Identification of the Quality and Quantity of (Biologically Significant) Cotton Mill Dust

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In the 1920's and 1930's the U.S. Public Health Service surveyed the hazards to workers from various dusts and found no dust-related respiratory health problem among textile workers.[1,2] One can dispute this early finding of no significant respiratory disease among textile workers but the finding of low dustiness in the textile industry is indisputable in comparison with dustiness in the mineral industries. Nor is it surprising that health problems in the cotton textile industry at that time seemed insignificant compared with the exposure-produced silicosis found in 80 per cent of workers with more than 10 years' experience.

There has been increased interest in cotton dust in the last decade generated by the findings of Roach and Schilling[3] in 1955 that byssinosis was prevalent in the Lancashire textile industry. The problem in the U.S. has reached the stage where cotton dust has been designated a health priority target by the U.S. Department of Labor.[4]

Causative agent(s) have not yet been identified definitely, although promising leads have been uncovered. Where indirect measures of toxicant are made, the safe concentration is difficult to determine and adequate control is hard to specify, but enough is known so that byssinosis can be prevented by environmental controls and medical surveillance.

Quality

Cotton textile mill dust is a mixture of cotton fibers, mineral dust, and trash. The fiber portion is a mixture of lint and fly, lint being staple length fibers, and fly, short bits of cotton fiber. Cotton fibers have no hygienic significance because (1) the cellulose of the fibers is biologically inert and (2) the fibers are either too large to be inspired or not small enough to penetrate any distance into the respiratory tract.

The mineral dust fraction, originating principally from soil, consists mainly of silicates and silica, but is of minimal hygienic significance because of its low airborne concentration. The absence, in byssinotics, of radiological changes such as those found in silicosis, confirms this. Industries where pneumoconiosis due to mineral dust is prevalent have mineral dust concentrations of the order of 100 times greater than that found in the cotton industry.[5]

By exclusion, then, the biologically active constituent of cotton dust is in the trash portion which consists mostly of plant debris containing a variety of complex organic compounds, mainly proteins and carbohydrates, many of which are water soluble. Much research in the last decade has been directed toward isolating the causative agent(s). A review of etiology is beyond the scope of this presentation. However, the importance of isolating the causative agent(s) will be emphasized from the standpoint of economic engineering control and, therefore, diminution of the disease.

Methods of Measurement

Prerequisite to establishing exposure limits, from an industrial hygiene viewpoint, is the necessity to develop a sampling method that can isolate consistently that fraction of dust that causes byssinosis. Further, the method should be valid, simple, reproducible, inexpensive, reliable, sensitive and require minimal attention during the sampling period.

If cotton fibers were in a reasonably constant ratio to the dust of hygienic significance, it would make little difference whether they were included or excluded from the sample. If, however, as appears likely, the concentration of cotton fibers varies by an order of magnitude for a given concentration of hygienically significant dust,[6] then cotton fiber must be excluded from the sample.

Table I lists the main constituents of cotton dust and their deposition potential.[7]

Three different sampling methods have been used which relate to byssinosis prevalence; (1) a total dust method, (2) a method which measures total and respirable (< 7μm) dust in parallel, and by substraction determines a medium size fraction, thus fractionating the dust into fine, medium, and coarse com-

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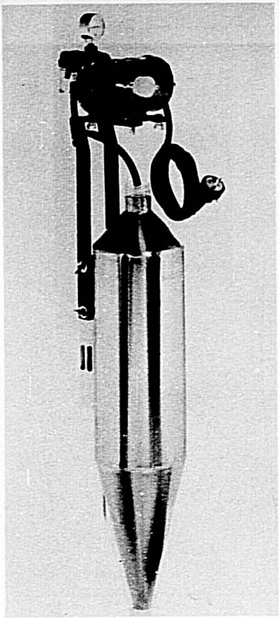

Fig 1. — Vertical Elutriator Cotton Dust Air Sampler

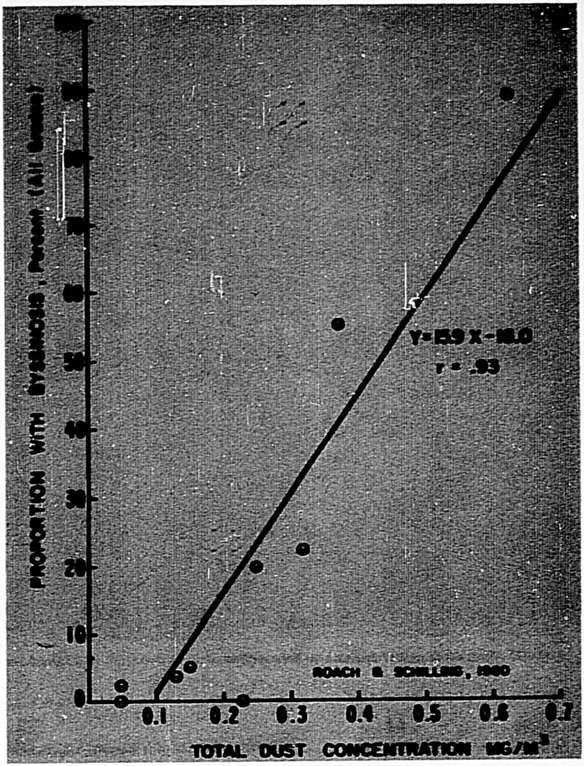

Fig 2. — Airborne Concentration of Dust Related to Prevalence of Byssinosis

ponents, and (3) the vertical elutriation method which excludes greater than 15μm aerodynamically equivalent particles.

The fractionation into fine, medium, and coarse components, dubbed the British method because its use originated in the British Isles in the work of Roach and Schilling,[5] employs two parallel sampling devices, both having 2 mm x 2 mm wire screen at the entrance. One device has a parallel plate horizontal elutriator designed to eliminate > 7μm particles from the sample; the other does not have the elutriator plates. The lint and dust mixture is periodically scraped off the wire screen and later is weighed to determine the coarse fraction. The dust collected on the elutriated filter is fine.

The cotton dust vertical elutriator, (Fig 1),[8] excludes most particles greater than 15 μm aerodynamic diameter because the upward velocity is too low to transport particles with a settling velocity greater than that of 15 μm unit density spheres. The falling speed of glass fibers in air and, by inference, the less regular shaped cotton fibers, is a function of diameter, not length. Because of this, the cotton fibers, which have aerodynamic diameters greater than 20 μm, whether they be long, or short, as in fly, are excluded from collection. Microscopic examination of vertical elutriator samples confirms that cotton fibers are excluded.

Dose-Response

Several studies are available from which allowable cotton dust concentration limits may be derived. The work of Roach and Schilling, (Fig 2), was the basis for the "total" dust TLV of the ACGIH.[5] Although Roach and Schilling fractionated the dust into fine, medium, and coarse components, using the "British method", their most significant correlation was with total dust. Molyneux and Berry, using the same sampling method in a follow-up study at the same Lancashire mills, stated that "two components of the total dust, namely, the respirable (fine) and medium fractions correlate significantly with the prevalence of respiratory symptoms"[10 11] (Figs 3 and 4). Merchant, Lumsden, and Kilburn, using the vertical elutriator sampler, found a very high correlation between dust and byssinosis prevalence (Fig 5).[12] Not only did the vertical elutriator sampler correlate well with byssinosis prevalence, but the sampler is simple, repeatable, inexpensive, and requires minimal attention during the workshift. A study on prevalence[13] of byssinosis among almost 1000 workers in 18 cardrooms by the Industrial Health Foundation may provide further data on the vertical elutriator method when an

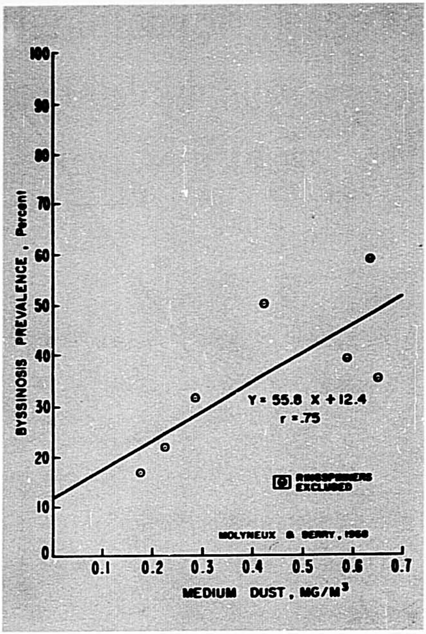

Fig 3. — Correlation Byssinosis in 5 Occupations

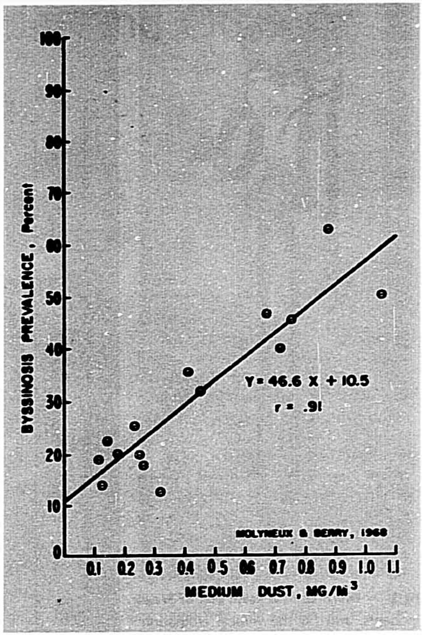

Fig 4. — Correlation Byssinosis in Speedframe Tenters

equivalence study between their sampling method and the vertical elutriator method is completed by the U.S. Public Health Service.[14]

Environmental Control

The major approach toward reducing the incidence of byssinosis is to reduce the amount of dust in the environment using engineering controls.

Local exhaust ventilation for cotton cards is widely used to control dust. Local exhaust is also used for other preparation operations, but much less frequently than on the cards. Dust-laden air collected from exhaust hoods is filtered and recirculated in the mill, conserving the conditioned air necessary for spinning. Adequate filtration is a problem in most existing local exhaust recirculation systems. Studies are being conducted by NIOSH to develop filtration units efficient for respirable dust.

The spinning and weaving operations in the mill do not easily lend themselves to control by local exhaust ventilation because of the size of the equipment and the large air volumes necessary for adequate ventilation. In these areas, then, it is necessary to rely on general room ventilation for dust control. The general room air is recirculated, usually through filtration units not very efficient for respirable dust. The technology is available to construct ventilation systems that will create sub-TLV levels of dust in all mill areas, but implementation is impeded by economic considerations. NIOSH is conducting research to develop general room air filtration units adequate for removal of respirable dust and that are economically feasible.

Attempts have been made to eliminate or deactivate the etiologic agent from cotton before processing. To date, the most promising attempt appears to be a process in which the raw cotton is steamed before entering the mill.[15] The combination of a deactivating process and suitable ventilation systems may be the answer to reducing the incidence of byssinosis.

Summary

Cotton dust has been clearly related to occupational respiratory disease among textile workers. Although the specific etiologic agent has not been isolated, it is believed to be contained in the "trash" portion, the mineral and lint portions being of minor hygienic importance. Several sampling techniques for cotton dust have been reported with the vertical elutriator correlating most promising with medical data.

Until the etiologic agent is isolated and/or can be removed from cotton before processing, it will be necessary to use exhaust ventilation to dust control systems to reduce dust levels below the

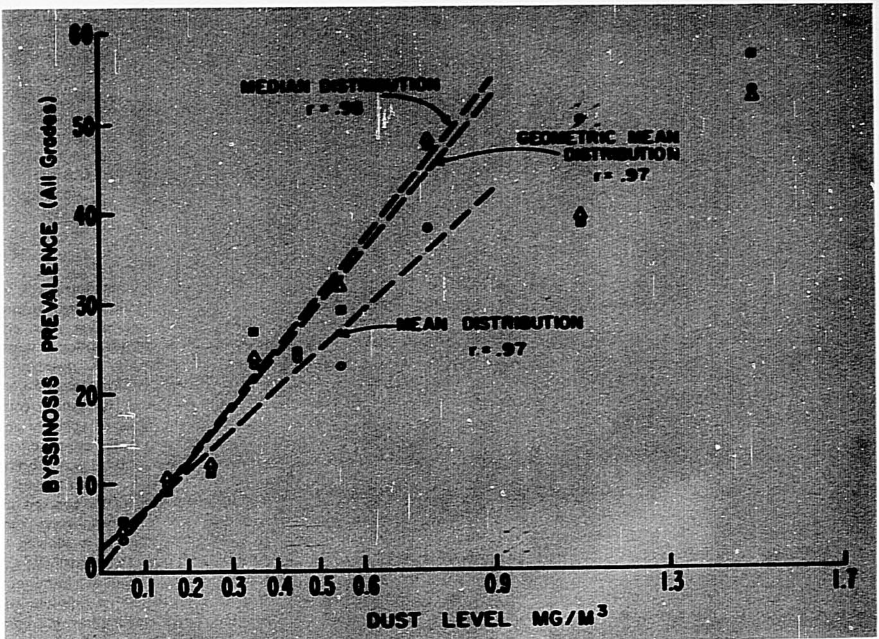

Fig 5. — Byssinosis Prevalence by Mean Median and Geometric Mean Dust Levels among Cotton Preparation and Yarn Area Workers. North Carolina, 1970-1971.

threshold limit value. The technology for such exhaust ventilation equipment is available but further development will be required for economic optimization of the systems.

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