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DESIGN OF INDUSTRIAL EXHAUST SYSTEMS

How to Design, Build or Buy an Exhaust System that Will Adequately and Economically Perform the Functions Required by Law or Prescribed by Specialists. Covers Exhaust Ventilation, Low-Pressure Pneumatic Conveying, Hood Design, Piping and Structural Details, and Selection of Dust Separators and Exhaust Fans.

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THIRD EDITION
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PREFACE

This book makes no attempt to cover the broad fields of health hazards, industrial dusts or the pathological phases of industrial hygiene. Able investigators have extended the horizon of these subjects immensely in recent years. Industry, therefore, is well informed of the need for exhaust sanitation. It is *not* well informed as to how best to satisfy that need. The purpose of this book is to tell the engineer how to design and build or how to buy an exhaust system that will adequately and economically perform the functions prescribed by the industrial hygiene expert or by law.

Although exhaust ventilation has been practiced for more than 90 years and has been recognized by statute for more than 60 years, the literature is astonishingly scanty. There seem to have been two major contributing factors. First, the field has been relatively small and inconspicuous and has not attracted the attention of colleges and other independent investigators. The second, and perhaps predominant, factor has been that many of those within the industry have treated their accumulated data as precious trade secrets to be divulged neither to competitors nor to customers. The author aims to dispel most of the mystery surrounding exhaust work and to express many of the trade secrets in straight-forward engineering terms. He is fully conscious of the shortcomings of this book but believes that sufficient data have been presented to permit the design of adequate and low-cost systems or to appraise competitive designs and the claims of rival contractors. It is hoped that the reader will be encouraged to measure, record and publish engineering facts concerning exhaust systems to the end that our collection of basic data will become more complete and more reliable.

The subject of exhaust ventilation embraces the theory of air flow, the application of this theory to practical design, the selection of commercial fans and dust collectors, the construction of the physical plant and the testing of the completed system. There is no lack of published material on the subject of fluid flow. Unfortunately, the information is widely scattered and much of it is to be found in papers not easily accessible to the busy engineer. Moreover, many confusing contradictions are encountered, requiring intensive study to reconcile conflicting statements and conclusions. The author has selected and abridged the most authentic data for the theoretical portions of the book.

Acknowledgments are due to C. H. B. Hotchkiss, Editor, HEATING & VENTILATING, who guided portions of the material through serial publication, and to E. J. Crane, Western Electric Co., Inc., for his advice and criticism of the earlier chapters.

PREFACE TO SECOND EDITION

In the intervening years since this book was first published, advances and refinements in exhaust system practices have taken place. In recognition of these developments, two new chapters have been prepared as well as many lesser additions. The growth of electrochemical processes for surface preparation and finishing of metals has warranted broader treatment of fume control. Axial flow fans, also, have acquired new importance in exhaust work.

In 1914 the author installed a trial exhaust unit on a granite surfacing machine in Barre, Vermont. This unit was never fully developed because of worker opposition. It is, therefore, with considerable personal satisfaction that he reports the successful efforts of others whose persistence in recent years has gained acceptance of exhaust protection in the stone cutting industry.

Appreciation is due to Miss Grace N. Donovan, Librarian of the Kearny Works of the Western Electric Co., Inc., for her patience in reading and abstracting the several hundred technical articles reviewed in the preparation of the second edition of this book.

PREFACE TO THIRD EDITION

Since publication of the second edition advances have been made in the variety and quality of devices available to the engineer. For the most part they have come about as a result of the increased emphasis on industrial hygiene. Industrial firms are less reluctant to spend the sums necessary to secure adequate atmospheric cleanliness. The development of fog filters, reverse flow filters and venturi scrubbers and the increased application of multiple miniature cyclones are noticeable advances. A recent examination of 1700 patents related to dust control devices shows increasing appreciation of sound engineering principles on the part of the inventors. Additional material presented herein updates the basic text to account for these changes.

J. L. A.

March, 1959

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2. Place the hood as close to the source of contamination as possible, preferably enclosing it.
3. Locate and shape the hood so that the dust particles thrown from the source are directed into the mouth of the branch pipe.
4. Cause air to flow past the dust source and into the hood with a velocity at the point of dust origin greater than the velocity of escape of the particles.
5. So locate the hood that the operator is never between the dust source and the hood.

Machine hoods intended for the reduction of health hazards require somewhat different design technique than do those installed for refuse removal purposes. The distinction lies in the size of the dust particle which each type is designed to handle. Dusts promoting occupational disease are microscopic in dimensions whereas industrial refuse may include a high percentage of large and heavy bodies.

Dusts

It is believed that the practical maximum limit of inspired dusts cannot be much over 20 microns[1] in longest dimension. In fact, relatively few particles over 10 microns are found in silicotic lungs. Some authorities doubt the retention in the lungs of substantial quantities of dusts finer than 0.5 microns. Regardless of the question of a possible lower limit of dangerous size, there is certainly a maximum limit and that limit is very small indeed. Expressed in shop terms, the dangerous particles are all substantially less than 0.001 in. long. It appears that numbers of particles rather than total weight of dust is significant in the evaluation of health hazards. Thus, it is reported that of certain foundry dusts investigated, 99%, by number of particles, were of dangerous size, 10 microns or finer, whereas these particles comprised but 27% of the total weight of the samples.

The author makes no pretense of treating the pathological aspects of dusts and fumes. It is recommended strongly that the more recent literature be consulted. It must be recognized that knowledge of dusts and their effects is far from complete. The field has been cultivated intensively, however, and much valuable material has been published. The engineer concerned with dust control in hazardous industries will do well to inform himself of the latest results available.

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[1] 1 micron = 1/1000 millimeter = 0.00003937 in.

Relative Dust Hazard

While authorities differ as to the harmfulness of certain industrial dusts, a few are known definitely to be hazardous. Chief among these is silica, occurring commonly as quartz. It is encountered in industries as dissimilar as granite cutting and hard-rock mining on the one hand and those employing abrasive processes such as sand blasting and grinding on the other. Asbestos, also, is known to produce pulmonary disability.

The toxic dusts, including lead, mercury, arsenic and others, are hazardous when inhaled. In fact, there is considerable evidence that the likelihood of poisoning through inhalation may be greater than that through food contamination.

Coal dust alone is believed not to produce disabling fibrosis. Calcium and magnesium carbonates as represented by limestone, marble, dolomite and magnesite have been shown to be comparatively harmless. The vegetable dusts such as cotton, jute, hemp and wood also are in this category. However, lacking positive evidence that a given dust is not harmful, it is best to assume that it is dangerous and to provide adequate protection.

Dispersion of Dusts

The manner and degree of dispersion of dust is a function of particle size. Large particles thrown from a wheel or cutter may be distributed over a wide area by virtue of their kinetic energies and without assistance from air currents. Small particles, on the other hand, are dependent entirely upon air currents for their dispersion. The mass of a tiny particle is so small and the kinetic energy so little that it is incapable of sustained flight. It loses velocity rapidly and cannot be projected far from the point of generation.[2]

Fine dusts in suspension drift with the general air currents. Their dispersion depends almost entirely upon drift. Fine dusts, therefore, must be controlled by controlling the flow of the entraining air. Coarse particles, on the contrary, are but little affected by local currents of mild intensity. Their dispersion by dynamic projection requires that the hood be placed, target-like, so that the particles are thrown directly into the pipe mouth.

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[2] A 10 micron abrasive particle thrown from a wheel at 10,000 f.p.m. can fly about 1 in. in still air. At the same speed a particle 1/16 in. diameter may be thrown 100 ft.