RSPH Level 3 Award in Asbestos Bulk Analysis

Pre-Read Qualification Information

Qualification Overview

To provide the knowledge and competency to analysts for carrying out the identification of asbestos by polarised light microscopy (PLM).

Instruction: 15 hours over 3 days
Prior learning/pre-reading: 3 hours
Assessment:
1. Written exam - short answer questions
2. Practical assessment – witnessed exercises and analysis of AIMS samples.

Day 1
Unit 1 Asbestos types, uses, health effects and legislation.
Unit 2 Theory and equipment used in asbestos bulk analysis.
Unit 3 Bulk analysis methods.

Day 2
Unit 3 Continued.

Day 3
Unit 3 Continued.
Written exam and analysis of AIMS samples.

The RSPH Qualification

Royal Society for Public Health (RSPH) is the awarding body for the level 3 qualification in Asbestos Bulk Analysis.

The Level 3 qualification is equivalent standard to an A Level.
The qualification depends on a candidate achieving 60% in a written exam for EACH unit and a satisfactory witnessed practical assessment in;

1. Set-up and use of stereo microscope and PLM
2. Analysis of 6 AIMS samples

Contents

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UNIT 1
Asbestos types, uses, health effects and legislation

HSE Statement

'Asbestos is the greatest single cause of work related deaths in the UK.' Currently around 5,000 deaths per annum.

The Current Problem

Approximately 6million tonnes of imported fibres went into 30 to 40million tonnes of building products. Large numbers of buildings still contain asbestos with between 500,000 and 2million commercial premises and around 2.5million domestic dwellings.

There is a large potential for exposure in the population with 2million working in building trades and 20million general building users/ occupants.

The problem is workers still don't know what it looks like, where it is or what the actual risks are from the products.

HSE Report RR696 – Prof. Peto

The predicted total of 90,000 UK mesotheliomas between 1970 and 2050 will include around 15,000 carpenters. The particularly high risk to carpenters is thought to be due to exposure to amosite (brown asbestos) while cutting AIB.

In the 1960s the UK imported almost half of all amosite mined to put into AIB products.

The HSE estimates 20% of ceiling area of public buildings built between 1967 and 1973 are AIB (plus all the Boots, M&S, Woolworths premises). Miscellaneous use of AIB is a bigger problem than lagging or sprayed coatings.

Section 1: Properties and characteristics of asbestos

Asbestos - "Natures Wonder Fibre"

Asbestos is a general name given to several naturally occurring fibrous minerals that have crystallised to form fibres. Asbestos fibres have properties that have been utilised to en-hance other products. These properties are:

a) Strength – stronger than steel
b) Flexibility – easily woven
c) Stability – will deteriorate only slowly
d) Very good thermal insulator
e) Have fantastic fire retardant properties.
f) Chemical and electrical resistant

Asbestos Types and Characteristics

Asbestos is generally divided into two sub-groups:

a) **Serpentine asbestos** (chrysotile or white asbestos) was the most commonly used type of asbestos.

   i} Chrysotile is a sheet/layer silicate with silky, flexible, curly, inelastic fibres.. The fibres are hydrophilic (water loving) and less acid resistant than amphiboles, however far more alkali resistant and used extensively in cement and textile products.

b) **Amphibole fibres** (crocidolite - blue asbestos, amosite - brown asbestos, tremolite, actinolite and anthophyllite).

   i) The amphibole fibres are hydrophobic (water hating) and much better acid resistance than chrysotile.

   ii) Tremolite and actinolite form a 'solid-solution' series and have continuously variable composition depending on the source of the material.

   iii) Crocidolite, amosite, tremolite, actinolite and anthophyllite, are brittle fibres and are often rod or needle-like in appearance. It is this form that is more hazardous to health. Crocidolite was the most commonly used amphibole asbestos in the past.

   iv) Amosite was used in boarding products and ceiling tiles, but also as insulation and in sprayed coatings.

   v) Crocidolite has the best thermal properties and was used as insulation and as a spray coating

Section 2: Types and uses of asbestos containing materials (ACM's)

Location of ACM's in buildings

Cut Off Dates for Use of ACM

1969	Voluntary ban on blue asbestos commences
1974-75	Spray coating cease to be used.
1980-85	Pipe/boiler lagging cease to be used.
1985	AIB panels/ceiling tiles finally cease to be used.
1985	Statutory ban on brown and blue asbestos.
1985-89	Textured coating ceases to be used.
1990-95	Floor tiles/coverings and cement flues to boilers cease being used.
1999	Corrugated roof sheets cease to be used.
1999	Statutory ban on white asbestos in 1999, although there may still have been imports after domestic ban.

Loose fill insulation

Loose fibre such as blankets and mattresses were used as insulation. Some was packed in bags and used in flooring / Jiffy etc and some was hessian wrapped.

Loose fill was usually pure asbestos with the exception of linings or bags.

Mattresses and quilts were commonly filled with raw crocidolite and chrysotile and it can also used for acoustic insulation.

Dry material = high levels of exposure

Asbestos Product	Location/use	Asbestos and time/ date last used	Ease of fibre release and product names
Loose Insulation			
Bulk loose fill, bulk loose fibrefilled mattresses, quilts and blankets. Also 'jiffy bag' type products used for sound insulation.	Bulk loose fill insulation is now rarely found but may be encountered unexpectedly, eg DIY loft insulation and firestop packing around cables between floors. Mattresses and quilts used for thermal insulation of industrial boilers were filled with loose asbestos. Paper bags/sacks were also loose-filled and used for sound insulation under floors and in walls..	Usually pure asbestos except for lining/ bag. Mattresses and quilts usually contain crocidolite or chrysotile. Acoustic insulation may contain crocidolite or chrysolite.	Loose asbestos may readily become airborne if disturbed. If dry, these materials can give rise to high exposures. Covers may deteriorate or be easily damaged by repair work or accidental contact.

Sprayed Coatings

Sprayed coatings (limpet) were both a dry and wet application with usually a trowel finish. Crocidolite was the major type of asbestos fibre used until 1962 and then completely stopped in 1969 with a voluntary import ban. Amosite and chrysotile was used until 1974 when sprayed coatings were stopped as the process was too dangerous due to the high fibre concentrations. The amount of fibre used varied but up to 85% asbestos fibre was not uncommon. High fibre release was also associated due to its high friability

Sprayed coatings Its primary use was as fire protection in ducts, firebreaks and around structural steel work were used for both thermal and anti-condensation insulation usually on the undersides of roofs and occasionally sides of industrial buildings and warehouses. It can also be found as acoustic insulation in theatres and swimming pools.

Another use was as fire protection on steel and reinforced concrete beams / underside of floors.

Overspray of target areas can be found where the sprayed material is found anywhere around and beyond the sprayed area.

Residue from the original application and residual splats either side of the target area are what to look for.

The material is far more friable and prone to fibre release than the actual coating and could have contaminated areas which appear to be asbestos free.

It was very rarely used in domestic housing.

Below; Spray coat on a car park ceiling for fire protection.

Asbestos Product	Location/use	Asbestos and time/date last used	Ease of fibre release and product names
Sprayed Coating			
Dry applied, wet applied and trowelled finish.	Thermal and anti-condensation insulation on underside of roofs and sometimes sides of industrial buildings and warehouses. Acoustic insulation in theatres, halls etc. Fire protection on steel and reinforced concrete beams/columns and on under-side of floors. Over-spray of target areas is common.	Sprayed coatings usually contain 55%–85% asbestos with a Portland cement binder. Crocidolite was the major type until 1962. Mixture of types including crocidolite until mid–1971. Asbestos spray applications were used up to1974.	The surface hardness, texture and ease of fibre release will vary significantly depending on a number of factors. Sprays have a high potential for fibre release if unsealed, particularly if knocked or the surface is abraded or delami-nates from the underly-ing surface. Dust released may then accumulate on false ceilings, wiring and ventilation systems.' Limpet' (also used for non-asbestos sprays).

Thermal Insulation

Thermal insulation is generally regarded as high/medium risk material. The content of asbestos fibre used is highly variable and can vary greatly, 6 - 85%. Ad hoc mixtures were used on bends / pipe runs.

Pre-formed sections 85% magnesia 15% amosite.

Trade names such as 'Caposil' which is calcium silicate slabs / blocks contain 8 – 30% amosite and 'Caposite' sections which can contain 85% amosite.

An outer coating was usually applied to protect against damage. This could be a number of applications such as a hard setting compound or rolled metal such as aluminium.

Thermal insulation could contain blue, brown or white asbestos and was mixed on site prior to application.

Pre-formed sectional ("Caposite") lagging was also available and gives a more uniform finish. Pre-formed sections were very expensive.

Thermal insulation can come in many forms such as hand applied thermal lagging used for pipe and boiler lagging.

Preformed pipe sections, slabs and blocks used to lag very quickly but very expensive to buy.

Also tapes, ropes corrugated papers, quilts, felts and blankets were available.

All these applications may have outer coating of scrim, metal, cement or chicken wire.

All types of asbestos have been used in thermal insulation. Crocidolite was used in lagging until 1970.

Amosite phased out by manufacturers during 1970s.

The friability of the material depends on nature of lagging, high potential for fibre release unless sealed, and increases with age.

Common encapsulation methods include calico and paint, PVA, "ET150", or polymer emulsions such as "DECADEX".

A harder weather resistant finish for external pipe runs - commonly known as Bulldog.

Asbestos Product	Location/use	Asbestos and time/ date last used	Ease of fibre release and product names
Thermal Insulation			
Hand-applied thermal lagging, pipe and boiler lagging, pre-formed pipe sections, slabs, blocks. Also tape, rope, corrugated paper, quilts, felts and blankets.	Thermal insulation of pipes, boilers, pressure vessels, calorifiers etc	All types of asbestos have been used. Crocidolite used in lagging until 1970. Amosite was phased out by the manufacturers during the 1970s. Content varies 6-85%. Various ad hoc mixtures were handapplied on joints and bends and pipe runs. Pre-formed sections were widely used, eg '85% magnesia' contained 15%.	The ease of the fibre release often depends on the type of lagging used and the surface treatment. Often it will be encapsulated with calico and painted (eg PVA, EVA, latex, bitumen or propietary polymer emulsions or PVC, neoprene solutions}, eg 'Decadex' finish is a proprietory polymer.

Asbestos Insulating Board (AIB)

Asbestos insulating board (AIB) is generally regarded as a medium risk material. There is usually a fibre content present of 15 to 25%.
The material is less friable as compressing the board and paint acts as protective coating.

Asbestos Insulation Board (AIB) was mainly used to provide:

a) structural fire protection – Walls panels, ceiling tiles, fire breaks, door linings
b) heat resistance
c) acoustic insulation
d) partitioning, (e.g. doors, meter cupboards, ovens, domestic boiler casings, fire breaks etc) and
e) general building board (infill panels, bath panels, wall lining, canopies and porch linings).

Crocidolite used infrequently up to 1965 but Amosite is the main asbestos component and was used up to 1980 when manufacture ceased. There is usually 15 – 25 % amosite or a mixture of amosite and chrysotile in calcium silicate but older boards and early marine boards can contain up to 40%.

There are also a number of trade names to look out for such as

a) Asbestolux – 16 - 40 %
b) Turnasbestos
c) LDR
d) Asbestos Wallboard
e) Insulation Board
f) Marine Boards (Marinite – Shipboard).

AIB was used extensively up to 1985.

The UK was the world's largest importer of amosite (brown) with approximately 24,000 tons in 1960 and 40% of the global total.
It is known that 20% of the ceiling area of all new public buildings between 1967 and 1973 are made out of AIB ceiling tiles.
Former Woolworths stores are estimated to have 1 million sqm of ceiling tiles.

External canopy

Asbestos Product	Location/use	Asbestos and time/ date last used	Ease of fibre release and product names
AIB			
Insulating board in cores and linings of composite products.	Found in fire doors, cladding infill panels, domestic boiler casings, partition and cailing panels, oven linings and suspended floor systems. Used as thermal ionsulation and sometimes as acoustic attenuators.	Crocidolite used for some boards up to 1965, amosite up to 1980, when manufacture ceased. 16-40% amosite or a mixture of amosite and chrysolite.	Can be broken by impact; significant surface release possible by abrasion, but usually painted or plastered. Sawing and drilling will also give significant releases. 'Asbestolux' Caposil.

Fire break in ceiling void

Ceiling Tiles.

Millboard

A softer board than AIB and was used for heat insulation and fire protection, also as insulation to electrical equipment and plant.

Crocidolite used in some manufacture but usually chrysotile with a content of 37 – 97% asbestos with a remaining matrix of starch clay.

Millboard in a blown air heater.

Paper, Felt and Cardboard

Used for electrical heat insulation of electrical equipment and plant. These materials can be found in air conditioning systems as insulation and as an acoustic lining. Used to reinforce bitumen and as face linings to flooring products.

Corrugated cardboard can be used for duct and pipe insulation. Asbestos Paper can contain up to 100% chrysotile asbestos.

Asbestos corrugated paper as insulation.

Textiles and Rope

Woven and spun materials can contain up to 100% asbestos. All three main types of asbestos used until 1970, after which chrysotile was used.

Asbestos Rope used as an infill.

The content of asbestos is 100% unless combined with other fibres.

The material is liable to degrade if exposed to the atmosphere and also likely to become more friable with age.

Asbestos flashguards

Gaskets

These were widely used in domestic and industrial plant. The content can be variable, 5 to 20% or more, usually chrysotile.

Crocidolite used if the product was used in a chemical environment. There are a number of trade names including;
Klingerit, Lion jointing and Permanite

CAF – Compressed Asbestos Fibre.

Asbestos Cement

Generally contains 10 - 15 % asbestos bound in Portland cement or calcium silicate.

All three types of asbestos used but Chrysotile is most common. Crocidolite used– 1950-1969 and Amosite used 1945-1980

Used as compressed flat or corrugated sheets or moulded into products.

Asbestos cement is the most common type of asbestos containing material.

Fully compressed flat sheets, tiles and slates for cladding, decking and promenade tiles, roofing,

Preformed moulded products such as:
Cisterns, water tanks, drains, sewer pipes, rainwater goods, flue pipes, fencing, fascias, soffits, cable troughs and conduits and window flower boxes.

Corrugated asbestos cement sheets.

Textured Coatings and Paint

Commonly known as 'Artex' (applied mainly on ceilings) with an asbestos content of 1- 5% Chrysotile. The asbestos was added up to a base date of 1984 as a anti-slumping agent.

Be aware of dates as old stocks were re used.

There are a number of trade names such as, Artex, Wondertex, Suretex, Newtex , Pebblecoat and Marblecoat.

Bituminous Products

Asbestos bitumen products were used as bitumen roofing felt, damp-proof course, gutter linings and flashings.

Also, asbestos bitumen as a coating on metals known as 'Galbestos'.

The content was around 5 - 8% and was used up to 1992. Some adhesives may also have small content.

Asbestos containing sink pad.

Flooring material

Thermoplastic floor tiles can have up to 25% asbestos content.

PVC vinyl floor tiles and un-backed PVC flooring can contain less than 10% chrysotile.

Asbestos paper backed PVC floors – paper backing can be 100% chrysotile.

All these products used up to base date of 1992.

Any Fibre release is unlikely under normal usage conditions – more likely when paper backing removed or disturbed.

Vinyl floor tile adhesive.

Reinforced PVC and plastics

Asbestos was used as a reinforcement for domestic goods, toilet cisterns, battery cases, plastic handles etc.

The content was usually around 10% and amphiboles were used to improved acid resistance.

Bakerlite toilet cistern.

Debris and residues

Debris and residues could come from old lagging applications or inadequate removal and poor clearance tests.

Asbestos residue on a plant room wall.

Hazard and risk

Risk depends on the ease of fibre release (loosely or firmly bound) and the percentage content of fibres in the product itself.

Also the fibre type – blue, brown or white.

Below is a list in order of fibre release if disturbed (highest to lowest.)

1. Sprayed coatings
2. Thermal insulation
3. Asbestos insulation board (AIB)
4. Asbestos cement (AC)
5. Textiles
6. Composites/resins/reinforced plastics/bitumen.

Section 3: Risk to health

The Risk from Asbestos

Asbestos is only a problem if it is being disturbed and if fibres are released and become airborne. Those fibres can then enter your breathing zone and if you actually inhale the fibres they then reach deep into your respiratory system and they have to stay there. This has to happen repeatedly.

The Main Diseases

The main asbestos related diseases are as follows:

a) **Asbestosis.** This is scarring or fibrosis of the lung.
b) **Mesothelioma.** This is a cancer of the pleura or peritoneum.
c) **Asbestos related lung cancer.** Caused from dual exposure to Asbestos Containing Material (ACM) and tobacco.

However, there are non-fatal diseases such as asbestos warts, pleural plaques and pleural effusion thickening

Risk of Disease

Asbestos related lung cancer incidences are equal to the number of mesotheliomas, approximately 2000

Asbestosis related deaths are less than 300 and falling.

The dose-response relationship for mesothelioma and lung cancer is unknown but mesothelioma and lung cancer deaths will continue to rise until 2020 and then start to decrease.
The HSE estimates the number will peak in 2020 at around 5000.

Mesothelioma Projected Deaths

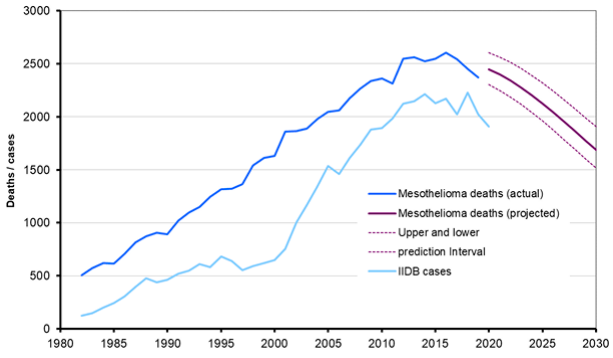


Figure 1 - Mesothelioma annual deaths, IIDB cases and projected future deaths to 2030 in GB.

Mesothelioma is a form of cancer that takes many years to develop following the inhalation of asbestos fibres but is usually rapidly fatal following symptom onset. Annual deaths in Britain increased steeply over the last 50 years, a consequence of mainly occupational asbestos exposures that occurred because of the widespread industrial use of asbestos during 1950-1980.

Defenses against Exposure

The respiratory system has certain defense mechanisms such as:

a) 'muco-ciliary escalator'
b) macrophages

Asbestos fibres have to be respirable in size –

a) Less than 3 microns in DIAMETER
b) Greater than 5 microns in LENGTH
c) Overall aspect ratio (length to diameter) of 3:1

Cumulative and repeated exposure is more significant than single 'events'.
Asbestos fibres within the body cannot be broken down and remain in the lungs, this is known as BIOPERSISTANCE

Background levels cause inevitable exposure but 1 fibre does not kill.

Exposure Limits

The Control Limit (Control of Asbestos Regulations 2012) for asbestos in the UK is:

- 0.1f/ml (also written as cm^3) averaged over a continuous 4 hour period

There is also a peak (or short term) exposure assessment of:

- 0.6 f/ml over 10 minutes

The Clearance Indicator Level for Certificate of Reoccupation is:

- 0.01f/ml

CAR 2012 Regulation 3 – Exemption

Licensing, notification and medicals shall not apply if:

a) Work is "sporadic and low intensity" which is defined as not exceeding 0.6f/ml over 10 minutes.
b) The Control Limit is also not exceeded
c) The work is short non-continuous maintenance activities.
d) The work is the removal of materials in which the asbestos fibres are firmly linked into the matrix, e.g. asbestos cement, vinyl tiles, textured coatings
e) The work is the encapsulation and sealing of ACM that are in good condition, e.g. AIB
f) Or if air monitoring or bulk sampling

Examples of sporadic and low intensity (i.e. non-licensed) work are described on the HSE Asbestos Essentials web pages.

a) Minor repairs to AIB or removal of single small boards
b) Cleaning and repairs to asbestos cement
c) Removal of asbestos cement or asbestos cement debris
d) Removal of vinyl floor tiles
e) Removal of asbestos fibre gaskets and rope seals
f) Laying cables in areas containing undamaged asbestos materials

Even though work may be non-licensed CAR 2012 still applies. This requires the following actions;

a) A risk assessment is carried out.
b) Procedures are used that prevent or reduce asbestos exposure to the lowest level possible
c) A plan of work is prepared
d) Staff carrying out the work are to be properly trained
e) If specific clearance testing is not required the work area should still be visually inspected to check that it is fit for re occupation.
f) Arrangements must be made for the safe disposal of any asbestos waste.

Section 4: Legislation

a) H&S legislation has different layers, each with different legal status
b) Acts of Parliament are legally binding such as The Health and Safety at Work Act 1974.
c) Regulations or Statutory Instruments are also legally binding such as The Control of Asbestos Regulations 2012.
d) Approved Codes of Practice (ACOPs) are not legally binding, but you must prove you did something at least equal, in other words, it is the minimum you need to do to comply with the regulations.
e) Guidance is not legally binding, you are not obliged to follow it, but it is regarded as best practice.

Health and Safety at Work etc Act 1974

For securing the health, safety and welfare of persons at work, for protecting others against risks to health or safety in connection with the activities of persons at work, for controlling the keeping and use and preventing the unlawful acquisition, possession and use of dangerous substances, and for controlling certain emissions into the atmosphere

Section 2 states:

It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.

a) Provide safe plant and systems of work
b) Information, instruction, training and supervision
c) Safe handling, storage and transportation of items or substances
d) Provision and maintenance of a safe work place
e) Provision and maintenance of a safe working environment

Section 3 states:

It shall be the duty of every employer (or self-employed) to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.

Management of Health and Safety Regulations 1999

The main duty placed on employers by the Management of Health and Safety at Work Regulations is to undertake risk assessments to:

a) Identify hazards
b) Identify existing controls
c) Assess if additional controls are required

Construction (Design and Management) Regulations 2015

Client's duty in relation to arrangements for managing projects:
Every client shall take reasonable steps to ensure that the arrangements made for managing the project are suitable to ensure that:

a) the construction work can be carried out so far as is reasonably practicable without risk to the health and safety of any person.

Client's duty in relation to information:
Every client shall ensure that (a) every person designing the structure; and (b) every contractor who has been or may be appointed by the client, is promptly provided with pre-construction information

a) The pre-construction information shall consist of all the information in the client's possession (or which is reasonably obtainable)

This is likely to include Health and Safety information such as an Asbestos Register

Hazardous Waste Regulations 2005

Hazardous waste if defined as any material containing more than 0.1% asbestos by weight.

Asbestos waste must be disposed at a Licensed Landfill site and transported under consignment note by a carrier holding a Waste Carriers License.

Control of Substances Hazardous to Health Regulations 2002 (as amended)

States the general requirements imposed on employers to protect employees and other persons from the hazards of substances used, or encountered, at work by risk assessment, control of exposure, health surveillance and incident planning.

COSHH substances can take many forms and include –

a) Chemicals used at work
b) Products containing a mixture of chemicals
c) Substances generated by work such as fumes, dust, vapours and mist
d) Gas
e) Biological agents encountered during work (like surveying) such as Guano, contaminated sharps (needles), Leptospirosis weils disease from rat urine, mould/fungi and Legionnaires disease

COSHH does not include Asbestos, Lead, Noise or Radiation as these have their own individual regulations.

Control of Asbestos Regulations 2012

Sets out the minimum standards for the protection of employees from risks related to exposure to asbestos. Employers should also take account of people not directly employed by them but who could be affected by the work being done on asbestos (including employees of other employers, people occupying buildings, members of the public etc) and control and prevent spread.

Regulation 4 – The Duty To Manage Asbestos in Non-Domestic premises.

Owners and occupiers of non-domestic premises, who have maintenance and repair responsibilities for those premises, have a duty to assess them for the presence and condition of asbestos – ***The Survey.*** Where asbestos is present the duty holder must ensure that the risk is assessed – ***The Register.*** That risk must then be managed by using The Asbestos Management Plan.

HSE also produce guidance such as: ***A Comprehensive Guide to***

Regulation 11 – Prevention or reduction of the exposure of Asbestos

Requires employers to prevent the exposure to asbestos so far as is reasonably practicable, or of this is not possible, then put in place measures and controls necessary to reduce exposure to as low as reasonably practicable, by means other than the use of RPE.

Regulation 16 – Duty to prevent or reduce the spread of asbestos

Requires employers to prevent or, where this is not reasonably practicable, reduce to the lowest level reasonably practicable the spread of asbestos from any place where work under their control is carried out.

HSG248 Asbestos: The Analyst Guide for Sampling, Analysis and Clearance Procedures

Health and Safety guidance prepared by the Health and Safety Executive for analysts involved in asbestos work and is the authoritative source of asbestos analytical procedures within Great Britain. It provides clarification on technical and personal safety issues, especially in relation to sampling and 4-stage clearances. Information to assess the presence of asbestos in soils and made ground is included for the first time. The guidance is also designed to assist analysts in complying with the Control of Asbestos Regulations 2012. The document should also be particularly useful to several other groups, including asbestos consultants, occupational hygienists, safety professionals, asbestos removal contractors, building owners and people with responsibility for managing asbestos in properties and estates.

Typical Questions from Unit 1

Q1. ***Briefly outline the requirements in regulation 4 (Duty to Manage Asbestos in Non Domestic Premises).***

Requires the dutyholder to identify asbestos locations, the type of asbestos present and its current condition. Then using the management plan ensure that potential exposure is kept to a minimum at least below the control limit, re-inspect on a regular basis to constantly assess the material and its likelihood of fibre release.

Q2. ***Describe where the following asbestos products are most likely found***

A) Sprayed coating
Structural fire protection to steelwork or concrete.

Q3. ***What is the 4-hour control limit?***

0.1f/ml over a continuous 4-hour period.

Q4. ***Outline the main duty as stated in Section 2 of the Health and Safety at Work Act 1974?***

Employers duty to employees with regards to protecting their health, safety and welfare.

Q5. ***List 5 properties of Crocidolite.***

It's blue in colour, hydrophobic, sharp springy elastic fibres, highly acid resistant.

UNIT 2
Theory and equipment used in asbestos bulk analysis

Section 1:
Understanding the theory of sample analysis by Polarised Light Microscopy

Asbestos Bulk Analysis

The HSG 248 method

a) A preliminary visual assessment of the whole of the bulk sample
b) Sample treatment (if required) to release or isolate fibres
c) Detailed search under the stereo microscope
d) Representative fibres mounted in appropriate RI liquid
e) Different fibrous components identified using PLM

The identification method

a) Can be very sensitive – down to ~1ppm
b) Cheap, quick and easy

BUT

a) Requires good training and plenty of experience
b) Depends on analyst's diligence
c) Poor accuracy (quantification)
d) Poor for distinguishing anthophyllite and tremolite
e) Problems with very fine fibres added during manufacturing stage to textured coatings and floor tiles.

Polarised Light Microscopy

a) Crystalline materials such as asbestos exhibit particular optical properties
b) The most important property is the Refractive Index (RI), for example, the way light behaves as it passes through
c) The McCrone objective is used to observe dispersion staining colours

Stereo Microscopy

a) In order to analyse a fibre under polarised light, the fibre has to be separated from the product or material
b) The stereo microscope is housed within a dust cabinet
c) Magnification range should be between 6x and 40x, though most examinations done between 7x and 10x.
d) Top quality illumination important, for example, focusable, and preferably fibre optic or transmitted light

Dust Cabinets

a) Should comply with BS 7258
b) Inlet face velocity should be 0.5 - 1.0 m/sec
   but in practice > 0.7 m/sec is too strong!
c) Cabinets should be tested for filtration efficiency every six months
d) Recommended air testing every month in laboratory area

Polarised Light Microscopes

a) Binocular head
   Intermediate tube holds analyser and tint plate
b) Intermediate tube with analyser
c) Polarising filters at right angles
   Conventionally polariser is East - West
d) Eyepiece should have cross-hairs parallel to planes of polarising filters
e) Calibrate with fibre known to be parallel extinction
   e.g. anthophyllite
f) Rotating stage with vernier scale
   attachable rectangular slide holder is optional
g) Condenser - Abbe type
h) Sub-stage / condenser iris should close sufficiently to give good dispersion colours
   iris should be open for all other observations
i) Centre the condenser iris and McCrone centre stop using phase telescope and centring adjusters

Köhler Illumination

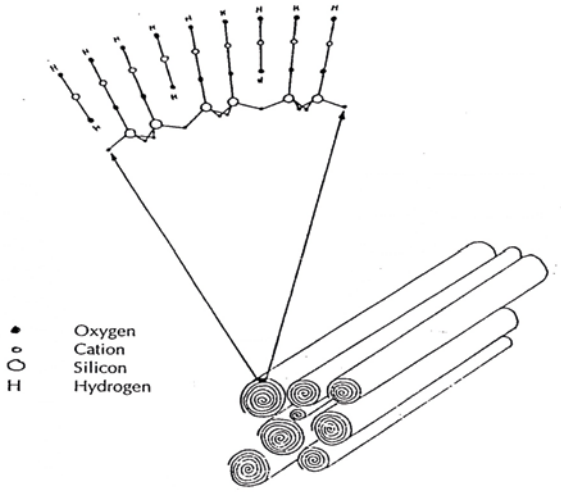
a) Intended to give even illumination across the field of view
b) Nearly all microscopes are now 'Köhler – type', not true Köhler illumination
c) Should be able to adjust lamp in three dimensions to centre and focus lamp filament
d) Most now just have a fixed lamp holder and incorporate a diffuser in the light path
e) Close field iris and focus edge of diaphragm – centre and open until field of view fully illuminated

Asbestos Mineral Structures

Chrysolite

a) Sheet or layer silicate
b) Structure is double layered scroll
brucite (magnesium hydroxide) silicate
c) Hydrophilic - external surface is hydroxyl (-OH) groups
d) Much lower acid resistance than amphiboles
e) Silky, flexible, curly, 'inelastic' fibres
f) Tends to be charged – electrostatic

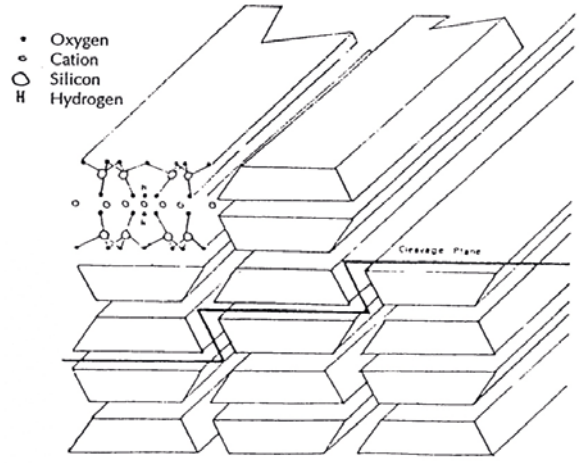
Chrysolite Structure



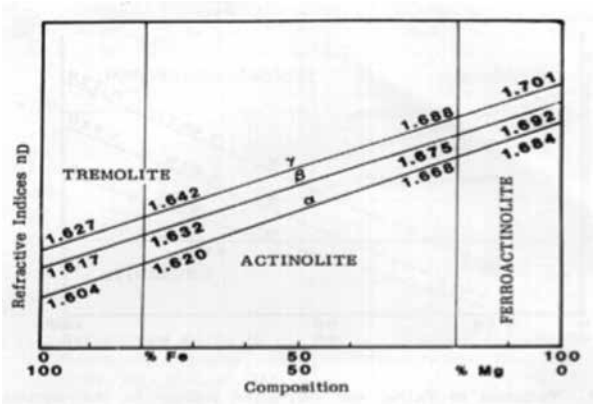
Amphiboles

a) Chain silicates
b) Tend to be sharp, springy, elastic fibres
c) Hydrophobic and greater acid resistance
d) Tremolite and actinolite are closely related and form a 'solid solution' series
i) continuously variable composition depending on source material
ii) Fe replacing Mg in lattice
iii) RI increases as %Fe increases

Amphibole Structure



Tremolite - Actinolite Solid Solution Series



The rarer fibre types

a) Tremolite as contaminant (up to 1%?) in chrysotile
b) Tremolite and actinolite found as contaminants in other minerals
i) vermiculite (Libby mine in Montana)
ii) haematite (iron oxide)
iii) olivine (magnesium silicate)
c) Tremolite also found in talc (up to 25%?)
d) Tremolite and anthophyllite mostly found in older insulation
e) Tremolite and anthophyllite found occasionally in asbestos cement
f) Actinolite very rarely seen in UK samples
g) Anthophyllite - beige to off-white or pinkish
h) Tremolite - bright white
i) Actinolite - pale green
j) Colours often very hard to determine and may be masked by the material matrix
k) Difficult to distinguish between the fibre types on colour alone

Other fibrous materials

a) Fibrous Wollastonite
i) mixed 'length slow' and 'length fast' along the fibre
ii) RI 1.63 - 1.65 and low birefringence
b) Talc fibres
i) RI 1.54 - 1.59
c) Fibrous Brucite (Nemalite) - magnesium hydroxide
i) 'length fast' with RI 1.57 - 1.59
d) Diatomaceous earth
i) low RI - 1.42

Thermal Safety

a) Thermal resistance up to about 650°C
b) Loss of elements of water (dehydroxylation)
c) May form other silicate crystal forms
i) chrysotile → forsterite + silica, etc
d) Oxidation of Fe in the crystal lattice - discolouration
i) particularly for iron-bearing amphiboles - amosite and crocidolite
i) behaviour depends on the presence of oxygen
e) Thermal breakdown leads to;
i) loss of mechanical strength and crumbles
ii) discolouration
iii) increase in RI

Typical Compositions

a) Spray coating
   i) *85% (a) crocidolite or (b) amosite or (c) amosite + chrysotile mixture*
   ii) *possibly layered coatings?*
b) Pipe insulation – hard set
   i) *up to 70% of all or any mixture of asbestos types*
   ii) *other non-asbestos fibres (hair, straw, wood, cotton)*
c) Pipe insulation – sectional
   i) *15 to 60% amosite mainly, but also mixtures*
d) Asbestos cement
   i) *10 - 15% chrysotile*
   ii) *(may also find trace crocidolite and (rarely) amosite)*
e) Asbestos insulating board (AIB)
   i) *15 - 25% amosite (earlier boards up to 40%)*
   ii) *may contain some chrysotile in combination with amosite*
   iii) *can be crocidolite alone*
f) Roofing felt - ~ 5% chrysotile
g) Floor tiles - ~ 5 - 10% chrysotile
h) Gaskets - ~ 95% chrysotile
i) Rope or textiles - ~ 100% chrysotile or blended with synthetic organic or cellulose fibres
j) Eternit window boards - ~ 10% chrysotile
k) Toilet cisterns - ~ 10% amosite (chrysotile and/or crocidolite)
l) Textured coatings - ~ 0.5 - 3% chrysotile

Trade Names

The asbestos information centre

http://www.aic.org.uk/Tradenames.htm

Section 2: Understanding the requirements of sample analysis by Polarised Light Microscopy

Stages of Identification

a) Colour and morphology
b) Birefringence
c) Sign of elongation
d) Pleochroism
e) Angle of extinction
f) Dispersion colours
g) Estimate of quantity (not all labs do this)

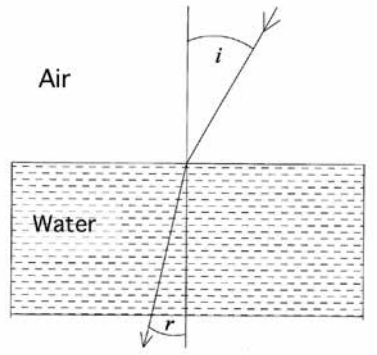
Refractive Index

$$RI = \frac{\sin i}{\sin r}$$

or

$$RI = \frac{C_{vacuum}}{C_{substance}}$$

$$RI = \frac{C_{vacuum}}{C_{substance}}$$



***C**vacuum* is a constant. ***C**substance* is always < ***C**vacuum*.
RI is always > 1.00
As speed decreases, RI increases. High RI = slow speed.

Isotropic

a) Same refractive index in all directions
b) Same for all physical properties
   i) *(colour, density, electrical resistance, etc, etc...)*
c) Applies to gases, liquids, glass ('supercooled liquid')
   i) *also to crystals in cubic system (e.g. sodium chloride)*

Anisotropic

Asbestos is anisotropic

Crystalline materials have regular arrays of atoms in lattice

Imagine billiard balls in a box, different sized balls represent different atoms

Different packing densities in three different axes
   i) *different refractive indices*

Birefringence

a) Defined as the numerical difference between the highest and lowest RI along three axes
b) Two conventions, either;
   i) α, β, γ, *or*
   ii) x', y', z'
   iii) $x' < y' < z'$
c) Therefore γ or z' always highest RI axis – (slowest speed)
d) So birefringence is $z' - x'$ and is classed as low, medium or high
e) The tint plate will always have the slow direction marked on it
f) Crocidolite - low
   i) RI from ~1.696 to ~1.700 or 0.004

g) Chrysotile - low
   i) RI from ~1.546 to ~1.552 or 0.006
h) Amosite - medium
   i) RI from ~1.676 to ~ 1.696 or 0.020
i) Anthophyllite, tremolite and actinolite
   i) medium birefringence
j) No asbestos has high birefringence

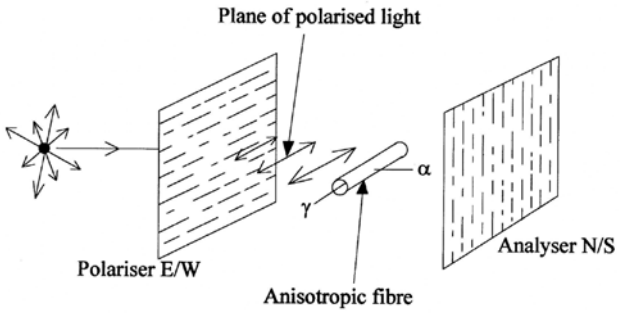
Sign of Elongation

a) If $RI_{along} > RI_{across}$ = length slow or positive sign of elongation
b) If $RI_{along} < RI_{across}$ = length fast or negative sign of elongation
c) Also referred to as optic orientation
d) Crocidolite usually length fast (but can be length slow if heated)
e) All other asbestos forms length slow
f) Non-asbestos crystalline materials also slow or fast

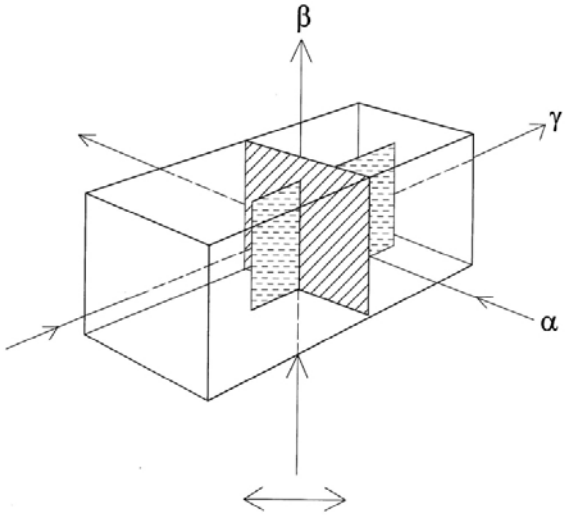
Polarised Light

Plane polarised light
Either by

a) polarising filters or
b) reflection from polished surface



Birefingence



Interference colours

When a fibre is rotated at 45° it appears white to grey
At vertical and horizontal (parallel to planes of polarisation) it is 'extinguished'

Positions of extinction - parallel or oblique
Oblique or inclined extinction
   i) where optical plane is not coincident with crystal axis

Phase differences produce interference colours
Interference ∝ t x Δ RI
Michel-Levy chart*
   i) orders of interference

See Michel-Levy chart on following page

Anomalous Interference Colours

Crocidolite often shows 'anomalous interference colours' under crossed polars

Brown to pink colours

a) Very variable intensity
b) Very characteristic
c) 'Anomalous interference colours' because they don't appear in the Michel Levy chart

Angle of extinction

Normally optical plane coincides with geometric plane
Fibre is 'extinct' parallel to planes of polarisation
For some crystal systems the optical plane is inclined to the crystal plane

a) position of 'extinction' is 'oblique' or 'inclined'
b) depends also on rotation about fibre axis
c) Chrysotile, amosite and crocidolite - parallel
d) Tremolite and actinolite - oblique extinction angles
   i) may be difficult to observe, HSG 248 says 'parallel or small (5°) angle of extinction'
e) Anthophyllite is orthorhombic and always parallel extinction

Glass Fibre (MMMF)

Glass fibre is isotropic – one RI only

No interference colours therefore no birefringence under crossed polars

Appears transparent with first order red compensator

Immediate distinction from asbestos fibres or crystalline materials

First Order Red

First order red compensator or sensitive tint plate

a) quartz or selenite with thickness and birefringence equivalent to first order red (530 nm)

z´/ γ direction always aligned and marked - NE/SW
Slow directions parallel – fibre and tint plate

a) add interferences → '2nd order blue'

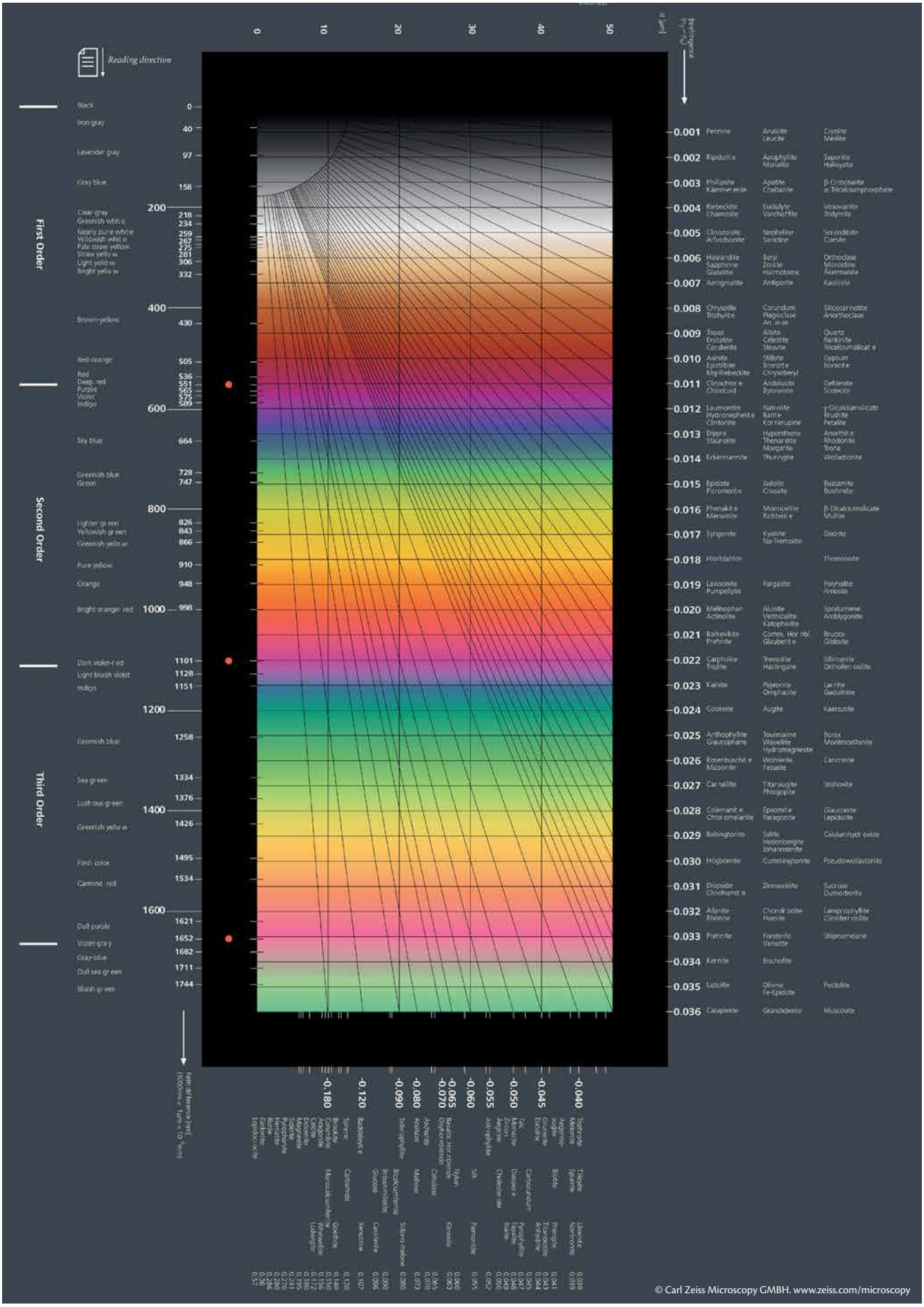
Slow directions perpendicular – fibre and tint plate

a) subtract interferences → '1st order yellow'

First Order Red Colours

Fibres	NE-SW	NW-SE
Chrysotile	Blue	Yellow
Amosite	Blue	Yellow
Crocidolite	Yellow/Green	Blue/Green
Anthophyllite	Blue	Yellow
Tremolite	Blue	Yellow
Actinolite	Blue	Yellow

Michel Levy Chart



Pleochroism

Defined as "Differential absorption of visible wavelengths with orientation in plane polarised light"

Different crystal axes have different absorption spectra

Observed only with strongly coloured minerals

Only crocidolite and actinolite are pleochroic

a) (occasionally pale yellow for amosite)
b) Normally observed with plane polarised light
c) HSG 248 – para A2.30 - suggests also use crossed polars with one polar rotated ± 10° -15° from position of extinction (adapted from a US method)

Excellent results for crocidolite

Becke Line

White fringe at particle interface with liquid of different RI

Movement of Becke line as it goes in and out of focus

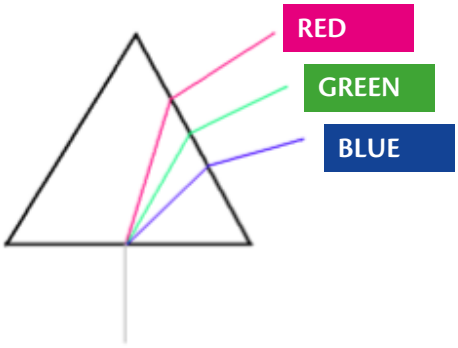
a) white fringe moves into liquid or particle

"As objective is raised, fringe moves from lower to higher RI"

Limited usefulness? (but see heat-degraded asbestos)

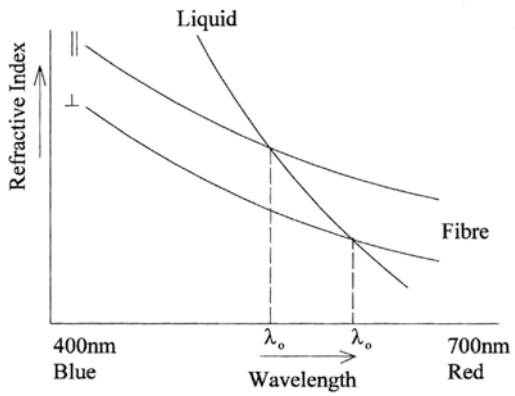
Dispersion Staining

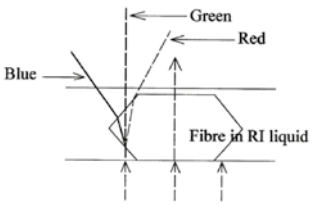
Refractive index is wavelength dependent
Usually higher RI at blue end of visible spectrum
Dispersion curves characteristic of material
Intersection points at refractive index match - λ_0 (aka lambda nought wavelength)



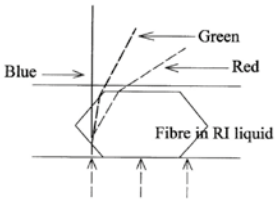
Dispersion

Refraction of light by glass prism





Fibre parallel to polariser.
Centre stop colour is PURPLE



Fibre perpendicular to polariser.
Centre stop colour is YELLOW

McCrone Objective

Intersection points represent wavelengths (colours) at which particle and fibre match exactly - λ_0

Central, annular and open stops

a) central stop colours are 'white light' minus the λ_0 (or refracted) colours
b) (annular stop shows λ_0 colours against a bright background – difficult to see and very little used)

Observe each RI with polarised light

RI match gives purple colour

a) RI fibre > RI liquid - yellow/orange colour
b) RI fibre < RI liquid - blue colour

If RI » liquid or RI « liquid - no colour at all

Dispersion Staining Colours

Asbestos	RI	Colour n-s	Colour e-w
Chrysotile	1.55	Blue	Purple
Amosite	1.67	Blue/Purple	Gold/Yellow
Crocidolite	1.70	Blue/Green	Blue/Green
Anthophyllite	1.605	Red/Blue	Yellow
Tremolite	1.605	Red/Blue	Yellow
Actinolite	1.64	Blue	Yellow

Chrysotile dispersion colours

Depends on

a) source and
b) history (acid treatment or weathering)
c) Classically: blue to purple

But can be:

a) light blue to darker blue
b) or purple/magenta to orange

IOM reference minerals include Zimbabwe and Cassiar, Canada

UNIT 3
Bulk Analysis Methods

Section 1:
Undertake analysis by Polarised Light Microscopy

HSG 248 Method

Unpack samples in fume cabinet and carry out initial visual examination

↓

Take sub-sample if necessary

↓

Remove interfering matrix materials which may hamper identification (if necessary)

↓

Conduct careful search under stereo microscope using tweezers and tools to find and isolate fibres

↓

If fibres observed:-
Note individual fibre types by observing appearance and handling properties under stereo microscope

↓

Make tentative identification of fibres present

↓

Extract several fibres or fibre bundles of each type of asbestos and tease apart

↓

Mount in matching RI liquid for PLM assessment

↓

If no fibres observed:-
Consider further sample preparation to see if fibres are still embedded or encapsulated

↓

Take random samples and place each between two microscope slides and disperse by gently grinding then draw apart
Place RI liquid on coverslip and invert onto slide and allow capillary action to immerse sample. Scan sample at 80x or greater for fine fibres using PLM

↓

If fibres observed, prepare additional slide for PLM

Problem Fibres

Organic fibres which mimic chrysotile

a) Leather
b) Polypropylene or polyethylene
c) Spiders' web
d) Paper swarf
e) Feathers?

Check with flame!

Polyethylene ("Tyvek") used as substitute fibre in new cement sheeting

a) visually similar but birefringence higher
b) no dispersion staining colours
c) fibres will melt in a flame

Leather swarf

a) similar dispersion staining colours to chrysotile
b) but morphology slightly different
c) fibrils visible

Aramids ("Kevlar")

a) similar morphology to chrysotile
b) but extreme birefringence
c) highly variable relief

Spider webs/paper/feathers

a) RI close to chrysotile
b) similar interference colours
c) beware of dust samples with mixed particles
d) fibres will melt in a flame

Talc

a) higher RI than chrysotile, different dispersion staining colours Brucite and Wollastonite
b) similar morphology to amosite, but brittle and soluble in acid

Diatomaceous earth (lagging with fossilised sea creatures!)

a) can look fibrous but low RI so dispersion staining colours different

Thermally Degraded Asbestos

Amphiboles (amosite and crocidolite)

a) Fe(II) will be oxidised and appear brown to orange
b) Structural strength will be lost and fibres will be very fragile when handled in tweezers
c) Still birefringent (and pleochroic?) but dispersion colours not seen in expected RI liquid
d) RI will usually be higher than expected

Heated Above 3 - 400°C

Crocidolite

a) stereo colour changes to grey/yellow or orangey-brown
b) increased RI and birefringence
c) sign of elongation reverses

Amosite

a) stereo colour changes through yellow to dark brown
b) becomes pleochroic

So above this temperature, amosite and crocidolite can be indistinguishable

Heated Above 600°C

Chrysotile

a) stereo colour changes slightly to pale brown
b) loses strength and becomes more fragile
c) RI increases, birefringence decreases
d) sign of elongation may reverse

Sample Preparation

Sample must be dry for dispersion colour

a) no water at fibre / liquid interface

Prepare by

a) acid wash in dilute HCl for about 15 minutes
b) crush in pestle and mortar
c) acetone wash and ultrasonic bath
d) solvent extraction, e.g. for bituminous material
e) low temperature ash for organics

New HSG 248 to give guidance on compulsory prep for floor tiles and TC

Drying

Oven or hot plate - need HEPA extraction, for example in fume cabinet
Infra-red lamp inside the cabinet
Rinse with acetone and allow solvent to evaporate

Acid Wash

Removes binders based on calcium silicate or calcium carbonate
Use 10% hydrochloric or 50% acetic acid

a) When preparing diluted acids, always add the acid to the water slowly with stirring
b) Use suitable extraction
c) Use protective clothing and wear safety glasses

Treat for about 10 minutes at room temperature or until effervescence has stopped (do not heat or boil)
Filter on a Buchner filter, rinse with acetone and allow to dry in the fume cabinet

Crushing

Especially important for cement or board samples

a) May have small amounts of asbestos and the sample needs to be broken up
b) Use a pestle and mortar (inside fume cabinet)
c) Place the sample in two polythene bags to avoid contaminating the mortar
d) Break up the sample as much as possible

Solvent Extraction

Some bituminous materials can be cleaned more easily with organic solvents

Check hazards

a) Toxicity and flammability – all organic solvents are flammable!

Avoid skin contact and inhalation

a) Use only in suitable extraction / fume cabinet
b) May need to test for different solvents
c) Avoid high toxicity solvents such as benzene, toluene
d) Cyclohexane is a better choice

Low Temperature Ashing

Suitable for samples with an organic matrix –
e.g. Floor tiles, roofing felt?

Ashing can only be done under suitable extraction

Ash at 300° - 350° C, above 400°C asbestos will start to degrade

Takes some time and therefore this technique is only rarely used

AIB v AC

A quick test…
How would you define AIB?
How would you define AC?

There is a legal definition in CAR 2012;

a) "asbestos cement is a material which is predominantly a mixture of cement and chrysotile which absorbs less than 30% water by weight"
b) "AIB means any flat sheet, tile or building board consisting of a mixture of asbestos and other material except asbestos cement"
c) Used to be a density test (above or below 1000g/kg) but is now water absorption

Water Absorption Test

Take a 3 x 3cm sample

Dry it and weigh it

Immerse in water for 15 mins

Remove and re-weigh

If weight of water absorbed is <30% of original weight, report as AC

If >30% report as AIB

Section 2: Understand safety and quality control

AIMS QC Scheme

Asbestos In Materials Scheme - run by the Health and Safety Laboratory in Buxton

Three circulations per year - four samples per round

Laboratory given a Performance Score over the last three rounds

Samples based on pre-prepared mixtures and real materials

Real samples have problems with homogeneity and presence of trace contaminants

Some samples with low levels included to check quantitation ability

Scores based on different degrees of errors

Three levels

a) Supercritical - 20 points (miss asbestos)
b) Critical - 12 points (miss 1 fibre type in the presence of others)
c) Non-critical - 7 points (miss trace amount of rarer type or false positive)
d) Confusing tremolite and anthophyllite – 0 points

Laboratory should score not more than 39 points in three rounds

Exam pass mark – 18 or below!

Internal QC

Monthly bulk QC samples – usually 2 per analyst

Reanalysis – 1 or 2 samples per month reanalysed by another analyst

Exceeding daily points/samples budget – reanalysis of a certain percentage as stated in your procedures

UKAS Accreditation

CAR 2012 - Regulation 21 requires laboratories doing asbestos identification to be accredited by UKAS

ISO 17025 (2005) is the quality management standard

LAB 30 states analysts to have P401, CoCA or RSPH equivalent qualification

Sample Handling

Aim is to prevent cross-contamination

One sample only in cabinet at any one time

Open bagged samples only inside cabinet

Disposable petri-dishes preferable

a) glass dishes should be cleaned after each sample

Health and Safety – Cargille Liquids

Organic compounds, including brominated naphthalenes – no longer contain PCBs, nor carcinogenic

MSDS states use of latex gloves advisable but not mandatory – check your procedures!

COSHH assessment and procedure in the event of a spillage

Manufacturer's risk assessment – no risk during normal use

Precautions – avoid prolonged and repeated skin contact

Emergency procedures

a) Inhalation – remove to fresh air
b) Skin and clothes – liberal quantities of soap and water
c) Eyes – flush with water for 15 mins, consult doctor
d) Ingestion – administer water or milk, consult doctor

Safety Aspects

Check cabinet is working properly before use

a) Check airflow – should be 0.5 to 1.0 m/sec

Clean cabinet – preferably between samples but especially at the end of the day using type-H vacuum

Do air testing monthly in analysis area to ensure no measurable airborne fibre levels

Airborne fibre release – bags must only be opened inside a working fume cabinet

Chemicals – should be kept in lockable metal cabinet and decanted into smaller containers for use in cabinet

Waste – disposal via red bags and licensed contractor