RELATIONSHIP OF DUST CONCENTRATION AND RELATED FACTORS ON PULMONARY FUNCTION OF CONCRETE PILE FACTORY WORKERS

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RELATIONSHIP OF DUST CONCENTRATION AND RELATED FACTORS ON PULMONARY FUNCTION OF CONCRETE PILE FACTORY WORKERS

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ABSTRACT

This study was aimed at determining the concentration levels of total dust (TD) and respirable dust (RD) and the relationship between the pulmonary functions of concrete pile factory workers and related factors, i.e., TD concentration, RD concentration, work history, work duration for the company, working areas, using of dust protection equipment, illness history with respiratory tract infection, location of residence, smoking, and physical exercise. The first part of the research was to collect air samples for TD and RD in 6 sampling sites in the concrete pile factory as follows: the Factory's Administration Office, Processing Platform 1, Processing Platform 3, Processing Platform 5, Silo 1, and Silo 3. The second part of the research was to study the pulmonary functions of the factory workers who work in each studied areas where the air samples were collected.

The results of the first part of the study showed that all 218 samples, over an 8-hour average of TD and RD concentrations, did not exceed the OSHA work area air standards. Concentration levels of TD in the Administration Office, Processing Platform 1, Processing Platform 3, Processing Platform 5, Silo 1, and Silo 3 varied from 0.90-1.20, 0.83 -2.60, 1.13-3.75, 1.10-2.50, 0.31-5.00, 1.70-3.70 mg/m^3, respectively, whereas concentration levels of RD at Administration Office, Processing Platform 1, Processing Platform 3 , Processing Platform 5 , Silo 1, and Silo 3 varied from 0.37-1.00, 0.16-2.30, 0.25 -2.20, 0.49-1.90, 0.37-2.50, 0.65-2.30 mg/m^3, respectively. In addition, there were significant relationships between TD and RD concentrations (p-value <0.05) at 3 studied areas, i.e., the Processing Platform 1 (r=0.869); Processing Platform 5 (r=0.744); and Silo 3 (r=0.504).

For the second part of the study, it was found that among the sample group of 125 workers (24 workers from Administration Office, 39 workers from Processing Platform 1, 36 workers from Processing Platform 3 , 17 workers from Processing Platform 5 , 6 workers from Silo 1, and 3 workers from Silo 3), there were 103 workers who had "normal" pulmonary function while 22 other workers had "abnormal" pulmonary function. The factors that showed significant relationships with pulmonary function (p-value <0.05) were: smoking duration, number of cigarettes smoked per day, duration of working in the factory and duration of exposure to chemical vapors while working in other factories.

KEY WORDS : TOTAL DUST / RESPIRABLE DUST / DUST CONCENTRATION / PULMONARY FUNCTION

90 Pages

ความสัมพันธ์ของความเข้มข้นของฝุ่นและปัจจัยที่เกี่ยวข้องต่อสมรรถภาพปอดของพนักงานในโรงงานผลิตเสาเข็ม

RELATIONSHIP OF DUST CONCENTRATION AND RELATED FACTORS ON PULMONARY FUNCTION OF CONCRETE PILE FACTORY WORKERS

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บทคัดย่อ

การศึกษามีวัตถุประสงค์เพื่อวิเคราะห์หาความเข้มข้นของฝุ่นรวม (Total dust,TD) และฝุ่นที่เข้าสู่ระบบทางเดินหายใจได้ (Respirable dust, RD) และหาความสัมพันธ์ของสมรรถภาพปอดของพนักงานในโรงงานผลิตเสาเข็มกับปัจจัยที่เกี่ยวข้อง ได้แก่ ปริมาณความเข้มข้นของฝุ่นรวม (TD) และฝุ่นที่เข้าสู่ระบบทางเดินหายใจได้ (RD) ประวัติการทำงาน ระยะเวลาการทำงานในโรงงานนี้ พื้นที่ทำงาน การใช้อุปกรณ์ป้องกันฝุ่น ประวัติเกี่ยวกับโรคระบบทางเดินหายใจ ที่พักอาศัย การสูบบุหรี่ และการออกกำลังกาย ในส่วนแรกเป็นการเก็บตัวอย่างฝุ่นในอากาศในบริเวณต่างๆของโรงงานผลิตเสาเข็มรวม 6 บริเวณ ได้แก่ สำนักงาน แท่นผลิต1 แท่นผลิต3 แท่นผลิต5 ไซโล1 และไซโล3 ในส่วนหลังเป็นการศึกษาสมรรถภาพปอดจากกลุ่มศึกษา ซึ่งเป็นพนักงานที่ปฏิบัติงานในบริเวณทีเก็บตัวอย่างฝุ่นทั้ง 6 บริเวณ

ผลการศึกษาในส่วนแรกพบว่าความเข้มข้นของฝุ่นรวมและฝุ่นที่เข้าสู่ระบบทางเดินหายใจได้เฉลี่ย 8 ชั่วโมงที่เก็บมาจากทั้ง 6 จุดเก็บตัวอย่างรวม 218 ตัวอย่างมีความเข้มข้นไม่เกินค่ามาตรฐานของ OSHA โดยมีค่าพิสัย (Range) ความเข้มข้นของฝุ่นรวม ในบริเวณสำนักงาน แท่นผลิต1 แท่นผลิต3 แท่นผลิต5 ไซโล1 และไซโล3 ดังนี้ 0.90-1.20, 0.83 -2.60, 1.13-3.75, 1.10-2.50, 0.31-5.00, 1.70-3.70 มก./ลบ.ม. ตามลำดับ และค่าพิสัย (Range) ความเข้มข้นของฝุ่นที่เข้าสู่ระบบทางเดินหายใจได้ ในบริเวณสำนักงาน แท่นผลิต1 แท่นผลิต3 แท่นผลิต5 ไซโล1 และไซโล3 มีดังนี้ 0.37-1.00, 0.16-2.30, 0.25 -2.20, 0.49-1.90, 0.37-2.50, 0.65-2.30 มก./ลบ.ม. ตามลำดับ และนอกจากนี้ยังพบว่าความเข้มข้นของฝุ่นรวมและฝุ่นที่เข้าสู่ระบบทางเดินหายใจได้ มีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติ (p-value<0.05) ใน 3 บริเวณ คือ แท่นผลิต 1 (r=0.869) แท่นผลิต5 (r=0.744) และไซโล3 (r=0.504)

ผลการศึกษาในส่วนหลัง ซึ่งเป็นการหาความสัมพันธ์ของสมรรถภาพปอดกับปัจจัยอื่นๆ ที่เกี่ยวข้องจากกลุ่มตัวอย่างทั้งหมดรวม 125 ตัวอย่าง (สำนักงาน 24 ตัวอย่าง แท่นผลิต1 39 ตัวอย่าง แท่นผลิต3 36 ตัวอย่าง แท่นผลิต5 17 ตัวอย่าง ไซโล1 6 ตัวอย่าง ไซโล3 3 ตัวอย่าง) จากการตรวจสมรรถภาพปอดพบว่าตัวอย่างที่มีสมรรถภาพปอดปกติมีจำนวน 103 คนและที่ผิดปกติมีจำนวน 22 คน โดยปัจจัยที่มีความสัมพันธ์ต่อสมรรถภาพปอดอย่างมีนัยสำคัญทางสถิติ (p-value <0.05) ได้แก่ ระยะเวลาการสูบบุหรี่ จำนวนบุหรี่ที่สูบต่อวัน ระยะเวลาการทำงานในโรงงานนี้ และระยะเวลาที่เคยทำงานในที่บริเวณที่มีไอสารเคมี

90 หน้า

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CHAPTER I
INTRODUCTION

1.1 Background and significance of the problem

Working is an important activity that helps people earn income for living. Generally, the majority of the people spend 8 hours or one third for working a day. Some persons may spend time in their workplace more than 8 hours. During the long period of time at workplace, workers may have a chance to expose to various types of environmental factors surrounding them, for example, machines, equipment, materials, chemical substances, microorganism, heat, cold, loud noise, x-ray, too much or too little light, including relationship with superiors and co-workers, etc. All of these environmental factors have impact on health of workers. In some cases, the impacts are very obvious, for example, working with the machine that the safety equipment are not installed may cause accident to the workers due to the dangers from the moving parts, or clamping points, cutting points of the machines. The workers may loss their body organs. But in case of the breake-paddle production factory workers, where the mineral asbestos has been used in the production process. It may take as long as 10 years or more to develop the symptom of pulmonary disease called “Asbestosis”. Asbestosis is an occupational disease that can not be cured and it will lead to death. The two situations as have been mentioned above are evident for the adverse impacts of work on workers. Moreover, the health conditions of the workers also have impact on their works. If unhealthy workers have stress, fatigue, or mental health problems, they will not be able to work efficiently and will be more risky to have accident or diseases than those who are healthy. Therefore, the relationship between “work” and “health” has led to the science of “Occupational health and safety” (1).

Particles in the polluted-air is an important air pollutant causing adverse effects on productivity and health of workers especially the particle or dust that are smaller than 10 micrometers which can penetrate deep into the lower respiratory system and can deposit and accumulate in alveoli in the lungs (2). The respiratory system is composed of upper respiratory tract and lower respiratory tract, and lungs. The respiratory tract may have abnormal signs and symptoms due to breathing in foreign particles and these particles will irritate the lung tissue as well as imbedding in the lung tissues. This situation lowered the lung function. Foreign particles can be suspended in the air, for example, dust, smoke, vapor, fog which are poisonous to human body and environment (3).

Dust affected lung function which may lead to pulmonary diseases which depends on the type of dust. Generally, dust can be divided into 2 types, organic and inorganic dust. In order to affect on the pulmonary function, it depends on many factors such as types of the dust, its concentration, exposure, body's immunity, and smoking. These factors can decrease the efficiency of the lung which will affect health of the contacted person and may lead to a lung disease caused by occupation (3). Therefore, the researcher was interested in assessing the effect of dust and other related factors on pulmonary function of concrete pile factory workers. It was expected that this research will provide beneficial results for performing a health surveillance program for the workers who are at risk from exposure to cement dust through respiratory tract system.

1.2 Research objectives

1.2.1 To study the concentration levels of the total dust (TD) and respiratory dust (RD) in the working area of the concrete pile factory (Concrete Productive Materials Co.,Ltd.).

1.2.2 To study the relationship between pulmonary function and other related factors which includes the concentration levels of respirable dust and total dust, age, body height, body weight, work history, time duration of working in this company, working areas, using of dust protection equipment, illness history with respiratory tract infection, location of residence, smoking, and physical exercise.

1.3 Research hypotheses

1.3.1 The concentration levels of total dust and respirable dust are statistically related and respirable dust can be estimated from the concentration of the total dust.

1.3.2 The concentration levels of total dust and respirable dust, age, height, body weight, work history, time duration of working experience, working areas, using of dust protection equipment, illness history with respiratory tract infection, residence, smoking, and physical exercise affected pulmonary function of studied workers.

1.4 Scopes of the research

1.4.1 Studied Areas. The studied areas were the areas nearby the administration office, silos, and processing platforms of the concrete pile factory, Concrete Productive Materials Co.,Ltd. Donkhoy Subdistrict, Kampaengsaen District, Nakhon Pathom Province.

1.4.2 Population of the study were the workers who worked in the administration office, silos, and processing platforms of the concrete pile (Concrete Productive Materials Co.,Ltd.) Donkhoy Subdistrict, Kampaengsaen District, and had been working for at least one year.

1.4.3 The study was carried out during the years 2009-2010.

1.5 Research conceptual framework

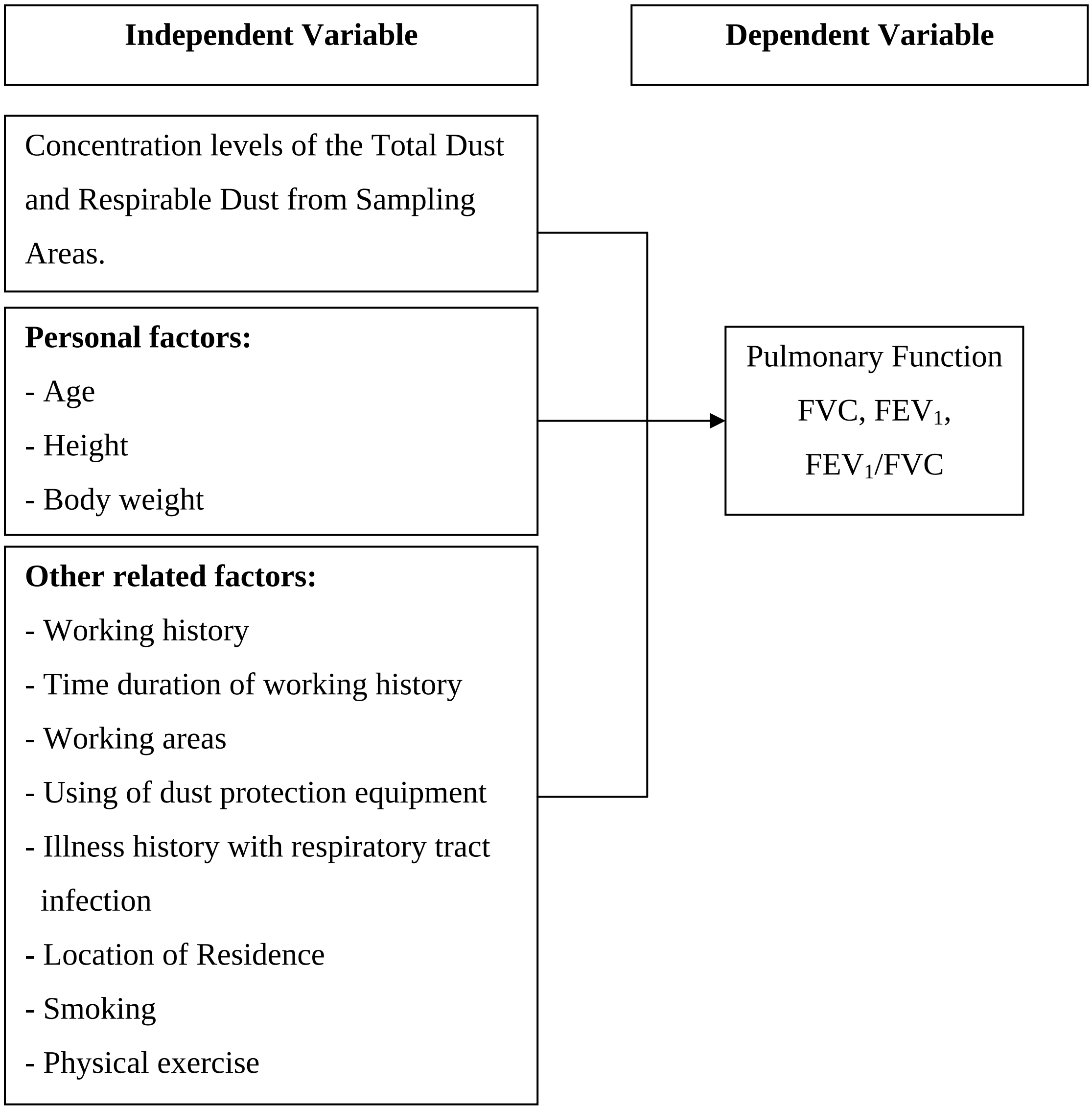


Figure 1-1 Research Conceptual Framework

1.6 Expected outcomes

1.6.1 The concentration levels of total dust and respirable dust in the studied areas.

1.6.2 The concentration levels of respirable dust can be estimated from the concentration level of the total dust.

1.6.3 Related factors that showed significant relationship with pulmonary function were obtained.

1.7 Operational definitions

1.7.1 Environment: Various physical and biological characteristics surrounding human beings that were made both by man and nature (4).

1.7.2 Air Pollution: "The presence in the atmosphere of one or more contaminants or combinations there of such quantities and of such duration as may be or may tend to be injurious to human, plant, or animal life or property or the conduct of business."

1.7.3 Dust: solid or liquid particles with the diameter of 0.3-100 micrometers that diffused in the atmosphere, for example, ash, metal dust, carbon dust, etc.

1.7.4 Total Dust (TD): The dust with the size equal to or less than 100 micrometers.

1.7.5 Respirable Dust (RD): The dust with the size equal to or less than 10 micrometers which can penetrate into the lower respiratory tract (5).

1.7.6 Pulmonary Function: Capacity of the lungs in exchanging air, moving in and out of the lungs.

1.7.7 Vital Capacity (VC): Maximum amount of air that can be exhaled after a maximum inhalation.

1.7.8 Forced Vital Capacity (FVC): Amount of air that can be exhaled completely after a maximum inhalation.

1.7.9 Forced Expiratory Volume Time (FEV_1): Amount of air that can be exhaled quickly and strongly at the first minute of inhalation.

1.7.10 Forced Expiratory Volume$_1$/Forced Vital Capacity% (FEV_1/ FVC%): Percentage of amount of air that can be exhaled at the first minute of inhalation divided by maximum amount of air that can be exhaled quickly and strongly.

1.7.11 FEF 25-75% (Forced Expiratory Flow): Average ratio of exhalation during 25-75 percent of FVC.

CHAPTER II
LITERATURE REVIEW

The basic information and related theories used as the guideline of this study can be divided into various important parts as follows: Concrete Productive Materials Co.,Ltd., concrete, air pollution, dust, effects of dust on health, and pulmonary function test. In regard to related literature reviewed, the presentation was made in regard to the effects of dust on pulmonary function.

2.1 Concrete Productive Materials Co., Ltd.

2.1.1 General information and products

Concrete Productive Materials Co.,Ltd. Has been established since 1978 with the authorized share capital of 2,000,000 Bahts and the first factory was established at Soi Saint Petro, Sarmprarn District, Nakhon Pathom Province. The company has run its business smoothly with the continuous development. In 1993, the new factory has been built in Kumpaengsaen District, Nakhon Pathom Province and the authorized share capital of the company was increased to 20,000,000 Bahts. At present, there are 500 workers and the company's management is divided into 12 Departments as follows: Business Development and Promotion; Sale and Marketing, Accounting and Finance; Human Resources; Occupational Health and Environmental Safety; Purchasing; Production; Production Quality Control; Transportation; Repairing; Field Services; and Field Quality Control.

The company produces and sells pressed concrete piles "I" shape and "square" shape that are used for the construction of general projects, for example, housing, commercial buildings, different sizes of factories. The base of the concrete production has been moved to the factory with area more than 40 rais in Kampaengsaen District, Nakhon Pathom Province. The pressed concrete pile produced from the company has been certified by the Standards of Industrial Products Office

396-2549. Therefore, the quality of the products are warranted. As the company has been managed the researches and quality development of the products, it has been done continuously. The policy of the company in regard to management of the production as well as occupational health and safety of workers in order to produce the products that could serve the customers' satisfaction has been done continuously. In 2006, the company's management system has been certified ISO 9001:2000 by UKAS and the quality management system has been maintained continuously up to the present time.

2.1.2 Concrete pile production process

The process of concrete pile production starts from straightening PC-wire in order to make the structure of pile and then follows by tieing the steel case with the PC-wire. The mixed concrete from Silo is poured in the structure prepared. The silo for cement mixing is the main source of cement dust. After pouring the mixed concrete, the surface of concrete is smoothed. After the concrete pile has adequate compressive strength, cut the PC-wire, cut and take the concrete pile from the block and grouping the concrete piles in accordance with their sizes and is ready to be distributed.

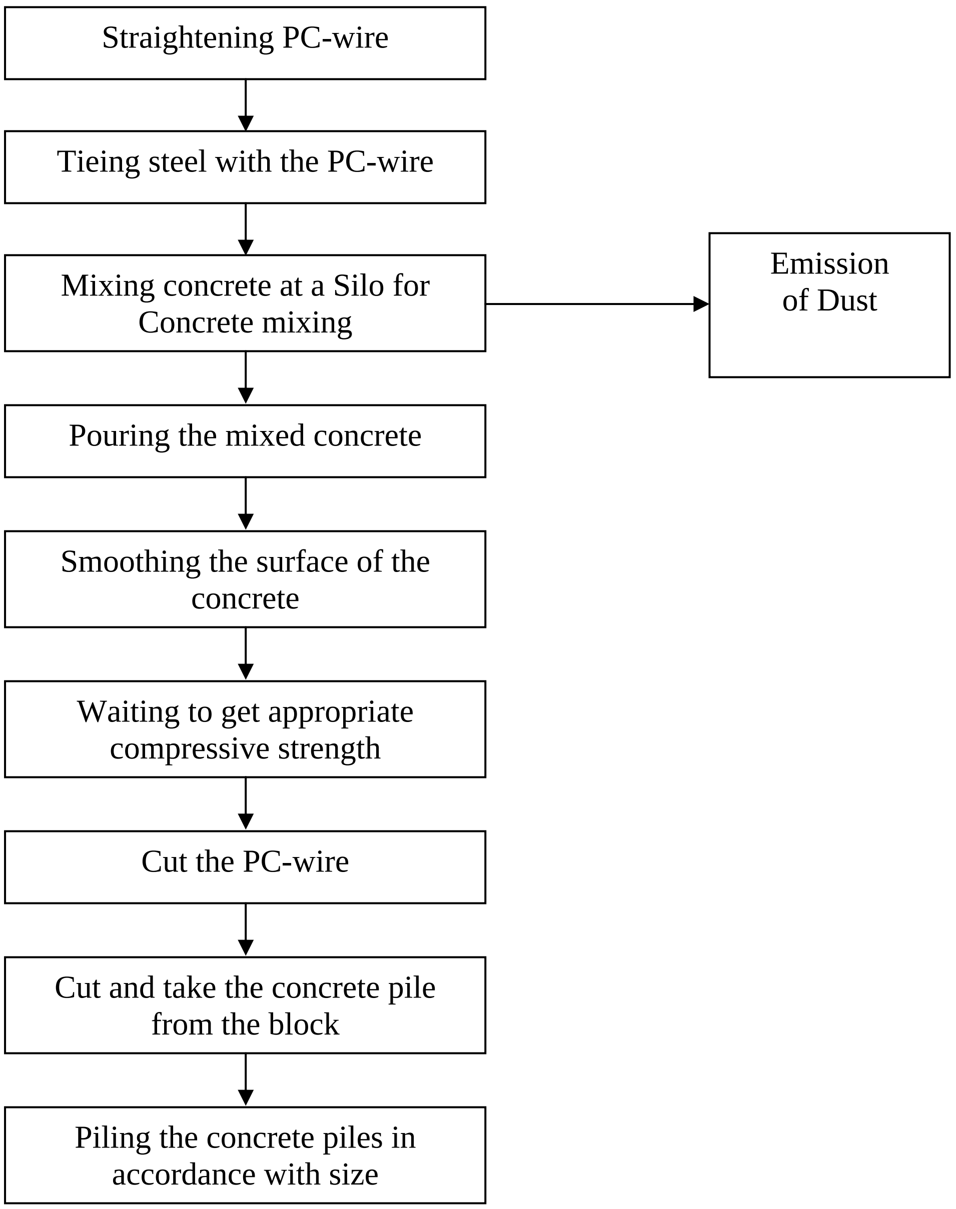


Figure 2-1 Process of Concrete Pile Production

Source : Concrete Productive Materials Co.,Ltd.,2010

2.1.3 The quantity of concrete piles produced

The company produced approximately 350 cubic metres a day or about 720 piles a day by using about 128 tons of mixing concrete a day. The concrete mixing was done in 3 silos and the number of concrete piles produced per day are as follows.

Silo 1 produced about 150 cubicmetres/day and used cement about 56 tons
Silo 2 produced about 147 cubicmetres/day and used cement about 54 tons
Silo 3 produced about 50 cubicmetres/day and used cement about 18 tons.

2.1.4 Results of total dust concentration in 2009

The company earrired the Workplace's environment monitoring on May 11,2009. The mornitoring was done by C.T. Environment And Chemical Company Ltd. The results are presented in Table 2-1.

Table 2-1 The results of total dust concentrations in 3 sampling site of Concrete Productive Materials Co.,Ltd., in May 11,2009.

Sampling Data	Sampling site	Unit	Total dust (8 hr. average)	Standards [1/] (8 hr. average)	Note [2/]
11/5/2009	Processing Platform 3	mg/m^3	2.5	15	✓
11/5/2009	Mill for concrete mixing	mg/m^3	0.833	15	✓
11/5/2009	Workers' Residence No.4	mg/m^3	3.333	15	✓

Source: [1/] Announcement of the Ministry of Interior B.E. 2520 regarding "Safety Work in Relating to Environment (Chemical Substance)

[2/] ✓ = agreed with the Quality Standards

2.2 Air pollution

Air pollution refers to the condition that the air is contaminated with a high concentration of toxic substances for a long period of time that can produce adverse effects to health of human-beings, animals, plants, and various materials (6). Those substances may be elements or compounds that occurred naturally or man-made. They could be found in the form of gas, liquid, or solid. The important air pollutants were total suspended particulate (TSP), PM-10 and PM 2.5, lead (Pb), carbondioxide (CO_2), sulphurdioxide (SO_2), oxide of nitrogen (NO_x) and ozone (O_3). The sources of air pollutants are 2 types, the natural sources and man-made sources. The natural sources, this type of sources produce air pollutants through the natural process, without intervention of human-beings, for example, the explosion of a volcano, forest fire, sea and ocean which are the sources of salt vapor, etc. For the man-made sources, they include transportation, industry, and agriculture, etc. which cause the wide spreading of air pollutants (6).

2.3 Dust

According to the definition, dust means "dried soil or a very fine powder". And for "Mist", it refers to "a very fine powder or particle". According to the environmental science concept, dust refers to solid or liquid particles with the diameter of 0.3-100 micrometre that spread widely in the atmosphere, for example, ash dust, metal dust, carbon dust, etc (6).

2.3.1 Types of Dust. Dust can be divided in accordance with its size as follows:

1) Repairable dust is the dust with the size equal to or less than 10 micrometers and less, which can penetrate into the lower respiratory tract.

2) Total dust is the dust with the size equal to or less than 100 micrometers.

2.3.2 Air Quality Standards. The air quality standards in working atmosphere set by various organizations as shown in Table 2-2.

Table 2-2 Air quality standards in working atmosphere for the whole working period

Organization	Total Dust size of 100 micrometers and less	Respirable Dust size of 10 micrometers and less
Thailand [1]	15 mg/m^3	5 mg/m^3
OSHA [2]	15 mg/m^3	5 mg/m^3
US.EPA [3]	15 mg/m^3	5 mg/m^3
ACGIH [4]	15 mg/m^3	5 mg/m^3

[1] Announcement of the Ministry of Interior B.E. 2520 regarding "Safety Work in Relating to Environment (Chemical Substance)

[2] Occupational Safety and Health Administration, Code of Federal Regulations in United States Government Title 29, Chapter XVII, Part 1910, Subpart Z, Section 1910.1000

[3] Environmental Protection Agency USA.

[4] American Conference of Government Industrial Hygienist

Source: Department of Health, Ministry of Public Health, 2000

2.4 Effects of dust on health

Dust affected people's health in many aspects and the body organs that are frequently affected by dust are eyes, skin and respiratory tract system because these organs exposed directly to dust, for example, eating food and drinking water containing toxin-contaminated dust will cause diseases of the digestive system, inhaling dust or consuming food and water contaminated with lead will cause lead poisoning of the nervous system, or if the dust covered or darkened visibility, it may cause depress which will lead to stress, etc. However, the most important effect is the problem of the respiratory system.

Dust in the atmosphere has different sizes (0.3-100 micrometres). Entering into various organs of the respiratory tract system and causing pathological conditions depend largely on the size of the dust. Dust particles size 0.3-6.0 micrometres can get into bronchi but the size of 0.5-2.5 micrometres can be at the lungs. The dust with the size less than 0.5 micrometres can float freely in and out of the lung while the person is breathing. The larger dust will be filtered at the nose while the smaller ones can penetrate through and are dangerous to the organs where the dust deposit. At first, the dust will cause irritation that may lead to infection. Some may cause allergy. Contacting a large quantity of dust for a long period of time will lower body's immunity as well (3).

Because nose and pharynx especially nose is the first station that has to contact dust so irritation is occured oftenly and sneeze and sore throat are oftenly followed. The dust that is as large as 10 micrometre and larger usually are found in this area. Most of the dust are caught by nose hair and the complicated nasal sinuses and will be excreted with nasal secretion. The person who contact dust regularly for a long period of time may have allergy.

The dust with the size equal to or less than 10 micrometres (PM-10) that can be suspended in the atmosphere for a long period of time can get into the deep area of the respiratory tract which will cause irritation of larynx and trachea which will cause itching-throat, cough, and hoarse voice. If the contact has been for a long period of time chronic infection will occur and may turn to cancer.

The very small dust (0.3-6 micrometres) can get into bronchi which may cause chronic bronchitis or pneumonia.

Pneumoconiosis may occur if there are too many disease-causing dust, for example, silica, asbestos, etc. This disease was oftenly found among the workers who work in some industrial factories, for example, stone-mill factory, break-pad production factory, etc.

2.5 Pulmonary function test

The pulmonary function test is designed to assess lung capacity and volume whereas these values will be the indicators describing characteristic and status of the lungs as well as of the respiratory mechanical system the important components of the pulmonary function test are presented as follows:

1) Volume. Volume is composed of 4 subparts as follows:

a) Tidal Volume (TV): is the amount of air that can be inhaled and exhaled normally, usually about 500 ml.

b) Inspiratory Reserve Volume (IRV): is the reserve amount of air that can get through a maximum inhalation after normal exhalation. This volume is about 3000 ml.

c) Expiratory Reserve Volume (ERV): is the reserve amount of air that can get through a maximum exhalation after normal inhalation. This volume is about 1100 ml.

d) Residual Volume (RV): is the amount of air left over in the lungs after a maximum exhalation. The volume is about 1200 ml. This volume will prevent immediate flat lungs.

2) Capacity. It is composed of the following types:

a) Total Lung Capacity (TLC): is the amount of all air after a maximum inhalation. This capacity is about 5,800-6,000 ml.(100%).

b) Vital Capacity (VC): is the maximum amount of air that can be exhaled after a maximum inhalation, which is composed of IRV + TV + ERV. This capacity is about 4,600-5,000 ml. (80%).

c) Inspiratory Capacity (IC): is the maximum amount of air that can be inhaled after a normal exhalation. This capacity is about 3,000-4,000 ml. (60%) and is composed of TV + IRV.

d) Function Residual Capacity (FRC): is the amount of air left over in the lungs after normal exhalation. This capacity is about 2,000 + 2,300 ml. (40%) and is composed of ERV + RV.

The various values derived from the measurement and test operated are the actual value. This value will be compared with the predicted value of that individual which will vary with age, body weight, and height. If the actual value is higher than ± 20 percent, it will be interpreted as “abnormal”. Besides, race is another important variable, for example, the predicted value of Thai people whose lung size is smaller than of American people with the same age, body weight and height. The predicted values of Thai males are as follows:

Forced Vital Capacity = -0.020 (age) + 0.049 (height) - 3.92 (2-1)

Forced Expiratory Volume Time = 0.023 (age) + 0.040 (height)-2.71 (2.2)

2.5.1 Spirometry and Pulmonary Function

Spirometry is the process of assessing pulmonary function by measuring the amount of air after exhalation. This value has been compared with the predicted value of each factor in regard to age, sex, weight, height. Another assessment is concerned with the testing of bronchostriction and the degeneration of pulmonary function in the forms or obstruction or restriction. The instrument used to assess pulmonary function is spirometer and the recording of the breathing movements from the spirometer is called a spirogram.

Spirogram is the graph resulting from the test using spirometer in which the graph will show the lung volume camparing with time. The components of spirogram are as follows:

1. The amount of air that can be exhaled completely after a maximum inhalation (Forced Vital Capacity, FVC) whereas this value is close to the value of Vital Capacity (VC).

2. The amount of air that can be exhaled quickly and strongly at a specific time of inhalation (Forced Expiratory Volume Time, FEV_1), for example, at the 1^{st}, 2^{nd}, 3^{rd} minute which are called FEV_1, FEV_2, FEV_3.

3. Forced Expiratory Volume/Forced Vital Capacity%, for example, FEV_1/FVC%, FEV_2/FVC%, FEV_3/FVC%, etc.

4. Forced Expiratory Flow (FEV), for example, Forced Expiratory Flow 25-75% (FEV 25-75%), which refers to the average speed within 25-75% of FVC.

5. Forced Expiratory Time (FET). This value is the time duration at the starting exhalation until stopping the flow or when the new inhalation is started. The unit of this value is second and normally, it is not longer than 6 seconds.

2.5.2 Interpretation of Pulmonary Function From Spirometry

The results of employing spirometry composed of 3 types: 1) normal, 2) abnormal, obstructive pattern, 3) abnormal, restrictive pattern. The detailed explanation of the abnormal functions are presented below:

1) Abnormal, obstructive pattern. This abnormal function characterized by having an obstruction of the airway that makes the airway becomes smaller. The obstruction may caused by inflammation or sputum, etc. The obstruction will lead to narrow airway and the air-flow rate will be lower.

2) Abnormal, restrictive pattern. This abnormal function caused by the decreased pulmonary capacity which may be due to the lack of elasticity of lung tissues and lead to smaller size of the lungs, along with the restriction of lung tissues. This condition produced the lower level of lung capacity comparing to the predicted value.

In regard to comparing the actual value for the interpretation of data, the comparison can be made with FEV_1/FVC, FEV 25-75%, and FVC whereby each researcher will use different comparable values. For Thai researchers, the values used are as follows (7):

- **Normal Function:**
  FVC $\geq$ 80% of the normal value
  FEV_1/FVC $\geq$ 80% of the normal value
- **Abnormal Function – Obstructive Pattern:**
  Low FEV_1/FVC show large airway obstruction
  Normal FEV_1/FVC and low FEV 25-75% show small
  Airway obstruction

Severity level of the abnormal function-obstructive pattern:

Low	FEV/FVC = 60-79%
Moderate	FEV/FVC = 40-59%
High	FEV/FVC = < 39%

- **Abnormal Function-Restrictive Pattern:**

  The comparable value was FVC < 80% of the normal value

Severity level of abnormality-restrictive pattern:

Low	FVC = 60-79%
Moderate	FVC = 40-59%
High	FVC < 40%

2.6 Related literature

Jawana, 1999 (8) studied the effects of dust on health of the people in the Na-pralarn Community, Saraburi Province. The results of the study showed that there was dust problem in the studied area whereas the concentration of PM_{10} in the atmosphere was exceeded the standard value of 0.12 mg/m^3. This condition was found to affect directly on health of the people resided in the sampling area and nearby. The morbidity rate of the people with the diseases of respiratory system in studied area was found to be higher than those of the people in the comparison area (4.7% compared to 0.5%, respectively) and this illness caused economic loss obviously.

Mongdee et al., 2003 (9), studied the prevalence of symptoms of respiratory tract illness and pulmonary function of students in industrial stone-mine and stone-mill areas in Saraburi Province. It was found that at the area of Napralarn School the range of concentration levels of the total dust (TSP) and, 24-hour average, in the atmosphere outside the buildings were 0.26-0.77 and 0.07-0.39 mg/m^3, respectively. The range of concentration levels of the total dust and the PM_{10}, 8-hour average, in the buildings were 0.49-1.22 and 0.32-0.69 mg/m^3 respectively. In Ban-Koktoom School, the range of concentration levels of the total dust and PM_{10}, 24-hour average, in the atmosphere outside the buildings were 0.04-0.12 and 0.03-0.1 mg/m^3 respectively while the rage of concentration levels of PM_{10}, 8-hour average, in the buildings were 0.03-0.2 mg/m^3. In regard to health data, it was found that among the students of Napralarn School, the significantly higher prevalence level of respiratory illness symptoms was found compared to the students of Ban-Koktoom School, in every symptom group. In regard to pulmonary function, the level of pulmonary function of students in Napralarn School was found to be significantly lower than those of the students in Ban-Koktoom School. The factors that were found to be significantly related with pulmonary function of students in the areas with and without industrial stone-mine or stone-mill factories were sex, age, body weight, height, and the distance between residence and stone-mine or stone-mill factories.

Boonpluang, 2004 (10) studied the effects of cement dust on pulmonary function : a case study of TPI Polene Public Company Limited. The study showed that the mean of the respirable dust concentrations for 8 hours average was 2.1823 ± 1.2186 mg/m^3 and the mean of the total dust concentrations for 8 hours average was 5.002 ± 2.7768 mg/m^3. A significant relationship between the total dust concentration and the respirable dust concentration was found and the relationship between the time of working in the cement company and their pulmonary function was also found to be statistically significant.

Poonkaew, 2009 (11) studied the estimation of the PM_{10} concentrations from the total dust : a case study, in the Tobacco Factory, Ministry of Finance. It was found that the concentration of TSP in every sampling area was different with uncertain pattern whereas the range of concentrations levels were between 0.48-13.65 mg/m^3 and the mean concentration value was 4.23 mg/m^3. In regard to the range of concentration levels of PM_{10}, the quite similar value was found in each sampling area which were between 0.03-2.69 mg/m^3 with the mean of 0.34 mg/m^3. A significant relationship was found between the concentration of TSP and PM_{10} ($p < 0.05$). In all sampling areas, the relationship between the concentration of TSP and PM_{10} was found with $R^2 = 0.2119$. The estimation of the concentration of PM_{10} could not be made from the concentration of TSP in every sampling area because there were other interfering variables that affected the dust concentration. Therefore, in order to watch closely the health of the factory workers, the Tobacco Factory should assess the dust concentration of PM_{10} instead of TSP.

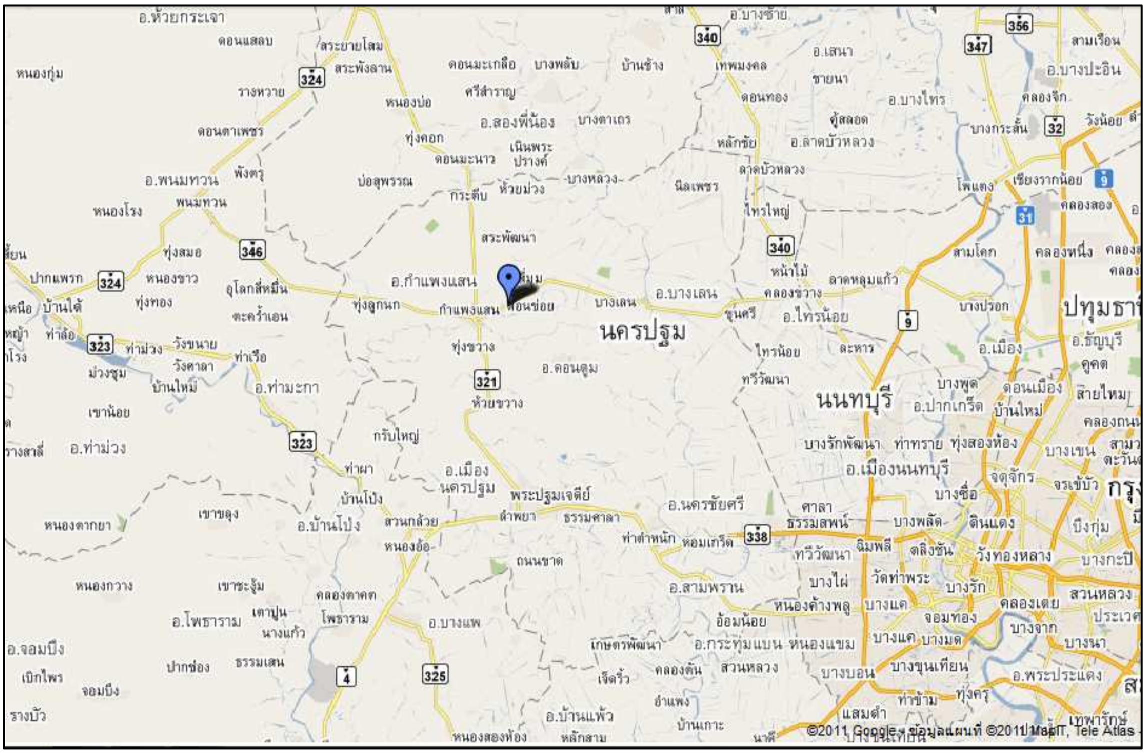
CHAPTER III

RESEARCH METHODOLOGY

3.1 Materials and methods

This section was divided into collection of data on air quality and on pulmonary function as follows:

3.1.1 Collection of dust samples. The samples of dust were collected from Concrete Productive Materials Co.,Ltd. Donkhoy Subdistrict, Kampaengsaen District, Nakhon Pathom Province. During January, February and March, 2010 which was the winter season. (see Figure 3-1)



Concrete Productive Materials Co.,Ltd.

Figure 3-1 Location of the Concrete Productive Materials Co.,Ltd. (12)

3.1.1.1 The sampling sites

The dust samples were collected from 6 sampling sites in accordance with the types of the factory workers' job characteristics in order to compare dust concentrations among each of the sampling sites of the concrete pile factory.
Those sampling sites are as follows:

- Sampling site 1 : Administration Office (see Figure 3-2)
- Sampling site 2 : Processing Platform 1(see Figure 3-3)
- Sampling site 3 : Processing Platform 3(see Figure 3-4)
- Sampling site 4 : Processing Platform 5(see Figure 3-5)
- Sampling site 5 : Silo for Cement Mixing 1(see Figure 3-6)
- Sampling site 6 : Silo for Cement Mixing 3(see Figure 3-7)

Figure 3-2 Sampling site 1 : Administration Office

Figure 3-3 Sampling site 2 : Processing Platform 1

Figure 3-4 Sampling site 3 : Processing Platform 3

Figure 3-5 Sampling site 4 : Processing Platform 5

Figure 3-6 Sampling site 5 : Silo for Cement Mixing 1

Figure 3-7 Sampling site 6 : Silo for Cement Mixing 3

Emission sources and sampling areas are shown in figure 3-8

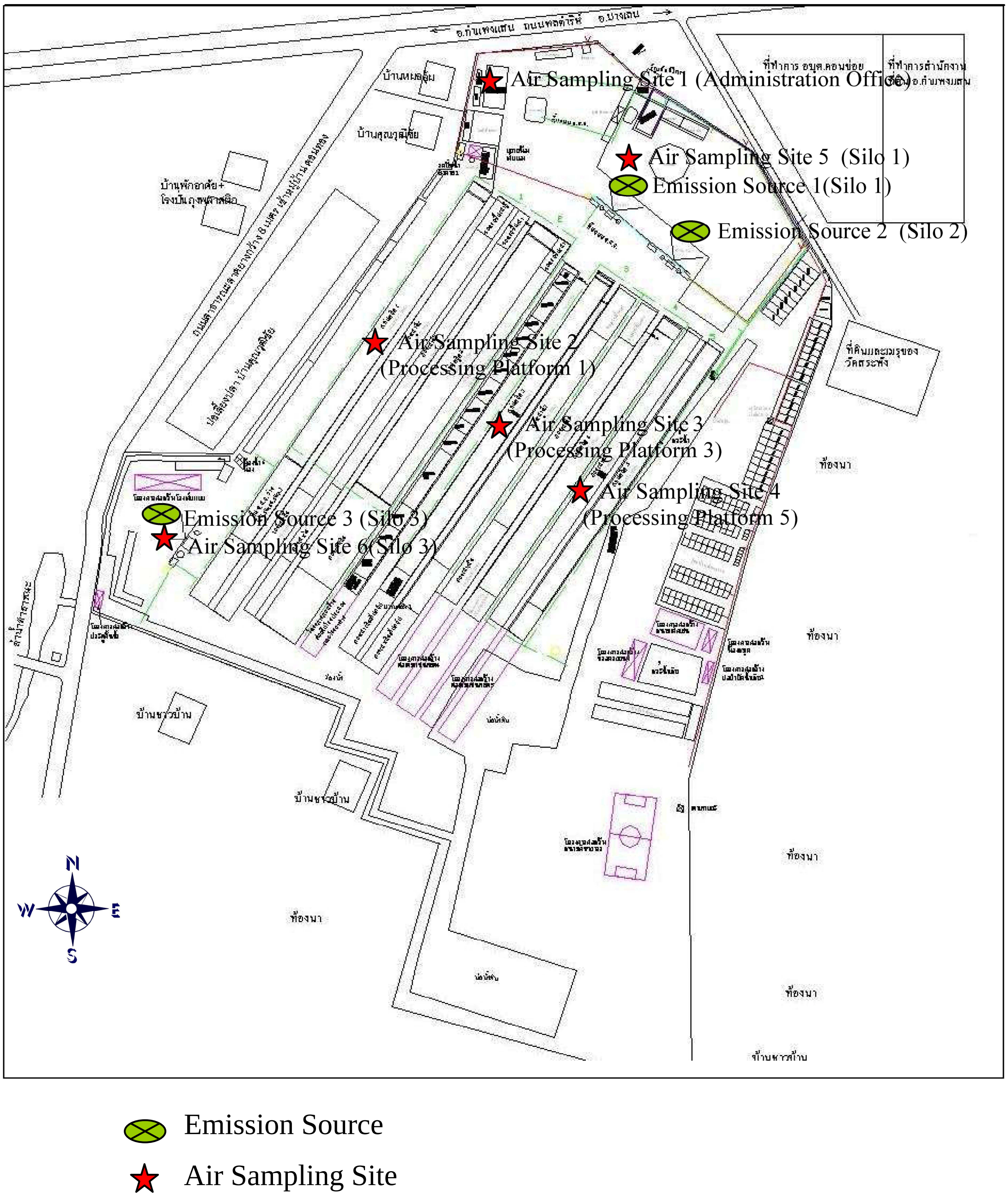


Figure 3-8 Location of emission sources and sampling sites

3.1.1.2 Sampling methods used for sample collection and analysis of the Total Dust and Respirable Dust (13) (14).

Total Dust. The sample of total dust was collected by using the air flowrate of 1 litre/minute and getting one single sample for full period (the time for collecting one sample was 8 hours), with the quantity of dust loading not higher than 2 milligrams (13).

Respirable Dust. The sample of respirable dust collected by using the air flowrate of 1.7 litres/minute (Nylon cyclone) and getting one single sample for full period (the time for collecting one sample was 8 hours), with the quantity of dust loading not higher than 2 milligrams (13).

(1) Equipment used for dust collection

1.Electronic scale for weigh the pre-weight, with the ability to weigh at 0.0001 gram.

2.Media for collecting total dust which is composed of 37 m.m.-diametere-PVC filter, with 5-micrometre-hole and a pad contained in the 3-layer-filter case.

3.Media for collecting respirable dust which is composed of 37 m.m.-diameter-PVC filter, with 5-micron-hole and a pad contained in the plastic case putting in the cyclone.

4.Orifice plugs

5.Glue paper for wrapping the filter case.

6.Vacuum pump that has been tested for its quality. (see Figure 3-9)

7.Adaptor between plastic line and the filter case, and approximately, 2-feet-rubber pipe.

8. One dull-end-forceps.

Figure 3-9 Apparatus for collection of dust samples

(2) Preparation of equipment for sample collection

1. Checking and setting the scale, to be ready to be used.

2. Weighing the filter after conditions it for at least 24 hours and recorded its weight.

3. The filter's weight recorded is called "Pre-weight".

4. Using the forceps to pick-up the cellulose pad and put it on the outlet of the filter.

5. Using the forceps to pick-up the filter gently from the dish of the scale and placed it on the pad.

6. Pressing the layers of the filter case together and then closed the orifice pump at the opening of the filter case at both sides.

7. Wrapping the filter case with the glue paper and write the sample number on the glue paper.

(3) Steps of collecting dust samples

1.Installing vacuum pump at the area where the dust sample will be collected.

2.Turning on the vacuum pump and let it run for at least 1 minute in order to check pressure. Then, turn off the pump before connecting it with the plastic line and the mediator used for collecting the samples (for collecting the respirable dust, the connection was done between the filter case and the plastic line with the cyclone set)

3.Installing the equipment for collecting dust samples by having the filter case moved down a little bit in a forward direction in order to prevent the blowing of dust into filter by the wind.

4.Opening the orifice plug at upper part of the filter case (the side that air can be inhaled), then turning on the pump.

(4) Analysis of the samples

1.Opening the orifice plugs at the upper and lower parts of the filter case and leave it in the desiccator for 24 hours.

2.Taking the filter out carefully from the case and do not let the dust to fall out from the filter.

3.Setting the scale to be ready to be used and it must be the same scale as the one used before getting the samples.

4.Weighing the filter.

5.Calculating the concentration of the total dust, as follows:

$$C = \frac{(W2 - W1)}{V} \text{ mg/m}^3$$

Where

	C	=	Concentration of the dust (mg/m^3)
	W1	=	The weight in the filter before collecting the sample (mg)
	W2	=	The weight of the filter after collecting the sample (mg)
	V	=	Total air volume (m^3)

3.1.2 Collection of data on pulmonary function

The collection of this part of information concerned with human-beings. In order to carry on this research project in accordance with the Ethical Committee on Research in Human Subject, the researcher carried on the data collection by making the announcement to recruit the volunteers who willing to join the research project. The researcher explained to the volunteers about research objectives, research procedures as well as their right. The interview was then followed and pulmonary function test was done with the samples.

3.1.2.1 Collection of data by employing questionnaire

The questionnaire used was composed of the questions in regard to : name of the respondent, age, sex, time duration of working, working area, residence, type of threats that have been exposed before taking this job, illness history, smoking history, working history, using of dust protection equipments, etc. The interview has been operated before testing pulmonary function. Only the workers who have worked in the sampled company for at least 1 year have been interviewed.

3.1.2.2 Pulmonary function test

The data on respondents' pulmonary function were collected from 125 workers who were selected purposively. This sampled group were those workers who have worked in the sampled areas in this factory for at least 1 year and the spirometer (see Figure 3-10) was used to test the samples. The personnel of Nakhon Pathom Hospital were kindly carried on pulmonary function test of the samples. Two major parts of the data were needed from pulmonary function test: the Static Test Vital Capacity, VC and the Dynamic Test Force Vital Capacity, FVC.

1) Primary Preparation. The person who was responsible for operating the pulmonary function test should possess basic knowledge about pulmonary function test and have to be willing to do the test as well as providing operation by doing the following preparations:

- The samples need to have a normal physical well-being, no signs and symptoms of respiratory tract infections which affect directly on pulmonary function as well as the illness that will affect the test which included heart disease and hypertension. Besides, the samples should not be at the post-operation period in which the pulmonary test will affect the post-operative wounds, for example, abdominal surgery, chest-surgery, dental surgery, etc.
- The samples should stop smoking before taking the pulmonary test for at least 1 hour.

- The samples should not consume food too much as to reach “very full” level before taking the test, for at least 1 hour.

- The samples must manage the foreign materials in their mouths, for examples, denture, tooth bending equipment,

- Explaining the samples about the methods to blow the air, breathing through mouth, positions while breathing, rhythm of performing proper blowing, in order to get the most reliable test result.

- Loosing the samples’ clothes in order to make them feel comfortable.

- Having the samples practiced inhaling and exhaling deeply and slowly for several times.

2) The Static Test Vital Capacity, VC. Starting the test by having the respondent made maximum inhalation and then exhaled slowly through the mouth-air-blower only until reaching all lung volume. Repeat the test for 1-2 times in order to get the best result.

3) The Dynamic Test Force Vital Capacity, FVC. After taking the Static Test Vital Capacity, the samples should take a rest for 1 minute before taking the Dynamic Test Vital Capacity. The samples were asked to take the deepest inhalation and then exhaled quickly and strangly through the mouth-air-blower until reaching all lung volume. Repeat the test for 1-2 times in order to get the best result (7).

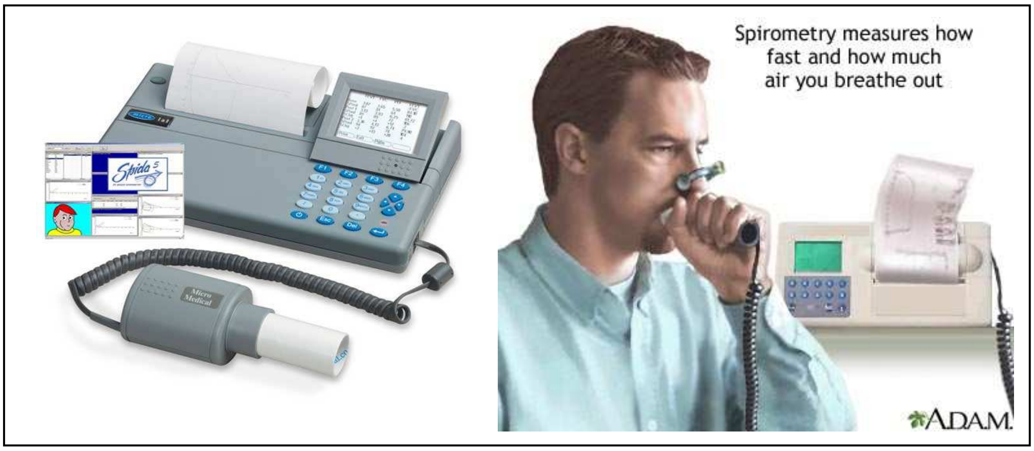


Figure 3-10 Spirometer

3.2 Quality control of the data

3.2.1 Calibrating the dust checking equipment and Spirometer in accordance with the using guideline of each equipment.

3.2.2 Reliability testing of the equipment used for collecting dust samples (6 equipment for collecting total dust and 6 equipment for collecting respirable dust), by installing all equipment at one area and then turned on and off the equipment at the same time. The measurement of dust concentration was then followed and compared. A t-test was used to test hypotheses in regard to the difference of dust concentration between the respirable dust and the total dust from all 6 equipments.

3.2.3 Questionaire. The questionaire was developed by the researcher by applying the lessons learned from related researches reviewed. The Questionaire concerned with general data, areas of residence, illness history related to respiratory tract system, working history and year, the use of dust protection equipment, and smoking history. The drafted Questionaire was checked by the thesis advisors and experts. The revised Questionaire was pretested with 30 workers working in the Ring Wire Cutting Section and the welders of the sampled factory. The Questionaire has been revised and prepared for the field study.

3.3 Data analysis

Statistical analysis was used for analyzing the collected data by the computer using Statistical Package for Social Science for Window (SPSS/FW).

The analysis was divided into 2 parts:

3.3.1 The samples' General Data. The presentation of data was made in Tables in regard to frequency, percentage, arithmetic mean, and standard deviation of the variables.

3.3.2 Analysis was made in regard to each measurement as follows:

3.3.2.1 Comparing the 8-hour-average concentrations of the total dust and the respirable dust from the 6 sampling areas with the standard concentration.

3.3.2.2 Finding the relationship between the concentrations of the total dust and the respirable dust by analysis of variance and correlation coefficient. Then, the Simple Linear Regression was employed in order to predict the concentration of the respirable dust from the concentration of the total dust.

3.3.2.3 Finding the relationship between personal characteristics, environmental factors and behaviors and the main indicators of pulmonary function test by comparing the variables regarding: age, smoking, time duration of working, residence, working history, history of illness related to respiratory tract infections, physical exercise, and the frequency of using dust protection equipment with the values of FEV_1 and FVC which were the indicators used for assessing pulmonary function. Multipleregression analysis was employed to test the mentioned relationship.

CHAPTER IV
RESULTS AND DISCUSSION

4.1 Concentration of TD and RD in 6 sampling sites

The results of this part were obtained from all 6 sampling sites in the concrete pile factory as follow : sampling site 1- Administration Office; sampling site 2 - Processing Platform 1; sampling site 3 – Processing Platform 3; sampling site 4 – Processing Platform 5; sampling site 5 – Silo 1; and sampling site 6 – Silo 3.

A total of 109 samples were collected from those 6 sampling sites as shown in Table 4-1 and Appendix B. The results showed that or TD concentrations did not exceed the standard concentration of 15 mg/m^3. In addition, it was found that the minimum concentration of 0.31 mg/m^3 , the maximum concentration of 5.00 mg/m^3 and the highest average value of 3.08 mg/m^3 were observed at Silo 1.

Table 4-1 The results of total dust concentrations from all 6 sampling sites

Areas of Air Sample Collection	Number of Samples	Total Dust Concentration (Average of 8 hours) (mg/m^3)				
		Minimum	Maximum	Range	Mean	Standard Deviation
Administration Office	4	0.90	1.20	1.30	0.99	0.13
Processing Platform 1	18	0.83	2.60	1.77	1.63	0.54
Processing Platform 3	22	1.13	3.75	2.60	2.70	0.71
Processing Platform 5	20	1.10	2.50	1.40	1.86	0.41
Silo 1	21	0.31	5.00	4.69	3.08	1.21
Silo 3	24	1.70	3.70	2.00	2.59	0.60

F = 13.313 df = 5 p-value = 0.000

The analysis of variance of the total dust concentrations showed that there was a significant difference between the mean of the total dust concentrations in each sampling sites (F = 13.313, df = 5, p-value = 0.000)

A total of 109 samples of air were collected from the 6 sampling sites during January – March 2010 as shown in the Table 4-2. The results showed that all

RD concentrations did not exceed the standard concentration of 5 mg/m^3. Moreover, the minimum concentration of 0.16 mg/m^3 was found at the Processing Platform 1, the maximum concentration of 2.50 mg/m^3 was found at the Silo 1 and the highest mean of 1.43 was found at Silo 3.

Table 4-2 The results of respirable dust concentrations from all 6 sampling sites

Areas of Air Sample Collection	Number of Samples	Respirable Dust Concentration (Average of 8 hours) (mg/m^3)				
		Minimum	Maximum	Range	Mean	Standard Deviation
Administration Office	4	0.37	1.00	0.63	0.58	0.29
Processing Platform 1	18	0.16	2.30	2.14	1.28	0.57
Processing Platform 3	22	0.25	2.20	1.95	1.12	0.50
Processing Platform 5	20	0.49	1.90	1.41	1.28	0.40
Silo 1	21	0.37	2.50	2.13	1.39	0.63
Silo 3	24	0.65	2.30	1.65	1.43	0.36

F=2.756 df=5 p-value=0.022

The analysis of variance of the respirable dust concentrations showed that there was a significant difference between the mean of the respirable dust concentrations in each sampling site (F = 2.756, df = 5, p-value = 0.022).

The results of the total dust concentrations and the respirable dust concentrations are compared and shown in Figure 4-1.

Dust concentration means in each sampling site (mg/m^3)

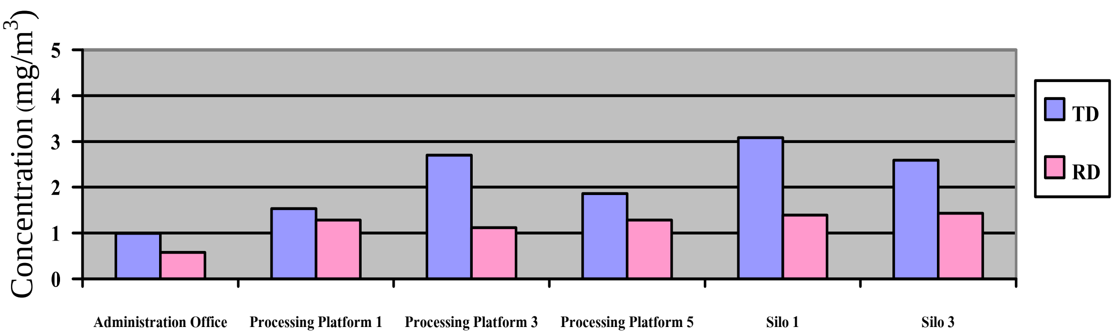


Figure 4-1 Means of 8–hour average TD and RD concentrations in each sampling site

4.2 The relationship between the total dust concentrations and the respirable dust concentrations

Pearson's Product Moment correlation coefficient test was employed to determine the relationship between the total dust concentrations and the respirable dust concentrations which were measured in the same day and at the same sampling site.

It was found that the sampling site where the significant relationship of the total dust concentrations and the respirable dust concentrations were found (p-value < 0.05) as follows : the Processing Platform 1 (p-value = 0.000); Processing Platform 5 (p-value = 0.000) ; and Silo 3 (p-value = 0.012). as shown in Table 4-3.

Table 4-3 Correlation coefficient between the total dust concentrations and the respirable dust concentrations at each sampling site

Sampling site	Correlation coefficient (r)	Sig.(2-tailed)	df
Administration Office	0.872	0.128	3
Processing Platform 1	0.869**	0.000	17
Processing Platform 3	0.116	0.607	21
Processing Platform 5	0.744**	0.000	19
Silo 1	0.046	0.842	20
Silo 3	0.504*	0.012	23

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

From the results of this analysis, the simple linear regression was employed in order to predict the respirable dust concentrations from the total dust concentrations at the Processing Platform 1, Processing Platform 5, and Silo 3 as shown in Table 4-4.

Table 4-4 Linear regression between the total dust concentrations and the respirable dust concentrations at processing platform1, processing platform5 and silo3

Sampled area	a	b	r	df
Processing Platform 1	-0.225	0.919	0.869	17
Processing Platform 5	-0.066	0.726	0.744	19
Silo 3	0.639	0.309	0.504	23

From the above a and b values, the linear regression equations are as follows:

Processing Platform 1: RD = 0.919 TD - 0.225

Processing Platform 5: RD = 0.726 TD - 0.066

Silo 3 : RD = 0.309 TD + 0.639

The concentrations of total dust and respirable dust did not show significant relationship in every sampling site because there might be some other are factors influencing the variation of dust concentrations e.g. emission source, wind direction, spraying water to reduce the spread of dust in each working area and the path of cars running conveyor concrete.

4.3 General characteristics and results of the pulmonary function test from the sampled workers

The samples of this study were factory workers whose jobs related to the production of cement pile, who have been working for 1 at least year and were grouped according to the sampling sites as follows: 24 workers at the Administration Office, 9 workers at the silos, and 92 workers at the Processing platforms. The data were presented as the following groups: general characteristics, illness history, work, history, smoking history, and data regarding physical exercise behavior as shown in Tables 4-5 to 4-9.

Results of the pulmonary function test obtained from the factory workers participated in the test are shown in Tables 4-10 and 4-11.

Table 4-5 Distribution of number and percentage of the samples by general characteristics

Detail	Samples			
	Number	**Percentage**	**Mean**	**Standard Deviation**
1. Number of samples	125	100	-	-
2. Age (year)	125	-	37.44	10.02
3. Sex				
Male	84	67.2	-	-
Female	41	32.8	-	-
4. Body weight (kg.)	125	-	62.14	12.83
5. Height (cm.)	125	-	163.61	89.59
6. Status				
Single	38	30.4	-	-
Married	77	61.6	-	-
Widowed	6	4.8	-	-
Separated	4	3.2	-	-
7. Education				
Illiteracy	5	4	-	-
Lower than Grade 4	3	2.4	-	-
Grade 4	13	10.4	-	-
Grade 5-6	54	43.2	-	-
Grade 7-9	54	43.2	-	-
Grade 10-12	16	12.8	-	-
Vocational certificate	5	4	-	-
Diploma	5	4	-	-
Bachelor/Postgrad	13	10.4	-	-
8. Location of residence				
In the factory	55	44	-	-
Outside the factory	70	56	-	-
9.Time in residence (year)	125	100	15.92	13.39

Table 4-6 Distribution of number and percentage of the samples by illness history to diseases and symptoms related to abnormality of respiratory tract system

Detail	Samples	
	Number	Percentage
1. Did you ever have been diagnosed as asthma or lung disease?		
No.	117	93.6
Yes. (Asthma)	6	4.8
Yes. (Tuberculosis)	2	1.6
2. Did you ever have a cough with thick sticky mucus?		
No.	91	72.8
Yes.	34	27.2
3. Did you ever have been coughing with blood?		
No.	121	96.8
Yes, once.	2	1.6
Yes, rarely.	1	0.8
Yes, often.	1	0.8
4. Did you ever have symptoms of respiratory tract such as asthma, breathless.etc?		
No.	105	84.0
Yes.	20	16.0
5. When did the symptoms occur?		
During working.	5	25
When it rains.	3	15
When expose to dust.	3	15
No.	9	45

Table 4-6 Distribution of number and percentage of the samples by illness history in regard to diseases and symptoms related to abnormality of respiratory tract system (cont.)

Detail	Samples	
	Number	Percentage
6. Did your members in the home / family ever have a symptom or respiratory diseases such as asthma, breathless, etc?		
Yes.	18	14.4
No.	98	78.4
Do not know.	9	7.2
7. Did your neighbors / roommate ever have a symptom or respiratory diseases such as asthma, breathless, etc?		
Yes.	12	9.6
No.	80	64.0
Do not know.	33	26.4
8. Did you ever have respiratory disorders when expose to dust?		
Respiratory discomfort:		
- Degree of discomfort		
None	60	48.0
Slightly.	50	40
Moderate.	15	12.0
- How often		
Very much.	0	0
None.	60	48.0
Rarely	47	37.6
Frequently.	15	12.0
Quite often.	3	2.4

Table 4-6 Distribution of number and percentage of the samples by illness history in regard to diseases and symptoms related to abnormality of respiratory tract system (cont.)

Detail	**Samples**	
	Number	**Percentage**
Suffocate:		
- Degree of suffocate		
None.	88	70.4
Slightly.	30	24.0
Moderate.	3	2.4
Very much.	4	3.2
- How often?		
None.	88	70.7
Rarely.	31	24.8
Quite often.	6	4.8

Table 4-7 Distribution of number and percentage of the samples by working history

Detail	**Samples**	
	Number	**Percentage**
1. Did you ever have been working in the area that expose to dust?		
No.	93	74.4
Yes.	32	25.6
2. For how long did you work in that area?		
1-5 years.	14	43.8
6-10 years.	16	50.0
More than 10 years.	2	6.3

Table 4-7 Distribution of number and percentage of the samples by working history (cont.)

Detail	Samples	
	Number	**Percentage**
3. Did you ever have been working in the environment that have incineration or smoke?		
No.	114	91.2
Yes.	11	8.8
4. For how long did you work in the place that have incineration or smoke?		
1-5 years.	3	27.3
6-10 years.	7	63.7
More than 10 years.	1	9.0
5. Did you ever have been working with chemical vapor/ metal fumes/ nuisance odor.?		
No.	112	89.6
Yes.	13	10.4
6. For how long did you work with chemical vapor /metal fumes/ nuisance odor?		
1-5 years.	6	46.1
6-10 years.	5	38.4
More than 10 years.	2	15.4
7. For how long have you been working in this company?		
1-5 years.	84	76.2
6-10 years.	24	19.2
More than 10 years.	17	13.6

Table 4-7 Distribution of number and percentage of the samples by working history (cont.)

Detail	Samples	
	Number	Percentage
8. When do you work? (which department?)		
Administration Office	24	19.2
Processing Platform 1	39	31.2
Processing Platform 3	36	28.8
Processing Platform 5	17	13.6
Silo1	6	4.8
Silo3	3	2.4
9. Do your working conditions need to expose to any of these?		
Dust	107	85.6
Chemicalท	10	8.0
Machinery	100	80.0
Loud noise	100	80.0
Smell of oil paint form.	78	62.4
10. Did you wear a dust protection N95?		
No.	29	23.2
Sometimes.	1	0.8
Wear other types.	94	75.2

Table 4-8 Distribution of number and percentage of the samples by smoking history

Detail	Samples			
	Number	**Percentage**	**Mean**	**Standard Deviation**
1. Do you smoke?				
No.	63	50.4	-	-
Yes.	48	38.4	-	-
Yes, but quit.	14	11.2	-	-
2. For how long (years) ?				
	62	100	7.22	9.73
3. Average number of cigarettes smoked (cigarettes / day).				
	62	100	4.78	6.12

Table 4-9 Distribution of number and percentage of the samples by physical exercise behavior

Detail	Samples			
	Number	**Percentage**	**Mean**	**Standard Deviation**
How often do you exercise ?				
No, never.	55	44.0	-	-
Exercise less than one hour per week.	25	20.0	-	-
Exercise more than 1 hour per week.	44	35.2	-	-
Exercise every day.	1	0.8	-	-

Table 4-10 Results of the pulmonary function test

Detail	Number	pulmonary function			
		Mean	**Standard Deviation**	**Minimum**	**Maximum**
Forced Vital Capacity, FVC	125	3.2645	0.81116	1.70	5.40
Forced Expiratory Volume Time, FEV_1	125	2.7878	0.70255	1.29	4.47
Forced Expiratory Ratio, FEV_1/FVC	125	99.60	6.005	82	114

Table 4-11 Results of the pulmonary function test according to the sampled working areas

Working areas	pulmonary function		Total
	normal	abnormal	
Administration Office	18	6	24
Processing Platgorm 1	30	9	39
Processing Platgorm 3	32	4	36
Processing Platgorm 5	15	2	17
Silo1	6	0	6
Silo3	2	1	3
Total	103	22	125

4.4 Comparison and relationship between independent variables and pulmonary functions

4.4.1 Results of the samples' pulmonary function test, the relationship with the degeneration of pulmonary function. The relationship analysis will be tested between independent variables and pulmonary functions obtained from questionnaire and the results of pulmonary function test.

Result of pulmonary function test according to working areas. The total of 125 samples from 6 sampling sites were collected which included the Administration Office, Processing Platform 1, Processing Platform 3, Processing Platform 5, Silo 1, and Silo 3. The pulmonary function test with the samples at the time before start working for 3 types of values were tested: Forced Vital Capacity (FVC), Forced Expiratory Volume Time (FEV_1), and Forced Expiratory Ratio (FEV_1/FVC).

The analysis of variance of pulmonary function according to working areas. No significant difference was found among the mean values of pulmonary function obtained from the 6 working areas in regard to Forced Vital Capacity (FVC), Forced Expiratory Volume Time (FEV_1) and Forced Expiratory Ratio (FEV_1/FVC) (p-value > 0.05). (Table 4-12).

Table 4-12 Comparison of mean values of pulmonary functions among all the sampled working areas

Pulmonary function values	Number of samples	Mean	Standard Deviation	Minimum	Maximum	F	d.f.	p-value
1.Force Vital Capacity, FVC						0.882	5	0.495
Administration Office	24	3.31	0.73	1.72	4.72			
Processing Platgorm 1	39	3.20	0.85	1.73	4.89			
Processing Platgorm 3	36	3.16	0.77	1.70	4.45			
Processing Platgorm 5	17	3.30	0.93	2.09	5.40			
Silo1	6	3.85	0.64	3.16	4.88			
Silo3	3	3.55	1.01	2.45	4.45			
2. Forced Expiratory Volume Time, FEV_1						0.582	5	0.714
Administration Office	24	2.82	0.63	1.39	4.09			
Processing Platgorm 1	39	2.78	0.75	1.59	4.34			
Processing Platgorm 3	36	2.71	0.68	1.29	3.95			
Processing Platgorm 5	17	2.74	0.72	1.81	4.47			
Silo1	6	3.18	0.57	2.54	4.06			
Silo3	3	3.08	1.15	1.92	4.23			
3. Forced Expiratory Ratio, FEV_1/FVC						1.080	5	0.375
Administration Office	24	98.63	5.84	89	110			
Processing Platgorm 1	39	100.54	6.40	87	112			
Processing Platgorm 3	36	100.50	6.47	82	114			
Processing Platgorm 5	17	98.29	4.47	90	107			
Silo1	6	96.00	4.38	91	104			
Silo3	3	99.00	5.19	96	105			

4.4.2 Relationship of degeneration between pulmonary function of the samples and dust concentrations. The results of total dust concentration and the respirable dust concentrations were determined for their relationship with the pulmonary function test results in regard to Forced Vital Capacity (FVC), Forced Expiratory Volume Time (FEV_1) and Forced Expiratory Ratio (FEV_1/FVC) by employing Pearson's Product Moment Correlation Coefficient test (Table 4-13).

Table 4-13 Correlation coefficient between the pulmonary functions and dust concentrations

Independent variable	Parameter	FVC	FEV_1	FEV_1/FVC
Average total dust concentration	Correlation Coefficient	0.024	0.008	0.023
	p-value	0.790	0.926	0.798
	Samples size	125	125	125
Average respirable dust concentration	Correlation Coefficient	0.013	0.013	0.042
	p-value	0.882	0.888	0.640
	Samples size	125	125	125

The results of analysis showed that the correlation coefficient of the total dust concentrations and the respirable dust concentrations did not relate significantly with the pulmonary functions measured in regard to Forced Vital Capacity (FVC), Forced Expiratory Volume Time (FEV_1), and Forced Expiratory Ratio (FEV_1/FVC).

The reason for relationship between the dust concentrations and pulmonary functions did not relate significantly might be due to the concentration levels of the total dust and respirable dust were too low in the studied areas.

4.4.3 Relationship of degeneration of pulmonary function of the samples and their general characteristics. The relationship between pulmonary functions and the samples' general characteristics was tested by computing correlation coefficient (ρ) of the independent variables, through the use of Pearson Correlation test (Table 4-14).

Table 4-14 Correlation coefficient between the pulmonary functions and the independent variables

Independent variable	Parameter	FVC	FEV_1	FEV_1/FVC
Age (year)	Correlation Coefficient	-0.341**	-0.458**	0.133
	p-value	0.000	0.000	0.138
	Samples size	125	125	125

Table 4-14 Correlation coefficient of the quantitative data (cont.)

Independent variable	Parameter	FVC	FEV_1	FEV_1/FVC
Body weight (kg.)	Correlation Coefficient	0.295**	0.277**	-0.077
	p-value	0.001	0.002	0.395
	Samples size	125	125	125
Height (cm.)	Correlation Coefficient	0.752**	0.734**	-0.159
	p-value	0.000	0.000	0.077
	Samples size	125	125	125
Duration of smoking (years)	Correlation Coefficient	0.219*	0.108	-0.178*
	p-value	0.014	0.229	0.047
	Samples size	125	125	125
The average number of cigarettes smoked per day (Roll)	Correlation Coefficient	0.407**	0.320**	-0.210*
	p-value	0.000	0.000	0.019
	Samples size	125	125	125
Period of work in this factory (years)	Correlation Coefficient	-0.226*	-0.239**	0.176
	p-value	0.011	0.007	0.050
	Samples size	125	125	125
Time worked in dusty before (years)	Correlation Coefficient	0.053	0.009	-0.003
	p-value	0.558	0.923	0.712
	Samples size	125	125	125
Time worked with smoke before (years)	Correlation Coefficient	-0.009	-0.046	-0.066
	p-value	0.923	0.611	0.464
	Samples size	125	125	125
Time worked With chemical vapor before (years)	Correlation Coefficient	0.074	-0.015	-2.238**
	p-value	0.414	0.867	0.008
	Samples size	125	125	125

** correlation is significant at the 0.01 level (2-tailed)

* correlation is significant at the 0.05 level (2-tailed)

The results of analysis showed that there was a significant correlation between the general characteristics with regard to age, body weight, height, and the values of Forced Vital Capacity (FVC) and Forced Expiratory Volume Time (FEV_1) which was the expected relationship because in computing the predicted value of pulmonary function, age and height were the variables used for computation.

The relationships which were beyond the expected variables and had the significant relationships were found as follows: time duration of smoking related significantly with Forced Vital Capacity (FVC) and Forced Expiratory Ratio (FEV_1/FVC), p-value = 0.014 and 0.047 respectively; number of cigarettes smoked per day related significantly with all 3 values of pulmonary function tested, Forced Vital Capacity (FVC) (p-value = 0.000), Forced Expiratory Volume Time (FEV_1) (p-value = 0.000), and Forced Expiratory Ratio (FEV_1/FVC) (p-value = 0.019); time duration of working with this factory related significantly with Forced Vital Capacity (FVC) (p-value = 0.011) and Forced Expiratory Volume Time (FEV_1) (p-value = 0.007); and time duration of working in the polluted area contaminated with chemical vapor before related significantly with Forced Expiratory Ratio (FEV_1/FVC) (p-value = 0.008).

The relationship between pulmonary function with the duration of smoking and the average number of cigarettes smoked per day. The result of the data analysis showed that there were a significant correlations as follows: duration of smoking for at least 20 years was related significantly with Force Expiratory Volume Time (FEV_1) (p-value = 0.049); number of cigarettes smoked (11-15 rolls per day) was related significantly with Forced Expiratory Ratio (FEV_1/FVC) (p-value =0.026).See Table 4-15, Table 4-16.

Table 4-15 Correlation coefficient of the pulmonary function with duration of smoking

Duration of smoking	Parameter	FVC	FEV_1	FEV_1/FVC
1-10 years	Correlation Coefficient	0.246	0.175	0.015
	p-value	0.207	0.374	0.941
	Samples size	28	28	28
11-20 years	Correlation Coefficient	-0.321	-0.408	-0.090
	p-value	0.145	0.059	0.689
	Samples size	22	22	22
20 years and longer	Correlation Coefficient	-0.566	-0.578*	0.239
	p-value	0.055	0.049	0.455
	Samples size	12	12	12

* correlation is significant at the 0.05 level (2-tailed)

Table 4-16 Correlation coefficient of the pulmonary function with the average number of cigarettes smoked per day (roll)

The average number of cigarettes smoked per day (roll)	Parameter	FVC	FEV_1	FEV_1/FVC
1-5 rolls per day	Correlation Coefficient	-0.108	-0.193	-0.158
	p-value	0.752	0.570	0.642
	Samples size	11	11	11
6-10 rolls per day	Correlation Coefficient	-0.059	-0.097	0.033
	p-value	0.728	0.570	0.848
	Samples size	37	37	37
11-15 rolls per day	Correlation Coefficient	0.673	0.571	0.192
	p-value	0.327	0.429	0.808
	Samples size	4	4	4
15 rolls and more per day	Correlation Coefficient	-0.281	-0.155	0.694*
	p-value	0.431	0.669	0.026
	Samples size	10	10	10

* correlation is significant at the 0.05 level (2-tailed)

When the Simple Linear Regression was done for the independent variables that related significantly with pulmonary functions (p-value < 0.05), those independent variables were age, body weight, height, time duration of smoking, number of cigarettes smoking per day, time duration of working in this factory. The results of the linear regression equations obtained were as follows:

Forced Vital Capacity (FVC)

$$FVC = -0.20\ X_1 – 0.003\ X_2 + 0.058\ X_3 + 0.001\ X_4 + 0.035\ X_5 + 0.006\ X_6 -5.519$$

$$FEV_1 = -0.027\ X_1 + 0.002\ X_2 + 0.048\ X_3 + 0.24\ X_5 + 0.011X_6 – 4.192$$

Where

X_1 = Age (year)

X_2 = Body weight (kg.)

X_3 = Height (cm.)

X_4 = Time duration of smoking (yr.)

X_5 = Number of cigarettes per day (roll)

X_6 = Time of working in this sampled factory (yr.)

4.4.4 Relationship of degeneration of pulmonary functions of the independent variable data from sampled workers. The data collected from questionnaire had been tested their relationship with the results from pulmonary functions test which were divided into normal and abnormal functions. Chi-square test was used for testing the relationship because the independent variables were the qualitative variables or group variables.

The independent variables that may affect the pulmonary functions which were dependent variables were as follows: present residence, history symptoms of the illness's related to pulmonary diseases, working history and job characteristics, and physical exercise.

4.4.4.1 Residence. Residence refers to the place where the respondent stayed while working in the factory, which was divided into 2 types-in the factory and outside the factory. The relationship test showed that there was no significant relationship between the present residence and pulmonary function (X^2 = 1.608, df = 1, p-value = 0.243). See Table 4-17.

Table 4-17 Relationship between pulmonary functions and location of present residence

Independent variable	Normal		Abnormal		X^2	d.f.	p-value
	Number of samples	Percent	Number of samples	Percent			
Residence					1.608	1	0.243
In the factory	48	38.4	7	5.6			
Outside the factory	55	44	15	12			

4.4.4.2 History of the symptoms of pulmonary-related diseases. These factor included asthma, pulmonary disease, cough with thick sputum, bloody cough, symptoms of respiratory tract system, family members had ever been sick with or had symptoms of respiratory tract diseases, neighbor or room-mate had ever been sick with or had symptoms of respiratory tract diseases.

The p-values of the results of the relationship test of every factor regarding history of the symptoms of pulmonary-related disease were found to be > 0.05. Therefore, it could be concluded that there was no significant relationship between the factors regarding history of the symptoms of pulmonary-related diseases and pulmonary function (Table 4-18).

Table 4-18 Relationship between pulmonary function and history of the symptoms of pulmonary-related diseases

Independent variable	Normal		Abnormal		X^2	d.f.	p-value
	Number of samples	Percent	Number of samples	Percent			
Diagnosed as asthma or lung disease					2.621[a]	2	0.270
No.	98	78.4	19	15.2			
Yes. (Asthma)	4	3.2	2	1.6			
Yes. (Tuberculosis)	1	0.8	1	0.8			
Cough with thick sticky mucus.					0.288[a]	1	0.592
No	76	60.8	15	12			
Yes	27	21.6	7	5.6			

Table 4-18 Relationship between pulmonary functions and history of the symptoms of pulmonary-related diseases (cont.)

Independent variable	Normal		Abnormal		X^2	d.f.	p-value
	Number of samples	Percent	Number of samples	Percent			
Coughing with blood					0.883[a]	3	0.830
No.	99	79.2	22	17.6			
Once.	2	1.6	0	0			
Rarely.	1	0.8	0	0			
Often.	1	0.8	0	0			
Symptoms of respiratory tract diseases					0.899[a]	1	0.343
No	88	70.4	17	13.6			
Yes	15	12	5	4			
Members in the home / family with a symptom of respiratory diseases					3.947[a]	2	0.139
Yes	12	9.6	6	4.8			
No	84	67.2	14	11.2			
Do not know	7	5.6	2	1.6			
Neighbors / roommate with a symptom of respiratory diseases					1.123[a]	2	0.570
Yes	9	7.2	3	2.4			
No	68	54.4	12	9.6			
Do not know	26	20.8	7	5.6			

4.4.4.3 Working history and job characteristics which included: ever worked in the place where there was dust; ever worked in the place where there was smoke; ever worked in the place where there was chemical vapor; working location/area, using of a mask to prevent dust.

The p-values of the results of the relationship test of every factor regarding working history and job characteristics was found to be > 0.05. Therefore, it could be concluded that there was no significant relationship between working history and job characteristics and pulmonary function (Table 4-19).

Table 4-19 Relationship between pulmonary function and working history and job characteristics

Independent variable	Normal		Abnormal		X^2	d.f.	p-value
	Number of samples	Percent	Number of samples	Percent			
Had worked in other industry before					3.218[a]	8	0.920
No	75	60	18	14.4			
Yes (Pile)	11	8.8	1	0.8			
Yes (Sewing)	4	3.2	1	0.8			
Yes (Construction)	5	4	2	1.6			
Yes (Animal feed)	1	0.8	0	0			
Yes (Furniture)	2	1.6	0	0			
Yes (Woven sacks)	3	2.4	0	0			
Yes (Steel plant)	1	0.8	0	0			
Yes (Plastic plant)	1	0.8	0	0			
Working environment with incineration or smoke					0.254[a]	2	0.881
No	94	75.2	20	16			
Yes (incineration)	1	0.8	0	0			
Yes (Smoke)	8	6.4	2	1.6			
Worked with chemical vapor/ metal fumes/ nuisance odor					2.750[a]	3	0.432
No	91	72.8	21	16.8			
Yes (chemical vapor)	8	6.4	0	0			
Yes (Odor nuisance)	2	1.6	0	0			
Yes (fume)	2	1.6	1	0.8			
Present working area					4.951[a]	5	0.422
Administration Office	18	14.4	6	4.8			
Processing Platgorm 1	30	24	9	7.2			
Processing Platgorm 3	32	25.6	4	3.2			
Processing Platgorm 5	15	12	2	1.6			
Silo1	6	4.8	0	0			
Silo3	2	1.6	1	0.8			
Wear a dust protection N95					0.640[a]	3	0.887
No	23	18.4	6	4.8			
Sometimes	1	0.8	0	0			
Often	1	0.8	0	0			
Other types	78	62.4	16	12.8			

4.4.4.4 Physical exercise which included: never practiced physical exercise; practice physical exercise less than 1 hour/week, practiced physical exercise longer than 1 hour/week, practiced physical exercise every day. No significant relationship was found between physical exercise and pulmonary function, X^2 = 5.496, df = 3, p-value = 0.139 (Table 4-20).

Table 4-20 Relationship between pulmonary function and physical exercise

Independent variable	Normal		Abnormal		X^2	d.f.	p-value
	Number of samples	Percent	Number of samples	Percent			
Exercise					5.496	3	0.139
No	49	39.2	6	4.8			
Exercise less than one hour per week.	17	13.6	8	6.4			
Exercise more than 1 hour per week.	36	28.8	8	6.4			
Exercise every day.	1	0.8	0	0			

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

This research was aimed to determine the concentration levels of the total dust (TD) and respirable dust (RD) in the working areas of Concrete Productive Materials Co.,Ltd. and to study the relationship between the pulmonary function and various related factors with regard to concentrations of the total dust and of the respirable dust, work history, time duration of working in this company, working areas, using of dust protection equipment, illness history with respiratory tract infection,location of residence, smoking, and physical exercise. All of these data were collected directly from the sampled workers in the factory.

Pulmonary function test and data collected by using questionnaire were determine as follow: pulmonary function test was administered with the samples of the workers who have worked in the sampled factory for at least 1 year and were working either at the Administration Office or Silos or Processing Platforms. The samples were asked to answer the questionnaire for collecting the related data follow the pulmonary function test.

5.1 Conclusions

5.1.1 The 8-hour average total dust (TD) and respirable dust (RD) concentrations of all 218 workplace air samples (109 samples each) collected from 6 sampling sites, i.e, Administration office, Processing platform 1, Processing platform 3, Processing platform 5, Silo 1 and Silo 3 did not exceed the OSHA workplace air standards of 15 mg/m^3 in TD and 5 mg/m^3 in RD.

5.1.2 The range of 8-hour average concentrations at Administration office, Processing platform 1, Processing platform 3, Processing platform 5, Silo 1 and Silo 3 for TD varied from 0.90–1.20, 0.83–2.60, 1.13–3.75,1.10–2.50, 0.31–5.00,1.70-3.70 mg/m^3, respectively and RD varied from 0.37-1.00, 0.16-2.30, 0.25-2.20,0.49-1.90, 0.37-2.50, 0.65-2.30 mg/m^3, respectively.

5.1.3 There were significant relationships between TD and RD concentrations (p-values < 0.05) at 3 studied areas,i.e., Processing platform 1 (r=0.869), Processing platform 5 (r=0.744) and Silo 3 (r=0.504)

5.1.4 The concentration of RD can be estimated from The concentration of TD at 3 studied areas, i.e., Processing platform 1, Processing platform 5 and Silo 3 by using the following simple linear regression equations : RD = 0.919TD – 0.225, RD = 0.726TD – 0.66, RD = 0.309TD + 0.639, respectively.

5.1.5 There were 22 workers showed abnormal pulmonary function from a total of 125 workers participated in this study from all 6 studies areas.

5.1.6 The related factors that showed significant relationship with pulmonary function (p-values < 0.05) were as follows : time duration of smoking, number of cigarettes smoked per day, time duration of working in this factory and working in other factory.

5.1.7 The correlation coefficient of the TD and RD concentrations did not relate significantly with the pulmonary functions. This might be due to the concentration levels of TD and RD were too low in the studied areas.

5.2 Recommendations

From the aforementioned results of the study, the recommendations could be made in order to reduce the impact from the factors related to the degeneration of pulmonary function of concrete pile factory workers and for further studies as follows:

1. From the interview, workers 90% have recommend to the company that it should reduce the spread of dust in working areas. The working environment should be improved in order to reduce the wide spread of dust by applying engineering principles, for example, the control of the concrete mixing at silos to prevent the wide spread of dust, 5 S_s principles in regard to storages and cleansing the working areas, availability of water-container-can that can water the ground for preventing dust spreading, and control the speed of the cars using for moving concrete piles which is one cause of dust spreading. Besides, dust concentration, both for the total dust and respirable dust, must be monitored at least twice a year in accordance with the law. If

the dust concentration exceed the standard value, searching for causes and solutions must be made urgently.

2. Training program and public relations activities should be organized for the workers in order to help them gain adequate knowledge and understand the factors affected pulmonary function, rules and regulations about safe working, including the provision of appropriate and effective dust-protection equipment for workers working in the areas with high level of dust concentration, for example, Silo, etc. The training should be made in regard to the effective methods for using dust-protection equipment as well as managing the workers to use those equipment all the time while they were working. Besides, stop-smoking campaign should be organized since smoking was one factor related significantly to pulmonary function.

3. The workers who exposed to dust should receive pulmonary function test regularly once a year and get lung x-ray as prescribed by doctors in order to carry on a health surveillance program for workers. However, the pulmonary function test should not be done too quickly which may lead to false results. The factory should have a policy of providing 1 day for pulmonary function test.

4. The collection of the dust samples was carried out during January to March, the duration of 3 months, which was the winter time that the highest level of dust concentration was expected. But these dust samples could not represent the average dust concentration of the whole year. Thus, for the next research project, the dust samples should be collected for the whole year in order to get the real average dust concentration of that factory.

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APPENDICES

APPENDIX A

NIOSH MANUAL OF ANALYTICAL METHODS (NMAM)

1A. METHOD: 0500

PARTICULATES NOT OTHERWISE REGULATED, TOTAL 0500

DEFINITION: total aerosol mass CAS: NONE RTECS: NONE

METHOD: 0500, Issue 2 **EVALUATION: FULL** **Issue 1: 15 February 1984**
Issue 2: 15 August 1994

OSHA: 15 mg/m³
NIOSH: no REL
ACGIH: 10 mg/m³, total dust less than 1% quartz

PROPERTIES: contains no asbestos and quartz less than 1%

SYNONYMS: nuisance dusts; particulates not otherwise classified

SAMPLING		MEASUREMENT	
SAMPLER:	FILTER (tared 37-mm, 5-µm PVC filter)	**TECHNIQUE:**	GRAVIMETRIC (FILTER WEIGHT)
FLOW RATE:	1 to 2 L/min	**ANALYTE:**	airborne particulate material
VOL-MIN: -**MAX:**	7 L @ 15 mg/m³ 133 L @ 15 mg/m³	**BALANCE:**	0.001 mg sensitivity; use same balance before and after sample collection
SHIPMENT:	routine	**CALIBRATION:**	National Institute of Standards and Technology Class S-1.1 weights or ASTM Class 1 weights
SAMPLE STABILITY:	indefinitely	**RANGE:**	0.1 to 2 mg per sample
BLANKS:	2 to 10 field blanks per set	**ESTIMATED LOD:**	0.03 mg per sample
BULK SAMPLE:	none required	**PRECISION ($\bar{s}_r$):**	0.026 [2]

ACCURACY	
RANGE STUDIED:	8 to 28 mg/m³
BIAS:	0.01%
OVERALL PRECISION ($\hat{S}_{rT}$):	0.056 [1]
ACCURACY:	±11.04%

APPLICABILITY: The working range is 1 to 20 mg/m³ for a 100-L air sample. This method is nonspecific and determines the total dust concentration to which a worker is exposed. It may be applied, e.g., to gravimetric determination of fibrous glass [3] in addition to the other ACGIH particulates not otherwise regulated [4].

INTERFERENCES: Organic and volatile particulate matter may be removed by dry ashing [3].

OTHER METHODS: This method is similar to the criteria document method for fibrous glass [3] and Method 5000 for carbon black. This method replaces Method S349 [5]. Impingers and direct-reading instruments may be used to collect total dust samples, but these have limitations for personal sampling.

EQUIPMENT:

1. Sampler: 37-mm PVC, 2- to 5-µm pore size membrane or equivalent hydrophobic filter and supporting pad in 37-mm cassette filter holder.
2. Personal sampling pump, 1 to 2 L/min, with flexible connecting tubing.
3. Microbalance, capable of weighing to 0.001 mg.
4. Static neutralizer: e.g., Po-210; replace nine months after the production date.
5. Forceps (preferably nylon).
6. Environmental chamber or room for balance (e.g., 20 °C ± 1 °C and 50% ± 5% RH).

SPECIAL PRECAUTIONS: None.

PREPARATION OF FILTERS BEFORE SAMPLING:

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h.
   NOTE: An environmentally controlled chamber is desirable, but not required.
2. Number the backup pads with a ballpoint pen and place them, numbered side down, in filter cassette bottom sections.
3. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight, W_1 (mg), and the mean laboratory blank tare weight, B_1 (mg).

a. Zero the balance before each weighing.

b. Handle the filter with forceps. Pass the filter over an antistatic radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.

4. Assemble the filter in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette. Place a cellulose shrink band around the filter cassette, allow to dry and mark with the same number as the backup pad.

SAMPLING:

5. Calibrate each personal sampling pump with a representative sampler in line.
6. Sample at 1 to 2 L/min for a total sample volume of 7 to 133 L. Do not exceed a total filter loading of approximately 2 mg total dust. Take two to four replicate samples for each batch of field samples for quality assurance on the sampling procedure.

SAMPLE PREPARATION:

7. Wipe dust from the external surface of the filter cassette with a moist paper towel to minimize contamination. Discard the paper towel.
8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in the balance room.
9. Remove the cassette band, pry open the cassette, and remove the filter gently to avoid loss of dust.

NOTE: If the filter adheres to the underside of the cassette top, very gently lift away by using the dull side of a scalpel blade. This must be done carefully or the filter will tear.

CALIBRATION AND QUALITY CONTROL:

10. Zero the microbalance before all weighings. Use the same microbalance for weighing filters before and after sample collection. Maintain and calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
11. The set of replicate samples should be exposed to the same dust environment, either in a laboratory dust chamber [7] or in the field [8]. The quality control samples must be taken with the same equipment, procedures, and personnel used in the routine field samples. The relative standard deviation calculated from these replicates should be recorded on control charts and action taken when the precision is out of control [7].

MEASUREMENT:

12. Weigh each filter, including field blanks. Record the post-sampling weight, W_2 (mg), and the mean post-sampling weight of laboratory blank filters, B_2 (mg). Record anything remarkable about a filter (e.g., overload, leakage, wet, torn, etc.).

CALCULATIONS:

13. Calculate the concentration of total particulate, C (mg/m³), in the air volume sampled, V (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1) \times 10^3}{V}, \text{ mg/m}^3.$$

EVALUATION OF METHOD:

Lab testing with blank filters and generated atmospheres of carbon black was done at 8 to 28 mg/m³ [2,6]. Precision and accuracy data are given on page 0500-1.

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METHOD REVISED BY:

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2A. METHOD: 0600

PARTICULATES NOT OTHERWISE REGULATED, RESPIRABLE 0600

DEFINITION: aerosol collected by sampler with 4-µm median cut point | CAS: None | RTECS: None

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METHOD: 0600, Issue 3 | EVALUATION: FULL | Issue 1: 15 February 1984; Issue 3: 15 January 1998

OSHA : 5 mg/m^3
NIOSH: no REL
ACGIH: 3 mg/m^3

PROPERTIES: contains no asbestos and quartz and quartz less than 1%; penetrates non-ciliated portions of respiratory system

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SYNONYMS: nuisance dusts; particulates not otherwise classified

SAMPLING

SAMPLER: CYCLONE + FILTER (10-mm nylon cyclone, Higgins-Dewell [HD] cyclone, or Aluminum cyclone + tared 5-µm PVC membrane)

FLOW RATE: nylon cyclone: 1.7 L/min
HD cyclone: 2.2 L/min
Al cyclone: 2.5 L/min

VOL -MIN: 20 L @ 5 mg/m^3
-MAX: 400 L

SHIPMENT: routine

SAMPLE STABILITY: stable

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 0.5 to 10 mg/m3 (lab and field)

BIAS: dependent on dust size distribution [1]

OVERALL PRECISION ($\hat{S}_{rT}$): dependent on size distribution [1,2]

ACCURACY: dependent on size distribution [1]

MEASUREMENT

TECHNIQUE: GRAVIMETRIC (FILTER WEIGHT)

ANALYTE: mass of respirable dust fraction

BALANCE: 0.001 mg sensitivity; use same balance before and after sample collection

CALIBRATION: National Institute of Standards and Technology Class S-1.1 or ASTM Class 1weights

RANGE: 0.1 to 2 mg per sample

ESTIMATED LOD: 0.03 mg per sample

PRECISION: <10 µg with 0.001 mg sensitivity balance;
<70 µg with 0.01 mg sensitivity balance [3]

APPLICABILITY: The working range is 0.5 to 10 mg/m^3 for a 200-L air sample. The method measures the mass concentration of any non-volatile respirable dust. In addition to inert dusts [4], the method has been recommended for respirable coal dust. The method is biased in light of the recently adopted international definition of respirable dust, e.g., □ +7% bias for non-diesel, coal mine dust [5].

INTERFERENCES: Larger than respirable particles (over 10 :m) have been found in some cases by microscopic analysis of cyclone filters. Over-sized particles in samples are known to be caused by inverting the cyclone assembly. Heavy dust loadings, fibers, and water-saturated dusts also interfere with the cyclone's size-selective properties. The use of conductive samplers is recommended to minimize particle charge effects.

OTHER METHODS: This method is based on and replaces Sampling Data Sheet #29.02 [6].

EQUIPMENT:

1. Sampler:
   a. Filter: 5.0-µm pore size, polyvinyl chloride filter or equivalent hydrophobic membrane filter supported by a cassette filter holder (preferably conductive).
   b. Cyclone: 10-mm nylon(Mine Safety Appliance Co., Instrument Division, P. O. Box 427, Pittsburgh, PA 15230), Higgins-Dewell(BGI Inc., 58 Guinan St., W altham, MA 02154)[7], aluminum cyclone (SKC Inc., 863 Valley View Road, Eighty Four, PA 15330), or equivalent.
2. Personal sampling pump, 1.7 L/m in ± 5% for nylon cyclone, 2.2 L/m in ± 5% for HD cyclone, or 2.5 L/min ± 5% for the Al cyclone with flexible connecting tubing.
   NOTE: Pulsation in the pump flow must be within ± 20% of the mean flow.
3. Balance, analytical, with sensitivity of 0.001 mg.
4. Weights, NIST Class S-1.1, or ASTM Class 1.
5. Static neutralizer, e.g., Po-210; replace nine months after the production date.
6. Forceps (preferably nylon).
7. Environmental chamber or room for balance, e.g., 20 °C ± 1 °C and 50% ± 5% RH.

SPECIAL PRECAUTIONS: None.

PREPARATION OF SAMPLERS BEFORE SAMPLING:

1. Equilibrate the filters in an environmentally controlled weighing area or chamber for at least 2 h.
2. Weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight, W_1 (mg).
   a. Zero the balance before each weighing.
   b. Handle the filter with forceps (nylon forceps if further analyses will be done).
   c. Pass the filter over an anti-static radiation source. Repeat this step if filter does not release easily from the forceps or if filter attracts balance pan. Static electricity can cause erroneous weight readings.
3. Assemble the filters in the filter cassettes and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassette.
4. Remove the cyclone's grit cap before use and inspect the cyclone interior. If the inside is visibly scored, discard this cyclone since the dust separation characteristics of the cyclone may be altered. Clean the interior of the cyclone to prevent reentrainment of large particles.
5. Assemble the sampler head. Check alignment of filter holder and cyclone in the sampling head to prevent leakage.

SAMPLING:

6. Calibrate each personal sampling pump to the appropriate flow rate with a representative sampler in line.
   NOTE 1: Because of their inlet designs, nylon and aluminum cyclones are calibrated within a large vessel with inlet and outlet ports. The inlet is connected to a calibrator (e.g., a bubble meter).The cyclone outlet is connected to the outlet port within the vessel, and the vessel outlet is attached to the pump. See APPENDIX for alternate calibration procedure. (The calibrator can be connected directly to the HD cyclone.)
   NOTE 2: Even if the flowrate shifts by a known amount between calibration and use, the nominal flowrates are used for concentration calculation because of a self-correction feature of the cyclones.
7. Sample 45 min to 8 h. Do not exceed 2 mg dust loading on the filter. Take 2 to 4 replicate

samples for each batch of field samples for quality assurance on the sam pling procedure (see Step 10).

NOTE : Do not allow the sampler assembly to be inverted at any time. Turning the cyclone to anything more than a horizontal orientation may deposit oversized material from the cyclone body onto the filter.

SAMPLE PREPARATION:

8. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 2 h in an environmentally controlled area or cham ber.

CALIBRATION AND QUALITY CONTROL:

9. Zero the microbalance before all weighings. Use the same m icrobalance for weighing filters before and after sample collection. Calibrate the balance with National Institute of Standards and Technology Class S-1.1 or ASTM Class 1 weights.
10. The set of replicate field sam ples should be exposed to the same dust environm ent, either in a laboratory dust chamber [8] or in the field [9]. The quality control samples must be taken with the same equipm ent, procedures, and personnel used in the routine field samples. Calculate precision from these replicates and record relative standard deviation (S_r) on control charts. Take corrective action when the precision is out of control [8].

MEASUREMENT:

11. Weigh each filter, including field blanks. Record this post-sam pling weight, W_2 (mg), beside its corresponding tare weight. Record anything rem arkable about a filter (e.g., visible particles, overloading, leakage, wet, torn, etc.).

CALCULATIONS:

12. Calculate the concentration of respirable particulate, C (mg/m^3), in the air volume sampled, V (L):

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V} \cdot 10^3, mg/m^3$$

where: W1 = tare weight of filter before sampling (mg)
W2 = post-sampling weight of sample-containing filter (mg)
B1 = mean tare weight of blank filters (mg).
B2 = mean post-sampling weight of blank filters (mg)
V = volume as sampled at the nominal flowrate (i.e., 1.7 L/min or 2.2 L/min)

EVALUATION OF METHOD:

1. Bias: In respirable dust measurements, the bias in a sample is calculated relative to the appropriate respirable dust convention. The theory for calculating bias was developed by Bartley and Breuer [10]. For this method, the bias, therefore, depends on the international convention for respirable dust, the cyclones' penetration curves, and the size distribution of the ambient dust. Based on measured penetration curves for non-pulsating flow [1], the bias in this method is shown in Figure 1.

   For dust size distributions in the shaded region, the bias in this method lies within the ± 0.10

criterion established by NIOSH for method validation. Bias larger than ± 0.10 would, therefore, be expected for some workplace aerosols. However, bias within ± 0.20 would be expected for dusts with geometric standard deviations greater than 2.0, which is the case in most workplaces.

Bias can also be caused in a cyclone by the pulsation of the personal sampling pump. Bartley, et al. [12] showed that cyclone samples with pulsating flow can have negative bias as large as -0.22 relative to samples with steady flow. The magnitude of the bias depends on the amplitude of the pulsation at the cyclone aperture and the dust size distribution. For pumps with instantaneous flow rates within 20% of the mean, the pulsation bias magnitude is less than 0.02 for most dust size distributions encountered in the workplace.

Electric charges on the dust and the cyclone will also cause bias. Briant and Moss [13] have found electrostatic biases as large as -50%, and show that cyclones m ade with graphite-filled nylon eliminate the problem. Use of conductive sam plers and filter cassettes(Omega Specialty Instrument Co., 4 Kidder Road, Chelmsford, MA 01824) is recommended.

2. Precision: The figure 0.068 mg quoted above for the precision is based on a study [3] of weighing procedures employed in the past by the Mine Safety and Health Administration (MSHA) in which filters are pre-weighed by the filter manufacturer and post-weighed by MSHA using balances readable to 0.010 mg. MSHA [14] has recently completed a study using a 0.001 mg balance for the post-weighing, indicating imprecision equal to 0.006 mg.

   Imprecision equal to 0.010 mg was used for estimating the LOD and is based on specific suggestions [8] regarding filter weighing using a single 0.001 mg balance. This value is consistent with another study [15] of repeat filter weighings, although the actual attainable precision may depend strongly on the specific environment to which the filters are exposed between the two weighings.

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METHOD REVISED BY: David L. Bartley, Ph.D., NIOSH/DPSE/ARDB and Ray Feldman, OSHA.

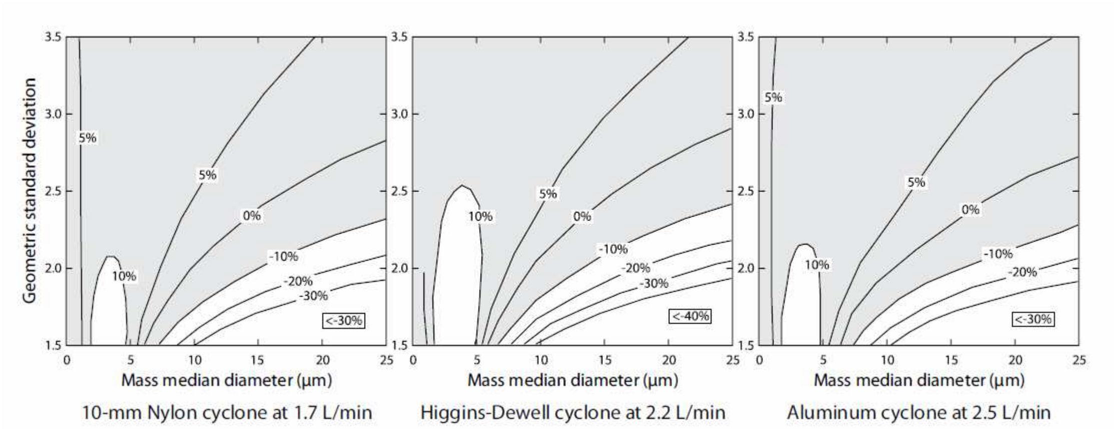

Figure 1 Bias of three cyclone types relative to the international respirable dust sampling convention.

APPENDIX: Jarless Method for Calibration of Cyclone Assemblies

This procedure may be used in the field to calibrate an air sampling pump and a cyclone assembly without using the one-liter “calibration jar”.

(1) Connect the pum p to a pressure gauge or water manometer and a light load (adjustable valve or 5-µm filter) equal to 2" to 5" H2O with a “TEE” connector and flexible tubing. Connect other end of valve to an electronic bubble m eter or standard bubble tube with flexible tubing (See Fig. 2.1).

NOTE: A light load can be a 5-:m filter and/or an adjustable valve. A heavy load can be several 0.8-:m filters and/or adjustable valve.

(2) Adjust the pump to 1.7 L/min, as indicated on the bubble meter/tube, under the light load conditions (2" to 5" H_2O) as indicated on the pressure gauge or manometer.

(3) Increase the load until the pressure gauge or water m anometer indicates between 25" and 35" H_2O. Check the flow rate of the pump again. The flow rate should remain at 1.7 L/min ± 5%.

(4) Replace the pressure gauge or water manometer and the electronic bubble meter or standard bubble tube with the cyclone having a clean filter installed (F ig. 2.2). If the loading caused by the cyclone assembly is between 2" and 5" H2O, the calibration is complete and the pump and cyclone are ready for sampling.

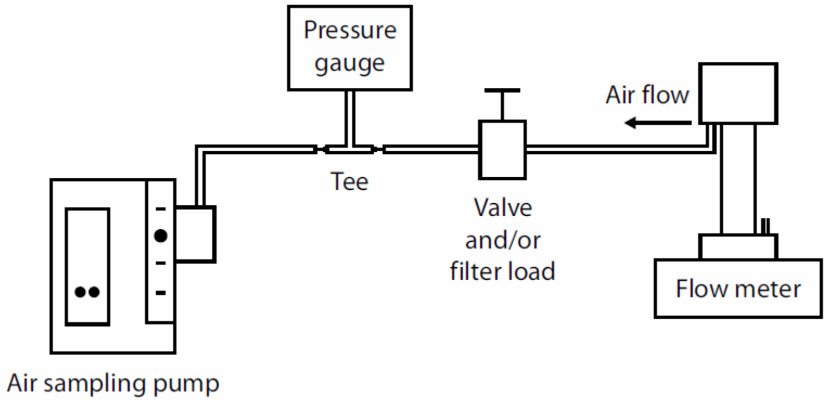

Figure 2.1. Block diagram of pump/load/flow meter set-up.

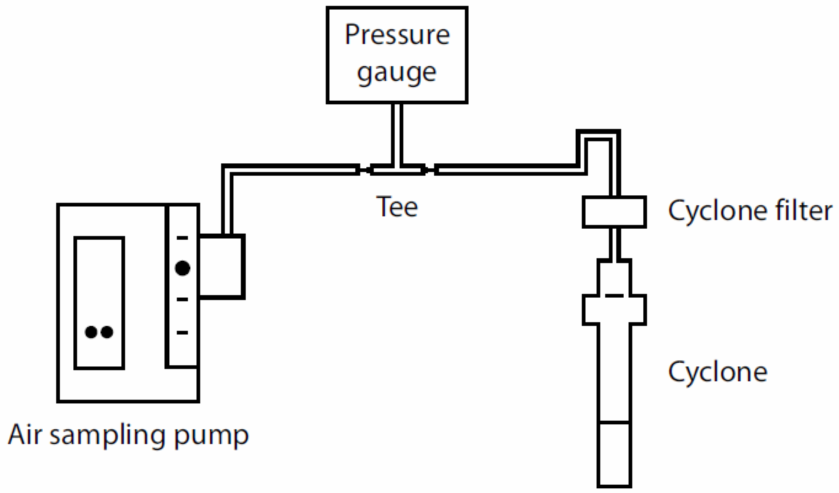

Figure 2.2. Block diagram with cyclone as the test load.

APPENDIX B

INFORMATION ON TD AND RD MEASUREMENT DATA

Date	Administration Office							
	Total dust*				Respirable dust**			
	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)
3/3/2010	0.01784	0.92024	0.90	0.94	0.0146	0.31652	0.30	0.37
5/3/2010	0.01589	0.91829	0.90	0.94	0.01473	0.31665	0.30	0.37
6/3/2010	0.01508	1.16708	1.15	1.2	0.01467	0.83067	0.82	1
20/3/2010	0.01661	0.88061	0.86	0.9	0.0158	0.50540	0.49	0.6

Date	Processing Platform 1							
	Total dust*				Respirable dust**			
	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)
14/1/2010	0.01665	0.88065	0.86	0.9	0.01756	0.42556	0.41	0.5
16/1/2010	0.01661	1.16861	1.15	1.2	0.01797	0.91557	0.90	1.1
21/1/2010	0.01751	1.45751	1.44	1.5	0.01784	1.16024	1.14	1.4
26/1/2010	0.017	0.82340	0.81	0.84	0.01811	0.14867	0.13	0.16
28/1/2010	0.01752	0.81432	0.80	0.83	0.01603	0.54643	0.53	0.65
11/2/2010	0.01763	2.14883	2.13	2.22	0.01779	0.81747	0.80	0.98
2/3/2010	0.01764	1.55364	1.54	1.6	0.01742	0.91502	0.90	1.1
5/3/2010	0.01756	1.74556	1.73	1.8	0.01762	0.99682	0.98	1.2
9/3/2010	0.01778	1.21778	1.20	1.25	0.01815	0.81783	0.80	0.98
10/3/2010	0.01762	1.55362	1.54	1.6	0.01706	1.15946	1.14	1.4
12/3/2010	0.01779	2.32179	2.30	2.4	0.01785	1.81305	1.80	2.2
13/3/2010	0.01584	2.01264	2.00	2.08	0.01706	1.61642	1.60	1.96
16/3/2010	0.01773	1.64973	1.63	1.7	0.01818	1.32378	1.31	1.6
18/3/2010	0.01752	2.01432	2.00	2.08	0.01717	1.51861	1.50	1.84
19/3/2010	0.01737	2.51337	2.50	2.6	0.01782	1.89462	1.88	2.3
20/3/2010	0.01736	2.03336	2.02	2.1	0.0176	1.32320	1.31	1.6
23/3/2010	0.01823	1.65023	1.63	1.7	0.01751	0.99671	0.98	1.2
24/3/2010	0.01756	1.07356	1.06	1.1	0.01813	0.75253	0.73	0.9

INFORMATION ON TD AND RD MEASUREMENT DATA (cont.)

Date	Processing Platform 3							
	Total dust*				Respirable dust**			
	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)
14/1/2010	0.017	2.41700	2.40	2.5	0.0176	0.58880	0.57	0.7
16/1/2010	0.01747	2.82067	2.80	2.92	0.01761	0.68673	0.67	0.82
21/1/2010	0.01785	3.21465	3.20	3.33	0.01697	0.54737	0.53	0.65
26/1/2010	0.01808	3.47408	3.46	3.6	0.0177	0.99690	0.98	1.2
28/1/2010	0.01753	2.99353	2.98	3.1	0.01711	0.83311	0.82	1
11/2/2010	0.01709	3.37709	3.36	3.5	0.01778	1.24178	1.22	1.5
16/2/2010	0.01753	2.80153	2.78	2.9	0.01669	0.66949	0.65	0.8
19/2/2010	0.01731	2.91651	2.90	3.02	0.01662	1.07742	1.06	1.3
25/2/2010	0.01753	3.61753	3.60	3.75	0.01755	1.11915	1.10	1.35
2/3/2010	0.01688	3.28088	3.26	3.4	0.01821	0.22221	0.20	0.25
3/3/2010	0.01767	2.60967	2.59	2.7	0.01794	0.67074	0.65	0.8
5/3/2010	0.01712	2.80112	2.78	2.9	0.01778	1.24178	1.22	1.5
6/3/2010	0.01767	1.21767	1.20	1.25	0.01742	0.31934	0.30	0.37
9/3/2010	0.01664	2.11904	2.10	2.19	0.01778	1.51922	1.50	1.84
10/3/2010	0.0165	2.51250	2.50	2.6	0.01709	0.91469	0.90	1.1
12/3/2010	0.01777	3.21457	3.20	3.33	0.01736	1.31480	1.30	1.59
13/3/2010	0.01692	2.51292	2.50	2.6	0.01746	0.99666	0.98	1.2
18/3/2010	0.01791	1.84191	1.82	1.9	0.0113	1.23530	1.22	1.5
19/3/2010	0.0177	2.51370	2.50	2.6	0.018	0.91560	0.90	1.1
20/3/2010	0.01797	1.12197	1.10	1.15	0.01097	0.31289	0.30	0.37
23/3/2010	0.0176	1.74560	1.73	1.8	0.01143	1.31703	1.31	1.6
24/3/2010	0.01761	2.32161	2.30	2.4	0.01109	1.80629	1.80	2.2

INFORMATION ON TD AND RD MEASUREMENT DATA (cont.)

Date	Processing Platform 5							
	Total dust*				Respirable dust**			
	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)
14/1/2010	0.01726	2.03326	2.02	2.1	0.01203	1.31763	1.31	1.6
16/1/2010	0.01093	2.31493	2.30	2.4	0.01157	1.39877	1.39	1.7
21/1/2010	0.01646	1.84046	1.82	1.9	0.01133	0.99053	0.98	1.2
26/1/2010	0.01773	1.84173	1.82	1.9	0.01109	1.15349	1.14	1.4
11/2/2010	0.01746	2.12946	2.11	2.2	0.01771	1.56811	1.55	1.9
25/2/2010	0.01775	1.91855	1.90	1.98	0.01112	0.61496	0.60	0.74
2/3/2010	0.01165	1.54765	1.54	1.6	0.01149	0.99069	0.98	1.2
3/3/2010	0.01147	1.25947	1.25	1.3	0.01146	0.90906	0.90	1.1
5/3/2010	0.01154	1.16354	1.15	1.2	0.01124	0.50900	0.50	0.61
6/3/2010	0.01163	1.06763	1.06	1.1	0.01168	0.41152	0.40	0.49
9/3/2010	0.01131	1.45131	1.44	1.5	0.01091	0.50867	0.50	0.61
10/3/2010	0.01183	2.12383	2.11	2.2	0.01362	1.23762	1.22	1.5
12/3/2010	0.01179	2.31579	2.30	2.4	0.01262	1.39982	1.39	1.7
13/3/2010	0.01123	2.41123	2.40	2.5	0.01154	1.31714	1.31	1.6
16/3/2010	0.01134	2.12334	2.11	2.2	0.01155	0.99075	0.98	1.2
17/3/2010	0.01161	1.73961	1.73	1.8	0.01403	1.15643	1.14	1.4
18/3/2010	0.01134	1.73934	1.73	1.8	0.01272	1.23672	1.22	1.5
20/3/2010	0.0112	1.64320	1.63	1.7	0.01233	1.31793	1.31	1.6
23/3/2010	0.01208	1.35608	1.34	1.4	0.01174	0.99094	0.98	1.2
24/3/2010	0.01203	2.02803	2.02	2.1	0.01152	1.23552	1.22	1.5

INFORMATION ON TD AND RD MEASUREMENT DATA (cont.)

Date	Silo 1							
	Total dust*				Respirable dust**			
	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)
14/1/2010	0.01149	2.54589	2.53	2.64	0.01146	0.54186	0.53	0.65
16/1/2010	0.0119	2.14310	2.13	2.22	0.01839	0.81807	0.80	0.98
21/1/2010	0.01166	4.54286	4.53	4.72	0.01104	1.08000	1.07	1.31
26/1/2010	0.01349	4.14149	4.13	4.3	0.01111	1.31671	1.31	1.6
28/1/2010	0.01386	3.37386	3.36	3.5	0.0173	1.07810	1.06	1.3
11/2/2010	0.0175	2.70550	2.69	2.8	0.01096	0.90856	0.90	1.1
16/2/2010	0.01745	2.89745	2.88	3	0.01668	1.48548	1.47	1.8
19/2/2010	0.01663	3.37663	3.36	3.5	0.01795	1.73155	1.71	2.1
25/2/2010	0.01664	2.03264	2.02	2.1	0.01842	1.48722	1.47	1.8
2/3/2010	0.01795	3.47395	3.46	3.6	0.01759	2.05759	2.04	2.5
3/3/2010	0.01831	4.81831	4.80	5	0.01759	0.31951	0.30	0.37
5/3/2010	0.01434	4.23834	4.22	4.4	0.01137	0.41937	0.41	0.5
6/3/2010	0.01773	3.08973	3.07	3.2	0.01138	0.90898	0.90	1.1
9/3/2010	0.01138	1.64338	1.63	1.7	0.01781	1.40501	1.39	1.7
10/3/2010	0.01758	4.52958	4.51	4.7	0.01185	1.80705	1.80	2.2
12/3/2010	0.01825	2.13025	2.11	2.2	0.01171	1.23571	1.22	1.5
13/3/2010	0.01754	0.31514	0.30	0.31	0.01157	0.41141	0.40	0.49
16/3/2010	0.01793	3.91553	3.90	4.06	0.01174	0.71350	0.70	0.86
18/3/2010	0.01983	2.99583	2.98	3.1	0.01138	1.96978	1.96	2.4
20/3/2010	0.01808	2.13008	2.11	2.2	0.01166	1.56206	1.55	1.9
23/3/2010	0.01187	1.41347	1.40	1.46	0.01146	1.01514	1.00	1.23

INFORMATION ON TD AND RD MEASUREMENT DATA (cont.)

Date	Silo 3							
	Total dust*				Respirable dust**			
	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)	Initial Wt.(g)	Finish Wt.(g)	Dust Wt.(g)	Dust conc.(mg/m^3)
14/1/2010	0.01163	2.12363	2.11	2.2	0.01145	0.54185	0.53	0.65
16/1/2010	0.01143	2.02743	2.02	2.1	0.01287	0.74727	0.73	0.9
21/1/2010	0.01123	3.37123	3.36	3.5	0.01723	1.08619	1.07	1.31
26/1/2010	0.01187	3.56387	3.55	3.7	0.01735	1.24135	1.22	1.5
28/1/2010	0.01121	3.17921	3.17	3.3	0.01846	0.99766	0.98	1.2
11/2/2010	0.01174	2.41174	2.40	2.5	0.01174	0.90934	0.90	1.1
16/2/2010	0.01157	3.08357	3.07	3.2	0.01137	1.48017	1.47	1.8
19/2/2010	0.01128	3.37128	3.36	3.5	0.01573	1.81093	1.80	2.2
25/2/2010	0.011	2.60300	2.59	2.7	0.01136	1.31696	1.31	1.6
2/3/2010	0.01515	2.70315	2.69	2.8	0.01254	1.48134	1.47	1.8
3/3/2010	0.01289	3.18089	3.17	3.3	0.01152	1.88832	1.88	2.3
5/3/2010	0.01183	2.91103	2.90	3.02	0.01284	1.11444	1.10	1.35
6/3/2010	0.0117	2.60370	2.59	2.7	0.01739	1.24139	1.22	1.5
9/3/2010	0.01218	2.31618	2.30	2.4	0.01703	1.10231	1.09	1.33
10/3/2010	0.01208	1.83608	1.82	1.9	0.01187	0.90947	0.90	1.1
12/3/2010	0.01346	1.74146	1.73	1.8	0.01644	1.24044	1.22	1.5
13/3/2010	0.01457	2.12657	2.11	2.2	0.01783	0.99703	0.98	1.2
16/3/2010	0.01178	2.69978	2.69	2.8	0.01157	1.31717	1.31	1.6
17/3/2010	0.01768	2.03368	2.02	2.1	0.01096	1.15336	1.14	1.4
18/3/2010	0.01655	2.22455	2.21	2.3	0.01157	1.23557	1.22	1.5
19/3/2010	0.01164	1.83564	1.82	1.9	0.01289	1.15529	1.14	1.4
20/3/2010	0.01298	1.64498	1.63	1.7	0.01768	0.99688	0.98	1.2
23/3/2010	0.01253	2.02853	2.02	2.1	0.011	1.23500	1.22	1.5
24/3/2010	0.0116	2.41160	2.40	2.5	0.01189	1.31749	1.31	1.6

* Sampling at a constant flow rate of 2 L/min for 8 hrs.

** Sampling at a constant flow rate of 1.7 L/min for 8 hrs.

APPENDIX C
PULMONARY FUNCTION TESTS

No.	Code	Age	FVC (l iter)			FEV$_1$ (l iter)			% FEV$_1$	Test results**
			Measured values	Standard* values	% Measured values	Measured values	Standard* values	% Measured values		
1	3	52	3	3.45	87	2.2	2.76	80	92	normal
2	5	25	3.65	4.53	81	3.46	4.06	85	106	normal
3	8	27	3.52	4.78	74	2.94	4.26	69	94	lower threshold
4	19	31	3.87	4.46	87	3.54	3.93	90	104	normal
5	20	27	4.23	5.23	81	3.65	4.66	78	97	normal
6	21	45	3.33	3.35	99	2.89	2.79	104	104	normal
7	22	31	3.46	4.11	84	2.92	3.61	81	96	normal
8	23	29	3.9	4.44	88	3.13	3.93	80	91	normal
9	24	30	3.49	3.95	88	3.22	3.48	93	105	normal
10	25	34	3.16	3.81	83	2.61	3.32	79	95	normal
11	26	45	4.09	3.7	111	2.78	3.08	90	82	normal
12	28	22	4.45	4.98	89	4.23	4.51	94	105	normal
13	29	38	3.74	3.91	96	3.08	3.35	92	96	normal
14	30	48	2.45	3.42	72	1.92	2.8	69	96	lower threshold
15	31	43	3.19	3.96	81	2.54	3.32	77	95	normal
16	32	37	3.96	3.66	108	3.19	3.15	101	94	normal
17	33	38	4.88	4.65	105	4.06	3.98	102	97	normal
18	34	44	4.58	4.39	104	3.44	3.67	94	90	normal
19	35	43	4.04	4.05	100	3.54	3.4	104	104	normal
20	37	39	3.93	4.16	94	3.38	3.55	95	101	normal
21	38	20	3.82	4.77	80	3.55	4.34	82	102	normal
22	39	45	3.3	3.15	105	2.67	2.62	102	97	normal
23	40	38	3.27	4	82	2.86	3.43	83	102	normal
24	41	25	2.45	3.05	80	2.36	2.74	86	107	normal
25	42	47	3.13	3.33	94	2.61	2.74	95	99	normal
26	43	27	3.46	3.19	108	3.13	2.86	109	101	normal
27	44	27	3.52	4.25	83	3.16	3.79	83	101	normal
28	47	47	3.27	3.54	92	2.43	2.92	83	90	normal
29	49	38	4.31	4.19	103	3.52	3.59	98	94	normal
30	52	26	3.6	4.39	82	2.92	3.92	74	91	lower threshold
31	53	26	3.68	4.6	80	3.11	4.11	76	95	lower threshold
32	54	45	3.6	3.7	97	2.89	3.08	94	97	normal
33	55	26	3.25	4.08	80	2.78	3.65	76	96	lower threshold
34	56	28	3.52	4.11	86	3	3.65	82	96	normal
35	57	38	2.84	4.05	70	2.51	3.47	72	103	lower threshold

PULMONARY FUNCTION TESTS (cont.)

No.	Code	Age	FVC (l iter)			FEV_1 (l iter)			% FEV_1	Test results**
			Measured values	Standard* values	% Measured values	Measured values	Standard* values	% Measured values		
36	58	27	3.6	4.62	78	3.25	4.11	79	101	lower threshold
37	59	46	3	3.66	82	2.48	3.03	82	100	normal
38	64	28	4.12	4.96	83	3.32	4.41	75	91	lower threshold
39	66	38	2.36	2.77	85	1.92	2.4	80	94	normal
40	67	30	2.67	3.28	81	2.39	2.91	82	101	normal
41	68	38	4.72	3.95	119	4.09	3.39	121	101	normal
42	69	61	2.39	2.86	84	1.87	2.17	86	103	normal
43	70	23	3.19	3.63	88	2.58	3.29	78	89	lower threshold
44	71	31	2.69	2.75	98	2.28	2.44	93	96	normal
45	72	26	2.8	3.14	89	2.23	2.82	79	89	lower threshold
46	75	52	1.72	2.22	77	1.39	1.82	76	99	lower threshold
47	80	27	3.57	4.3	83	3.3	3.83	86	104	normal
48	81	56	3.24	3.38	96	2.8	2.65	106	110	normal
49	82	27	3.68	4.05	91	3.35	3.61	93	102	normal
50	83	41	4.2	4.03	104	3.24	3.41	95	91	normal
51	84	33	2.69	3.04	88	2.67	2.68	100	113	normal
52	85	54	1.76	2.38	74	1.43	1.93	74	100	lower threshold
53	86	48	1.7	2.4	71	1.29	2	65	91	lower threshold
54	87	50	2.25	2.29	98	1.87	1.89	99	101	normal
55	88	47	2.67	3.54	75	2.32	2.92	79	105	lower threshold
56	89	43	2.14	2.51	85	1.92	2.14	90	105	normal
57	139	59	2.53	2.75	92	2.01	2.11	95	104	normal
58	141	35	2.95	2.84	104	2.54	2.49	102	98	normal
59	142	45	3.49	3.15	111	2.97	2.62	113	102	normal
60	143	54	1.81	2.09	87	1.59	1.69	94	109	normal
61	144	52	2.86	3.53	81	2.34	2.83	83	102	normal
62	164	30	4.42	4.24	104	3.71	3.75	99	95	normal
63	166	32	4.01	4.22	95	3.46	3.7	94	98	normal
64	167	24	4.2	4.36	96	3.74	3.92	95	99	normal
65	169	17	3.82	4.06	94	3.65	3.78	97	103	normal
66	171	29	4.45	4.97	90	3.71	4.4	84	94	normal
67	173	28	2.59	3.01	86	2.4	2.69	89	104	normal
68	174	55	2.35	3.14	75	2.07	2.47	84	112	lower threshold
69	177	28	4.2	4.11	102	3.74	3.65	102	100	normal
70	178	38	3.16	3.91	81	2.86	3.35	85	106	normal
71	180	48	2.06	2.3	90	1.87	1.92	97	109	normal
72	181	38	2.18	2.96	92	2.02	2.04	99	107	normal
73	182	33	2.83	2.67	106	2.61	2.35	111	105	normal
74	184	37	3.38	3.48	97	2.78	3	93	95	normal
75	185	49	2.7	3.3	82	1.99	2.69	74	90	lower threshold

PULMONARY FUNCTION TESTS (cont.)

No.	Code	Age	FVC (l iter)			FEV$_1$ (l iter)			% FEV$_1$	Test results**
			Measured values	Standard* values	% Measured values	Measured values	Standard* values	% Measured values		
76	186	39	4.74	4.25	112	3.95	3.63	109	98	normal
77	187	49	2.1	2.57	82	1.88	2.13	88	108	normal
78	189	37	3.22	3.85	84	2.89	3.31	87	104	normal
79	191	27	3.46	4.62	75	3.38	4.11	82	110	lower threshold
80	192	44	3.54	4.25	83	3.05	3.54	86	103	normal
81	196	40	3.03	3.65	83	2.4	3.1	77	93	lower threshold
82	197	39	2.69	2.85	94	2.42	2.46	98	104	normal
83	198	44	2.37	2.93	81	2.07	2.45	84	104	normal
84	200	26	3.16	3.18	99	2.75	2.86	96	97	normal
85	201	23	2.01	2.82	71	1.9	2.55	75	105	Not full blown
86	202	43	1.73	2.38	73	1.59	2.03	78	108	Not full blown
87	203	43	3.55	3.82	93	3	3.2	94	101	normal
88	205	36	3.68	3.74	98	3.11	3.23	96	98	normal
89	209	36	4.2	4.17	101	3.9	3.6	108	108	normal
90	210	41	3.68	3.8	97	2.7	3.22	84	87	normal
91	213	36	2.39	2.64	91	1.84	2.3	80	88	normal
92	218	34	4.89	4.45	110	4.34	3.87	112	102	normal
93	221	40	2.36	2.76	86	1.76	2.37	74	87	lower threshold
94	224	22	2.51	2.96	85	2.21	2.69	82	97	normal
95	227	42	2.45	2.57	95	2.21	2.2	100	105	normal
96	228	48	2.05	2.49	82	1.8	2.08	87	105	normal
97	229	38	4.47	4	112	3.76	3.43	110	98	normal
98	231	40	4.06	4.21	96	3.46	3.58	97	100	normal
99	235	29	4.06	4.54	89	3.55	4.02	88	99	normal
100	236	45	2.58	2.7	96	2.2	2.28	96	101	normal
101	237	42	2.39	2.71	88	2.09	2.31	90	103	normal
102	239	21	2.72	3.14	87	2.42	2.86	85	98	normal
103	240	30	2.5	2.78	90	2.36	2.47	96	106	normal
104	243	50	3.82	3.52	109	3.38	2.85	119	109	normal
105	245	56	2.62	3.07	85	2.21	2.4	92	108	normal
106	248	50	3.82	3.52	109	3.52	2.85	124	114	normal
107	251	17	3.63	3.69	98	3.14	3.43	92	93	normal
108	252	24	4.45	4.73	94	3.95	4.26	93	99	normal
109	253	23	3.93	4.61	85	3.55	4.16	85	100	normal
110	255	44	4.2	4.15	101	3.38	3.47	97	96	normal
111	259	37	2.75	2.9	95	2.56	2.52	102	107	normal
112	264	43	2.34	2.42	97	2.03	2.06	99	102	normal
113	265	46	3.74	3.8	98	3.05	3.14	97	99	normal
114	266	45	2.18	2.57	85	1.85	2.17	85	101	normal
115	267	38	2.7	2.81	96	2.32	2.43	95	99	normal

PULMONARY FUNCTION TESTS (cont.)

No.	Code	Age	FVC (l iter)			FEV_1 (l iter)			% FEV_1	Test results**
			Measured values	Standard* values	% Measured values	Measured values	Standard* values	% Measured values		
116	268	46	2.69	2.58	104	2.2	2.17	101	97	normal
117	269	53	2.15	2.25	96	1.91	1.84	104	109	normal
118	275	45	4.5	3.66	123	3.38	3.04	111	90	normal
119	276	40	4.47	3.61	124	3.49	3.07	114	92	normal
120	278	17	3.79	3.92	97	3.46	3.65	95	98	normal
121	283	47	2.09	2.45	85	1.81	2.06	88	103	normal
122	287	52	3.41	3.24	105	2.62	2.6	101	96	normal
123	288	50	2.92	3.6	81	2.54	2.92	87	107	normal
124	289	41	2.42	2.27	107	2.09	1.94	108	101	normal
125	292	44	2.86	3.92	73	2.43	3.27	74	102	lower threshold

***Standard values**

FVC (L) Male -2.601+0.122A-0.00046A2 + 0.00023 H 2 –0.00061AH

female -5.914+0.088A+0.056H-0.0003A2 –0.0005AH

FEV1 (L) Male -7.697+0.123A+0.067H-0.00034A2 –0.0007AH

female -10.6+0.085A+0.12H-0.00019A2 –0.00022H2 –0.00056AH

when A : Age

H : Body Height

****Test results : Normal when**

FVC > 80 %

FEV_1> 80 %

FEV_1 /FVC% > 75 % (Use 70 % for more than 50 years of age .)

APPENDIX D
QUESTIONNAIRE

แบบสัมภาษณ์พนักงาน

ประกอบการวิจัยเรื่อง "ความสัมพันธ์ระหว่างความเข้มข้นของฝุ่นซีเมนต์และปัจจัยอื่นๆ ที่มีผลต่อสมรรถภาพปอดของพนักงานในโรงงานผลิตเสาเข็ม"

ส่วนที่ 1 ข้อมูลทั่วไป

1. รหัส...
2. เพศ ( ) ชาย ( ) หญิง
3. อายุ......................ปี น้ำหนัก.......................กิโลกรัม ส่วนสูง.....................เซนติเมตร
4. สถานภาพ
   ( ) โสด ( ) สมรส ( ) หม้าย/หย่าร้าง ( ) แยกกันอยู่
5. ระดับการศึกษาสูงสุด
   ( ) 1.ไม่ได้เรียนหนังสือ ( ) 2.ต่ำกว่า ป.4 ( ) 3. ป.4
   ( ) 4.ป.5-ป.6 ( ) 5.ม.ต้น ( ) 6. ม.ปลาย
   ( ) 7. ปวช./เทียบเท่า ( ) 8.ปวส./เทียบเท่า ( ) 9. ปริญญาตรีหรือสูงกว่า
6. บริเวณที่พักอาศัย
   ( ) 1. อยู่ในบริเวณเขตโรงงาน (บ้านพักพนักงานของบริษัท)
   ( ) 2. อยู่นอกเขตโรงงาน (พื้นที่อื่น)
   ( ) 3. อื่นๆ (ระบุ)...
7. อาศัยอยู่ในที่พักปัจจุบันเป็นเวลา...........ปี.................เดือน
8. ท่านสูบบุหรี่หรือไม่
   ( ) 1.ไม่สูบ
   ( ) 2. สูบ รวมระยะเวลาที่สูบตั้งแต่เริ่มจนถึงบัดนี้เป็นเวลารวม............ปี เฉลี่ยสูบวันละ...........มวน สูบทุกวันหรือบางวัน..
   ( )3. เคยสูบแต่เลิก รวมระยะเวลาที่สูบมา...............ปี ระหว่างที่สูบเฉลี่ยสูบวันละ...........มวน สูบทุกวันหรือบางวัน...
   ( ) 4.อื่นๆ ระบุ..

9. ระยะเวลาในการออกกำลังกาย

( ) 1.ไม่ออกกำลังกาย ( ) 2.น้อยกว่า 1 ชม./สัปดาห์ ( ) 3.มากกว่า 1 ชม./สัปดาห์

( ) 4.อื่นๆ ระบุ...

10. ก่อนมาทำงานโรงงานผลิตเสาเข็มบริษัทวัสดุภัณฑ์คอนกรีต จำกัด ท่านเคยทำงานในที่มี ฝุ่น เป็นช่วงเวลาหนึ่งบ้างหรือไม่

( ) 1.ไม่เคย ( ) 2.เคย งานดังกล่าวคืออะไรบ้าง

ระบุ [เช่นเคยอยู่หรือทำงานโรงโม่หิน โรงปูน งานช่างปูน ช่างไม้ งานแกะสลัก หรืออื่นๆ]

....

ตั้งแต่เมื่อไหร่ และนานกี่เดือน กี่ปี..

11. ท่านเคยทำงานที่อื่น หรืออยู่ในที่ที่มีการเผาขยะ อยู่ใกล้เครื่องจักร เครื่องยนต์ที่มีการปล่อยควันหรือท่อไอเสียบ่อยๆหรือเป็นประจำหรือไม่

( )1. ไม่เคย ( ) 2.เคย [อธิบายว่าคืออะไร]

....

ตั้งแต่เมื่อไหร่ และนานกี่เดือน กี่ปี..

12. ท่านเคยอยู่ หรือทำงาน<u>ที่อื่น</u>ที่มีไอ สารเคมี กรด ด่าง ที่ฉุน แสบจมูก หรือมีกลิ่นน่ารำคาญคอยรบกวนอยู่<u>บ่อยๆหรือเป็นประจำหรือไม่</u>

( )1. ไม่เคย ( ) 2.เคย [อธิบายว่าคืออะไร]

....

ตั้งแต่เมื่อไหร่ และนานกี่เดือน กี่ปี..

ส่วนที่ 2 ประวัติเกี่ยวกับโรคและอาการที่เกี่ยวกับความผิดปกติของระบบทางเดินหายใจส่วนล่าง

1. ท่านเคยเป็นโรคหอบหืด หรือถูกวินิจฉัยว่าเป็นโรคเกี่ยวกับปอด หลอดลม เยื่อหุ้มปอดหรือไม่

( ) 1.ไม่เคย ( ) 2.เคย (ระบุ) คือโรค...

ระยะเวลาที่ได้รับการวินิจฉัยถึงปัจจุบัน....................................ปี

ในปัจจุบันยังเป็นอยู่หรือไม่...

2. ท่านเคยมีอาการไอร่วมกับมีเสมหะข้นเหนียวหรือไม่

( ) 1.ไม่เคย ( ) 2.เคย [ระบุ เป็นมานานกี่เดือน กี่ปี] ....ตั้งแต่เมื่อไหร่..................ถ้าเป็นหลายๆครั้งต่อปี ระยะเวลาที่เป็นแต่ละครั้งรวมกันคิดเป็นกี่เดือน............................และเป็นทุกๆปี ปีเว้นปี หรือหลายๆปีถึงจะเป็นครั้งหนึ่ง [ระบุ]...

ในปัจจุบันยังเป็นอยู่หรือไม่...

3. ท่านเคยมีอาการไอเป็นเลือดหรือไม่

( )1. ไม่เคย ( ) 2. เคย ครั้งเดียว ( )3. เคย นานๆครั้ง ( ) 4. เคย บ่อยๆ

( )5. อื่นๆระบุ...

ถ้าเคย [แม้แต่ครั้งเดียว] ให้ระบุว่า ตั้งแต่เมื่อไร เช่นกี่ปี กี่เดือนมาแล้ว [ถ้าเป็นหลายครั้งให้ระบุด้วยว่ากี่ครั้ง]...

ในปัจจุบันยังเป็นอยู่หรือไม่...

4. ท่านเคยเป็นหรือเคยมีอาการของระบบทางเดินหายใจ เช่น หอบ หืด หายใจขัด หรือหายใจไม่ออก หรือไม่

( ) 1.ไม่เคย ( ) 2.เคย ระบุ..

อาการดังกล่าวเกิดขึ้นเวลาใด ( ) ในระหว่างการทำงาน ( ) เวลาฝนตก ( ) เวลาถูกฝุ่น

( ) 3. อื่นๆ ระบุ..

ในปัจจุบันยังเป็นอยู่หรือไม่...

5. สมาชิกในบ้าน /ครอบครัว มีใครเคยเป็นโรคหรืออาการเกี่ยวกับโรคระบบทางเดินหายใจ เช่น หอบ หืด หายใจขัด หรือหายใจไม่ออกหรือไม่ ถ้ามีเกี่ยวข้องกับท่านอย่างไร และคือโรค/อาการอย่างไร

( ) 1.มี เกี่ยวข้องคือ.......................................เป็นโรค/มีอาการ...

( ) 2.ไม่มี ( ) 3.ไม่ทราบ ( )4.อื่นๆ ระบุ...

6. ผู้ที่อาศัยในบริเวณที่พัก/เพื่อนบ้าน/เพื่อนร่วมห้องของท่านมีใครเคยเป็นโรคหรืออาการเกี่ยวกับโรคระบบทางเดินหายใจ เช่น หอบ หืด หายใจขัด หรือหายใจไม่ออกหรือไม่ ถ้ามีคือโรค/อาการอย่างไร

( ) 1.มี เป็นโรค/มีอาการ..

( ) 2.ไม่มี ( ) 3.ไม่ทราบ ( ) 4.อื่นๆ ระบุ..

ส่วนที่ 3 ข้อมูลในเรื่องการสัมผัสฝุ่น และการใช้อุปกรณ์ป้องกัน

1. ระยะเวลาในการทำงานในโรงงานผลิตเสาเข็มของบริษัทวัสดุภัณฑ์คอนกรีต จำกัด......................ปี ....เดือน

2. ตำแหน่ง/จุดที่ปฏิบัติงาน

( ) 1. แท่นผลิต ( ) 2. ไซโลปูน ( ) 3. สำนักงาน

( ) 4. อื่นๆระบุ....................................

3. ทำงานวันละ(รวมเวลาพักเที่ยง).......................ชั่วโมง สัปดาห์ละ........................วัน

4. สภาพงานที่ทำเกี่ยวข้องหรือสัมผัสกับสิ่งใดบ้างต่อไปนี้ (ตอบได้มากกว่า 1 ข้อ)

( ) 1. ฝุ่น ( ) 2. สารเคมี ( ) 3. เครื่องจักรกล ( ) 4. เสียงดังน่ารำคาญ รบกวน

( ) 5. กลิ่นเหม็น จาก (ระบุ) .... ( ) 6. อื่นๆ [ระบุ].....................................

5. เมื่อท่านอยู่ในที่ที่มีฝุ่นท่านจะมีอาการหายใจผิดปกติอย่างไร (ตอบได้มากกว่า 1 ข้อ)

อาการ	ความรุนแรง	ความถี่บ่อย
1.หายใจอึดอัด	( )1.ไม่เคยเป็น ( )2.บ้างเล็กน้อย ( ) 3.ปานกลาง ( ) 4.มาก	( )1.นานๆครั้ง ( )2.บ่อยครั้ง ( ) 3.ประจำ
2.ไอ จาม	( )1.ไม่เคยเป็น ( )2.บ้างเล็กน้อย ( ) 3.ปานกลาง ( ) 4.มาก	( )1.นานๆครั้ง ( )2.บ่อยครั้ง ( ) 3.ประจำ
3.หายใจไม่ออก	( )1.ไม่เคยเป็น ( )2.บ้างเล็กน้อย ( ) 3.ปานกลาง ( ) 4.มาก	( )1.นานๆครั้ง ( )2.บ่อยครั้ง ( ) 3.ประจำ

6. ขณะทำงานท่านใช้อุปกรณ์ป้องกันอันตรายจากฝุ่น (หน้ากากป้องกันฝุ่น N95)หรือไม่
   ( ) 1.ไม่ใช้ ( ) 2.ใช้เป็นบางครั้ง ( ) 3.ใช้บ่อยๆ ( ) 4.ใช้เป็นประจำ
   ( ) 5.อื่นๆ ระบุ...

ส่วนที่ 4 ความคิดเห็นและข้อเสนอแนะของพนักงาน

1. ท่านคิดว่าฝุ่นละอองในโรงงานส่งผลกระทบต่อท่านหรือไม่ อย่างไร ?
   ....
   ....
   ....
   ....
2. ท่านมีข้อคิดเห็นหรือข้อเสนอแนะเกี่ยวกับแนวทางการจัดการปัญหาที่เกิดจากฝุ่นละอองในโรงงาน อย่างไรบ้าง ?
   ....
   ....
   ....
   ....

APPENDIX E
THE STATISTICAL ANALYSES FROM SPSS

1E. The analysis of variance of the total dust concentration and respirable dust concentration

ANOVA

Total Dust

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	36.531	5	7.306	13.313	.000
Within Groups	56.524	103	.549		
Total	93.055	108			

ANOVA

Respirable Dust

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.372	5	.674	2.756	.022
Within Groups	25.206	103	.245		
Total	28.578	108			

2E. Correlation coefficient between the total dust concentration and the respirable dust concentration

Station 1 Administration Office

Correlations

		TD office	RD office
TD office	Pearson Correlation	1	.872
	Sig. (2-tailed)		.128
	N	4	4
RD office	Pearson Correlation	.872	1
	Sig. (2-tailed)	.128	

Correlations

		TD office	RD office
TD office	Pearson Correlation	1	.872
	Sig. (2-tailed)		.128
	N	4	4
	Pearson Correlation	.872	1
	Sig. (2-tailed)	.128	
	N	4	4

2E. Correlation coefficient between the total dust concentration and the respirable dust concentration (cont.)

Station 2 Processing Platform 1

Correlations

		TD platform1	RD platform1
TD platform1	Pearson Correlation	1	.869**
	Sig. (2-tailed)		.000
	N	18	18
RD platform1	Pearson Correlation	.869**	1
	Sig. (2-tailed)	.000	
	N	18	18

**. Correlation is significant at the 0.01 level (2-tailed).

Station 3 Processing Platform 3

Correlations

		TD platform3	RD platform3
TD platform3	Pearson Correlation	1	.116
	Sig. (2-tailed)		.607
	N	22	22
RD platform3	Pearson Correlation	.116	1
	Sig. (2-tailed)	.607	
	N	22	22

Station 4 Processing Platform 5

Correlations

		TD platform5	RD platform5
TD platform5	Pearson Correlation	1	.744**
	Sig. (2-tailed)		.000
	N	20	20
RD platform5	Pearson Correlation	.744**	1
	Sig. (2-tailed)	.000	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

2E. Correlation coefficient between the total dust concentration and the respirable dust concentration (cont.)

Station 5 Silo for Cement Mixing 1

Correlations

		TD silo1	RD silo1
TD silo1	Pearson Correlation	1	.046
	Sig. (2-tailed)		.842
	N	21	21
RD silo1	Pearson Correlation	.046	1
	Sig. (2-tailed)	.842	
	N	21	21

Station 6 Silo for Cement Mixing 1

Correlations

		TD silo3	RD silo3
TD silo3	Pearson Correlation	1	.504*
	Sig. (2-tailed)		.012
	N	24	24
RD silo3	Pearson Correlation	.504*	1
	Sig. (2-tailed)	.012	
	N	24	24

*. Correlation is significant at the 0.05 level (2-tailed).

3E. Linear correlation between the total dust concentration and the respirable dust concentration

Station 1 Administration Office
Regression

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.225	.225		-1.000	.332
	TD platform1	.919	.131	.869	7.035	.000

a. Dependent Variable: RD platform

Station 4 Processing Platform 5
Regression

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.066	.293		-.225	.824
	TD platform5	.726	.154	.744	4.721	.000

a. Dependent Variable: RD platform5

Station 6 Silo for Cement Mixing 3
Regression

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.639	0.299		2.135	0.044
	TD silo3	0.309	0.113	0.504	2.741	0.012

a. Dependent Variable: RD silo3

4E. The Analysis of Variance of Pulmonary Function By Working Areas

FVC ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.916	5	0.583	0.882	0.495
Within Groups	78.674	119	0.661		
Total	81.590	124			

FEV_1 ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.461	5	0.292	0.582	0.714
Within Groups	59.742	119	0.502		
Total	61.203	124			

FEV_1/FVC ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	194.153	5	38.831	1.080	0.375
Within Groups	4277.847	119	35.948		
Total	4472.000	124			

5E. Correlation coefficient of the pulmonary function with dust concentration

Average Total Dust Concentration and FVC

Correlations

		TDavg	FVC
TDavg	Pearson Correlation	1	.024
	Sig. (2-tailed)		.790
	N	125	125
FVC	Pearson Correlation	.024	1
	Sig. (2-tailed)	.790	
	N	125	125

Average Total Dust Concentration and FEV_1

Correlations

		TDavg	**FEV_1**
TDavg	Pearson Correlation	1	.008
	Sig. (2-tailed)		.926
	N	125	125
FEV_1	Pearson Correlation	.008	1
	Sig. (2-tailed)	.926	
	N	125	125

Average Total Dust Concentration and FEV_1/FVC

Correlations

		TDavg	**FEV_1**/FVC
TDavg	Pearson Correlation	1	.023
	Sig. (2-tailed)		.798
	N	125	125
FEV_1/FVC	Pearson Correlation	.023	1
	Sig. (2-tailed)	.798	
	N	125	125

5E. Correlation coefficient of the pulmonary function with dust concentration (cont.)

Average Respirable Dust Concentration and FVC

Correlations

		RDavg	FVC
RDavg	Pearson Correlation	1	.013
	Sig. (2-tailed)		.882
	N	125	125
FVC	Pearson Correlation	.013	1
	Sig. (2-tailed)	.882	
	N	125	125

Average Respitable Dust Concentration and FEV_1

Correlations

		RDavg	FEV1
RDavg	Pearson Correlation	1	.013
	Sig. (2-tailed)		.888
	N	125	125
FEV1	Pearson Correlation	.013	1
	Sig. (2-tailed)	.888	
	N	125	125

Average Total Dust Concentration and FEV_1/FVC

Correlations

		RDavg	FEV1.FVC
RDavg	Pearson Correlation	1	.042
	Sig. (2-tailed)		.640
	N	125	125
FEV1.FVC	Pearson Correlation	.042	1
	Sig. (2-tailed)	.640	
	N	125	125

6E. Correlation coefficient of the quantitative data

		FVC	FEV1	FEV1.FVC
Age	Pearson Correlation	-0.341**	-0.458**	0.133
	Sig. (2-tailed)	0.000	0.000	0.138
	N	125	125	125
Weight	Pearson Correlation	0.295**	0.277**	-0.077
	Sig. (2-tailed)	0.001	0.002	0.395
	N	125	125	125
Hight	Pearson Correlation	0.752**	0.734**	-0.159
	Sig. (2-tailed)	0.000	0.000	0.077
	N	125	125	125
Duration of smokking	Pearson Correlation	0.219*	0.108	-0.178*
	Sig. (2-tailed)	0.014	0.229	0.047
	N	125	125	125
The average number of cigarettes	Pearson Correlation	0.407**	0.320**	-0.210*
	Sig. (2-tailed)	0.000	0.000	0.019
	N	125	125	125
Length of employment	Pearson Correlation	-0.226*	-0.239**	0.176
	Sig. (2-tailed)	0.011	0.007	0.050
	N	125	125	125
Time worked in the dust.	Pearson Correlation	0.053	0.009	-0.033
	Sig. (2-tailed)	0.558	0.923	0.712
	N	124	124	124
Time worked in the smoke	Pearson Correlation	-0.009	-0.046	-0.066
	Sig. (2-tailed)	0.923	0.611	0.464
	N	125	125	125
Time worked in a chemical vapor	Pearson Correlation	0.074	-0.015	-0.238**
	Sig. (2-tailed)	0.414	0.867	0.008
	N	125	125	125

**. Correlation is significant at the 0.01 level (2-tailed

*. Correlation is significant at the 0.05 level (2-tailed).

7E. Multiple regression analysis between FVC with age, weight, height, smoking duration.The average number of cigarettes smoked. And length of employment

Regression

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.519	0.988		-5.589	0.000
	Age	-0.020	0.006	-0.251	-3.629	0.000
	Weight	-0.003	0.004	-0.050	-0.788	0.432
	Hight	0.058	0.006	0.644	9.459	0.000
	Duration of s moking	0.001	0.007	0.011	0.137	0.891
	The average number of cigarettes	0.035	0.010	0.267	3.549	0.001
	Length of employment	0.006	0.011	0.032	0.513	0.609

a. Dependent Variable: FVC

8E. Multiple regression analysis between FEV_1 with age, weight, height is the averagenumber of cigarettes smoked. And length of employment

Regression

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.192	0.824		-5.089	0.000
	Age	-0.027	0.004	-0.379	-6.184	0.000
	Weight	-0.002	0.003	-0.033	-0.531	0.596
	Hight	0.048	0.005	.617	9.369	0.000
	The average number of cigarettes	0.024	0.007	0.211	3.660	0.000
	Length of employment	0.011	0.009	0.072	1.190	0.236

a. Dependent Variable: FEV1

BIOGRAPHY

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