



Report to Client

**Sampling and Analysis of Crude Vermiculite Samples
For Possible Asbestiform Fibre and Quartz Content**

For

**Mr M Darling,
Palabora Mining Company
Palabora Europe Ltd
Palabora America Ltd
Palabora Asia PTE Ltd
1A Guildford Business Park
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**CONTRACT NO: 609-00950
DATE OF ISSUE: 09.08.05**

Report Prepared by:

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1. INTRODUCTION

The Palabora Mining Company produces crude vermiculite from open cast mines at Phalaborwa, Limpopo Province, South Africa. The crude vermiculite is transported by rail from the mine to the port of Richards Bay on the Indian Ocean coastline of KwaZulu-Natal in South Africa. From this port it is shipped in bulk to a variety of destinations. Palabora Europe Limited stores Palabora vermiculite in both Rotterdam in the Netherlands and North Killingholme in the U.K.

In order to address concern on Health and Safety issues in the world-wide market for vermiculite, Palabora Europe have previously commissioned IOM Consulting to undertake a detailed analysis of vermiculite from the main PP & V ore body at Phalaborwa. This original study produced favourable results and has been followed up by routine screening of stocks.

The main aims were to collect representative samples from each grade of vermiculite as available in the European market, split them and analyse them at the IOM Consulting's Edinburgh headquarters for asbestiform minerals and crystalline silica.

2. PROCEDURE

Mr Damien Eaves of IOM Consulting and Mr Mike Darling of Palabora Europe Limited visited the Palabora Europe Ltd vermiculite bulk store at North Killingholme Humberside, on 9th August 2005. All samples were collected by Damien Eaves of IOM Consulting. At the North Killingholme site, there are normally five different grades of vermiculite stored inside large silos of approximately 27 metres diameter and 9 metres high (Micron PP & V, Superfine PP & V, Fine PP & V, Medium PP & V and Large PP & V). At the time of this exercise there were five grades in stock and the approximate stocks at the time of sampling are summarised in Table 1.

Samples were collected from each grade as representatively as possible, by clearing away loose dust from the top of the material and digging into the stock as far as possible, avoiding any material falling in and re-mixing. A number of sub-samples per grade were extracted and mixed from each stockpile. Each sample was split on site with one sample being retained by Palabora Europe and the rest by IOM Consulting.

Table 1 Details of Crude Vermiculite Stocks at North Killingholme on 9th August 2005

Vermiculite Grade	Silo	Approx. Stock on 9 th August 2005 (tonnes)
Micron (PP & V)	924	1,573
Superfine (PP & V)	932	1,672
Fine (PP & V)	906	302
Medium (PP & V)	915	406
Large (PP & V)	915	536

3. METHODS OF ANALYSIS

3.1 Asbestos

The main objective was to identify any hazardous asbestos fibres present in the samples of vermiculite collected by IOM Consulting. This was achieved as follows:

- i) Initial examination by stereo-binocular microscopy and polarised light microscopy using methods described in HSE document HSG 248 (HSE, 2005a).

A portion of each sample was examined for the presence of fibrous asbestos minerals at X8 – X40 magnifications, using stereo-binocular microscopy. Any fibres detected, were mounted in appropriate refractive liquid and identified at 125X magnification using Polarised Light Microscopy (PLM) and dispersion staining microscopy.

This part of the analysis was carried out under IOM's external quality accreditation, awarded by the United Kingdom Accreditation Service (UKAS).

- ii) Quantitative assessment of amphibole asbestos by electron microscopy and X-ray diffractometry would normally then be carried out for samples in which asbestos fibres were detected in (i) above. In this instance, this was not done as there were no fibres identified.

3.2 Crystalline Silica

A portion of each August 2005 sample was ground up and analysed using X-ray diffraction techniques using modified versions of MDHS 101 (HSE, 2005b). Additional preparation of the 2005 Large grade PP&V sample was carried out to achieve a lower detection limit. Detailed method descriptions are shown in the certificates of analysis in Appendix 1.

4 RESULTS

- 4.1 Polarised Light Microscopy examinations did not detect any amphibole or chrysotile asbestos fibres present in any of the samples of vermiculite. As there were no amphibole or chrysotile asbestos fibres detected in any of the samples of vermiculite collected, quantitative analysis of the vermiculite materials was not undertaken.
- 4.2 X-ray diffractometry of the August 2005 bulk materials detected no concentrations of crystalline silica present in the samples of vermiculite.
- 4.3 For the sample subjected to chemical digestion prior to analysis by XRD, concentrations recorded were below the limit of detection for the methodology adopted.
- 4.3 A summary of results is given in Tables 2a, 2b and 2c below. Certificates of Analysis are attached (Appendix 1).

Table 2a Summary of Results August 2005 sampling exercise

Silo Number	Description	Asbestos	Crystalline Silica
915	Large (PP & V)	None Detected	None Detected
915	Medium (PP & V)	None Detected	None Detected
906	Fine (PP & V)	None Detected	None Detected
932	Superfine (PP & V)	None Detected	None Detected
924	Micron (PP & V)	None Detected	None Detected

Table 2b Crystalline Silica Results

Silo Number	Sample Description	Cristobalite %	Quartz %
915	Large (PP & V)	None Detected (<0.3)	None Detected (<0.3)
915	Medium (PP & V)	None Detected (<0.3)	None Detected (<0.3)
906	Fine (PP & V)	None Detected (<0.3)	None Detected (<0.3)
932	Superfine (PP & V)	None Detected (<0.3)	None Detected (<0.3)
924	Micron (PP & V)	None Detected (<0.3)	None Detected (<0.3)

Table 2c Crystalline silica content of Large grade PP&V, after chemical digestion.

Sample	Original weight (g)	Weight after digestion (g)	Percentage Cristobalite	Percentage Quartz
Large PP&V	1.56103	0.06938	None detected <0.03	< 0.03

5. CONCLUSIONS

- 5.1 The vermiculite materials tested comply with the 0.1% European packaging and labelling of carcinogen (asbestos) requirements (HSE, 2002) and the 0.1% trigger value for asbestos required for labelling of hazardous materials in the US.

The levels are also lower than the 0.001% for asbestos in loose aggregates proposed by Addison *et al* (1988) based on work at the IOM using asbestos and soil mixtures. Therefore, it is concluded that these materials or products containing them should not present a significant asbestos-related health hazard when used in controlled occupational environment.

- 5.2. Similarly with there being no crystalline silica (<0.3%) detected in the five bulk samples and the result obtained from the Large grade vermiculite after digestion <0.03% quartz, there should not be any health hazard, specifically related to crystalline silica, when the materials are used in a controlled environment.

REFERENCES:

Addison J, Davies LST. (1990). Analysis of amphibole asbestos in chrysotile and other minerals. *Ann.Occ.hyg.*; 34: 159-175.

Health and Safety Executive (2005a). *Workplace Exposure Limits 2005*. EH40/05. HSE Books, Sudbury.

Chung (1974). *Quantitative Interpretation of X-ray Diffraction patterns of Mixtures*. III

Simultaneous Determination of a set of Reference Intensities. Sherwin-Williams Research Centre, Chicago, Illinois.

Health and Safety Executive (2002). *Approved Supply List. Information approved for the classification and labelling of substances and preparations dangerous for supply (seventh edition)* L129 HSE Books, Sudbury.

Health and Safety Executive (2005b). "Crystalline Silica in respirable airborne dusts". *Laboratory method using x-ray diffraction (direct method)*. *Methods for the Determination of Hazardous Substances No. 101*. HMSO, London.

Health and Safety Executive (2005). HSG 248 "Asbestos: The analyst's guide for sampling, analysis and clearance procedures." HMSO, London

Appendix 1

Certificates of Analysis



**CERTIFICATE OF ANALYSIS
FIBRE IDENTIFICATION IN BULK MATERIAL**

Client Details:	Palabora Europe Limited, 1A Guildford Business Park, Guildford, Surrey, GU2 8XG	Contract No.	05767-1a
Requested By:	Damien Eaves - IOM Consulting	OH Contract Code:	609-00950
Date Samples Rec'd:	11/08/05	Project No:	610
Date of Analysis:	16/08/05	Date of Issue:	24/08/05

The samples detailed below have been analysed qualitatively for asbestos by polarised light and dispersion staining as described by the Health and Safety Executive in HSG248. The results are given below:

IOM No.	Clients Sample No.	Sample Details	Asbestos Type(s) Present
R25100	00950-1	CRUDE VERMICULITE SAMPLE SILO 915 LARGE GRADE VERMICULITE	NONE DETECTED
No. of Samples:		ONE	

IOM Consulting accepts responsibility only for results obtained from samples as received. No responsibility is accepted for errors, which may have arisen during sampling or transportation of samples by external clients.

Authorised by: 

S Clark
Mineralogy Section Manager

**CERTIFICATE OF ANALYSIS
FIBRE IDENTIFICATION IN BULK MATERIAL**

Client Details:	Palabora Europe Limited, 1A Guildford Business Park, Guildford, Surrey, GU2 8XG	Contract No.	05767-1b
Requested By:	Damien Eaves - IOM Consulting	OH Contract Code:	609-00950
Date Samples Rec'd:	11/08/05	Project No:	610
Date of Analysis:	16/08/05	Date of Issue:	24/08/05

The samples detailed below have been analysed qualitatively for asbestos by polarised light and dispersion staining as described by the Health and Safety Executive in HSG248. The results are given below:

IOM No.	Clients Sample No.	Sample Details	Asbestos Type(s) Present
R25101	00950-2	CRUDE VERMICULITE SAMPLE SILO 915 MEDIUM GRADE VERMICULITE	NONE DETECTED
No. of Samples:		ONE	

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Authorised by: 

S Clark
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CERTIFICATE OF ANALYSIS FIBRE IDENTIFICATION IN BULK MATERIAL

Client Details: Palabora Europe Limited, 1A Guildford Business Park, Guildford, Surrey, GU2 8XG **Contract No.** 05767-1c

Requested By: Damien Eaves - IOM Consulting **OH Contract Code:** 609-00950

Date Samples Rec'd: 11/08/05 **Project No:** 610

Date of Analysis: 16/08/05 **Date of Issue:** 24/08/05

The samples detailed below have been analysed qualitatively for asbestos by polarised light and dispersion staining as described by the Health and Safety Executive in HSG248. The results are given below:

IOM No.	Clients Sample No.	Sample Details	Asbestos Type(s) Present
R25102	00950-3	CRUDE VERMICULITE SAMPLE SILO 906 FINE GRADE VERMICULITE	NONE DETECTED
No. of Samples:		ONE	

IOM Consulting accepts responsibility only for results obtained from samples as received. No responsibility is accepted for errors, which may have arisen during sampling or transportation of samples by external clients.

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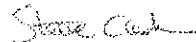
Client Details:	Palabora Europe Limited, 1A Guildford Business Park, Guildford, Surrey, GU2 8XG	Contract No.	05767-1d
Requested By:	Damien Eaves - IOM Consulting	OH Contract Code:	609-00950
Date Samples Rec'd:	11/08/05	Project No:	610
Date of Analysis:	16/08/05	Date of Issue:	24/08/05

The samples detailed below have been analysed qualitatively for asbestos by polarised light and dispersion staining as described by the Health and Safety Executive in HSG248. The results are given below:

IOM No.	Clients Sample No.	Sample Details	Asbestos Type(s) Present
R25103	00950-4	CRUDE VERMICULITE SAMPLE SILO 932 SUPERFINE GRADE VERMICULITE	NONE DETECTED
No. of Samples:		ONE	

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FIBRE IDENTIFICATION IN BULK MATERIAL**


Client Details:	Palabora Europe Limited, 1A Guildford Business Park, Guildford, Surrey, GU2 8XG	Contract No.	05767-1e
Requested By:	Damien Eaves - IOM Consulting	OH Contract Code:	609-00950
Date Samples Rec'd:	11/08/05	Project No:	610
Date of Analysis:	16/08/05	Date of Issue:	24/08/05

The samples detailed below have been analysed qualitatively for asbestos by polarised light and dispersion staining as described by the Health and Safety Executive in HSG248. The results are given below:

IOM No.	Clients Sample No.	Sample Details	Asbestos Type(s) Present
R25104	00950-5	CRUDE VERMICULITE SAMPLE SILO 924 MICRON GRADE VERMICULITE	NONE DETECTED
No. of Samples:		ONE	

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CERTIFICATE OF ANALYSIS

ANALYSIS REQUESTED BY: Mr M Darling
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Guildford
Surrey
GU2 8XG

CONTRACT NO: 05767-2
PROJECT NO: 610
DATE OF ISSUE: 25.08.05

ANALYSIS REQUESTED: Crystalline silica content of five bulk vermiculite samples, with further more detailed analysis of the Large grade (PP&V) sample (see 05767-3).

SAMPLES: Five bulk samples of Palabora vermiculite (see Table 1)

METHOD:

Portions of the samples were ground up to a uniform size then scanned qualitatively using routine X-ray diffraction techniques. The resultant diffraction patterns were then matched with those of standard minerals (quartz, cristobalite etc.) to determine the presence of crystalline silica in the samples. The method followed was as described by Chung (1974).

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CONTRACT NO: 05767-2
PROJECT NO: 610
DATE OF ISSUE: 25.08.05

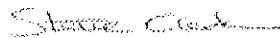
RESULTS: Crystalline silica in bulk vermiculite.

Vermiculite Grade	% Cristobalite	% Quartz
Micron (PP&V)	ND<0.3*	ND<0.3*
Superfine (PP&V)	ND<0.3*	ND<0.3*
Fine (PP&V)	ND<0.3*	ND<0.3*
Medium (PP&V)	ND<0.3*	ND<0.3*
Large (PP&V)	ND<0.3*	ND<0.3*

*The detection limit for quartz and cristobalite by this method is around 0.3%. This figure is based upon three times the standard deviation of the measurement of a blank sample run on a quantification programme. Previously, the detection limit was based upon the lowest amount, which could be detected on a qualitative programme, which was 0.1%. Although this has not changed, we are now required by the United Kingdom Accreditation Service (UKAS) to base our detection limit on the quantitative rather than the qualitative part of the analysis.

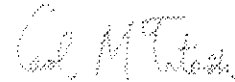
COMMENTS:

No crystalline silica was detected in any of the bulk samples.



ANALYSED BY:

Steve Clark
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AUTHORISED BY:

Carol McIntosh
Operations Manager

CONTRACT NO: 05767-2
PROJECT NO: 610
DATE OF ISSUE: 25.01.05

REFERENCES:

Addison J, Davies LST. (1990). Analysis of amphibole asbestos in chrysotile and other minerals. *Ann.Occ.hyg.*; 34: 159-175.

Health and Safety Executive (2005). *Workplace Exposure Limits*. EH40/2005. HSE Books, Sudbury.

Chung (1974). *Quantitative Interpretation of X-ray Diffraction patterns of Mixtures. III Simultaneous Determination of a set of Reference Intensities*. Sherwin-Williams Research Centre, Chicago, Illinois.

Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". *Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101*. HMSO, London.



CERTIFICATE OF ANALYSIS

ANALYSIS REQUESTED BY: Mr M Darling
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CONTRACT NO: 05767-3
PROJECT NO: 610
DATE OF ISSUE: 25.08.05

ANALYSIS REQUESTED: Detailed analysis of one vermiculite sample for crystalline silica content – PMC Large grade (PP&V).

SAMPLES: One bulk sample of Palabora vermiculite.

METHOD:

Approximately 1.5 grams of the vermiculite was accurately weighed into a porcelain crucible, exfoliated in an oven, allowed to cool and re-weighed. The vermiculite was removed by digestion in a re-flux condenser with 2M H₂SO₄, followed by 4M NaOH. The residue was collected by filtration and re-weighed (Addison and Davies, 1990). This process extracts vermiculite, chlorite, chrysotile and other minerals, but leaves amphiboles, feldspar, quartz, etc. effectively unaltered. Aqueous suspensions were prepared from which aliquots were deposited on to 25mm 0.2µm pore size polycarbonate filters for analysis by X-ray diffractometry for crystalline silica content. Samples were analysed using a modified version of MDHS 101 (HSE 2005).

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PROJECT NO: 610
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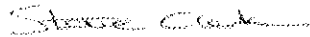
RESULTS:

Crystalline silica content of Large grade PP&V, after chemical digestion.

Sample	Original Weight (g)	Weight After Digestion (g)	Percentage Cristobalite	Percentage Quartz
Large PP&V	1.56103	0.06938 (4.4%)	ND<0.03*	ND<0.03*

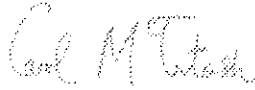
ND - Not Detected

* - Detection Limit. Our current detection limit for crystalline silica on filter by XRD is 0.02 mg. The detection limits quoted for the sample above are based upon 0.02 mg expressed as a percentage of the weight of dust on the sample filter. The detection limits therefore vary as a function of the weight of dust on the filter and weights of the original samples and digestion residues.



ANALYSED BY:

S Clark
Mineralogy Section Manager



AUTHORISED BY:

C McIntosh
Operations Manager



Review of Current and Proposed European Legislation Relating to Asbestos,
Crystalline Silica, Respirable Dust and Total Inhalable Dust

for

Mr Mike Darling
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Vermiculite Operations Department
1A Guildford Business Park
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Contract No: 00950L
Project No: 609
Date: 19.09.05

Report Prepared by:

LST Davies

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Asbestos, Crystalline Silica, Respirable Dust and Total Inhalable Dust
(An update of current legislation)
September 2005

1. Introduction

The greater majority of European legislation concerning limits for asbestos, respirable dust, total inhalable dust and crystalline silica has historically related to airborne concentrations. This position has not changed since the previous review carried out in September 2003. Airborne concentrations of dusts and minerals are normally classified on the basis of their carcinogenicity or toxicity and there are often a number of different types or classes of limit, which relate to this.

In the European Union (EU), European Directives normally form the basis of national regulations. However, individual member countries may enforce different limits, within their own country, providing they are more stringent than the EU limits.

The three main areas of legislation, which would apply to vermiculite, remain unchanged from our last review in September 2003. These are Exposure Limits for airborne dust concentrations (or national equivalents), asbestos prohibition regulations and packaging and labelling requirements for carcinogens.

However, since the 2003 review, the UK Health & Safety Executive has changed the terminology used to define Exposure Standards. The terms MEL and OES have now been replaced by a single "Workplace Exposure Limit" or WEL. These changes came into effect in April 2005. EH40/2005 (HSE, 2005a) defines the new WEL as exposure limits set under COSHH (HSE, 2005b) and are concentrations of hazardous substances in air averaged over a specified period; either long term (8 hours) or short term (15 minutes).

2. Airborne Dust Concentrations

2.1 United Kingdom

The current UK exposure limits are published annually by the Health and Safety Executive (HSE) in EH40. The limits outlined below were taken from EH40/2005.

- For crystalline silica (including quartz and cristobalite), the current WEL is set at 0.3 mg.m^{-3} (8hr Time Weighted Average) and remains the same as the previous MEL. The WEL for respirable silica is currently under review. The HSE now believe that regular exposure to 0.3 mg.m^{-3} crystalline silica will result in a much higher risk of lung damage than was previously thought. As a result HSE is now proposing that in 2006 the WEL is reduced to either 0.1 mg.m^{-3} or 0.05 mg.m^{-3} (8hr TWA) (HSC, 2005).
- General nuisance dust, both total inhalable and respirable, are covered by the Control of Substances Hazardous to Health (COSHH) regulations and limits of 10 mg.m^{-3} and 4 mg.m^{-3} (8hr TWA) apply respectively. These limits are unchanged from the previous review.
- Asbestos is covered by The Control of Asbestos at Work Regulations; these regulations were last amended in 2002. The main changes were the introduction of the duty to manage asbestos in buildings and a revised four stage asbestos clearance test. The Control Limits for Chrysotile ($0.3 \text{ fibres per millilitre (fml}^{-1})$ and 0.9 fml^{-1} for 4 hour and 10 minute periods) and amphibole asbestos (0.2 fml^{-1} and 0.6 fml^{-1}) remain unchanged. However, new asbestos guidance has been published in the form of HSG 248, "The analyst's guide for sampling analysis and clearance procedures" (HSE, 2005c). This document replaces various asbestos guidance documents including the asbestos identification method, MDHS 77 and introduces the new WHO fibre counting rules due to be implemented in 2006.

2.2 Europe

In Europe, limits vary from country to country and a brief summary of the current position is described below.

- Crystalline silica (quartz), limits for respirable dust range from 0.05 mg.m⁻³ in Ireland and Italy, 0.1 mg.m⁻³ in Belgium, Denmark, France, Germany (mines), Sweden, Russia and Norway, Portugal and Spain to 0.15 mg.m⁻³ in Austria, Germany (workplace), Luxembourg and Switzerland (all are Time Weighted Averages).
- Cristobalite, limits are 0.05 mg.m⁻³ in Belgium, Denmark, France, Greece, Italy, Norway, Portugal, Spain and Sweden.
- General dust (respirable and total) limits are largely similar to those in the UK, although in Germany the limits are 1.5 mg.m⁻³ and 4 mg.m⁻³ (TWA) for respirable and inhalable dust respectively.
- Asbestos control limits are fairly variable, ranging from 0.1 fml⁻¹ for amphibole asbestos up to 1.0 fml⁻¹ for chrysotile asbestos.

3. Asbestos in Materials

In Europe the packaging and labelling requirements apply to materials containing substances which may be hazardous to health. In the UK these requirements are described in The Chemicals (Hazard Information and Packaging for Supply) Regulations 1994. These regulations were replaced by CHIP 3 in July 2002 (HSE, 2002). However, the changes did not affect existing requirements for materials containing asbestos or crystalline silica.

Asbestos is classified as a Class 1 carcinogen and materials containing more than 0.1% must be labelled as such.

The International Association for Research into Cancer (IARC) has classified crystalline silica as a carcinogen (IARC, 1997). However, this classification is unlikely to be adopted by the European Union in the near future. As a result materials containing crystalline silica do not currently have to be labelled.

4. The UK Asbestos (Prohibitions) (Amendment) Regulations 2003

The importation of asbestos into the UK has been banned since the 1999 asbestos Prohibition Regulations came into force. However, these regulations were amended in August 2003 and now clarify the position for materials where the asbestos has not been intentionally added. The Asbestos Prohibition Regulations were amended as follows: "The amendment modifies the existing ban on importing asbestos-containing materials (ACMs), so that only those where asbestos has been intentionally added are prohibited from being imported. Minerals for which specific concerns have been expressed over asbestos impurities include olivine, vermiculite, talc, dolomite, haematite, iron ore, basalt, marble, chrome ore, magnetite and wollastonite." This amendment brings the importation ban into line with the obligations of the European single market regulations (HSE, 2003).

5. Other Legislation

The only other European legislation that specifically refers to a permitted level of a particular substance or material, are the various waste disposal regulations. In the UK, the Special Waste Regulations (1996) apply to waste materials that contain asbestos. Again the threshold has been set at 0.1% and it applies to any type of asbestos in any form. Crystalline silica is not currently classified as a special waste.

6. Future Changes

The UK Health & Safety Executive has decided to implement the new European WHO fibre counting rules. New guidance was published in February 2005 to support the new methodology which is expected to be implemented in April 2006. The main effect of the new rules will be upon airborne fibre concentrations, i.e. on average more fibres will be counted than was previously the case. The existing Control Limits for asbestos will remain unchanged, but the overall effect will be that these limits will be effectively reduced.

The UK Control of Asbestos at Work Regulations is due to be amended in 2006 (this will incorporate the requirements of the second amendment to the European Directive 83/477/EC). The main changes are likely to include a single control limit of 0.1fml^{-3} for all asbestos types, Asbestos Action limits (based upon a 12 week cumulative exposure) will be abolished and the definition of asbestos materials requiring a license will change. These requirements will also be implemented across the European Union.

7. References

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