Background Information on the Efforts in South Africa to Combat Silicosis

David W Stanton, Chamber of Mines of South Africa, April 2006

1. The Chamber of Mines of South Africa (COM)

The discovery of the Main Reef Series of the Witwatersrand led to the formation of the first Chamber of Mines in 1887. This was based on individual rather than corporate membership with the aim to disseminate authoritative information about the new goldfields.

By mid-1889 the leading mining houses had become aware of the urgent necessity to replace the Chamber of Mines with an organization with wider powers, fully supported by the whole industry. The establishment on 5 October 1889 of the Witwatersrand Chamber of Mines to promote and protect the mining interests and industries of the Witwatersrand Gold Fields was the response to those needs.

The rapid expansion of mining activities soon highlighted the dangers involved and the heavy toll they could enact. In 1894 the Rand Mutual Assurance Company was established to insure mining employees against accidents suffered at work.

In 1903 the very serious dust problems in the gold mining industry were widely reported with the publication of the Report of the Miners' Phthisis Commission, 1902-1903.

With the concerns around airborne dust, the Transvaal Chamber of Mines offered substantial awards in 1903 for the best methods of allaying dust caused by machine drilling. The Chamber placed advertisements for the three best practical suggestions and devices in newspapers in the United Kingdom, Europe, Australia, South Africa and America.

Provision for hospital care and treatment of miners with phthisis was provided by the Chamber starting in 1910 at Springkell Sanitorium.

The South African Institute for Medical Research (SAIMR), initiated and largely financed by the Chamber, was established in 1913 and has since done invaluable work being of great value in maintaining the health of the mineworkers, in the prevention of certain diseases and in therapy. Dr. A. Mavrogordato (former assistant to Dr. J.S. Haldane) was a Fellow in Industrial Hygiene at the SAIMR who taught and conducted research on the control of miner's phthisis.

The Chamber established a Standing Committee on Dust Sampling in 1914. This Committee undertook the standardisation of methods for the determination of dust in mines. It carried out periodic surveys of all the mines and created a laboratory for accurately determining the samples. At the same time it embarked on a considerable programme of research work, as well as being available to test any dust preventive devices submitted to it or to the industry. The Chamber's Dust Ventilation Department would be involved in the publication of information on mine ventilation and the training of mine officials to prepare them for examinations to obtain the Chamber certificate in mine ventilation. Various anti-dust campaigns were run by the Chamber over the years including in the 1960s and early 1970s a campaign based on the cartoon character Stoffel Waterman.

The Chamber became heavily involved in working to improve mine health and safety through its committees, occupational health and safety departments, research organisations, and training departments for mine rescue, ventilation, and health and safety. The Chamber published and sponsored health and safety publications, Codes of Practice, Conference and Congress proceedings. The Chamber also fostered the development of a number of societies related to mining and housed them for many years (including the Mine Medical Officers Association (MMOA) and the Mine Ventilation Society of South Africa (MVSSA)).

2. Commissions of Inquiry and Early Legislation

It is not until the Government Mining Engineer of the Transvaal Mines Department in his report up to June 1902, introduces the subject of health of workmen that any appreciation seems to have been given to health. In his report first mention is made of "miners phthisis" as a disease "which seems to be peculiar to men employed in rock drill work". Careful enquiry at this time elicited the fact that out of the 1,177 rock drill men employed on the Rand prior to the Anglo-Boer War, 225 or 16.75 percent were known to have died from miners' phthisis. The actual number may have been greater.

2.1 Weldon 1902-1903

In 1902 the Governor of the Transvaal appointed a Commission to enquire into and report upon the prevalence and causes of the disease known as "miners' phthisis" and to make recommendations as to the preventative and curative measures which should be adopted. One result of their enquiry was that: Although the incidence of the disease appears to be more marked in miners who have been working rock drills for some years, yet it is also found to prevail amongst miners who have never worked them. The Weldon Miners Phthisis Commission of 1902-03 recommended that it will be urgently necessary to:

1. To prevent the discharge of the minute, hard, angular particles of dust already referred to into the mine atmosphere, and which are largely produced by blasting and rock drill operations.
2. To supply the working places throughout the mine with air in sufficient quantities and in such a manner as to render harmless and sweep away all vitiated atmosphere.
3. To maintain underground workings in every mine in a clean condition, and to provide for this purpose a suitable sanitary system.
4. To provide change houses, suitably warmed and within reasonable distance from each shaft, where the miners can dry and change their clothes.
5. To avoid the use of low flash point lubricants in the air cylinders of compressors, and to provide that the air intake be outside the engine house, so as to ensure a pure supply.

With regard to the "Use of Water Sprays to Allay Dust" they stated that "Analysis made of mine air has shown that the use of water, both in the form of sprays and jets, is most efficacious in allaying the dust produced by various mining operations".

It was realised that there was a need for special legislation to enforce the use of any recognised means for the prevention of silicosis. Act No. 54 of 1903, and the Mines and Works Regulations promulgated thereunder, is the first step of a long series of legislative measures to control the conduct of mines in the direction of the use of the best form of preventive measures, which continuous research in the cause and prevention of miners' phthisis showed to be desirable.

Chapter VI of the 1903 Regulations, contained four regulations on ventilation, and one reference, Chapter IX, Regulation 97(8), that the ganger shall be responsible that no person enters the working place "until the fumes caused by the explosives shall have been sufficiently dissipated".

2.2 Krause 1907-1910

Preventive Measures

In 1907 the Government of the Transvaal appointed a Commission known as the "Mining Regulations Commission" to report on the working of the Mines, Works and Machinery Regulations, with special reference to (amongst other things) ventilation and the better protection of the health and safety of persons working in mines.

The Krause Commission (1910) considered it very clear that efforts must be directed to:

(1) the prevention of dust inhalation;

(2) the prevention or removal of noxious fumes resulting from explosives;

(3) the prevention of tuberculosis

(1) The Prevention of Dust Inhalation.-The rock-driller is far more exposed to dust than any other miner. This dust is produced (a) by drilling dry holes and (b) by blasting. In dry working places it is raised again after its subsidence (a) by the air escaping from the rock-drills and (b) by the lashing or shovelling of broken rock which is not wet. Holes drilled from above downwards are usually kept filled with water, and, as work progresses, exude only mud; 'backholes' or holes drilled from below upwards, will obviously not retain water, and unless a jet or spray be played upon them, give off a continuous stream of fine dust. The chief occasions of dust inhalation are therefore (a) when the escaping air from the rock-drills raises the dust from the floor and sides of dry working places; (b) in drilling backholes; (c) on returning to the working face after blasting before the dust has had time to subside; and (d) in lashing without keeping the rock thoroughly wet.

As a result of the recommendations of this Commission the following additions to the Mining Regulations were gazetted on 24th December, 1908:

Prevention of Dust.

(5) Every place where development work is carried on and where the natural strata are not wet, and every dry and dusty stope shall be adequately supplied at all times with suitable clean water. Such supply shall be continuous, and shall be sufficient for effectively damping the broken ground and for allaying the dust caused by drilling operations.

(6) Blasting shall be so arranged that men working in other places shall be exposed as little as practicable to dust and smoke.

(7) All plant, material, and other things necessary to enable the above rules to be carried out shall be provided and maintained in working order.

146. (ii) The manger or miner in charge of workmen shall be responsible that the following provisions be observed :-

(1) No person shall in the drilling of holes use any percussion machine drill unless a water-jet or spray or other means equally efficient is provided and used so as to prevent the escape into the air of dust caused by the drilling.

(2) No person shall in any part of a mine remove any broken rock or ground if such rock or ground is in a dusty condition until it has been effectively damped so as to prevent the escape of dust into the air during removal.

(3) No person shall, after firing has taken place, whether by electricity or in any other manner, enter the place in which such firing has occurred until the fumes caused by the explosion shall have been sufficiently dissipated, unless such person is wearing an effective respirator or other apparatus to prevent the inhaling of fumes or dust.

2.3 Miners' Phthisis Prevention Committee 1912-1919

This Committee conducted extensive investigations into improved methods of dust measurement and dust control. The General Report of the Miners' Phthisis Prevention Committee (1916) made a number of recommendations for the amendment of the Mining Regulations, and these were substantially incorporated in the amendments promulgated during the year 1917. In the early part of 1911 there were eleven Mining Regulations dealing with precautions to prevent miners' phthisis and to ensure good ventilation, by 1918 there were sixty-three such regulations.

One of the amendments provided for the appointment of officials on the mines whose special duty was to examine and report to the manager on conditions in the mines which have a bearing on health, and particularly with reference to miners' phthisis. It became evident that many of these officials had an insufficient knowledge of their duties and it was therefore considered necessary to compile an abstract of the Regulations specifying their duties, containing all the Regulations referring to the prevention of miners' phthisis. The Committee prepared such an abstract and the Chamber undertook its publication.

Pamphlet for Dust Officials - Foreword (1918)

"The appointment of dust officials, with duties as specified in Regulation 161 (10), has as its broad object the greater efficiency and better control of the measures taken for the diminution and suppression of miners' phthisis. It is expected of such an official that he should promptly discover and have remedied as soon as possible any condition in the mine which is conducive to the disease, such as the existence of dusty conditions, a deficiency of the water supply, defective ventilation, or exposure of men to dust and fumes from blasting.

The Regulations contained in this pamphlet are an abstract from the Mines and Works Regulations, and include all the Regulations which fall within the sphere of duty of the dust official. If any person is found to be contravening any of these regulations, the dust official should point out the fact to him, and, if necessary, the attention of the shift boss or of a higher official should be also directed to the matter.

Some of these Regulations refer to permanent arrangements, such as those affecting the water supply, the condition of the water used, the wetting of the drives, the efficiency and adequacy of the ventilation, the suitable splitting of air currents, the conditions of fans, air-doors, and ventilating pipes, and the exposure of men to dust and fumes from blasting. When any of these are defective, immediate steps should be taken to have the matter put right.

The dust official should also periodically inspect the crusher-stations and ore-sampling rooms on the mine, and satisfy himself that proper measures are taken for the suppression of dust, and that the fans, sprays, and other appliances for the purpose are in proper order and are being utilized.

Mines employing more than 1000 persons below, one or more competent persons to be appointed, whose principle duty to be to examine and report to the manager on all matters relating to dust conditions and ventilation.

161. (10) In every mine included in the list of mines framed under section two of Act No. 19 of 1912, the manager shall, when the total number of persons employed underground on any

one shift exceeds one thousand persons, appoint one or more competent persons whose principle duty it shall be to examine and report to the manager on-

(a) all matters relating to the mine's water supply, its quality, distribution, and use:
(b) the condition of the necessary appliances for using water at each working place and elsewhere;
(c) the dust sampling of the mine;
(d) the conditions of the mine relating to ventilation and health.

The manager shall by letter notify the Inspector of mines of the person or persons so appointed from time to time, and the reports made by them shall be open to the inspection of the Inspector."

In more recent years the Leon Commission of Inquiry and the Benjamin and Greef Committee of Inquiry have made comments on dust levels in mines.

2.4 Leon 1995

Commission of Inquiry into Safety and Health in the Mining Industry

Some relevant sections are given below:

4.6.5 As a result of his own work, on the basis of dust measurements made between 1956 and 1960, Beadle concluded that there was little evidence of a decline in dust levels between 1938 and 1969. As a result of the work done by Du Toit and the unpublished review by King the Commission is of the opinion that dust levels have remained roughly the same over a period of about 50 years. This constitutes a priori evidence that the absence of a downward trend in the official figures for certification is correctly interpreted as a failure to control dust related disease.

4.6.6 It is not the role of the Commission to re-examine all the available evidence, but to form an opinion on the basis of the evidence submitted to it. No evidence was submitted to show that dust levels had decreased. It is a matter for concern that there is undue reliance on data which is now nearly 40 years old, and that the results of the many thousands of dust measurements which have been made in recent years have not been analysed and published in a form which makes it possible for experts in the field to describe the trends accurately, nor is it possible without access to the raw data to determine whether current sampling strategies and methods used to measure dust levels succeed in identifying the highest exposures accurately.

4.6.7 The data available on the time taken to acquire certifiable dust related disease indicates that although this has decreased steadily for white miners, it has not changed for black miners. The explanation for this is probably that white miners are now in supervisory positions and therefore less exposed to dust, whereas workers in the stopes are exposed to the same dust levels as in the past.

The closing submission of the National Union of Mineworkers to the Leon Commission stated with regard to Respirable Dust that An Expert Task Force on Industrial Hygiene Should Be Established to Investigate and Monitor the Respirable Dust Hazard in Underground Mining.

2.5 Benjamin and Greef 1997

Committee of Inquiry into a National Health and Safety Council in South Africa
(Report still not published by the Department of Labour)

p165

"It is now generally acknowledged that the ODMW Act's compensation system contributed significantly to the poor control of health hazards in the mining industry as noted by the Leon Commission. First, the extremely low levels of compensation paid to black mineworkers under the ODMW Act prior to 1994, and the correspondingly low compensation assessment paid by mines, meant that the compensation system contained no financial incentive for employers to tackle dust problems in the mines.

The cost of the compensation system to employers is further reduced by the fact that the State covers the cost of administering this compensation system. Second, larger mines were permitted to monitor dust levels to determine their compensation levies. In the case of small mines, the state performed this function. The method of measurement adopted (gravimetric sampling) did not provide any meaningful feedback to effectively control hazardous dust levels. The result was a system in which more was spent on determining air quality indices for mines for the purpose of calculating contributions and on anatomical pathology than on either controlling and rectifying hazardous conditions or on compensating workers. This approach has been criticised by the Department of Health, the Leon Commission and the mining employers and trade unions."

3. Dust Measurements in Mines

The first determinations of dust in mine air on the Witwatersrand were carried out for the Miners' Phthisis Commission of 1902. In 1911 the systematic determination of dust was begun by the Consolidated Gold Fields Group. The method adopted was a gravimetric one, a known quantity of mine air being drawn through a column of pure sugar, the sugar being then dissolved in distilled water, and the dust filtered off, ignited and weighed.

3.1 Changes in Dust Determination Techniques in South Africa

The main changes introduced from the beginning of dust sampling are:

Year	Method
1902	Sugar tube, all sizes weighed
1915	Sugar tube with 300 mesh screen to eliminate coarse particles
1917	Sugar tube with 350 mesh screen
1919	Kotzé konimeter and sugar tube
1923	Acid-vapour treatment of Konimeter slides and dark-field illumination
1931	Routine Konimeter results published in Government Mining Engineer Annual Reports
1935	Sugar tube sampling discontinued
1935	Casella Thermal Precipitator (TP) introduced. The TP became the research instrument against the Konimeter as the Routine instrument was checked
1949 - 1960	Kotzé Konimeters replaced by Rand Konimeters
1960's	Dust research in SA gold mines directed largely at finding a replacement for the Konimeter
1970's	Research work on respirable gravimetric dust sampling with cyclones
1980's	Routine respirable gravimetric dust sampling

3.2 Number of Samples Taken on Controlled Gold Mines

In 1916 some 10,000 sugar tube samples were taken. This figure rose steadily to about 35,000 during 1919, but came down to about 17,000 during 1936.

On Controlled Gold Mines mines the frequency of sampling has been governed by regulations for many years. The regulations stipulated that dust concentrations shall be determined not less than once in every three months of the air of every working place. In compliance with this regulation, about half a million Konimeter samples (spots) were taken

on Controlled Gold Mines per annum by Mine Ventilation Officials during routine investigations.

On Controlled Gold Mines Government Inspectors of Mines took about 20,000 to 30,000 Konimeter samples per annum during routine inspections. These results were classified into 36 different classes of places and they were published annually. From these results Dr. R.S.J. Du Toit utilized the dust levels recorded at six strategic classes of places to reveal the trend in dustiness with calendar year. The six classes of places are as follows:

(a) At the top of downcast shafts

(b) at the bottom of downcast shafts

(c) in main intake airways away from downcast shafts

(d) in stopes

(e) in development ends, and

(f) in sinking shafts

The choice was limited to these six classes of places out of a total of thirty-six for a number of reasons including the fact that these six classes of places were listed since 1931, whereas some of the thirty-six classes listed were introduced long after 1931, such as 'intake air" to stopes and "return air" from stopes.

In 1984 Dr Du Toit plotted the results of the mean of the 6 Strategic Positions up until 1983 (when the DMEA stopped publishing the Konimeter results). The graph indicated little change for the Mean concentration.

Summary of Routine Konimeter Counts at Six Strategic Classes of Places, From 1931 to 1965

Year	P.P.C.C.							
	UNDERGROUND POINTS						Total	Mean
	1	3	6	7	8	9		
1931	56	145	167	309	450	330	1,457	243
1933	50	125	148	257	335	295	1,210	202
1935	46	105	130	215	250	260	1,006	168
1937	43	90	110	178	210	225	856	143
1939	40	73	95	156	188	200	752	125
1941	40	67	85	149	183	187	711	119
1943	40	60	82	149	177	180	688	115
1945	40	60	82	149	170	180	681	114
1947	40	60	82	149	163	180	674	112
1949	40	60	82	149	155	180	666	111
1951	40	60	82	149	150	180	641	107
1953	40	60	82	149	147	180	658	110
1955	40	60	82	149	147	180	658	110
1956	30	60	82	150	150	140	620	103
1957	50	70	90	140	140	120	610	102
1958	40	60	90	150	150	140	620	102
1959	40	60	80	140	140	140	600	100
1960	30	60	80	140	140	130	560	93
1961	50	70	80	150	150	200	720	120
1962	50	80	100	150	140	120	640	107
1963	50	60	100	170	160	150	680	113
1964	50	72	90	150	154	190	715	119
1965	42	81	99	147	150	185	713	119
1966	39	78	102	160	163	121	663	111
1967	46	76	101	169	165	210	767	128

Key to columns:

1 = Top of downcast shafts. 3 = Bottom of downcast shafts.
6 = Main intake airways from downcast shafts.
7 = Stopes, working points.
8 = Development ends, working points.
9 = Sinking shafts, working points (excluding blowing over operations).

4. Occupational Exposure Limits

4.1 Early Recommended Standards

A tentative standard of 5 mg/m^3 for a sugar tube sample was put forward in the Miners' Phthisis Prevention Committee General Report of 1916. The analysis involved dissolving the sugar and use of a 260-mesh screen mounted in a funnel to eliminate particles greater than 50 microns from the suspension obtained. The Committee was fully aware that their improvement of using the 260-mesh screen was only a partial remedy for the immense discrepancy between the size of particles (say 40 microns) still entering the samples when the screen was used and the very minute size of those particle found in the lungs (average 1-2 microns, maximum about 10 microns).

The General Report indicated that the dust derived from different classes of operations varied greatly in the average size of its particles. From this the obvious inference was drawn that a comparison of weights of different samples may result in a misleading interpretation of the relative danger of the air sampled. The gravimetric method was considered to under-estimate the danger when the dust is very fine, since a low weight may be obtained from a comparatively large number of particles.

The Final report of the Miners' Phthisis Prevention Committee (Kotzé 1919) recommended a standard based on particle count using the Kotzé Konimeter. The report stated "A standard based on the number of particles can, at this stage, be based only on what is readily attainable in practice. Our results have shown that to reduce the dust, as determined by the Kotzé Konimeter, breathed by persons below 300 particles is not difficult in any operation. Anything above this is to be classified as unsatisfactory. Between 200 and 300 may be considered as fair, between 100 and 200 as good, and below 100 as very good." Particles 0.5 to 5 microns were counted under the microscope with this method.

It was pointed out that a gravimetric sugar tube sample of 1 or 2 mg/m^3 does not imply that the air is satisfactory as such air may contain up to 400 particles per c.c. as determined with the Konimeter.

In 1950 the Chamber issued a Circular dealing with the "Dust Count Technique" and stated that "Mine Managements should also be informed that the Department of Mines considers as satisfactory counts under 300 particles per c.c. treated by the ignition – immersion – ignition method." In order to ascertain the background to this figure of 300 p.p.c.c., Mr. P.H. Kitto, who was referred to in the correspondence of that time, was contacted in 1978 and to the best of his recollection could recall only that this dust count was one used as a general guideline and never set down in writing by the Mine's Department.

D.G. Beadle reported in his MVS Presidential address of 1958 that "Although no legal limit of dustiness is set in our Mining Regulations, there is the figure of 200 particles per cubic centimeter (by konimeter count) used as an "unofficial standard" by the Mines Department. I do not know the basis on which this figure was determined, and as far as I know no one has ever claimed that if all dust concentrations were kept below this level at all times, there would be no pneumoconiosis" (MVSJ Vol. 11 No. 10 1958 p200-201).

In 1968 the Chief Inspector of Mines, Witbank, forwarded a letter to the managers of all collieries under the Witbank Inspectorate. The letter stated that:

"As a guide.... if any of the operations listed below gives rise in your mine to a higher dust concentration than that shown by the relevant figure in the right hand column of the table, you are urged to seek the reason and apply whatever further dust control measures are feasible in bringing about improvements.

OPERATION	P.E.R. SI-100
Cutting............................	100
Drilling............................	35
Loading..........................	20
Return Air (from a section) ….	15
Intake Air (to a section) ……..	7
Surface ……………………….	20

In 1978 the Government Mining Engineer established a Committee on Dust Standards the terms of reference of which were: To advise the Government Mining Engineer on the subject of standards, the limits to be specified for the main types of dust encountered in mines, and works, and to spell out the procedure to be followed to prove, or demonstrate, when a standard is being violated………In this connexion it was noted that Mines and Works Regulation 10.6.6 (f), reads: "the concentration of dust shall not exceed such standard as may from time to time be specified by the Government Mining Engineer".

Dr. R.S.J. du Toit, Deputy Government Mining Engineer and Chairman of the Committee on Dust Standards at the first meeting (20th November 1978) stated that a dust concentration of 200 p/cm^3 for the type of dust produced on the W.W. Rand gold mines had been accepted by the Department of Mines as a target based on the experience, that dust with this concentration, as a standard, compensatable diseases were under control.

The concentration of 200 p/cm^3 referred to a four spot mean konimeter dust count as obtained after the normal heat and acid treatment of the slides, counting being done at a magnification of x 150 under darkfield illumination.

The Chairman mentioned that the target value in terms of Mines and Works Regulation 10.6.6. (f) for dust the respirable fraction of which contains different percentages of alpha quartz varies as shown in the following table:

Free silica content	Target concentrations
More than 20%	200 p/cm^3
10 - 20 %	300 p/cm^3
5 - 10 %	400 p/cm^3
Less than 5%	500 p/cm^3

Coal Mines: The Chairman pointed out that the current targets for coal mines, as recorded by means of the photo-electric evaluator, are given below:

Operation	Target
Cutting	100 Persi - 100.
Drilling	35 Persi - 100.
Loading	20 Persi - 100.
Return Air (from a section0	15 Persi - 100.
Intake air (to a section)	7 Persi - 100.
Surface (plant)	20 Persi - 100.

Persi - 100 = photo electric reading standard instrument 100 cm^3 sampled.

Diamond Mines: It was noted that the current target concentration for diamond mines is 500 p/cm^3.

The "unofficial standard" of 200 particles per c.c. for gold mines appears to have been used by the Government Mining Engineer from the 1950's until the Konimeter was replaced in the 1980's by respirable gravimetric dust sampling. The purpose of the Konimeter sample limit was to identify working places where dust levels are high and where remedial action is required.

4.2 Permissible Standards of Dustiness

4.2.1 U.S. Public Health Service

Public Health Bulletin No. 187, "The Health of Workers in Dusty Trades – II. Exposure to Siliceous Dust (Granite Industry)." U.S. Public Health Service, Government Printing Office, Washington, D.C., July, 1929 (p185-206)

In an investigation of granite-cutting plants conducted by the United States Public Health Service in the 1920's, most of the workers were found to be exposed to an average of about 60 million particles of dust less than 10 microns in greatest diameter per cubic foot (60 mppcf or 2000 ppcc). The dust contained about 70% silica, of which about 35%, was in the form of quartz or free silica. Under such conditions, there was an almost universal occurrence of silicosis among those exposed twenty years and longer, and a large proportion of the workers developed pulmonary tuberculosis. It was found in this investigation that little or no evidence of lung injury could be observed in workers exposed to a concentration of between 9 and 20 mppcf (300 - 700 ppcc). The report suggests within broad limits a tentative concentration of air dustiness which can be tolerated over a period of years without serious consequences.

The Chamber textbook Mining Practice on the Witwatersrand by Professor C. Biccard Jeppe published in 1946 has in Volume II an extensive chapter on Ventilation (Chapter XIV). This goes into detail on dust sampling and dust control and refers to suggested maximum safe concentrations of dust. On page 1518 it is stated:

"In 1940 Sayers suggested the following " safe limits " – " the Primary Threshold " as Cummins terms it :-

Percentage of Free Silica.	Maximum Safe Concentration of Dust.
Less than 18 per cent. ..	350-530 particles per c.c.
Less than 5 per cent. ..	1,765 particles per c.c.

Similar standards have been set by numerous other authorities."

........"Thus Cummins states : "A working lifetime of exposure to free silica is not hazardous to men with healthy lungs if the concentration of particles between 10.0 microns and 0.5 microns does not exceed a limiting value (" the Primary Threshold "). In general, a mine atmosphere is potentially dangerous at any point where the concentration of silica particles between 0.5 and 10.0 microns in size exceeds 523-700 particles per c.c. (dark field count) or 0.02 mg. of silica per cu. ft."

4.2.2 ILO Guide

In 1965 the ILO published a Guide to the Prevention and Suppression of Dust in Mining, Tunneling and Quarrying. Permissible Standards of Dustiness were reported for Australia, Canada, Poland, United Kingdom and the United States.

Australia

In New South Wales a dust concentration in a coal mine was not deemed to be safe if an average concentration in particles under 5 microns in size per cubic centimetre exceeded the appropriate value given in the following table:

Free-silica content of parent rock (including coal and oil shale)	Average dust concentration (in particles under 5 microns per cm^3) not to exceed-
Not exceeding 10%	700
Over 10% and not exceeding 20%	600
Over 20% and not exceeding 30%	500
Over 30% and not exceeding 40%	400
Over 40% and not exceeding 50%	300
Over 50%	200

Canada

Permissible limits of dustiness in Quebec, where the midget impinger was the sampling instrument used, are as follows:

Dust composition	Millions of particles per cu.ft.	Particles per c.c. (Calculated)
Above 40% silica	5	177
5-40% silica	10	353
Below 5% silica	50	1765
Asbestos	10	353

United Kingdom

Standards of approval were defined as follows:

Conditions are approved according as they comply with the standards of permissible dustiness as follows:

Nature of dust	No. of particles per cm^3
(1) For coal-dust clouds in anthracite collieries	Not more than 650 between 1.0 and 5.0 microns in size
(2) For coal-dust clouds in other collieries	not more than 850 between 1.0 and 5.0 microns in size
(3) For stone drifts and hard headings in all collieries	not more than 450 between 0.5 and 5.0 microns in size

United States

The American Conference of Governmental Industrial Hygienists has laid down the following threshold values:

Dust composition	Millions of particles per cu.ft.	Particles per cm^3 (Calculated)
Above 50% silica	5	177
5-50% silica	20	706
Below 5% silica	50	1765
Asbestos	10	353

4.3 ACGIH Threshold Limit Values (TLVs)

The Threshold Limit Values (TLVs) issued by the American Conference of Governmental Industrial Hygienists (ACGIH) have been used as guidelines in the South African mining industry. The Department of Mineral and Energy Affairs (DMEA) published in 1992 "Supporting Document No 2 List of Threshold Limit Values (TLV) under the Guidelines for the Gravimetric Sampling of Airborne Particulates for Risk Assessment in Terms of the Occupational Diseases in Mines and Works Act No. 78 of 1973. This incorporated a TLV of 0.1 mg/m^3 for Alpha Quartz based on the ACGIH TLV at that time.

ACGIH Documentation Summary for Silica, Crystalline - Quartz

TLV-TWA, 0,025 mg/m^3, respirable silica
A2 Suspected Human Carcinogen

A TLV of 0,025 mg/m^3, as respirable quartz is recommended for occupational exposure to the alpha-quartz form of crystalline silica. This value is intended to minimize the potential for development of the progressive, fibrotic lung disease, silicosis. ACGIH believes even subtle, silicosis, undetected by chest X-ray, may be a risk factor for lung cancer.

Historical ACGIH TLVs for Quartz

1946-47: MAC-TWA, 5 mppcf – high (above 50% free silica); 20 mppcf – medium (5% to 50% free silica); 50 ppcf – low (below 5% free silica)
1948-1961; TLV-TWA, 5 mppcf – high (above 50% free silica); 20 mppcf-medium (5% to 50% free silica); 50 mppcf – low (below 5% free silica)
1962-1971: TLV-TWA, 250 mppcf/(% respirable quartz + 5)
1972-1985: TLV-TWA, 300 mppcf/(% quartz + 10);
10 mg/m^3/(% respirable quartz + 2) for respirable dust; 30 mg/m^3/(% quartz + 3) for "total" dust
1986-1999: TLV-TWA, 0.1 mg/m^3, respirable dust
2000: TLV-TWA, 0.05 mg/m^3, respirable dust ; A2, Suspected Human Carcinogen
2006: TLV-TWA, 0.025 mg/m^3, respirable dust; A2 (alpha-Quartz and Cristobalite)

4.4 Current OELs for Crystalline Silica

Under the regulations for occupational hygiene (Gazette 23583, 2 July 2002) the Department of Minerals and Energy (DME) Occupational Exposure Limit (OEL) for respirable quartz was again set at 0.1 mg/m^3 but with the wording "Exposure must be kept as far below the OEL as is reasonably practicable". Under these regulations mines are required to conduct an improved sampling strategy to assess exposure to airborne pollutants. This should help focus on elevated dust exposures and the implementation of the necessary controls to reduce dust exposures.

Currently the DME are working to establish an occupational hygiene database, which will store the airborne pollutant exposure data submitted by the mines. The Inspectorate will then be able to focus on mines with high dust exposures.

The majority of countries overseas have OELs for crystalline silica at or less stringent than 0.1 mg/m^3.

In the USA the Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA) OEL for respirable quartz is 0.1 mg/m^3. The National Institute for Occupational Safety and Health (NIOSH) recommend an OEL of 0.05 mg/m^3. The ACGIH introduced their 0.025 mg/m^3 TLV in 2006. The ACGIH assigned an A2 notation (Suspected Human Carcinogen) to quartz in 2000. This is based on the International Agency for Research on Cancer (IARC) evaluation of silica: Crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1).

In 2005 Australia reduced their OEL for crystalline silica from 0.2 mg/m^3 to 0.1 mg/m^3. The UK is currently at 0.3 mg/m^3 but are planning to move in 2006 to 0.1 mg/m^3.

5. Education and Training

Mine Ventilation/ Dust Control

The need for competent, trained persons to be employed in the ventilation departments of gold mines was recognised at an early stage in the exploitation of the Witwatersrand gold fields and training schemes were introduced to satisfy this need. In June 1916, the Chamber issued a book entitled "Dust and Miners Phthisis". One object of this book, which contained details on dust prevention and measurement, was to ensure that samplers used a standard method when determining the dust content of air. After publication of this book, a series of lectures to mine dust samplers was commenced in September 1916, at the South African School of Mines and Technology. The lectures were given by J.S. Cellier, Professor of Mining at the School, and ended in January 1917. The training of ventilation officials had commenced.

The Government Mining Engineer in 1919, and again in 1923, expressed his concern at he lack of competent mine dust inspectors and requested the industry to make improvements in the station and training of these officials. The mining industry through the Chamber informed the Government Mining Engineer that it would satisfy itself that men employed as dust officials would be adequately educated in the subject of ventilation and arranged for a course of lectures for mine dust inspectors to be held at the University of the Witwatersrand between August and November 1923. The subjects covered included underground hygiene, phthisis prevention and ventilation. The lecturers were Dr. Mavrogordato and Professor Watermeyer, and at the end of the course an examination was held.

On completion of these lectures a system of monthly meetings of mine dust inspectors commenced. These meetings served as forums to educate ventilation officials and were to continue until 1927 when JP Rees commenced his duties as Ventilation Officer to the Chamber. Rees had been engaged previously on the staff of Birmingham University, U.K., and as one of his first duties he organised a series of lectures to be given to mine ventilation officials. The first series of lectures commenced in January 1928, and the last of these lectures was given in October 1947. Examples of the calculations given in these lectures were collated in book form by Rees and published in 1950. At the completion of each series an examination was held and certificates were issued to successful candidates.

J. Lawrie of the Chamber's Dust and Ventilation Laboratory visited mines in 1938 to advise mine staff on the treatment and counting of konimeter slides. This may have been the first instance of "on the job training" in mine ventilation given by a Chamber official.

The methods of examination and training of ventilation officials were reviewed during 1947 and 1948 and a new system of examinations and lectures was introduced during 1949. Examination now included a practical and written examination for an elementary certificate in dust prevention and mine ventilation, and once candidates had successfully completed these papers they could progress to the advanced certificate. These lectures were to continue until 1966. The examinations were known as the Chamber Elementary and Advanced Examinations in Mine Ventilation. The Department of Mining at the Witwatersrand Technical

College introduced a National Diploma in Mine Ventilation course in 1949 (evening classes) to assist persons studying for the above Chamber examinations. DG Beadle wrote a correspondence course in ventilation for use by the College, which was introduced in 1959. The Chamber sponsored the writing of the book but responsibility and credit were given to the MVS.

In 1964 a Chamber committee of ventilation engineers and training officers reviewed the system of training ventilation officials. As a result of the recommendations of this committee a system of centralised courses under the direction of a Ventilation Consultant and a Ventilation Training Officer commenced in 1966.

In recent years the occupational hygiene content of the Chamber examinations has been expanded by the MVS.

An employee training package called Dust Watch was developed in the early 1990's by the CSIR for the South African coal industry and included A4 size posters, employee leaflets, course handouts, a trainers guide and trainer manuals with 35 mm slide sets. The information was available in Afrikaans, English, Southern Sotho, Xhosa and Zulu.

For addition to the Silicosis Prevention Information Resources CD, the printed documentation was scanned and the text captured by OCR for layout and adjustment in Microsoft Word and printing to PDF. The 35 mm slides were scanned, redrawn and added to PowerPoint.

The Dust Watch training package is a useful starting point for anyone developing an employee training package on dust (Electronic copy prepared by D.W. Stanton). Some updating will be required with regard to references to legislation

In March 2003 Dust control courses were held in Cape Town and Johannesburg under the WHO/ILO Joint Effort on Occupational Health and Safety in Africa. The courses were based on the WHO (1999) Hazard Prevention and Control in the Work Environment: Airborne Dust document and were presented by members of the Swedish National Institute for Working Life (NIWL) and the Finish Institute of Occupational Health (FIOH). A key component of the course was the use of the PIMEX (Picture and measurement of Exposure) system whereby video clips were played back on a portable computer showing worker activity and airborne pollutant exposure. The system can be considered a key tool to assist in the control of exposure to airborne dust.

The training material was further developed for the WHO and published by the NIWL and FIOH as a 2-CD training resource on airborne dust in 2004. This 2-CD set is part of the Silicosis Prevention Information Resource.

6. Publications

The Chamber has widely published on airborne dust starting with a report on the international competition for suggestions and devises for combating the diseases known as Miners' Phthisis. The Report of Judges for the Miners' Phthisis Competition Committee was published in April 1904. In 1915 a booklet was issued by the Chamber for Mine Managers on "Appliances & Methods for Laying Dust in and about Mines" which updated information on sprays and waterblasts for laying dust in mines published by the Miners' Phthisis Prevention Committee in 1912. The booklet also included information on dust control for surface operations: main crusher stations, sample grinding and sample quartering rooms.

To work to ensure dust measurements were taken in a uniform way a booklet "Dust and Miners Phthisis" was published in 1916. The results of dust measurements taken by Chamber staff were published in the Annual Reports of the Chamber from 1914 -1950. Subsequent results from airborne dust surveys were published in reports of the research arm of the Chamber which had moved to new premises in Melville in 1951. A booklet which detailed the duties of dust officials and included all the relevant regulations for dust control was published in 1918. In 1921 an educative cinema film, prepared at the instance of the Chamber, was widely screened by the African Film Productions, Ltd. The film illustrated the various influences contributing to the incidence of miners' phthisis and the measures employed in counteracting them. An extensive textbook Gold Mining on the Witwatersrand by Professor C. Biccard Jeppe was published in 1946. Chapter XIV on Ventilation in Volume II covers 335 pages and has detailed sections dealing with airborne dust.

Subsequent Chamber publications on airborne dust measurement and control include "Quality of mine air: dust content and cooling power (1947), "Ventilation Calculations" (1950), "Quality of mine air" (1965, 1968), "Routine mine ventilation measurements" (1972), Measurements in mine ventilation control" (1982, 1988), "Intermediate Workbook for the certificate in mine environmental control" (1997) and "Workbook for the certificate in mine environmental control" (1997). The textbook "The Ventilation of South African Gold Mines" was sponsored by the Chamber and published under the Mine Ventilation Society in 1974. Mr. J.H.J Burrows, Chamber, was editor. Other MVS publications include: Mine Ventilation Notes for Beginners (Afrikaans 1971 English version 1972), Environmental Engineering in South African Gold Mines (the so-called Black Book first published in 1982), Le Roux's notes on mine environmental control (1990) and The Mine Ventilation Practitioner's Data Book (1992). The Chamber has often assisted with the costs of publishing MVS textbooks. An annual grant to assist with the publication of the Mine Ventilation Society Bulletin was made by the Chamber in 1956 and in 1957 the Monthly Bulletin changed its name to the Journal of the Mine Ventilation Society of South Africa. This journal has included hundreds of articles on airborne dust measurement and control.

The Chamber publication Measurements in mine ventilation control (1988) is now being updated under SIMRAC project SIM 04-09-03 Measurements in Mine Occupational Hygiene.

The Mine Ventilation Society of South Africa (MVS) is conducting a major update of Environmental Engineering in South African Mines (1989) which includes chapters on airborne dust and dust control.

7. Anti-Dust Campaigns

A major anti-dust campaign was initiated in 1965 through the Chamber Anti-Dust Campaign Sub-Committee and some 29,600 copies of 23 different posters were printed. Some 10,000 pamphlets on dust were printed in English and 18,000 in Afrikaans. In 1966 lecturers from various mine training centres were sent to Randfontein Estates for approximately one week to be trained on presenting lectures on dust control. In 1967 the cartoon film Dust is Dangerous was produced in colour and various recall materials were issued to remind those who have seen the film of its message. The film was launched at the Chamber Sports Club and members of several Chamber Committees were invited to attend. In addition invitations were sent to the Government Mining Engineer, District Inspectors of Mines, the Superintendent of the Government Miners' Training Schools, the Head of the Collieries Training School and the anti-dust lecturers.

The anti-dust lecturers attended a meeting before the preview when they were briefed on the use of the film and its associated follow-up materials.

Follow-up materials

The following materials were purchased for use in conjunction with the film.

Scotchlite stickers, slogan slips, banners, ashtrays with figure of Stoffel Waterman, book matches, gramophone records and key cases. The gramophone records were for use by lecturers and to be played at shaft-heads, in change houses etc.

A film was also made of an anti-dust lecture given in Fanakalo by an instructor team leader. Regular publicity was provided in The Reef magazine including articles on dust and a painting competition for children of mine employees.

Via the Chamber all lecturers were provided with copies of the ILO publication 'A Guide to the Prevention and Suppression of Dust in Mining, Quarrying and Tunnelling ' (Geneva 1965).

Prize money was awarded for anti-dust slogans.

In 1965 arrangements were made for an Anti-dust campaign on Collieries and the Sub-committee was expanded to include representatives of the collieries.

The Sub-committee of Group Ventilation Engineers had been asked to advise the Ant-Dust Campaign Sub-Committee of any internal mine anti-dust competitions or campaigns that came to its notice.

Details were provided of the propaganda campaign and competition based on dust counts in mine overseer's sections, which had been introduced at West Driefontein by the Ventilation Officer. The campaign included Newsletters and Prizes. A floating shield was presented monthly to the Mine Overseer with the lowest monthly dust count. In addition, he was presented with a beer mug. At the end of each month pamphlets recording the average dust counts taken during the month in each M.O.'s section was distributed to management and M.O.s.

Information on the above campaign was circulated to all managers for information and West Driefontein was commended on its campaign.

A Chamber Anti-Dust Campaign Poster Catalogue was published in 1968 containing examples of some 60 anti-dust posters. The Anti-Dust Campaign Sub-Committee in the catalogue encouraged managers to submit new ideas for posters.

16-mm Films

The Film Catalogue of the Chamber Mine Safety Division includes several 16-mm films on dust control:

Dust is Dangerous Colour 13 minutes.
The film shows by means of animated drawings how minute particles of silica damage lungs. The cartoon character, Stoffel Waterman, then shows the various methods used to reduce the dust hazards.

Pas op lo tayises Colour
Fanakalo version of 'Dust is Dangerous'

Pas op lo tuli Colour 36 minutes
The film is a record of an anti-dust lecture given in Fanakalo by an instructor team leader.

The Miner and Dust
Part 1 10 minutes
Part 2 10 minutes

The purpose of the film is to show the miner some of the anti-dust measures, which are under his direct control and with which he comes in contact. Produced by the Department of Mineral and Energy Affairs.

Die Mynwerker en Stofbestryding
Afrikaans version of 'The Miner and Dust'

Dust suppression in continuous miners. 20 mins
Produced for the Research Organisation of the Chamber of Mines, it discusses sources of dust in the continuous mines and methods of suppressing this dust, i.e. effective coal cutting, water sprays and proper ventilation.

Language: English, Afrikaans and Fanakalo on one tape.

8. Research

8.1 Chamber of Mines of South Africa

Initial Chamber occupational health research was on miners' phthisis and airborne dust. By 1920, some mines in the Central Reef had penetrated to 1300 m below the collar of the shaft and there was increasing awareness that the temperature and humidity of the air at these depths could affect the health and productivity of the workmen. Research led to new improved methods of acclimatisation to heat. The Applied Physiology Laboratory (A.P.L.) was established in 1950 to investigate the effects of heat on the performance of work underground. The Chamber of Mines Research Organisation (COMRO) was established in 1964 with a total staff complement of over 200. COMRO consisted of the Human Sciences Laboratory (formerly the A.P.L.), the Environmental Sciences Laboratory, the Physical Sciences Laboratory and the Mathematical Statistics Division. A great deal of research was conducted concerning environmental conditions and human heat stress. After a transitional period COMRO was officially transferred to the Council for Scientific and Industrial Research (CSIR) in 1994.

The Chamber through its Mine Safety Division organised its own Mine Safety and Health Congress in November 1987 and published the proceedings in 1988. This was reported to be the first congress held in South Africa devoted solely to the discussion of subjects related to safety and health in mining. Dr. L.R. Gardiner (Industrial Hygiene Laboratory, Chamber Research Organisation) presented a paper titled "Feasibility of Personal Gravimetric Dust Sampling for Health Hazard Assessment in the South African Mining Industry". This reviewed the Chamber research work on gravimetric airborne dust sampling over a 25-year period. It reported that the Executive Committee of the Chamber authorized in 1963 independent surveys of gold mines by a newly formed Dust Sampling Unit in order to obtain, at regular intervals, more precise information on the dust exposure of miners than was possible from routine surveys by mine ventilation departments. The Executive Committee further requested that efforts be made to devise improved instrumentation and strategies, which would provide more useful information to assess the health hazard associated with dust exposure.

8.2 National Institute for Occupational Health (NIOH)

Following a Committee of Inquiry into Pneumoconiosis and Tuberculosis in 1955 the Pneumoconiosis Research Unit (PRU) was formed in 1956 under the CSIR. The NIOH has its origins in the PRU, which was established to investigate mineworkers' lung disease. The first Director of the PRU was Dr. A.J. Orenstein who in 1956 had a staff of some 25 persons. (Dr. Orenstein became the first Vice-President of the Mine Medical Officers Association in 1921). The PRU was financed jointly by the Department of Mines and the Chamber. The PRU work focused primarily on the pathology of occupational lung disease and the dust exposure survey work was contracted out to the Corner House Laboratories (work conducted by D.G. Beadle).

With the need to investigate a broad range of occupational diseases the PRU in 1971 was expanded to become the National Research Institute for Occupational Diseases (NRIOD) under the Medical Research Council. Further expansion of occupational health activities occurred in 1979 with the formation of the National Centre for Occupational Health (NCOH) under the then Department of Health and Welfare. The research work continued but the NCOH was given an additional task of assisting industry in defining and combating its occupational health problems. In 2004 the NCOH become the NIOH under the National Health Laboratory Service (NHLS).

8.3 D.G. Beadle

The Relationship between the Amount of Dust Breathed and the Incidence of Silicosis: An Epidemiological Study of South African European Gold Miners
D.G Beadle, E. Harris and G.K. Sluis-Cremer

Paper presented at the Johannesburg Pneumoconiosis Conference 1969 (Proceedings p473-477).

The British National Coal Board made detailed studies amongst a large group of its employees of the relationship between exposure to coal dust and the development of pneumoconiosis. Work of a similar nature had been reported from German collieries. So far as was known, no similar studies had been conducted on silicosis. The desirability of making such studies amongst South African gold miners was recognised by Dr. A.J. Orenstein, first Director of the PRU, and his successors. The Rand Mines Dust Research Team (later to be part of the Corner House Laboratories) was asked to undertake this investigation under contract to the PRU. In 1966 the Chamber of mines took over the sponsorship of the project.

The fact that medical histories of all underground European workers in the gold mines, as well as details of their working histories were available, was of great importance in this connection. The main information lacking related to the average daily dust-exposure levels of different types of mining personnel. This could not be derived from the data from routine dust sampling on these mines, since this is designed to provide basis for dust control and not to reflect the exposures of personnel to dust.

Measurements were made of the amounts of dust breathed throughout their full underground shifts by approximately 650 men, chosen from 20 gold mines representative of various geographical and mining conditions. The occupations were classified into 5 main groups based on similarity of work and dust levels. The Konimeter, standard thermal precipitator and modified thermal precipitator were used to take samples.

This work showed a clear relationship between dust exposure and radiological signs of silicosis. Due to the death of Beadle progress on this project did not continue and the mass of dust exposure data collected in the occupational dust surveys was not published. However, a former assistant to Beadle at the Corner House Laboratories, R.J. Page-Shipp published the dust exposure data in 1972 in the Journal of the South African Institute of Mining and Metallurgy.

A study of dust exposure of South African white gold miners
R.J. Page-Shipp and Elizabeth Harris J SA Institute of Mining and Metallurgy August 1972 p10-24.

This paper stated that the occupational dust survey commenced in 1956, and all the samples were collected prior to 1960. Since the individuals whose medical histories were studied had commenced work either in 1936 or 1946, some assumptions with regard to their dust exposure had to me made:

It was assumed that dust conditions had not varied greatly in the year 1936-1960. This was justified by the fact that the mean dust levels reported to the Chamber of Mines had not altered appreciably in this period. The clear dose-response relationship which resulted from this study gives retrospective confirmation that this was a reasonable assumption.

It was assumed that miners doing the same type of work would be exposed to similar dust levels.

A conclusion of this paper was that:

"There is unquestionably a dose-response relationship between exposure to siliceous dust and the incidence of silicosis. There is no evidence of a lower limit of airborne dust below which the probability of contracting silicosis is zero. This does not necessarily mean that such a level does not exist."

8.4 PhD Thesis

Several PhD theses have been completed in South Africa on airborne dust and silicosis in mining and include:

- R.S.J. Du Toit - Wits 1968
  The functional relationship between dust hazard and the rate of collecting fund to pay compensation for pneumoconiosis

- P.C. Grey - UNISA 1969
  The development of the gold mining industry on the Witwatersrand 1902-1910

- P.C. Pirow - Wits 1979
  An investigation into the relationship between dust exposure and the incidence of phthisis

- R.L. Cowrie - UCT 1987
  Silicosis. Pulmonary dysfunction and respiratory symptoms in the South African Gold mines

- E.N. Katz - Wits 1990
  White Death – Silicosis (Miners' Phthisis) on the Witwatersrand Gold mines in 1886-1910

- J. Donsky - RAU 1993
  A history of silicosis on the Witwatersrand gold mines, 1910-1946

- A. Trapido - Wits 2000
  An Analysis of the Burden of Occupational Lung Disease in a Random Sample of Former Gold Mineworkers in the Libode District of the Eastern Cape

- R.E.G. Rendall - Wits (submitted 1999 but not yet awarded)
  The Nature of Dusts in the Air of Gold Mines and Foundries and the Risk of Silicosis

8.4.1 I.J. Donsky

A History of Silicosis on the Witwatersrand Gold Mines, 1910-1946, RAU 1993

Chapter 4 - The Prevention of Silicosis states that the problem of silicosis could be categorised into successive time slots of:

- Ignorance (Before 1902)
- Awareness (1902)
- Investigation (1902 onwards)
- Control and Prevention (1911-1919)

Between the 1920's and 1940's preventative controls were being carefully monitored, but now the emphasis had shifted more towards compensation for silicosis sufferers, and the question of prevention played a minor role towards the silicosis problem.

A detailed account of the Prevention of Silicosis 1910-1946 has been provided in this thesis. Much of the information was gathered at the Library of the Chamber of Mines of South Africa.

8.4.2 A. Trapido

An Analysis of the Burden of Occupational Lung Disease in a Random Sample of Former Gold Mineworkers in the Libode District of the Eastern Cape
Wits 2000 PhD Thesis

Chapter 5 Dust and Occupational Diseases in the South African Gold Mining Industry

P87
TLV standards have been criticized for several reasons. First, section 4.14.1 of the regulations of the Mine Health and Safety Act, Act 29, 1996, which was brought forward from the Minerals Act, Act 50, 1991, which was in turn, brought forward from the Mines and Works Act, Act 27, 1956 (variously amended), restricts underground risk work to 48 hours per week plus 60 minutes daily travelling time rather than 40 hours on which the TLV is based.

Secondly, TLV international standards are based on a normal respiration rate rather than on the increased respiration rate that is associated with extremes of depth (and associated heat) of the South African gold mines. The depth and heat is likely to cause an increase in the ventilation requirements of South African gold mineworkers for any given work load. And places them at a further disadvantage vis a vis other hard rock miners working at lesser depth. Consequently, the TLV formula fails to adequately protect South African mineworkers.

Chapter 5.5 Conclusion

This chapter has shown that there is a high silica content in the reef formation of the Witwatersrand gold fields and that there are high prevalences and incidences of occupational lung diseases which result from the inhalation of silica dust. This chapter makes it clear that while South Africa has had a gold mining industry for over a century and whereas legislated dust management mechanisms and regulations have been in place for most of that time, the prevalence of silicosis, tuberculosis and COPD presented above, indicate that neither past nor present practices are safe.

Previous legislation has been criticized for its artificial separation of occupational hygiene surveillance from the surveillance of occupational disease. This has lead to a culture within the South African Mining Industry which has concentrated on monitoring dust levels rather than monitoring disease prevalence and finding engineering solutions to reduce dust levels.

8.4.3 R.E.G. Rendall

R.E.G. Rendall at the NCOH had a desire to re-examine and re-analyse the data generated by Beadle and his colleagues and used this research as the basis for a PhD thesis to be submitted to the University of the Witwatersrand. Rendall reviewed mine and foundry dust exposure surveys conducted in South Africa and converted the Beadle particle count data to mg/m^3. He conducted additional airborne dust surveys in Foundries to compare the risk of silicosis in mines with that in foundries.

The Nature of Dusts in the Air of Gold Mines and Foundries and the Risk of Silicosis
R.E.G. Rendall – PhD Thesis

R.E.G. Rendall died in 1995 and the thesis was completed by Dr. D.W. Stanton and Dr. R.S.J. Du Toit on behalf of R.E.G. Rendall. It was submitted to the University of the Witwatersrand in 1999. Two of the three external examiners accepted that the award of PhD be given to R.E.G. Rendall but a third requested further statistical analysis. As the PhD thesis was submitted posthumously this could not be carried out.

Thesis Conclusions

If either dust, or quartz, is chosen as the independent variable, then small doses of mine dust give rise to higher rates of silicosis than the same dose of foundry dust i.e. mine dust is more harmful by inhalation, weight for weight than foundry dust.

There is evidence that the airborne dust in mines is more toxic than that in foundries.

If an ILO radiological classification of 1/0 is accepted as denoting silicosis in a person then a 1% Risk of Silicosis will be associated with a dust exposure of 4,2 mg/m^3 x years in mines and 9,4 mg/m^3 x years in foundries and a quartz exposure of 0,97 mg/m^3 x years in mines and 1,10 mg/m^3 x years in foundries.

The data suggests that there is a dust exposure below which the risk of silicosis is negligible.

As an example from the above if an underground worker spent ten years at the DME OEL level of 0.1 mg/m^3 for respirable quartz (1 mg/m^3 x years) he would have a 1% Risk of Silicosis. Rendall calculated that a 5% Risk of Silicosis would be associated with a quartz exposure of 1,46 mg/m^3 x years in mines (i.e. 15 years at 0.1 mg/m^3) and 1,73 mg/m^3 in foundries.

8.5 Safety in Mines Research Advisory Committee (SIMRAC)

The Safety in Mines Research Advisory Committee (SIMRAC) was established in 1992 under the Minerals Act, (Act 50 of 1991) with the principal objective of advising the Mine Health and Safety Council on the determination of the safety risk on mines, and the need for research into safety on mines based on the safety risk.

SIMRAC identifies research projects to address and reduce safety risks on mines, and determines the cost and priorities of projects, concludes agreements for carrying out projects, imposes a levy to fund research, monitors the progress on these projects and communicates research results to all stakeholders.

Since 1995, SIMRAC has been constituted on a tripartite basis with employers, employees and regulatory authorities represented on all committees. This tripartite structure follows the recommendations of the Leon Commission of Inquiry into safety and health in the mining industry. The report highlighted the fact that efforts to improve health and safety in the workplace are most effective when cognizance is taken of the needs of all the affected parties. The SIMRAC Subcommittee SIMHEALTH was established in 1999 to deal with occupational health matters. A wide variety of occupational health projects were enacted through this committee including the preparation of a Handbook of Occupational Health Practice in the South African Mining Industry (2001). SIMHEALTH was replaced in 2002 by the Mining Occupational Health Research Advisory Committee (MOHRAC) under the Mining Occupational Health Advisory Committee (MOHAC). MOHRAC was replaced in 2004 by the Occupational Health Technical Advisory Committee (OHTAC) under SIMRAC.

The SIMRAC administrative and secretarial functions were initially undertaken by Chamber employees in terms of an agreement between the Government Mining Engineer and the Chamber. SIMRAC project support services relocated in 1998 to new offices to ensure impartiality.

Several SIMRAC projects have addressed dust measurement and dust suppression.

8.5.1 Coal Research

Initial SIMRAC research on airborne dust focused on reducing exposures to coal dust starting with COL 027 Reduction of worker exposure to dust in collieries (1996). COL 027 research was conducted by Miningtek, CSIR, and steered by a Special Interest Group on Dust Suppression (SIGDS). A SIMRAC handbook was produced to reduce the exposure of workers. Several COL research reports followed.

The SIMRAC reports on dust measurement, dust control and respiratory disease are available via the SIMRAC page of the Silicosis Prevention Information Resources CD.

8.5.2 SIMRISK 401 (1997)

Exposure data for airborne dust in South African mines is presented in SIMRAC Report SIMRISK 401 and includes data from the DME dust exposure database. It was stated that despite the availability of a comprehensive airborne dust database, there is considerable uncertainty on the exposure of mineworkers to dust. The reliability of the sampling equipment used and the strategies used by mines for dust monitoring have been called into serious question with a strong suspicion that dust levels may be substantially under-reported.

8.5.3 SIMRAC Occupational Health Handbook (2001)

Chapter 5: Occupational Lung Disease - Prof. Neil White

"Beadle believed that there was little evidence of any improvement in dust exposure levels in the years between 1938 and 1969. This finding still has relevance. In 1995 the Leon Commission concluded that there had been little significant change in dust exposure in South African gold mines for fifty years. In 1999 the National Centre for Occupational Health published data based on 26 000 underground dust measurements in 48 South African Gold mines from 1995 - 1997. Only 8 (17%) of these mines had all of their estimated time weight average (TWA) measurements for respirable quartz below the DME's standard of 0.1 mg/m^3. Of the remainder 21 mines (43%) had a high proportion of dust measurements in the range 0.1 - 0.4 mg/m^3, whilst 19 (40%) had most of their measurements above 0.4 mg/m^3."

8.5.4 SIMHEALTH 606 (2003)

Silicosis prevalence and exposure response relationships in older black mineworkers on a South African goldmine.

The setting was a goldmine in the Northwest Province where a sample of 520 mineworkers underwent medical examinations, including a questionnaire and chest x-ray. Amongst these 520 men, 85 different occupations were represented. Cumulative dust exposures were calculated for each individual by incorporating all jobs worked by an individual on the mine and a time weighted average (TWA) respirable dust and quartz concentration assigned to each job. The assumption was made that current dust concentrations are a reasonable proxy for average dust concentrations experienced in those jobs over the previous three decades, and similarly for average quartz fractions. All the workers in the sample were reported to have worked at an average exposure to quartz below the current OEL of 0.1 mg/m^3.

The report conclusions were that:

- Using ILO profusion ≥1/0 as the definition of silicosis, the prevalence was 23.9 percent. Using the ILO profusion ≥1/1 as the cut point, the prevalence of silicosis was 18.3 percent.

- Almost one in five of these older, longer service black mineworkers had developed silicosis, despite having worked for an average of 22 years with average quartz concentrations under the OEL.

- Allowing for the fact that the sample in this study was chosen to represent older mineworkers, if one extrapolates these results to the goldmining industry in general, they confirm the existence of a significant epidemic of silicosis in the industry.

- The findings support the conclusion of Hnizdo and Sluis-Cremer ten years ago in 1993 as well as international practice, that a reduction of the OEL from 0.1 mg/m^3 is indicated to substantially reduce the risk of silicosis. Both that study and the current one suggest that a reduction to at least 0.05 mg/m^3 will be necessary to substantially reduce the risk of silicosis.

8.5.5 SIM 03-06-03

In 2002 SIMRAC established a long-term project to eliminate silicosis in the South African Mining industry (SIM 02-06-03). The project team for Phase 1 of this project to scope the Phase 2 work included two Chamber staff, Dr. D.W. Stanton and Dr. C. Mbekeni and a member from the Department of Minerals and Energy, Mr. D. Rowe. As part of this project regional workshops on silicosis elimination were held in 2002/03 and a National Workshop in 2003. Recommendations from the workshops were published on the Internet at http://silicosis.sheafrica.info. This web site includes links to information on silicosis from around the world. The SIMRAC Silicosis Elimination Programme Phase 2 (SIM 03-06-03) was launched in 2005 and consists of three tracks:

Track A: Dust Measurement and Analysis (Track Leader: NIOH)
Track B: Dust Control (Track Leader: CSIR)
Track C: Silicosis Prevention Awareness (Track Leader: NIOH)

A Silicosis Prevention Information Resource prepared by Dr. D.W. Stanton, Chamber, will be made available under Track C. This includes a Best Practice Booklet on Silicosis Prevention with supporting CDs and DVDs containing training material, silicosis prevention information and videos.

9. International Conferences on Pneumoconiosis and Related

The Chamber assisted with a number of International Conferences in South Africa on pneumoconiosis and related. The landmark International Labour Office (ILO) Conference on Silicosis held in Johannesburg in 1930 was sponsored by the Chamber who also provided the staff to support the ILO Conference secretariat. This conference dealt predominantly with the medical aspects of silicosis. Following on from this, subsequent ILO conferences were held in Geneva (1938), Sydney (1950), Bucharest (1971), Caracas (1978), Bochum (1983), Pittsburgh (1988), Prague (1992) and Kyoto (1997). The 10th International Conference on Occupational Respiratory Diseases (10th ICORD), was held in Beijing, China in 2005.

Following the formation of the PRU in 1956 scientists from many countries were invited to Johannesburg to advise the PRU research team on the best evolution of their research projects. This resulted in the second International Conference on Pneumoconiosis held in South Africa in 1959. The Conference Rapporteurs on Dust/ Engineering were from the mining industry (Mr. D.G. Beadle) and the Chamber (Mr. P.H.Kitto, Director, Dust and Ventilation Laboratory). Several papers were presented on dust measurement and control including papers on "Sources of Dust and Methods of Prevention", "Sources of Dust in Mines and Methods of Prevention at Source", "Behaviour of Mine Dust after Formation", "Methods of Controlling Dust after it has been Formed", and "Methods of Lessening Exposure to Dust".

Modern principles of dust sampling for hazard assessment are founded on three main recommendations adopted at the 1959 Conference in Johannesburg which have remained largely unchanged to the present day:

(i) measurement of the respirable dust fraction
(ii) gravimetric assessment of the collected dust
(iii) long period sampling to give average dust levels over a shift.

The third International Conference on Pneumoconiosis was held in Johannesburg in 1969. The Chamber was one of the Conference sponsors and P.H. Kitto, Chamber, was responsible for the Dust Physics sessions and was Chairman of the Symposium on the Engineering Aspects of Pneumoconiosis.

The first International Conference on Mine Ventilation was held in Johannesburg in 1975 and was organised by the Mine Ventilation Society of South Africa. The Chamber sponsored the Conference and Mr. J. Burrows, Chamber, was Chairman of the Organising Committee. The Conference was to enable ventilation engineers, mining engineers, academics, government representatives and others to gather together and to discuss their problems and to find solutions. An International Committee was established with Burrows as the Chairman with the primary assignment of arranging a similar congress to be held every four years. The second International Mine Ventilation Congress was held in Reno, Nevada, USA in 1979. The Chamber was represented on the International Committee through J. Burrows. The 5th International Mine Ventilation Congress was again hosted in South Africa in 1992.

International Occupational Hygiene Association (IOHA) 6th International Scientific Conference, Pilanesberg, South Africa

The International Occupational Hygiene Association 6th International Scientific Conference was held in South Africa on the 19-23 September 2005 and included sessions on silicosis. The Chamber sponsored in 2003 the Initial Announcement for this Conference and Dr. D.W. Stanton, Chamber, was Chairman of the Conference Organising Committee.

10. Global Programme for the Elimination of Silicosis

In 1995 the International Labour Organization (ILO) and the World Health Organization (WHO) Joint Committee on Occupational Health launched a Global Programme for the Elimination of Silicosis from the world by 2030. Positive experience gained by many countries shows that it is possible to significantly reduce the incidence of silicosis by using appropriate technologies and methods of dust control. It is strongly believed that the goal of the global elimination of silicosis is realistic and can be achieved through effective prevention through:

- Enforcement of laws and regulations
- Health education and training
- Cooperation between employers and workers
- Establishment of OELs and technical standards
- Surveillance of the working environment
- Compliance with OELs and technical standards
- Surveillance of workers health
- Application of appropriate technologies
- Use of engineering methods of dust control
- Use of PPE

There is a need for political will, motivation and commitment as well as collaboration at national and international level. This should involve individuals, institutions and governments.

It is considered that the disease is shame for those who have decision making opportunities to eliminate silicosis but do not do it.

11. Milestones Set for Silicosis Elimination in Mining, South Africa

At the Mine Health and Safety Summit on the 24th October 2003 the Minister of Minerals and Energy, Phumzile Mlambo-Ngcuka, stated that further improvements were needed in health and safety in the South African mining sector, with Silicosis a major concern. The Summit agreed that milestones for the eradication of silicosis needed to be set. The agreed milestones are:

> By the year 2008, 95% of all exposure measurements results will be below the occupational exposure limit (OEL) for respirable crystalline silica of 0.1 mg/m^3. These results are individual readings and not averaged results.
>
> From the year 2013, using present diagnostic techniques, no new cases of silicosis will occur among previously unexposed individuals.

To address the OHS milestones, a Chamber OHS Summit was held on the 15th June 2005 with the theme Achieving the 'Unachievable'. South Africa's major mining companies signed a commitment to achieve the sectors agreed OHS targets for zero accidents and injuries and the elimination of silicosis and noise induced hearing loss.

12. National Programme for the Elimination of Silicosis

The Advisory Council for Occupational Health and Safety (ACOHS) identified silicosis as an important occupational disease in South Africa that should be prevented and an occupational disease placing a large burden on the Compensation Fund. ACOHS decided that the Department of Labour as a lead agent in occupational health and safety should develop a National Programme for the Elimination of Silicosis (NPES). Other driving forces for a NPES include the ILO/WHO Global Programme on the Elimination of Silicosis and the Southern African Development Community (SADC) silicosis survey of member countries.

The Minister of Labour, Mr. Membathisi Mdladlana, officially launched the National Programme for the Elimination of Silicosis in South Africa (NPES) on the 28th June 2004. The Department of Labour has established a National Working Group to develop and manage the NPES. The National Working Group consists of the major role players namely government (including representation from the Department of Minerals and Energy), organised labour, organised business and interested and affected parties.

The Department of Labour in their booklet titled "National Programme for the Elimination of Silicosis" issued at the launch of the NPES (2004) states that "Silicosis rates in former gold miners now living in labour-sending areas illustrate the importance of silicosis in the region. Steen and co-workers found a silicosis prevalence of 26 to 31% in former miners living in Thamanga village, Botswana, and Trapido et al. 22-37% in Libode, Eastern Cape, South Africa. Generalising these rates to an estimated two million former miners living in Southern Africa produces an astonishing 480 000 cases of pneumoconiosis. If silicosis were an innocuous disease these high rates would not be of great concern, but the strong association between silicosis and tuberculosis in South Africa combined with the HIV epidemic, makes the situation alarming. Cowie found an increasing incidence of tuberculosis with increasing severity of silicosis in South African gold miners: 1% per annum in men without silicosis; 2.2% in men with mild silicosis; 2.9% with moderate silicosis; and 6.3% with advanced silicosis. Cowie suggested that one quarter of his subjects with silicosis would have developed tuberculosis by 60 years of age. This was before the surge in the HIV epidemic. In addition, the International Agency for Research on Cancer (IARC) has classified silica dust as a cancer causing agent in humans".

The NWG met monthly in each province in 2004/5 to hold Provincial Workshops and establish Provincial Working Groups (PWGs) for the elimination of silicosis. PWGs have been established in all nine provinces. Because of the extent of industry in Gauteng, this province has two PWGs (North and South).

Duties of the PWGs include the development of provincial profiles to identify the number of workplaces with exposure to airborne respirable crystalline silica and to establish awareness campaigns to minimise exposure to airborne respirable crystalline silica.

Objectives of the NWG include:

- to develop the National Programme for the Elimination of Silicosis (NPES),
- ensure that the NPES is implemented,
- ensure adequate consultation on the development and implementation of the NPES,
- open up channels of communication between the NPES and stakeholders,
- monitor progress in the implementation and achievements of the NPES,
- provide advice and direction in the implementation of the NPES,
- identify stakeholders and provide training where needed,
- comment on documents submitted by stakeholders,
- provide input and guidance on future campaigns to eliminate occupational lung disease,
- facilitate coordination, monitoring and evaluation of joint campaigns,
- deal with any other matter ACOHS may delegate to it.

What has been done So Far by the NWG?

- Developed a Work Plan that Guided the NWG Towards the Launch of the NPES
- Produced an Information Brochure on the NPES
- Produced a booklet "What you should know about Silicosis?"
- Produced a Poster on Silicosis
- Developed the NPES
- Organised the Launch and had the NPES launched by the Minister of Labour
- Silicosis elimination workshops held in each province
- Established Provincial Working Groups (PWGs) in each province.
- The South African NPES is now part of the ILO/WHO Global Programme for the Elimination of Silicosis and will interact and collaborate with the global programme.
- Prepared a draft budget for the NPES
- Prepared a draft proposal with budget for an administrative centre and staff dedicated on a full-time basis to the NPES.
- National workshop on silicosis held in 2005.
- Secured funding through the DoL for a national profile on silicosis to be developed.

13. Further Information

See also Some Landmark Dates in South Africa With Regard to the Control of Silicosis (1886-2005), the Chamber section and the Historical section of the Topic Index on the Silicosis Prevention Information Resources CD.