international test method.

Acknowledging the arbitrary nature of any criteria devised for the counting of complex fibre configurations it was agreed that the new rules should recognise the subjective nature of manual counting and therefore be as simple as possible so as to minimise the number of decisions made by a counter during the evaluation procedure. The resultant CRS 'Reference Method' is detailed in Appendix 2.

3.3 Use of the CRS Reference Method

Following a training course attended by all participating counters further slide exchanges took place to assess the reproducibility of the CRS method. The results for textile (chrysotile) samples are shown in Figure 2 and those from a range of sample types are shown in Figure 3.

It will be seen that the employment of the CRS Reference Method brought about a considerable improvement in reproducibility in comparison with that obtained from the first exchange involving the 'in-house' methods. For the textile chrysotile samples 90% of counts were within ± 30% of the mean count (cf. ± 60% in the first exchange) and at worst there was a two-fold difference between individual samples. For the other samples 90% of counts were within ± 40% of the mean count; the ratio of highest to lowest counts did not exceed 3:1. Despite this level of improvement, up to two-fold systematic differences remained between the counts from certain laboratories.

3.4 Further Investigations - Subjective Differences

Although the use of the CRS Reference Method had brought about improved inter-laboratory reproducibility it was recognised that this could have occurred, to some degree, with any other single method. Indeed, it should be emphasised that the Reference Method was based purely on technical considerations and in recognition of the indication that various subjective factors, as yet not quantified, were likely to dominate differences due to methodological aspects alone. It was therefore decided that further interlaboratory work was necessary to bring about a more detailed understanding of between-laboratory and within-laboratory variations.

In consequence a new series of experiments was undertaken:

(a) to provide an indication of the magnitude of differences in the level of count produced by the various microscopes, graticules, mountants and counting rules specified in three 'standard' protocols (detailed later), and

(b) to compare such differences with the scale of random, systematic and temporal subjective differences arising from visual counting operations.

Subjective differences are those which will arise whenever a human observer is required to make a judgement on a particular aspect of the test procedure, e.g. a decision on whether or not a fibre has an aspect ratio less than 3:1, or is in contact with a particle, etc. Such subjective issues will lead to differences of a systematic, random, or temporal nature as illustrated by the following examples taken from the CRL investigations involving experienced counters.

- one counter consistently and systematically producing counts over twice the level achieved by another counter despite the fact that both were ostensibly using the same counting protocol.

- large, (ten-fold) inter-counter variation resulting from counts made on the same sample by different counters, again using the same protocol.

- temporal change (i.e. drift) in counting levels from a team of counters over a particular time period.

The results of the above trials are summarised in Table 1 which shows estimates of the average effect on counting levels arising from differences in microscope, mountant, graticule, counting rules and subjective factors. In most instances, differences in average levels associated with differences in method amounted to no more than about 20% whereas the observed between- and within-laboratory variations were much larger, illustrating the dominance of subjective factors on the counts produced.

The above findings confirmed the belief that whilst the adoption of a single method specification will help to reduce variation, any debate on standardisation must not only concern itself with what should be measured, and how, but should also take account of the main problems in the evaluation procedure, namely subjective effects.

4. INTERNATIONAL DEVELOPMENTS ON THE STANDARDISATION OF METHODOLOGY

In addition to the CRL, a number of other organisations were involved in the standardisation of methodology. Foremost amongst these were the Asbestos International Association (AIA) (through the work of its Dust Measurement Advisory Panel); the Council of European Communities (CEC), operating through its appropriate Committees, and the International Standards Organisation. All these organisations contributed to technical discussions on membrane filter evaluation methods (the CRS being represented by technical experts from the HSE and the IOM) in an attempt to reach agreement on counting protocols. A CEC sponsored international interlaboratory comparison study showed that CRS-based counting methods were most successful at reducing inter-laboratory differences, and were much preferred by microscopists (COWIE and CRAWFORD, 1982; CRAWFORD *et al*, 1982). The method published by the AIA (AIA, 1979) was less satisfactory in these respects and of the candidate methods it also produced the lowest counts, confirming findings of 'in-house' work by the CRS master laboratories. The AIA protocol was however chosen as the basis of the method annexed to the European Directive (EEC, 1983), now known as the European Reference Method (ERM), and in the interests of international standardisation the United Kingdom's Health and Safety Commission and the CRL member laboratories have now adopted the ERM. The CRS method is therefore unlikely to find much regular use in Britain, but its demonstrated technical superiority has led to its inclusion (in modified form) in the NIOSH method (NIOSH, 1984) in the United States and in the WHO/EURO reference method for man-made mineral fibres (WHO/EURO, 1985).

5. AUTOMATED COUNTING TECHNIQUES

In view of the degree of subjective error associated with the visual counting of airborne asbestos fibres, attention has been given over a number of years to the development of automated counting methods. A number of instruments have been considered for such purposes, but the CRS concentrated its attention on the Magiscan image analyser (Joyce Loebl Limited, Gateshead), using software known as the Manchester Asbestos Program (MAP). This was developed by the Department of Medical Biophysics at Manchester University, initially with the support of the Asbestosis Research Council and then Turner & Newall PLC, and later in collaboration with HSE's Occupational Medicine and Hygiene Laboratory. The use of the MAP on Magiscan and its relation to manual methods of counting have been described by KENNY (1984) who concluded that, on routine industrial samples, results by the MAP cannot be distinguished within the range of manual counting laboratories, and, at least at higher concentrations, cannot be distinguished within the range of individual manual counters within HSE. The Manchester University unit provided counts by early versions of the MAP during the CRL sample exchanges, and Magiscan MAP counts are being used as a reference datum for the RICE quality control scheme described in Section 6.

6. QUALITY CONTROL OF ASBESTOS FIBRE COUNTS

Because the international discussion on standardisation of method had delayed progress on a UK quality control scheme under the CRS, the HSE laboratory, in April 1982, invited the other CRS laboratories to participate in regular slide exchanges, to keep a check on performance until some more permanent arrangement could be made. Later in the year the scheme was expanded, taken over formally by the CRS, and operated by the Institute of Occupational Medicine. This scheme is known by the acronym RICE (Regular Interlaboratory Counting Exchanges). Similar schemes have operated for several years to check the performance of laboratories engaged in the evaluation of lead and other substances. Between 1982 and 1984, RICE operated informally, with over 100 laboratories taking part. To facilitate the running of such a large scheme, laboratories were subdivided into small groups. Each laboratory in each group, at quarterly intervals, received eight coded 'reference slides' selected by the IOM from a stock of samples (obtained primarily from the asbestos industry) and distributed these amongst its counters for evaluation. The results from each slide were then passed back to the IOM who processed the results. A group mean was calculated for each slide and each laboratory's result was normalised to the mean. Two performance statistics were calculated for each laboratory:

(a) an inter-laboratory index which gave a measure of the mean position of the laboratory relative to the mean of the group; this was calculated by subtracting 1 from each normalised result, taking the mean and multiplying by 100.

(b) an intra-laboratory index which measured the variability from sample to sample in the laboratory's position relative to the group mean; this was the coefficient of variation of the normalised results.

The first four slide exchanges by this system were completed by the end of 1983. The results for the CRS group are shown in Figure 4. It should be emphasised that in these initial exchanges each laboratory used its 'in house' method which differed in regard to the experimental factors detailed in Section 3.1.1 - 3.1.4. (All the CRS laboratories later changed to the European Reference Method of counting).

During the informal stage of RICE, the CRS steering committee was disbanded and the control of the scheme passed to a new HSE committee, the Committee on Asbestos Measurement (CAM), a subgroup of the HSE Committee on Analytical Requirements (CAR). Also, in addition to simply comparing inter- and intra-laboratory data, attention was given to the derivation of laboratory 'satisfactory' performance criteria. These criteria, based on a comparison on visual counts with Magiscan MAP counts, have been detailed by CRAWFORD and COWIE (1984). Three categories of performance were defined, based on 75 per cent or more of laboratory counts lying within the following ratios:

	Ratio	$\frac{\text{Laboratory Visual Count}}{\text{Magiscan Count}}$
Category 1		0.65 - 2.6
Category 2		0.45 - 3.8
Category 3		outside the above limits

Laboratories producing Category 1 and 2 performance over four consecutive slide exchanges were considered to be 'satisfactory', whilst laboratories in Category 3 were deemed to be 'unsatisfactory'.

These criteria were introduced formally when RICE became self-financing in July 1984, and operated until November 1987 during which time membership expanded to include some 320 laboratories. Typically, about 25 per cent of new members needed to take early corrective action to ensure that they achieved and maintained a satisfactory counting performance. (Up to 300-fold differences between counts occurred for some samples). Many of them attended a National Training Programme which was established for this purpose. New, more stringent criteria were introduced in November 1987, the category 1 and 2 limiting ratios being redefined as 0.70 - 1.70 and 0.55 - 2.2 respectively. The scheme currently operates under the control of a new committee, the Committee on Fibre Measurement (CFM) which was formed as a result of CAM's terms of reference being extended.

7. ACCREDITATION

Because of the importance attached to all aspects of Quality Control, in 1983, the CRS invited a representative from the then National Testing Laboratory Accreditation Scheme (NATLAS) to join its Steering Committee. As a result of this initiative the NATLAS organisation formulated a list of requirements (NATLAS NIS11, 1984) over and above its normal requirements, for laboratories wishing to obtain NATLAS accreditation for asbestos fibre evaluation. Membership of the RICE scheme, together with category 1 or 2 performance, is a prime requirement of the NATLAS scheme and many UK laboratories are now accreditated. In 1985, NATLAS merged with the British Calibration Service to form the National Measurement Accreditation Service (NAMAS). The 1988 revision of HSE Guidance Note EH10 makes reference to NAMAS accreditation in relation to airborne asbestos fibre evaluation.

8. THE FUTURE

The CFM inherited a working RICE scheme, together with criteria for standards of performance, and will continue to manage the RICE scheme through the IOM. Future developments in the scheme are likely to include:

- development of satisfactory performance criteria based on visual reference counts, with Magiscan MAP counts providing a back-up reference system.
- appreciable alteration in the stock of reference samples so that they are more representative of the samples typically evaluated by member laboratories, i.e. low density samples.

An international slide exchange scheme operating under the acronym AFRICA (Asbestos Fibre Regular Informal Counting Arrangement) was also established in 1984. Some of the UK laboratories participating in the RICE scheme are also taking part in the AFRICA scheme. Current membership of AFRICA comprises 40 laboratories representing a total of 20 countries. At the moment AFRICA is not a quality assurance scheme like RICE; it is an informal comparison scheme operating similarly to RICE but only permitting participants to compare their counting performance using the RICE satisfactory performance criteria as guidelines. Possible future developments in AFRICA include

- formal recognition and support of the scheme by appropriate international bodies (e.g. CEC, WHO).
- parallel developments to the RICE scheme, e.g. inclusion of low density clearance samples
- expansion to an 'all-fibre' scheme
- extension to include electron microscopy evaluations.

By continuing and increasing national and international participation in such reference schemes, in conjunction with appropriate training programes for analysts and with adoption of automated counting methods in appropriate circumstances, the large and still somewhat unacceptable levels of interlaboratory variation will improve.

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TABLE 1

Effects of method and subjective factors on counting variation

METHOD

Microscope	-	a few per cent
Mountant	-	± 10 per cent of triacetin
Graticule	-	± 10 per cent of Walton-Beckett
Counting rules	-	± 20 per cent of modified CRS rules

SUBJECTIVE FACTORS

Inter-observer random variation	-	up to 10:1
Inter-observer systematic difference	-	up to 2.5:1
Intra-observer temporal variation	-	up to 2:1

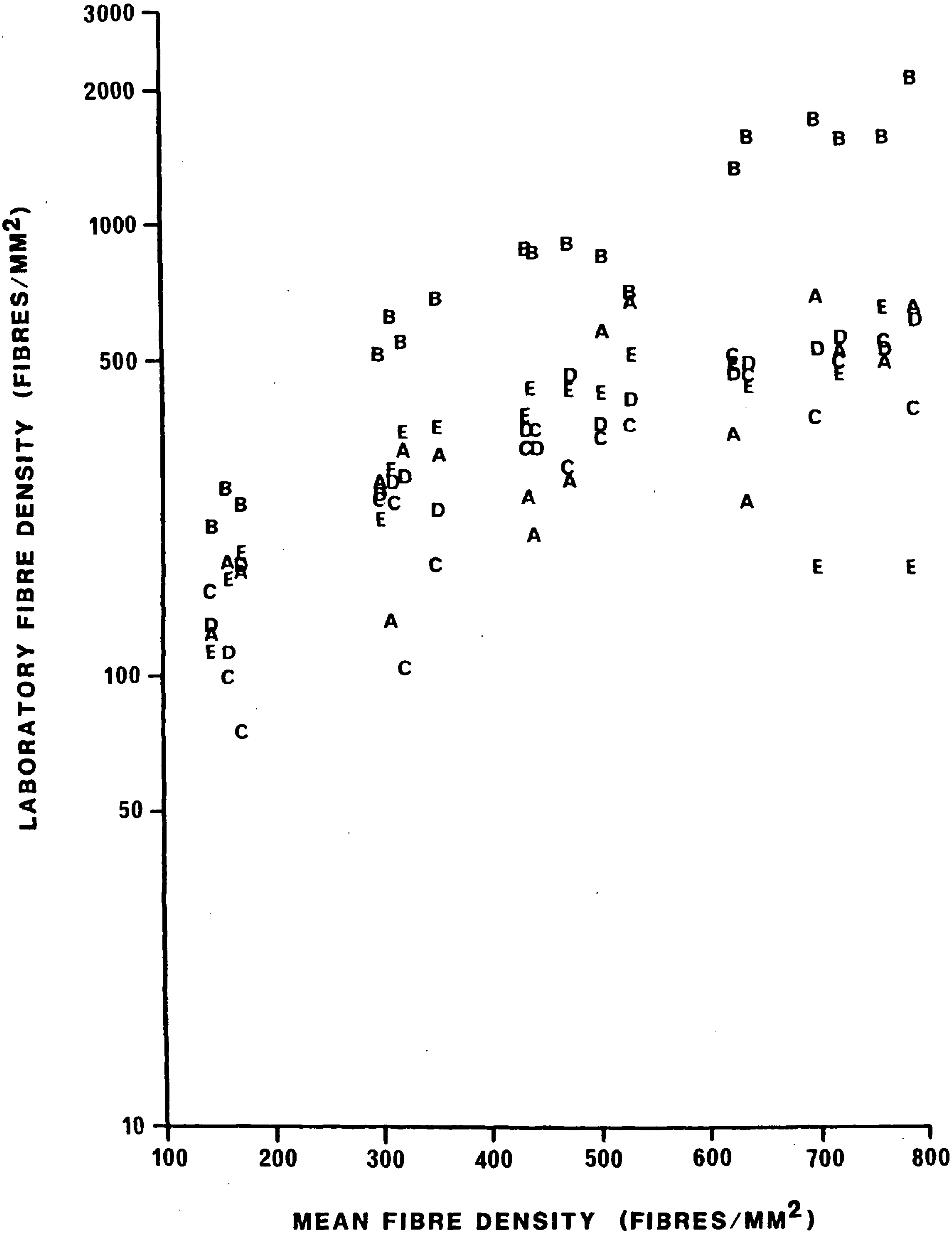

Fig. 1 Fibre densities recorded in the first slide exchange

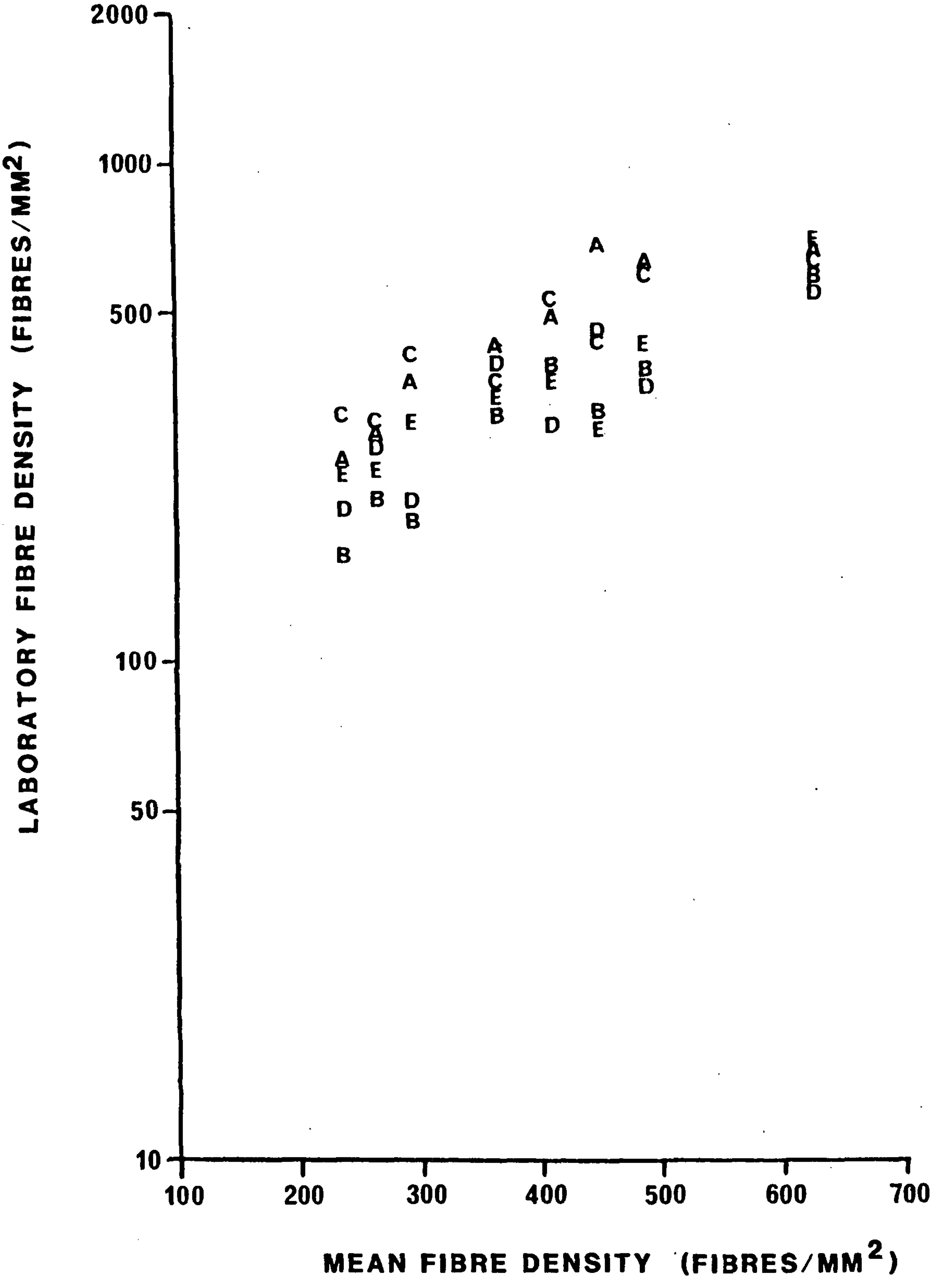

Fig. 2 Fibre densities recorded in the second slide exchange

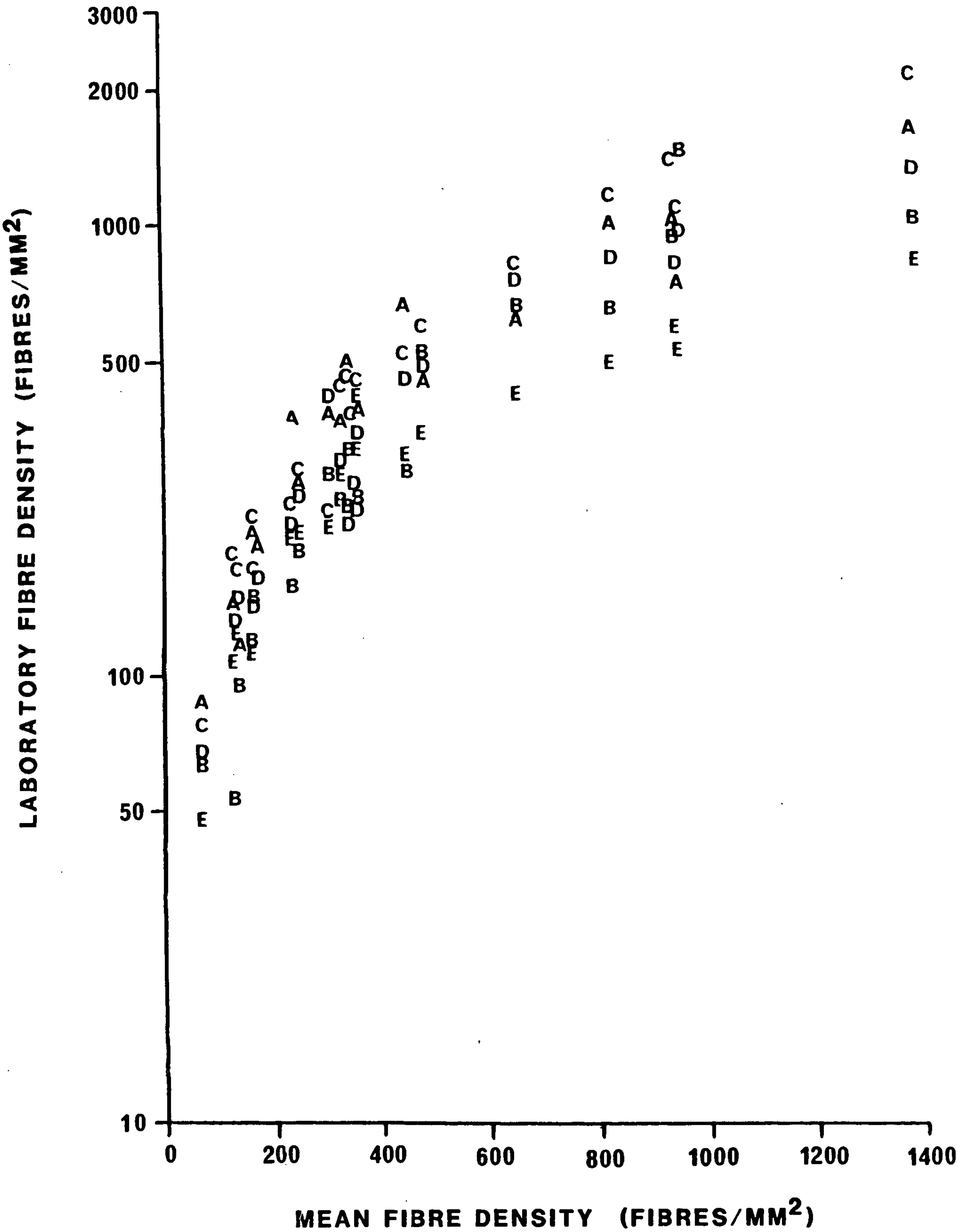

Fig. 3 Fibre densities recorded in the third slide exchange

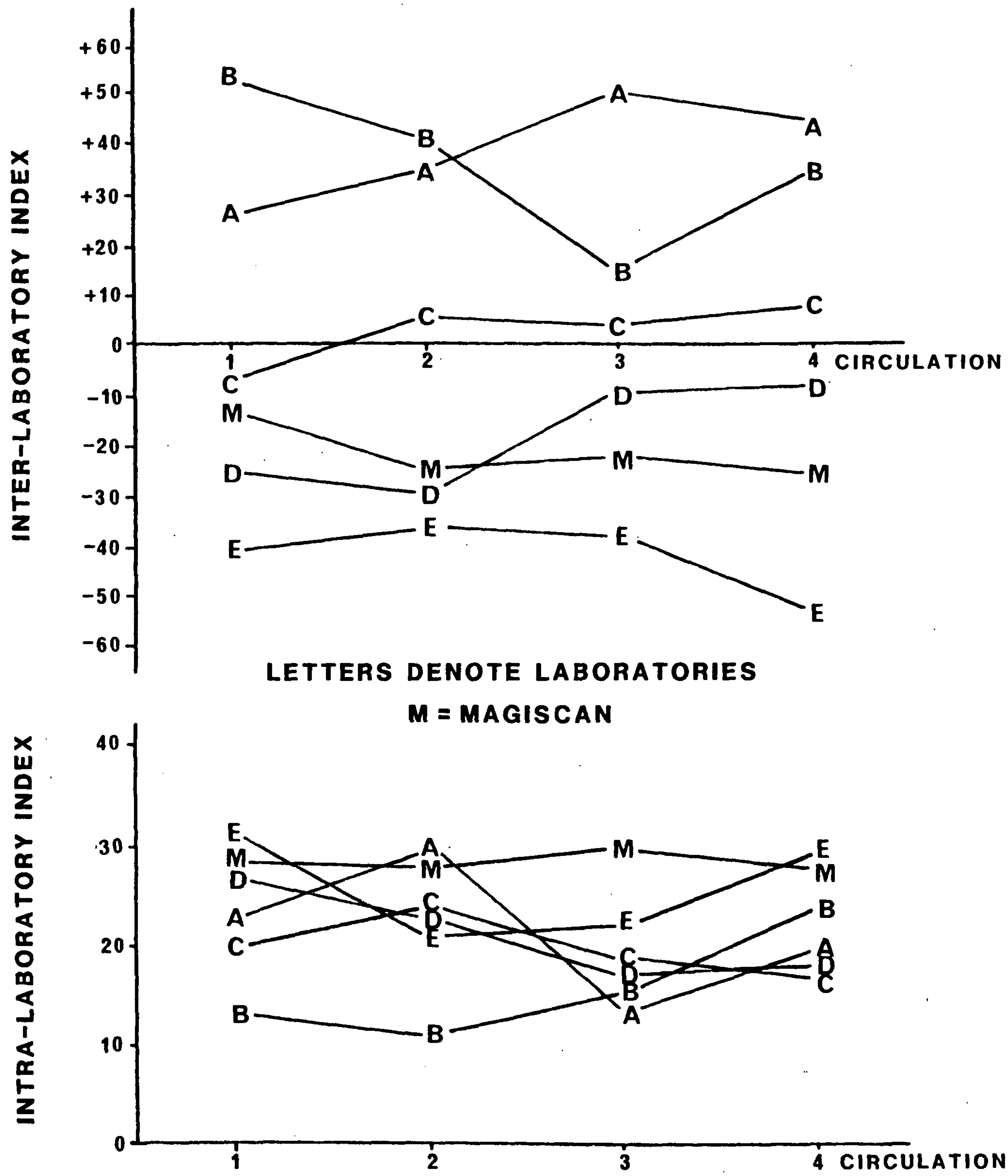

Fig. 4 Performance indices of CRS group laboratories in each of four exchanges

APPENDIX 1

HSE Reference 1611

CENTRAL REFERENCE SCHEME FOR THE EVALUATION OF ASBESTOS FIBRES

Constitution and Terms of Reference of the Steering Committee

The Steering Committee shall consist of three members appointed by the Health and Safety Executive (of whom one shall be appointed by the Executive as permanent chairman), three members appointed by the Asbestosis Research Council (of whom one shall be appointed by the Council as permanent secretary), and one member appointed by the Institute of Occupational Medicine. Members may be accompanied by technical advisors at meetings of the Committee.

The Committee shall

(1) nominate certain laboratories, to be known as the Reference Group, which will be invited to participate in the Scheme,

(2) guide the Institute on matters of policy regarding the Scheme,

(3) consider the reports and recommendations from the Institute, discuss and agree the operational procedures of the Scheme and advise HSE and ARC on relevant issues including publications,

(4) consider counting performance standards and procedures whereby laboratories other than those in the Reference Group may be accredited for the purposes of the Scheme.

APPENDIX 2

DESCRIPTION OF THE CRS REFERENCE METHOD

Mountant	Acetone/Euparal
Microscopes	Those used routinely by the Master Laboratories. Specification of these microscopes (Table 1) generally conform, with only a few minor differences, to that presented in the AIA Reference Method. Either positive or negative phase may be used.
Graticule	Walton-Beckett, nominal diameter 100 μm in the object plane.
Dimensions of 'Countable' fibre	An object with length >5 μm, diameter <3 μm and length: diameter ratio >3:1.
Split fibres Fibres in contact with particles Grouped fibres	Split into individual fibrous components, wherever possible, and count each component subject to its meeting the dimensions of a countable fibre. Where a grouped fibre cannot be split readily into components (a 'clump') count that group as 8 fibres.
Fibres overlapping graticule perimeter	A fibre is counted as one fibre if its lowest point lies within the graticule area having crossed the graticule perimeter.
Number of fibres counted or fields evaluated	100 fibres or 100 fields.

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