FILE NAME: Pennsylvania (PA)

DATE: 1952 June

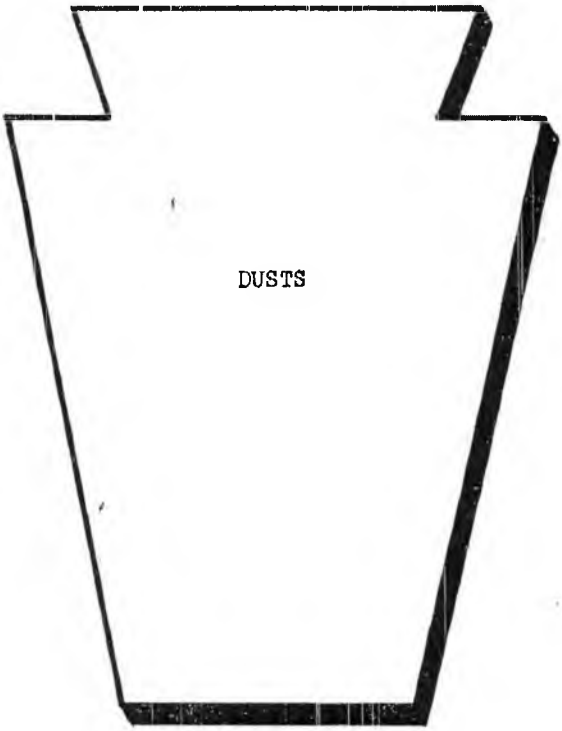
DOC#: PA018

DOCUMENT DESCRIPTION: PA Dept of Health Report - Dusts

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF HEALTH
HARRISBURG

RUSSELL E. TEAGUE, M.D. SECRETARY



BUREAU OF INDUSTRIAL HYGIENE

JOSEPH SHILEN, M.D. DIRECTOR

JUNE 1952

INDUSTRIAL PROGRESS THROUGH INDUSTRIAL HEALTH

DUSTS

Revised by
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Director

I. Definition - dust may be defined as solid particles ranging in size from less than 1 micron to about 150 microns (1 micron equals 1/25000th of an inch). In industry dusts are produced by reducing solid materials to small sizes by such operations as crushing, grinding, screening, drilling, and blasting

II. Physical properties - when a solid is broken up into finely-divided particles, important changes occur

A. Surface area is greatly increased, e.g., if 1 cubic centimeter of quartz with a total surface area of 6 square centimeters is crushed into particles 1 cubic micron in size, the new total surface area will be 6 square meters

B. Space occupied is increased many times over volume of original mass

C. Physical and chemical activity of materials in form of dust is greater than when not divided

1. Increase in rates of

a. Oxidation
b. Evaporation
c. Solubility
d. Electrostatic activity
e. Absorption properties
f. Brownian motion

D. Settling velocities - resistance to the settling motion of a dust particle through air varies with the

size and shape of the particle, with its velocity, and with the fluidity of the air

E. Flocculation of dusts - Brownian motion of dusts in air increases frequency of collision resulting in formation of flocculated masses
   1. Effect of air motion
      a. Increased air motion accelerates formation of flocs
   2. Effect of humidity
      a. Ordinary changes in humidity have little or no effect on flocculation
      b. Supersaturated atmospheres have a noticeable effect on flocculation

F. Wetting
   1. Certain dusts more easily wetted than others
   2. Wetting can be obtained by
      a. Intimate and violent contact between dust and liquid
      b. Application of liquid at dust source
      c. Addition of agents with low surface tension such as ammonia, alcohol, etc., to increase wetting power of water

G. Effect of electrostatic charge
   1. Electrostatic charges on dusts are produced by
      a. Friction
      b. Chemical reaction or direct dissociation
      c. Direct action of ionizing agents

III. Classification of dusts according to composition

A. Organic dusts
   1. Animal dusts
      a. Feather
      b. Hair
      c. Leather
      d. Bone
   2. Vegetable dusts
      a. Pollens
      b. Grain, flour, straw
      c. Hemp, cotton, jute, rag, paper

d. Spices, tobacco, coffee
e. Wool, coal, etc.

B. Inorganic dusts
1. Metallic dusts
a. Lead arsenic, mercury, manganese, zinc, etc.
2. Non-metallic dusts
a. Silica (quartz, tridymite, cristobalite, etc.), asbestos, talc, gypsum, lime, limestone, carborundum, emery, marble, granite, slag, cement, glass

IV. Classification of dusts according to physiologic reaction
A. Allergic reactions
1. Pollens, most organic dusts
B. Skin and other contact surfaces
1. Lime, chromic acid
C. Systemic poisonings
1. Lead, manganese
D. Reactions in the lungs (based on experimental peritoneal injections)
1. Inert reactions
a. Coal
b. Precipitator ash
c. Soapstone
d. Talc
e. Asbestos
f. Feldspar
g. Carborundum
h. Hematite
i. Sericite
2. Absorptive reactions
a. Calcite
b. Limestone
c. Gypsum
d. Cement
3. Proliferative reactions
a. Quartz
b. Tripoli
c. Siliceous chert

V. Factors influencing hazardous effect of dusts
  A. Composition - physical response is dependent upon composition
    1. Calcium carbonate - absorptive reaction
    2. Silica - proliferative reaction
    3. Carbon - inert reaction
    4. Lead - systemic poisoning
  B. Particle size - practically all industrial dusts are of the same particle size range
    1. Particles greater than 10 microns in diameter seldom present in industrial atmospheres
    2. Physiological significance of particles greater than 10 microns not definitely shown because
      a. Relatively few are present in the breathing zone
      b. Larger particles are caught in the upper respiratory tract and removed by ciliary action
      c. Alveoli are not large enough to admit particles greater than 10 microns in diameter
      d. Particles greater than 10 microns in size cannot be phagocyted
    3. Recent work indicates that particles greater than 3 microns in diameter have less physiological importance than those under 3 microns
    4. Particle size of toxic dusts is probably less important physiologically than their wettability and solubility
    5. Asbestos dust - particles ranging in size up to about 180 microns are of physiological importance, probably as a result of mechanical irritation of pulmonary tissue
  C. Concentration - may be expressed in terms of weight or number of particles per unit volume of air
  D. Length of exposure
  E. Dust retention
    1. Approximately 50 per cent of inhaled dusts are retained

2. Percentage retained increases with increasing respiratory rates up to 20 respirations per minute. Above this rate no further change occurs
3. Mouth breathers retain less dust than nose breathers
4. Fibrosis-producing dusts are more readily retained in the lungs than smokes which consist of much smaller-sized particles

F. Individual susceptibility

VI. Methods employed in dust determinations

A. Composition - air-borne dust may differ from the material from which it is derived because of differential disintegration and selective settling

1. Collection of air-borne samples
   a. Settlement - rafter samples
   b. By means of
      (1) Liquid media
      (2) Electrical precipitation
      (3) Filtration
      (4) Impingement
      (5) Thermal precipitation
2. Analysis
   a. Chemical
   b. Petrographic
   c. X-ray diffraction

B. Particle size

1. Collection - similar methods employed as noted above under "composition"
2. Methods of measurement
   a. Linear measurement
      (1) Eye-piece micrometer in conjunction with microscope
      (2) Projection of microscopic field or photomicrograph on a screen for comparison with scale
      (3) Elutriation
      (4) Count-weight method - based on knowledge of the density of the material

and the number of dust particles per gram

C. Concentration
  1. Collection
    a. Settlement - rafter samples
    b. Filtration - sugar tube, paper thimble, filter paper
    c. Washing - rain, mist, spray
    d. Impingement - dust-laden air impinged on stationary surface produces a sudden change in the direction of flow with consequent loss of kinetic energy of the dust and separation of the dust from the air
      (1) Grab sample impingers - (impingement on microscope slide)
        (a) Konimeter - air stream induced by a spring-actuated valveless piston pump against a microscope slide covered with a thin film of petroleum or glycerine jelly
        (b) Owens' Jet dust counter - nozzle velocity higher than that of konimeter and no adhesive substance used on impinging surface. Dust particles are caused to adhere to cover slip by condensation of moisture about dust particles which results from a great drop in pressure with consequent lowering of temperature incurred by air passing through the nozzle
      (2) Interval sampling impingers - (impingement and trapping in liquid media)
        (a) Greenburg-Smith impinger - nozzle and impinging plate are immersed in liquid. Impingement takes place in air since incoming air stream keeps plate dry. Physical state of dust particles with this

method of impingement is altered and wettability is increased so that they may be retained in the liquid medium

(3) Continuous sample impingers

(a) Hazard recorder - (impingement on a celluloid strip and photo-electric determination of dust intensity)

e. Electrical precipitation - based on electrostatic attraction and ionic bombardment of the electric wind created by corona discharge

f. Thermal precipitation - based on the principle of the presence of a well-defined dust-free area around a hot rod. When dust-laden air is passed through a hot-cold tube, the dust is precipitated on the cold surface

2. Measurement

a. Weighing - weight of dust determined after collection in paper thimbles, interval impingers, electrical precipitators, thermal precipitators

b. Counting - by means of a microscope and necessary calculation, the total number of particles of dust is determined for a unit volume of air. This procedure is quite similar to that used in making blood counts

c. Comparison method - determination of total dust concentration per unit volume of air based on a comparison of an unknown sample having a given appearance with that of a known standard

d. Chemical analysis - solution of dusts in chemical reagents and their subsequent quantitative determination

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