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 and health effects.
Unit 2 Equipment used in the analysis of samples.
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 this qualification.

The qualification is set at Level 3 which is equivalent to an A Level.

The qualification depends on the candidate achieving 60% in exam for EACH unit.

A Quick Quiz...

a) Is it a legal requirement to be UKAS accredited in order to carry out bulk analysis?

b) Does the individual analyst have to have the P401, RSPH or CoCA qualification?

c) Do you have to use the method described in HSG 248?

d) Do you have to use Cargille liquids to mount the fibres?

e) Does the lab have to participate in the AIMS scheme?

f) Does the HSG 248 method allow you to analyse asbestos in soil?

Answers: a) Yes b) Yes c) No d) No e) No f) Yes and No

Contents

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UNIT 1
Risks and Responsibilities relating to Asbestos in Buildings

HSE Statement

'Asbestos is the greatest single cause of work related deaths in the UK.' Currently around 4,500 deaths per annum.

The Current Problem

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

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

Workers don't know what it looks like, where it is or what the actual risks are from the products.

The Hidden Killer - HSE Campaign

With the Hidden Killer Campaign the HSE hoped to educate the construction industry in matters regarding asbestos, as 25% of all asbestos related illness comes from the construction industry.

HSE Report RR696 - Prof. Peto

Mesothelioma risk is determined largely by asbestos exposure before age 30. The predicted total of 90,000 mesotheliomas between 1970 and 2050 will include approximately 15,000 carpenters. The particularly high risk to carpenters is thought to be due to exposure to amosite while cutting AIB. In the 1960s the UK imported almost half of all amosite mined.

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.

Section 1: Properties and usage of asbestos

Asbestos – "Nature's Wonder Fibre"

Asbestos is the name for a group of naturally occurring fibrous mineral / silicates with amazing properties of:

a) Strength – stronger than steel
b) Flexibility – easily woven
c) Stability – will deteriorate only slowly
d) Thermal & electrical resistance (fire & insulation)
e) Chemical and electrical resistant
f) But can be deadly...

Asbestos Facts

Fibrous silicate mineral:

Amphiboles:

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

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

a) Crocidolite (blue)
b) Amosite (brown)
c) Tremolite
d) Anthophyllite
e) Actinolite

Serpentine:

Chrysotile is a chain silicate that tends to be sharp, springy, (elastic) fibres. The fibres are hydrophilic (water loving and less acid resistant than amphiboles.

a) Chrysotile (white)

Asbestos Types

Chrysotile (white) is the most commercially used type of asbestos and was used extensively in cement and textile products.

Crocidolite (blue) has the strongest and best thermal properties and was used as insulation and as a spray coating.

Amosite (brown) used in board products and ceiling tiles
Use finally banned in 1999.

Asbestos Applications

a) Fire retardant
b) Insulation
c) Strength
d) Friction
e) Resistance to chemical attack
f) Noise attenuation

Cut Off Dates for Use of ACM

a) Voluntary ban on blue asbestos - 1969
b) Spray coating - up to 1974/5
c) Pipe/boiler lagging - early 1980s
d) AIB panels/ceiling tiles - up to 1985
e) Statutory ban on brown and blue asbestos - 1985
f) Textured coating ("Artex") - up to late 1980s
g) Floor tiles/coverings – early 1990s
h) Cement flues to boilers - up to early 1990s
i) Corrugated roof sheets - up to 1999
j) Statutory ban on white asbestos – 1999

Beware of imports after domestic ban

Sprayed Asbestos

Sprayed asbestos ("Limpet") is a gun-applied mixture of hydrated asbestos-cement with up to 85% asbestos fibre.
It was used as fire protection in ducts, firebreaks and around structural steel work also as acoustic insulation in swimming pools/ theatres.
This material is regarded as high risk due to high content and high friability.
Very rare in domestic housing

Thermal Insulation Engineer applying fire protection to structural steel.

Sprayed coating applied to structural steel. Note the damage around the electrical junction box.

Thermal Insulation

This material is generally regarded as high/medium risk with a medium to high content – highly variable from 15 to 80%. There is usually a protective coating which guards against damage.

The asbestos used could be blue, brown or white asbestos. Hard set insulation was mixed on site but there are variable types and compositions.

Pre-formed sectional ("Caposite") lagging was more uniform in nature.

Asbestos Insulating Board (AIB)

Production started in 1930s, peaked in 1970s. There are a number of trade names such as "Turnasbestos", "Asbestolux", "Marinite".

UK was the world's largest importer of amosite (brown) with approximately 24,000 tons in 1960 – 40% of the global total.

20% of the ceiling area of all new public buildings between 1967 and 1973 are constructed out of AIB ceiling tiles with former Woolworths stores estimated to have 1 million sqm of ceiling tiles.

AIB was generally regarded as medium risk as there is a lower content – usually 15 to 25%. The material is less friable as compressed and paint acts as protective coating and the asbestos fibre used was usually only brown.

AIB was mostly used internally for:

i) wall panels
ii) ceiling tiles
iii) fire breaks
iv) packing and shuttering
v) door panels

AIB was used extensively up to 1985.

AIB as a firebreak in a ceiling void.

Asbestos Cement

Production started late 1880s, peaked in 1960/70s. Asbestos cement usually is made up of 10 - 15 % asbestos bound in Portland cement or Calcium Silicate.

There are a number of different products such as compressed flat or corrugated sheets or pre-formed moulded products these are used externally as resistant to weathering.

Asbestos cement is generally regarded as low risk due to its lower content – usually 10 to 15%, its low friability as very dense and fibres firmly bound in cement matrix and it was usually only white asbestos used.

Asbestos cement is very resistant to weathering and has a service life - 40 years +?. With the material predominantly being used externally, any fibre release is immediately diluted in atmosphere.

Miscellaneous Products

There are a number of miscellaneous products such as:

Asbestos textiles. Used in the production of fire protection clothing, gloves, overalls and fire-blankets and curtains.

Asbestos-bitumen products such as roofing felts and damp-proof courses.

Asbestos textured coating used on walls as well as ceilings.

Plastics such as bakelite toilet cisterns.

Flooring such as "Marley" floor tiles and sheets with paper backing.

Textured Coating

Toilet Cistern

Section 2: Health Risks

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.*** Scarring or fibrosis of the lung.
b) ***Mesothelioma.*** Cancer of the pleura or peritoneum.
c) ***Asbestos related lung cancer*** caused from dual exposure to Asbestos Containing Material (ACM) and tobacco.

There are also a number of benign conditions such as pleural plaques, pleural thickening and effusions and asbestos warts and corns.

Benign Conditions

Pleural plaques
Pleural thickening and effusions
Asbestos warts and corns

Hazard and Risk

Risk depends on:

a) Ease of fibre release (loosely or firmly bound)
b) % content of fibre in the product itself
c) Type of fibre – blue brown and white.

The list below of asbestos products is in descending order of risk with the greatest risk at the top.

1. ***Sprayed coatings***
2. ***Insulation***
3. ***Asbestos insulating board (AIB)***
4. ***Asbestos cement (AC)***
5. ***Textiles***
6. ***Composites***

Defences against Exposure

Respiratory system defences are 'muco-ciliary escalator' and macrophages. Respirable fibres are fibres of a certain size - between 1 and 5 microns (approx.)

Cumulative and repeated exposure more significant then single 'events' Background levels cause inevitable exposure but 1 fibre does NOT kill!

Exposure Limits

Control Limit (CAR 2012)

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

Sporadic and low intensity exposure

0.6 f/cm^3 over 10 minutes

Balance between 'what is desirable (nil)' and 'what is reasonably achievable in practice'

Exceeding the Control Limit

If the control limit is likely to be exceeded then the employer needs a licence from HSE for this work. The work must be notified to HSE / Local Authority. All employees undertaking this work must be under medical surveillance and their exposure should be monitored.

The area has to be identified as an 'asbestos area' and eating, drinking and smoking in this area is prohibited.

There must also be other facilities provided such as a decontamination unit (DCU) and the employer must minimise the number of people entering the area.

There should also be an emergency procedure for dealing

Clearance Indicator

The clearance indicator is the "Lowest level reliably detectable above background". This level has no relation to "safety".

Limit of Quantification are based on RICE counts on blank filters.

LOQ is still 20 fibres in 200 fields.

0.01 f/cm^3 for 480 litres and 200 fields counted.

LOQ must be quoted for each result.

Section 3: Legislation and The Duty To Manage

Health and Safety Legislation

UK health and safety legislation has different layers, each with different legal status.

Acts of Parliament

– legally binding such as Health and Safety at Work Act 1974.

Regulations or Statutory Instruments

– legally binding such as Control of Asbestos Regulations 2012.

ACOPs

– not legally binding, but must prove you did something at least equal to it.

Guidance

– not legally binding, not obliged to follow it, but is regarded as best practice.

Regulations

Regulation 1	Citation and commencement
Regulation 2	Interpretation
Regulation 3	Application of these Regulations
Regulation 4	Duty to manage asbestos in non-domestic premises
Regulation 5	Identification of the presence of asbestos
Regulation 6	Assessment of work which exposes employees to asbestos
Regulation 7	Plans of work
Regulation 8	Licensing of work with asbestos
Regulation 9	Notification of work with asbestos
Regulation 10	Information, instruction and training
Regulation 11	Prevention or reduction of exposure to asbestos
Regulation 12	Use of control measures etc
Regulation 13	Maintenance of control measures etc
Regulation 14	Provision and cleaning of protective clothing
Regulation 15	Arrangements to deal with accidents, incidents and emergencies
Regulation 16	Duty to prevent or reduce the spread of asbestos
Regulation 17	Cleanliness of premises and plant
Regulation 18	Designated areas
Regulation 19	Air monitoring
Regulation 20	Standards for air testing and site clearance certification
Regulation 21	Standards for analysis
Regulation 22	Health records and medical surveillance
Regulation 23	Washing and changing facilities
Regulation 24	Storage, distribution and labelling of raw asbestos and asbestos waste
Regulation 25	Interpretation of prohibitions
Regulation 26	Prohibitions of exposure to asbestos
Regulation 27	Labelling of products containing asbestos
Regulation 28	Additional provisions in the case of exceptions and exemptions
Regulation 29	Exemption certificates
Regulation 30	Exemptions relating to the Ministry of Defence
Regulation 31	Extension outside Great Britain
Regulation 32	Existing licences and exemption certificates

Regulation 33 Revocations, amendments and savings
Regulation 34 Defence
Regulation 35 Review

Addition Guidance

Regulation 4 – The Duty To Manage

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 - ***The Asbestos Management Plan***

Impact of Recent EU Ruling

The EU has ruled the HSE did not fully implement the EU Directive with respect to "sporadic and low intensity" work.

Short non-continuous maintenance should only apply to work on ***non-friable materials***.

Removal of ACM with fibres firmly linked should only be on non-degraded materials and without deterioration.

New CAR 2012 will create a 3 tier system:

- ***Licensed work (no change)***
- ***Non-licensed work(no change)***
- ***New category: notifiable non-licensed work (NNLW)***

Non licensed work requires	NNLW requires	Licensed work requires
Compliance with risk assessment	Notification before work starts	Licensing
Control of exposure	Medical exam every 3 years	Notification 14 before work
Training requirements	Health records	Emergency arrangement
	Compliance with risk assessments	2 year medicals
	Control of exposure	Health records
	Training requirements	Compliance with risk assessments
		Designation of asbestos areas
		Control of exposure
		Training requirements

What Has Not Changed?

No change to Duty to Manage.
No changes to most other Regulations e.g. prevent exposure, spread, training etc.
No changes to SALI exposure criteria.
No changes to Control Limits.
L143 ACOP and guidance still in place.
Everything unaffected is still in place.

Guidance: Examples of Non-Licensed Work

Short, non-continuous maintenance work involving AIB eg

a) drilling holes for fittings
b) repairing very minor damage
c) lifting tiles for access/inspection
d) Removing single sheet as part of maintenance task
e) Removal of AC: Most AC can be removed whole
f) Inadvertent breakage of the occasional piece will not attract NNLW requirements.
g) Weathered AC not regarded as degraded.

Guidance: Examples of Notifiable Non-licensed Work.

Minor maintenance work involving asbestos insulation where work is 'short duration work' e.g. repairing minor damage to a small section of pipe insulation.

Removal of large scale textured decorative coatings with deterioration of the material e.g. where the material is treated by steam, hydrating gel etc and scraped off the underlying surface.

Who Will Have To Notify?

a) Organisations carrying out AC roof removal/demolition
b) Organisations which deal with "non-licensed" rubble e.g. AC
c) Companies who carry out "larger-scale" removal of textured coatings e.g. insurance related work
d) Companies who do short-duration work on asbestos insulation
e) Companies who do "short-duration" "removal" of AIB e.g. demolition

UNIT 2
Equipment used in analysis

Section 1:
Understanding the theory of sample analysis by PLM

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), ie 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 eg 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 E-W
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

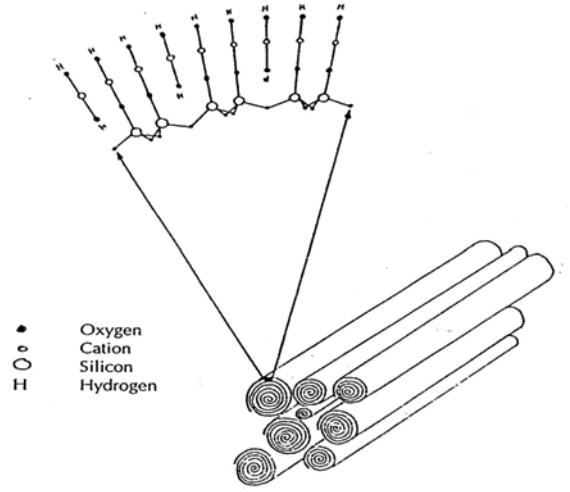
a) Intended to give even illumination across the field of view
b) Nearly all microscopes are now 'Köhler – type', not true Köhler illumination
c) Should be able to adjust lamp in three dimensions to centre and focus lamp filament
d) Most now just have a fixed lamp holder and incorporate a diffuser in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

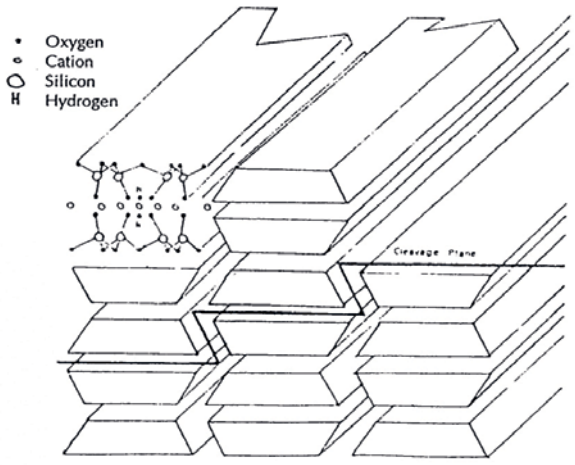
Chrysolite Structure



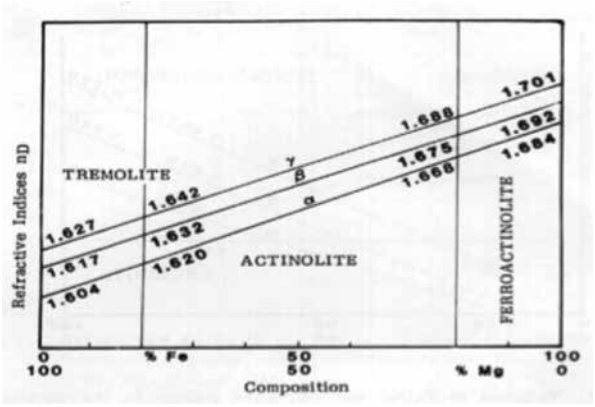
Amphiboles

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
1. continuously variable composition depending on source material
2. Fe replacing Mg in lattice
3. RI increases as %Fe increases

Amphibole Structure



Tremolite - Actinolite Solid Solution Series



The rarer fibre types

1. Tremolite as contaminant (up to 1%?) in chrysotile
2. Tremolite and actinolite found as contaminants in other minerals
   - *vermiculite (Libby mine in Montana)*
   - *haematite (iron oxide)*
   - *olivine (magnesium silicate)*
3. Tremolite also found in talc (up to 25%?)
4. Tremolite and anthophyllite mostly found in older insulation
5. Tremolite and anthophyllite found occasionally in asbestos cement
6. Actinolite very rarely seen in UK samples
7. Anthophyllite - beige to off-white or pinkish
8. Tremolite - bright white
9. Actinolite - pale green
10. Colours often very hard to determine and may be masked by the material matrix
11. Difficult to distinguish between the fibre types on colour alone

Other fibrous materials

1. Fibrous Wollastonite
   - *mixed 'length slow' and 'length fast' along the fibre*
   - *RI 1.63 - 1.65 and low birefringence*
2. Talc fibres
   - *RI 1.54 - 1.59*
3. Fibrous Brucite (Nemalite) - magnesium hydroxide
   - *'length fast' with RI 1.57 - 1.59*
4. Diatomaceous earth
   - *low RI - 1.42*

Thermal Safety

1. Thermal resistance up to about 650°C
2. Loss of elements of water (dehydroxylation)
3. May form other silicate crystal forms
   - *chrysotile → forsterite + silica, etc*
4. Oxidation of Fe in the crystal lattice - discolouration
   - *particularly for iron-bearing amphiboles - amosite and crocidolite*
   - *behaviour depends on the presence of oxygen*
5. Thermal breakdown leads to;
   - *loss of mechanical strength and crumbles*
   - *discolouration*
   - *increase in RI*

Typical Compositions

a) Spray coating
   - *85% (a) crocidolite or (b) amosite or (c) amosite + chrysotile mixture*
   - *possibly layered coatings?*

b) Pipe insulation – hard set
   - *up to 70% of all or any mixture of asbestos types*
   - *other non-asbestos fibres (hair, straw, wood, cotton)*

c) Pipe insulation – sectional
   - *15 to 60% amosite mainly, but also mixtures*

d) Asbestos cement
   - *10 - 15% chrysotile*
   - *(may also find trace crocidolite and (rarely) amosite)*

e) Asbestos insulating board (AIB)
   - *15 - 25% amosite (earlier boards up to 40%)*
   - *may contain some chrysotile in combination with amosite*
   - *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 PLM

Stages of Identification

- Colour and morphology
- Birefringence
- Sign of elongation
- Pleochroism
- Angle of extinction
- Dispersion colours
- Estimate of quantity (not all labs do this)

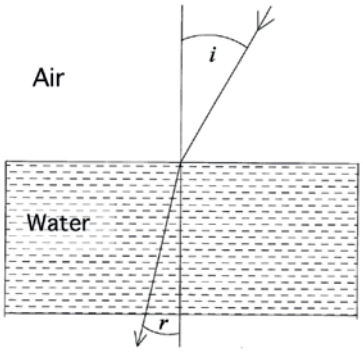
Refractive Index

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

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
   - *(colour, density, electrical resistance, etc, etc…)*

c) Applies to gases, liquids, glass ('supercooled liquid')
   - *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
   - *different refractive indices*

Birefringence

a) Defined as the numerical difference between the highest and lowest RI along three axes

b) Two conventions, either;
   - α, β, γ, *or*
   - x', y', z'
   - $x' < y' < z'$

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
   - RI from ~1.696 to ~1.700 or 0.004

g) Chrysotile - low
   - RI from ~1.546 to ~1.552 or 0.006

h) Amosite - medium
   - RI from ~1.676 to ~ 1.696 or 0.020

i) Anthophyllite, tremolite and actinolite
   - medium birefringence

j) No asbestos has high birefringence

Sign of Elongation

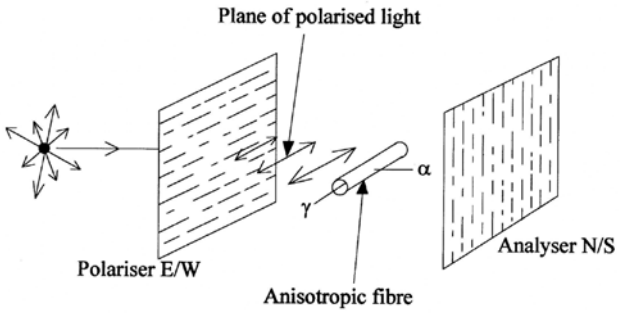
1. If $RI_{along} > RI_{across}$ = length slow or positive sign of elongation
2. If $RI_{along} < RI_{across}$ = length fast or negative sign of elongation
3. Also referred to as optic orientation
4. Crocidolite usually length fast (but can be length slow if heated)
5. All other asbestos forms length slow
6. Non-asbestos crystalline materials also slow or fast

Polarised Light

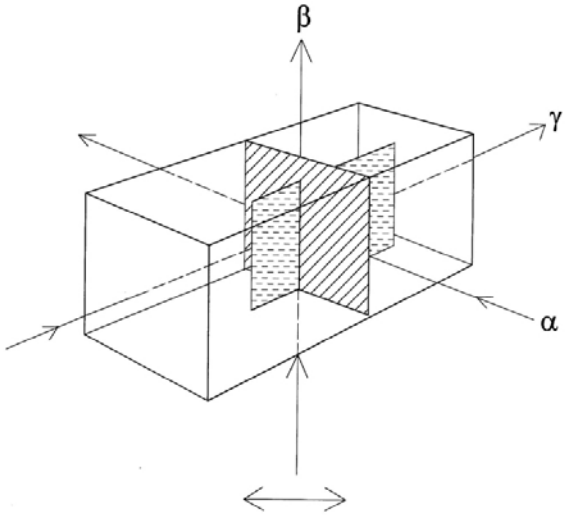
Plane polarised light

Either by

- polarising filters or
- 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

- where optical plane is not coincident with crystal axis

Phase differences produce interference colours

Interference $\propto t \times \Delta RI$

Michel-Levy chart*

- 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

- Very variable intensity
- Very characteristic
- '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

- position of 'extinction' is 'oblique' or 'inclined'
- depends also on rotation about fibre axis
- Chrysotile, amosite and crocidolite - parallel
- Tremolite and actinolite - oblique extinction angles
  - *may be difficult to observe, HSG 248 says 'parallel or small (5°) angle of extinction'*
- 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

- 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

- add interferences → '2nd order blue'

Slow directions perpendicular – fibre and tint plate

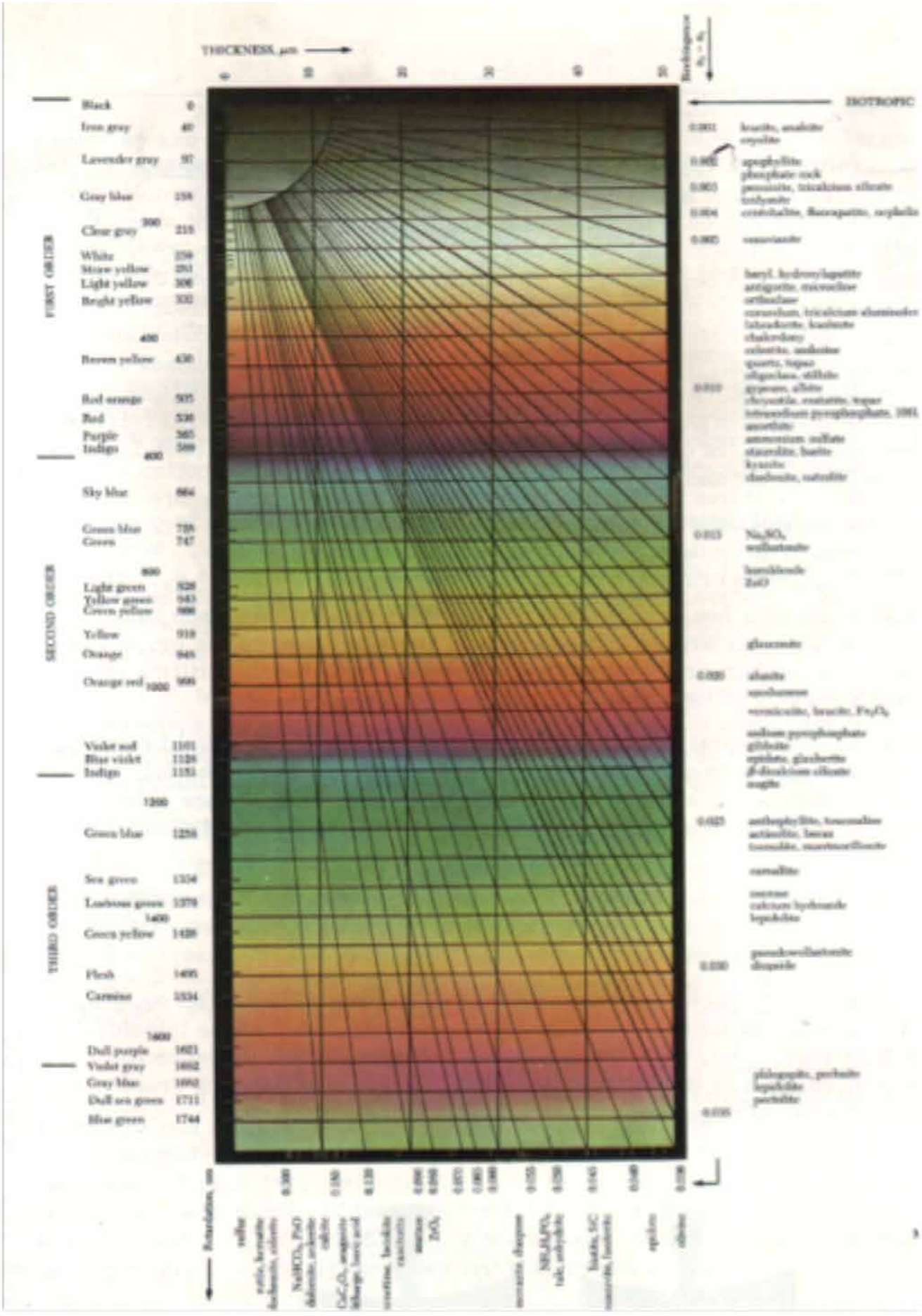
- subtract interferences → '1st order yellow'

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

→ Thickness
↓ Birefringence



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

- (occasionally pale yellow for amosite)
- Normally observed with plane polarised light
- 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

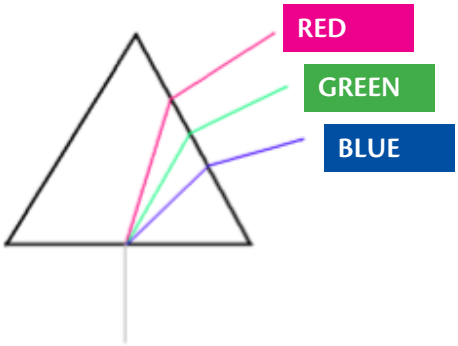
- white fringe moves into liquid or particle

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

Limited usefulness? (but see heat-degraded asbestos)

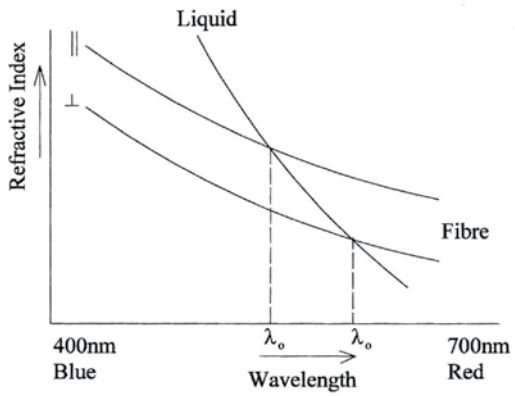
Dispersion Staining

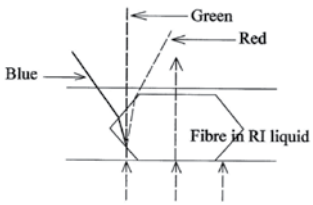
Refractive index is wavelength dependent
Usually higher RI at blue end of visible spectrum
Dispersion curves characteristic of material
Intersection points at refractive index match - λ_0 (aka lambda nought wavelength)



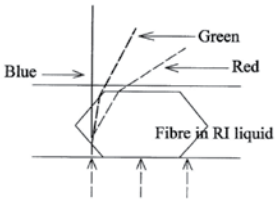
Dispersion

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

- central stop colours are 'white light' minus the λ_0 (or refracted) colours
- (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

- RI fibre > RI liquid - yellow/orange colour
- 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

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

But can be:

- light blue to darker blue
- or purple/magenta to orange

IOM reference minerals include Zimbabwe and Cassiar, Canada

UNIT 3
Bulk Analysis Methods

Section 1:
Undertake analysis by PLM

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

- Leather
- Polypropylene or polyethylene
- Spiders' web
- Paper swarf
- Feathers?

Check with flame!

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

- visually similar but birefringence higher
- no dispersion staining colours
- fibres will melt in a flame

Leather swarf

- similar dispersion staining colours to chrysotile
- but morphology slightly different
- fibrils visible

Aramids ("Kevlar")

- similar morphology to chrysotile
- but extreme birefringence
- highly variable relief

Spider webs/paper/feathers

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

Talc

- higher RI than chrysotile, different dispersion staining colours

Brucite and Wollastonite

- similar morphology to amosite, but brittle and soluble in acid

Diatomaceous earth (lagging with fossilised sea creatures!)

- can look fibrous but low RI so dispersion staining colours different

Thermally Degraded Asbestos

Amphiboles (amosite and crocidolite)

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

Heated Above 3 - 400°C

Crocidolite

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

Amosite

- stereo colour changes through yellow to dark brown
- becomes pleochroic

So above this temperature, amosite and crocidolite can be indistinguishable

Heated Above 600°C

Chrysotile

- stereo colour changes slightly to pale brown
- loses strength and becomes more fragile
- RI increases, birefringence decreases
- sign of elongation may reverse

Sample Preparation

Sample must be dry for dispersion colours

- no water at fibre / liquid interface

Prepare by

- acid wash in dilute HCl for about 15 minutes
- crush in pestle and mortar
- acetone wash and ultrasonic bath
- solvent extraction, e.g. for bituminous materials
- 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, ie in fume cabinet
Infra-red lamp inside the cabinet
Rinse with acetone and allow solvent to evaporate

- BUT.....acetone highly flammable!

Acid Wash

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

- When preparing diluted acids, always add the acid to the water slowly with stirring
- Use suitable extraction
- 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

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

Solvent Extraction

Some bituminous materials can be cleaned more easily with organic solvents
Check hazards

- Toxicity and flammability – all organic solvents are flammable!

Avoid skin contact and inhalation

- Use only in suitable extraction / fume cabinet
- May need to test for different solvents
- Avoid high toxicity solvents such as benzene, toluene
- 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;

- "asbestos cement is a material which is predominantly a mixture of cement and chrysotile which absorbs less than 30% water by weight"
- "AIB means any flat sheet, tile or building board consisting of a mixture of asbestos and other material except asbestos cement"
- 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

- Supercritical - 20 points (miss asbestos)
- Critical - 12 points (miss 1 fibre type in the presence of others)
- Non-critical - 7 points (miss trace amount of rarer type or false positive)
- 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

- 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

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

Saferty Aspects

Check cabinet is working properly before use

- 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