THE ACHIEVEMENTS IN DUST-CONTROL AND DUSTPROOF MEASURES TAKEN SINCE THE FOUNDING OF THE PEOPLE'S REPUBLIC OF CHINA

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Mr. Chairman and fellow delegates,

At the invitation of the International Labour Office, the Chinese trade union has been offered the opportunity to be able to attend the VIIth International Pneumoconioses Conference. Therefore, I would like first of all to thank the ILO for its kind invitation. It is my wish, Mr. Chairman, to address the Conference on our efforts to control dust in China for the purpose of promoting mutual understanding, exchanging information and experience in the course of this Conference.

THE ACHIEVEMENTS MADE IN CHINA IN THE DUST-CONTROL WORK

With regard to dust harm affecting our country, we insist on priorities given to the preventive measures against dust harm and apply the principle of three-stage prevention namely, at the first stage, to eliminate dust harm and control dust sources; at the second stage, to provide check-up regularly to ensure the early diagnosis of diseases; at the third stage, to make sure that diseases are controlled and treated at a possible early stage. The stress is placed upon the first stage prevention when applying the above-mentioned principle.

To apply this principle, the state, with the active participation of our trade unions, has formulated in the last thirty-odd years a series of laws, decrees, instruments and standards. In 1956, "The Safety and Health Regulations at Workplaces" was promulgated and applied following which, "The Resolution on the Prevention of Silicon Dust Hazards at Workplaces" was published. Then "101-56 Standard"—health design standards on dust concentration—was set by the state, based upon which the maximum allowable concentration (MAC) of the dust is set to 2mg/m^3 if free silicon dioxide content is greater than ten percent in the dust and MAC is set to 10mg/m^3 if less than ten percent. In 1958, the relevant departments issued "The Provisional Regulations on the Technological Measures Against Silicon Dust Hazards at Workplaces," illustrating demands on the practice to control dust. In 1962, the state formally promulgated "The Health Design Standards on the Industrial Enterprises," prescribing in detail the provisions on ventilation and dust sources control at the workshops. In 1979, that Standard was revised. In 1963, "The Managerial Measures against Silicon Dust Hazard" was put into practice on a trial basis in our country, thus making our work on dust-control even more systematic. Therefore, these laws, decrees and standards have constituted a very important guarantee for the prevention and treatment of pneumoconiosis. Particularly, in recent years, the State Council, taking into account new problems arising from the economic reform of our country, has made "the Decision on Strengthening the Work of Preventing Dust and Toxicant and Pneumoconiosis," thus pushing the dust-control work further.

Positive steps have been taken in China actively by various industries, enterprises and relevant departments in accordance with the state's laws, decrees and regulations. Three nationwide working conferences on dust-control were held in 1957, 1962 and 1985 respectively, summarizing and spreading afterwards the experience on dust-control throughout the country. In the field of dust-control, we focus our attention on our own efforts by taking such comprehensive measures against dust as: to transform old enterprises; to improve technology and regenerate equipment. Of many years in China, we have found out a number of ways of our own to prevent and treat pneumoconiosis, i.e. mechanical ventilation; wet-operation; dust-sealing; personal protection; maintenance and management of dustproof installations; technological innovation and improvement of technology; regular check-up for the workers exposed to dust; propaganda and education on dust-control. This comprehensive measure against dust has been proved by the fact to be a successful experience suitable to China's situation. And we have already achieved tangible results. According to the statistics collected from 16 key refractory factories, the average working age to acquire silicosis in the 1950s was 7.55 years; in the 1960s 14.52 years; in the 1970s 20.73 years; at the early stage of the 1980s it was 25.89 years. There has been a big reduction in the dust concentration in factories. Various steps have been taken to control dust in all industries in accordance with their own industrial features and experience. Take coal mining for example. A whole series of effective measures against dust has already been taken as follows:

1. Wet-drilling;
2. Coal seam infusion to increase moisture content;
3. Making use of "water stemming" i.e. to suppress dust by incompressibility and vaporization of water at exposure;
4. Spraying to minimize dust in the course of transportation and blast loading;
5. Mechanical ventilation, dust suppression by water mist and purification of airflow;
6. Replacing dry-mix shotcreting with wet-mix shotcreting;
7. Cleaning the fallen dust in the tunnels, on the rock sidewalls, support and road so as to prevent dust from floating again.

Sucun Coalmine of the Xinwen Coal Mining Management Bureau in Shandong province, well-known for its dust-control work throughout our country, has taken nothing but the above-mentioned measures. By so doing, up to now, none of the miners employed in 1959 has suffered from pneumoconiosis.

In our country, great importance has been attached to training and scientific research in this respect. So far there are more than twenty universities and colleges where departments or specialities of safety and health have been set up; there are thirty-one research institutions with more than four thousand research fellows all over China.

THE PRESENT COUNTER-MEASURES AGAINST DUST IN CHINA AND THE ROLE OF THE TRADE UNIONS

Being a developing country, in the last thirty-odd years since the founding of the People's Republic of China, tremendous work has been done in the field of prevention and treatment of pneumoconiosis and fairly great progress made. However, as is known, the occurrence of pneumoconiosis is closely related to the development of the industrial modernization. China is now undergoing the primary stage of socialism under which, except some modern industries, a large number of our industries still remain quite backward, falling behind those modern levels for several decades or even a hundred years. In recent years, there has been a big boom of rural enterprises. The mode of production in most of those rural enterprises is fairly backward. Apart from that, our management and technical levels on dust-control for the time being remain quite backward on the one hand, and on the other, the level of science, technology and culture of our workers as a whole is not high enough. This is the situation in our country under which dust harm still remains very serious and pneumoconiosis can not be controlled yet. Therefore, we are still faced with a very arduous task. I think that almost all the developed countries in the process of their industrialization have gone through this dust-harm stricken period, longer or shorter, respectively. And this seems to be one of the common features of all the countries to prevent and treat pneumoconiosis. The crux of the problem lies in how we should, proceeding from our own situation, draw lessons from other countries so as to shorten this dust-harm stricken period.

- First, the government has promulgated "The Regulations on the Prevention and Treatment of Pneumoconiosis" and inspects the application of the Regulations in enterprises of different economic forms;

- Second, it is stipulated by our government that for the newly-built, extended, rebuilt, on-going projects or those projects introduced from abroad, the dustproof installations must be designed, constructed and operated simultaneously with the principal part of those projects mentioned above. The state departments responsible for labour, health and environment protection as well as the trade unions have the rights to examine, check and approve the projects. Without the signatures of the above-mentioned organizations, the projects can never be put into operation, thus to ensure that new dust sources will never be produced again;

- Third, a great importance is attached to the research on the dust-free or dust-reducing techniques as well as new anti-dust technique. In the course of our Seven-Five-Year plan, the state has allocated special funds to place the item of occupational dust-harm control, prevention and treatment techniques into the state target projects of science and technology, thus making efforts to resolve completely the problem of dust hazards;

- Fourth, it is necessary to enforce macro-control by the state over the work of preventing dust, the management of enterprises and guidance to the industries and to carry out training on dust-control techniques for the leaders at different levels and workers as a whole for the purpose of enhancing their awareness of preventing dust and the abilities to protect oneself.

As far as our work on occupational safety and health is concerned, the system of combining state inspection, management by enterprises and industries and trade union surpervision is practised. Therefore, the trade unions have important roles to play in the dust-control mainly as follows:

1. To participate, representing the interests of their members and workers, in the studies and formulation of laws and decrees related to them.
2. To take part in the procedure of design, construction and operation of the anti-dust installations related simultaneously with the principal part of the projects and to supervise the management of enterprises to bring the dust under the control in a well-planned way and to draw and use funds for dust-control purposes in accordance with the regulations.
3. To organize and mobilize workers and trade union members to carry out activities of technical cooperation so as to pool the wisdom and efforts of everyone involved to control dust.
4. To exercise mass supervision to raise criticism and constructive suggestions over those enterprises with dust hazards problems. A deadline is imposed by trade unions to the settlement of the dust problem and workers and staff members will be organized and supported by the trade unions if necessary to refuse to work under serious dust-harm stricken conditions of their workplaces.
5. To carry out an extensive education and propaganda activities among the workers and trade union members.
6. To strengthen cooperations and exchanges with the ILO/CIS and all the countries the world over, learning from their advanced experience.

At present, the All-China Federation of Trade Unions is making positive efforts to prevent pneumoconiosis. Last year, a general survey was carried out in the dust-stricken enterprises from all 29 provinces, municipalities autonomous regions except Taiwan province of our country. In addition, a major analysis was made to the 125 workplaces where dust hazards remained serious still. As a result, the foundation has been laid to better represent and safeguard the interests and rights of the workers and staff members.

Mr. Chairman and fellow delegates,

I sincerely wish that through this Conference we will be able to strengthen the exchanges and cooperations between China and all the countries the world over, and at same time to obtain useful experience and measures of other countries so as to speed up the work to prevent and treat pneumoconiosis in my country.

Thank you Mr. Chairman.

RISK ASSESSMENT OF PULMONARY EXPOSURE TO RESPIRABLE DUST WHILE WEARING DUST RESPIRATOR UNDER SIMULATED WORK CONDITIONS

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INTRODUCTION

One of the most serious problems influencing the effectiveness of respiratory protection in the workplace is the degree of fitness between worker's face and respirator mask. This problem has been the focus of several investigators, particularly during the past decade.[1,2,5–7,9–13] In spite of significant advancement in development of numerous types of respirator masks, difficulties are still encountered with respect to the ability of worker to obtain an efficient face seal with the mask of a "tight-fitting respirator." Despite the requirements for thorough qualitative and/or quantitative fit testing of tight-fitting respirators on workers in order to select the best fitted respirator mask, under actual working conditions the degree of assurance as to (1) how long a respirator mask will remain fit, (2) what factors affect the face-seal efficiency the most, and (3) what would be the potential exposure risk involved, are still uncertain. In addition to facial hair and morphology, which have been studied by several investigators in the past, factors such as repeated and prolonged head and body motion, rate of respiratory ventilation, respirator strap tension, temperature and humidity, etc. may affect the respirator fit resulting in increased exposure risk to air contaminants.

In our laboratory, we have developed a unique automated motion and breathing system that utilizes NIOSH-adopted dummy heads. These dummy heads have been used by NIOSH and other investigators for respirator bench test.

The purpose of this attempt was to develop a respirator testing system that simulates the actual working conditions. The prime objectives were: (1) to test the integrity of respirator masks, (2) to study the effects of dynamic factors that affect the respirator mask face seal such as head and body motion as well as breathing rate and frequency. Other factors that may also affect respirator seal, such as strap tension, temperature and humidity, can also be studied with this system.

INSTRUMENTS AND METHODS

System Components

The experimental system consists of a dummy, referred to as "Dusty", equipped with automated motion and breathing system. Dusty is installed inside a 1000-liter inhalation chamber and is connected to the motion and breathing systems outside the chamber by means of cables and tubings. The major components of the system are described below:

The chamber. The chamber is equipped with gas and vapor generation systems and a Wright dust feeder. Other commonly used aerosol systems such as DOP, mineral oil or salt aerosol can also be used to generate the desired concentration of aerosol. The aerosol concentration within the chamber is monitored by means of a light-scattering particulate counter. In case of use of gas or vapor for experiment, the concentration can be continuously monitored by means of an infrared gas spectrophotometer and strip chart recorder. The chamber is also equipped with a dynamic airflow system and necessary gauges for temperature, pressure and airflow control. An electrostatic precipitator followed by an absolute filter, continuously cleans the chamber air from air contaminants before discharging it to the environment. (Figure 1)

Human-form dummy (Dusty). Dusty comes in three different sizes: small, medium and large for use with various size respirator masks. Dusty's face is made out of soft and flexible plastic and approximates normal shape of human face. Similar dummies, as stated earlier, have been used by NIOSH Respiratory Research Section in Morgantown, WV, for primarily Bench Test.[2] (Figure 2)

Motor drive/indexers. The 3180-PI Motor Drive/Indexers used in this system are line-operated, energy efficient motor drive modules. An integral power supply provides the necessary DC voltages required to operate the indexer and drive. The indexer/drive modules are capable of driving stepping motors allowing a wide range of functions. The indexers are also used for memory storage up to 400 lines of program in non-volatile memory.[3]

There are three drive indexers in this system: A, B and C. Each drive/indexer controls one motion of the dummy in two opposite directions. Drive/indexer A also controls the breathing system.

Stepping motors. There are three stepping motors in the system: 1, 2 and 3. These motors are controlled by motor/drive indexers, A, B and C, respectively. Each motor runs in two opposite directions: positive and negative. For

Figure 1. Inhalation chamber and automated motion and breathing simulators.

example, in vertical motion of Dusty, positive motion is "moving up" and negative motion is "moving down." In horizontal rotation (turning head) moving head to the left is positive and to the right is negative. In vertical translation (nodding head), forward head motion is positive and backward movement is negative.[3]

Indexer programmer. The SSP-500 indexer programmer is a dedicated programmer which is designed to be used with a variety of drive/indexers including the 3180-PI used in this system. All functions, parameters, data, and commands for the microseries indexers can be easily entered, edited, uploaded and downloaded using this device. All information is clearly displayed on the two-line by 40-character liquid crystal display (LCD) panel. Seven function keys, Bi-Directional Cursor Locators, Numerical Keypad, Entry, and Mode keys provide easy and convenient data entry. All programming functions are menu-driven, and are presented in a clear, easy to follow sequence. The SSP-500 is designed to be either hand-held or affixed on an exterior surface.[4]

Breather. The Breather is a box containing a vacuum/compressor pump and two three-way selenoid valves which alternate the flow of air from and to the vacuum/compressor pump.

Figure 2. Human-form dummy (Dusty) used in the system.

The opening and closing of these valves are controlled by the Drive/Indexer "A". The frequency of opening and closing of valves (same as respiration frequency) can be changed by programming the Drive/Indexer through the Indexer Programmer. A breath warmer/humidifier is also used on the exhalation line. For inhalation, the computer opens up the two valves in direction from the Dusty's mouth toward the vacuum pump; as a result, Dusty inhales the contaminated air from the chamber through the respirator being worn. At the end of inhalation cycle, the computer reverses the direction of airflow by switching the two selenoid valves in the opposite direction, i.e., from the pump toward Dusty; as a result, room air is pushed through the warmer/humidifier and then into the Dusty's respirator cavity and out into the chamber through the respirator's exhalation valve. Volume and rate of breathing is adjustable through the indexer programmer. Therefore, increased rate of breathing can be set corresponding to the assumed rate of a worker's metabolic rate.

Portacount. Portacount is a highly versatile particle-counting instrument. It can accurately measure respirator fit factors, filter penetrations, and particle concentrations. Based on the technology of continuous flow condensation nucleus counters, the portacount counts individual airborne particles from variety of sources. The instrument has two modes: Count Mode and Fit-test Mode. In the Count Mode, the portacount measures the concentration of airborne particles, whereas in the Fit-test Mode, the instrument measures the concentrations of particles inside and outside a respirator and calculates the respirator penetration or protection factor.[8]

METHODS

The system can be used to conduct variety of experiments on respirators. For example, to assess the risk of dust exposure associated with a specific respirator fit under a certain head and body motion and/or breathing rate, the following procedure may be followed:

1. The "test respirator" is fit-tested on Dusty's face by means of the Portacount, until satisfactory fit is achieved.
2. The Chamber is set on desired flowrate and dust (or other aerosols) generation rates so that the desired concentration is achieved within a reasonable time, i.e., approximately 5 minutes.
3. Dusty's motion and breathing systems (as programmed) are activated to run for a pre-determined length of time.
4. Dust concentrations outside and inside respirator is recorded continuously throughout the experiment. The extent of dust penetration into the respirator either through the face seal or any other route is detected at any time during the experiment and recorded on the strip chart. Any fluctuations in dust penetration for example, can also be matched with the Dusty's motion and breathing pattern. Such experiment is expected to provide answers to questions such as: (1) how long the respirator mask remains fit before a dust leak occurs? (2) which movement disturbs the respirator face seal, and to what extent? (3) what would be the effect of inhalation (negative pressure inside respirator mask), exhalation and/or breathing rate on dust penetration through the respirator? and (4) what would be the estimated risk of dust exposure involved under a set of conditions.

Operating the Robotic Dusty

Programming and operating the motion/breathing system, as stated earlier, is done through the Indexer/Programmer (Figure 3). The following is an example of the many programs used in this system. In this example, Dusty will carry out a consecutive combination of head and body motions: i.e., turning head, pumping tire, jogging in place, bending, turning head while bending, and turning while nodding. These motions will be accompanied by breathing at a rate of 15 respirations per minute and approximately 750 mL of air per respiration.

When using this program, the first mode appearing on the display of the Indexer/Programmer is the "OPERATING MODE" (Figure 3). The function key beneath each lowercase word will act on that word. For example, f7 key activates the indexers. Pressing this key will bring the display in Figure 4 which is "SELECT FUNCTION". Pressing f7 key (motion) again will move the system to the "MOTION" options

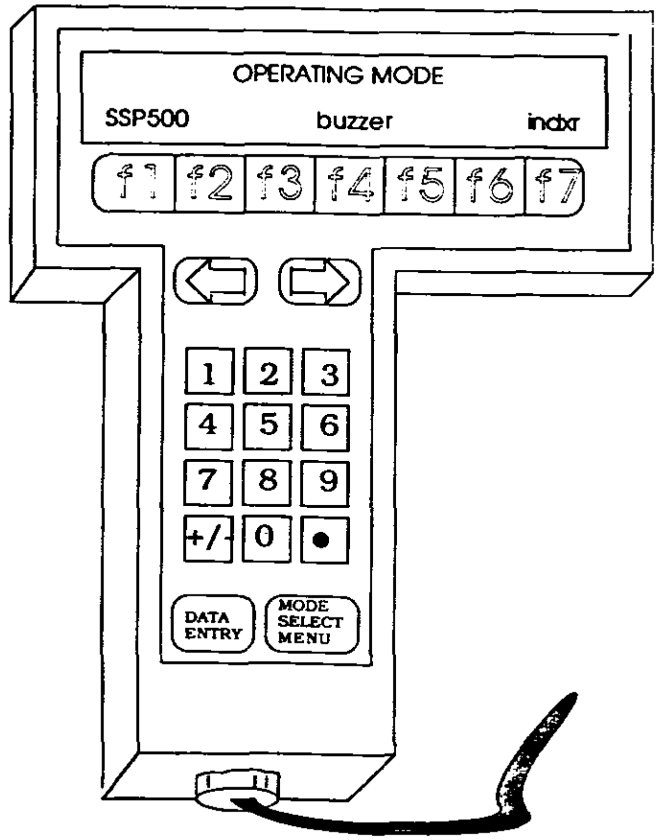

Figure 3.

(Figure 5). Here, the operator has several options; however, in this example, pressing f3 key (exec) would be the right choice. The next display (Figure 6) is "EXEC MOTION". Here again, several options are available; however, since the operator is asking Dusty to carry out all the motions, f4 key (all) should be pressed which will activate all indexers. This will take the operator to the last step of this program: "AUTO EXEC MOTION" (Figure 7). Out of several options available in this mode, pressing f1 key, CYCST (Cycle start) will start the system. Dusty will start the head and body motions, as stated earlier, in a consecutive fashion while breathing. Indexer/Programmer display during the operation would be "AUTO EXECUTING" (Figure 8). The system will continue to operate until the end of pre-set time on the program unless the operator wishes to stop the system at any time by pressing f1 key (stop). Pressing f4 (hold) may also be used should the system have to be stopped momentarily.

The robotic Dusty can also be run manually for each single motion by pressing f1 (man) in the "MOTION" mode (Figure 5). The next screen will show "ATT'N INDXR (01-99)" (Figure 9). The cursor on this screen will be flashing asking for the Drive/Indexer number of choice. Using the numeric key pad, one of the three indexers is activated by typing a zero and then the Indexer number: 01, 02 or 03. Once an Indexer is chosen, the "DATA ENTRY" key on the

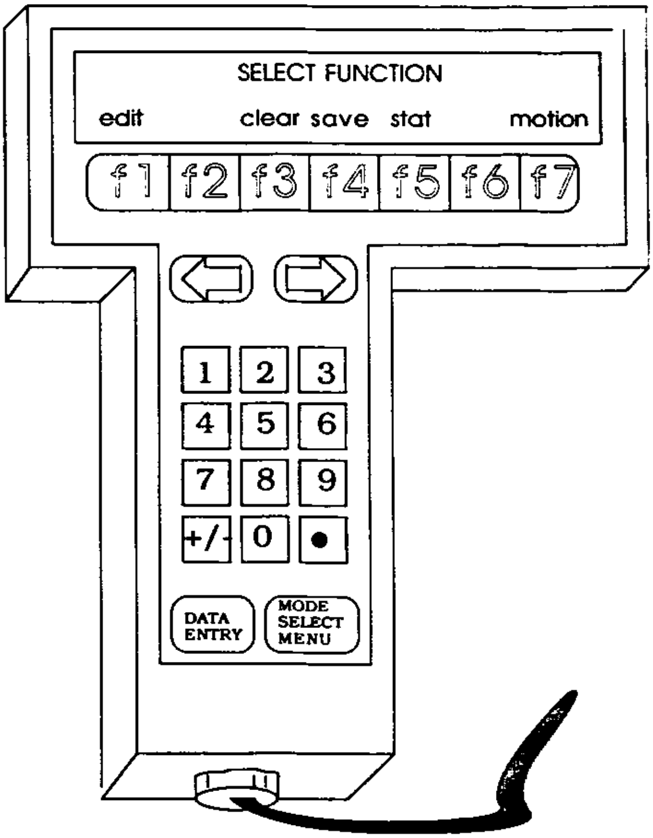

Figure 4.

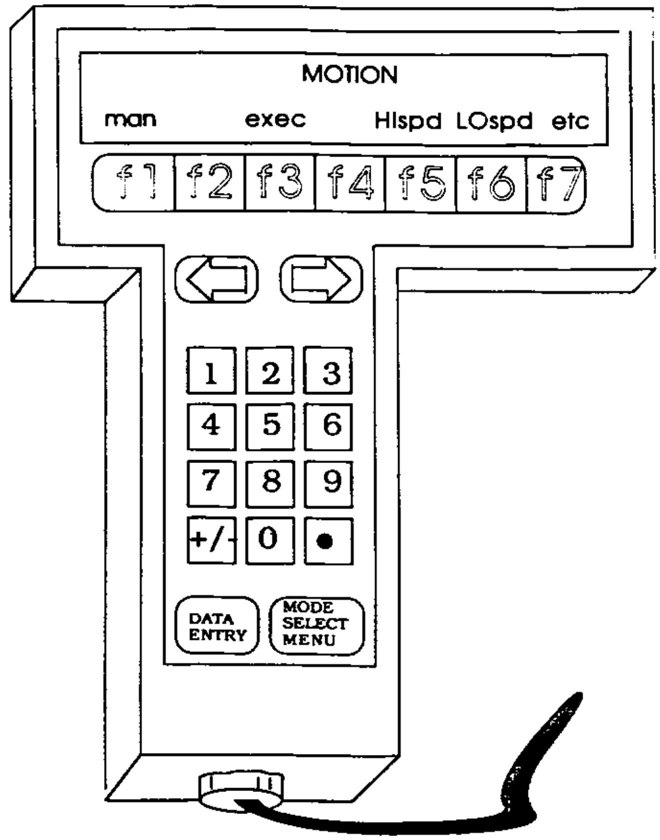

Figure 5.

Indexer/Programmer is pressed to activate the next screen of choice: "MANUAL MOTION" (Figure 10). The number in the upper left, here shown as "OX", will be the number of the indexer chosen. Several options are available on this screen. The one primarily used in manual control of the system is f2 (Jog). Pressing f2 will activate a continuous motion of the Dusty depending on the Indexer number chosen. The screen appearing during this operation will be "JOG MOTION".

In addition, the system can be programmed and executed to carry out varieties of desired motions or combination of motions (up to 999 choices). To execute the desired motion, f5 key (N) should be pressed during the AUTO EXEC MOTION (Figure 7). Using the numerical keypad, the desired motion number is then entered and followed by pressing "DATA ENTRY" key. The system is now ready to execute the desired motion indefinitely by pressing f1 key (Cycst).

If the system is stopped at any time during the operation, Dusty must be "returned" to its "electrical home" before a new cycle can be started. This is done by pressing f6 key (reh) in "MANUAL MOTION" mode (Figure 10).

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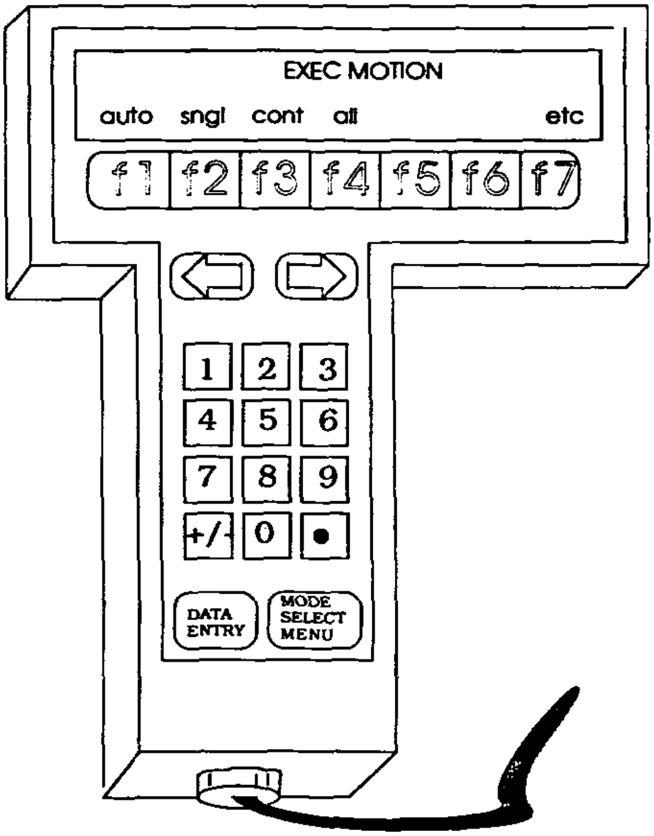

Figure 6.

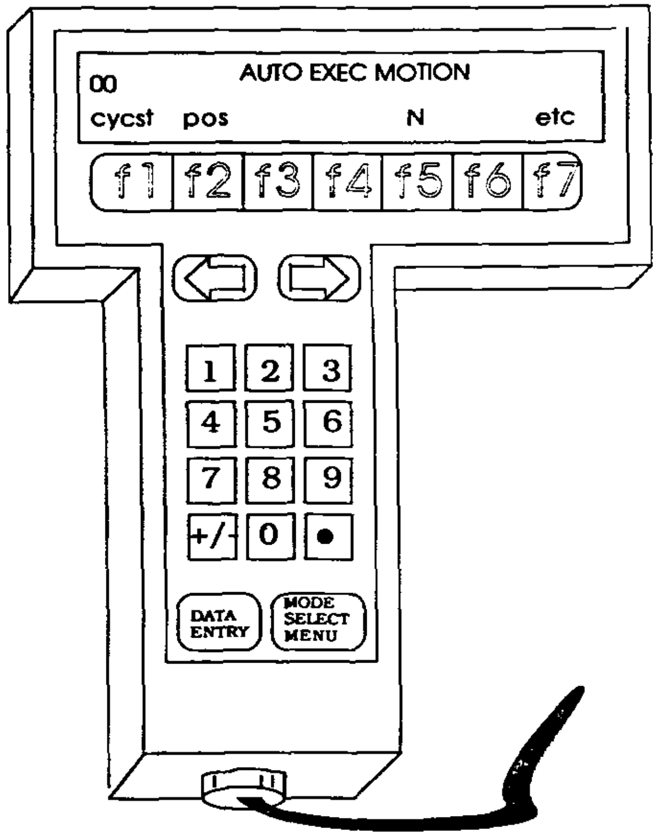

Figure 7.

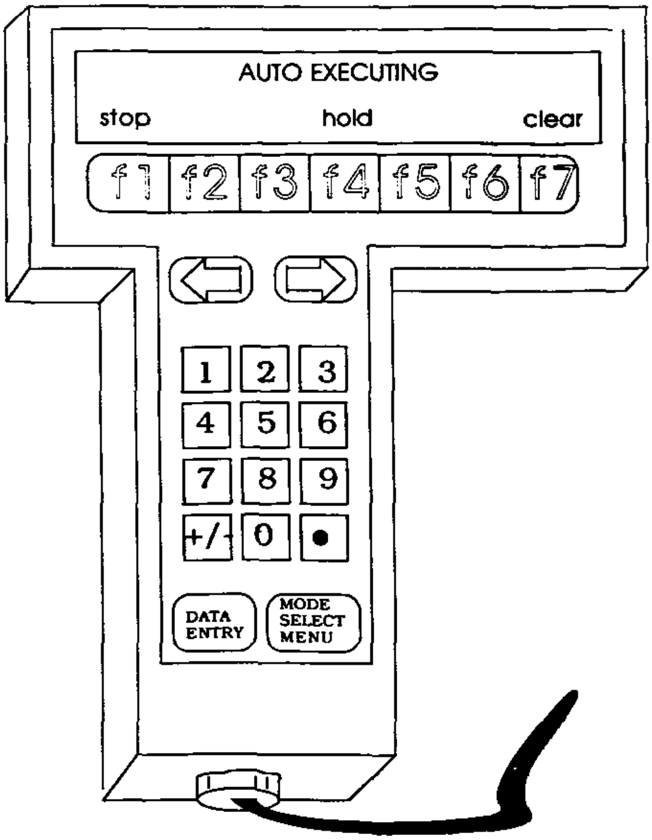

Figure 8.

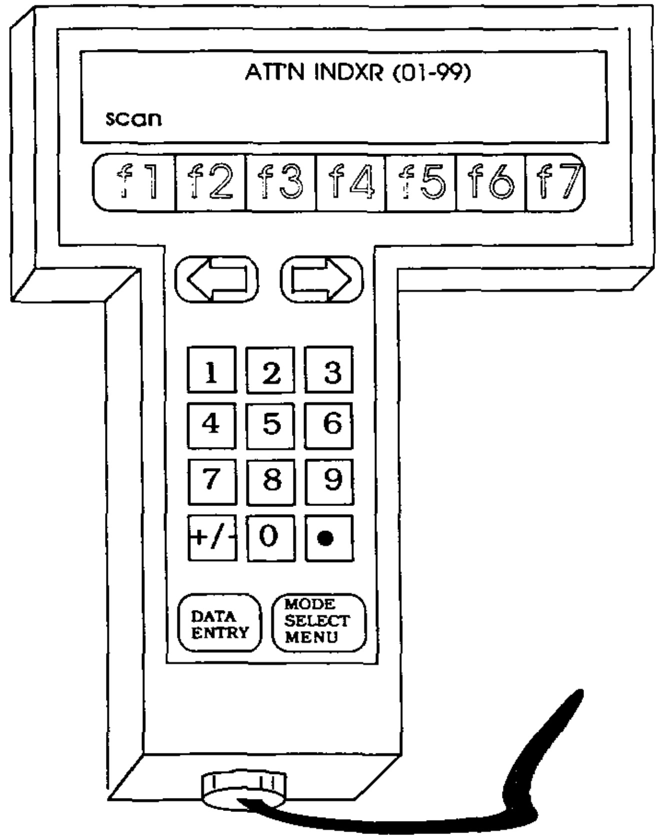

Figure 9.

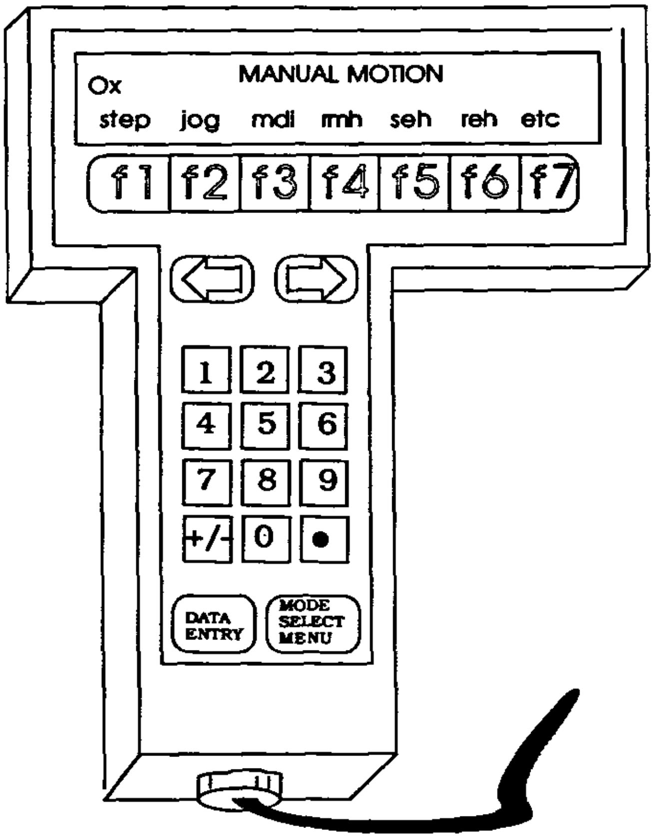
Ox
MANUAL MOTION
step jog mdi rmh seh reh etc
f1 f2 f3 f4 f5 f6 f7
1 2 3
4 5 6
7 8 9
+/- 0 •
DATA ENTRY
MODE SELECT MENU

Figure 10.

RESPIRATORY PROTECTION EQUIPMENT PERFORMANCE STANDARDS IN DEVELOPING COUNTRIES

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Respirators are a very important factor in the line of defense against pneumoconioses. In less developed countries where resources are very limited to control the disease producing dusts and mists, respirators are probably the only viable method available for worker protection. Unfortunately, in these same countries, there are few standards or regulations governing the performance or use of respirators. Standards and regulations need to be developed to assure an adequate level of respirator performance and their proper use.

An effective certification procedure need not be complicated, especially for particulate respirators. Modern technology has made evaluation of the performance of respiratory protection much easier and more reliable than in the past. Simple procedures can be implemented to assure continued compliance with the standards.

For respirators offering protection against harmful dusts and mists the following aspects of respirator performance must be addressed:

1. Particulate penetration
2. Breathing resistance
3. Respirator fit

I would like to briefly discuss each of these aspects along with my recommendations as to how they can best be addressed in a certification program.

The most important aspect of respirator performance is its ability to exclude through its filters and components the harmful dust from the breathing air of the worker in a contaminated environment. In the past, filters or the entire respirator would be challenged with a laboratory generated test agent, such as silica dust. Air would be drawn through the respirator or filter at a specified rate. The amount of dust penetrating the filter or respirator would be collected on a second filter. After a specified period of time the second filter would again be weighed and the performance of the respirator reported as the total particulate penetrating the device, or the percent efficiency of the respirator or filter, if the challenge concentration was measured. This is the current NIOSH certification test.

The results of such tests are highly variable and are often poor predictors of actual respirator performance. For example two respirators that give equivalent results on the NIOSH silica dust test could give differing results if the instantaneous penetration were measured at any given time during the test. The old methods simply do not have the analytical sensitivity necessary to measure the actual performance of respirators. In addition the equipment necessary to perform such a test is very expensive and difficult to operate and would consume a great deal of the testing agency's time.

Fortunately technology has simplified particulate respirator performance evaluation. Commercial equipment is now available to test particulate respirators in a manner applicable to respirator certification. This equipment uses a small worst case test aerosol so extrapolation to the aerosol found in the workplace is unnecessary. In European certification testing the aerosol is sodium chloride or paraffin oil generated by a controlled atomization.

TSI Inc. of St Paul, Minnesota, for instance, manufactures a unit that reliably and accurately measures the filtration performance of respirators. Their equipment can function with a variety of test aerosols. We have evaluated this test equipment with very encouraging results. The state of the art equipment was able to reproducibly measure filter performance with a coefficient of variation of less than 4% whereas the silica dust test has a coefficient of variation typically in the range of 60%.

The new equipment costs less than 20% of what a silica dust chamber would cost and is essentially a "turn key" test whereas the dust chamber would take at least 18 months to build and start up. This type of filter efficiency testing correlates very closely with tests that are performed in Europe and what is currently being proposed for use in the United States.

The second important aspect of respirator certification is the determination of acceptable breathing resistance of the respirator. This attribute of a respirator is important because it affects the user acceptance of the respirator. A respirator not worn when it should be will offer no protection. Determination of breathing resistance is a simple matter. In fact the state of the art filtration testing equipment automatically measures breathing resistance while determining filter efficiency.

The last aspect of respirator performance that requires addressing is facefit. In order for a respirator to provide adequate protection it must seal to the wearer in some manner that excludes the harmful dusts from penetrating the interface between the respirator and the wearer. This ability to seal is termed facefit. There are many accepted methods for determining how well a respirator fits. Because of limited time I will not discuss these methods but rather discuss approaches of applying facefit testing to a respirator certification program.

Faces are highly variable. They come in many sizes and shapes and contain highly variable features. Generally, no one model of respirator will fit all faces. No one to date has been successful predicting the fit of a respirator on an individual using any scheme. Yet fit is a very important aspect in respiratory protection.

Generally two approaches have been used to address this problem. A method that is currently used in Europe and elsewhere requires that a respirator demonstrate some level of minimum fit on a substantial percentage of people on a test panel during the certification process. The fit of the respirator on the actual user is then largely ignored during actual use. The other method currently used in this country is to minimally address fit in the certification process but require through respirator use standards that an acceptable level of fit be determined on each respirator wearer. The first method acknowledges that some percentage of respirator users will not be protected because their respirator does not adequately fit whereas the second method places a burden on the employer to find a respirator that fits the individual if respiratory protection is required.

I believe that the second method is a much more protective standard. The availability of a greater variety of respirator sizes, shapes and models in this country than in Europe is indicative that this method provides respirators with potentially better facefit.

I believe that a respirator certification scheme should require that a respirator manufacturer in the respirator user instructions specify a validated fit test must be performed to assure adequate facefit before the respirator can be relied upon for protection. This would provide assurances that the user has a respirator that adequately fits.

These three items are the most important aspects of a respirator certification program. However, a method of enforcement must also be implemented to assure continued compliance. The best method to accomplish this is for the agency to purchase product from the open market and test for compliance.

Before effective respiratory protection can be assured respirator use standards must be developed. If the proper respirators are not selected, if adequate fit cannot be ascertained and if the respirator wearers are not adequately trained in the proper use of the respirator protection will not be assured.

With the advancement of technology and existence of practical respirator use standards as models, regulations and standards should be adopted to assure adequate protection is available against pneumoconioses producing dusts and mists.

OPTIMIZATION OF FREELY SUSPENDED EXTERIOR HOODS IN INDUSTRIAL VENTILATION

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INTRODUCTION

In the design of an exterior hood, the value of the airflow rate through the hood can be found if specification of the "reach" of the hood is given. By the reach of the hood we mean a set of air speeds induced by the hood, to be achieved or exceeded at specified locations in front of the hood. If the velocity profile generated by the hood air flow is known, the problem is simply matching the velocity profile with the specifications to obtain the flow rate which will achieve the correct air speeds. There are a number of expressions which give velocity profiles with about equivalent accuracy.[1-4] Thus, any one of these expressions can be used to design a hood. Clearly, if the air speed specifications are given correctly, then the capture efficiency of the hood is expected to be optimal. It must be noted that the optimum for the capture efficiency can be made independent of cross currents, because the effect of cross currents can be included into the specification of the air speed. This seemingly direct and simple method of computation, which determines the minimum flow rate to accomplish the desired result, is flawed with respect to the mechanical efficiency of the hood. This flaw is due to the a priori selection of the hood geometry and orifice size without a quantitative investigation of the possibilities of achieving the same end result with a hood of different geometry and/or orifice size. Although the experience of the designer may be invoked as an influencing factor in the design, even for an experienced designer it is unlikely that the consequences of such alternatives have ever been a consideration.

In order to simplify the theoretical development, it will be assumed that a specific value of air speed on all points of a regular geometric shape defined on a plane located in front of a hood is given as the design criterion for the hood. It is important to note that the restriction of specification surface to a plane rather than a curved surface will not give a general solution. Therefore, it may be considered to be a limitation of the theoretical development. However, such a specification would be sufficiently common in the industrial applications and more importantly, the methodological approach can be presented without undue complexity of the mathematical formulation so that the results would be useful to a ventilation system designer.

THEORETICAL CONSIDERATIONS

In the investigation of the implications of hood orifice geometry and in the selection of proper size of the orifice, the development of the theory is facilitated if the specification geometry is chosen in a way that the distances measured from the point on the hood is readily accomplished. This will suggest that the shape of the specification surface is symmetric with respect to both of the axes of the plane. An oblong or a circle would satisfy this criterion. Since a square has four extremal points, then the structuring of the optimization problem can be reduced to matching the air speed generated by the hood to the specified air speed at the extrema. This process would be sufficiently general, in the sense that the specification can be in terms of a component of a vector.

Suppose it is necessary to generate air speed of V_C at the surface of an oblong located on a plane parallel to the hood surface and centered on the x-axis with its sides parallel to the xz and yz planes. Furthermore, suppose that it is necessary to keep the hood face velocity equal to or below a specified value V_o. Let A and B be the maxima of the y and z coordinates respectively. For an oblong hood, with sides a fraction c of A and B placed with its center at the origin (Figure 1) minimization of the flow rate Q might be sought by the object function:

$$Q = L^2 f(a,b,h)\, V_C \tag{1}$$

Subject to:

$$V_C\, f(a,b,h)/\, 4abc^2 < V_o \tag{2}$$

where,

a = Dimensionless specification oblong side, A/L
b = Dimensionless specification oblong side, B/L
h = Dimensionless distance to the specification surface, H/L

For an oblong orifice, the function f(a,b,h) may be shown to be represented by the non-dimensionalized velocity scaling function (1) multiplied by the hood orifice area:

$$f(a,b,c,h) = \pi(a+b)cr + 2\pi r^2 + 4abc(c+h(a+b)/(a^2+b^2))^{1/2} \tag{3}$$

with,

$$r^2 = h^2+(1-c)^2 \tag{4}$$

Equations 1 through 4 can be extended directly to a circular orifice by taking c.L to be the radius of the orifice. In such an extension, Equations 2 and 3 will have to be modified to conform to the description of the flow field in front of a circular orifice. The modified equation for a circular orifice hood

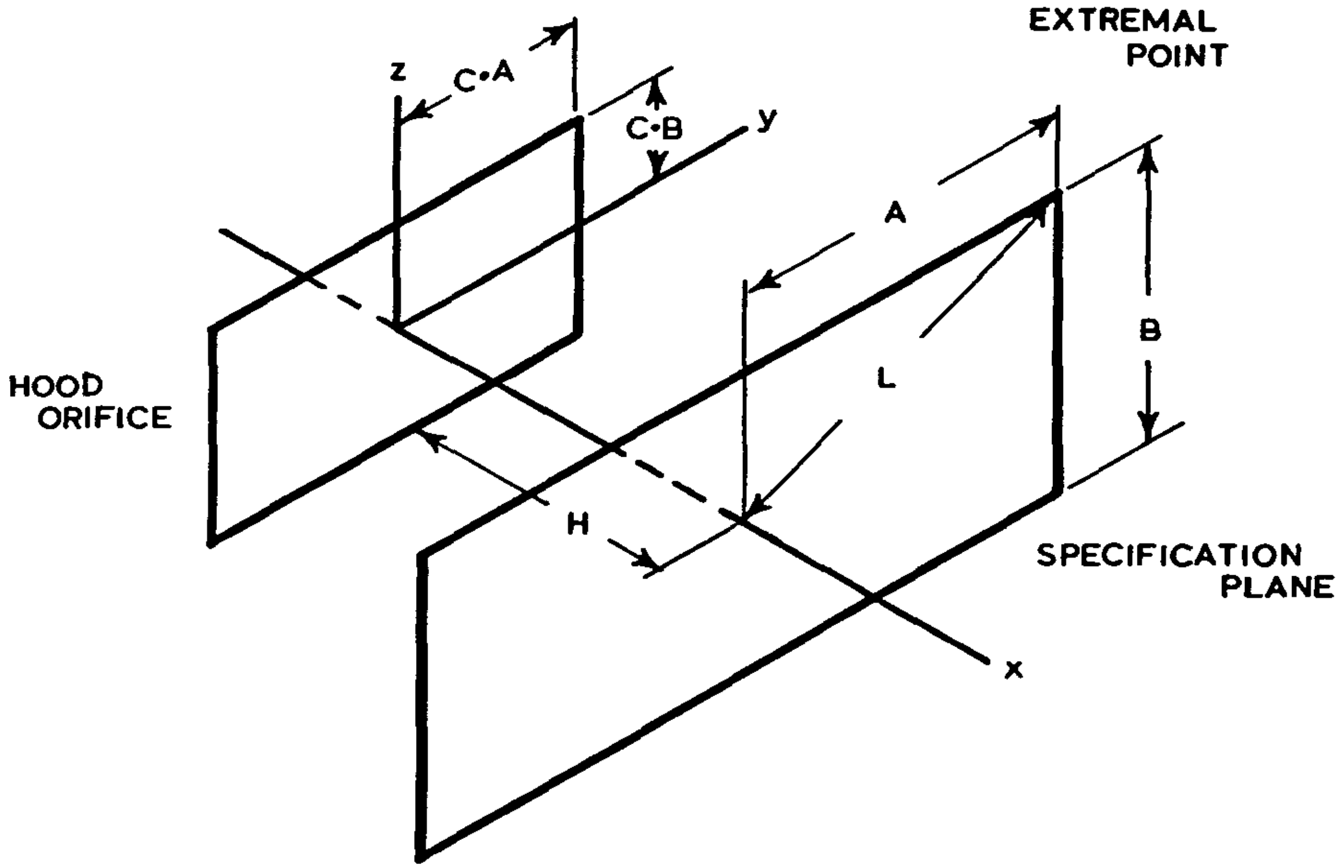

Figure 1. The parameters and the configuration used in the derivation of hood optimization.

may be shown to be 3:

$$f_C(a,b,c,h) = \pi^2(cr+r^2)/2+\pi c(c^2+Kh^2)^{1/2} \tag{5}$$

$$K = 4/(\pi^2-2\pi)$$

and,

$$V_C\ f(a,b,h)/\pi(a^2+b^2)c^2 < V_o \tag{6}$$

The minimum sought may be found directly by differentiating either equation 3 or equation 6 with respect to c and finding the root of the resulting equation which is between zero and one. For an oblong orifice, the non linear equation to be solved is:

$$\pi(a+b)\frac{h^2+1-3c+2c^2}{(h^2+1-2c+c^2)^{1/2}}+4\pi(c-1)+4abc\,\frac{2c^2+h(a+b)}{(c^2+h(a+b))^{1/2}}=0 \tag{7}$$

and similarly for a circular orifice:

$$\frac{\pi}{2}\bullet\frac{h^2+1-3c+2c^2}{(h^2+1-2c+c^2)^{1/2}}+\pi(c-1)+\frac{2c^2+Kh}{(c^2+Kh)^{1/2}}=0 \tag{8}$$

If the specification surface, instead of oblong, is a circular one then calculation process may be modified by taking two different values for square or circular hoods. It may be shown that for a square orifice hood the square hood A = B and L = A $\sqrt{2}$ and for a circular orifice hood L = A. With these altered specifications equations 1 through 8 apply to optimization without further change. (Table I)

In general, the process of calculation is straight forward and with the use of a computer presents no significant problems. However, in certain cases no root may exist in the zero to one interval. This suggests that the global optimum design does not exist for that condition. This situation will arise when the dimensionless frontal distance h is sufficiently large. Consequently, the local optimum which is defined by the maximum face velocity specified in equation 2 or 6 and the corresponding orifice size may be used.

For infrequent design problems where the use of a computer is not warranted or for those who do not have ready access to a computer, there are a number of simplifications, albeit limited, that reduce the calculations to simple use of tables. To develop these simplifications, consider the specification surface to be bounded by a square, i.e. the sides are such that A = B. Then the optimization can be carried out utilizing the values shown in Table II. The simplest use of this table may be illustrated by an example. Suppose the specification surface is located 10 cm from the hood plane with A = .0.25 m.

If the air speed desired on this surface is 1 m/sec and the maximum face velocity allowed is 25 m/sec then the optimum hood size for a square hood is calculated as follows:

$L = A\sqrt{2} = 0.35355$ thus $h = H/L = 0.283$. Therefore, interpolating the proper values from Table II, $f(h) = 3.6191$ and $c = 0.784$; consequently, the optimum value of the side of the square hood is 19.6 cm and from equation 1 the a volumetric flow rate is 0.45 m^3/sec. Similarly, for a circular hood, the optimum radius is 22.5 cm and the flow rate is 0.49 m^3/sec. Thus for this simple illustration, a square orifice hood would be an optimum choice.

If the example above is recalculated using a circular specification, the optimum square hood would be the same, but the optimum circular hood would have $L = 0.25$, $h = 0.40$ which results in a hood radius of 13.0 cm and flow rate of 0.31 m^3/sec. In this case a circular hood would be superior.

It is important to note that the theoretical results developed

Table I

Optimization Parameters for Squares and Circles

Dimensionless	Circle		Square	
Distance	C	f(a,h)	C	f(a,h)
0.05	0.9351	2.2007	0.7734	3.1161
0.10	0.8926	2.4464	0.7344	3.2874
0.15	0.8594	2.7265	0.6953	3.4966
0.20	0.8291	3.0372	0.6641	3.7355
0.25	0.8018	3.3768	0.6211	3.9989
0.30	0.7754	3.7440	0.5859	4.2843
0.35	0.7598	4.1381	0.5508	4.5893
0.40	0.7266	4.5588	0.5156	4.9126
0.45	0.6992	5.0057	0.4805	5.2530
0.50	0.6758	5.4785	0.4414	5.6094
0.55	0.6562	5.9770	0.4062	5.9811
0.60	0.6328	6.5012	0.3672	6.3672
0.65	0.6104	7.0511	0.3203	6.7667
0.70	0.5869	7.6263	0.2634	7.1790
0.75	0.5635	8.2270	0.2266	7.6030
0.80	0.5400	8.8531	0.1719	8.0375
0.85	0.5166	9.5044	0.1094	8.4809
0.90	0.4932	10.1810	0.0312	8.9307
0.95	0.4688	10.8828	------	------
1.00	0.4434	11.6098	------	------
1.05	0.4209	12.3619	------	------
1.10	0.3965	13.1391	------	------
1.15	0.3721	13.9414	------	------
1.20	0.3467	14.7688	------	------
1.25	0.3203	15.6211	------	------
1.30	0.2949	16.4984	------	------
1.35	0.2695	17.4007	------	------
1.40	0.2441	18.3278	------	------
1.45	0.2148	19.2799	------	------
1.50	0.1914	20.2567	------	------

Circular orifices with maximum face velocity:

$$L^2 f_c(a,b,h) V_c - \pi(a^2 + b^2) c V_0 = 0$$

Oblong orifices with maximum face velocity:

$$L^2 f(a,b,h) V_c - 4 abc^2 V_0 = 0$$

Table II
Comparison of Traditional and Optimized Designs
(Unit Control Speed)

Design	B vert. cm	A Hor. cm	H cm	Diameter or Height cm	Width cm	Flow m^3/sec
CASE I	15	15	15			
Traditional Square				30	-	0.354
Optimum Square				27	-	0.254
CASE II	20	30	25			
Traditional Oblong				40	60	1.12
Optimum Oblong				33	49	1.01
CASE III	10	20	30			
Traditional Oblong				20	40	0.902
Optimum Oblong				12	24	0.880
CASE IV	20	20	25			
Traditional Square				40	-	0.889
Optimum Square				25	-	0.830
CASE V	20	20	10			
Traditional Square				40	-	0.421
Optimum Square				19	-	0.358
Circle				15	-	0.359

above are not inherently limited to applications which involve specification surfaces assumed in the development. Obviously, if the specification surface is not nearly a square circular or square orifice hoods will be inherently inappropriate but must be replaced by oblong orifice hoods. Finding the roots of the derivative of the objective function may be carried out by hand but such a calculation would be cumbersome. Although the computerized solution is simple, when a computer is not available, the optimization of each dimension of the orifice may be carried out approximately, one at a time by treating each side as an independent imaginary square hood. Although the orifice dimensions determined in this manner may not predict the exact optimum design values, the resulting dimensions are expected to be near the optimum values. The flow rate for such an orifice cannot be calculated directly from Equations 1 to 4.

EXPERIMENTAL RESULTS

The direct experimental verification of the optimization procedure given above is at best cumbersome. Such an experiment would involve the construction of a very large number of hoods. However, an indirect experimental verification of the procedure may be accomplished by showing that a few representative hoods may be constructed and studied. In the experimental study carried out to verify the theoretical calculations indirectly, three oblong hoods were constructed. These hoods were 5 cm by 5 cm square, 3 cm by 5 cm oblong and 4 cm by 8 cm oblong. With hood opening fixed, conditions under which these hoods will be optimum were calculated for different values of frontal distance and for each condition, the optimum flow rate was predicted. The air speed was measured at each, the theoretically determined specification point and the flow rate was adjusted until the air speed specification is fulfilled. This experimentally determined flow rate was then compared to the theoretical flow rate. All air flow and air speed measurements were carried out by hot wire anemometry. The hot film sensor in X configuration was calibrated in our laboratory and it is capable of measuring velocities with good accuracy and reproducibility. The hood airflow measurement was carried out by measuring the air speed by a traverse as close to the orifice plane as possible.

The comparison of the calculated optimum and the measured flow rates are given in Figure 2. The results suggest that the optimization procedure is satisfactory and perhaps slightly pessimistic in the indication of the flow rate required. On the average, about 10 percent less flow was required than it was calculated as necessary.

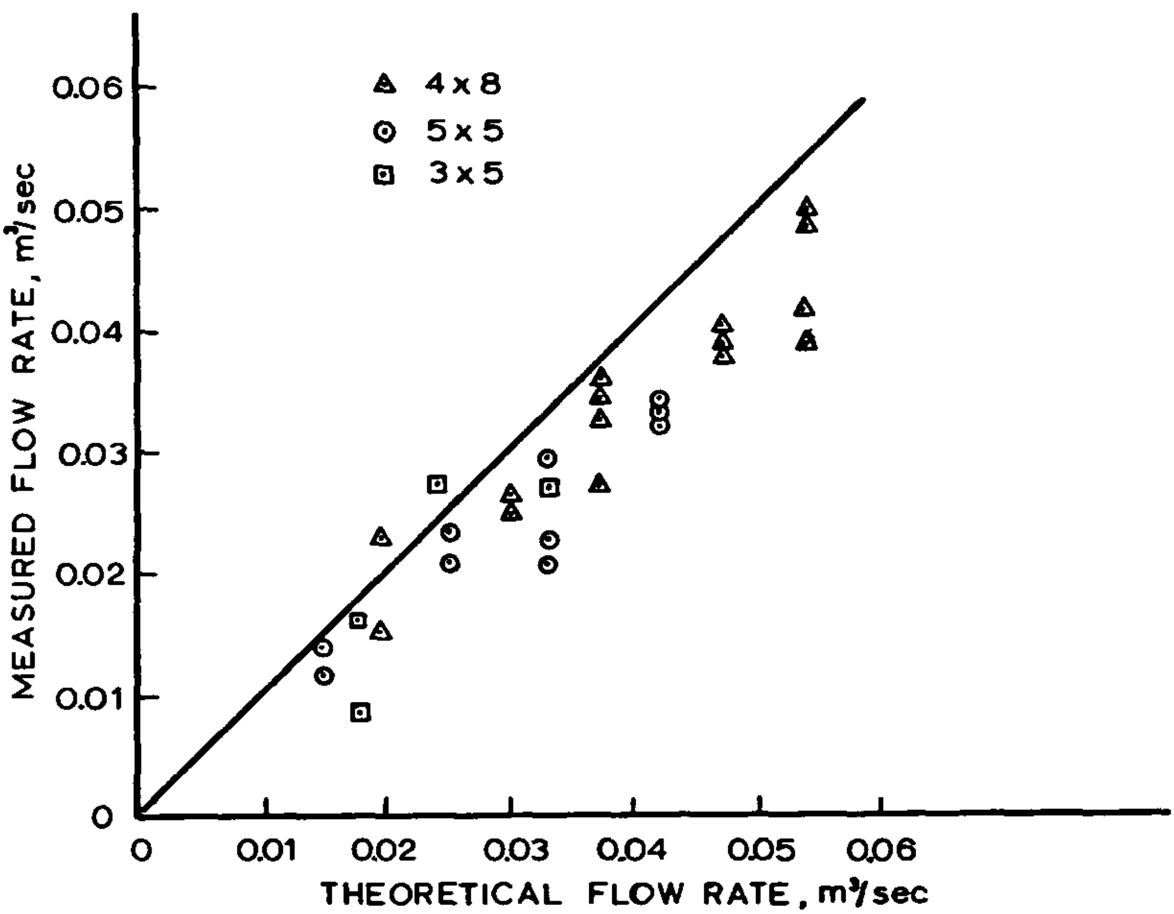

Figure 2. Comparison of theoretically and experimentally obtained flow rates for three hoods.

DESIGN APPLICATIONS AND DISCUSSION

The application of the results presented above to the design of freely suspended hoods with single square, circular or oblong orifices is a straight forward process but it must be recognized that the success of the hood design based on such calculations will ultimately depend upon the correct specification of the velocities to be generated at specific locations. The estimation of these velocities is beyond the scope of this paper and may be found in manuals dealing with currently accepted practice. If the specification surface is judged to be a curved surface rather than a plane or if the vector components of the velocity at specified points are sought, new objective functions following the theoretical development above can be found. Alternately, the hood size may be selected at an external point by considering that point to be one of the vertices of an oblong specification surface and the proper flow rate through the system can be calculated by point matching between the generated flow field and the required flow field.

In order to show the efficacy of the optimization procedure developed here, five hypothetical cases were compared to the traditional design procedure. The results of this comparison are shown in Table II. For the cases shown in Table II, the efficiency gain through optimization is about 13 percent with a range from 2 to 30 percent. These cases were not constructed with a forethought to show the effectiveness of the optimization procedure, but rather they were arbitrarily selected. Since the optimization process is based on the velocity profile in front of the hood, and the traditional design procedure which is based on the adjustment of the centerline velocity of the hood, then the hood designed by the optimization procedure ensures that the air speeds specified on the specification plane are satisfied. On the other hand such a statement would not necessarily be correct for the design based on centerline velocity. Consequently, the hoods designed through the process described above would always have a superior total efficiency as compared to the traditionally designed hoods.

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SIGNIFICANT REDUCTION OF QUARTZ DUST CONCENTRATIONS IN THE NATURE STONE INDUSTRY DUE TO THE INTRODUCTION OF VENTILATION SYSTEMS

VERRINGERUNG VON SCHADSTOFFKONZENTRATION DURCH LÜFTUNGSTECHNISCHE MAßNAHMEN IN DER NATURSTEININDUSTRIE

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EINLEITUNG

Die wirksame Erfassung luftfremder Stoffe und ihre gefahrlose Niederschlagung stellt eine der zentralen Arbeitsschutzmaßnahmen dar. Beim Umgang mit diesen Stoffen können diese in Form von Stäuben, Gasen oder Dämpfen in den Arbeitsbereich der Beschäftigten gelangen.

Im Bereich der Steinbruchs-Berufsgenossenschaft haben wir es vor allem mit silikogenen Stäuben zu tun. In der Natursteinindustrie, heir insbesondere in der Granitindustrie, war es dringend notwendig, Maßnahmen zur Emissionsminderung zu ergreifen. Eine der Maßnahmen zur Emissionsminderung war die Erfassung luftfremder Stoffe an der Emissionsquelle. Die hierzu notwendigen Einrichtungen waren in ihrer Wirkung zu optimieren. Für die Berechnung lagen selten geschlossene Lösungen vor, vielmehr war man auf Praxiserfahrung angewiesen.

Möglichkeiten der Verringerung von Schadstoffkonzentration durch lüftungstechnische Maßnahmen sollen an Beispielen der Staubbekämpfung in der Granitindustrie aufgezeigt werden.

TECHNISCHE SCHUTZMAßNAHMEN

Allgemeines

Die Absaugeinrichtung soll den bei den Bearbeitungsvorgängen entstehenden Feinstaub an der Ausbreitung über die Entstehungsstelle hinaus hindern.

Der nicht flugfähige Grobstaub sedimentiert schnell und lagert sich ab. Der Feinstaub dagegen breitet sich mit jeder Luftströmung aus. Er gelangt in die Atemzone und sein Anteil kleiner als 5 μm in die Atemorgane. Die Erfassung des Staubes an der Entstehungsstelle kann z. B. bei der Verwendung von Druckluftwerkzeugen durch eine das Werkzeug weitgehend umschließende Kapselung oder durch punktförmige Absaugung erfolgen.

Bei uberwiegender Handarbeit oder auch bei Verwendung von Schleif—oder Trennwerkzeugen in geschlossenen Hallen werden als Erfassungselemente vielfach Saugtrichter in den unterschiedlichsten Formen eingesetzt. Bei maschineller Bearbeitung werden Kapselung, Absaugdüsen oder auch die Absaugung durch eine Bohrung im Werkzeug angewandt.

Stauberfassung bei der Bearbeitung mit Werkzeugen

1. Kapselung

In der Granit-Werksteinindustrie befinden sich eine große Anzahl der Arbeitsplätze im Freien oder in halboffenen Steinhauerhütten. In diesen Hütten werden überweigend Rand-, Leisten-, Grenz- und Mauersteine hergestellt. Für die Bearbeitung werden Druckluftwerkzeuge verwendet.

Eine Erfassung des bei der Bearbeitung entstehenden Staubes kann an diesen Arbeitsplätzen nur durch eine möglichst weitgehend das Werkzeug umschließende Kapselung erfolgen.

In den früheren Jahren hatte man sich bei der Staubbekämpfung an diesen Arbeitsplätzen überwiegend auf den Arbeitsvorgang "Stocken" konzentriert, da hierbei die größte Staubentwicklung auftrat.

Es wurde als Stauberfassungs-Einrichtung für diesen Arbeitsvorgang zunächst der Schärdinger Topf entwickelt. Der "Topf" wird über den Meißelhals gesteckt und ist an diesem festgelegt. Der "Topf" selbst liegt auf der zu bearbeitenden Fläche und wird mit dem Keillochhammer zusammen über die Fläche geführt. Bedingt durch die Bewegung über die rauhe Oberfläche des Werkstückes wird er stark abgenutzt. Auch ergeben sich gelegentlich Schwierigkeiten beim Bearbeiten an den Kanten der Werkstücke.

Beim sogenannten Hauzenberger Topf wurde eine neuer Weg beschritten. Der Absaugkopf ist an einem Rillenstück, welches die Haltemutter des Hammers ersetzt, drehbar angebracht. Mit einem Handgriff kann der Absaugkopf auf die jeweilige Länge des Werkzeuges eingestellt werden. Der untere Rand des Topfes soll sich stets im geringstmöglichen Abstand über dem Werkstück befinden. Bedingt durch das zusätzliche Gewicht müssen die mit dem Hauzenberger Topf ausgestatteten Hämmer von einer besonderen Führung gehalten werden. Ein freihändiges Arbeiten ist nicht möglich.

Eine Weiterentwicklung des Hauzenberger Topfes ist eine Gummihaube mit seitlichem Saugstutzen. Diese Gummihaube wird fest mit dem Stockhammer verbunden und beim "Stocken" mit Hartmetallwerkzeugen verwendet. Der Hammer kann auch von Hand geführt werden.

Schwierigkeiten bei der Benutzung dieser Absaugeinrichtungen treten beim Bossieren, Spitzen und Keillochmachen, d.h. bei Arbeiten mit dem Spitzeisen auf.

Bei der groben Bearbeitung von Flächen ist es notwendig, den Hammer in mehrere Richtungen zu bewegen. Für diese Arbeitsvorgänge, die außerdem noch mit Spitzeisen unterschiedlicher Länge durchgeführt werden, waren die starren Absaugtöpfe nicht geeignet. Ein Heranführen der Absaugdüse an die Bearbeitungsstelle war nicht möglich.

In den letzten 10 Jahren ist es gelungen, auch Einrichtungen zum Erfassen des Staubes für diese Arbeitsvorgänge zu schaffen und zu verbessern. Die Stauberfassungs-Einrichtungen bestehen aus einer Gummikappe mit seitlichem Saugstutzen, die über die Haltemutter des Keillochhammers gezogen wird. In eine in dieser Grundhaube angebrachte Nut werden die mit einem Falz versehenen Absaugdüsen von unterschiedlicher Länge und Form für die verschiedenen Arbeitsvorgänge eingesteckt.

Man ging auch hier wieder davon aus, den Staub möglichst nahe an der Entstehungsstelle zu erfassen. Je näher die Erfassung des Staubes an der Entstehungsstelle erfolgt, desto geringer kann die erforderliche Absaugluftmenge gehalten werden. Das bedeutet wiederum, daß die Absaugvorrichtung am Hammer klein und gering im Gewicht und der erforderliche Absaugschlauch auch klein im Durchmesser bleiben können.

Im unmittelbaren Zusammenhang mit einer Absaugluftmenge steht auch die Größe der Anlage und damit deren Kosten.

2. Punktförmige Absaugung

Für verschiedene Arbeiten mit schlagenden Druckluftwerkzeugen, überwiegend in geschlossenen Hallen, wird die Punktabsaugung verwendet. Die Absaugung erfolgt mit einem flexiblen Saugrohr oder Schlauch. Der Schlauch oder das Saugrohr sind am Drucklufthammer befestigt. Das Ende des Schlauches bzw. des Rohres ist so nahe wie möglich an die Entstehungsstelle des Staubes nachzuführen, damit eine ausreichende Erfassung des Staubes erfolgt. Bei der Punktabsaugung wird ebenfalls mit einer geringen Absaugluftmenge gearbeitet.

3. Absaugung mit dem Saugtrichter

Es ist allgemein bekannt, daß auch bei der Steinbearbeitung mit Handwerkzeugen eine erhebliche Staubentwicklung auftritt.

In diesen Fällen ist eine Erfassung des Staubes nur durch Saugtrichter möglich. Diese Art der Absaugung erfordert jedoch wesentlich höhere Absaugluftmengen als bei Kapselung oder Punktabsaugung. Bei Verwendung von Druckluftwerkzeugen oder elektrisch angetriebenen Werkzeugen ist besonders darauf zu achten, daß die Flugrichtung des Staubes zur Haube hin zeigt.

4. Absaugung mit Absaugtischen

In Jura-Marmorbetrieben werden bei der Steinbearbeitung auch Absaugtische eingesetzt.

Bei trockener Bearbeitung von Kanten mit Elektrowerkzeugen wird hier der Staub über einen unter dem Tisch eingebauten Entstauber abgesaugt. Bei Arbeiten mit dem Absaugtisch ist darauf zu achten, daß die Halterung für das zu bearbeitende Werkstück entsprechend nachgestellt wird. Die zu bearbeitende Kante muß möglichst nahe der Ansaugöffnung liegen. Nur so kann eine einwandfreie Erfassung des Staubes erfolgen.

Hilfseinrichtungen

Außer bei den Stockarbeiten mit Gestängeführung des Druckluftwerkzeuges bereitete das Nachführen der Erfassungseinrichtungen und der Schläuche stets Schwierigkeiten.

Dieses Problem ist jedoch weitgehend gelöst. Bei Druckluftwerkzeugen, bei denen die Erfassungseinrichtungen unmittelbar am Werkzeug angebracht sind, werden Druckluft- und Saugschlauch gemeinsam über einen Gelenkarm zum Werkzeug geführt. Der Gelenkarm mit aufgesetztem Pendelarm hat eine Länge von ca. 3 m, so daß ein ausreichend großer Schwenkbereich vorhanden ist. Eine Zugentlastung sorgt für den Gewichtsausgleich.

Bei Anlagen mit Saugtrichter wird dieser an eine nach allen Seiten bewegliche und in der Höhe verstellbare Rohrleitung angebaut oder der Trichter befindet sich an einem flexiblen Schlauch bzw. an flexibel über Schlauchstücke verbundenen Rohren, die an Gelenkarmen verschiedenster Bauart befestigt sind. Die Leichtgängigkeit der Gelenkarme muß stets gewährleistet sein, da die Saugrüssel sonst nicht ständig nachgeführt werden. Eine ausreichende Staubabsaugung ist dann nicht mehr gegeben.

Sind die Hilfseinrichtungen umständlich zu handhaben oder schwergängig, so wird die gesamte Staubabsaugung in der Regel von den Arbeitern abgelehnt.

Staubabsaugung bei Bearbeitung mit Maschinen

1. Pflasterstein-Spaltmaschine

Der beim Spalten entstehende Staub wird durch seitlich neben dem Obermesser und unter dem Tisch angeordnete Düsen abgesaugt.

2. Randstein-Stockmaschine

Mit der Randstein-Stockmaschine werden die von Hand grob vorbereiteten Steine durch im Innern der Einkapselung angeordnete Stockhämmer bearbeitet.

Der dabei anfallende Grobstaub wird mit einer Förderschnecke, der Feinstaub durch Absaugung aus dem

Gehäuse entfernt.

3. Trog-Fräsmaschine

Bei der Trog-Fräsmaschine erfolgt die Absaugung des Staubes durch das einem Holhbohrer ähnlich gestaltete Fräswerkzeug.

STAUBABSCHEIDER

Als Staubabscheider werden meistens Gewebefilter, neuerdings auch Sinterlamellenfilter verwendt. Als Antriebsenergie benutzt man überwiegend Strom oder Druckluft.

Um den Energieverbrauch für die Entstaubung bei der teinbearbeitung mit Druckluftwerkzeugen und Stauberfassung am Werkzeug möglichst niedrig zu halter, werden in verschiedenen Betrieben sogenannte Einzelentstauber verwendet. Jeder Arbeitsplatz hat für sich ein Absauggerät. Es handelt sich hier um Injektor-Geräte.

Ein Steuerventil sorgt dafür, daß das Entstaubungsgerät nur läuft, wenn mit dem Drucklufthammer gearbeitet wird. Der Druckluftverbrauch wird bei dieser Arbeitsweise erheblich gesenkt.

SCHLUßBETRACHTUNG

Für alle bei der trockenen Bearbeitung von Werkstein vorkommenden Arbeiten gibt es entsprechende Staubabsaugungen.

Voraussetzung für eine einwandfreie Entstaubung der Arbeitsplätze ist jedoch die bestimmungsgemäße Verwendung und sorgfältige Wartung der Erfassungseinrichtungen und Anlagen.

Bei der Steinbearbeitung mit handgeführten Geräten oder Handwerkzeugen bedeutet die Verwendung der Absaugeinrichtungen stets eine leichte Behinderung. Nach einer Einarbeitungszeit werden die Einrichtungen von den Beschäfigten im allgemeinen angenommen, da die meisten von ihnen erkannt kaben, daß die Anlagen der Erhaltung ihrer Gesundheit dienen.

EXPLORATIONS TO SOME PROBLEMS IN ESTABLISHING DUST ALLOWABLE CONCENTRATIONS

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Certain difficulty exists, either theoretically or methodologically, in studies on dust allowable concentration.

Before the 1950s, allowable concentration only existed for silicon dioxide and, later, that for asbestos was added. In the past decade of years, the establishing of dust allowable concentration has developed rapidly, but is still far from meeting the practical need.

To improve method for study and to speed up its development, therefore, has become an urgent problem to be solved at present. The present article is exploring some problems in establishing dust allowable concentration as follows:

TREND IN DEVELOPMENT OF DUST ALLOWABLE CONCENTRATION

Along with increase in number of newly-established dust allowable concentration, classification naturally appears. The ACGIH of the United States divides mineral dust TLV into four major categories.[2] In the Soviet Union, in addition to 53 kinds of mixed dust allowable concentrations established separately,[1] the maximum dust allowable concentrations are classified into silicate, carbon, metal and organic matter except that of silicon dioxide. The dust allowable concentration published by Japanese Industrial Society falls into three major categories: silicon dioxide, "various dusts" and asbestos,[3] while in China, dust allowable concentration may be divided into six major categories: silicon dioxide, silicate, carbon and coal, metal, organic dust, and others.[4]

A tendency toward grading has turned up. As for free silicon dioxide dust, in some countries, it is classified into two grades, while in some other countries it is classified into four grades and in some countries, it is calculated by equation (see Table I). In Japan, the "various dusts" with free silicon dioxide content less than 10% are divided into three grades.[3] In Soviet Union, no apparent grading is done, but in effect, the 65 kinds of other various dusts with free silicon dioxide less than 20% are classified into six grades as 1, 2, 4, 6, 8, and 10.[2] In China, the various dusts except silicon dioxide are divided into five grades as 3, 4, 5, 6, and 10.[4]

GENERAL STRUCTURAL CONSTRUCTION OF DUST ALLOWABLE CONCENTRATION

Having analyzed historical development tendency, we propose to establish structure with classification and grading for dust allowable concentration.

1. Seven categories are classified according to dust characteristics:
   a) silicon dioxide dust
   b) silicate dust
   c) metal dust
   d) coal dust and various carbon dust
   e) organic dust
   f) various mixed dust
   g) other dust.

   One of the purposes of classification is to work as reference for identical dust allowable concentration developed.

2. Four categories are classified according to extent of harm done by dust (see Table II).

One of the purposes of classification is to simplify the method, to speed up establishing concentration, as well as to benefit monitoring. In recent years, some countries have adopted the method of calculating the SiO_2 dust allowable concentration with formula, which gives an impression of accurate quantity, but in effect, by present available method and means it is difficult to reflect accurately the changing factors of pneumoconioses' occurrence due to the complex nature of the disease's developing course and the unstableness of workers exposed to dust in production. This method gives rise to a series of problems to monitoring. According to the study results of pneumoconioses in the province in the past twenty years, we think that to divide dusts into four major grades according to occupational harm they have done may generally distinguish the extent of harm done by various dusts.

ON THE STUDY METHOD OF DUST ALLOWABLE CONCENTRATION

Data on epidemiology disease is doubtless the key basis for establishing dust allowable concentrations as well as a must data, but pneumoconioses is a chronicle developing process, especially the new industrial dust for which its allowable concentration cannot be established after long periods of time waiting for the data of epidemiology disease. Then, is it possible to take it as a basis for establishing dust allowable concentrations with animal experiments?

We think it is. As is known, pneumoconioses is a disease that can be studied with certain pathological models established on animal experiments. Analysis of animal experiments on about twenty kinds of dusts, conducted in contrast with data

Table I

Grading of Free Silicon Dioxide Dust Allowable Concentration in Various Countries (mg/m³)

Country	Other dusts	Content of free silicon dioxide (%)								
		-1	-2	-10	-30	-40	-50	-70	-80	>80
China	10				2					1
Soviet Union	10			4	2				1	
Japan	1.5	3.0		6.0	$R=\frac{2.9}{0.22Q+1}$			$T=\frac{12}{0.22Q+1}$		
U.S.A.	10				0.05~0.1					

Note: R = The inhalant dust

T = Total dusts

Q = Content of free SiO_2 in dust (%)

Table II

Grading of Dust Allowable Concentration

Extent of harm	Grading	Max. allowable concentration (mg/m³)	Dust
Very serious	I	1	Pure quartz dust with free SiO_2 over 80%
Serious	II	2	Various dusts with free SiO_2 between 10~80%. Asbestos dust.
Moderate	III	5	Various dusts with free SiO_2 between 5~10%; partial silicate dust (as talcum dust); partial metal dust (as metalic aluminium dust).
Slight	IV	10	Various dusts with free SiO_2 less than 5%; partial silicate dust (as pearlite and dolomite); carbon and coal dust; partial metal dust (as tin); and organic dust, etc.

Table III

Cases of Grading of Harm Done by Dust
(According to Length of Time for Appearence of Fibering)

Grading	Length of time of appearence of fibering of pulmonary tissue when animal is contaminated (month)	Name of dust experimented
I	3	Pure quartz dust (with 85~90% of free SiO_2)
II	6	Ceramic mixed dust, caly (A) dust (15~35% of free SiO_2)
III	12	Mixed clay (B) dust (5.9% of free SiO_2)
IV	18	Pearlite dust, clay (C) dust (0.5~3.6% of free SiO_2)

Fibering standard, appearence of gelatinizing fiber on the basis of hyperplasia of netted fiber

of epidemiology, may basically reflect the extent of occupational harm done by various dusts with animal experiments. The pneumoconioses with high occurrence, short work age, rapid development and high mortality (such as that caused by quartz dust) appears rapid fibering of pulmonary tissue and serious extent of pathological change in animal experiments, while in reverse, the pneumoconioses with low occurrence, long work age of occurrence, slow development and low mortality (such as pneumoconioses caused by clay dust) appeared slow in fibering of pulmonary tissue and slighter extent of pathological exchange in animal experiments. With the time for rat lung to show fibering as the basis of grading, results of grading at various dusts are shown in Table III. These results provide a possibility to use animal experimental data for establishing dust hygienic standard. The united animal experiment method can be determined by the National Hygiene Standard Commission. The standard dust for contrast may be supplied by the National Labour Hygiene Study Center and it is for all the local labour hygiene study centers to direct the experimental method. All labour hygiene and scientific research departments can engage in study and development of dust allowable concentration. Checked and approved by the Hygiene Standard Commission, the study results can be published and put into force as a provisional standard. In the second stage, the standard can be revised according to data of epidemiologic investigation. Thus it is possible to speed up the establishment of dust allowable concentration.

The pathological grading of animal experiments can be based on the speed of the appearence of fibering for the time being. Obviously, there are many problems to be further explored such as, the biological effect of dust cannot be attributed to whether there is fibering effect. Therefore, it is very important to set up a systematic study method for pulmonary toxicity experiments. It is, however, advisable, from technical development strategy, to select a practical and feasible method.

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