MINE DUST

Definition of dust:

- Generally finely divided solid particles of mineral, rock and other matters of less than 1 mm size are considered as dust.
- All dust, however, do not become airborne.
- Only particles with an upper size limit of 100 μm are considered as airborne dust.

Production of dust in mines

- Dust is produced whenever coal or rock is broken by impact, abrasion, crushing, cutting, grinding or explosives.

- Dust is produced during winning of mineral and its transport out of the mine as well as from ancillary operations, viz. roadway maintenance and roof support operations.

Main sources of dust production in mines

1. Coal or rock cutting machinery:

- It is the most prolific one in the mechanised coal getting machine, generally shearer.
- Other similar coal or rock cutting machines, viz. continuous miners, road headers, tunnelling machines, raise borers, coal cutting machines and drills are the also prolific producers of dust.
- Dust production depends not only on the action of cutting picks (tensile and compressive), but also on pick penetration and pick spacing on a cutting head.
- The greater the penetration, the less the proportion of fine dust per tonne cut.
- Cutting with blunt picks results in increased crushing and enhanced dust production.

- For shearer loaders, it is accepted that optimum size distribution of product is obtained by deep cuts using relatively few picks correctly spaced on the cutting head.

- Dust production also depends on the pick peripheral speed with lower dust production for lower speed.

- As coal gets loaded onto the armoured face conveyor, secondary crushing of some coal takes place producing dust.

- A machine cutting into a shale or sandstone roof or floor of a coal seam produces higher dust concentration.

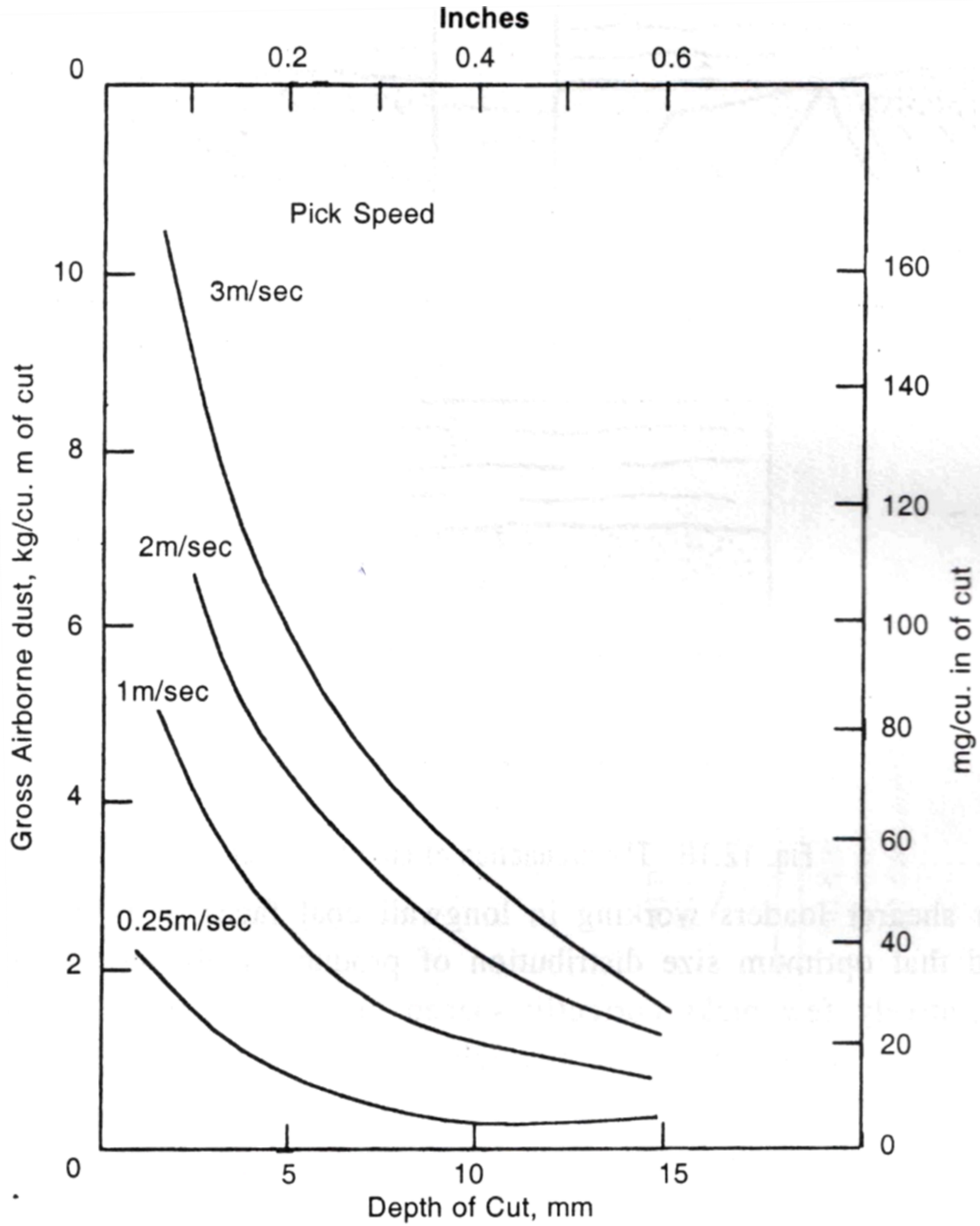


Fig. 12.17 The effect of pick speed and depth of cut on dust production

2. Drilling:

- It is the major source of dust in development headings where mineral is won by blasting.

- Rotary drills produce dust that is coarser and contains less of fine material than do percussive machine.

- According to Skochinsky and Komarov (1969), approx. 70-130 kg of dust is produced from drilling 10 to 20 shot holes of 1.8 to 2.3 m length in a development face in a hard rock mine.

- They estimated that 85% of the dust produced in mine was from drilling, 10% from blasting and other activities such as loading and transportation of mineral accounted for only 5% of the total dust production.

- In surface mines, the large diameter rotary blast hole drills produce a lot of dust.

3. Blasting:

- Blasting, particularly in hard rock, produces a large quantity of dust.

- The amount of dust produced depends upon a number of factors including
  - the type of rock,
  - choice of explosive,
  - the drilling pattern,
  - the charge density and
  - type of stemming used.

4. Roof support:

- In powered support longwall faces, the movement of high setting and yield load supports crush the ridges left on the roof or floor by the cutting machine and produce significant amount of dust.

5. Loading operation:

- Lots of dust is released during loading operation in case of development headings and bord and pillar districts in coalmines employing LHDs, SDLs and gathering arm loaders.

- In hard rock mine, dust is produced by slushers, load-haul-dump (LHD) vehicles or directly from the stopes by opening of chutes provided in the ore passes.

6. Transportation and crushing:

- Dust is produced at various points in the mineral transportation system, including conveyors, transfer points, bunkers (discharge points), skips and airlocks.

- Dust on conveyors may become airborne owing to the vibration of the belt as it passes over the rollers.

- Spillage of mineral falling on the bottom belt if not cleared, gets crushed by return rollers and produce dust.

- Dust produced at transfer points depends on the drop of the mineral and degree of wetting of the mineral.

- As ore is unloaded at ore bins or bunkers, the amount of dust produced depends upon the free fall and the impact of material.

- Crushers in mine are prolific sources of dust.

7. Dust raised in travelling and material transport roadways:

- Pedestrian traffic often raises the dust level in the air stream.

- Similarly, dust is raised in mineral transportation, irrespective of whether carried out by tracked or trackless vehicles.

Various dust sources in a typical retreat longwall face

In a typical retreat longwall face with antitropal ventilation system, the intake air starts picking up dust in the gate road itself long before reaching the face.

The various dust sources may be:

1. Outbye bunker at pit bottom or main intake.
2. Belt transfer point between gate belt and main belt (there may be no. of such transfer points in an extensive mine with long panels).
3. Conveyor belt tension end and loop take up.
4. Pick-up from conveyor belt by ventilation air.
5. Dust adhering to bottom belt.
6. Dust raised by men while walking in gate roads.
7. Dust raised while material transportation in the bottom gate.

8. Dust from conveyor rollers and structures.
9. Transfer point from stage loader to belt conveyor.
10. Transfer point from AFC to stage loader and feeder breaker.
11. From drilling and blasting or other operation at the stable end.
12. Coal wining machine, say a shearer.
13. Dust pick-up over the AFC at the face.
14. Chock movement and grinding of roof over chocks.
15. Waste flushing.
16. Auxiliary ventilation or a venturi at tailgate end of the face.
17. Material transport in the return gate.
18. Drilling for roof bolting and other support operations in the return gate.
19. Drilling for methane drainage and water infusion if practiced.

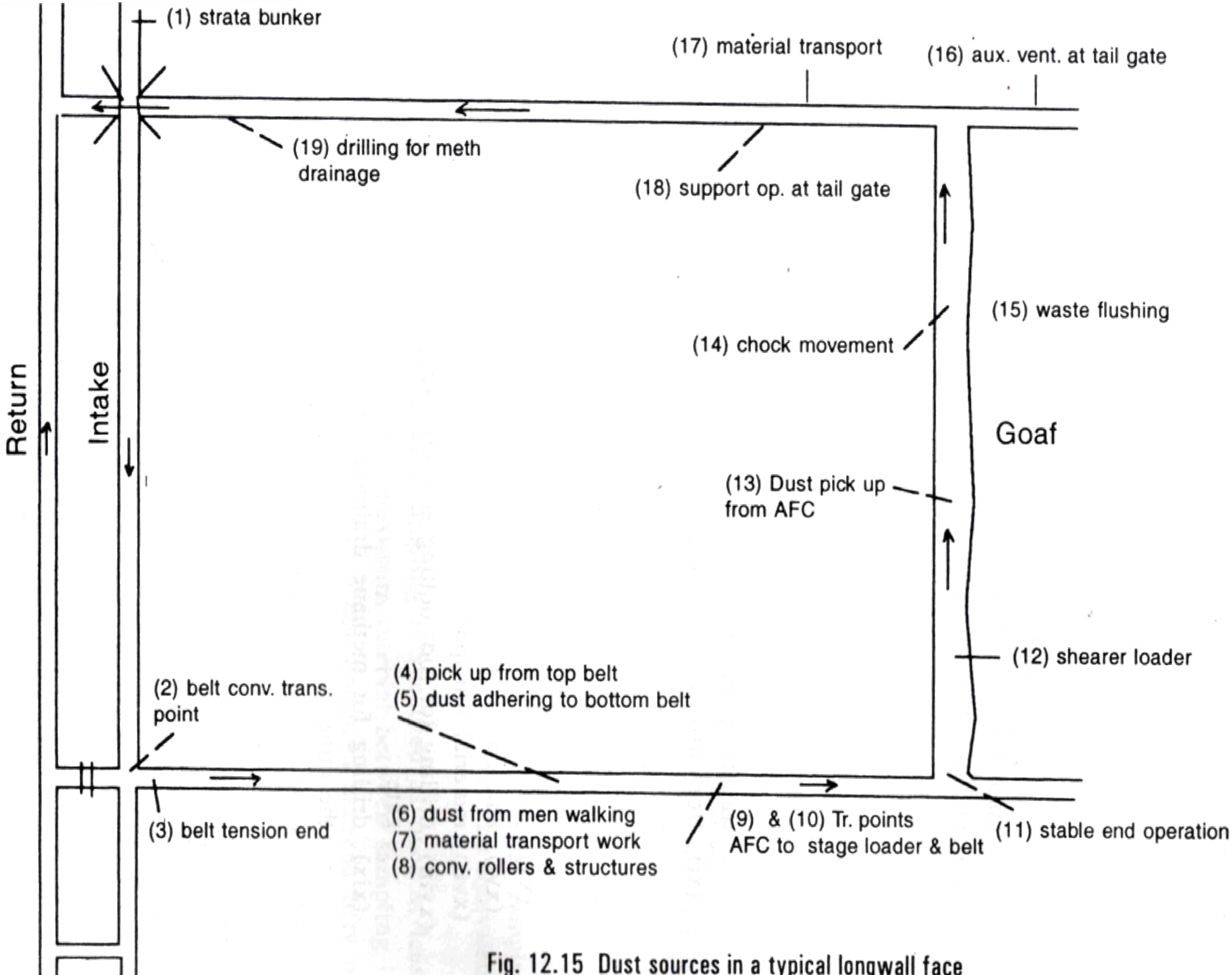


Fig. 12.15 Dust sources in a typical longwall face

Airborne respirable dusts

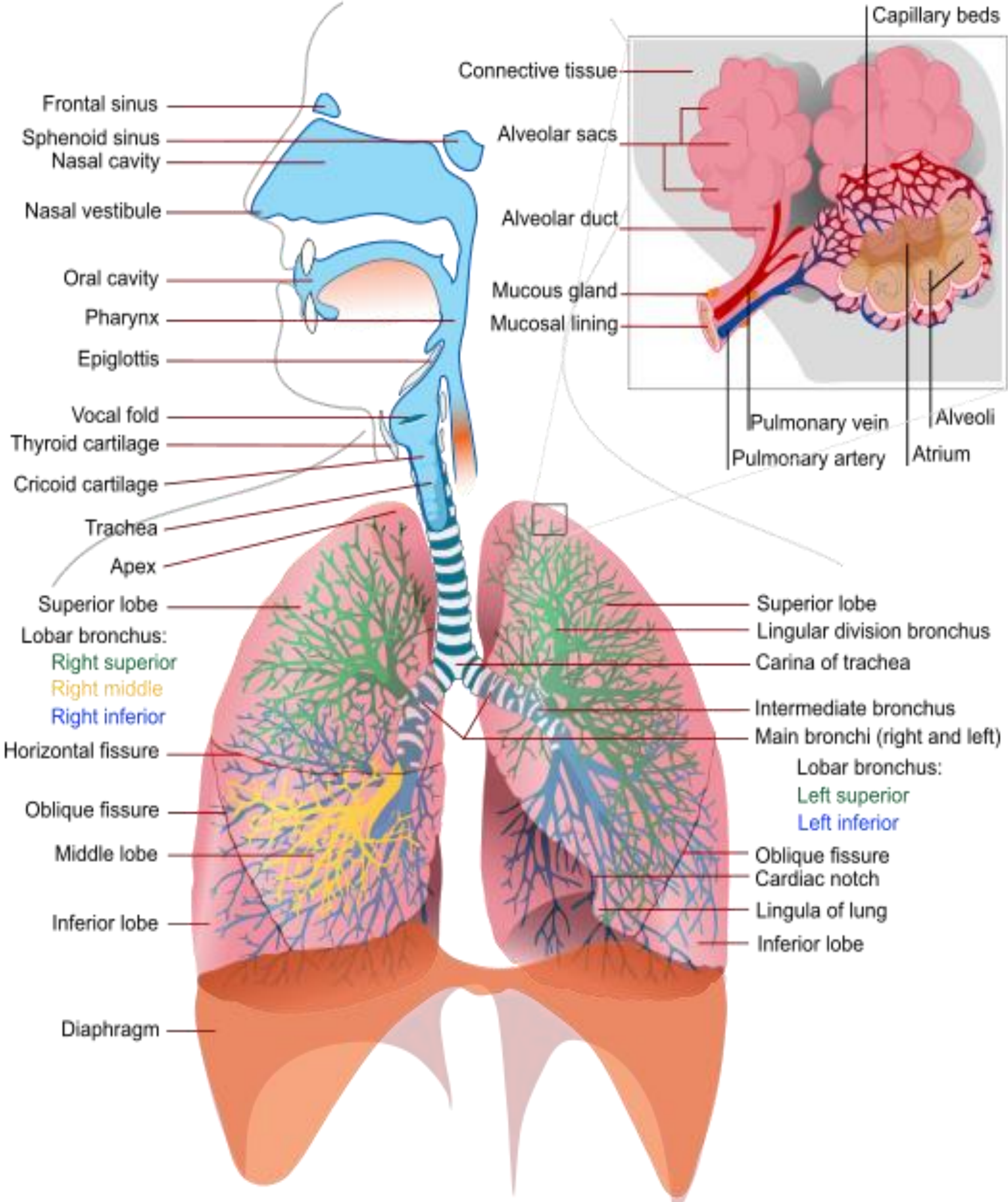
- All dust, however, do not become airborne. Only particles with an upper size limit of 100 μm are considered as airborne dust.

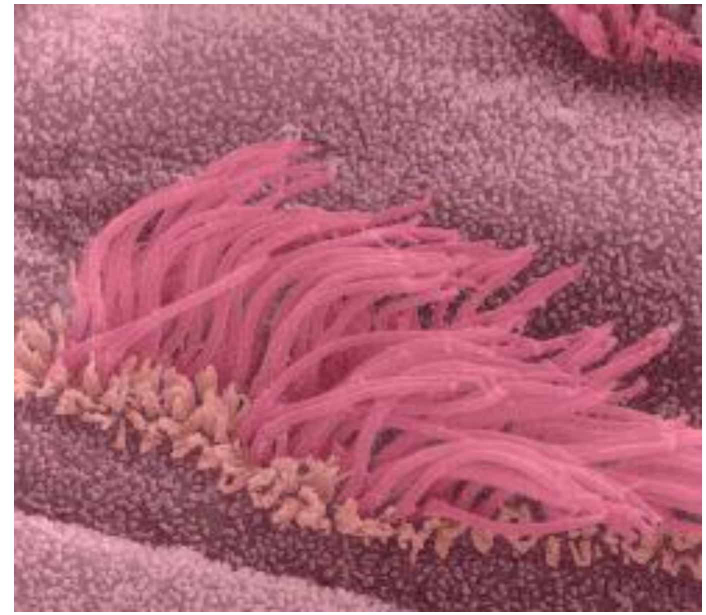
- Again all airborne dust particles cannot enter the human respiratory system, since nasal hairs in the nostrils act as a filter.

- The nasal cavity being of much larger cross-section than the nostril, cause reduction in inhaled air velocity that causes deposition of large size dust, say +10 μm size.

- The upper respiratory passages, i.e. the naso pharynx, trachea, bronchi and bronchioles are all lined with hair like structures (cilia) and mucous secreting cells.

- Cilia move back and forth, pushing the dust either towards the nostrils, where it is blown out or towards pharynx, where it travels through the digestive system and out with the rest of the body's waste.


Capillary beds
Connective tissue
Alveolar sacs
Alveolar duct
Mucous gland
Mucosal lining
Pulmonary vein
Pulmonary artery
Alveoli
Atrium
Frontal sinus
Sphenoid sinus
Nasal cavity
Nasal vestibule
Oral cavity
Pharynx
Epiglottis
Vocal fold
Thyroid cartilage
Cricoid cartilage
Trachea
Apex
Superior lobe
Lobar bronchus:
Right superior
Right middle
Right inferior
Horizontal fissure
Oblique fissure
Middle lobe
Inferior lobe
Diaphragm
Superior lobe
Lingular division bronchus
Carina of trachea
Intermediate bronchus
Main bronchi (right and left)
Lobar bronchus:
Left superior
Left inferior
Oblique fissure
Cardiac notch
Lingula of lung
Inferior lobe



- Maximum particulates in the size range of 5-10 μm get trapped in the upper respiratory tract by deposition, impact, diffusion or interception on the mucous and thus eventually gets out of the respiratory system as cough through whip like motions of cilia.

- Hence, only a few dust particles greater than 5 μm (depending also upon the density and shape of the particles) reach the alveoli.

- **Only -5 μm fraction is generally considered as respirable dust (some statutes define it as -10 μm).**

- According to Hamilton (1970), less than 5% of the respirable dust is produced at a mine face .

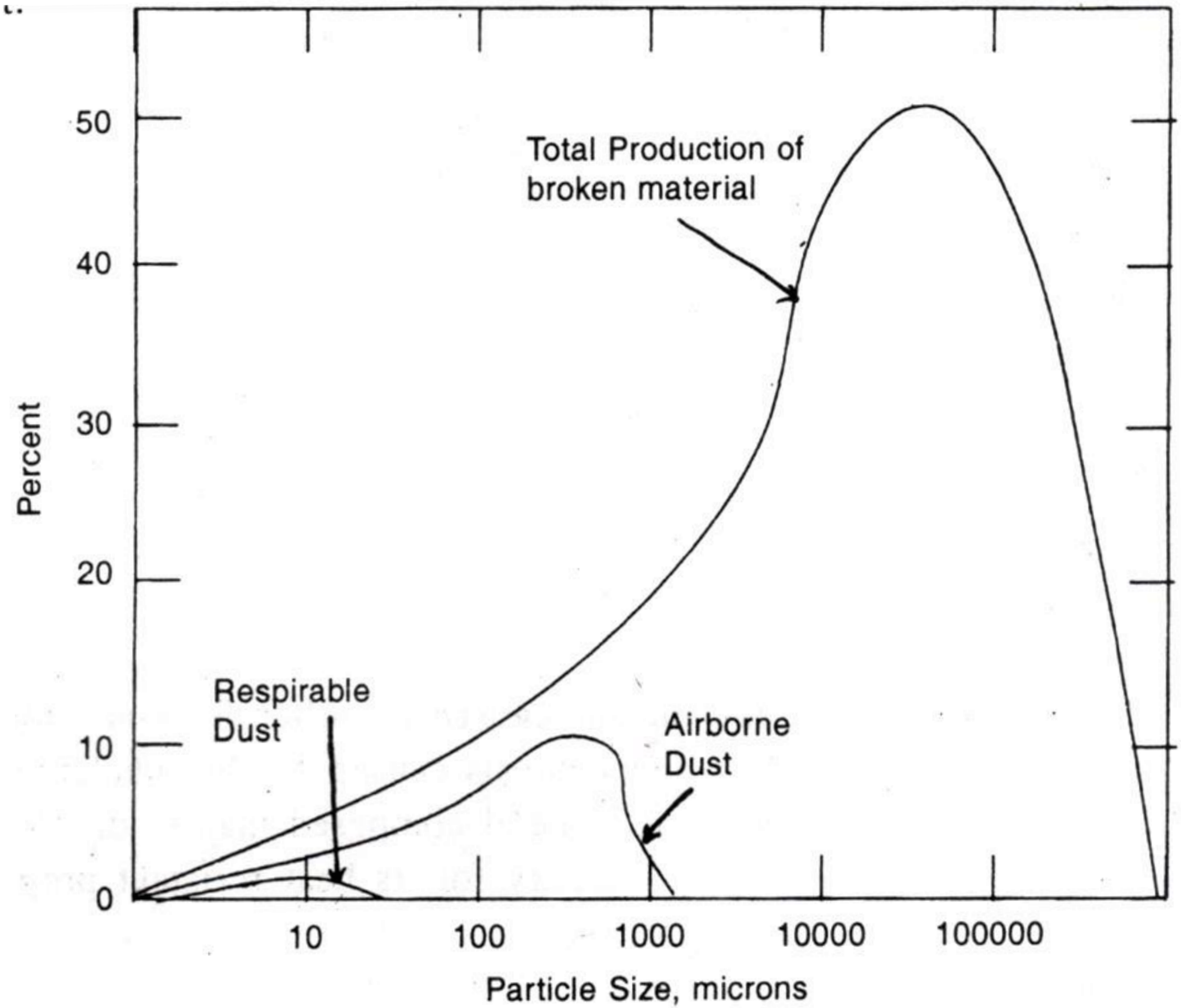
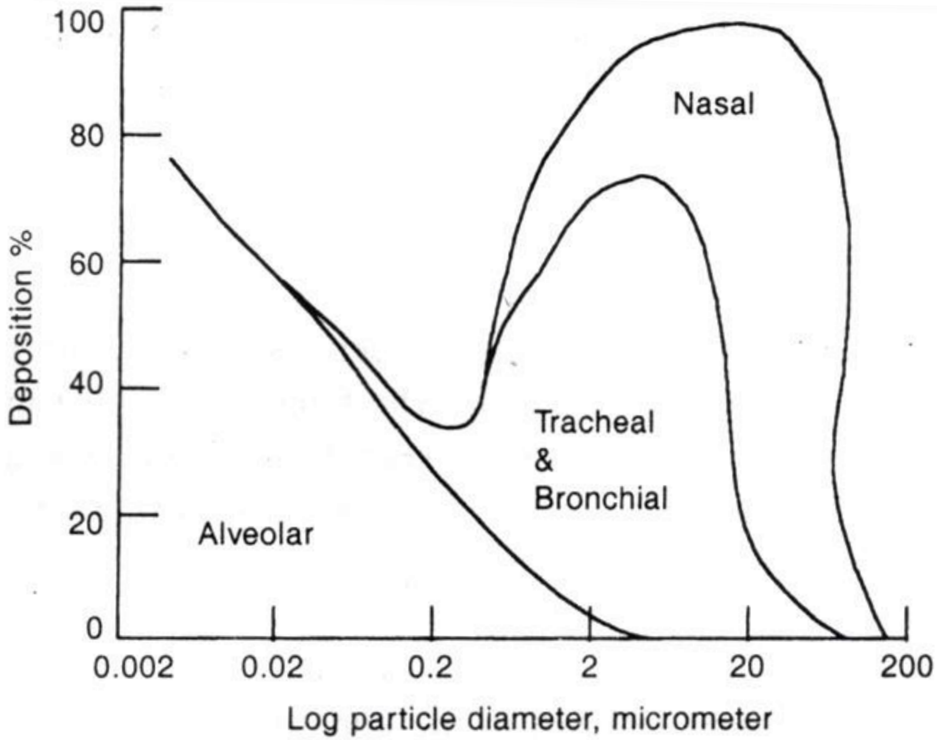


Fig. Typical size distribution of dust produced by mining machine such as Anderton shearer (by Hamilton, 1970)

- Most of the dust reaching the alveoli and does not settle in the lungs goes out with the exhaled air and only a part is retained.

- Very small particles of say less than 0.3 μm size are imparted a random motion (Brownian motion) by continuous bombardment by air molecules and hence these particles get deposited in the lungs mainly by diffusion.



(a) Dust deposition

Figure (by Walli) shows the deposition of dust of various sizes in different parts of the respiratory system.

Dust size (µm)	Max. deposition
20 to 200 µm	In nasal passage
2 to 20 µm	In the tracheal and bronchial parts
< 0.2 µm	Mostly in the alveolar region

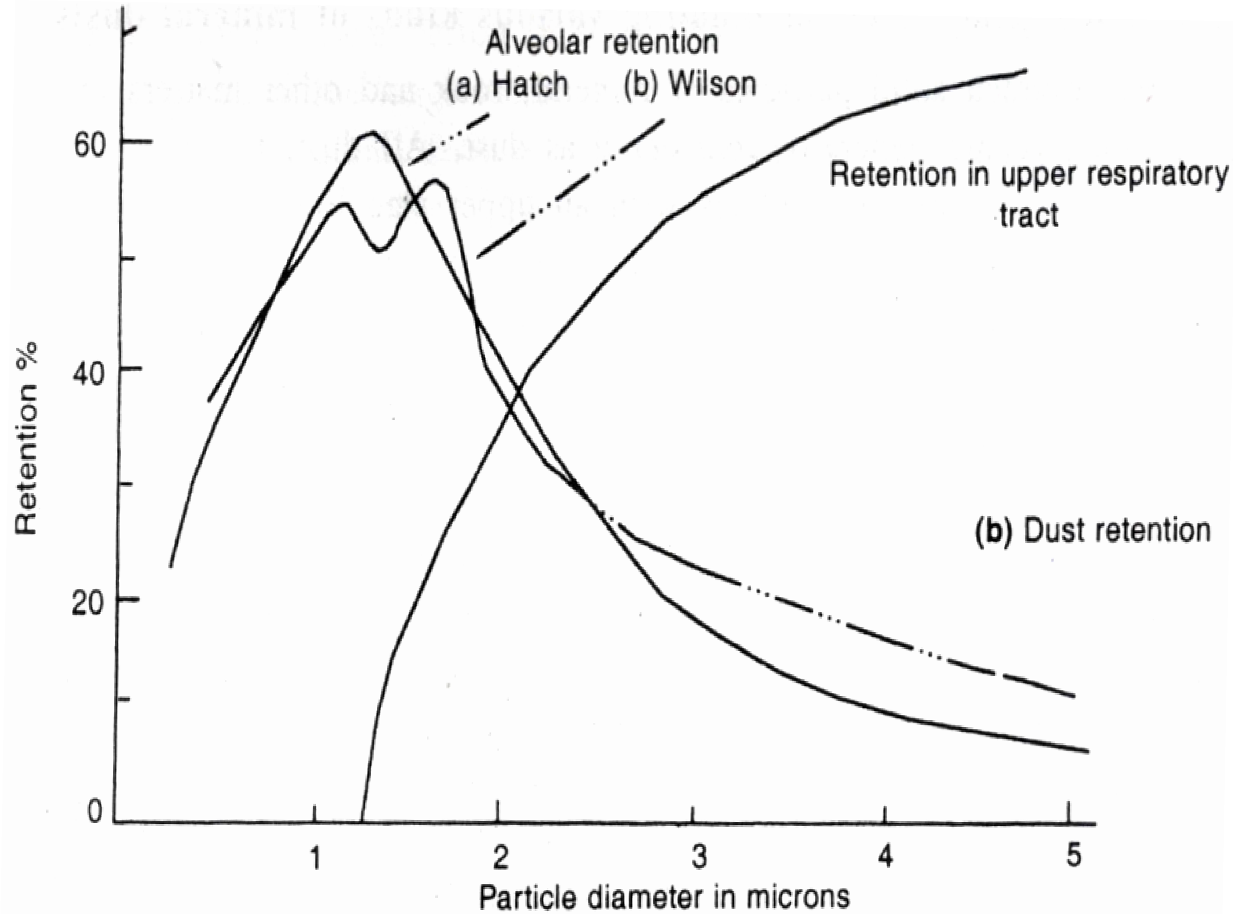


Fig. Curves for alveolar and upper respiratory tract retention of dust for various particle sizes

•Maximum retention in alveoli is for dust of size between 1 to 2 μm at around 60%, reduces exponentially to about 6% as the size goes up to 5 μm and the retention percentage also falls down to about 20% as the dust goes down to 0.2 to 0.3 μm size.

•There is a gradual decrease of retention percentage in the upper respiratory tract for dust sizes smaller than 5 μm and hardly any dust size less than 1.2 μm is retained in the upper respiratory tract.

- In 1952, the British Medical Research Council (BMRC) adopted a definition of ‘respirable dust’ based on the dust fraction reaching the alveolar region.

- It is based on the use of an ideal horizontal elutriator having such cut off characteristic that the dust passing the elutriator matches the lung deposition size characteristic.

TABLE 12.2 CUT-OFF PERCENTAGE FOR DIFFERENT DUST SIZES AS PER BMRC CURVE (AFTER LIPPMANN[10])

Dust size (Aerodynamic diameter or unit density sphere, μm)	% Respirable	% Cut off
2.2	90	10
3.2	80	20
3.9	70	30
4.5	60	40
5.0	50	50
5.5	40	60
5.9	30	70
6.3	20	80
6.9	10	90
7.1	0	100

A second sampling criteria has been adopted by ACGIH in 1968 as below :

Dust size (Unit density sphere, μm)	<2.0,	2.5	3.5	5.0	10
% respirable	90	75	50	25	0

ACGIH: American Conference of Governmental Industrial Hygienists

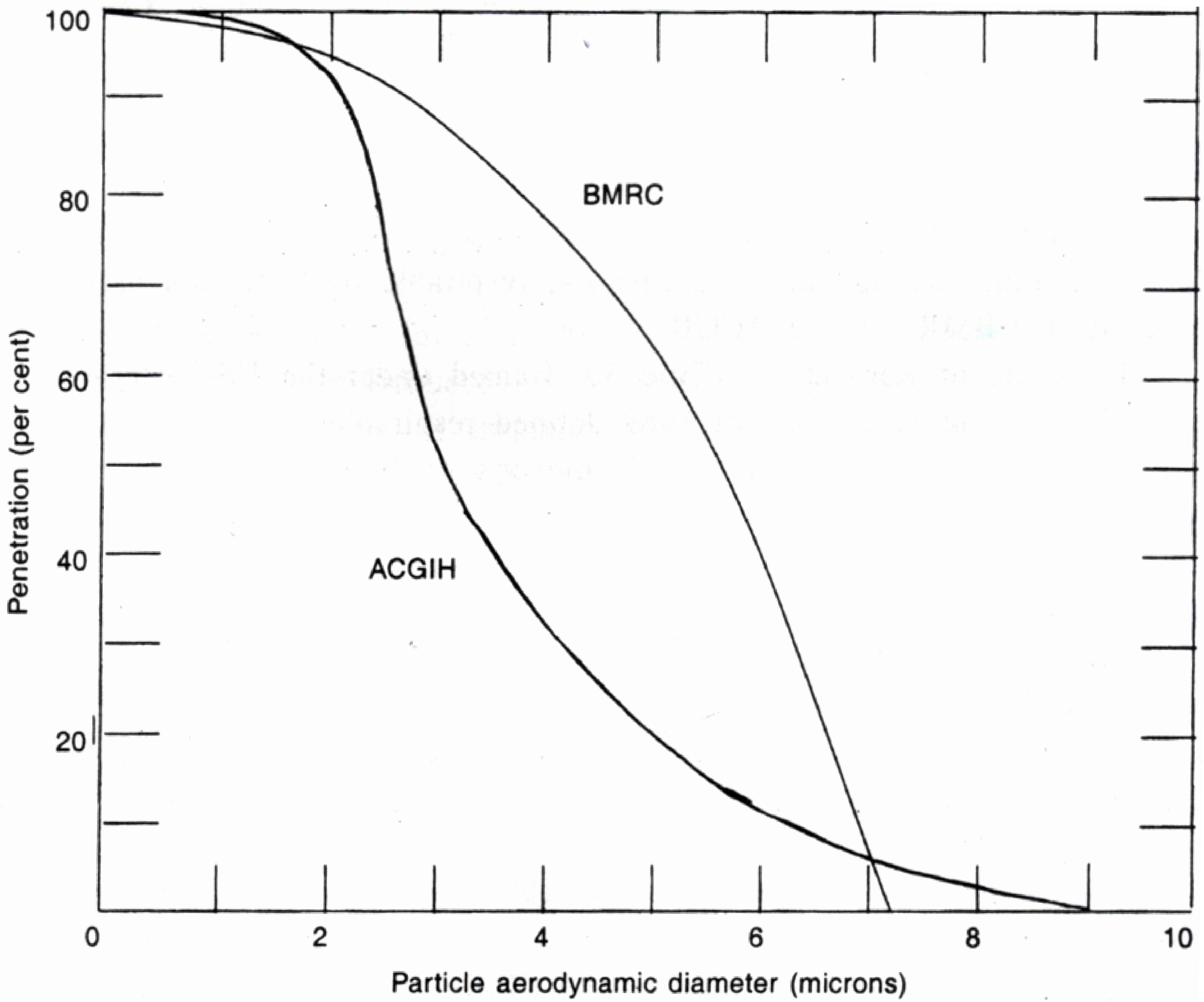


Fig. 12.4 Cut-off characteristics of dust samplers (a) BMRC (b) ACGIH curves

Aerodynamic diameter: It is the diameter of a spherical particle with a density of 1000 kg/m3

Physiological effects of inhalation of dust and dust related diseases

- The deposited dust in the lungs gradually accumulates, some of the lungs tissues get affected, suffering reduction of elasticity of the lungs and hence the volume of air that a person can inhale.

- The affected person then suffers from breathlessness, especially while doing hard manual work.

- Deposition of fibrogenic dust (e.g. silica) over a long period of time, say 10-15 years, cause development of fibrotic lesions and permanent scarring of lung tissues.

- Deposition of non-fibrogenic dust such as coal, limestone etc. does not lead to development of fibrotic lesions but can give rise to over-loading of defence mechanism of lungs and formation of plaques, in advance cases scarring of lung tissues takes place along with progressive massive fibrosis (PMF).

- Some dusts are toxic, e.g. arsenic, lead, cadmium, manganese etc. and causes damage by chemical reaction with the respiratory fluids.

- Some dusts are carcinogenic in nature, e.g. radon daughters, asbestos, etc (cause irritation).

- A major part of the deposited dust is removed from the lungs by the macrophages (a type of blood cell that patrols the body looking for germs to destroy) present in the lungs.

Pneumoconiosis

- Dust of any kind when inhaled in large quantities lead to the development of respiratory diseases such as chronic bronchitis and pneumoconiosis.
- **Pneumoconiosis is a generic term used for occupational lung disease due to dust.**
- It has been derived from two Greek words: ‘**Pneumono**’ means ‘lungs’ and ‘**konios**’ meaning ‘dust’.
- The ILO working group in 1971 redefined pneumoconiosis as **the accumulation of dust in the lungs and tissue reactions to it**.
- More specific names such as silicosis, asbestosis, talcosis, siderosis etc. have been given to lung diseases caused by particular type of dust.

- From pathological point of view, pneumoconiosis can be divided into two groups, viz.
  - Collagenous pneumoconiosis and
  - noncollagenous pneumoconiosis.

- **Noncolagenous pneumoconiosis :** caused by nonfibrogenic dusts and characterised by alveolar architecture remaining intact.

- Examples of noncollagenous pneumoconiosis are stanosis caused by tin oxide and barytosis by barium sulphate.

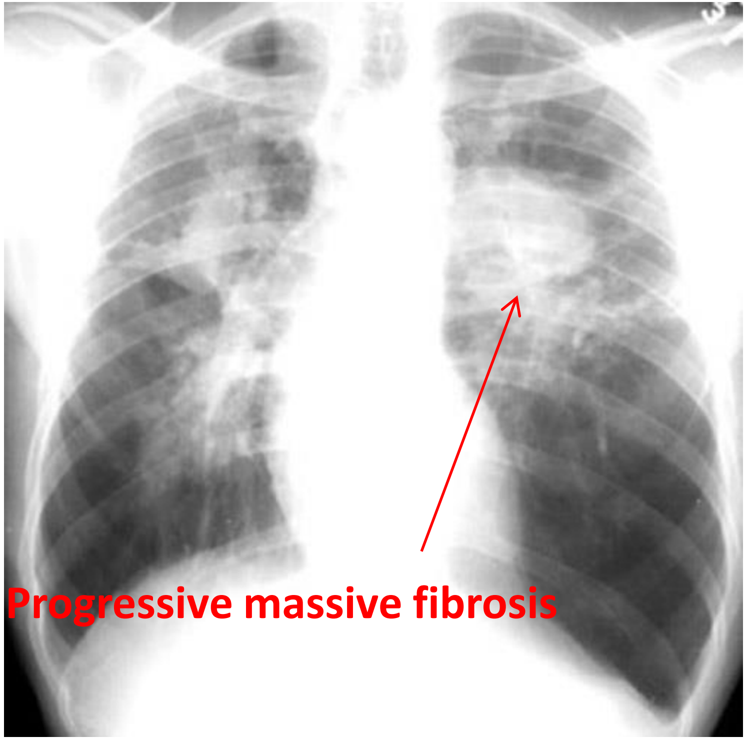
- **Collagenous pneumoconiosis:** characterised by permanent alteration or destruction of alveolar architecture and permanent scarring of lungs.

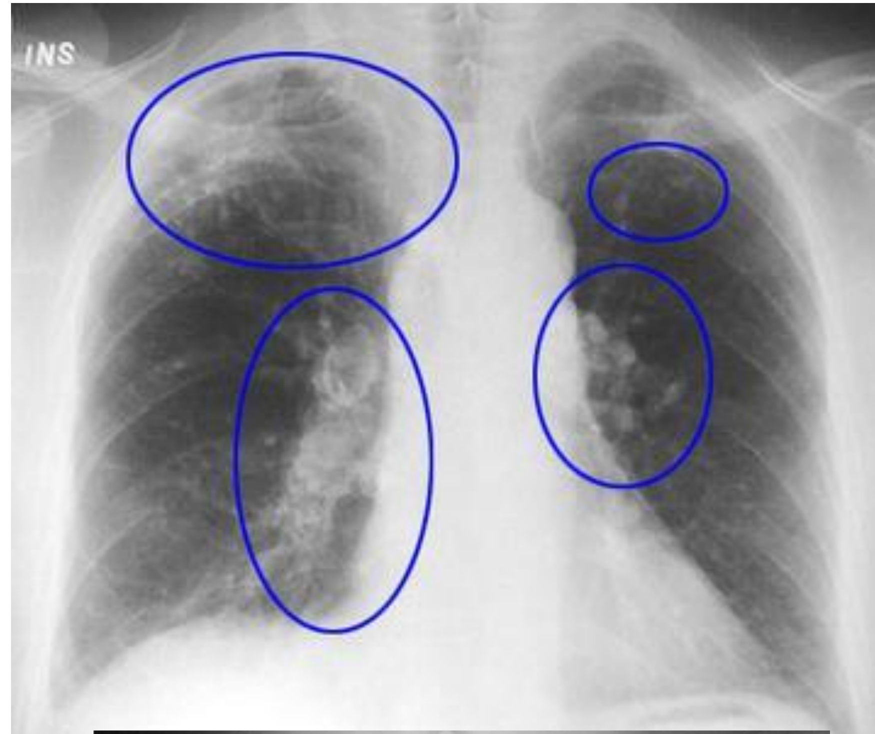
- It is mainly caused by fibrogenic dusts (silicosis and asbestosis) or altered tissue response to non-fibrogenic dusts (coal miners’ pneumoconiosis).

- **Detection of pneumoconiosis:** Pneumoconioses in living individuals are typically detected through radiological imaging. Traditionally this has been the chest x-ray taken on film, but now increasingly being acquired through digital computer technology.

Silicosis

- It is the most dangerous of all the types of pneumoconiosis met within mines, since it can affect people fatally and is progressive in nature.
- Silicosis is a chronic lung disease caused by breathing of dust containing free silica over a long period of time.
- After Feldspars (40-60%), Silica is the second most common mineral (30-50%) in the earth's crust, and is a major component of sand, rock, and mineral ores like quartz.
- The dust promotes the development of fibrous tissues in lungs where it is deposited within the alveolar clusters.
- In the beginning, small foci of fibrous tissue are formed which radiate outwards to form '**fibroblasts**'.
- These with further progression of fibrosis, can merge into nodules with an onion-like cross section, characteristic of silicosis (**nodular fibrosis**).
- The nodules are of 1 to 3 mm in diameter but can be much larger.
- As the disease progresses, these may fuse forming larger masses and end up in **progressive massive fibrosis**.





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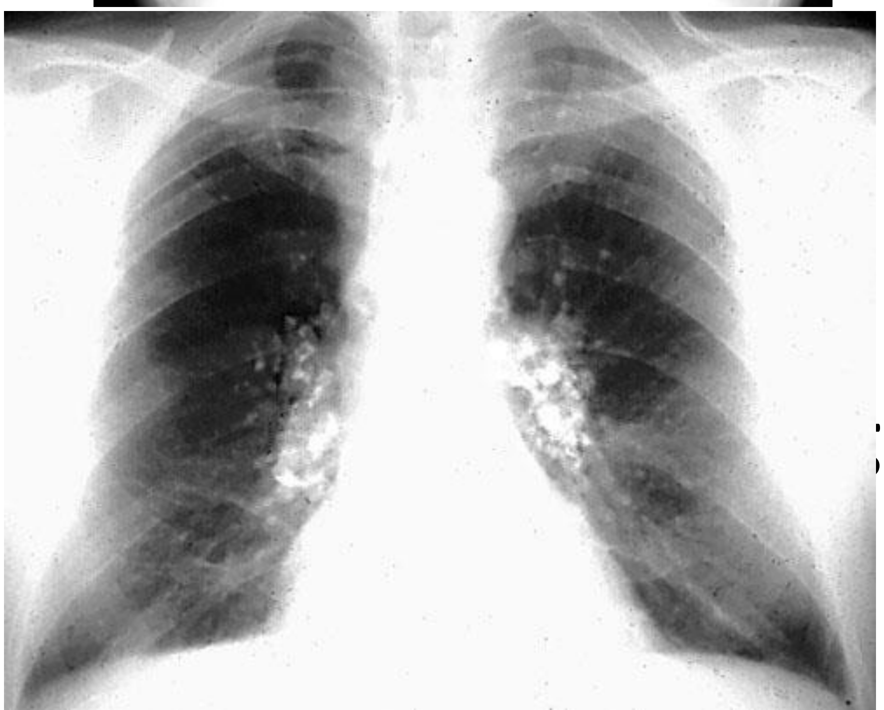

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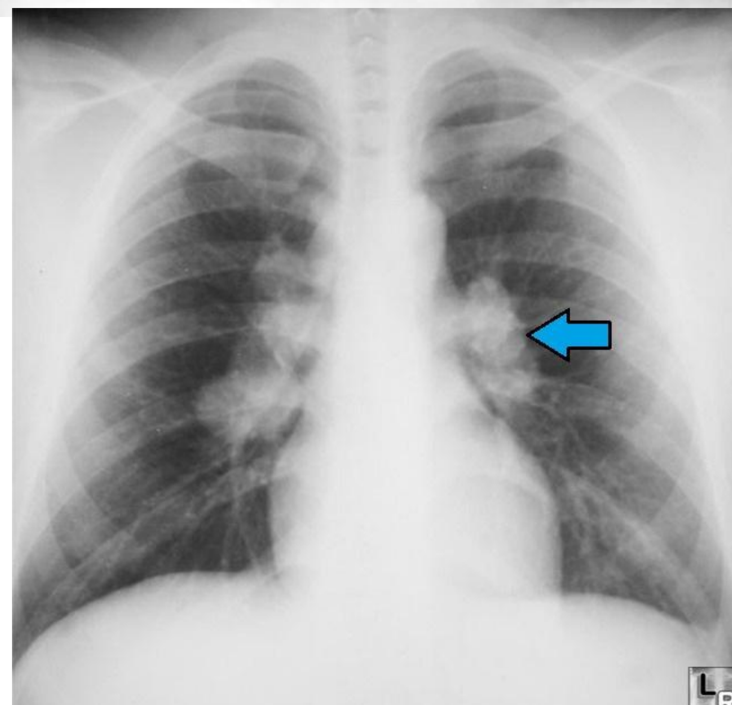


There are 3 basic pathologic patterns of response to silica

- **Fibrotic nodules** are most common. They are usually <1 cm in diameter, spherical, hard and gray to black.

- **Progressive massive fibrosis** is a form of silicosis characterized by dense agglomeration of nodules causing massive scarring usually in the upper lobes

- **Alveolar proteinosis** is a pattern of lung injury caused by inhalation of large amounts of silica resulting in accumulation of proteinaceous material in the air spaces.

Long nodules

There are three types of silicosis:

- **Chronic silicosis**, the most common type of silicosis, usually occurs after 10 or more years of exposure to crystalline silica at low levels.
- **Accelerated silicosis** is caused after 5 to 10 years exposure to higher levels of crystalline silica.
- **Acute silicosis** can occur after only weeks or months of exposure to very high levels of crystalline silica. Acute silicosis progresses rapidly and can be fatal within months.

Many miners in the past have met with untimely death from the joint effect of silicosis and tuberculosis.

Theories on silicosis

A number of theories have been advanced at different times to explain how silica exerts its harmful action on lungs:

- **The chemical theory:** The silica partially dissolves in the alveolar fluid and the toxic action is due to the slow release of silica acid.

- **The mechanical theory:** The ill effects are due to damage caused by the hard, sharp angular surfaces and edges.

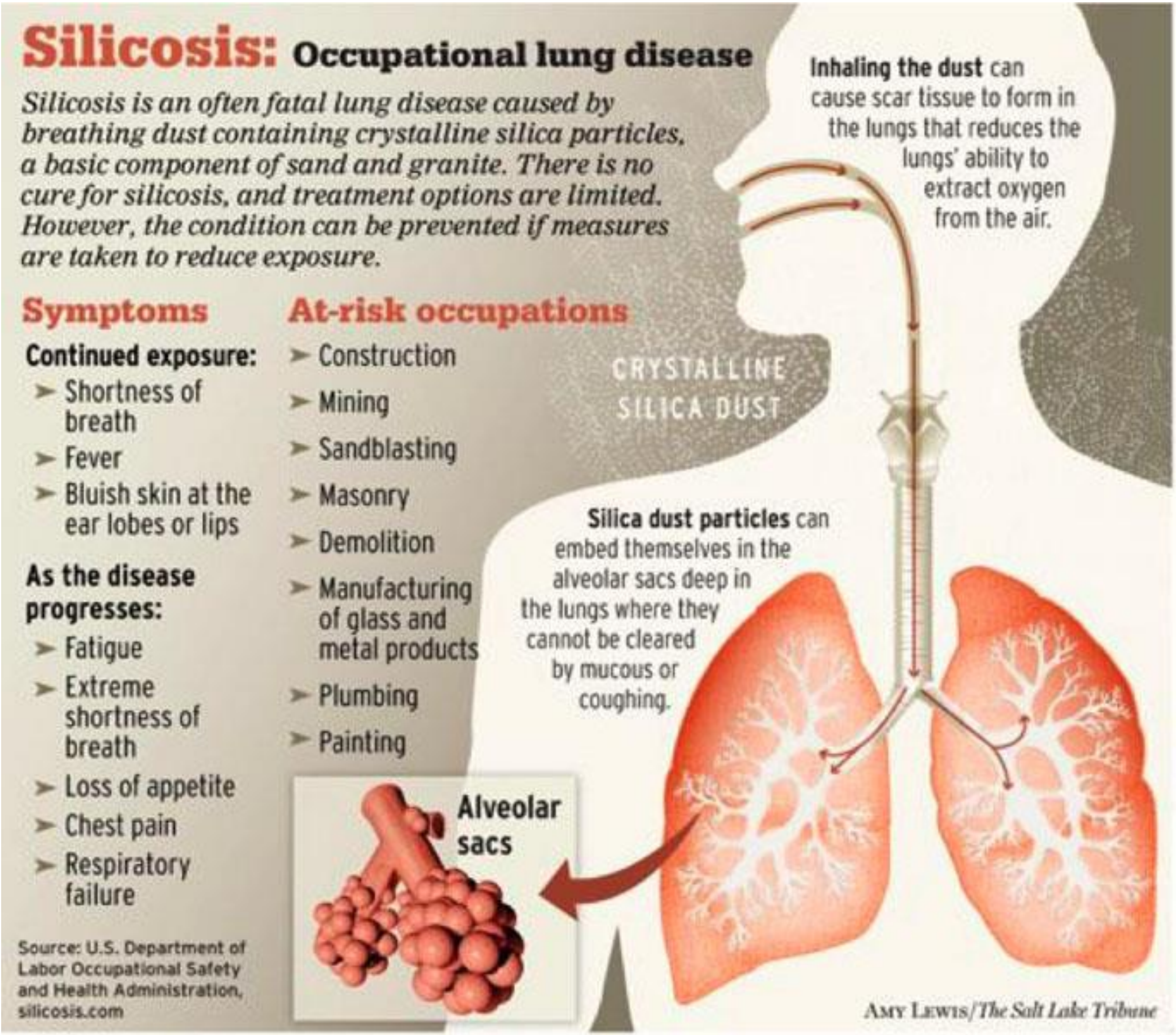
- **The electro-chemical theory:** Energy is concentrated on the surface of freshly fractured silica causing interaction with cellular components.

- **The auto-immune theory:** The microphages die early after ingestion of silica and liberates enzymes which evoke immune reaction resulting in fibrous antibody-antigen structures.

- The chemical and auto-immune theories are more widely accepted.

Symptoms and diagnosis of silicosis

- The clinical symptom of silicosis, as in case of other pneumoconiosis diseases, are
  - shortness of breath especially upon exercising and
  - lessened capacity of work.
- The degree of incapacitation depends on the amount of lung tissue rendered functionless or scar tissue formed or by both.
- The disease can be confirmed by radiological examination.


Silicosis: Occupational lung disease
Silicosis is an often fatal lung disease caused by breathing dust containing crystalline silica particles, a basic component of sand and granite. There is no cure for silicosis, and treatment options are limited. However, the condition can be prevented if measures are taken to reduce exposure.
Symptoms
Continued exposure:
Shortness of breath
Fever
Bluish skin at the ear lobes or lips
As the disease progresses:
Fatigue
Extreme shortness of breath
Loss of appetite
Chest pain
Respiratory failure
At-risk occupations
Construction
Mining
Sandblasting
Masonry
Demolition
Manufacturing of glass and metal products
Plumbing
Painting
Inhaling the dust can cause scar tissue to form in the lungs that reduces the lungs' ability to extract oxygen from the air.
CRYSTALLINE SILICA DUST
Silica dust particles can embed themselves in the alveolar sacs deep in the lungs where they cannot be cleared by mucous or coughing.
Alveolar sacs
Source: U.S. Department of Labor Occupational Safety and Health Administration, silicosis.com
Amy Lewis/The Salt Lake Tribune

Asbestosis:

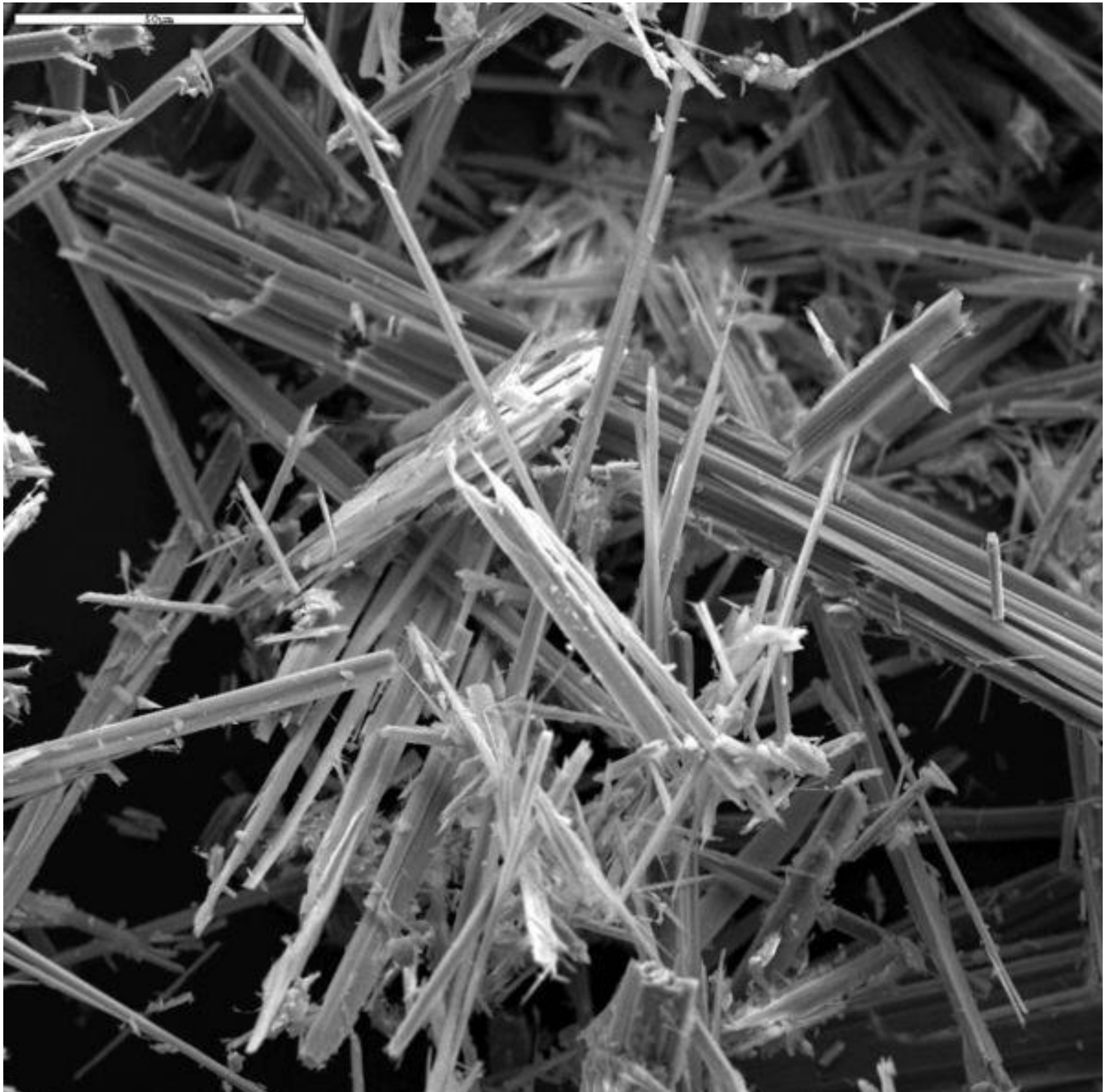
- It is a type of pneumoconiosis caused by the inhalation of asbestos fibres.

- Asbestos is an inorganic mineral composed mainly of silicate chains, which find wide application in industry for its heat resistance property.

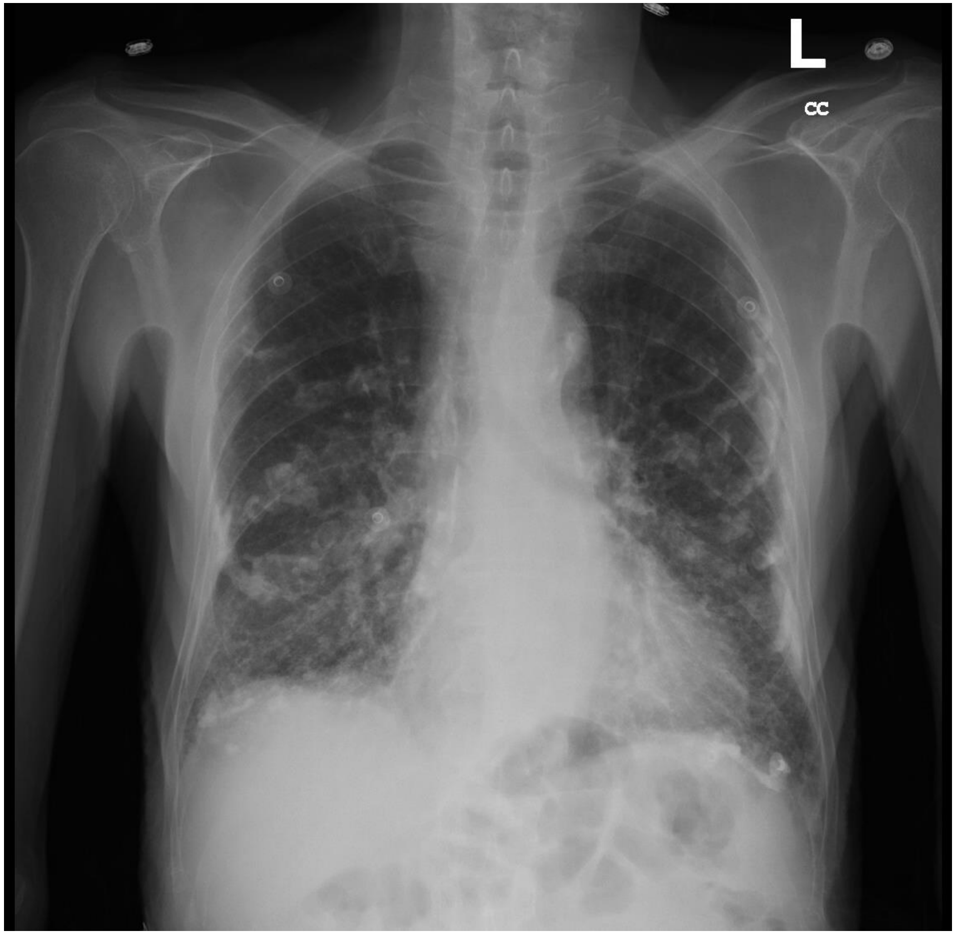
- Asbestos fibres not only cause fibrosis of the lung tissues but also lung cancer and mesothelioma (a rare form of cancer that develops from cells of the mesothelium).

- Because of the thin cylindrical shape (dia 0.1 to 3µm, length 5 to 200µm) of the asbestos fibres, their aerodynamic behaviour in the respiratory system is different from that of other dusts and a majority of fibres entering the lungs has a length of 50µm.

- The fibrosis produced by inhalation of asbestos fibres is different from the nodular fibrosis typical of silicosis.



Radiographs of an asbestosis affected lung shows a **cobweb like appearance** with the fibrosis diffused throughout the lung.



- Progress of fibrosis in asbestosis is more rapid than in silicosis and a person may die of asbestosis within 5 years of the onset of the symptom.

- Carcinogenic nature of asbestos fibres has been recognised since 1940s and stringent standards have been laid down for asbestos mining and processing in most countries.

- Besides asbestos, a few other mineral silicates, viz. talc, mica, kaolin etc. can also cause fibrosis of the lungs but these are not as severe as that caused by asbestos fibre.

- Pneumoconiosis caused due to talc is known as talcosis, and that due to mica dust is known as micatosis.

Coal workers pneumoconiosis (CWP):

- It is also referred to as **black lung disease** and commonly caused by long exposure of coal miners and others who work with coal to coal dust.

- In the first quarter of 12^{th} century, legislations framed to deal with dust diseases in various countries were aimed at silicosis only as coal dust was not regarded as harmful.

- However, the Silicosis Boards set up in the UK in the 1930s found changes in many coal miner’s X-ray films, which were not typical of silicosis.

- This led the British Medical Research Council (BMRC) to carry out an investigation amongst the miners in South Wales Coalfield of UK during 1937-42.

- Radiographic examination however revealed the coal plaques as black spot in the chest X-rays.

Black lung

- In the simplest form of coal miners' pneumoconiosis, coal dust usually collects at a number of foci all over the lung around small bronchioles and their accompanying arteries and a network of reticulin fibres is developed all around these foci.
- Excessive inhalation of coal dust particles over a long period of time (10-15 years) results in accumulation of coal dust as soft plaques within the alveoli, small airways and in the interstitial supporting tissues.
- With continuous accumulation of coal dust in the lungs, the black spots grow in size and number until they join together and form into larger nodules.
- In more advanced cases scarring of lung tissues takes place leading to development of **progressive massive fibrosis (PMF)** of the lungs.

Classification of CWP

- In 1959, ILO classification divided CWP into two groups- **simple and complicated.**

- **In simple CWP,** a person suffering does not exhibit any symptoms and only his chest x-ray reveals the onset of CWP.

- **In case of complicated CWP (or PMF),** the lung function is impaired, the patient exhibits breathlessness and the chest x-ray shows large shadows.

- When coal dust contains sufficient silica dust, development of progressive nodular fibrosis, characteristic of classical silicosis occurs.

Limits of dust concentration

TABLE 12.1 THRESHOLD LIMIT VALUES (TWA)+ FOR VARIOUS MINERAL DUSTS

			TLV in mg/m^3 unless otherwise stated	
1. Coal dust	(i)	RF++ from workings wholly in a coal seam with < 5% f.s.*	3	India
	(ii)	RF++ with > 5% f.s.*	$\frac{15}{\%\ \text{f.s.}}$	India
	(iii)	RF++ in longwall face in return airway at 70 m from face.	7	U.K.
	(iv)	RF++ in heading face with low quartz (less than 0.45 mg/m^3).	5	U.K. with working hours assumed 5 h.
	(v)	RF++ in rock headings with quartz exceeding 0.45 mg/m^3.	3	- do -
	(vi)	Total dust with <2% f.s.*	10	Poland
	(vii)	Total dust with 2-10% f.s.*	4	Poland
	(viii)	Total dust with 10-50% f.s.*	2	Poland
	(ix)	Total dust with >50% f.s.*	1	Poland
	(x)	RF++, f.s. 2-10%	2	Poland
	(xi)	RF++, f.s. 10-50%	1	Poland
	(xii)	RF++, f.s. >50%	0.3	Poland
	(xiii)	Total dust with <5% f.s.*	10	ACGIH (USA)
	(xiv)	RF with <5% f.s.* (general) (based on portal to portal survey)	2	MSHA(USA)
	(xv)	RF++ with <5% intake air within 60m of a working face.	1	USA (ACGIH)
	(xvi)	RF++ with >5% f.s.*	$\frac{10}{\%\ \text{f.s.}}$	MSHA(USA)
	(xvii)	RF++, <5% f.s.*	3	NSW (Australia)
	(xviii)	RF++, >5% f.s.* based on respirable quartz content	0.15 (of f.s.)	NSW (Australia)

2. Mineral dust containing f.s.* in appreciable %	R.F++	$\frac{15}{\% \text{ f.s.}}$	India
3. Crystalline silica,	R.F++. Quartz	0.1	USA, ACGIH
	R.F++. Cristobalite	0.05	USA, ACGIH
	R.F++. Tridymite	0.05	USA, ACGIH
4. Lime stone with very low f.s.	Total	10	ACGIH, Canada
5. Manganese ore	R.F++	5	ACGIH, India
6. Talc containing no asbestos fibre	R.F++	2	ACGIH
7. Soap stone	R.F++	3	ACGIH
	Total	6	ACGIH
8. Mica	R.F++	3	ACGIH
9. Asbestos			
Crocidolite		0.2 fi/ml	ACGIH
Amosite		0.5 fi/ml	ACGIH
Tremolite		0.5 fi/ml	
Chrysotile		2 fi/ml	ACGIH, India - Fibre L:D>3 - Min.length 5μ
Other forms including talc containing asbestos fibre		2 fi/ml	ACGIH

+ TWA = Time weighted average

++ R.F. = Respirable fraction of the dust

* f.s. = Free silica (used synonymously with quartz in coal mines as in reality it is the only form of free silica found in coal deposits).

Sampling of Airborne Dust

- It is essential to have suitable device to estimate or sample airborne dust to effect suitable preventive and suppressive measures for allaying dust in a mine.

The following facts must be considered in sampling of airborne dust:

- Whether the parameter of dust assessed is a true measure of the danger to health.

- The sample should be able to give knowledge of the necessary dust concentration in the dangerous size range. Mass concentration of the respirable fraction of dust is widely accepted today as the relevant concentration.

- Sample should be able to assess the dangerous component of dust as regards composition, which necessitates adequate volume of sample to be collected for chemical and mineralogical analysis.

- The duration of sampling should be such as to give a true picture of dustiness of any mining operation or place of work without necessitating a large number of samples to be taken.

- The present trend is to obtain a continuous sample over at least a working shift.

- The sample should be representative of the dust cloud in the breathing zone of the worker.

- The sampling instrument should be
  - portable and robust for rugged underground conditions
  - should require minimum maintenance,
  - should be operated with minimum skill,
  - should have self-contained power supply and
  - should render the dust measurement in as little time as possible.

Duration and interval/frequency of sampling

- The cycle and duration of sampling should be carefully chosen to give a fairly accurate estimation of the dustiness of any particular operation over a long period.

- A true estimate however be obtained by a continuous sampling device working over the whole shift or even over several shifts, from which a true shift mean can be obtained.

- **The frequency of respirable dust sampling** is specified as once at least every six months in CMR 1957.

- The maximum interval between sampling is reduced to 3 or 1 month when the dust concentration exceeds 50 or 70% respectively of the allowable value.

Position of sampling

- The following points must be borne in mind while considering the positioning of sampling points:
  - uniformity of distribution of dust in an air-stream is dependent on the uniformity of flow in the airway.
  - In order to get a representative sample, it is necessary to collect the sample in a straight portion of the airway at least 10 diameters away from any bend or major obstruction.
  - The sampling velocity should be as far as practicable, equal and equidirectional to the velocity of air from which the sample is being collected. This is essential for minimizing the loss of particles by inertial separation before entry into the sampler.

- The best sample having direct relevance to health hazard is one collected at the breathing point of the worker.

- This has led to the development of personal dust samplers (PDS) which collect a sample of the respirable dust fraction over a sufficiently long period, usually a shift.

- For fixed point ‘area sampling’ (also called static sampling), the location is so chosen as to obtain representative concentration of respirable dust associated with the dust generating sources.

- **The National Dust Prevention Commitee (NDPC) for coal mines in India by its recommendation of 1993 gave sampling locations for area sampling in (a) board and pillar, (b) longwall, (c) drivage and (d) opencast workings and surface plants.**

Location of sampling in bord and pillar workings:

- **Intake airway of a working district** within 20 to 30m of immediate outbye ventilation connection from the 1st working face (a).

- **Return airway of a working district** within 20 to 30m of immediate outbye ventilation connection from the last working face (d). Where there is more than one return airway, all the return airways are to be sampled.

- **Working place or face** where dust concentration is likely to be maximum (b).

- **Resting place** of workers.

- 3 to 5m on the **return side of other places** where substantial dust is generated, e.g. loading/transfer point (c).

- **Main return airway of the mine**.

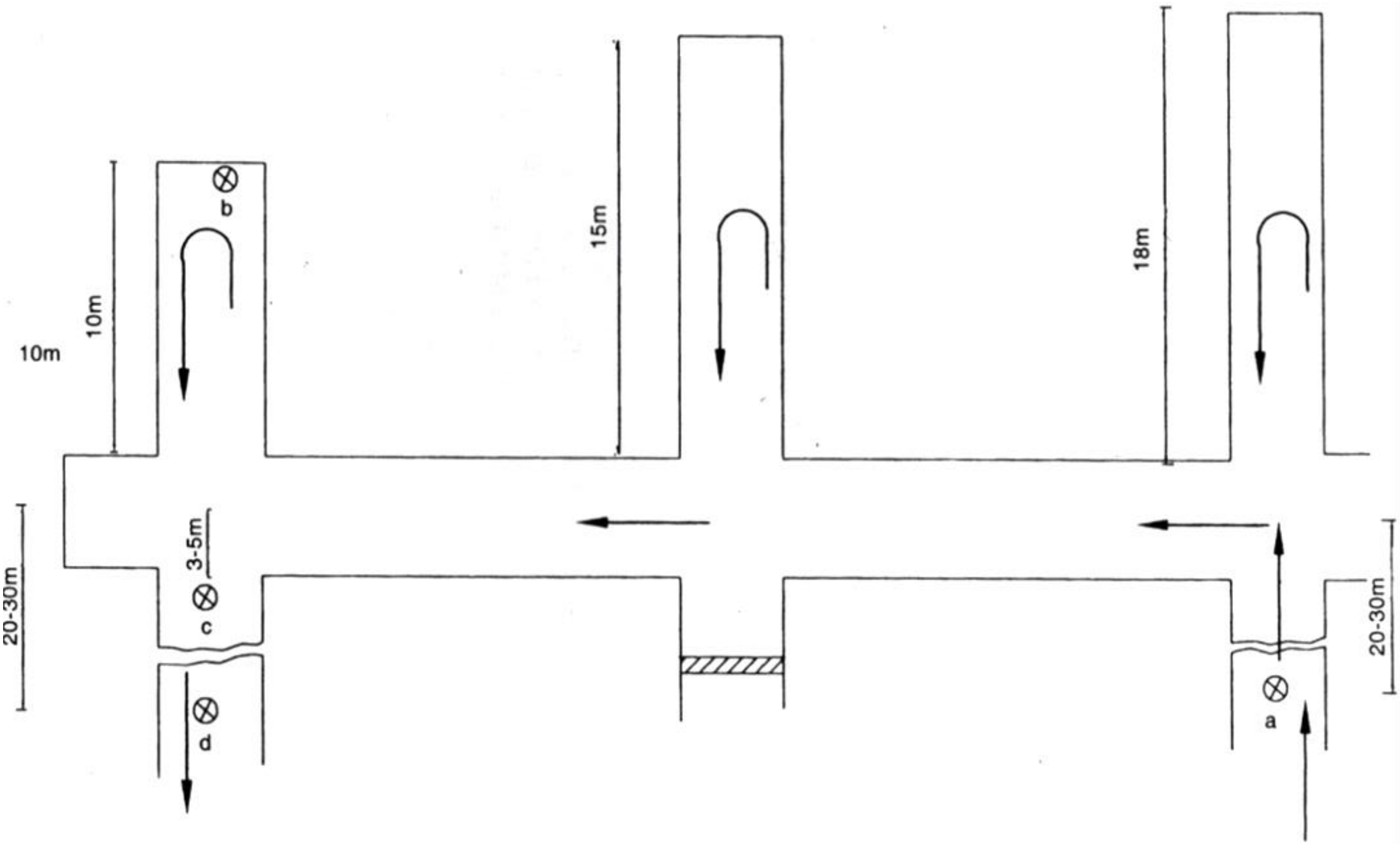


Fig. 12.13 Dust sampling locations in a bord and pillar district

Location of sampling in longwall workings:

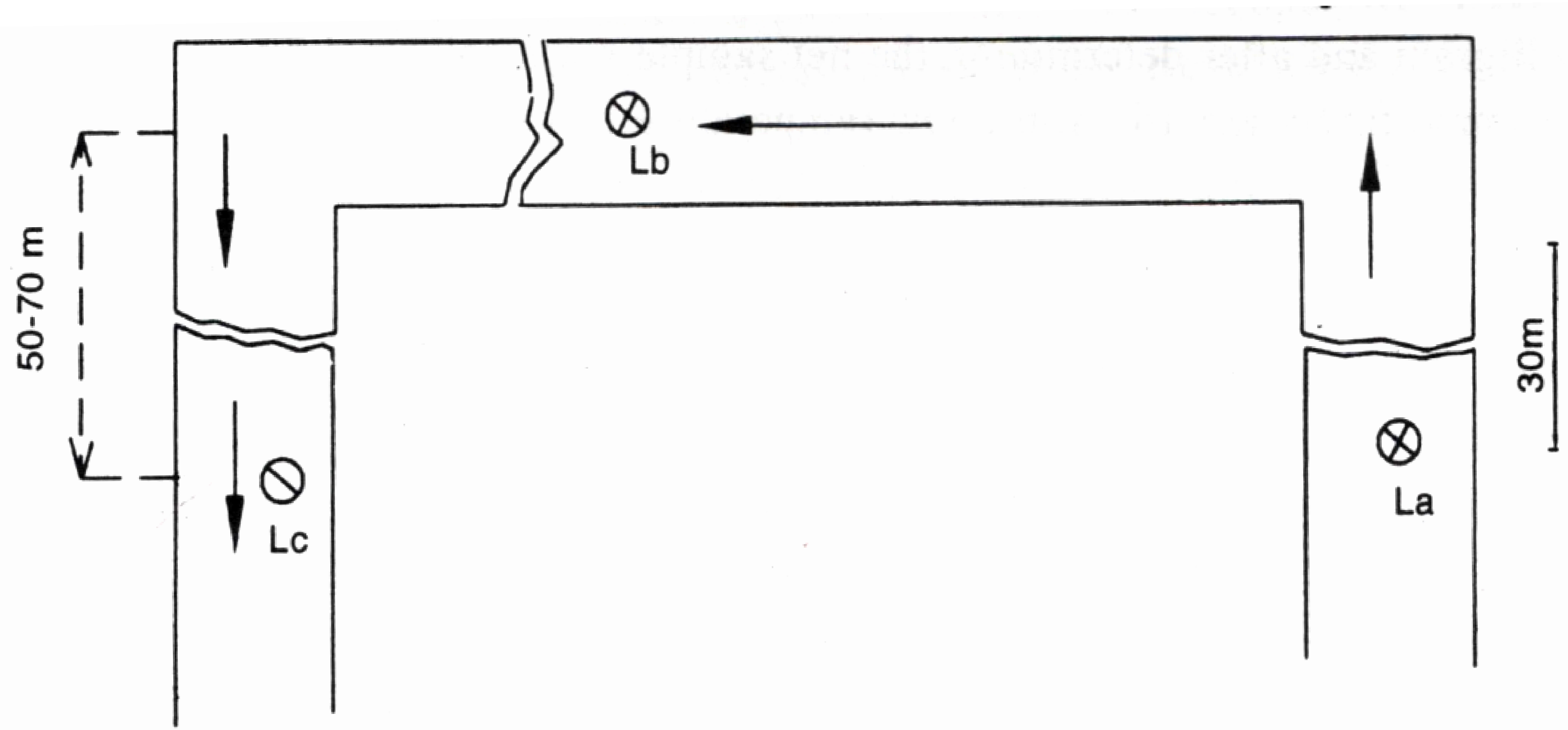


Fig. 12.14 Dust sampling locations in a longwall working

- 30m outbye of the face in the intake airway (La).
- At the centre of the face (Lb), and
- 50 to 70m outbye of the face in return airway (Lc).

Location of sampling in drivages and long headings:

- Sampling shall be done in the drivage when they are driven more than 30m or when the system of working is fully established to enable collection of a representative sample.

Location of sampling in opencast workings/surface plants:

- Samples should be taken at the working places near workers.

- In surface plants like coal handling plant (CHP), crusher house, siding and other places in processing plants where dust is generated.

In opencast workings, sampling by personal dust samplers is considered more reliable than sampling by fixed-point samplers.

Sampling time for a static sampler during a working shift is defined as the starting of the sampling instrument as soon as the first man arrives at the work place and switching of the instrument when the last man leaves the work place.

Control of Dust in Mines

- Every effort should be made to prevent the formation of dust as well as prevent it from becoming airborne at its sources.

- The following rules should be followed for prevention and suppression of dust to keep its concentration in mine air below dangerous limit:

  – Prevention of dust production: Produce minimum amount of dust at its source.

  – Prevention of dust, already formed, getting airborne.

  – Dilution and suppression of airborne dust: dilute it as soon as possible by ventilation and suppress it.

  – Separation of dust

Prevention of the dust formation

The following measures to be taken for minimizing dust formation at the sources in mines:

Drilling:

- Using sharp bits
- Applying sufficient thrust on the bit at low rotational speed and making suitable arrangement for the clearance of cuttings from the hole.

Coal cutting machines

- Machines should have sharp picks and the chain should have complete set of picks.
- Chain should not run at an excessive speed in comparison with the advance of the machine.
- Making arrangements for cleaning the gummings to avoid crushing.

Blasting

- By suitably controlling the pattern of holes and the quantity and strength of the explosive to avoid excessive fragmentation.
- The number of blasting should be kept down to the minimum.
- To confine shot-firing to relatively idle periods such as in between shifts.

Loading and Transportation

- Reducing free fall of material at the face during transport and at transfer points as far as practicable.

- The haulage system should be designed to minimize spillage of materials.

Other measures

- Keeping ore bins, chutes etc. always full to minimize dust production by free fall of mineral.

- Isolating the crushers, if installed underground, so the dust produced by them does not get into the general mine air.

- Right method of working with adequate roof control should be practiced to reduce dust production by reducing crushing of pillars.

Terrajet™ air/water atomizing air mover used in long wall operations

Terrajet (Courtesy: Terramin (Pty) Ltd., South Africa)

DUST CONTROL MEASURES IN MINES

Measures to prevent/reduce formation and dissemination of coal dust underground

- The following important measures should be adopted to reduce the formation, distribution, and accumulation of dust in mine workings

WATER INFUSION

- Water infusion of the coal face at normal (5-20 atg) or high (80-250 atg) water pressure.
- The effectiveness of coal face infusion depends on the amount of water injected and its uniform distribution in coal.
- The amount of water required varies between 8 and 10 litres per cubic meter of solid coal.

- ‘**Wet winning**’ of coal using wet pneumatic picks.

•**With machine cutting,**

- using sharp picks of suitable type,
- selecting optimal cutting traveling speeds of the machine,
- using wet-cutting.

•**During blasting** in coal

•Use of stemming cartridges of CaCl2 powder containing 82-85% CaCl2 and 15-18% water reduces dust production.

- **With conventional shearer loader**
  - using sharp picks of suitable type and pick lacing,
  - selecting suitable drum design, optimal rotational speed of drum, traveling speed of the machine and proper direction of drum rotation;
  - introducing water to the pick clearance line through hollow drum shaft
  - flushing the cutting edge of the picks from jets located either in or close to the pick boxes,
  - using external water sprays during cutting.
  - Internal water sprays with a water pressure greater than 15 kg/cm^2 have been found to be more effective than external water sprays.

- **Preventing spillage and degradation of coal during transport in roadways by**
  - Using undamaged dust tight cars
  - Avoiding overloading so that it will not spill in transit
  - Water spraying the full and empty trains during their transit.
  - Maintaining the haulage track in good condition

- **On coal conveyor roadways, reducing spillage by**
  - selecting suitable capacity conveyor as well as proper belt width and speed
  - providing adequate bunker capacity at loading points, and
  - centralizing the flow of coal.

Proper ventilation

- Restricting velocity of air current in mine airways to less than 3 m/s.
- Adopting homotropal ventilation.

- **<u>Preventing dust accumulations in mine workings by</u>**
  - Dry suction at loading and unloading points at where large quantities of dust are produced and can not be suppressed in the ordinary way.
  - Cleaning systematically and regularly main haulage roads and main return airways of dust (3 to 4 times a year) by transportable roadway suction apparatus.
  - Regularly cleaning at and near transfer and loading points.
  - Locating dry coal preparation plants far away from down cast shafts (not less than 80m)

- Selecting a method of winning with which the dust production is less.
- Controlling caving of roof coal in thick seam mining using sub-level caving method.
- Consolidating the floor dust to prevent it from being raised.

Airstream anti-dust helmet:
Respirator, safety-helmet and face protection in one product

- It is the simplest and most effective way of protecting operators from the dangers of dust and other respiratory hazards while at the same time protecting their head and face from injury.
- It incorporates a small axial-flow fan powered by a battery.
- It is a three in one headset consisting of helmet, face visor and personal dust extractor.
- Fresh air is blown across the face by the fan, after first being filtered.
- POWERED by a belt mounted battery the integral motor fan draws contaminated air through filters in the helmet. It then directs a cooling stream of clean air over the wearer’s face.
- Respirators draw contaminated air through filters with a motor fan powered by a rechargeable battery and supply clean air to the wearer's face. This avoids discomfort and fatigue caused by the effort of having to inhale air through filters permitting longer work periods for more strenuous tasks.

- For extremely contaminated or oxygen-lacking air, compressed air operated helmets are also available.