Exposures to: Mold, Mildew, and Metalworking Fluids

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I. INTRODUCTION

This paper addresses some of the issues of exposures to mold, mildew, bacteria, and related toxins in metalworking fluids. The linkage among these items is initially based on industrial occupational illnesses from metalworking fluids, that had become biologically contaminated with molds, fungus and bacteria; and the subsequent concerns about indoor air quality in other locations that might be affected by these microorganisms and their byproducts. Currently, many non-industrial buildings also have problems and concerns due to elevated levels of these contaminants.

KEYWORDS (Mold, Fungus, Bacteria, Metalworking Fluids, Indoor Air Quality, Mycotoxins, Endotoxins)

Abstract: During the early 1970's, concerns of overexposure to airborne components of metalworking fluids resulted in considerable investigation into this problem. These concerns were based on both the exposure to the chemical components of metalworking fluids, and the biological contamination and amplification that can occur. Chronic exposure to some chemicals was found to be associated with cancers. Entire work forces in some plants experienced "Pontiac Fever" (a flu-like illness) from overexposure to the biological contamination components of metal working fluids. Similar outbreaks of "Humidifier Fever" had occurred in non-industrial locations, that subsequently were found to be contaminated with molds and bacteria.

Previous outbreaks of disease and poisonings were also known to be related to the consumption of biologically contaminated grains that contained endotoxins and mycotoxins, two classes of toxins produced by some microorganisms. In the early to mid-1990's it was becoming increasingly common to find that indoor air problems were often associated with biological sources (e.g. molds, fungus, bacteria, and biological byproducts) and less often from chemical sources. This paper presents some of the current knowledge about these contaminants and the complications associated with evaluating exposures. It is presented in the context of metalworking operations, but applies to other locations and activities.

II. The Complexity of Metalworking Fluids and Establishing a Cause and Effect Relationship

A. Metalworking Fluids and Applications

In the context of this discussion, metalworking fluids are all of those liquids that are used to lubricate, prevent rust, and cool tooling and dies for the purpose of improving metalworking operations. This is intentionally a very general definition. As the application of metalworking fluids has increased to include many different operations, the metalworking fluids have evolved to include many new classifications and types, and the means of application of these fluids has improved to minimize use and increase efficiency.

It is estimated that there may be in excess of a hundred million gallons of such fluids used annually within the United States. The use varies considerably from facility to facility based on application method, machining operation, and production levels. Facility ventilation is apt to be specific to the operational demands. The application of metalworking fluids is often at or near the point of metal forming operation; in larger installations metalworking fluids may be recycled within the machining operation for filtering and re-application; and in many situations, metalworking fluids will be re-fortified with various components to maintain their stability and performance characteristics. This means there is considerable variability in the mechanics of forming airborne contaminants and the resulting exposures.

The composition and machine-type application of metal working fluids is quite diverse and evolving. Rudnick (1999) lists at least seventeen categories of synthetic fluids, and the American Society of Tool and Manufacturing Engineers lists over twenty-nine machining processes employed over the past thirty years regularly using metal working fluids. It has been reported that there were over two million machine tools in operation. Annual sales in the United States of new metalworking equipment topped 2.7 billion dollars

These kinds of variations have resulted in significant differences in the magnitude, composition, and physical characteristics of worker's exposures, and chronic dose levels; but there has been an appreciation over the years of an increase in the number of adverse health effects from working in this industry and around these processes.

B. Epidemiological Methods used to Identify and Establish a Cause and Effect Relationship

There are at least six basic components that are used to help establish the presence of a cause and effect relationship. These are:

1. a dose-response relationship
2. a consistency of adverse health effects associated with exposures,
3. a specificity of the association of disease with the exposure,
4. a correct temporal (time) relationship between the exposure and the health effect,

5. a biological plausibility for the adverse health effect and the exposure, and

6. a significant strength of the association between exposure and effect.

In effect, there should be: more adverse outcomes for higher or longer exposures; the adverse health effects should be consistent across borders and industries with similar exposures; the adverse health effects can be measured and are just not ephemeral subjective events; the latency period between exposure and the adverse effect make sense (e.g. tumor's and other tissue changes take time to grow and manifest themselves); there should be some plausible explanation of the mechanism of exposure and how the chemicals could cause the adverse health effect; and the size of the study population and health events should be sufficient to be able to detect and quantify the cause and effect relationship. It would be rare that all six of these components are included and evaluated in any single study. More commonly, a series of studies evaluate these various aspects to build a basis for the cause and effect relationship. Through the course of several studies, conflicts in findings and new directions for studies often occur, but generally a consistency in associations will surface.

One final global consideration with all epidemiological studies is the potential for an association to appear to exist, but it is only due to confounding effects. The easiest may to explain confounding may be by example. In the study of the causes of lung cancer, researchers would have found an apparent association between carrying a butane cigarette lighter and lung cancer. Those carrying a butane cigarette lighter are more likely to have lung cancer. But that relationship is due to confounding and not due to a cause and effect relationship, because carrying a cigarette lighter is a confounding association with the true exposure of cigarette smoking. Confounding is a situation where there appears to be a statistically higher than expected association, but this association is due to a collateral condition, and not the true condition initiating the cause and effect relationship.

C. Definitions:

Air-O-Cell - One type of sampling device for collection of airborne bioaerosols, but does not provide a viable count.

Anderson Sampler - One of the recognized sampling devices for airborne bioaerosols. It can provide an estimate of the viable count.

Bacteria - prokaryotic organisms that do not produce oxygen, reproduce by binary division and can live and flourish in various media found in buildings and industry (ACGIH Bioaerosols, Assessment & Control 1999)

Bioaerosols - All of those airborne particles that are living or originate from living organisms. (ACGIH Bioaerosols, Assessment & Control 1999)

Endotoxins - Heat stable molecules present in the cell walls of gram negative bacteria that have certain characteristic toxic effects (IAQ Microbiology Reference Guide, Aerotech, 1999)

Epidemiology - The study of the distribution and determinants of disease and injuries in human populations and is the major method used to establish a cause and effect relationship between

occupational exposures and adverse health effects. (Mausner, "Epidemiology"1985)

Fungi - Eukaryotic organism that lack flagella and develop from spores: Yeasts, mold, rusts & mushrooms (ACGIH Bioaerosols, Assessment & Control 1999)

Gram Positive & Negative Bacteria - A specific GP bacteria often associated with "humidifier Fever", which has 4 to 12 hours delayed effects. Farmer's lung, a respiratory disease is often associated with GN materials. (Industrial Toxicology, Hamilton & Hardy, 5th edition 1998)

Legionnella - a type of bacteria which may be amplified in quantity in water sources in building equipment, especially in cooling towers and potable hot water systems, source of Legionnaires' Disease (PathCom Laboratories, 1998)

Metalworking fluids - All of those liquids that are used to lubricate, prevent rust, and cool tooling and dies for the purpose of improving metalworking operations. (40CFR Part 747.195 (b)(2), 7-1-85)

Mildew - Often a lay person's term used to describe fungus growing on fabrics or bathroom surfaces. To mycologists the term mildew refers to a select group of fungi that damages crops. (ACGIH Bioaerosols, Assessment & Control 1999)

Mycotoxins - Secondary metabolites secreted by some fungi to assist in breaking down complex compounds. Many are harmful to humans if inhaled, ingested or brought into contact with skin. (ACGIH Bioaerosols, Assessment & Control 1999)

Yeasts - Are unicellular fungi that reproduce primarily by budding.

D. Implications

Microorganisms are ubiquitous in our environment. Many of these organisms, their cellular parts, and the chemicals they produce are benign, especially at the range of background levels we normally encounter. But, as we become more aware of their concentration, mixtures, and life cycle conditions, we have come to know they can have pronounced adverse health effects, especially on those already at risk. Many of these adverse health effects are short term and reversible. As with any exposure though, those more vulnerable, those exposed to high levels, and those exposed for longer periods of time can be at some level of elevated risk of more debilitating problems.

In industrial work environments, these exposures often result in self exclusion of certain individuals who are more responsive to exposure. In a home environment, extra concern must be given to young children and others more vulnerable to exposure. In a commercial or school environment, there is a potential, simply based on the size of the population exposed, that some subset of individuals will have a significant response, while the majority have no problem. In addition there is an opportunity for a hysterical response often based on miscommunication.

Currently there is no acceptable or unacceptable exposure criteria for these materials. While the CDC, OSHA, and the EPA have investigated these exposures, there is no national consensus about specific allowable exposure levels. This is in part due to the many combinations of bioaerosols possible, the

range of human response, and natural regional differences in background levels.

Certainly, the metal working industry; sewer, sewage and mulching related activities; those working in confined spaces; and agricultural and horticultural activities are associated with the potential for these exposures and effects.

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