Chasing ghosts

by Paul Gardner, AAusIMM

Sir Andrew Bryan in 'The Evolution of Health and Safety in Mines' (1975) wrote:

"The health of miners has been at question since the time of Hippocrates when in his Epidemics he speaks of the metal miner as a man who breathes with difficulty"

In addition, a quotes from George Bauer, better known as Agricola, in 'De Re Metallica' published in 1566, stated:

"Some mines are so dry that they are entirely devoid of water and this dryness causes the workman even greater harm, for the dust, which is stirred and beaten up by digging, penetrates into the windpipes and lungs and produces difficulty in breathing and, the disease which the Greeks call asthma. If the dust has corrosive qualities it eats away the lungs, and implants consumption in the body. In the mines of the Carpathian Mountains women are found who have married seven husbands, all of whom this terrible consumption has carried off to a premature death."

Although the importance of providing adequate ventilating airflow in mines has been recognised for many years, and much has been done to identify and quantify the effects of inadequate ventilation, the economics of mining has often caused mine operators to reduce ventilation to 'an afterthought' and at best provide only the absolute minimum standard requirement proscribed in legislation.

During the 1900s silicosis had many names, for example 'potters rot', 'miners' asthma' and 'miners' phthisis'. Whatever the name it is typically a chronic fibrotic lung disease caused by occupational exposure to respirable crystalline silica dust, and, for which there is no known cure. Although it occurs in many industries the prevalence of occurrence is well documented in the mining industry world wide.

Silicosis is still prevalent in the mining industry of under developed countries and there is some evidence to suggest that has been all but eliminated in the mining industry of the industrial world. But is it?

Cumpston (1968) reported that one of the most common diseases in the mining field at Broken Hill in the late 1880s was plumbism (excessive absorption of lead into the system leading to lead poisoning). A local board of inquiry was appointed in 1891 but were hampered by deficiencies in the evidence. The chairman in his report stated:

"Such officials of the various mines as could be examined had often no knowledge of lead poisoning among the workman they controlled or at least would admit knowledge of only rare and occasional cases."

Cumpston also noted that there was opposition from the manager of one mine who refused to allow an inspection of his operations. 'The Great Strike' 1 of 1892 delayed the investigations and the report of the board was not published until 1893. The report concentrated on the symptoms of the disease and noted that "work is done with reluctance as well as with difficulty". Cumpston linked this statement to the strike and suggested, "Neither the mining companies nor the unions appear to have recognised that the production rate could have been influenced by the effects of lead poisoning, causing the days work to be with reluctance as well as difficulty".

Industrial hygiene was first scrutinised in Australia in 1902 and up until 1911 was investigated by numerous boards, Royal Commissions and interested physicians in all states of the Commonwealth.

In 1912 in Broken Hill a conference of medical men considered the prevalence of pneumonia that was much larger in the male population than the women. A summary of the ensuing enquiry was presented in the Australian Medical Gazette:

"The excess mortality from pneumonia at Broken Hill is almost entirely among males and chiefly among the silver miners in whose work and habits of life the cause should therefore be sought."

Investigations continued and there was belief by some that the problems related to dust disease have been eliminated, and in fact a 1914 Royal Commission concluded that pneumoconiosis was practically unknown in Broken Hill and cases that had been noted had been introduced from other states. There was some thought in later years that many cases of pneumoconiosis were masked by plumbism.

In 1918 a New South Wales Board of Trade investigation into miners' health concluded that although there was an undue mortality from pulmonary disease in the case of stone masons and sand quarry workers working on stone containing free crystalline quartz, "there was not sufficient evidence to form an opinion as to the prevalence of these diseases among miners" and the Board went on to recommend that a Technical Commission of Inquiry be constituted to ascertain the actual facts.

Consequently a Technical Commission of Inquiry was set up to investigate the extent of 'miners' phthisis' as it was then termed. This investigation saw for the first time the use of X-rays as a diagnostic tool. The first reports, published in 1920 and further reports published in 1922, recognised the prevalence of dust disease in miners. These reports preferred to use the term pneumoconiosis rather than silicosis, because it considered that other constituents of the inhaled dust modified the effects of silica.

During the late 1920s and 1930s there was a rigorous campaign undertaken to prevent dust becoming airborne. In the most part this involved the use of water and a person (offsider) was to be employed specifically to 'ply water' to the broken rock whilst it was being scraped to the chute.

In 1955 a further investigation was undertaken "because the growth in mechanisation (referring to the use of 30HP scrapers) had increased concentrations of dust in suspension in the air". Again investigations showed that dust concentrations were usually below accepted permissible limits of the time, and it was unlikely that they will constitute a hazard to health. Whilst recognising that the final criterion of the incidence of silicosis cannot be determined by dust count, but only by medical examination and since all sections of the industry are aware of the hazards of dust, and are prepared to take steps to reduce its concentrations, fixed standards were not considered to be necessary.

But contrary to this finding new atmospheric dust exposure concentrations were introduced. The recommended measuring techniques involved the use of 'spot sampling' with the Owens Konimeter and the upper limit for exposure was set at 600 particles per cubic centimetre (ppcc). This was subsequently reviewed when the Watson Konimeter became the instrument of choice and the maximum allowable concentrations of dust in air became dependant upon the silica content of the dust.

In 1959 a conference was convened in South Africa to review all aspects of the control and prevention of pneumoconiosis. Although this was the second such conference, the first being held in 1930, its significance is widely regarded as the foundation for ongoing research into occupational respiratory diseases. This conference is often referred to simply as 'The Johannesburg Conference' and recommendations from this conference have formed the basis for dust measurements and monitoring ever since. One

Dust	Concentration in particles
1. Free Silica- (a) up to 10% (b) from 10 to 50% (c) over 50%	 700 per cubic centimetre of air 400 per cubic centimetre of air 200 per cubic centimetre of air
2. Asbestos	150 per cubic centimetre of air
3. Talc	400 per cubic centimetre of air
4. Mica	400 per cubic centimetre of air

Source: (NSW Mines Inspection Act, 1901 GR 55 (65B) reprinted 1973)

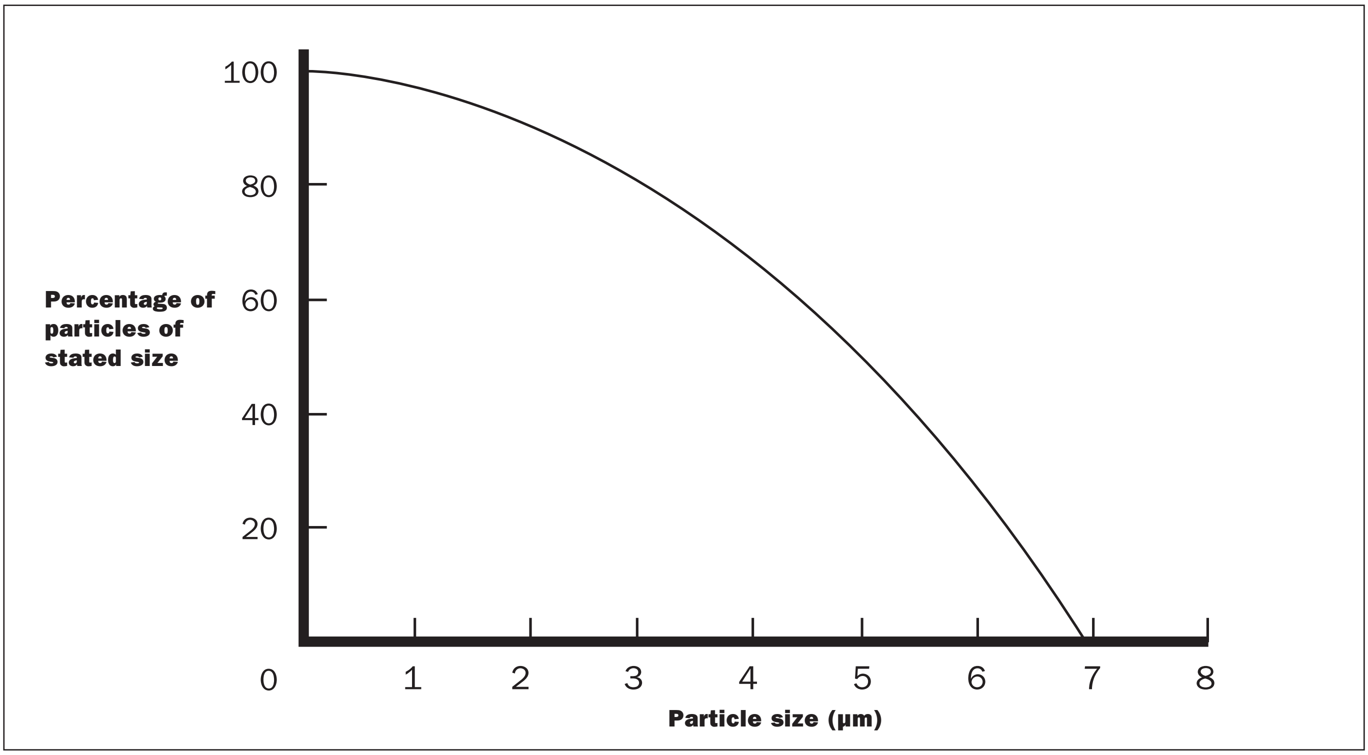

Fig. 1. The Johannesburg Curve (Reproduced from "Environmental Engineering in South African Mines." Published by The Mine Ventilation Society of South Africa. 1989. p 328)

Type Dust	Maximum Allowable Concentration
Respirable dust	5.0 milligrams per cubic metre of air
Quartz-bearing dusts	0.2 milligrams of respirable quartz per cubic metre of air
Asbestos dust: actinolite chrysotile, fibrous talc, or tremolite	1.0 fibres per millilitre of air
Asbestos dust: amosite or crocidolite	0.1 fibres per millilitre of air
Diatomite-bearing dust	1.5 milligrams of respirable diatomite per cubic metre of air
Nuisance dust	10.0 milligrams per cubic metre of air

recommendation adopted from this conference was:

"That measurements of dust in pneumoconiosis studies should relate to the 'respirable fraction' of the dust cloud, this fraction being defined by a sampling efficiency curve which depends on the falling velocity of the particles and which passes through the following points: effectively 100% efficiency at 1 micron and below, 50% efficiency at 5 microns, and zero efficiency for particles of 7 microns and upwards; all sizes refer to the equivalent diameters. (the 'equivalent diameter' of a particle is the diameter of a spherical particle of unit density having the same falling velocity in air as the particle in question.)"

A simplification of the dust deposition curve described by Hatch (1959) has since become known as 'The Johannesburg Curve'.

It was not until July 1964 that the konimeter was gazetted for use in New South Wales but by 1969 the Watson Konimeter was no longer being manufactured and the thermal precipitator became the instrument of choice. It is interesting to note that one of the recommendations of 'The First Australian Pneumoconiosis Conference' held in the same year, was to replace the Watson Konimeter with a continuous type sampler.

Although it was flagged in 1972 that the legislation requirement for dust sampling using gravimetric techniques was to be introduced, this methodology and new limits were not gazetted in New South Wales until May 1979.

The legislation did not define any frequency of sampling and there was an extensive transition period before the gravimetric sampling procedure totally replaced the konimeter. In fact the konimeter remained in use until the early 1980s before it was eventually removed from service.

Diesel powered equipment was in use in Australian underground mines as early as the 1950s, but it was not until the late 1960s that the use of diesel powered trackless equipment was introduced on any scale. In the 1970s cut and fill stoping was rapidly being replaced with the bulk mining methods of benching, sublevel and, longhole open stopes. It was during this period that trackless diesel equipment became the choice for most mines. This shift in mining technique has resulted in the large static (and predictable) ventilation circuits of yesterday becoming the dynamic and sometimes unpredictable circuits of today.

The introduction of diesel-powered equipment has introduced new atmospheric contaminants, new concerns and new legislation although diesel particulates were not new and were recognised in the 1959 Johannesburg Pneumoconiosis Conference.

Between 1989 and 1990 the New South Wales Division of Occupational Health conducted an investigation to:

"Examine the possibility of a link between exposure to diesel exhaust and the development of obstructive airways disease and emphysema".

Among other things the conclusions reached include: "there was no evidences of emphysema as a result of exposure to diesel exhaust found in this group" and that "Respiratory symptoms and impairment were predominantly associated with tobacco smoking" a view reported in many investigations before and since.

It is probable that after each investigation, some form of relaxation of standards was experienced, not by design, but by acceptance that "any problem was under control".

Much research into the effects of diesel exhaust emissions on workers was undertaken in the 1960s and 1970s and the results of this research necessitated rapid changes to existing legislation. It was difficult, almost impossible for legislators to keep abreast of the changes and as a consequence legislation has moved to duty of care and has pushed the burden of responsibility onto mine owners and operators.

As a note the first comprehensive legislation for elimination of diesel particulate matter was introduced into the USA in January 2001. There is still much debate world wide on what levels are required. Although Australia has not embraced the USA legislation the New South Wales Department of Primary Industries has issued a draft Guideline for Management of Diesel Engine Pollutants in Underground Environments (MDG29 January 2007) with Queensland soon to follow.

In Australia one published review by Wan (1999) concluded that the

Total Diagnoses Reported		
Diagnosis	**n=**	**%**
Non malignant pleural disease predominantly plaques	931	29.2
Mesothelioma	757	23.8
Non malignant pleural disease predominantly diffuse	711	22.3
Asbestosis	341	10.7
Lung Cancer	168	5.4
Asthma	80	2.5
Silicosis	80	2.5
Other (includes bronchitis, byssinosis, rhinitis, sinusitis, allergic alveolitis)	83	2.6
Inhalation Injury	35	1.1
Total	3186	

incidence of silicosis in Western Australia shows a progressively declining trend, and when the new cases still arising as a legacy of the past have all been accounted for, new incidences of this disease will have been virtually eradicated. This was in part supported by de Klerk (2006) who found that there have been no compensated cases of silicosis in Western Australia among miners first exposed to crystalline silica after introduction of the current exposure standard (0.2 mg.m3) in 1974, but in his discussion noted that the 95% confidence interval for the zero cases observed does not rule out the possibility of up to five cases per 100,000 person years under the current exposure standards.

Reviews continue and the most recent being the Australian Government Senate inquiry into Workplace Exposure to Toxic Substances (2006) who in summary, and not surprisingly, identified that:

"Many Australian Workers have suffered potentially harmful exposure to toxic dust because of poor work practices and slow response by regulators. Identifying the extent of illness related to toxic dust is difficult because the datasets are not compatible and most rely on workers' compensation data. Workers' compensation data is limited in scope as it does not record work-related illness that is of less than five days duration and does not record unsuccessful claims.

"Added to the limitations of the datasets is the impact of the long lag time for some dust related diseases to be diagnosed. This often means that disease is blamed on lifestyle factors such as smoking rather than workplace exposure to toxic dust."

Many mine operators today believe that although we operate in a potentially hazardous environment much of the hazard relating to airborne contaminants has been identified and the necessary systems put in place to eliminate or at least reduce the probability of occurrence. This belief can lead us to a culture of 'can do' on the basis that all risk has been identified, analysed and accepted. In recent times (1970s and onwards) the accepted (or residual) risk associated with many processes has in this way become 'the norm' and is seldom if ever revisited.

It can be argued that the acceptance of this residual risk is vital if we are to continue in business. The acceptance therefore becomes one of our strengths and leads us to success. Unfortunately this strength may make us successful in the business sense but may prove to be our weaknesses in the future.

History has shown us that in different studies the disease being studied was masked by another substance i.e. 1914 pneumoconiosis masked by plumbism, 1920 silicosis masked by pneumoconiosis, 1990 diesel exhaust emissions masked by tobacco smoking. Although research and investigation continues the evidence for and against still remains inconclusive and cases of emphysema, pneumoconiosis and silicosis are still being reported today.

Many of the standards that existed in years gone by have been analysed to the extent that they become outdated, modified to the extent that they are un-recognisable, or have simply disappeared into 'the norm' of acceptable risk. While some states legislate a requirement for dust monitoring, many mines collect only the minimum number of samples to satisfy this requirement. Because of this we no longer measure and therefore we are losing touch with the things that matter, (i.e. the quality of the air) and our efforts are concentrated on the legislative requirements for quantity of airflow.

Although many guidelines and standards (e.g. NOHSC, Australian Standards and state mining legislation) exist today, it is left to the mine operator to prepare the procedures under their Occupational Health and Safety Management Systems, to ensure that our duty of care is satisfied.

It is often the case on mine sites that these procedures are unwritten and have disappeared into the norm as 'common sense', and therefore should be understood by everyone. More often than not the procedures are not understood and if there is any understanding at all, it is contradictory from person to person.

In the period from 2001 up to November 2007, Surveillance of Australian Workplace Based Respiratory Events (SABRE) in New South Wales have been notified of 3017 cases with 3186 diagnoses notified - some cases have more than one condition.

Obviously this data includes all occupations in all industry but it demonstrates that silicosis is far from being eradicated.

Closing

In the early 1900s in Broken Hill workings were, back filled with dry sand, there was no means of mechanical ventilation and water was not used for suppression of dust. Mechanical ventilation was introduced in 1917, wet back fill was introduced in the late 1930s about the same time that the extensive use of hand held hoses to completely wet broken rock prior to removal was implemented.

With the introduction of mechanised mining in the 1960s and the introduction of bulk mining methods in the 1970s, dust again became an issue and suppression became the first line of defence. Water sprays at the top of stopes were employed and numerous water sprays for drawpoints and development headings were developed and used extensively. Single pass ventilation circuits were required and increased mine air volumes resulted.

In today's mines dust suppression at drawpoints and development headings has become an uncommon practice and dust is instead managed by application of water to roadways to prevent dust pickup and entrainment and by providing more ventilating air to dilute dust concentrations. With the exception of Western Australia, dust monitoring is now optional.

To the lay person, things such as chronic bronchitis, emphysema, asthma, pneumoconiosis and silicosis are all the same devil with different names. Do these devils still exist, are there new devils to be faced in the future, or am I just 'Chasing Ghosts'?

"It remains for me to speak of the ailments and accidents of miners and the methods by which they can guard against these, for we should always devote more care to maintaining our health, that we may freely perform our bodily functions, than to making profits." (Agricola, in 'De Re Metallica' published in 1566).

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