NIOSH

Recommendations for Control of Occupational Safety and Health Hazards . . .

Manufacture of Paint and Allied Coating Products

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

Cover photograph: This mural representing the paint and allied coating products industry, one of of fourteen murals depicting industrial scenes, is now on permanent display at the Greater Cincinnati International Airport. The murals, designed by Winold Reiss in the early 1930's, originally adorned the walls of Cincinnati's Union Terminal Railway Station.

RECOMMENDATIONS FOR CONTROL OF OCCUPATIONAL SAFETY AND HEALTH HAZARDS....

MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

U. S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

September 1984

DISCLAIMER

DHHS (NIOSH) Publication No. 84-115

PREFACE

The Occupational Safety and Health Act of 1970 (Public Law 91-596) states that the purpose of Congress expressed in the Act is "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources...by," among other things, "providing for research in the field of occupational safety and health...and by developing innovative methods, techniques, and approaches for dealing with occupational safety and health problems." Later in the Act, the National Institute for Occupational Safety and Health (NIOSH) is charged with carrying out this policy. One method by which NIOSH responds to this charge is to publish recommendations for control of occupational safety and health hazards.

These publications critically review the scientific and technical information available on the prevalence of hazards, the existence of safety and health risks, and the adequacy of hazard control methods in an industry. The information and recommendations presented should facilitate development of specific procedures for hazard control in individual workplaces. In addition, these publications list the Federal standards applicable to the industry and the specific hazardous substances that are present in its work environment. In the interest of wide dissemination of this information, NIOSH distributes these publications to other appropriate governmental agencies, organized labor, industry, and public interest groups. We welcome suggestions concerning the content, style, and distribution of these documents.

This document provides guidance for protecting workers involved in the manufacture of paint and allied coating products. It was prepared by the staff of the Division of Standards Development and Technology Transfer, NIOSH. I am pleased to acknowledge the many contributions made throughout the development of this document by reviewers and consultants, representatives of other Federal agencies, and the staff of the Institute. However, responsibility for the conclusions and recommendations belongs solely to the Institute. All comments by reviewers, whether or not incorporated into the final version, are being sent with this document to the Occupational Safety and Health Administration (OSHA) for consideration in standard setting.

J. Donald Millar, M.D., D.T.P.H. (Lond.)
Assistant Surgeon General
Director, National Institute for
Occupational Safety and Health
Centers for Disease Control

ACKNOWLEDGMENTS

The contributions to this publication by NIOSH staff, other Federal agencies, the review consultants, the reviewers selected by the American Industrial Hygiene Association (AIHA) and the Society for Occupational and Environmental Health (SOEH), and consultants William C. Nicoll and Robert B. O'Connor, M.D. are gratefully acknowledged.

The Division of Standards Development and Technology Transfer, National Institute for Occupational Safety and Health, had primary responsibility for the development of this publication. The initial development was performed by Paul A. Schulte and Charles H. Gorski. The publication was completed by Howard R. Ludwig.

Contributors to this document and previous unpublished versions of it are listed below and on the following pages. The NIOSH review of this publication was provided by Robert W. Mason, Ph.D., Richard A. Rhoden, Ph.D., Jon R. May, Ph.D., Paul E. Caplan, Gordon D. Nifong, Ph.D., Douglas L. Smith, Ph.D., William F. Todd, Nelson A. Leidel, Sc.D., Harold Van Wagenen, Patricia M. Gussey, Richard E. Piccirillo, M.D., Thomas K. Hodous, M.D., Stephen Berardinelli, Sr., Ph.D., Donald W. Badger, Ph.D., and Dennis D. Zaebst. Particular thanks are directed to Charles R. Butler for his assistance in the statistical analysis of the injury and illness data.

Although many persons contributed to the typing and editing of this document, a special appreciation is extended to Carolyn Browning, Martha DiMuzio, Myrtle M. Heid, Catherine Johnson, Rolland R. Rogers, and Kimble Varner.

REVIEW CONSULTANTS

Richard F. Brewster
Chemical Engineer
Williamsville, New York 14221

Charles R. Dancer, C.S.P., P.E.
Formerly Manager of Safety and Health
M & T Chemicals Inc.
Rahway, New Jersey 07065

Charles W. Fishburn, M.D.
Consultant, Occupational Medicine
New Berlin, Wisconsin 53151

William R. Gaffey, Ph.D.
Formerly Senior Epidemiologist
Center for Occupational and Environmental Safety and Health
SRI International
Menlo Park, California 94025

Patrick J. Hurd
National Paint and Coatings Association (NPCA)
Washington, D.C. 20005

Ruth Lilis, M.D.
Environmental Sciences Laboratory
Mount Sinai School of Medicine
New York, New York 10029

Theodore Loomis, M.D.
Professor of Pharmacology and Toxicology
School of Medicine
University of Washington
Seattle, Washington 98105

Daniel MacLeod
Industrial Hygiene Consultant
United Auto Workers Union
Detroit, Michigan 48214

REVIEW CONSULTANTS (CONTINUED)

John J. Riccio
The Voltax Co., Inc.
Bridgeport, Connecticut 06605

David G. Sarvadi
Formerly Industrial Hygienist
The Sherwin-Williams Co.
Cleveland, Ohio 44115

Glenn M. Strong
Industrial Hygienist
Glidden Coatings and Resins
SCM Corporation
Cleveland, Ohio 44115

Rod Wolford
Health and Safety Director
International Brotherhood of Painters
and Allied Trades
Washington, D.C. 20006

FEDERAL AGENCIES

Department of the Army
Army Environmental Hygiene Agency

Department of Health and Human Services
National Institutes of Health
National Heart, Lung, and Blood Institute
National Institute of Environmental Health Sciences

CONTENTS

CONTENTS (CONTINUED)

CONTENTS (CONTINUED)

FIGURES

TABLES

I. INTRODUCTION

This publication contains an assessment of occupational safety and health hazards during the manufacture of paint and allied coating products and recommends safe work practices and engineering controls. The term "Paint and Allied Coating Products" includes a variety of products having the broad functions of surface protection or decoration. Examples are paints, varnishes, lacquers, and stains as well as related products such as putties and paint and varnish removers. The scope of the document does not encompass the manufacture of raw materials used in coatings or the physical application of coatings (i.e., painting, staining, varnishing, etc.). Varnish production is included, although the manufacture of the resins used as raw materials is not. Paint and allied coating products facilities are included in the Standard Industrial Classification (SIC) code 2851, Paint, Varnishes, Lacquers, Enamels, and Allied Products.

Workers may be exposed to hazards as a result of lack of knowledge of potential problems, inadequate training, or lack of implementation of hazard controls. Workers are exposed to general safety hazards associated with the daily handling and storage of raw materials and the production of paint and allied coating products. These workers may also be exposed to chemical hazards such as pigment dusts, solvent vapors, and gases (during varnish manufacture) and to physical agents such as noise. In addition, many substances used are highly volatile and flammable, thus creating potential fire or explosion hazards.

The handling of raw materials and finished products; dispersion of pigment or resin particles; thinning, tinting, and shading; filling; and laboratory functions are some of the operations in the paint and allied coatings industry that will be discussed in this publication. The recommendations are broad-based to accommodate variations between facilities and the wide range of operations and processes encountered. Many of the recommendations, such as those addressing the use of personal protective equipment, machine guarding, container labeling, and worker training, are consistent with the Occupational Safety and Health Administration (OSHA) General Industry Standards contained in 29 CFR 1910. Other recommendations, such as those concerning substitution of raw materials, engineering controls, or safe lifting techniques are addressed only generally in OSHA standards or not at all. The recommendations are intended to enable management and labor to develop better work practices and training programs that will result in safer working environments.

Chapter II provides a discussion of basic characteristics for those persons who are not familiar with this industry. The document in its entirety provides safety and health information for organized labor; managers, technical consultants, and occupational safety and health personnel of companies involved in this industry; and the field staffs of various governmental agencies (i.e., NIOSH, OSHA, and EPA) responsible for the safety and health of workers.

II. CHARACTERISTICS OF THE PAINT AND ALLIED COATING PRODUCTS INDUSTRY

A. Overview

Paint and allied coating products constitute a general class of materials whose primary functions are the protection and decoration of surfaces. Coatings are also used for fire retardation, color coding, electrical insulation, and temperature control [1]. In the most narrow sense, "paint" refers only to pigmented products such as interior (wall), exterior (house), masonry, and traffic coatings; terms for other coatings include enamel, undercoater, primer, sealer, varnish, lacquer, stain, and industrial finishes. Historically, however, the term "paint" has sufficed as the common description for coating materials consisting of a covering material (pigment), a film-forming material (usually an oil or resin), and viscosity modifiers (thinners and solvents). The terms "organic surface coating," "paint and coating," or "chemical coating" are increasingly being used to describe a variety of products that are used for the protection or decoration of surfaces. Related to the various types of surface coatings are allied products such as putties and paint and varnish removers. The major types and end uses of paint and coating products are shown in Table II-1.

The manufacture of most coatings basically involves the incorporation of pigment particles in a film-forming matrix, thinning and adjusting the resultant product, and dispensing it into containers of various sizes for shipment and sale. The manufacture of varnishes, which contain no pigments, is a different type of batch process which involves mixing ingredients and "cooking" them in a reactor vessel or kettle. Definitions of various terms used in the coatings industry are listed in the Glossary (Appendix A).

Thousands of different raw materials [2] are used in the manufacture of approximately 20,000 different coating products [3-5]. The need for so many raw materials and products results from the great diversity of surfaces requiring treatment. There are numerous small manufacturers because paint-making is still largely a batch process that does not readily lend itself to automation or continuous flow processing [2]. Few firms sell nationwide because of high shipping costs, the difficulty of maintaining production schedules, and other distribution problems.

1. Industry Trends

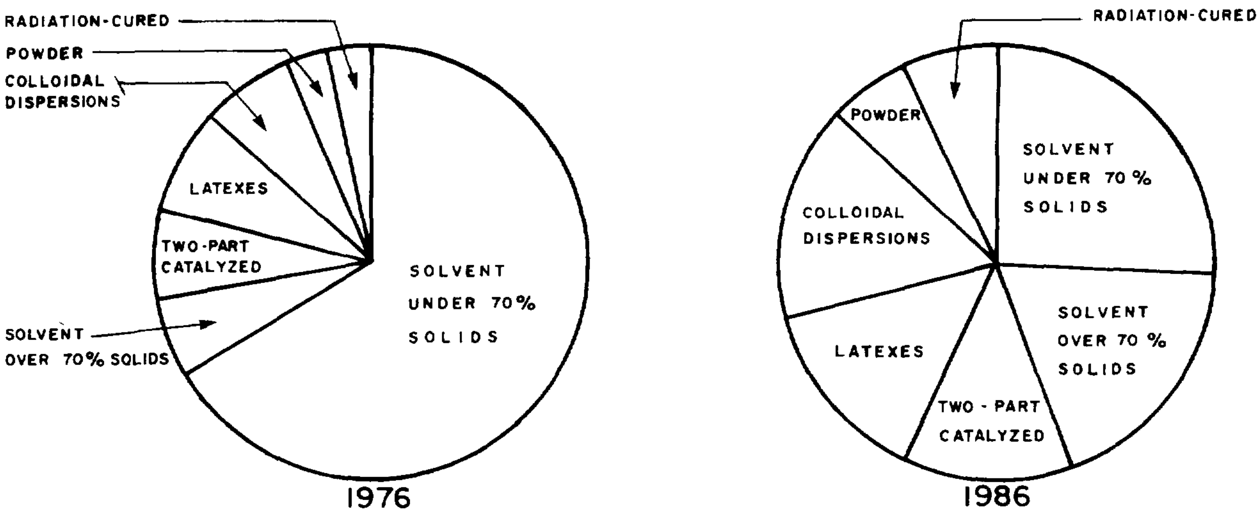
Growth in the total production of the U.S. paint and allied coating products industry has been about 2% annually since 1967 and is expected to continue at this rate through 1990 [6]. In 1981, over 900 companies produced architectural coatings, approximately 250 companies made product coatings for original equipment manufacturers, and approximately 250 companies made special purpose coatings [6]. The largest companies are active in all coatings categories; whereas, the smaller companies may specialize in only one segment of the industry [6].

TABLE II-1. TYPICAL END USES FOR THE MAJOR CATEGORIES OF PAINTS AND COATINGS [6]

Category	End Uses
Architectural Coatings	Exterior house and trim paints (including flat house paints and enamels) Exterior masonry paints Undercoaters, primers, and sealers Interior wall, ceiling, and trim paints (including flat wall paints, and gloss and semigloss enamels) Varnishes Stains
Product Coatings for Original Equipment Manufacturers	Automobile, truck, and bus finishes Wood furniture and fixture finishes Metal furniture and fixture finishes Finishes for railroad equipment Aircraft and missile coatings Appliance finishes Marine finishes Electrical and electronic insulation coatings Machinery and equipment finishes Prefinished metal (coil coatings) Prefinished wood and composition boards Container and closure coatings Paper and paperboard coatings Plastic and film coatings Pipe coatings
Special Purpose Coatings	Specially formulated high-performance maintenance finishes Automobile, truck, and bus refinish coatings Marine refinish coatings Other refinish coatings Traffic paints Metallic finishes Aerosol paints

Air pollution regulations limiting the amount of volatile organic compounds that can be used in coatings and the rapid rise in solvent prices are responsible for the trend in the coatings industry to replace conventional low-solids, volatile organic solvent-based coatings with high-solids (i.e., over 70%) or low solvent or water-based formulations such as radiation-curable coatings, powder coatings, two-part catalyzed systems, and nonaqueous dispersions [1,2,6]. However, it is believed that conventional organic solvent-based coatings will still have a large share of the market at least until 1990 [6-8]. Figure II-1 shows the relative market share in 1976 and an estimate for 1986 for the primary types of coatings.

FIGURE II-1. MARKET SHARES OF VARIOUS PAINT AND COATING SYSTEMS IN 1976 AND ESTIMATES FOR 1986 [8]
(Copyright by Chemical Marketing Services, Inc. Reprinted with Permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)



In addition to the air pollution emission potential of various coating systems, a factor in their selection is the amount of energy required for application and for engineering controls to reduce occupational exposure. Because of relatively high energy efficiencies, the use of high-solids and radiation-curable coatings is expected to increase [7,8].

2. Extent of Exposure

According to the 1978 Annual Survey of Manufacturers [9], the paint and allied coating products industry in the United States employed about 61,500 workers in 1,700 individual plants. About 60% of the paint facilities had fewer than 20 workers, and only about 3% of the facilities (i.e., about 50) had more than 250 workers [9]. According to NIOSH data generated in 1983 [10], there were about 68,000 workers in 1,800 individual plants. The Department of Labor estimated that there were 60,600 workers in Paints, Varnishes, Lacquers, Enamels, and Allied Coating Products manufacturing (SIC code 2851) in 1982 [11].

3. Product Classifications

In 1979, the Federal government revised its reporting system for categorizing paints and coatings classifying them as either (1) architectural coatings (paints), (2) product finishes for original equipment manufacturers, or (3) special purpose coatings [9]. The typical end uses for each of the three major categories of paints and coatings are shown in Table II-1.

"Architectural coatings" are generally classified as stock type or shelf goods that are formulated for normal environmental conditions and general applications on new and existing residential, commercial, institutional, and industrial structures [6]. Approximately 70% of all architectural coatings are water-based and most are applied by brush or roll [1].

"Product coatings for original equipment manufacturers" are formulated specifically to meet conditions of application and product requirements [6]. These coatings include paints, lacquers, and powders and are applied during the manufacturing process to the surfaces of products made from metal, wood, or plastic. About 60-65% of these coatings have been solvent-based, but in recent years applications for water-based, high-solids, powder coatings, and two-part catalyzed systems have been increasing [9].

"Special purpose coatings" may be stock-type or shelf goods, but they are formulated specifically for refinishing and specialty applications or for environmental conditions such as extreme temperatures or corrosive-chemical atmospheres [6]. These coating types include high-performance industrial maintenance paints, automotive and machinery refinishes, and traffic paints and can be either solvent- or water-based [9].

4. Job Classifications

A scheme for the classification and description of jobs in this industry has been developed by Discher et al. [12]. A revised version of this classification is presented in Table II-2. A similar description of job classifications in the varnish manufacturing process is shown in Table II-3. In many smaller plants, one worker might perform a number of different jobs rather than just one particular task.

TABLE II-2. JOB CLASSIFICATIONS IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Classification	Description
Raw materials handlers	Transport and store raw materials in the plant.
Prebatch assemblers	Weigh and assemble raw materials (usually dry) for the mixer, primarily in the raw materials storage and mixing areas.
Mixers (including mill operators)	Load mixing tanks or mills. Responsible for quality control checks for dispersion. May be responsible for cleaning the mills.
Tinters (including thinners, shaders, and body adjusters)	Responsible for the dispersed paint quality. Add solvents, driers, preservatives, and tinting paste. Responsible for quality control for color, viscosity, etc.
Fillers	Fill paint containers. Set up the filling line (if mechanized).
Tank and tub cleaners	Clean portable tanks and tubs.
Laboratory personnel	Test raw materials. Responsible for finished product testing and for research and development.
Others	Includes packagers, maintenance personnel, shippers, and loading personnel in the warehouse.

Adapted from Discher et al. [12]

TABLE II-3. JOB CLASSIFICATIONS IN THE MANUFACTURE OF VARNISHES

Classification	Description
Reactor operators	Load reactors with raw materials. Adjust and maintain reaction conditions.
Varnish cookers	Cook varnish and maintain reaction conditions (applies only to open-kettle process).
Filter press operators	Filter and reduce the varnish and clean the presses.
Fillers	Fill varnish containers.
Laboratory personnel	Test raw materials. Responsible for finished product testing and for research and development.
Others	Includes packagers, maintenance personnel, shippers, and loading personnel in the warehouse.

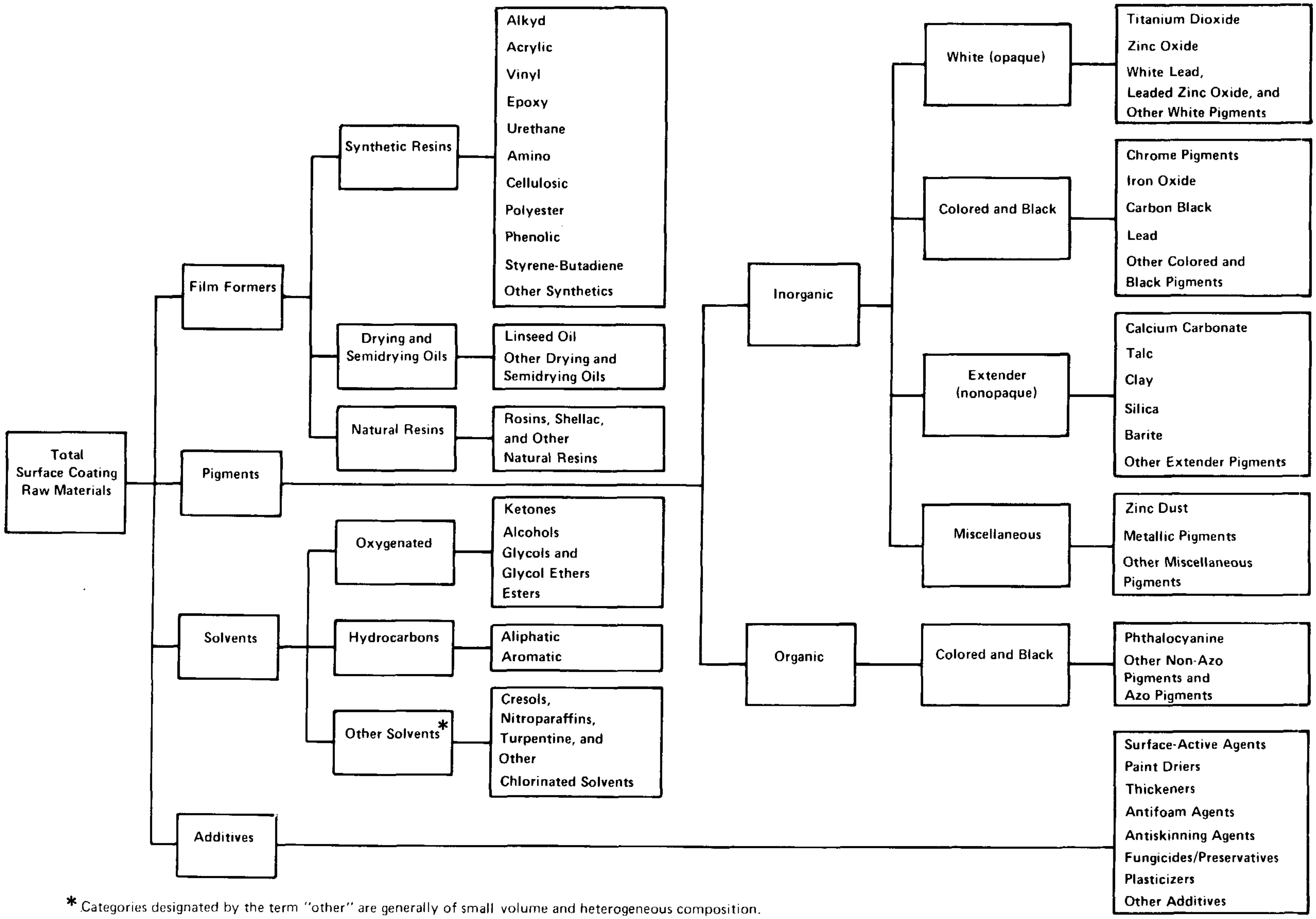
Adapted from Discher et al. [12]

B. Raw Materials

Liquid paint is a suspension of pigment particles in a mixture of film-former and volatile solvent. The solvent, which reduces viscosity to allow easy application, and the film-former hold the pigment in the dried film and cause it to adhere to the coated surface. The pigment confers hiding and coloring power as well as durability to the dried film. Various additives are used to obtain particular characteristics. Although drying is usually accomplished through evaporation of the solvent, drying may also be by polymerization of the film-former through oxidation (e.g., with oils and alkyds), by coalescence (e.g., with latexes), or by chemical reactivity (e.g., with epoxy resins) [13].

In 1980, an estimated 9.5 billion pounds of raw materials (excluding water) were used in the manufacture of paint and allied coating products [6]. The four general categories of raw materials used (film-formers, pigments, solvents, and additives) are identified in Figure II-2.

FIGURE II-2. RAW MATERIALS USED IN THE MANUFACTURE OF COATINGS
(Adapted from Chemical Economics Handbook [1])



* Categories designated by the term "other" are generally of small volume and heterogeneous composition.

1. Film-Formers

Film-formers are the nonvolatile binders or vehicle portions of coatings. They may be classified as one of three different chemical types: synthetic resins, drying and semidrying oils, and natural resins. Synthetic resins account for over 94% of all film-formers and include alkyds, acrylics, vinyls, epoxies, urethanes, aminos, cellulosics, polyesters, phenolics, styrene-butadienes, and others [1]. Linseed oil is the primary drying oil utilized as a film-former. Natural resin film-formers constituted less than 1% of all film-formers consumed in 1977, in contrast to about 50% prior to World War II [1]. Some of these natural resins include rosins and shellac.

2. Pigments

Pigments are incorporated into coatings to impart color, opacity, and properties such as durability, corrosion inhibition, and mildew control or to be a filler or extender [1]. They are finely powdered solids that are essentially insoluble in the medium in which they are dispersed. Almost all of the pigments utilized in the U.S. (99%) are inorganic [1,6] with titanium dioxide accounting for about one-third of total pigments used [6]. Pigments are generally classified as white (opaque) pigments, colored and black pigments, extenders (non-opaque), and miscellaneous (mainly metallic powders).

Extenders are white pigments that have a low refractive index and have little hiding or coloring ability by themselves in solvent-based coatings but have a strong influence on costs and the performance of most pigmented coatings in which they are used. Extender pigments are used to control gloss, texture, suspension, viscosity, and other physical characteristics of coatings [2,14]. In water-based coatings, however, extender pigments contribute to opacity and hiding ability. Extenders include talc, china clay (aluminum silicate), silica, asbestos, diatomaceous earth, calcium silicate, magnesium carbonate, and mica [2,14].

Generally, pigments are available as dry powders that are shipped in bags or in cardboard or fiber drums. Pigments are also shipped as aqueous slurries and pastes or as pellets.

3. Solvents

The primary function of solvents in paints and coatings is to dissolve or suspend film-formers, thereby providing a consistency suitable for application. Solvents also influence the rate of setting, the drying time, the flow properties, and the flammability of coatings [1]. Water-based paints consist of a dispersion of film-formers within an aqueous medium. Generally, organic solvents are classified as hydrocarbon solvents, oxygenated solvents, and "other." The latter category includes furans, nitroparaffins, chlorinated solvents, and terpenes.

a. Hydrocarbon Solvents

Among the organic solvents, hydrocarbon solvents rank first by volume of use (56%) in paint and allied coatings [1]. They are less expensive than many other types of organic solvents and have many uses. An organic solvent-based coating material that contains no hydrocarbon solvent is unusual. Hydrocarbon solvents used in the paint industry are classified as either aliphatic naphthas or aromatics. Aliphatic naphtha solvents such as mineral spirits or Varnish Makers' and Painters' (VM&P) naphtha are predominantly paraffins, with a smaller but appreciable content of cycloparaffins (naphthenes such as cyclopentane and cyclohexane). These solvents may also contain as much as 20-30% aromatics [2]. Mineral spirits constitute about three-fourths of all hydrocarbon solvents used in the paint and allied coating products industry overall. The aromatic hydrocarbon solvents such as toluene, xylene, high flash solvent naphthas, and aromatic naphthas predominantly exhibit higher solvency than aliphatic solvents.

b. Oxygenated Solvents

Oxygenated solvents are so designated because of the presence of oxygen which contributes polarity (a difference in the electric charge on various portions of the materials). This polarity is the fundamental difference between oxygenated and hydrocarbon solvents, which are essentially nonpolar. Because of their polarity, many oxygenated solvents are water-soluble and are better solvents for the more polar film-formers such as shellac, cellulose esters, amino-formaldehydes, vinyls, acrylics, epoxies, polyurethanes, and silicones [15]. Oxygenated solvents account for about 42% of the organic solvents used in the paint and allied coatings industry [1] and include glycols, glycol ethers, glycol ether esters, water-miscible alcohols such as methanol, ethanol, butanol, and isopropanol, acetate esters, and ketones such as acetone, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK) [6]. Since they are more expensive than the hydrocarbon solvents, a mixture of oxygenated and hydrocarbon solvents is used in most paint formulations [15].

c. "Other Solvents"

Other solvents, which account for only 1% of the organic solvents used, include furans such as tetrahydrofuran and tetrahydrofurfural alcohol, nitroparaffins such as 2-nitropropane, chlorinated solvents such as methylene chloride, and terpenes such as turpentine, dipentene, and pine oil [2,15].

4. Additives

Many substances that contribute to the ease of manufacture, the stability of the paint in the package, the ease of application, or the quality or appearance of the applied film are used in relatively small quantities in paint formulations. These substances are referred to under the broad term "additives." Each additive rarely exceeds 1% of the total formulation, and the total amount of all additives seldom exceeds 5% of the paint product [16]. The major classes of additives are plasticizers, surface-active agents, flow modifiers, driers, anti-skinning agents, biocides, and "other."

a. Plasticizers

A plasticizer is a substance added to a coating material to keep the finished film flexible and to avoid undesirable effects such as cracking or checking, without appreciable sacrifice of such desirable effects as film strength, continuity, and resistance to attack by chemicals [17]. True plasticizers are permanent and relatively nonvolatile components of coating films. Plasticizers account for about one-third of the additives consumed in coatings [1]. Over 500 different plasticizers are available [2].

b. Surface-Active Agents

Surface-active agents or "surfactants" are added to aqueous coatings (such as latexes) and comprise over 20% of the additives used in paints [1]. There are four general groups: anionic surfactants, used primarily to promote pigment dispersion by providing better wetting of the particles; nonionic surfactants, used to stabilize total dispersed systems; antifoam agents, used to prevent, reduce, or eliminate foam formation during coatings manufacture and application; and emulsifiers, which are materials used to stabilize mixtures of immiscible liquids such as oil and water by reducing interfacial tensions between liquids [16,17].

c. Flow Modifiers

Flow modifiers such as thickening (bodying) agents affect the viscosity of coatings. Thickening agents are used to provide desired paint consistency, prevent pigment settling, and assist in applying films of adequate and uniform thickness [16].

d. Driers

Driers promote or accelerate the drying, curing, or hardening of oxidizable coatings [16]. Driers should be clearly differentiated from curing agents that chemically react or condense with the coating material to become an integral part of the final polymer composition [16].

e. **Anti-skinning Agents**

Skinning refers to the drying of a coating, but at the wrong time and in the wrong place (e.g., while it is still packaged). Oxidative polymerization of the film-formers at the air-liquid interface can lead to the formation of a solid or gelatinous skin on the surface. Anti-skinning agents are volatile antioxidants which prevent oxidation of the paint in the package and volatilize while the coating is drying.

f. **Biocides**

Fungicides and preservatives are used to control the growth of fungi and other microorganisms. Microorganisms cause spoilage or deterioration and premature failure of paint and other coatings. Bacteria and fungi can use coatings, particularly water-based coatings, as food sources [2,16]. Biocides are used as mildewcides in exterior house paints, as antifoulants in marine paints, as preservatives and stains for wood used primarily as furniture, and as in-can preservatives in latex architectural coatings [9]. Zinc oxide, which is also a white pigment, is commonly used to confer mildew resistance to paints [13].

Due to environmental concerns, the use of phenylmercury salts as a biocide is declining [9]. Other traditional biocides such as creosote, pentachlorophenol, and coal tar products which are used in wood stains, preservatives, and coatings are also coming under regulatory scrutiny [9]. Replacements for these biocides include copper naphthenate, tributyltin oxide, zinc naphthenate, N-(trichloromethylthio)phthalimide, and cuprous oxide [9].

g. **"Other" Additives**

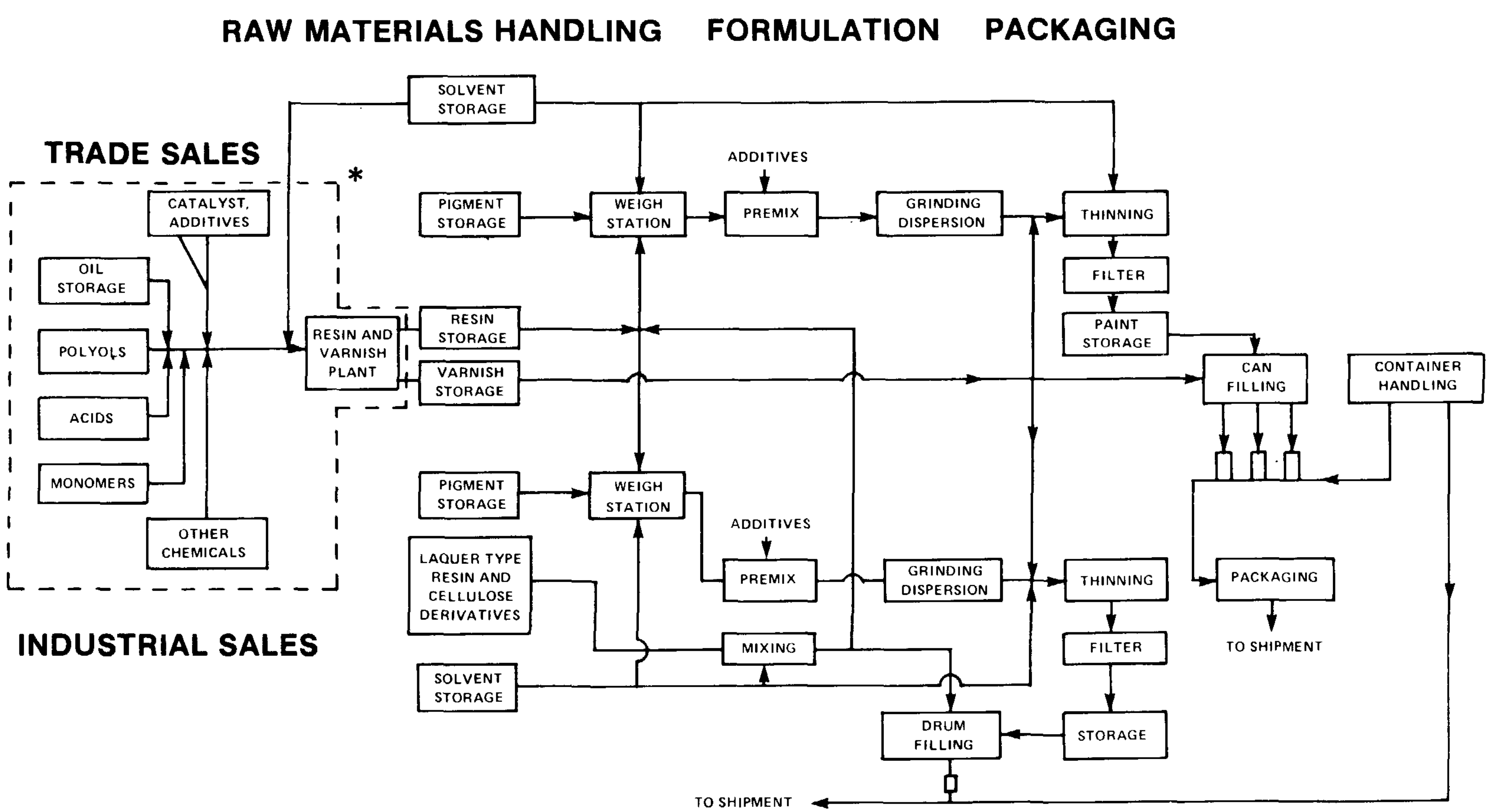
Many other substances are added to coatings in small amounts. These include coalescing agents, wet edge extenders, freeze-thaw and heat stabilizers, odorants, flame retardants, anti-livering agents, ultraviolet (UV) light absorbers, and agents that promote mar resistance [1].

C. Manufacturing and Related Operations

The manufacture of paint and allied coating products involves the assembling of materials, mixing, dispersing, thinning and adjusting, filling, and warehousing. Other related activities include materials handling, laboratory work, and shipping. The flow of materials in a typical paint manufacturing plant is shown in Figure II-3.

The manufacture of paint and allied coating products is essentially a series of unit operations (physical procedures) involving little or no chemical

FIGURE II-3. MATERIALS FLOW SHEET FOR THE MANUFACTURE OF PAINTS [19]



* Many plants purchase rather than manufacture their resins and varnishes.

reactions. Production is begun by mixing the pigment, film-former, and solvent (organic solvent or water). This is followed by the dispersion operation, which is a manipulation of the mixture to achieve pigment particle separation, wetting, and stabilization. The performance of the finished product depends on the maintenance of uniform interparticle distances in the dried film [2].

A variety of equipment is used to effect dispersion. The trend currently is to use equipment in which the paint formulation can be continuously mixed and dispersed, followed by thinning in the same unit [2]. After dispersion, the resultant material is tested for viscosity, color, and other physical properties while being adjusted or thinned. After passing this inspection, the batch is strained and loaded into containers.

The manufacture of varnishes is one of the most complex processes in a coatings plant, primarily because of the large variety of different raw materials, products, and cooking formulae used [18,19]. Varnishes are classified on the basis of the resins used. Oleoresinous varnishes are solutions of both oils and resins; whereas, spirit varnishes such as shellac are formed by dissolving a resin in a solvent. Varnish manufacture essentially consists of heating or cooking materials in a reactor vessel or kettle and then thinning and filtering the final product [18].

1. Paints

a. Materials Handling

Materials handling occurs primarily at both ends of the production process. Raw materials are available as liquids, solids, powders, pastes, and slurries.

b. Dispersion

The assembly of raw materials is followed by the mixing of pigments with film-formers, solvents, and additives and the dispersion of the pigment particles in the liquid matrix. Dispersion consists of a deagglomeration or separation of aggregates of individual particles, the wetting of particles with solvent and film-former, and uniformly distributing particles in the liquid phase. Types of dispersion equipment include high-speed shaft-impeller dispersers, dough mixers, and a variety of mills such as roller, stone, pebble, media, stator-rotor, attritor, Uniroll, resonant, vibratory, and Kady® [12]. After the dispersion operation, it may be necessary to clean the mills and tanks before a new batch is introduced. Tank and mill cleaning can involve hand and power tools as well as caustic cleaners and solvents.

c. Thinning, Tinting, and Shading

Thinning operations involve the further addition of a film-former or solvent to the batch following the mixing and dispersion operations. These operations may be performed in stationary tanks or in portable change cans. Tinting and shading operations involve adding color to white bases or adjusting the color of solid color bases that have been formulated as complete products. After these operations, the quality of the paint must be checked by sample collection and laboratory analysis.

d. Filling Operations and Finished Product Handling

After the desired paint quality is achieved, the paint is strained or filtered to remove foreign material. Fabric or metal screen filters, vibrating or variable-speed centrifugal clarifiers, vibrating screens, and cartridge filters can be used. After filtering, the coating is either manually or machine-filled into cans that are subsequently sealed, labeled, packed, and stored or shipped.

2. Lacquers

Lacquers differ from most other coatings in that the film dries or hardens entirely by evaporation. Therefore, it is impractical to manufacture lacquers in the customary manner because volatilization of the solvents results in deposits of a dry, solid film on processing equipment [12]. Thus, production is carried out in enclosed equipment such as tanks or mixers to reduce solvent loss, ensure ease of cleanup, and provide fire safety. However, lacquer is produced in the same general manner as paint.

3. Varnishes

All varnishes (i.e., oleoresinous and spirit) are solutions of film-formers in organic solvents. The manufacture of oleoresinous varnishes involves a cooking stage to render the oil and resin more compatible, to develop high molecular weight molecules or polymers, and to obtain solubility in the thinner or solvent. The manufacture of spirit varnishes usually involves cold cutting the resin with the solvent; however, mild heat may be used occasionally [18].

Varnish is cooked in portable kettles or in large reactors, although kettles are now used only to a limited extent and primarily by smaller manufacturers [19]. Large closed reactors with capacities of 1,000 to 8,000 gallons are more common [18].

a. Operation of Kettles

In facilities where portable kettles are still used, resin and oil or resin alone is added to the kettle and then heated to about 600°F (316°C). Natural resins must be heated prior to adding the oils to make the resin more compatible with the oils. All materials are poured in over the top of the kettle (150-375 gallon capacity). During the cooking phase, the kettles are covered with retractable hoods with exhaust pipes that may be fitted with solvent condensers. After the materials are cooked, the kettles are moved to rooms where the kettles are cooled quickly, often by water spray, and thinner and driers are added [19].

b. Operation of Reactor Vessels

Varnish production is different when reactor vessels are used instead of kettles. Most reactors range in size from 500 to 8,000 gallons [18,19]. Reactors are designed to give exact process control and usually can handle a variety of different varnishes, operate over a wide range of temperatures, and be cleaned easily. Varnish reactor vessels are similar to batch reactor equipment used in the chemical process industry. The vessels are fitted with agitators, manholes, sight-glasses, lines to charge liquid reactants, condensers, temperature measuring devices, sampling devices, discharge lines, and heat sources.

c. Filtering

Filtration of the thinned resin is the final step before the varnish is packaged. This is normally done while the resin is still hot. The filter press is the most commonly used filtering device [20].

4. Powder Coatings

Powder coatings are solventless systems based on the melting and subsequent fusion of resin and other additive particles onto surfaces of heated objects. Powder coatings, which may be either thermosetting or thermoplastic, are made from various types of resins such as epoxies, polyethylene, polyesters, polyvinyl chloride, and acrylics.

Three methods have been used to manufacture powder coatings: dry blending, extrusion melt-mixing, and a combination of the two. Dry blending of powder coating ingredients is usually accomplished by placing all components (powdered resin, pigments, additives, and powdered curing agents) into a cooled pebble mill with high density porcelain grinding media.

The extrusion melt-mixing method involves premixing the dry components to ensure homogeneity and to reduce particle size. The mix is placed in a specially-designed extruder where it is heated until molten. The molten material is then deposited on a cooling belt, and when it has cooled to a friable state, it is transferred to a coarse granulator. The granulated material is then passed through a fine grinder and particle size classifier and packaged. Figure II-4 shows a typical layout for the manufacture of powder coatings by the extrusion melt-mixing method.

5. Radiation-Curable Coatings

Radiation-curable coatings are composed of liquid components which polymerize to a hard surface when exposed to radiation. These coatings are manufactured in the same general manner and with the same general equipment as solvent-containing coatings. However, radiation-curable coatings do not contain solvents and are usually manufactured in enclosed equipment to prevent occupational exposure to volatile and reactive monomers, particularly acrylics.

6. Stains

The primary function of a stain is to furnish color [2]. Raw and polymerized linseed oils are often used as the film-former for exterior stains; the pigment content is very low to ensure a degree of transparency and to avoid undesirable film build-up [2]. Lightfast pigments such as iron oxide, titanium dioxide, and carbon black are used to color exterior stains [2]. A wider range of pigments is used with interior stains. The film-formers for interior stains are usually very low-solids alkyd resin solutions. Generally, the manufacture of stain is similar to that of paint.

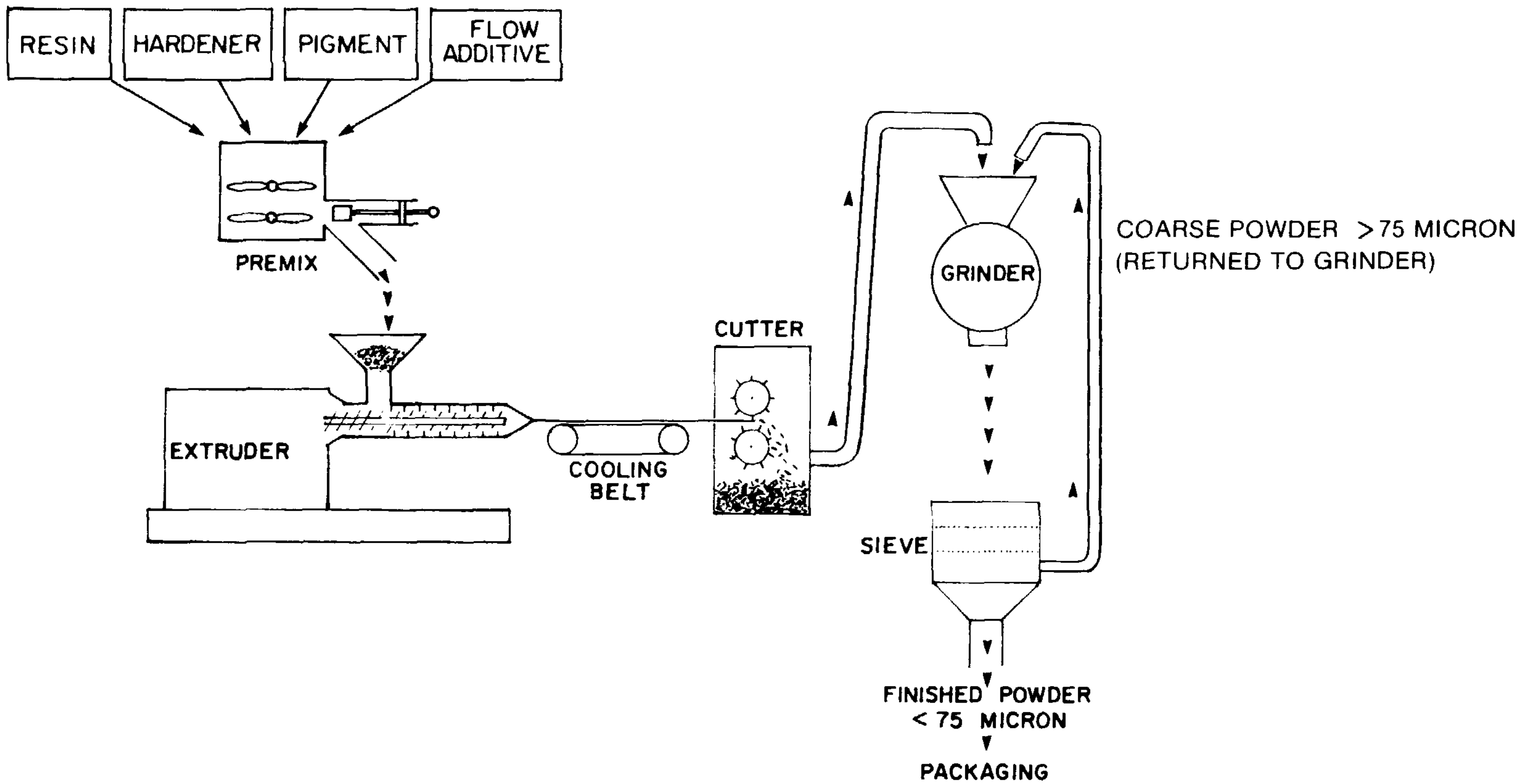
7. Allied Coating Products

Many of the allied or sundry products of the coatings industry are manufactured in the same plants as paint, with few variations in the processes previously discussed in this section.

a. Putties

The manufacture of putties involves the dispersion of calcium sulfate in oils and adjustment with small amounts of solvent in a dough-type mixer or in a mixer known as a putty chaser [21]. The viscous putty is usually put into containers directly from the dispersion stage.

FIGURE II-4. FLOW CHART FOR THE MANUFACTURE OF POWDER COATINGS BY THE EXTRUSION MELT-MIXING METHOD [22]
(Copyright by Communication Channels, Inc. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)



b. Paint and Varnish Removers

The production of paint and varnish removers involves the mixing of a solvent (usually methylene chloride, acetone, methyl ethyl ketone, toluene, or xylene) with activators, thickeners, evaporation retarders, and penetrants [23]. Alcohols are used to strip shellac, and mixtures of alcohols and acetates are used to remove lacquers [23].

8. Laboratory Functions

Analytical and developmental laboratory functions are integral to the manufacture of coatings. Four functional types of laboratories are found in coatings manufacture: analytical, quality control, formulation or product development, and research and development [24]. Many companies combine the various laboratory functions in one space; whereas, others separate each function. Analytical laboratories receive samples of incoming raw materials to be tested for conformity with purchase specifications. Other analytical laboratory functions include the analysis of competing products and "bad batches" of paint. Quality control laboratories test the product before it is packaged for various physical characteristics such as weight per gallon, viscosity, color, and drying time. In the formulation or product development laboratory, existing products are refined. This differs from the research and development laboratory which is involved with basic research and the development of completely new classes of products.

III. HEALTH AND SAFETY HAZARDS DURING THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

A. Injury and Illness Statistics

The number and severity of injuries and illnesses in the Paints, Varnishes, Lacquers, Enamels, and Allied Coating Products Industry (SIC code 285) may be estimated from information reported by the Bureau of Labor Statistics (BLS), U.S. Department of Labor [11,25-28]. Table III-1 shows the average annual employment and injury and illness incidence rates (per 100 full-time workers) from 1980 through 1982 for total cases, lost workday cases, nonfatal cases without lost workdays, and lost workdays in SIC code 285.

TABLE III-1. AVERAGE OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES FOR SELECTED INDUSTRIES, 1980-1982 [11,26,27]

Industry	Average Annual Employment (thousands)	Incidence Rates per 100 Full-time Workers			
		Total Cases	Lost Workdays Cases	Nonfatal Cases Without Lost Workdays	Lost Workdays
All Private Sector	74,966.0	8.2	3.8	4.5	61.9
All Manufacturing	19,775.0	11.3	5.0	6.3	81.4
Industrial Inorganic Chemicals (SIC Code 281)	160.7	4.6	2.0	2.6	37.9
Soaps, Detergents, Perfumes, and Cosmetics (SIC Code 284)	143.7	8.8	4.2	4.6	64.5
Paints, Varnishes, Lacquers, Enamels, and Allied Coating Products (SIC Code 285)	**63.1**	**12.0**	**5.5**	**6.6**	**74.3**
Industrial Organic Chemicals (SIC Code 286)	173.7	4.4	1.9	2.5	33.5

For comparison, average incidence rates are also shown in Table III-1 for specific industries (SIC code 281, Industrial Inorganic Chemicals; SIC code 284, Soaps, Detergents, Perfumes, and Cosmetics; and SIC code 286, Industrial Organic Chemicals) as well as for "All Private Sector" industries combined and for "All Manufacturing" industries. These data show an annual total of approximately 7,570 injuries and illnesses (employment times total case incidence rate divided by 100) in paint manufacturing facilities. Per 100 full-time workers, paint manufacturers had an average injury and illness incidence rate of 12.0 and an average lost workday incidence rate (severity rate) of 74.3, which are about the same as the average rates exhibited by "All Manufacturing" industries.

Also of interest are data included in Table III-2, which address occupational injury and illness rates by employment size in the paint and allied coating products industry. The highest incidence rates occurred in facilities with 20-249 workers.

TABLE III-2. OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES BY EMPLOYMENT SIZE FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1982 [25]

Employment Size	Incidence Rate per 100 Full-time Workers
1 to 19	9.6
20 to 49	11.9
50 to 99	13.2
100 to 249	13.5
250 to 499	8.1
500 to 999	9.0
All Sizes	11.1

Currently, workers' compensation information that is derived from initial injury forms is compiled and reported by the BLS Supplementary Data System (SDS) [28]. Table III-3 contains the number of compensation cases in the SIC code 285, reported between 1976 and 1981 by the 32 states participating in the SDS program.

TABLE III-3. DISTRIBUTION BY STATE OF SDS INJURY AND ILLNESS CASES FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

State	Number	State	Number
Alaska	3	Missouri	1,371
Arizona	14	Montana	39
Arkansas	112	Nebraska	37
California	3,498	New Jersey	1,239
Colorado	111	New Mexico	9
Connecticut	17	New York	400
Idaho	52	North Carolina	242
Indiana	291	Ohio	905
Iowa	70	Oregon	133
Kentucky	547	South Carolina	8
Maine	18	Tennessee	145
Maryland	327	Utah	1
Massachusetts	210	Vermont	71
Michigan	636	Virginia	13
Minnesota	171	Washington	468
Mississippi	14	Wisconsin	196

Total Cases = 11,368

Compiled from Bureau of Labor Statistics Supplementary Data System [28]

The purpose of the SDS system is to report occupational injury and illness information in sufficient detail to alert users to the patterns and relationships of injury causal factors. Information from workers' compensation first report of injury forms includes [28]:

- Source of injury/illness
- Type of accident/exposure
- Nature of injury/illness
- Part of body affected
- Worker's occupation
- Worker's age
- Worker's length of service
- Time of accident

The SDS data for SIC code 285 are summarized in Table III-4 for the first four categories.

TABLE III-4. SUMMARY OF SDS ACCIDENT/INJURY DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

Source of Injury/Illness	Number of Accidents	Percent
Boxes, barrels, containers	3,786	33.3
Working surfaces	1,222	10.7
Chemicals, chemical compounds	1,027	9.0
Vehicles	821	7.2
Metal items	768	6.7
Machines	676	5.9
Bodily motion	529	4.7
Wood items	341	3.0
Handtools, nonpowered	334	2.9
Buildings and structures	175	1.5
All other classifiable	1,335	12.0
Nonclassifiable	354	3.1
TOTAL	11,368	100.0

Types of Accident/Exposure	Number of Accidents	Percent
Overexertion	3,557	31.3
Struck by an object	1,754	15.4
Struck against an object	1,090	9.6
Caught in, under, or between	1,011	8.9
Contact with caustics or toxic substances	1,004	8.8
Fall on same level	895	7.9
Bodily reaction	567	5.0
Fall from elevation	536	4.7
Rubbed or abraded	281	2.3
Contact with temperature extremes	204	1.8
All other classifiable	221	2.1
Nonclassifiable	248	2.2
TOTAL	11,368	100.0

Nature of Injury/Illness	Number of Accidents	Percent
Sprain, strain	4,603	40.5
Contusion, bruise	1,723	15.2
Cut, laceration, puncture	1,180	10.4
Fracture	795	7.0
Burn (chemical)	491	4.3
Scratch, abrasion	274	2.4
Dermatitis	268	2.4
Burn (hot surface)	219	1.9
Hernia, rupture	199	1.8
Dislocation	99	0.9
All other classifiable	823	7.1
Nonclassifiable	694	6.1
TOTAL	11,368	100.0

Part of Body Affected	Number of Accidents	Percent
Back	2,777	24.4
Finger(s)	1,309	11.5
Multiple injuries (i.e., 2 major parts of the body)	682	6.0
Hand(s)	597	5.3
Foot	578	5.1
Eye(s)	553	4.9
Knee	514	4.5
Ankle	421	3.7
Shoulder	368	3.2
Abdomen	332	2.9
All other classifiable	2,883	25.4
Nonclassifiable	354	3.1
TOTAL	11,368	100.0

Compiled from Bureau of Labor Statistics Supplementary Data System [28]

The most prevalent sources of injuries and illnesses were boxes, barrels, containers, packages, etc. (33.3%), working surfaces (10.7%), and chemicals (9.0%). The most common types of accidents were overexertion (31.3%), struck by an object (15.4%), and struck against an object (9.6%). Sprains and strains (40.5%) were the most prevalent nature of injury, followed by contusions and bruises (15.2%), and cuts, lacerations, punctures, etc. (10.4%). The back (24.4%) and fingers (11.5%) were the parts of the body most frequently affected [28].

In an attempt to better elucidate accident causal factors, 38 "sources of injury" (which included 81% of the total cases) were cross-tabulated with the "type of accident," "nature of injury," and "part of body affected." These data are summarized in Table III-5. Another analysis of the SDS data is summarized in Table III-6 where 15 occupational groupings (which included 81% of the total cases) were similarly cross-indexed.

Mention needs to be made of some of the data constraints of the SDS reporting system. Although there are about 300 subcategories of "sources of injury," and 425 occupational classification codes, in many instances the subgroupings are still not useful for the purpose of quantifying accidents specific to paint manufacturing. For instance, there might not be specific SDS categories for the inclusion of equipment typically used in the paint industry which would necessitate its being grouped into a broad category such as "Machines, Not Elsewhere Classified." Similarly, although there is an occupational classification for mixing operatives, individual facilities when filling out the workers' compensation form could have coded paint mixers in a number of other categories (e.g., miscellaneous operatives, machine operatives, not specified, etc.). A further difficulty encountered in the data base, when using it for analysis of accident causal factors, is that, by definition, the "source of injury" is the object identified as most responsible for causing the injury. This may, in fact, not be directly associated with the actual cause of the accident. For example, if a worker cuts his finger while using a knife, the "source of injury" is the knife, which also is the tool most clearly associated with the cause of the accident. However, if a worker falls from a ladder and fractures his leg on the floor, the "source of injury" is the floor, which probably contributed very little to the actual cause of the accident.

However, once the constraints of the SDS data are recognized, the information included can be applied to further identify some of the hazards associated with occupations, tasks, tools, and equipment used in paint manufacturing. In Table III-5 the most frequent subcategories for each major heading are listed; all subcategories relate to the "source of injury" in the first column and are not expected to total with it. In Table III-6, the various subcategories listed (including "source of injury") relate to the occupational grouping shown above them.

TABLE III-5. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "SOURCES OF INJURY" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Boxes, Barrels, Containers, Packages	**3,786**						
Containers, NEC	1,399	Overexertion in lifting objects	789	Sprain, strain	1,011	Back	680
		Struck by falling object	151	Contusion, bruise	148	Finger(s)	83
		Overexertion in pulling objects	74	Cut, laceration	62	Shoulder	80
		Overexertion in throwing objects	74	Fracture	45	Abdomen	74
		Overexertion, UNS	69	Hernia, rupture	39	Multiple parts	53
		Overexertion, NEC	64			Foot	47
		Struck against stationary object	59			Wrist	44
Barrels, kegs, drums	1,391	Overexertion in lifting objects	399	Sprain, strain	804	Back	528
		Overexertion in pulling objects	180	Contusion, bruise	224	Finger(s)	171
		Struck by falling object	177	Fracture	115	Abdomen	82
		Overexertion, NEC	122	Cut, laceration	63	Shoulder	81
		Overexertion in throwing objects	119	Hernia, rupture	47	Hand	65
		Caught in, under, or between a moving and a stationary object	81			Foot	55
		Struck by, NEC	67			Toe(s)	54
Boxes, crates, cartons	493	Overexertion in lifting objects	306	Sprain, strain	368	Back	277
		Struck by falling object	60	Contusion, bruise	50	Abdomen	22
						Wrist	22
						Finger(s)	19

(Continued)

TABLE III-5. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "SOURCES OF INJURY" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Tanks, bins, etc.	271	Overexertion in pulling objects	60	Sprain, strain	128	Back	70
		Struck against stationary object	42	Contusion, bruise	60	Finger(s)	22
		Overexertion in lifting objects	34			Shoulder	20
		Fall on same level	30				
Working Surfaces	1,222						
Floor	635	Fall on same level	400	Sprain, strain	233	Back	124
		Fall to lower level	68	Contusion, bruise	150	Multiple parts	82
		Fall from ladders	54	Fracture	78	Knee	81
						Ankle	59
Ground (outdoors)	189	Fall from vehicles	54	Sprain, strain	78	Ankle	27
		Fall on same level	53	Fracture	30	Back	21
		Fall to lower level, NEC	34	Contusion, bruise	30		
Stairs, steps	122	Fall on stairs	109	Sprain, strain	43	Ankle	23
				Contusion, bruise	34	Knee	19
Working surfaces, UNS	116	Fall on same level	66	Sprain, strain	52	Back	32
Chemicals, Chemical Compounds	1,027						
Chemicals and compounds, NEC	651	Skin contact (absorption)	391	Burn (chemical)	303	Eye(s)	208
		Contact, NEC	92	Contact dermatitis	103	Multiple parts	96
		Contact by inhalation	52	Other injury, NEC	49	Hand	46
		Rubbed or abraded in eyes	50	Scratch, abrasion	33	Respiratory system	36
						Foot	34
Chemicals and compounds, UNS	81	Skin contact (absorption)	63	Burn (chemical)	31	Multiple parts	17
				Dermatitis, UNS	27	Eye(s)	11

Coal and petroleum products	79	Skin contact (absorption)	44	Burn (chemical)	25	Eye(s)	27
		Contact by inhalation	10	Burn (heat)	11	Hand	9
		Contact with a hot object	7	Dermatitis, UNS	11	Respiratory system	8
						Forearm(s)	7
Acids	61	Skin contact (absorption)	40	Burn (chemical)	44	Multiple parts	12
		Contact by inhalation	13	Poisoning due to toxic materials	13	Body parts, NEC	12
Vehicles	821						
Forklifts, stackers, lumber carriers, and other powered carriers	316	Struck by, NEC	90	Contusion, bruise	132	Foot	70
		Caught in, under, or between a moving and a stationary object	49	Sprain, strain	53	Finger(s)	54
		Caught in, under, or between, NEC	33	Fracture	48	Back	23
		Struck against moving object	16			Toe(s)	22
Handtrucks, dollies, and other nonpowered carriers	257	Struck by, NEC	67	Sprain, strain	95	Back	61
		Overexertion in pulling objects	66	Contusion, bruise	92	Foot	26
		Caught in, under, or between a moving and a stationary object	29			Toe(s)	26
		Struck against a stationary object	25			Knee	16
						Finger(s)	16
Highway vehicles, powered	197	Collision with a vehicle moving in same direction	30	Sprain, strain	51	Multiple parts	51
		Struck against a stationary object	20	Contusion, bruise	45	Back	25
		Collision with a vehicle moving in an intersecting trafficway	19			Finger(s)	13
Metal Items	768						
Metal items, NEC	426	Struck by falling object	107	Cut, laceration	121	Finger(s)	81
		Struck against stationary object	82	Contusion, bruise	103	Back	53
		Struck by, NEC	58	Sprain, strain	81	Hand	40
		Overexertion in lifting objects	41	Fracture	39	Toe(s)	33
				Scratch, abrasion	30	Eye(s)	28
						Knee	27

(Continued)

TABLE III-5. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "SOURCES OF INJURY" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Pipe and fittings	127	Struck against stationary object	42	Sprain, strain	38	Finger(s)	25
		Struck by falling object	30	Contusion, bruise	32	Back	21
Metal items, UNS	88	Struck against stationary object	27	Cut, laceration	44	Finger(s)	25
		Struck by, NEC	11	Sprain, strain	16	Foot	12
		Overexertion in lifting objects	11			Back	11
Machines	**676**						
Machines, NEC	288	Caught in, under, or between, NEC	72	Cut, laceration	76	Finger(s)	135
		Struck against stationary object	43	Contusion, bruise	69	Hand	37
		Caught in, under, or between in-running or meshing objects	28	Sprain, strain	57	Back	30
		Caught in, under, or between a moving and a stationary object	24	Fracture	33		
		Struck by, NEC	21				
		Overexertion, NEC	21				
Packaging, wrapping machines	81	Caught in, under, or between in-running or meshing objects	19	Contusion, bruise	27	Finger(s)	34
		Struck against stationary object	12	Sprain, strain	16	Hand	11
		Caught in, under, or between a moving and a stationary object	10	Cut, laceration	11		

Agitators, mixers, tumblers, etc.	74	Struck against stationary object Caught in, under, or between in-running or meshing objects Caught in, under, or between, NEC
<u>**Bodily Motion**</u>	529	Bodily reaction, UNS Bodily reaction by involuntary motions Bodily reaction by voluntary motions
<u>**Wood Items**</u>	341	
Skids, pallets	233	Struck by falling object Overexertion in lifting objects Overexertion in pulling objects Struck against stationary object Caught in, under, or between, NEC Struck by, NEC
Wood items, NEC	80	Struck against stationary object Struck by, NEC Overexertion in lifting objects
<u>**Handtools, Nonpowered**</u>	334	
Knife	102	Struck by, NEC
Handtools, nonpowered, NEC	88	Struck by, NEC Overexertion, NEC
Wrench	72	Struck by, NEC

12	Cut, laceration	21	Finger(s)	16
	Fracture	14	Hand	10
12	Contusion, bruise	11		
	Sprain, strain	10		
10				
225	Sprain, strain	464	Back	184
183	Fracture	26	Ankle	103
			Knee	90
109				
57	Sprain, strain	113	Back	56
	Contusion, bruise	50	Foot	33
38	Fracture	23	Ankle	21
	Cut, laceration	12	Toe(s)	16
37				
31				
17				
13				
21	Cut, laceration	24	Finger(s)	19
	Sprain, strain	22	Eye(s)	12
10	Contusion, bruise	11		
9				
72	Cut, laceration	102	Finger(s)	53
			Hand	25
37	Cut, laceration	32	Finger(s)	18
12	Sprain, strain	25	Back	17
			Hand	16
35	Sprain, strain	20	Finger(s)	24
	Contusion, bruise	19	Wrist	8
	Cut, laceration	17		

(Continued)

TABLE III-5. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "SOURCES OF INJURY" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Buildings and Structures	175						
Doors, gates	86	Caught in, NEC	14	Sprain, strain	31	Finger(s)	20
		Struck by a falling object	11	Contusion, bruise	24	Back	19
		Caught in, under, or between a moving and a stationary object	11				
		Overexertion in pulling objects	11				
		Struck by stationary object	10				
		Struck by, NEC	10				
Buildings and structures, NEC	30	Struck against stationary object	11	Sprain, strain	10	Back	6
				Contusion, bruise	10	Shoulder	5
		Fall on same level	8			Finger(s)	4
Towers, poles, etc.	17	Struck against stationary object	15	Contusion, bruise	11	Head, NEC	7
Walls, fences	15	Struck against stationary object	9	Contusion, bruise	5	Arm	5
				Cut, laceration	5	Hand	3
Furniture, Fixtures, Furnishings	123	Struck against stationary object	36	Sprain, strain	45	Back	33
				Contusion, bruise	38	Finger(s)	16
		Overexertion, NEC	12	Cut, laceration	20		
		Overexertion in lifting objects	11				
		Overexertion in pulling objects	11				
Flame, Fire, Smoke	102	Contact with hot objects or substances	70	Burn (heat)	88	Multiple parts	63
		Contact by inhalation	12				

Particles (Unidentified)	88	Rubbed or abraded in eyes	75	Scratch, abrasion	75	Eye(s)	82
Hoisting Apparatus	77	Struck by, NEC	16	Sprain, strain	19	Finger(s)	20
		Caught in, under, or between, NEC	12	Fracture	17	Hand	8
				Contusion, bruise	14		
		Caught in, under, or between a moving and a stationary object	11	Cut, laceration	14		
Conveyors	76	Struck against stationary object	16	Contusion, bruise	27	Finger(s)	35
				Cut, laceration	14	Hand	12
		Caught in, under, or between in-running or meshing objects	12	Fracture	12		
		Caught in, under, or between a moving and a stationary object	9				
Person	74	Struck by, NEC	22	Sprain, strain	22	Circulatory system	15
				Contusion, bruise	8	Back	13
Glass Items, NEC	65	Struck against stationary object	17	Cut, laceration	39	Hand	16
				Contact dermatitis	11	Finger(s)	14
						Multiple parts	10

Compiled from Bureau of Labor Statistics Supplementary Data System [28]
Note: NEC = Not Elsewhere Classified
UNS = Unspecified

TABLE III-6. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "OCCUPATION" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

LABORERS (MISCELLANEOUS AND NOT SPECIFIED) - 1,206 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Barrels, kegs, drums	165	Overexertion in lifting objects	189	Sprain, strain	411	Back	212
Containers, NEC	121	Struck against stationary object	116	Contusion, bruise	226	Finger(s)	154
Chemicals, NEC	117	Struck by, NEC	115	Cut, laceration	140	Hand	83
Floor	54	Skin contact (absorption)	109	Burn (chemical)	82	Eye(s)	80
Bodily motion	45	Struck by falling object	86	Fracture	69	Multiple parts	76
Boxes, crates, cartons	44	Caught in, under, or between, NEC	72	Other injuries, NEC	41	Knee	58
Metal items, NEC	39	Fall on working surface	55	Multiple injuries	30	Foot	57
Machines, NEC	38	Caught in, under, or between a moving and stationary object	47			Shoulder	45
Forklifts and other powered carriers	33	Overexertion in pulling objects	47				
		Overexertion, NEC	45				

MIXING OPERATIVES - 1,106 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Barrels, kegs, drums	266	Overexertion in lifting objects	228	Sprain, strain	518	Back	310
Containers, NEC	167	Skin contact (absorption)	92	Contusion, bruise	153	Finger(s)	91
Chemicals, NEC	89	Overexertion in pulling objects	82	Fracture	87	Multiple parts	62
Floor	64	Struck by falling object	82	Burn (chemical)	75	Eye(s)	61
Tanks, bins, etc.	59	Struck against stationary object	81	Cut, laceration	72	Foot	61
Bodily motion	54	Struck by, NEC	79	Contact dermatitis	20	Knee	58
Metal items, NEC	35	Overexertion in throwing objects	60			Ankle	48
Forklifts and other powered carriers	24	Fall on working surface	54			Elbow	29
		Overexertion, NEC	50			Wrist	26

MACHINE OPERATIVES, MISCELLANEOUS SPECIFIED - 1,095 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	151	Overexertion in lifting objects	184	Sprain, strain	448	Back	255
Barrels, kegs, drums	108	Struck against stationary object	99	Contusion, bruise	180	Finger(s)	151
Floor	72	Struck by, NEC	81	Cut, laceration	130	Hand	83
Chemicals, NEC	70	Fall on working surface	73	Fracture	72	Eye(s)	51
Bodily motion	70	Overexertion in pulling objects	73	Burn (chemical)	46	Multiple parts	51
Machines, NEC	63	Struck by falling object	66			Foot	45
Metal items, NEC	45	Skin contact (absorption)	60			Ankle	39
		Caught in, under or between, NEC	52			Knee	37

FREIGHT AND MATERIAL HANDLERS, STOCK HANDLERS, WAREHOUSEMEN (NEC) - 742 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	131	Overexertion in lifting objects	216	Sprain, strain	380	Back	210
Boxes, crates, cartons	110	Struck by falling object	84	Contusion, bruise	129	Finger(s)	71
Barrels, kegs, drums	82	Struck by, NEC	62	Cut, laceration	61	Foot	42
Floor	36	Struck against stationary object	46	Fracture	31	Knee	40
Handtrucks, dollies	35	Overexertion in pulling objects	46			Shoulder	39
Forklifts and other powered carriers	35	Fall on working surface	39			Abdomen	33
Skids, pallets	34	Overexertion in throwing objects	32				

(Continued)

TABLE III-6. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "OCCUPATION" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

MISCELLANEOUS OPERATIVES - 741 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	101	Overexertion in lifting objects	125	Sprain, strain	269	Back	171
Barrels, kegs, drums	93	Skin contact (absorption)	61	Contusion, bruise	117	Finger(s)	100
Chemicals, NEC	59	Struck against stationary object	55	Cut, laceration	80	Hand	52
Floor	40	Struck by falling object	54	Fracture	44	Multiple parts	45
Tanks, bins, etc.	32	Struck by, NEC	52	Burn (chemical)	35	Foot	38
Machines, NEC	26	Overexertion in pulling objects	44			Eye(s)	37
		Fall on working surface	42				

TRUCK DRIVERS, DELIVERYMEN, AND ROUTEMEN - 431 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Barrels, kegs, drums	80	Overexertion in lifting objects	98	Sprain, strain	204	Back	128
Containers, NEC	65	Struck by falling object	31	Contusion, bruise	70	Multiple parts	34
Highway vehicles, powered	57	Struck by, NEC	30	Cut, laceration	30	Knee	29
Ground (outdoors)	28			Fracture	25	Finger(s)	26
						Ankle	25

FOREMEN, NEC - 307 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Barrels, kegs, drums	39	Overexertion in lifting objects	48	Sprain, strain	128	Back	73
Containers, NEC	34	Struck against stationary object	29	Cut, laceration	35	Eye(s)	26
Chemicals, NEC	22	Overexertion in pulling objects	28	Contusion, bruise	31	Finger(s)	21
Floor	17			Fracture	16		
Bodily motion	15						

MECHANICS AND REPAIRMEN - 276 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Floor	23	Struck by, NEC	33	Sprain, strain	100	Back	53
Metal items, NEC	21	Overexertion in lifting objects	28	Cut, laceration	50	Finger(s)	44
Bodily motion	16	Struck against stationary object	16	Contusion, bruise	29	Hand	23
Machines, NEC	15	Struck by falling object	16	Fracture	24	Eye(s)	22
		Fall on working surface	16			Multiple parts	19

PACKERS AND WRAPPERS - 226 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	41	Overexertion in lifting objects	44	Sprain, strain	97	Back	58
Boxes, crates, cartons	23	Struck against stationary object	24	Contusion, bruise	51	Finger(s)	38
Barrels, kegs, drums	17	Struck by falling object	24	Cut, laceration	27	Foot	20
Skids, pallets	14	Struck by, NEC	14	Fracture	14		
Chemicals, NEC	12						
Packaging, wrapping machines	11						
Floor	11						

MACHINE OPERATIVES, NOT SPECIFIED - 224 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Packaging, wrapping machines	24	Overexertion in lifting objects	36	Sprain, strain	85	Back	53
Barrels, kegs, drums	23	Skin contact (absorption)	21	Contusion, bruise	30	Finger(s)	37
Chemicals, NEC	18	Overexertion in pulling objects	19	Cut, laceration	26	Eye(s)	21
Metal items, NEC	14	Struck against stationary object	18	Burn (chemical)	21	Shoulder	13
Floor	14	Struck by, NEC	18	Fracture	15	Ankle	13
Machines, NEC	13	Fall on working surface	15				

(Continued)

TABLE III-6. SUMMARY OF CROSS-TABULATION ANALYSIS OF SDS "OCCUPATION" DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

FORKLIFT AND TOWMOTOR OPERATIVES - 203 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Barrels, kegs, drums	37	Struck against stationary object	26	Sprain, strain	79	Back	40
Forklifts and other powered carriers	29	Overexertion in lifting objects	26	Contusion, bruise	39	Finger(s)	29
Skids, pallets	15	Fall on working surface	21	Cut, laceration	19	Ankle	14
Floor	14	Struck by falling object	17	Fracture	16	Multiple parts	14
Ground (outdoors)	14	Struck by, NEC	17				

NOT SPECIFIED OPERATIVES - 169 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Barrels, kegs, drums	29	Overexertion in lifting objects	33	Sprain, strain	64	Back	46
Chemicals, NEC	11	Skin contact (absorption)	19	Contusion, bruise	17	Finger(s)	19
Metal items, NEC	10	Overexertion in throwing objects	13	Burn (chemical)	16	Hand	16
		Struck by falling object	11	Cut, laceration	15	Multiple parts	12
				Fracture	13	Eye(s)	10

SERVICE WORKERS (CLEANERS, JANITORS, COOKS, GUARDS, ETC.) - 151 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	18	Skin contact (absorption)	19	Sprain, strain	63	Back	39
Bodily motion	14	Struck against stationary object	17	Contusion, bruise	22	Finger(s)	16
Barrels, kegs, drums	13	Struck by falling object	15	Fracture	16	Foot	15
Chemicals, NEC	10	Overexertion in lifting objects	13	Burn (chemical)	15		
Floor	10			Cut, laceration	12		

BOTTLING AND CANNING OPERATIVES - 120 CASES

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	30	Overexertion in lifting objects	30	Sprain, strain	61	Back	50
Barrels, kegs, drums	18	Struck by falling object	11	Contusion, bruise	21	Finger(s)	16
		Struck by, NEC	11	Cut, laceration	13		

NONPRODUCTION WORKERS - 1,306 CASES
(SHIPPING AND RECEIVING CLERKS, SALESMEN, MANAGERS, ADMINISTRATORS, STOCK CLERKS, CHEMISTS, SECRETARIES, ETC.)

Source of Injury	Number	Type of Accident/Exposure	Number	Nature of Injury	Number	Body Part Injured	Number
Containers, NEC	210	Overexertion in lifting objects	276	Sprain, strain	549	Back	313
Boxes, crates, cartons	95	Struck against stationary object	110	Contusion, bruise	179	Finger(s)	135
Barrels, kegs, drums	84	Struck by falling object	104	Cut, laceration	130	Multiple parts	98
Floor	77	Fall on working surface	104	Fracture	99	Foot	85
Bodily motion	69	Struck by, NEC	87	Multiple injuries	36	Knee	75
Chemicals, NEC	58	Skin contact (absorption)	50			Eye(s)	58
Highway vehicles, powered	55					Ankle	57
						Hand	50

Compiled from Bureau of Labor Statistics Supplementary Data System [28]
Note: NEC = Not Elsewhere Classified

As would be expected, Table III-5 indicates that injuries related to materials handling (i.e., containers, handtrucks, dollies, skids, pallets, etc.) were most often caused by overexertion and by being struck by falling objects. Sprains, strains, contusions, bruises, cuts, and lacerations were the most common injuries; the back and fingers were the parts of the body most frequently affected. An interesting finding was that 60% of the injuries caused by chemicals (i.e., 615 of 1,027) were from skin contact (absorption); 47% of these injuries were chemical burns of the skin.

Analysis of the SDS data by "occupation" yielded similar results. As Table III-6 indicates, various types of containers (i.e., barrels, boxes, crates, etc.) were the most common sources of injury (20-30%) in almost every occupational grouping. As before, overexertion and "struck by or against" type accidents were the most prevalent, with the most common injuries also being sprains, contusions, and cuts. Exposure to chemicals again accounted for a significant proportion of injuries in many of the occupational groups, usually resulting in chemical burns of the skin. Nonproduction workers (clerks, salesmen, managers, chemists, secretaries, etc.), who make up about 51% of the workforce in SIC code 285 [29], accounted for 13% of the cases in the SDS file [28]. Conversely, production workers were involved in 87% of the injuries and illnesses in paint and allied coating products manufacturing although comprising only about 49% of the total workforce.

Further analysis of the SDS data [28] showed that workers under 26 years of age accounted for about one-third of the injuries and illnesses and that workers under 31 years of age accounted for over half (51.6%). Although only about one-third of the SDS cases had length of service data, 36.9% of those injuries occurred within the first year with the company, 50.4% within the first 2 years, and 69.9% within the first 5 years [28]. The types and numbers of illnesses in the SDS data base are shown in Table III-7. Dermatitis was the most common illness noted (41.2%). The SDS data show that only 5.7% of the total number of injuries and illnesses were due to illnesses [28]. However, occupational illness data from the SDS suffer from the same degree of identification as that experienced in the BLS annual survey of occupational injuries and illnesses. Recognition of occupational illness depends on the "state of the art." Nevertheless, despite the underestimate of the incidence of occupational illnesses, it is evident that reducing injuries should be a high priority of the paint and allied coating products industry.

TABLE III-7. SUMMARY OF SDS ILLNESS DATA FOR PAINT AND ALLIED COATING PRODUCTS MANUFACTURING (SIC CODE 285) 1976-1981

Nature of Illness	Number	Percent
Dermatitis -- includes rash, skin or tissue inflammation, etc., from direct contact with irritants or sensitizing chemicals	268	41.2
Poisoning, systemic -- includes chemical or drug poisoning, metal poisoning, organic diseases, etc.	153	23.5
Inflammation or irritation of the joints, tendons, or muscles occurring over time as a result of repetitive activity -- includes bursitis, synovitis, tenosynovitis, etc., but does not include strains and sprains, or their aftereffects	73	11.2
Disease of the eye	34	5.2
Effects from physical agents -- includes sunburn, welder's flash, hearing loss, heat stroke, heat exhaustion, frostbite, etc.	25	3.8
Respiratory system effects -- includes influenza, pneumonia, bronchitis, asthma, etc.	23	3.5
All other illnesses	75	11.6
Total Illness Cases	**651**	**100.0**

B. Hazards

Workers in paint and allied coating products facilities may be exposed to a wide variety of hazardous conditions during the performance of their jobs. The majority of these hazards exist, to some extent, throughout industry, although certain characteristics in the paint industry may magnify the degree of risk. The hazards associated with the manufacture of paint and allied coating products involve materials handling; toxic, flammable, or explosive substances; and physical agents such as electrical shock, noise, heat, and cold. These hazards can be present at various stages of production. In this section, there will be a discussion of the hazards involved with the storage and handling of raw materials and finished products for the industry in general, followed by other hazards associated with specific types of paint and allied coating products manufacture.

1. **Materials Handling**

Materials handling hazards in the manufacture of paint and allied coating products are similar to those in most other processing industries. Handling of raw materials is estimated by the National Safety Council to account for 20-25% of all reported occupational injuries in the U.S. [30]. The SDS data finding that "boxes, barrels, containers, packages, etc." were the source of injury in 33.3% of the cases [28] would confirm this. These injuries are caused primarily by overexertion due to improper lifting, failure to wear appropriate protective equipment, slipping, and falling. Workers may be exposed to toxic substances during materials handling when containers leak, rupture, or are opened and when materials are transferred to weighing or processing containers. Inhalation is a primary route of exposure for materials handlers, but skin exposure and ingestion are also possible.

Dry materials such as pigments and additives can become airborne when containers leak or are ruptured and when materials are transferred. Loading pigments into grinding equipment and discarding empty bags can cause the surrounding plant areas to become contaminated with dust. Solvents are volatile and their vapors can escape when transferred in the open or if containers develop minor leaks or are accidentally ruptured. Because of both toxicity and danger of fire, solvent spills present a serious hazard to workers.

Many substances used in paint and allied coating products are highly volatile and flammable or are explosive. The fire and explosion risk is high wherever organic solvents are present. Combustible material can be ignited by a spark or by high temperatures. Sources of sparks or fires include faulty electrical equipment, smoking, friction, open flames, static electricity from moving vehicles or materials, spontaneous combustion, highly reactive chemical combinations, and the use of hand tools made of ferrous materials [30,31]. Leaks, spills, and escape of volatile materials from open containers and equipment can provide fuel for explosions and fires.

Preventing the accumulation of static electricity in the handling of liquid raw materials requires special techniques and precautions. Static electricity may be produced when nonconducting liquids flow through pipes or hoses; when liquids fall through the air in droplets or as a spray; when liquids are splashed around in tanks -- in the mixing, pouring, pumping, filtering, and agitation of liquids; or when air or other gases bubble through liquids [31,32].

In addition to potential exposures to the many raw materials handled, carbon monoxide emitted from engine exhausts may be a hazard on loading and shipping docks. Exposures may be greater in the winter when loading areas are often enclosed to minimize heat loss.

2. Manufacture of Paints and Lacquers

There are a number of potential hazards that confront workers in the various processes involved in the manufacture of paints and lacquers.

a. Dispersion

Pigment and resin particles may enter the breathing zones of workers when mixer and mill hoppers are filled. Airborne particles may also result when the mixers and the mills are operated. Workers may also be exposed to solvents during the loading, operation, and cleaning of mills.

A noise hazard may be associated with the use of ball and pebble mills, especially when the mills are improperly adjusted, as well as with the use of high-speed dispersers. The noise levels at dispersion equipment such as Kady® mills have been found to range from 109-114 dBA [33]. Several mills operating simultaneously will have a combined sound pressure level greater than any individual mill. Ball mills that do not have vibration isolators can be the source of structure-borne vibrations that could be reradiated by other objects in the building [34].

Cleaning the dispersion equipment involves the use of solvents and may result in potential exposure by inhalation or skin absorption. Cleaning may be performed manually or by automatic solvent wash. Since roller mills are often cleaned manually, there is also the potential hazard of catching and crushing arms and fingers between rollers. To clean sand mills or high-speed dispersion mills, automatic solvent washes are used. However, it is sometimes necessary to enter and manually scrape the insides of the equipment. Maintenance operations involve many of the same hazards associated with cleaning operations.

Nitrocellulose, which is used in lacquer production, is one of the most flammable materials used in the coatings industry; it will not burn when wet with water but becomes flammable when water is extracted and replaced with alcohol [2]. When nitrocellulose is dry, it burns very rapidly and can be ignited by friction or impact [2].

b. Thinning, Tinting, and Shading

Although exposure to additives either as dusts or vapors can also occur, solvent exposure is the primary hazard associated with these adjustment procedures. Since quality control checks are often made during these operations, exposures can also occur during sampling and transport of samples to the laboratory.

c. Filling

Solvent exposure is also the primary hazard of filling operations. Such exposures may result from direct evaporation of the solvent as the coatings flow into containers or from the cleaning and maintenance of the filling apparatus, particularly the filters used in the first step of the operation.

Extensive noise can be generated by the vibrating screens used for filtering. Packaging the products usually involves automated equipment with moving parts that may catch on clothing. Burns or vapor exposure may also result from the use of hot, melted glues to secure packaging and labels.

d. Handling Finished Products

Safety hazards involved in handling finished coating products are similar to those involved in handling raw materials (e.g., lifting, slippery working surfaces, poor clearance, reduced visibility, etc.). Finished products are usually in sealed metal containers and present little respiratory hazard. Automatic depalletizers are a potential source of excessive noise.

3. Manufacture of Varnishes

Varnish production requires an external source of heat and, therefore, differs from paint and lacquer production. Temperatures associated with the manufacture of varnish are often 200°-600°F (93°-316°C) and cause the formation of gaseous substances during varnish cooking [19].

a. Kettle and Reactor Operation Hazards

The major hazards associated with the cooking stage in varnish production involve airborne exposures while loading the vessels or emissions while processing. Loading or charging the reactor vessel is usually done by pumping in the liquid reactants such as oils, glycols, or acid anhydrides. When dry materials are added, they can release irritant dusts or vapors of maleic, phthalic, or fumaric anhydride. Splattered molten anhydride can harm eyes and skin. Moreover, temperature changes at vents and orifices must be avoided so that vapors of these materials will not condense and form pressure plugs.

Since these reaction vessels are mostly closed systems, only inadvertent or fugitive emissions present a hazard to workers during the reaction phase. In a few cases, however, open kettles may still be used in the manufacture of varnishes. Some of the emissions given off during the cooking of varnishes include acrolein, phenol, aldehydes, ketones, glycerin, fatty acids, and carbon dioxide [35].

Maximum reactor vessel emissions occur during "sparging," when an inert gas is blown through the reactor to remove the water of reaction. Emissions from solvent cooking operations do not vary significantly with the size of the reactor, but are more a result of the volatility of the solvent being used and the size and efficiency of the condenser. Startup, process upset, shutdown, and, particularly, emergencies offer further potential for worker exposure [18].

Ambient temperatures around reactors generally are not hazardous. However, when insulation or climate controls are inadequate, ambient temperatures may rise and workers may be subject to heat stress. In direct-fired kettles or reaction vessels, the constant heating and cooling can cause metal fatigue and subsequent cracks in the vessel. These cracks can be sources of vapor leaks and fire hazards. Also, open kettles, especially portable ones, pose the hazard of burns from contact with hot surfaces or from splattering material.

b. Thinning and Filtering

Exposure to solvents may occur during the thinning stage of varnish production. Thinning is usually done in separate tanks but may be performed in the varnish or resin kettle itself. Solvent exposure may also occur during filtering but is more likely during the subsequent cleaning of the filters.

c. Equipment Cleaning

The cleaning of equipment (e.g., reactors, kettles, thinning tanks, filters, etc.) is another source of worker exposure to toxic substances. Cleaning operations in confined spaces are especially hazardous. Workers may be exposed by skin contact or inhalation. Equipment is also sometimes cleaned with hot caustic solutions that may affect the skin, eyes, and respiratory tract. The cleaning of filters may be performed manually or by automatic washing with solvents. Respiratory exposure to diatomaceous earths and dusts from other finely ground materials used as filter aids is possible.

4. Manufacture of Powder Coatings

Many of the same types of hazards found during the manufacture of paints or varnishes also exist in the production of powder coatings. Dust exposure can occur during the charging of hoppers, mixers, and grinders and in packaging. The fine particle sizes associated with powder coatings increase the possibility of dust explosions [22]. Inhalation of resin powders, pigments, curing agents, and other additives is the primary health hazard associated with the production of powder coatings.

5. Manufacture of Radiation-Curable Coatings

Since the manufacture of radiation-curable coatings, which dry or cure as a result of radiation such as infrared, ultraviolet, and electron beam, is similar to that of other paints, so are most of its hazards. Radiation-curable coatings, however, contain reactive monomers in place of solvents. In addition, ultraviolet-curable coatings also contain photoinitiators. Both reactive monomers and photoinitiators may have acute or delayed effects on the skin, eyes, and respiratory tract causing skin sensitization and other effects [36]. Because of the likelihood of acute effects resulting from skin or eye contact with some components of radiation-curable coatings, this type of coating is manufactured in enclosed equipment. Enclosed equipment is also necessary to prevent vaporization of some components that have relatively high vapor pressures.

Various types of hazards are associated with acrylate monomers used in radiation-curable coatings. Acrylates cause irritation of the eyes, nose, throat, lungs, and skin. In addition, it is important to avoid contamination during the handling of acrylate monomers because contaminants may act as polymerization catalysts and result in uncontrolled reactions accompanied by heat and pressure, increasing the risk of fire or explosion [37]. Ethyl acrylate is one of the most volatile acrylate compounds. A flammable air-vapor mixture exists at normal storage temperatures unless air is excluded [37].

6. Laboratory Functions

In addition to the hazards associated with the manufacture of coatings, the operations associated with laboratory functions may also expose workers to other chemical substances (e.g., reagents) and physical agents such as ultraviolet or infrared radiation, heat, cold, and ionizing radiation used in curing processes and in exposure tests. A potentially hazardous practice in laboratories involves spraying a coating to match colors. Often no exposure controls are used, and exposure to airborne coatings is likely. This situation is easily remedied by providing a spray booth with negative pressure to remove the overspray and thus protect the worker.

C. Adverse Health Effects

OSHA has promulgated occupational exposure standards for many of the chemicals used in the manufacture of paint and allied coating products. NIOSH has also evaluated many of these materials and has published Criteria Documents and other reports which have recommended occupational safety and health standards for them, including occupational exposure limits. The current OSHA standards and the NIOSH-recommended exposure limits, as well as pertinent health effects, are listed in Appendix B. The materials used in coatings vary greatly in their toxicity. Some have been shown to be biologically inert, and others are proven or potential occupational carcinogens.

Pigments are usually handled as finely divided solids that can readily become airborne; adhere to skin, hair, and clothing; and generally coat the work area with dust. The primary routes of exposure to pigments are inhalation, skin contact, and eye exposure. Ingestion of pigments can result from eating, smoking, or drinking in the work areas as well as from swallowing material gathered by the mucociliary clearance mechanism in the respiratory tract. The volatility of many organic solvents and resins at room temperature accounts for the likelihood that workers will be exposed to them by inhalation. Exposure to solvents and resins by skin contact and skin absorption is also common.

An epidemiological study [38] was conducted on a cohort of 16,243 men from 32 plants who were employed in the manufacture of paint or varnish for at least one year after January 1, 1946. The total mortality data of these workers compared favorably with that of the United States white male population (i.e., 2,633 deaths observed, standardized mortality ratio [SMR] of 86). However, a statistically significant increased mortality risk from colon and rectal cancer (65 and 26 deaths observed, SMR's of 138 and 139, respectively) were found. The workers were also divided into seven subgroups on the basis of the type of exposure. In one of these subgroups (the pigment workers) there was a significant increase of liver cancer (7 deaths observed, SMR of 273, $p<0.05$). Lacquer workers had increased, although not significant, liver cancer and leukemia (SMR's of 255 and 212, respectively). The investigators [38] concluded that work in this industry presented no major health hazard. However, there were no analyses performed which took into account either exposure or latency. Without such analyses, positive findings would likely be obscured by the dilution of the study population with persons with inadequate exposure and latency for chronic disease to manifest. There is no basis for the author's conclusions.

IV. METHODS FOR WORKER PROTECTION

The occupational hazards that have been identified in the paint and allied coating products industry fall into three categories: (1) accidents, (2) fires and explosions, and (3) exposures to toxic substances and physical agents. Injuries are reported among coatings industry workers about 18 times more frequently than illnesses [11,28] and are the major cause of lost worktime [11]. The possibility of fires and explosions exists where solvents and other flammable materials are used. Workers who manufacture paint and allied coating products are also potentially exposed to numerous toxic solvents, pigments, film-formers, and additives. Possible adverse health effects resulting from exposure to many of these materials, particularly components of some of the more recently developed products, are unknown. In addition, workers are exposed to more than one substance at a time, and the possible synergistic or additive effects have not been determined.

A. Prevention of Accidents

To protect workers in the coatings industry, a critical objective is to reduce injuries. Sprains, strains, contusions, bruises, cuts, and lacerations constitute about 66% of the total injuries and illnesses in the coatings industry [28]. The largest source of injuries and illnesses (about 33%) is associated with the handling of boxes, barrels, and containers [28]. Accidents are caused by improper lifting, carrying a load that is too heavy, incorrect gripping, failure to wear appropriate protective clothing, and slips and falls resulting from sudden changes in friction between the shoes and the floor. It is evident that reducing the number of injuries should be a high priority in the paint and allied coating products industry.

Grimaldi and Simonds [39] suggested that the causes of all injuries can be divided into two categories: unsafe physical conditions and unsafe personal acts. Unsafe physical conditions are due to defects in the condition of equipment, errors in design, faulty planning, or omission of essential safety requirements for maintaining a relatively hazard-free physical environment. Unsafe physical conditions were grouped by Grimaldi and Simonds [39] in the following categories:

- Inadequate mechanical guarding.
- Defective (e.g., inferior composition, rough, sharp, slippery, decayed, corroded, frayed, or cracked) equipment, ladders, floors, stairs, and piping.
- Unsafe design or construction.

- Hazardous process, operation, or arrangement (i.e., unsafe piling, stacking, or storage; congested aisle space; crowding; and overloading).

- Inadequate or incorrect illumination.

- Inadequate or incorrect ventilation.

- Unsafe dress or apparel (e.g., loose clothing, or where use is required, absence of or defective gloves, aprons, or shoes).

Unsafe personal acts that have resulted in injury were grouped by Grimaldi and Simonds [39] in the following categories:

- Working unsafely (e.g., improper lifting, hazardous placing of materials, incorrect mixing of material, performing maintenance or repairs on moving machinery, working under suspended loads, failing to heed warnings, etc.).

- Performing operations for which supervisory permission has not been granted.

- Removing safety devices or altering their operation so that they are ineffective.

- Operating equipment at unsafe speeds.

- Using unsafe or improper equipment (e.g., using a chisel with a "mushroomed" head, using the hands instead of a brush to remove chips from cutting machines, or using a screwdriver of incorrect size for the slot in the screwhead).

- Using equipment unsafely.

- Engaging in horseplay.

- Failing to wear safe attire or personal protective clothing and equipment.

Accidents may be prevented and injuries reduced by evaluating the potential for accidents and neutralizing these sources with effective engineering controls and work practices. Follow-up of previous corrective actions to evaluate their effectiveness is an essential step in developing an overall injury control program [40].

Workforces with high or low accident rates were compared by Cohen et al. [40] to determine whether there were distinguishable differences between the two groups in safety program practices and other related factors. Descriptive and statistical analyses were performed on questionnaire data from 42 pairs of work forces with either high or low accident rates [40]. Workforces with low accident rates differed from those with high accident rates by virtue of the following characteristics:

- Greater stature and staff commitment were given to the direction of company safety efforts.

- Safety appeals were more personalized (including appeals to workers' families).

- A more concerted use was made of a variety of safety promotional and incentive techniques.

- Greater opportunities were provided for general and specialized job safety training with supplemental modes of instruction for all production personnel.

- More humanistic approaches were used in disciplining risk-takers and violators of safety rules.

- More frequent, less formal inspections of the workplace were made as a supplement to or instead of formal inspections at lengthy intervals.

- Safety programs emphasized better balance between engineering and nonengineering approaches toward accident prevention and control.

- More stable qualities in the makeup of the workforce (i.e., more older, married workers with longer time on the job) were found.

Safety control programs that have the preceding characteristics of workforces with low accident rates and that are oriented toward minimizing the number of unsafe conditions and acts should tend to reduce the number and severity of accidents and injuries in the coatings industry. Hazard control programs are most effective when they include both specific corrective actions and demonstrable involvement by senior management. Also, involvement of workers in decision processes leads to improvements in safety compliance [40].

1. Proper Lifting

Overexertion in the workplace accounts for a large number of disabling injuries. Most of these injuries involve the act of manually handling materials. A detailed analysis of hazard identification and control involved in lifting is given in the NIOSH technical report, Work Practices Guide for Manual Lifting [41]. It recommends that a job analysis be conducted for tasks associated with increased risk of injury; a detailed procedure for evaluating the analysis for lifting tasks is presented [41]. For workers to safely perform lifting jobs, employers should institute training, ergonomic/engineering controls, the use of materials handling aids and equipment, and the selection of appropriate individuals as discussed in the following sections.

a. Training

The training of workers in proper materials handling techniques is generally accepted as a potentially useful technique for reducing injuries. A detailed presentation on training is also given in the NIOSH technical report, Work Practices Guide for Manual Lifting [41]. In general, a training course should cover the following aspects:

- The risks to health resulting from unskilled lifting.
- The basic biomechanics of lifting.
- The effects lifting has on the body.
- Methods for estimating one's comfortable lifting capacity.
- Recognition of factors which may contribute to an accident.
- Handling skills (safe lifting postures, proper timing, etc.).
- Use of materials handling aids and equipment (rollers, jacks, platforms, shoulder pads, etc.).

Since the trainee should be actively involved in the training, classes should be small. Principles in reducing hazards associated with lifting should be demonstrated by supervisors and practiced by the trainees while they are observed by supervisors. It is not enough to teach only in a classroom because the lessons must be applied on site [41].

b. Ergonomic/Engineering Controls

There are more hazards in manual materials handling than overexertion of the musculoskeletal or cardiovascular systems. An ergonomically safe work environment is also important. Container design, worker/container coupling design (hand clearance), worker/floor surface coupling, and the visual environment all play a role in accidents and injuries related to materials handling [41].

The container itself affects safety directly through its weight and size and indirectly through the limitations it imposes on methods of holding and carrying it. Containers should be as small as possible. A compact load minimizes the compressive forces on the back because the center of gravity of the load can be brought close to the spinal column [41].

Worker/container coupling affects the ability to exert forces on the object, to maintain grip, and to exercise control -- all vital to safe handling. The major problems with most handles are insufficient hand clearance, sharp edges which can cut into the hand, and a handle diameter that is too small. Handle diameter should range from 2.5-3.8 cm (1.0-1.5 in). Handle width should be at least 11.5 cm (4.5 in) with 5.0 cm (2 in) clearance all around the handle. If gloves are used, at least 2.5 cm (1 in) should be added to the width and the clearance [41].

Worker/floor surface coupling is important for maintaining stability and preventing slips, trips, and falls. Accidents can be reduced by using good housekeeping procedures to reduce transient changes in surface friction such as spills, worn spots, and loose or irregular floors [41].

Although manual materials handling operations rarely demand the fine visual discrimination of delicate assembly work, lighting can have a large effect on surface texture and depth perception. Low, angled illumination is recommended for enhancing surface texture to warn workers of changes in surface friction. Color contrasts should be used on the edges of steps, loading docks, and ramps.

c. Materials Handling Aids and Equipment

The use of materials handling aids (rollers, jacks, and platforms) and mechanical equipment (conveyors, cranes, hoists, hand trucks, and forklifts) can be helpful or necessary in many lifting tasks. Particularly useful are conveyors and other devices which convert lifting into sliding tasks. The potential benefits of these devices, however, must be weighed against potential safety problems such as suspended loads with cranes and the many hazards in the use of hand-operated trucks and forklifts [41].

d. Selection of Appropriate Individuals

To avoid worker-job mismatch, selection of individuals for some jobs is considered desirable. Criteria for selection are lacking, however. For many industries the principal method has been self-selection by the workers based on their initial tolerance for the demands of the job, a poor choice for obvious reasons. Other selection methods that have been used are questionnaires on health and medical history; and tests of visual, auditory, and pulmonary function, of blood pressure, mobility, etc., often with the addition of a chest x ray. However, such tests have poor predictive power. In particular, x rays of the musculoskeletal system have little value in identifying workers who develop back injuries, and their routine use in screening employees is discouraged by medical authorities [41]. The most useful procedure is a medical history coupled with an objective test of performance capacity (e.g., strength testing).

2. Machine Guarding/Redesign

An important area of occupational safety and health is that which protects the operator from the hazards of machine operations. OSHA requires in 29 CFR 1910.212 that one or more methods shall be provided to protect the operator and other workers in the machine area from hazards such as those created by point of operation, in-running nip points, rotating parts, flying chips, sparks, power transmission equipment, etc. Guards shall be affixed to the machine where possible.

Workers who use powered handtools in chipping operations are exposed to hand-arm vibration and potential risk of developing vibration syndrome (also known as vibration white finger and Raynaud's phenomenon). Vibration syndrome has adverse circulatory and neural effects in the fingers; the signs and symptoms include numbness, pain, and blanching (turning pale and ashen) [42]. NIOSH recommends that jobs be redesigned to minimize the use of vibrating tools and that powered handtools be redesigned to minimize vibration [42].

3. Noise Control

Noise must be controlled wherever it is excessive, both as a means of preventing accidents and as protection from hearing loss. The noise in dispersion and filling operations is of special concern [33,43-45] as is the use of powered handtools to chip layers of coatings from the insides of containers [34].

Under the provisions of the OSHA Occupational Noise Standard (29 CFR 1910.95), protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table IV-1 when measured on the A scale of a standard sound level meter at slow response. Feasible administrative or engineering controls shall be utilized when employees are subjected to sound levels exceeding those listed in the table. If such controls fail to reduce sound levels to within permissible levels, personal protective equipment shall be provided. Whenever worker noise exposures equal or exceed an 8-hour time-weighted average sound level of 85 decibels, A-weighted scale, slow response (dBA), the employer shall administer a continuing, effective hearing conservation program which includes audiometric testing, hearing protectors, training, and recordkeeping.

Noise abatement by engineering controls and equipment maintenance or modification reduces the intensity of the noise either at the source or in the immediate work environment. The following are some examples [46]:

- Specify new or replacement equipment to have lower operating noise levels.
- Replace worn or unbalanced parts in existing equipment.

TABLE IV-1. PERMISSIBLE NOISE EXPOSURES* [29 CFR 1910.95]

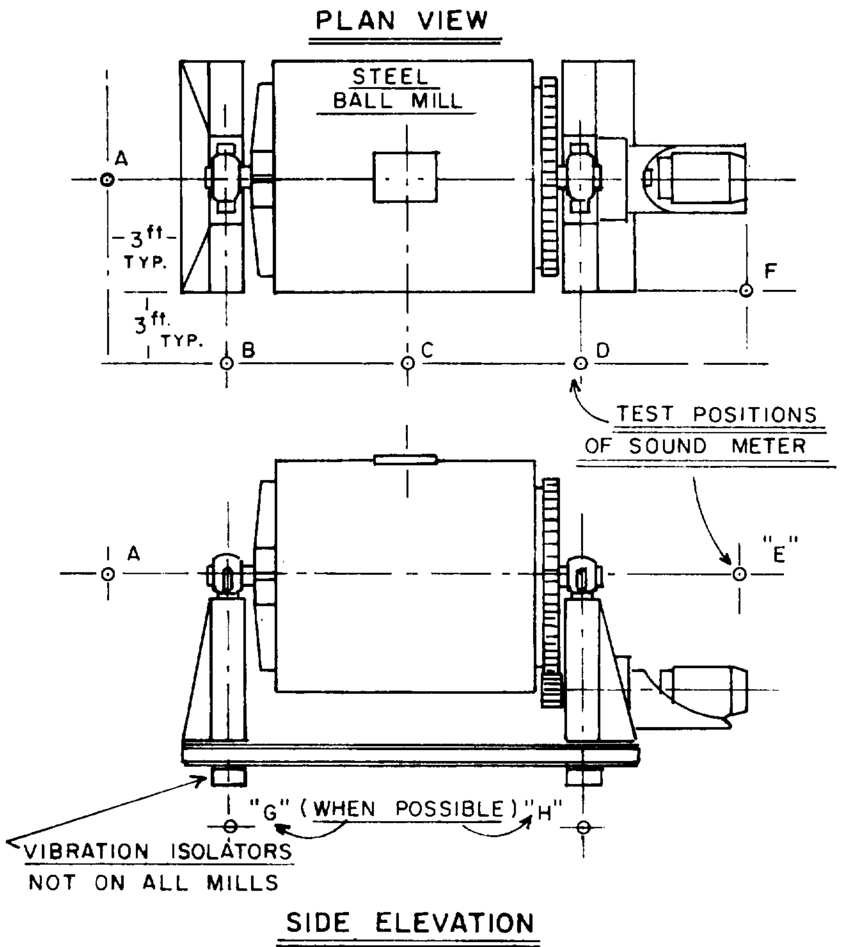
Duration Per Day Hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

* Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

- o Maintain proper adjustment of equipment.
- o Secure all covers or safety shields on machines.
- o Lubricate all moving parts on equipment.
- o Substitute belt drive for gears.
- o Use rubber or plastic linings for vibration dampening.
- o Use sound-absorbing materials such as lead sheet and various combinations of open-cell foam and sheet metal.
- o Install or replace mufflers on internal combustion engines and compressors.
- o Isolate the noise source.

An essential consideration in controlling noise is accurate monitoring. Figure IV-1 shows the results of sound pressure measurements at different locations around a ball mill [34].

FIGURE IV-1. SOUND PRESSURE LEVELS (dBA) AT DIFFERENT LOCATIONS AROUND A BALL MILL [34]



	Pos. A			Pos. B			Pos. C*			Pos. D	
Hi	Av	Lo	Hi	Av	Lo	Hi	Av	Lo	Hi	Av	Lo
93	90.7	90	93	91.7	88	106	93	85	94	92.7	92.3

	Pos. E			Pos. F			Pos. G			Pos. H	
Hi	Av	Lo	Hi	Av	Lo	Hi	Av	Lo	Hi	Av	Lo
95	94.1	93	94	92.8	92	96	92.1	88	96	92.1	88

*POSITION C HIGH READING WAS TAKEN WITH WASH SOLVENT IN A STEEL BALL MILL; LOW READING WAS FOR A WATER JACKETED LINED PEBBLE MILL USING HIGH DENSITY GRINDING BALLS.

B. Prevention of Fires and Explosions

Many of the organic substances used in the manufacture of paint and allied coating products are highly flammable, and some are also explosive. Thus, fires and explosions are a constant threat in most manufacturing operations where solvents and other flammable materials are used.

1. Static Electricity

The handling of the flammable or explosive liquid raw materials used in the coatings industry requires special techniques and precautions to prevent the accumulation of static electricity. The object of such measures is to provide a means whereby charges may recombine harmlessly before sparking potentials are attained or to avoid spark gaps where harmful discharges could occur [31]. During the transfer of the solvents from one container to another (whether in bulk or in small amounts), effective bonding and grounding should be used to prevent the accumulation of static electricity [32]. "Bonding" is the process of connecting two or more conductive objects together by means of a conductor [31]. "Grounding" is the process of connecting a conductive object to the ground and is a specific form of bonding [31]. Fill pipes should go to the bottom of tanks, drums, etc., to minimize the generation of static electricity in the free fall of flammable solvents [2]. Drums cleaned by steam should be electrically bonded to steam lines, and the entire assembly should be grounded. Before drums are emptied, they should be supported and blocked to prevent movement. Examples of bonding and grounding arrangements are shown in Figures IV-2, IV-3, IV-4, IV-5, and IV-6.

FIGURE IV-2. BONDING AND GROUNDING FOR A MECHANICAL PUMPING DEVICE [47]

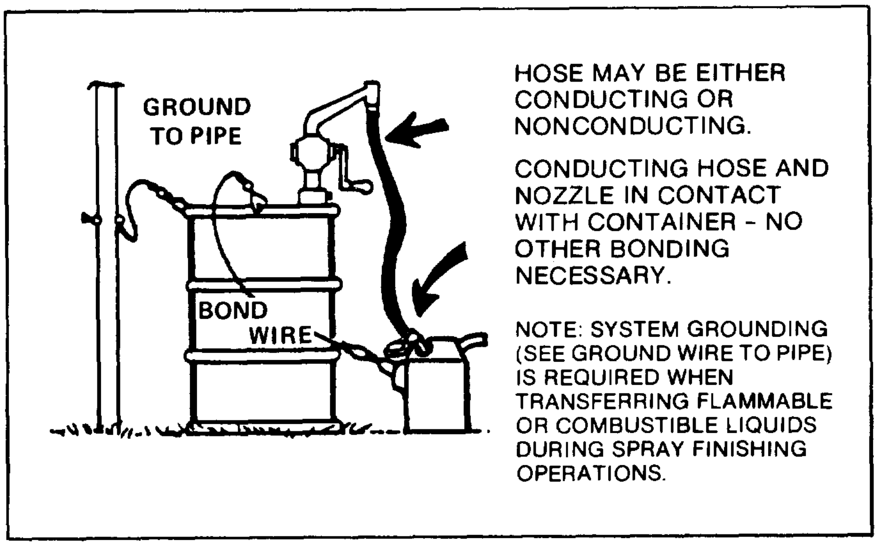


FIGURE IV-3. EXAMPLE OF A SMALL GROUND CLAMP STANDARD ASSEMBLY [32]
(Copyright by The Sherwin-Williams Company. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)

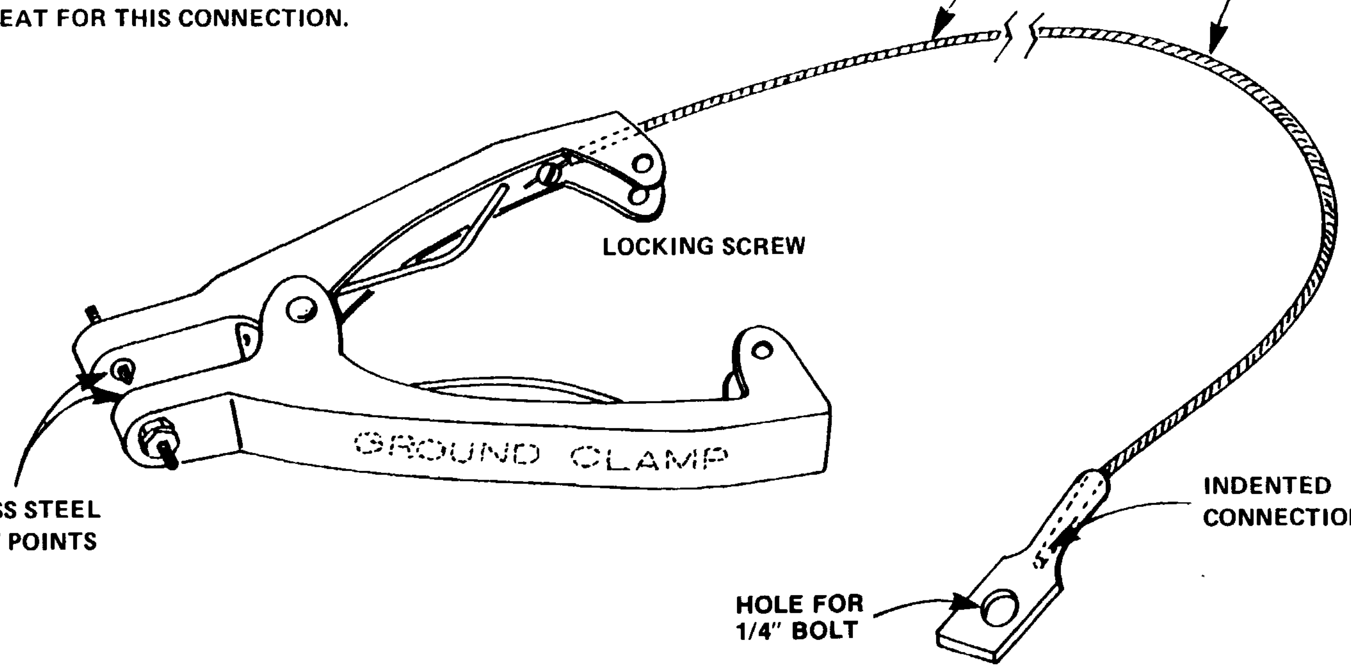


FIGURE IV-4. TYPICAL GROUNDING ARRANGEMENT FOR 55-GALLON DRUMS IN A STORAGE RACK [32]
(Copyright by The Sherwin-Williams Company. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)

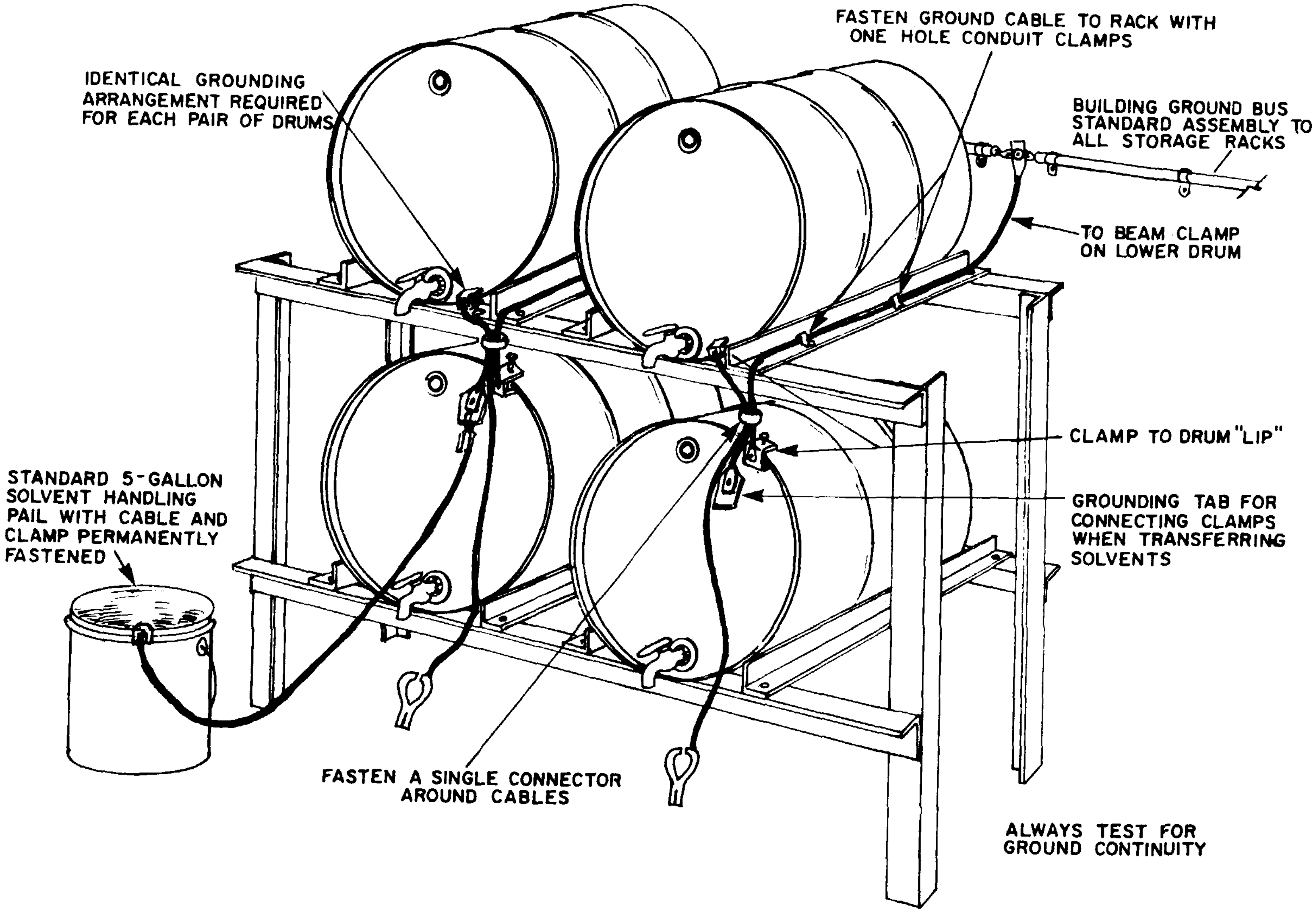


FIGURE IV-5. TYPICAL GROUNDING ARRANGEMENT FOR A BALL MILL CHARGING FITTING [32]

(Copyright by The Sherwin-Williams Company. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)

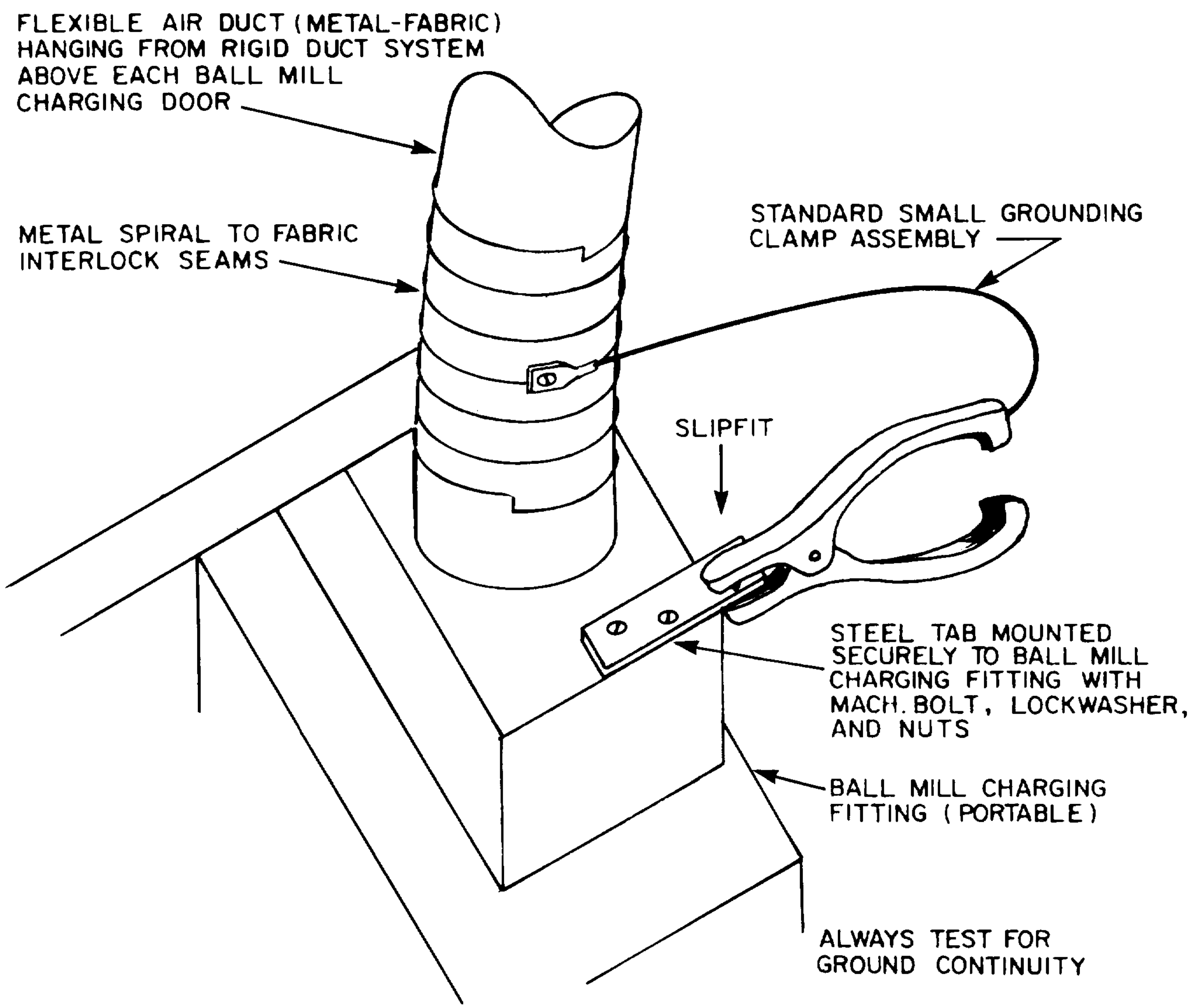
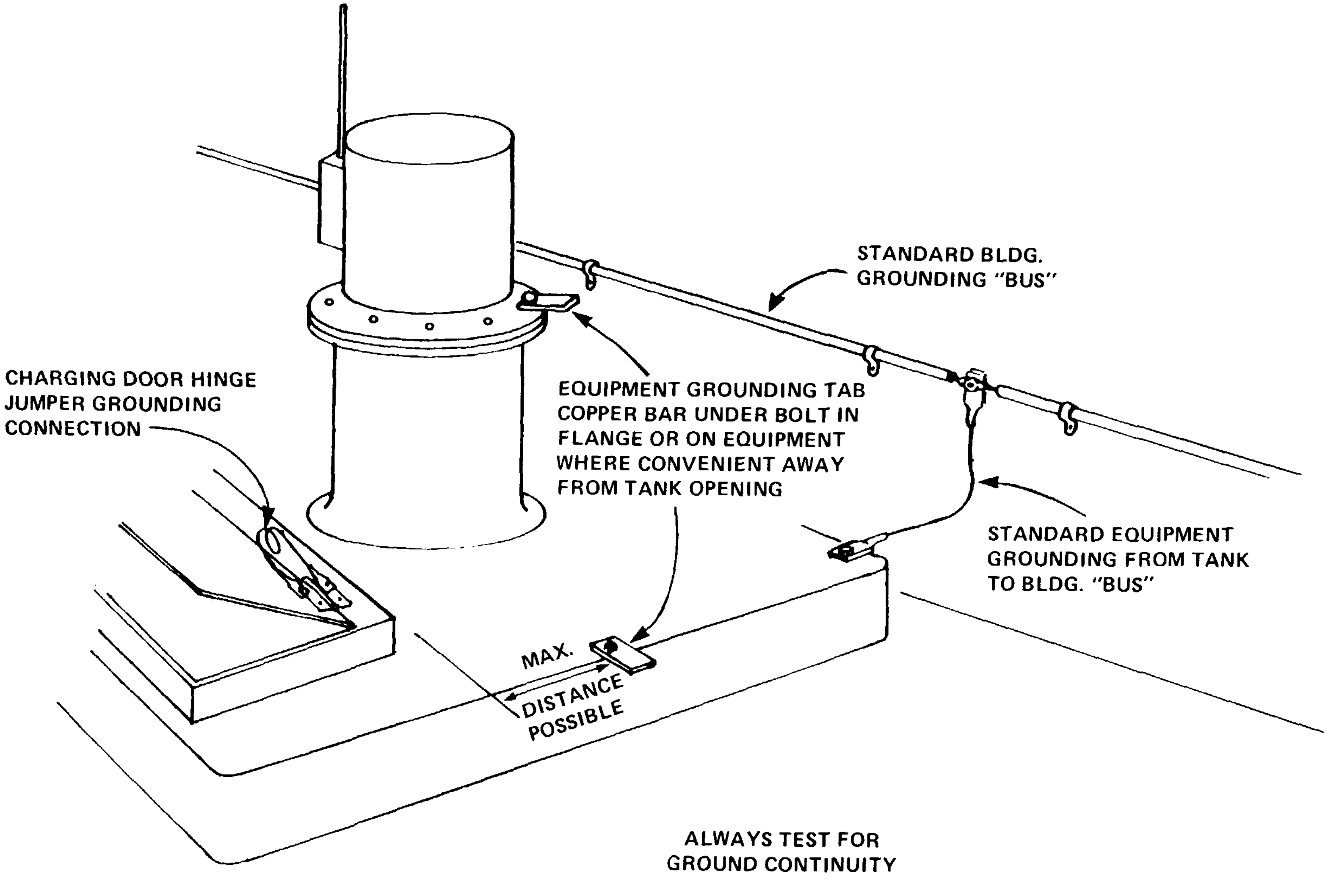


FIGURE IV-6. TYPICAL GROUNDING ARRANGEMENT FOR THINNING OR MIXING EQUIPMENT [32]
(Copyright by The Sherwin-Williams Company. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)



2. **Work Practices**

Procedures and precautions for preventing fires and explosions include: (1) regular inspection of equipment and storage tanks, (2) immediate repair of leaks, pumps, and lines, (3) periodic testing of pressure equipment, and (4) ventilation to reduce vapor concentrations.

Containers of solvents or hot resins should be tightly covered at all times except when material is transferred. Containers of not more than five gallons capacity, having a spring-closing lid and spout cover and so designed to safely relieve internal pressure when subjected to fire exposure, should be used to hold working amounts of solvents. Since small amounts of residue may remain and present a fire hazard, containers that have held solvents should be thoroughly cleaned with steam and then drained and dried before re-use. Fittings should not be struck with tools or other hard objects that may cause sparks. Special spark-resistant tools of non-ferrous materials should be used where flammable gases, highly volatile liquids, or other explosive substances are used or stored [30]. Additionally, all sources of ignition such as smoking, welding, and open heaters should be prohibited except in specified areas. Fire hazards around tank trucks and cars can be reduced by turning off their motors and not starting them during loading or unloading operations.

Good housekeeping is also imperative to prevent fires. After eliminating potential sources of ignition, spills should be cleaned up immediately after the area is ventilated. Stopping leaks and spills will eliminate fire hazards and help conserve raw materials, keep chemicals out of the effluent system, and reduce worker exposure. Combustible materials such as cleaning rags should be disposed of in metal containers filled with water [2].

Specific OSHA requirements for the storage and handling of flammable and combustible liquids are given in 29 CFR 1910.106.

C. Controlling Exposures to Toxic Substances

Exposure to the thousands of raw materials (i.e., pigments, solvents, film-formers, and additives) used in the paint and allied coating products industry also poses a potential hazard. A variety of technologies such as process enclosure, modification of existing equipment, mechanical pumping systems, local exhaust ventilation, hazardous substance identification systems, protective clothing and equipment, and implementation of safe work practices can be used to control exposures to toxic substances. The conclusions of a NIOSH-sponsored study [43] indicate that the coatings industry relies on relatively well-known technology and uses equipment and procedures that are commonly used in a wide variety of other industries.

The effectiveness with which the coatings industry has controlled worker exposure to toxic substances can be evaluated somewhat by reviewing the records of OSHA compliance investigations. For the industries within the SIC code 2851, data are available from OSHA health inspections completed during the period June 1979 to January 1984. Table IV-2 indicates the numbers of different samples collected and whether the concentrations found were above or below the Federal occupational standard in effect at the time [48]. The majority of tests (94%) showed that the concentrations of the substances evaluated were within applicable Federal standards. On the basis of these tests, it can be concluded that it is probably feasible in the coatings industry, through engineering controls and effective work practices, to limit exposures to most hazardous substances to within Federal standards.

TABLE IV-2. SUMMARY OF THE OSHA SAMPLING OF HAZARDOUS SUBSTANCES FOR THE PAINT AND ALLIED COATING PRODUCTS INDUSTRY (SIC CODE 2851) DURING THE PERIOD OF JUNE 1979 TO JANUARY 1984 [48]

Substance	Samples		
	Number Collected	Number Above OSHA Standard*	% Exceeding OSHA Standard*
Acetone	4	0	0
Antimony and compounds (as Sb)	2	0	0
Arsenic (inorganic compounds as As)	3	0	0
Asbestos (all forms)	20	1	5
Barium (soluble compounds)	2	0	0
Benzene	12	0	0
Benzoyl peroxide	2	0	0
Beryllium and compounds (as Be)	2	0	0
2-Butanone (methyl ethyl ketone)	58	3	5
2-Butoxy ethanol (butyl Cellosolve®)	4	0	0
n-Butyl acetate	20	0	0
Butyl alcohol	12	0	0
n-Butyl glycidyl ether (BGE)	4	0	0
Cadmium dust	3	0	0
Carbon black	1	0	0
Carbon monoxide	3	3	100
Carbon tetrachloride	2	1	50
Chromic acid and chromates (as CrO_3)	22	1	5
Chromium, metal and insoluble salts (as Cr)	10	0	0

(Continued)

TABLE IV-2. SUMMARY OF THE OSHA SAMPLING OF HAZARDOUS SUBSTANCES FOR THE PAINT AND ALLIED COATING PRODUCTS INDUSTRY (SIC CODE 2851) DURING THE PERIOD OF JUNE 1979 TO JANUARY 1984 [48]

Substance	Samples		
	Number Collected	Number Above OSHA Standard*	% Exceeding OSHA Standard*
Chromium, soluble chromic, chromous salts (as Cr)	15	0	0
Coal tar pitch volatiles (benzene soluble fraction)	3	0	0
Cobalt, metal, fume, and dust (as Co)	7	0	0
Copper dusts and mists (as Cu)	2	0	0
Copper fume (as Cu)	4	0	0
Cyclohexane	2	0	0
2-Ethoxy ethanol (Cellosolve®)	1	0	0
2-Ethoxyethyl acetate (Cellosolve® acetate)	8	0	0
Ethyl acetate	11	0	0
Ethyl alcohol (ethanol)	3	0	0
Ethyl sec-amyl ketone	1	0	0
Ethyl benzene	1	0	0
Furfural	1	0	0
2-Hexanone (methyl butyl ketone)	4	0	0
Hexone (methyl isobutyl ketone)	26	0	0
Hydrogen chloride	1	0	0
Inert or nuisance dust (respirable)	15	1	7
Inert or nuisance dust (total)	23	1	4
Iron oxide fume	11	0	0
Isobutyl acetate	3	0	0
Isobutyl alcohol	5	0	0
Isophorone	6	0	0
Isopropyl alcohol	8	0	0
Lead arsenate	34	7	21
Lead chromate	1	0	0
Lead, inorganic fumes and dusts (as Pb)	71	21	30
Maleic anhydride	1	0	0
Manganese and compounds (as Mn)	1	0	0
Mercury inorganic (as Hg)	2	0	0
Mercury (organo) alkyl compounds (as Hg)	4	0	0

(Continued)

TABLE IV-2. SUMMARY OF THE OSHA SAMPLING OF HAZARDOUS SUBSTANCES FOR THE PAINT AND ALLIED COATING PRODUCTS INDUSTRY (SIC CODE 2851) DURING THE PERIOD OF JUNE 1979 TO JANUARY 1984 [48]

Substance	Samples		
	Number Collected	Number Above OSHA Standard*	% Exceeding OSHA Standard*
Methyl Cellosolve® acetate	1	0	0
Methyl chloroform	1	0	0
Methylene chloride	7	1	14
Naphtha (coal tar)	23	2	9
Naphthalene	1	0	0
Nickel, metal and soluble compounds (as Ni)	2	0	0
Petroleum distillates (naphtha)	47	0	0
Phthalic anhydride	3	0	0
n-Propyl acetate	4	0	0
Silica (quartz), respirable	36	1	3
Stoddard solvent	21	0	0
Styrene	3	0	0
Sulfuric acid	2	0	0
Talc	2	0	0
Tetrachloroethylene (perchloroethylene)	5	1	20
Tin (organic compounds) (as Sn)	1	0	0
Titanium dioxide	3	0	0
Toluene	92	2	2
Toluene-2,4-diisocyanate (TDI)	1	0	0
Tributyl phosphate	1	0	0
Triethylamine	1	0	0
Trimellitic anhydride	5	2	40
Vinyl chloride	2	0	0
Xylene (xylol)	92	1	1
Zinc oxide fume	11	0	0
Total	**828**	**49**	**6**

*OSHA Standards in effect at time of surveys. Current OSHA Standards and NIOSH Recommended Exposure Limits are listed in Appendix B.

To identify specific hazards, comprehensive industrial hygiene evaluations (including appropriate measurements) should be conducted. Such evaluations should be conducted at least yearly or when any change in process, raw material, or engineering control occurs which could result in increased exposure to toxic substances. The results of these evaluations should be used to guide employers in implementing effective work practices and engineering controls, worker training, medical surveillance, and the use of personal protective clothing and equipment.

1. Informing Workers of Hazards

OSHA on November 21, 1983, promulgated an occupational safety and health standard titled "Hazard Communication." Under the provisions of this standard (29 CFR 1910.1200), employers in the manufacturing sector (i.e., SIC Codes 20 through 39) must establish a comprehensive hazard communication program which includes at least container labeling, material safety data sheets, and a worker training program. The hazard communication program is to be written and is to be made available to workers and their designated representatives.

Chemical manufacturers, importers, and distributors are required to ensure that containers of hazardous chemicals leaving their workplaces are labeled, tagged, or marked with the identity, appropriate hazard warnings, and the name and address of the manufacturer or other responsible party. Employers must ensure that labels on incoming containers of hazardous chemicals are not removed or defaced unless they are immediately replaced with other labels containing the required information.

Each container in the workplace must be prominently labeled, tagged, or marked with the identity of hazardous chemicals contained therein along with hazard warnings appropriate for worker protection. If there are a number of stationary containers within a work area which have similar contents and hazards, the employer may post signs or placards which convey the hazard information required rather than individually labeling each container. Employers may use various types of standard operating procedures, process sheets, batch tickets, or other such written materials as substitutes for individual container labels on stationary process equipment. However, these written materials must contain the same information as is required on the labels and must be readily accessible to workers in the work areas. Pipes or piping systems are exempted altogether from the OSHA labeling requirements although NIOSH recommends that filler ports and outlets be labeled. In addition, NIOSH recommends that a system should be set up to ensure that pipes containing hazardous materials are identified to avoid accidental cutting and discharge of hazardous materials.

Employers are not required to label portable containers into which hazardous chemicals are transferred from labeled containers and which are intended only for the immediate use of the worker who performs the transfer. According to the OSHA definition of "immediate use," for the exemption to apply, the container must be under the control of the worker performing the transfer and must be used only within the workshift in which it is transferred.

The OSHA Hazard Communication standard requires chemical manufacturers and importers to develop a material safety data sheet (MSDS) for each hazardous chemical they produce or import. Employers in the manufacturing sector (which includes paint and allied coating products manufacturing) are required to obtain or develop a MSDS for each hazardous chemical used in their workplaces. The MSDS is required to provide specific information such as the chemical and common names for the hazardous chemical. For hazardous chemical mixtures, each component which comprises 1% or more and which is itself a health hazard must be listed. Any chemical which is determined to be a carcinogen must be listed if it is present in quantities of 0.1% or greater. Ingredients present in concentrations of less than one percent must also be listed if there is evidence that the permissible exposure limit may be exceeded or if it could present a health hazard in those concentrations. Additional information on the MSDS must include data on the physical and chemical characteristics of the hazardous chemical, known acute and chronic health effects, precautionary measures, and emergency and first aid procedures. The NIOSH publication, A Recommended Standard--An Identification System for Occupationally Hazardous Materials [49], can be used as a guide when preparing the MSDS. Required information can be recorded on the "Material Safety Data Sheet" shown in Appendix C, or on a similar form.

Employers are to establish a training program for all workers exposed to hazardous chemicals. Training is to be provided at the time of initial assignment and whenever a new chemical hazard is introduced into their work area. Workers are to be informed of specific hazards involved in any operations in their work areas where hazardous chemicals are present. This may be done by individual chemical or by categories of hazards, but in any case the worker is to be aware that information is available on the specific hazards of individual chemicals through the MSDS.

Workers are also to be trained regarding methods and observations that may be used to detect the presence or release of hazardous chemicals (e.g., monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.). Training is to include the measures workers can take to protect themselves from exposure to hazardous chemicals such as appropriate work practices, emergency procedures, and the use of personal protective equipment.

OSHA did not propose a standardized labeling system in the Hazard Communication Standard, only that minimal information requirements be met. Principles for labeling hazardous industrial materials have been established by the American National Standards Institute [50]. A comprehensive system of labeling and posting has also been developed [51] and is being adopted by many of the members of the National Paint and Coatings Association (NPCA). Figure IV-7 shows an example of this latter type of labeling system.

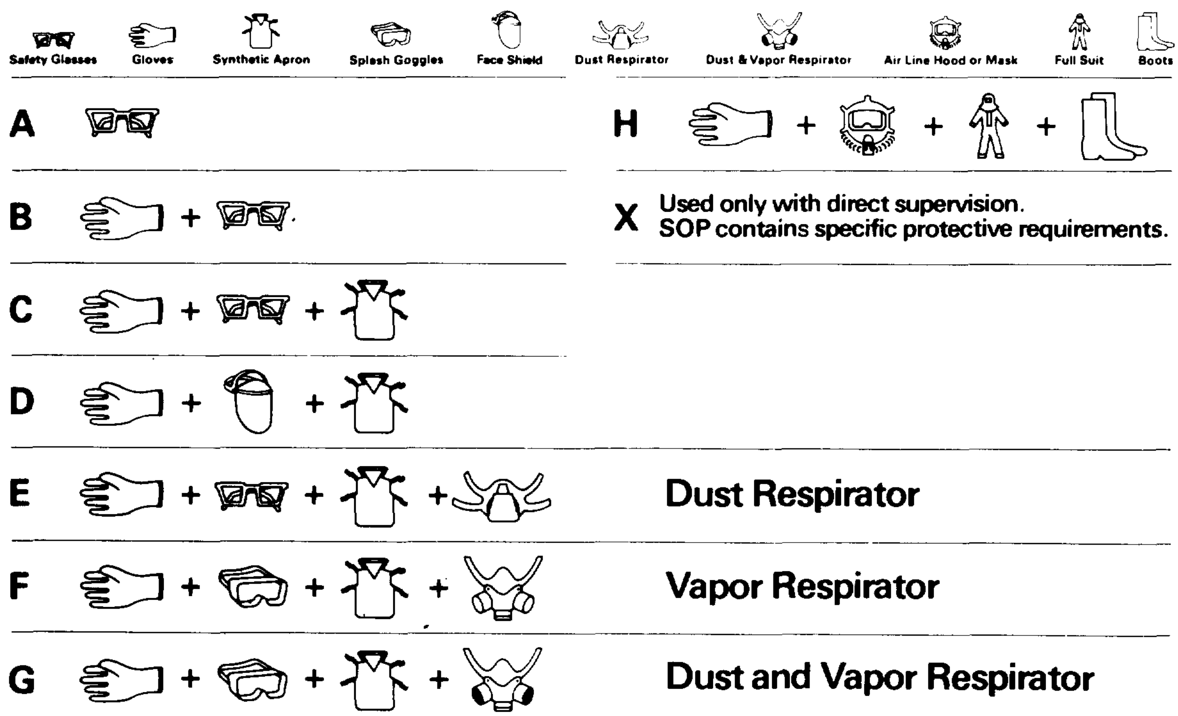
FIGURE IV-7. EXAMPLE OF A TYPE OF HAZARD LABEL
(Adapted from American Industrial Hygiene Association [51])

HEALTH Blue	4
FLAMMABILITY Red	3
REACTIVITY Yellow	2
PERSONAL PROTECTION White	G

HAZARD INDEX

4 Severe Hazard
3 Serious Hazard
2 Moderate Hazard
1 Slight Hazard
0 Minimal Hazard

PERSONAL PROTECTION INDEX



2. Work Practices

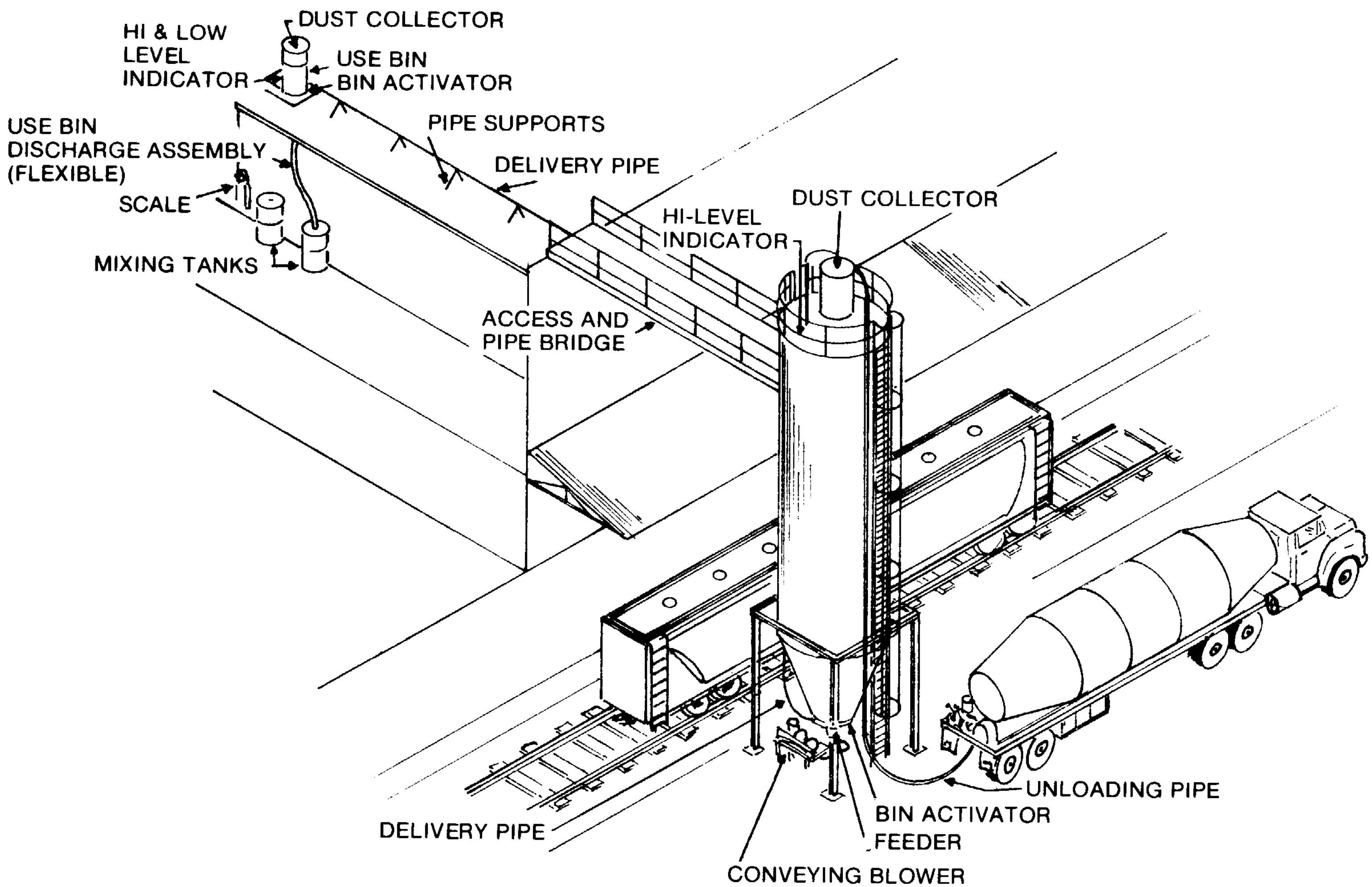
Proper materials handling procedures are important in controlling exposure to toxic substances as well as in preventing fires and explosions. Bulk handling methods for liquid raw materials which include techniques for bulk storage, piping, mechanical pumping (rather than pouring), and metering liquids minimize the opportunity for volatile liquids to contact ambient air. Systems for the bulk handling of pigments and other powdered materials also have been developed [52]. The bulk handling system shown in Figure IV-8 uses bulk delivery vehicles, the transfer of materials by pipes to tanks that have lids, and built-in dust collectors and operates in the following manner. Pigment is blown from trailers or rail cars into a steel storage silo. From the silo, pigment is blown through piping to a use bin located on the roof of the manufacturing building directly over the mixing area. Weighed quantities of pigment are delivered directly or via batch dollies to mixers. A low-level sensor actuates the transfer system to feed pigment from the silo when the pigment falls to a preselected level. Pigment is added to the use bin until its level activates a flow-cutoff sensor [52].

Despite precautions, the area around dispersion equipment often becomes quite dusty and frequent vacuum cleaning is recommended [43,44]. Compressed air should not be used to remove pigment dust from clothing or work surfaces because it will result in the secondary generation of airborne dust. It is also recommended that soiled clothing not be taken home for cleaning but be cleaned either by an industrial laundry or an on-site facility.

When solvents or caustic solutions are used for cleaning dispersion equipment, it is important to avoid skin, eye, and inhalation exposures, which are especially likely to occur during manual cleaning. When using caustic solutions, care should be taken during the preparation of the solution to prevent excessive heat generation; dry caustic, typically 3 pounds per gallon [23], should be added slowly to the water [53]. Caustic solutions should not be superheated because of the possibility that the tank will "boil over" [53]. Because caustics may react violently with aluminum, caustic solutions should not be used to clean out tanks that have contained aluminum paint [53]. Special precautions should also be taken in the handling of aluminum paste or powder which can generate hydrogen gas when in contact with moisture [2,54]. When this occurs in closed containers of aluminum pigments, sufficient pressure may build up to cause an explosion and fire [54].

Spills are likely to occur during filling operations when automated equipment malfunctions. Immediate spill cleanup can reduce vapor release. Worker training programs that address techniques for spill cleanup are useful. For major spills, some useful special procedures include the use of protective equipment (e.g., rubber boots), portable ventilation, absorbent material (e.g., floor sweeping compound, sawdust,

FIGURE IV-8. BULK HANDLING SYSTEM FOR PIGMENTS AND EXTENDERS [52]
(Copyright by Journal of Coatings Technology. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)



or earth), and restricted worker access to the immediate spill area [55]. Contact with coatings or their components (especially radiation-curable coatings) should be avoided, if possible, but should be followed by the immediate washing of contaminated skin with soap and water, immediate flushing of exposed eyes with copious amounts of water, and quick removal of contaminated clothing.

Exposure of workers to toxic substances may also occur through the use of food, beverages, or tobacco products in areas where toxic substances are present. For that reason, such activities (eating, smoking, etc.) should be prohibited in those areas. Good sanitation and hygiene practices should be encouraged by worker training, posting of warning signs, supervision, and provision for adequate eating and sanitation facilities, the latter of which should include change rooms, showers, and wash basins [44].

For all work areas in which there is a potential for emergencies involving toxic materials, the employer should take necessary steps to ensure that workers are instructed in and follow the specified procedures. Prearranged plans should be established for administering first aid and emergency medical care and for transportation of injured workers. Firefighting procedures should also be established and implemented. Personnel who may be required to shut off sources of solvents, clean up spills, and repair leaks should be properly trained in the appropriate procedures. In case of fire, solvent sources should be shut off or removed. Chemical foam, carbon dioxide, or dry chemicals should be used for fighting solvent fires, and proper respiratory protection and clothing should be worn. Nonessential workers should be evacuated from exposure areas during emergencies. Warning or alarm systems should be considered to alert workers to possible hazardous exposures during emergencies [56].

Entry into confined or enclosed spaces where there is limited egress, such as tanks, pits, trucks and tank cars, and process vessels, should be controlled by a permit system. Permits should be signed by an authorized employer representative and should certify that preparation of the confined space, precautionary measures, and personal protective equipment are adequate. Further information regarding entry into confined or enclosed spaces can be found in <u>Criteria for a Recommended Standard....Working in Confined Spaces</u> [57] and the <u>American National Standard: Safety Requirements for Working in Tanks and Other Confined Spaces</u> [58].

3. Substitution of Raw Materials

Occupational health hazards can also be controlled by the substitution of raw materials. Because of their potential for environmental damage or consumer injury, the use of lead, chromates, and mercury compounds and various highly volatile solvents in many applications has been reduced or eliminated with replacement by other, less hazardous substances. An example is the use of zinc metal, zinc oxide, molybdates, and phosphates instead of lead and chromates as pigments in industrial maintenance coatings or the use of cuprous oxide or organotin compounds in antifouling paints rather than organic mercury, lead, and arsenic compounds [13,59]. In addition, many potent paint and varnish removers such as benzene, phenol, and cresols are no longer used [23]. Another type of raw material substitution being utilized in paint manufacturing involves replacing dry pigments with pigment slurries [19]. As depicted in Figure IV-9, instead of storing and handling bagged dry pigments, slurries can be pumped from railroad cars into storage tanks and then to the mixing floor as needed, thus eliminating the release of pigment dust into the workplace air and simplifying pigment dispersion [60].

4. Engineering Controls

Occupational exposures to hazardous substances should be controlled at the source of the hazard wherever feasible. This can be achieved by process or equipment modification, isolation of stored materials and processes, and local exhaust ventilation.

One of the most effective methods of dust control during the weighing and assembling of raw materials is a system that utilizes a closed fabricated metal booth that rests on top of the mixer and is connected by ducts to both a dust collector and an empty bag shredder. Inside the booth, a bag of pigment is placed on a table and cut open as it is pushed over a mounted metal blade. The pigment falls through the cut in the bag into the mixer, and the empty bag is lifted slightly by the worker and is drawn upward and away by suction (Figure IV-10).

Another method that can effectively control dust and vapor is the use of a ventilated booth where materials are weighed or transferred. This results in reduced worker exposure and a decrease in the amount of dust and vapor released into the general workroom air. Dust-laden air that is exhausted should be collected in bag houses or forced through scrubbers or electrostatic precipitators. Vapor-laden air can be scrubbed, incinerated, condensed, or adsorbed [19,61].

Portable exhaust ventilation is another common control technique. This is accomplished with a hood attached to a flexible duct that leads to a fan. The effectiveness of this type of control varies, depending on the type of hood used, its placement, and its face velocity. Portable exhaust ventilation is generally, but not necessarily, less effective than ventilated hoods that enclose or confine a contaminant because exhaust volumes are large and control can be easily upset by cross drafts in the area [62]. Figure IV-11 shows several effective dispersion operation ventilation controls.

FIGURE IV-9. REPLACEMENT OF BAGGED DRY PIGMENTS WITH BULK PIGMENT SLURRIES [60]

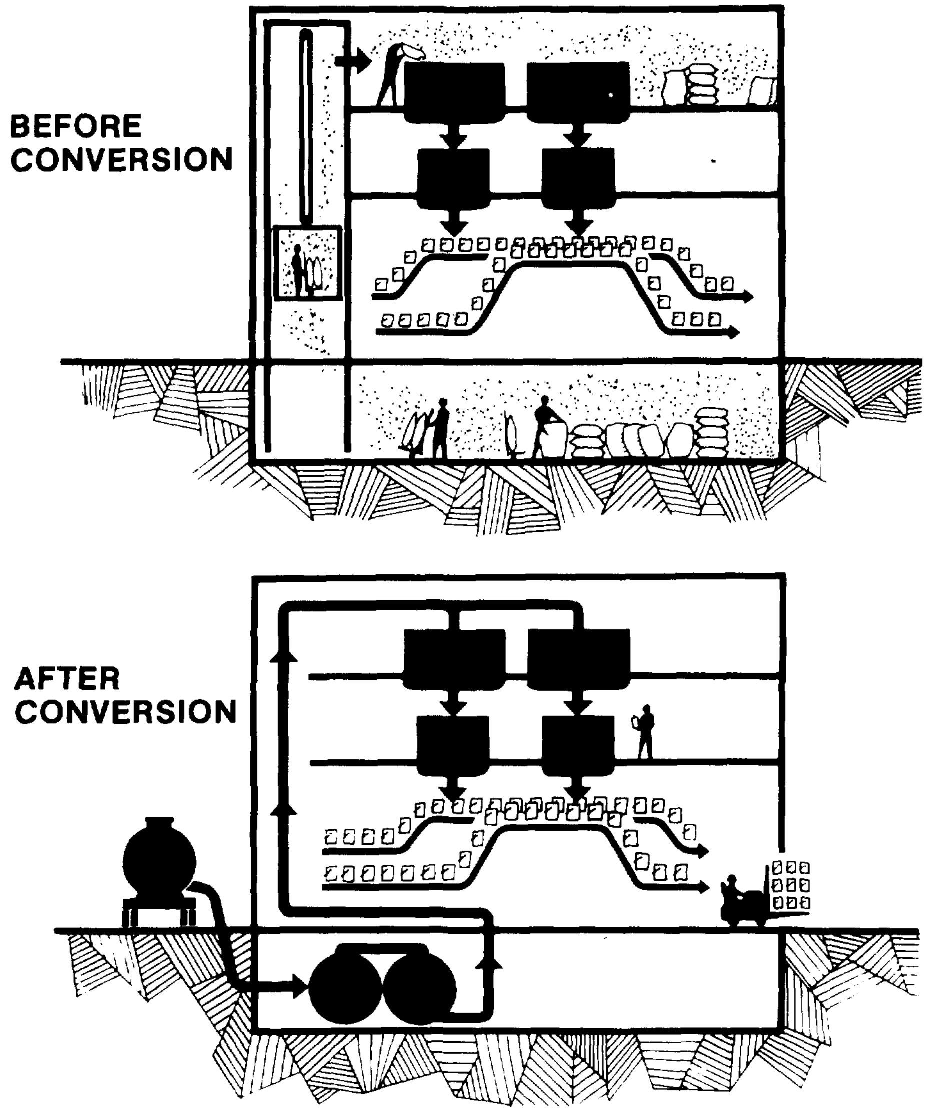


FIGURE IV-10. BAG AND DUST CONTROL SYSTEM
(Adapted from D. B. Sarvadi, written communication, August 1978)

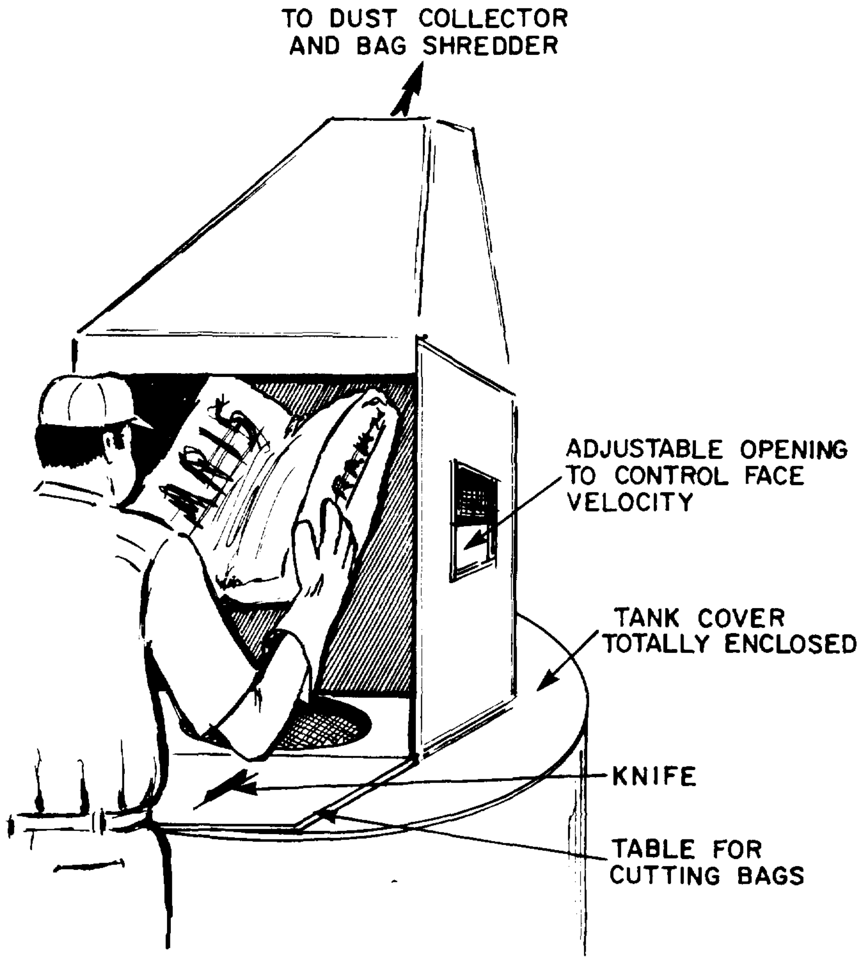
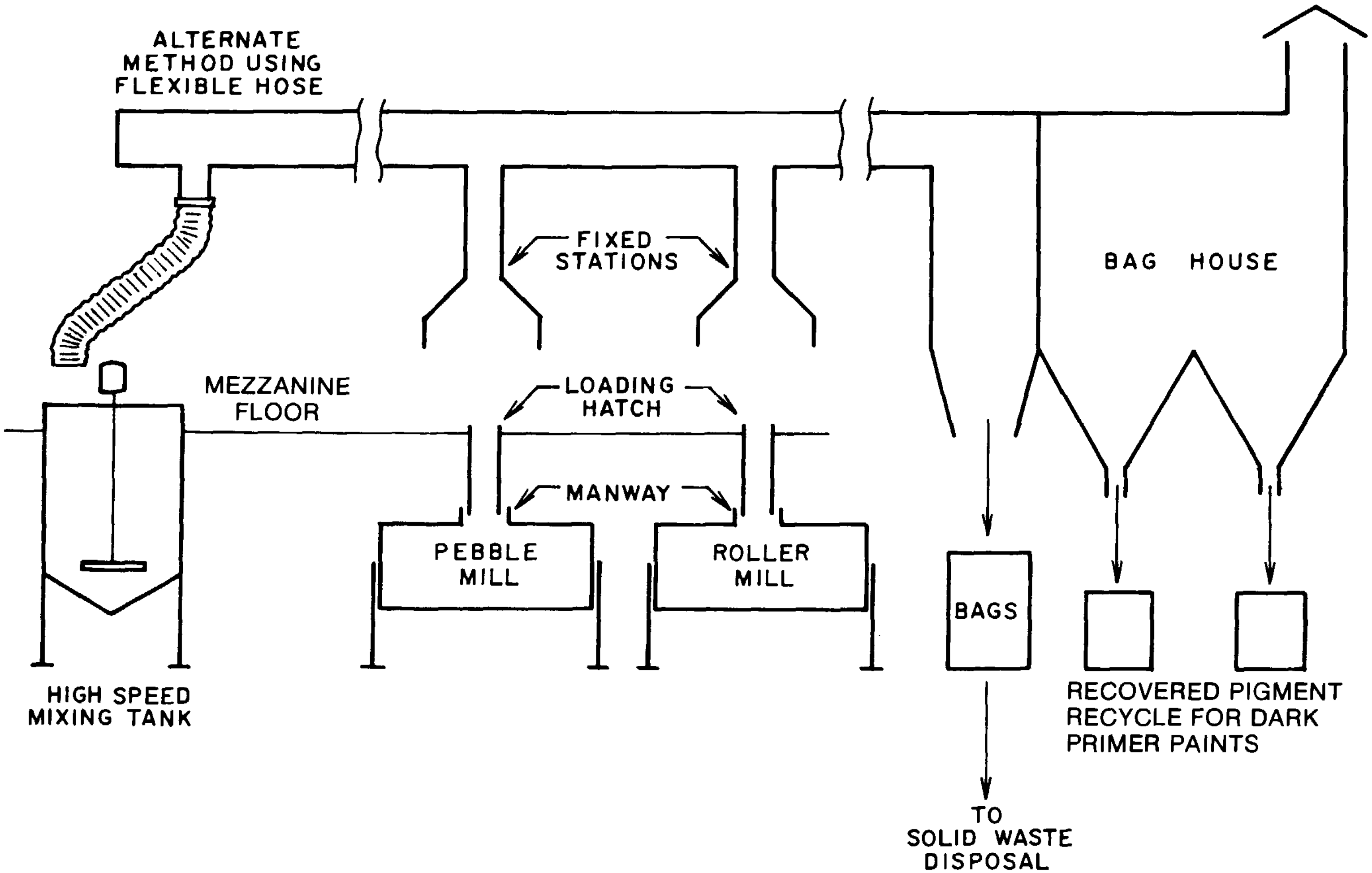


FIGURE IV-11. DISPERSION OPERATION VENTILATION CONTROL [19]

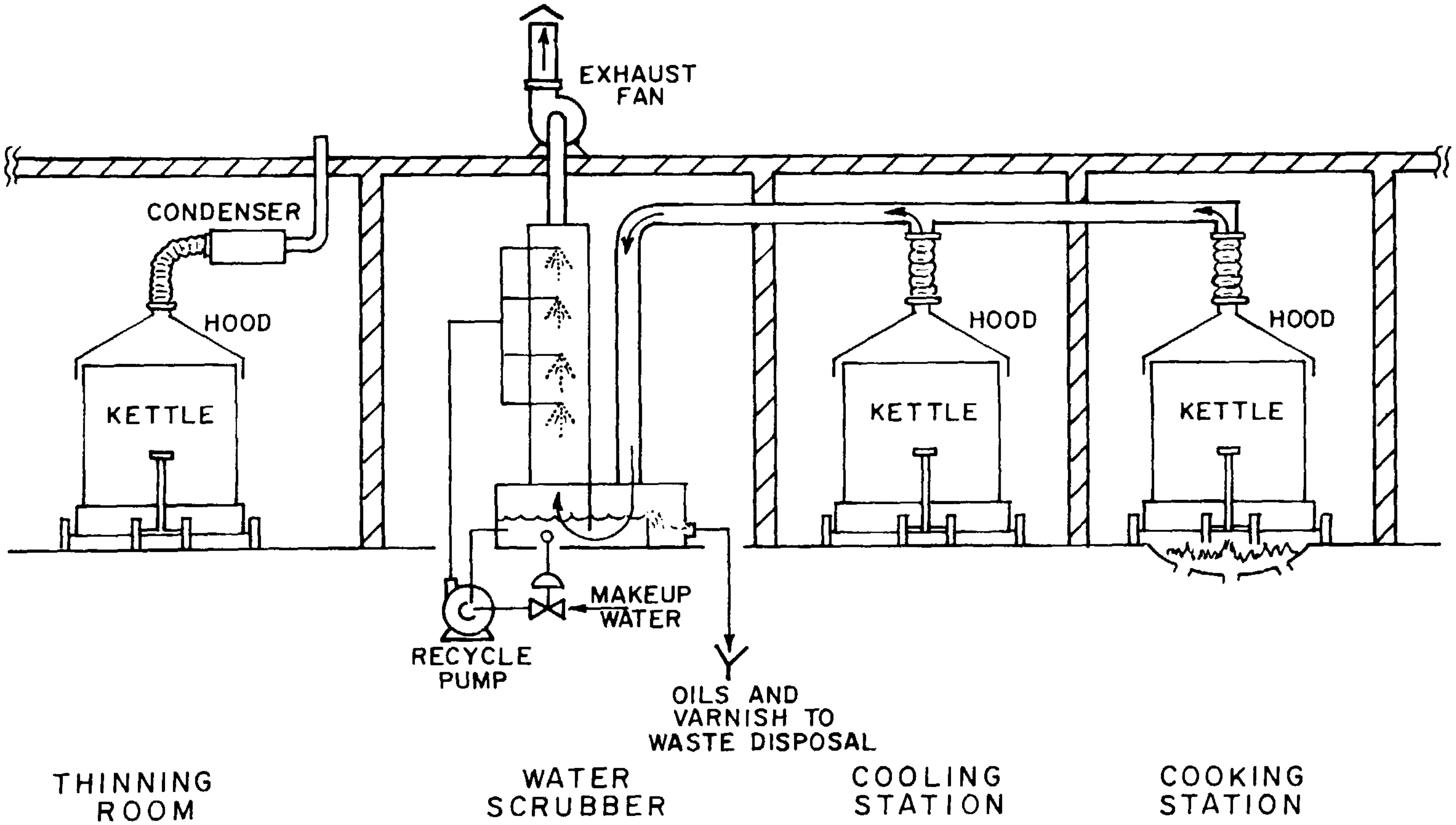


Enclosed equipment, such as ball or pebble mills, is free of vapor release during operation, but this is not the case with high-speed dispersers, which are open to the air. The use of covers and lids on containers can reduce vapor emissions. This is especially true during the thinning, tinting, and shading operations when temporary containers often remain open for long periods of time while laboratory analysis and subsequent adjustments are performed. Sand mills often discharge into open portable tanks resulting in potential solvent emissions [19]. Since vapors are emitted when containers are filled with solvent-based coatings, exhaust ventilation may be needed at the point of filling.

Because of the heat required and the by-products that need to be controlled, operations in varnish manufacture differ from other operations in the paint and allied coating products industry. Both reactors and open and closed kettles are used to produce varnishes with the hazard of exposure to toxic emissions being greatest for open kettles. Emissions are generated during cooking processes when kettles are opened for charging or product sampling. Most kettles are currently fitted with retractable hoods and exhaust systems, some of which incorporate solvent condensers [18,19,43,44]. Figure IV-12 shows the control measures used in a typical varnish cooking room. Ventilation systems used to control vapors are most effective when designed to control vapors generated at temperatures higher than the ambient air [19]. Condensed vapors collect to some extent as a sticky film on the relatively cool hood and duct walls, necessitating frequent cleaning and maintenance. Hood design should provide for access to the kettle during use of the hood and should be designed to prevent contamination or exposure by the dripping of condensate from its inner surfaces [63]. Varnish production vapor emissions can be controlled by water scrubbing, combustion, vapor incineration, high stack dispersal, or condensation [19]. Because of the nature of the process, workers in varnish manufacturing operations may be subject to heat stress or to contact with hot surfaces. Screens or guards can be used to shield workers from contact with hot surfaces and from radiant heat. In some cases, protective clothing (particularly gloves) is useful. With open kettles, the hot material can splatter on workers. This hazard can be prevented, however, by covering the kettles or by using enclosures or splatter-guards.

Special hazard controls are required in the manufacture of radiation-curable coatings. Usually these coatings are manufactured in enclosed systems to prevent skin, eye, or respiratory tract exposure. The enclosures are usually hoods fitted over the mixing containers. Reactive monomers, particularly ethyl acrylate, should be stored and handled in closed systems [37]. Because of the flammable air-vapor mixture that will exist in an ethyl acrylate tank vapor space at normal storage temperatures, nitrogen blanketing has been recommended [37].

FIGURE IV-12. ENGINEERING CONTROLS IN A VARNISH COOKING ROOM [19]



Enclosures, exhaust hoods, and ductwork should be kept in good repair so that designed airflows are maintained. Measurements of such parameters as capture velocity, duct velocity, or static pressure should be made at least semiannually, and preferably monthly, to demonstrate the effectiveness of the mechanical ventilation system. The use of continuous airflow indicators, such as water or oil manometers marked to indicate acceptable airflow, is recommended. Measurements of the effectiveness of the system should also be made as soon as possible after any change in production, process, or control which may result in any increase in airborne contaminants.

It is essential that any scheme that involves exhausting air from a work area should also provide for a positive means of bringing in at least an equal volume of air from the outside, conditioning it, and evenly distributing it throughout the exhausted area. The ventilation system should be designed and operated to prevent the accumulation or recirculation of airborne contaminants in the workplace. Technical criteria to ensure this are discussed in the NIOSH publication, The Recirculation of Industrial Exhaust Air [64].

Principles for design and operation of ventilation systems are presented in Industrial Ventilation--A Manual of Recommended Practices, published by the American Conference of Governmental Industrial Hygienists [62]; American National Standard: Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2(1971), published by the American National Standards Institute [65]; and Recommended Ventilation Guidelines, published by NIOSH [66].

Further information on engineering controls that might be useful in the coatings industry can be found in two NIOSH publications: Criteria for a Recommended Standard....Occupational Exposure During the Manufacture and Formulation of Pesticides [67] and Engineering Control Technology Assessment for the Plastics and Resins Industry [68].

5. Personal Protective Clothing and Equipment

Workers should use appropriate personal protective clothing and equipment which must be carefully selected, used, and maintained to be effective. The SDS data [28] indicated that 60% of the injuries or illnesses associated with chemicals or chemical compounds were caused by skin contact and 47% resulted in chemical burns. To prevent skin contact, gloves, aprons, boots, etc. should be made of materials resistant to the hazardous substances in question, particularly the solvents. Splash-proof chemical safety goggles or face shields, (20-30 cm minimum) should be worn in any operation in which there is a likelihood of a solvent, caustic, or other toxic substance being splashed into the eyes.

The choice of an appropriate respirator is complicated by the simultaneous exposure to many substances that often occurs in coatings manufacture. Respirator selection should be based on the most toxic material being used in any particular situation as well as on the chemical and physical properties of other hazardous substances present. Respirators should be NIOSH/MSHA approved. Use of respirators as the sole means of compliance with permissible exposure limits is not recommended except during the time needed to install, implement, test, or repair engineering control equipment, during maintenance and cleaning operations, during emergencies, and during times when engineering controls are not feasible. Workers should be thoroughly trained in the proper use, maintenance, and cleaning of their protective equipment including inspection, testing, and repair or replacement when necessary. Employers should provide adequate and easily accessible storage facilities for protective clothing and equipment.

6. Medical Surveillance

The medical officer responsible for the health of workers should be apprised of potential workplace hazards, based on safety and health evaluations, and appropriate medical surveillance should be conducted. The number and type of tests to be performed should be based on the substance or hazards to which the worker may be exposed. In any case, preplacement examinations should be performed and should include at least a medical and occupational history, a comprehensive physical examination, and a judgement of the worker's ability to use positive or negative pressure respirators. Emergency first-aid programs should be developed that are based on the results of the workplace occupational safety and health evaluation. Periodic examinations should be carried out at the discretion of the responsible physician based on the adverse health effects and nature of the hazards identified. Health hazards identified for which NIOSH has made specific recommendations should be addressed in accordance with those specific recommendations.

Pertinent medical records of all workers should be kept by employers for at least 30 years after termination of employment. Each worker should have access to information contained in his or her own medical records. These records should be made available to the designated medical representatives of the Secretary of Health and Human Services, of the Secretary of Labor, of the employer, and of the worker or former worker.

V. RESEARCH NEEDS

There is little published information on the health experience of workers engaged in the manufacture of paint and allied coating products. Additional epidemiological studies are needed to determine the morbidity and mortality experience of workers in this industry.

Frequent use of volatile solvents throughout the coatings industry increases the possibility that subtle behavioral and neurological effects will occur in workers. A potential problem of chronic deterioration of the central nervous system has recently been identified in Scandinavia among workers with long-term solvent exposures [69-71]. More information is needed to evaluate these effects. Fortunately, the need for this type of information becomes less urgent as solvent-based coatings are being progressively replaced by water-based coatings. However, it has been estimated that considerable quantities of solvents will still be used by the coatings industry in 1990 [6].

Documentation of the exposures that occur in operations where powder coatings and reactive coatings (e.g., radiation-curable coatings) are produced is needed since little is known of the hazards present during their manufacture.

Research is needed to develop more comfortable and effective personal protective equipment, particularly respirators. It is also important to determine the effect on respirator filter cartridge or canister life when there is a mixture of solvents in the surrounding air.

VI. REFERENCES

1. Connolly EM: CEH Product Review--An Overview of the U.S. Paint and Coatings Industry. In: Chemical Economics Handbook. SRI International, Menlo Park, CA, pp. 592.5100 A-592.5100 U (February 1981).

2. Martens CR (ed): Technology of Paints, Varnishes and Lacquers. Robert E. Krieger Publishing Co., Inc., Huntington, NY, pp. 1-11, 271-82, 310-312, 331, 339-49, 363, 423-28, 438-39, 505-06, 549, 614-616, 701, 727-28 (1974).

3. Marsich EE: Raw Materials Index--Solvents. National Paint & Coatings Association, Washington, DC (October 1976).

4. Marsich EE: Raw Materials Index--Resins. National Paint & Coatings Association, Washington, DC (April 1977).

5. Marsich EE: Raw Materials Index--Pigments. National Paint & Coatings Association, Washington, DC (May 1977).

6. Dean JC: Coatings '81--The U.S. coatings industry strategy for survival in the '80s. Chem Week Volume 29, Special Advertising Section (October 21, 1981).

7. Brown RA: The emerging technologies--A look into the future of the chemical coatings market and the roles to be played by exempt solvent, water-borne, high-solids, radiation cure and powder systems. Paint and Varn Prod 64:17-19 (1974).

8. Changes swirl over the coatings world. Chem Week 122(24):49-50, 52 (1978).

9. Rich S (ed): The Kline Guide to the Paint Industry. Sixth Edition. Charles H. Kline and Co., Inc., Fairfield, NJ (1982).

10. Unpublished NIOSH data generated by project "Utilization of Full File for Survey/Sampling Decisions." U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Surveillance, Hazard Evaluations, and Field Studies, Cincinnati, OH (October 1983).

11. Occupational Injuries and Illnesses in the United States by Industry, 1982. Bulletin 2196, U.S. Department of Labor, Bureau of Labor Statistics, Washington, DC (April 1984).

12. Discher DP, Curtis RA, Kaplan SD, et al.: Final Report NPCA Pilot Study--Part 1: Summary of Observations in the Paint and Coatings Industry. Stanford Research Institute Report Prepared for the National Paint and Coatings Association. Stanford Research Institute, Menlo Park, CA (October 1976).

13. Schurr GG: Paint. In: Kirk-Othmer Encyclopedia of Chemical Technology. Third Edition. John Wiley & Sons, Inc., New York, Volume 16, pp. 742-61 (1981).

14. Madson WH: White Hiding and Extender Pigments. In: Federation Series on Coatings Technology, Unit 7. Federation of Societies for Paint Technology, Philadelphia, PA (August 1974).

15. Fuller WR: Solvents. In: Federation Series on Coatings Technology, Unit 6. Federation of Societies for Paint Technology, Philadelphia, PA (August 1974).

16. Stewart WJ: Paint Driers and Additives. In: Federation Series on Coatings Technology, Unit 11. Federation of Societies for Paint Technology, Philadelphia, PA (August 1973).

17. Preuss HP: Paint Additives--1970. Noyes Data Corp., Park Ridge, NJ (1970).

18. Rheineck AE: Modern Varnish Technology. In: Federation Series on Coatings Technology, Unit 4. Federation of Societies for Paint Technology, Philadelphia, PA (August 1974).

19. Dowd EJ: Air Pollution Control Engineering and Cost Study of the Paint and Varnish Industry, Publication No. EPA-450/3-74-031. Environmental Protection Agency, Contract No. 68-02-0259, Research Triangle Park, NC (June 1974).

20. Mattiello JJ (ed): Protective and Decorative Coatings. Volume III. John Wiley & Sons, Inc., New York (1943).

21. Gosselin RE, Hodge HC, Smith RP, et al.: Clinical Toxicology of Commercial Products--Acute Poisoning. Fourth Edition. The Williams and Wilkins Co., Baltimore, MD, pp. 107-08, 127-28 (1976).

22. Esch FP: Rapid growth predicted for epoxy powder coatings. Paint and Varn Prod 62(4):23-26 (1972).

23. Mallarnee WR: Paint and Varnish Removers. In: Kirk-Othmer Encyclopedia of Chemical Technology. Third Edition. John Wiley & Sons, Inc., New York, Volume 16, pp. 762-68 (1981).

24. Fuller WR: Introduction to Coatings Technology. In: Federation Series on Coatings Technology, Unit 1. Federation of Societies for Paint Technology, Philadelphia, PA (May 1973).

25. Occupational Injury and Illness Incidence Rates for Paints and Allied Products (SIC Code 285) 1982. Unpublished report. U.S. Department of Labor, Bureau of Labor Statistics, Washington, DC (1982).

26. Occupational Injuries and Illnesses in the United States by Industry, 1980. Bulletin 2130, U.S. Department of Labor, Bureau of Labor Statistics, Washington, DC (April 1982).

27. Occupational Injuries and Illnesses in the United States by Industry, 1981. Bulletin 2164, U.S. Department of Labor, Bureau of Labor Statistics, Washington, DC (January 1983).

28. Supplementary Data System--Standard Industrial Classification Code 285 for Reference Years 1976-1981. Unpublished data. U.S. Department of Labor, Bureau of Labor Statistics, Washington, DC.

29. Supplement to Employment and Earnings, United States, 1909-1978, Revised Establishment Data. U.S. Department of Labor, Bureau of Labor Statistics, Washington, DC, p. 201 (July 1983).

30. Accident Prevention Manual for Industrial Operations--Engineering and Technology, Eighth Edition. National Safety Council, Chicago, IL, pp. 94, 530, 586, 641 (1980).

31. Recommended Practice on Static Electricity, NFPA 77-1983. In: National Fire Codes--1983. Volume 15. National Fire Protection Association, Boston, MA, pp. 77-1 to 77-58 (1983).

32. Grounding and Bonding Standards. The Sherwin-Williams Co., Cleveland, OH (1966).

33. Data Concerning Noise Levels. Unpublished report. Submitted to NIOSH by the Rust-Oleum Corp., Evanston, IL (February 1978).

34. Jeanne E, Blake M: Putting the damper on ball mills. Mod Paint Coat 66(1):41-43 (1976).

35. Stenburg RL: Control of Atmospheric Emissions from Paint and Varnish Manufacturing Operations. Technical Report A58-4. U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of State Services, Cincinnati, OH (1958).

36. Emmett EA, Taphorn BR, Kominsky JR: Phototoxicity occurring during the manufacture of ultraviolet-cured ink. Arch Dermatol 113:770-75 (1977).

37. Niehaus WR: Safe handling practice for acrylate monomers. Paint and Varn Prod 61(5):41-44 (1971).

38. Morgan RW, Kaplan SD, Gaffey WR: A General Mortality Study of Production Workers in the Paint and Coatings Manufacturing Industry--A Preliminary Report. J Occ Med 23(1):13-21 (1981).

39. Grimaldi JV, Simonds RH: Safety Management. Third Edition. Richard D. Irwin, Inc., Homewood, IL, pp. 119-20 (1975).

40. Cohen A: Factors in successful occupational safety programs. J Safety Research 9(4):168-77 (1977).

41. Work Practices Guide for Manual Lifting. DHHS (NIOSH) Publication No. 81-122. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1981).

42. Current Intelligence Bulletin 38--Vibration Syndrome. DHHS (NIOSH) Publication No. 83-110, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (March 29, 1983).

43. Hagopian JH, Bastress EK: Engineering Control Research Recommendations, DHEW Publication No. (NIOSH) 76-180. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

44. Stern AC, Horowitz LD: Industrial hygiene in the paint factory. NY State Department of Labor, Monthly Review 32(2):5-7 (1953).

45. Noise--Occupational Exposure. Safety and Health Bulletin No. 33. National Paint and Coatings Association, Washington, DC (July 1977).

46. Criteria for a Recommended Standard....Occupational Exposure to Noise. Publication No. HSM 73-11001. U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, Cincinnati, OH (1972).

47. Health and Safety Guide for Bulk Petroleum Plants. DHEW (NIOSH) Publication No. 76-118. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH, p. 32 (1975).

48. OSHA Report: OHDS 2N -- Health Sampling Report for all Substances in Standard Industrial Classification (SIC) Code 2851 from June 1, 1979 to January 31, 1984, Nation Report. Unpublished report. U.S. Department of Labor, Occupational Safety and Health Administration, Washington, DC (May 10, 1984).

49. A Recommended Standard....An Identification System for Occupationally Hazardous Materials. DHEW Publication No. (NIOSH) 75-126. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1974).

50. American National Standard for Hazardous Industrial Chemicals--Precautionary Labeling, ANSI Z129.1-1982. American National Standards Institute, Inc., New York (September 1982).

51. Keller LW, Schaper KL, Johnson CD: A hazardous materials identification system for the coatings and resins industry. Am Ind Hyg Assoc J 41(12):901-07 (1980).

52. Malkin G: Bulk handling dry pigments and inerts. J Paint Technol 40(523):353-57 (1968).

53. Safety Procedure No. 402-63--Making Caustic Solution. Unpublished report. Submitted to NIOSH by the Sherwin-Williams, Co., Cleveland, OH (1977).

54. Morton WI: Safety techniques for workers handling hazardous materials. Chem Eng 83(22):127-32 (1976).

55. Safety & Health Aspects of UV Cured Inks and Coatings. Unpublished report submitted to NIOSH by M and T Chemicals Inc., Rahway, NJ (July 1978).

56. Criteria for a Recommended Standard....Occupational Exposure to Refined Petroleum Solvents, DHEW (NIOSH) Publication No. 77-192. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1977).

57. Criteria for a Recommended Standard....Working in Confined Spaces. DHEW (NIOSH) Publication No. 80-106. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1979).

58. American National Standard--Safety Requirements for Working in Tanks and Other Confined Spaces, ANSI Z117.1-1977. American National Standards Institute, Inc., New York (1977).

59. Drisko RW: Coatings, Marine. In: Kirk-Othmer Encyclopedia of Chemical Technology. Third Edition. John Wiley & Sons, Inc., New York, Volume 6, pp. 445-54 (1979).

60. Nudged by OSHA...Valspar complies its way to more production. Am Paint Coat J 62(25):12-16 (1977).

61. State-of-the-art of waste disposal in the coatings industry (as of June 1973)--Based on a report by Raymond Tackett. J Paint Technol 46(590):63-68 (1974).

62. Industrial Ventilation--A Manual of Recommended Practice, Seventeenth edition. American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, Lansing, MI (1982).

63. Mills JL, Hammond WF, Adrian RC: Design of afterburners for varnish cookers. J Air Pollut Control Assoc 10(2):161-68 (1960).

64. The Recirculation of Industrial Exhaust Air...Symposium Proceedings. DHEW (NIOSH) Publication No. 78-141. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

65. American National Standard--Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1979. American National Standards Institute, Inc., New York (March 1979).

66. Hagopian JH, Bastress EK: Recommended Industrial Ventilation Guidelines. DHEW Publication No. (NIOSH) 76-162. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

67. Criteria for a Recommended Standard....Occupational Exposure During the Manufacture and Formulation of Pesticides. DHEW (NIOSH) Publication No. 78-174. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

68. Engineering Control Technology Assessment for the Plastics and Resins Industry. DHEW (NIOSH) Publication No. 78-159. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

69. Hane M, Axelson O, Blume J, et al.: Psychological function changes among house painters. Scand J Work Environ Health 3:91-99 (1977).

70. Husman K: Symptoms of car painters with long-term exposure to a mixture of organic solvents. Scand J Work Environ Health 6:19-32 (1980).

71. Husman K, Karli P: Clinical neurological findings among car painters exposed to a mixture of organic solvents. Scand J Work Environ Health 6:33-39 (1980).

72. Criteria for a Recommended Standard....Occupational Exposure to Antimony. DHEW (NIOSH) Publication No. 78-216. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

73. Workplace Exposure to Asbestos, Review and Recommendations. DHHS (NIOSH) Publication No. 81-103. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, and U.S. Department of Labor, Occupational Safety and Health Administration, Cincinnati, OH (1980).

74. Occupational Health Guidelines for Chemical Hazards. DHHS (NIOSH) Publication No. 81-123. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, and U.S. Department of Labor, Occupational Safety and Health Administration, Cincinnati, OH (1981).

75. Criteria for a Recommended Standard....Occupational Exposure to Cadmium. DHEW Publication No. (NIOSH) 76-192. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

76. Criteria for a Recommended Standard....Occupational Exposure to Carbon Black. DHEW (NIOSH) Publication No. 78-204. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

77. Criteria for a Recommended Standard....Occupational Exposure to Chromium (VI). DHEW Publication No. (NIOSH) 76-129. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1975).

78. Occupational Hazard Assessment--Criteria for Controlling Occupational Exposure to Cobalt. DHHS (NIOSH) Publication No. 82-107. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1981).

79. Criteria for a Recommended Standard....Occupational Exposure to Inorganic Lead--Revised Criteria-1978. DHEW (NIOSH) Publication No. 78-158. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

80. Criteria for a Recommended Standard....Occupational Exposure to Inorganic Mercury. Publication No. HSM 73-11024. U.S. Department of Health, Education, and Welfare, Public Health Service, National Institute for Occupational Safety and Health, Cincinnati, OH (1973).

81. Criteria for a Recommended Standard....Occupational Exposure to Inorganic Nickel. DHEW (NIOSH) Publication No. 77-164. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1977).

82. Criteria for a Recommended Standard....Occupational Exposure to Crystalline Silica. DHEW Publication No. (NIOSH) 75-120. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1974).

83. Criteria for a Recommended Standard....Occupational Exposure to Zinc Oxide. DHEW Publication No. (NIOSH) 76-104. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1975).

84. Criteria for a Recommended Standard....Occupational Exposure to Ketones. DHEW (NIOSH) Publication No. 78-173. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

85. Key MM, Henschel AF, Butler J, et al. (eds): Occupational Diseases--A Guide to their Recognition. Revised Edition. DHEW (NIOSH) Publication No. 77-181. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH, pp. 154-55 (1977).

86. Criteria for a Recommended Standard....Occupational Exposure to Furfuryl Alcohol. DHEW (NIOSH) Publication No. 79-133. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1979).

87. Criteria for a Recommended Standard....Occupational Exposure to Isopropyl Alcohol. DHEW Publication No. (NIOSH) 76-142. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

88. Criteria for a Recommended Standard....Occupational Exposure to Methyl Alcohol. DHEW Publication No. (NIOSH) 76-148. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

89. Criteria for a Recommended Standard....Occupational Exposure to Alkanes (C5-C8). DHEW (NIOSH) Publication No. 77-151. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1977).

90. Criteria for a Recommended Standard....Occupational Exposure to Toluene. Publication No. HSM 73-11023. U.S. Department of Health, Education, and Welfare, Public Health Service, National Institute for Occupational Safety and Health, Cincinnati, OH (1973).

91. Criteria for a Recommended Standard....Occupational Exposure to Xylene. DHEW Publication No. (NIOSH) 75-168. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1975).

92. Criteria for a Recommended Standard....Occupational Exposure to Methylene Chloride. DHEW Publication No. (NIOSH) 76-138. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

93. Criteria for a Recommended Standard....Occupational Exposure to Tetrachloroethylene (Perchloroethylene). DHEW Publication No. (NIOSH) 76-185. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

94. Criteria for a Recommended Standard....Occupational Exposure to Trichloroethylene. Publication No. HSM 73-11025. U.S. Department of Health, Education, and Welfare, Public Health Service, National Institute for Occupational Safety and Health, Cincinnati, OH (1973).

95. Special Occupational Hazard Review with Control Recommendations--Trichloroethylene. DHEW (NIOSH) Publication No. 78-130. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Rockville, MD (1978).

96. Criteria for a Recommended Standard....Occupational Exposure to Dioxane. DHEW Publication (NIOSH) 77-226. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1977).

97. Current Intelligence Bulletin 39--The Glycol Ethers, with particular reference to 2-methoxyethanol and 2-ethoxyethanol: Evidence of Adverse Reproductive Effects. DHHS (NIOSH) Publication No. 83-112. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (May 2, 1983).

98. Current Intelligence Bulletin Reprints--Bulletins 1 thru 18, Current Intelligence Bulletin 17--2-Nitropropane. DHEW (NIOSH) Publication No. 78-127. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH, pp. 111-17 (1978).

99. Current Intelligence Bulletin Reprints--Bulletins 1 thru 18, Current Intelligence Bulletin 18--Acrylonitrile. DHEW (NIOSH) Publication No. 78-127. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH pp. 119-25 (1978).

100. A Recommended Standard for Occupational Exposure to....Acrylonitrile. DHEW (NIOSH) Publication No. 78-116. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

101. Criteria for a Recommended Standard....Occupational Exposure to Toluene Diisocyanate. Publication No. HSM 73-11022. U.S. Department of Health, Education, and Welfare, Public Health Service, National Institute for Occupational Safety and Health, Cincinnati, OH (1973).

102. Criteria for a Recommended Standard....Occupational Exposure to Diisocyanates. DHEW (NIOSH) Publication No. 78-215. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

103. Criteria for a Recommended Standard....Occupational Exposure to Epichlorohydrin. DHEW Publication No. (NIOSH) 76-206. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

104. Current Intelligence Bulletin 30--Epichlorohydrin. DHEW (NIOSH) Publication No. 79-105. U.S. Department of Health, Education and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (October 12, 1978).

105. Criteria for a Recommended Standard....Occupational Exposure to Formaldehyde. DHEW (NIOSH) Publication No. 77-126. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

106. Current Intelligence Bulletin 34--Formaldehyde: Evidence of Carcinogenicity. DHHS (NIOSH) Publication No. 81-111. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (April 15, 1981).

107. Criteria for a Recommended Standard....Occupational Exposure to Glycidyl Ethers. DHEW (NIOSH) Publication No. 78-166. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1978).

108. Criteria for a Recommended Standard....Occupational Exposure to Styrene. DHHS (NIOSH) Publication No. 83-119. U.S. Department of Health, and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1983).

109. Recommended Standard for Occupational Exposure to Vinyl Chloride. Excerpts from a March 11, 1974, Memorandum from Marcus M. Key, Director, NIOSH. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1974).

110. Criteria for a Recommended Standard....Occupational Exposure to Inorganic Arsenic, New Criteria--1975. DHEW Publication No. (NIOSH) 75-149. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1975).

111. Criteria for a Recommended Standard....Occupational Exposure to Organotin Compounds. DHEW (NIOSH) Publication No. 77-115. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

112. Current Intelligence Bulletin 21--Trimellitic Anhydride (TMA). DHEW (NIOSH) Publication No. 78-121. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (February 3, 1978).

113. Criteria for a Recommended Standard....Occupational Exposure to Ammonia. DHEW Publication No. (NIOSH) 74-136. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1974).

114. Criteria for a Recommended Standard....Occupational Exposure to Benzene. DHEW (NIOSH) Publication No. 74-137. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1974).

115. Update Criteria and Recommendations for a Revised Benzene Standard. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (August 25, 1976).

116. Criteria for a Recommended Standard....Occupational Exposure to Benzoyl Peroxide. DHEW (NIOSH) Publication No. 77-166. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1977).

117. Baier, EJ, Deputy Director, National Institute for Occupational Safety and Health: Center for Disease Control, Public Health Service, Department of Health, Education, and Welfare. Statement before the Department of Labor, Occupational Safety and Health Administration Public Hearing on the Occupational Standard for Beryllium (August 19, 1977).

118. Criteria for a Recommended Standard....Occupational Exposure to Carbon Monoxide. Publication No. HSM 73-11000. U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, Cincinnati, OH (1972).

119. Revised Recommended Carbon Tetrachloride Standard. DHEW (NIOSH) Publication No. 76-133. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

120. Criteria for a Recommended Standard....Occupational Exposure to Chromic Acid. Publication No. HSM 73-11021. U.S. Department of Health, Education, and Welfare, Public Health Service, National Institute for Occupational Safety and Health, Cincinnati, OH (1973).

121. Criteria for a Recommended Standard....Occupational Exposure to Coal Tar Products. DHEW (NIOSH) Publication No. 78-107. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1977).

122. Criteria for a Recommended Standard....Occupational Exposure to 1,1,1-Trichloroethane (Methyl Chloroform). DHEW (NIOSH) Publication No. 76-184. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

123. Criteria for a Recommended Standard....Occupational Exposure to Oxides of Nitrogen (Nitrogen Dioxide and Nitric Oxide). DHEW Publication No. (NIOSH) 76-149. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1976).

124. Criteria for a Recommended Standard....Occupational Exposure to Sodium Hydroxide. DHEW Publication No. (NIOSH) 76-105. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1975).

125. Criteria for a Recommended Standard....Occupational Exposure to Sulfuric Acid. DHEW Publication No. (NIOSH) 74-128. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1974).

VII. APPENDIX A

GLOSSARY

Acrylic Resins	A family of synthetic resins made by polymerizing esters of acrylic acids.
Alkyd Resins	Synthetic resins that are the condensation products of polybasic acids (e.g., phthalic acid), polyhydric alcohols (e.g., glycerin), and fatty acids or fatty oils.
Anti-livering Agents	Substances added to decrease the consistency of paint (see livering).
Ball Mill	A revolving cylindrical metal mill that uses steel balls, stones, or other media to grind or disperse the pigment in the film-former.
Coating	Film-forming material applied for protection or decoration of surfaces.
Cold Cutting	The mixing of materials, usually liquids, without the addition of heat.
Cooking	The heating of the combined ingredients of a varnish.
Depalletizer	A machine that unloads a pallet of materials.
Diluent	A liquid that is blended with an active solvent to reduce cost.
Dispersion	Any heterogeneous system of solids, gases, or liquids.
Drying Oils	Oils capable of absorbing oxygen from the air and becoming solid films.
Extender	A pigment that contributes little hiding to the system but does reinforce the film and alter its gloss.
Film-Former	The nonvolatile binder portion of a coating. These may be classified as either thermoplastic or convertible (see vehicle).
Flash Point	The lowest temperature at which a substance in an open vessel gives off enough vapors to produce a flash of fire when a flame is passed near the surface as described by American Society of Testing and Materials (ASTM) test procedures.

Flush Colors	Water dispersions of organic and inorganic pigments that are supplied as organophilic pastes.
Hiding Power	The ability of a paint to obscure the background over which it is applied.
High-Solids Coatings	Coatings that contain more than 70% nonvolatile material.
Kettle	Vessel used in the production of varnish.
Lacquer	Usually indicates a material that dries by evaporation and forms a film from the nonvolatile constituents.
Latex	A generic term describing stable dispersions of resin particles in a water system.
Livering	An increase in the consistency of paint resulting in a rubbery or coagulated mass.
Oil	A general term for a water-insoluble viscous liquid usually consisting of triglycerides.
Oleoresinous	A material that has been made by a combination of oil and resin.
Organosol	A dispersion formed by the suspension of resin particles (usually a vinyl resin) in a liquid consisting of volatile solvents.
Pebble Mills	Mills usually lined with porcelain or buhrstone in which flint pebbles or porcelain balls are used as the grinding media.
Plastisol	A dispersion formed by the suspension of resin particles (usually vinyl) in a liquid consisting only of plasticizers.
Powder Coatings	Pigmented polymer coatings applied in powder form by various techniques such as electrostatic spray, fluidized bed, flocking gun, flame spray, or cloud chamber.
Prebatch	The phase of coatings production in which raw materials are weighed and assembled for mixing.
Radiation-Curable Coatings	Coatings that dry or cure as the result of initiation of polymerization by radiation such as infrared, ultraviolet, or electron beam.

Resin	An organic polymer in the form of a crystalline or amorphous solid or viscous liquid of either natural or synthetic origin.
Thermoplastic Resins	Resins that soften and flow when heated and, on cooling, regain their original physical and chemical properties.
Thermosetting Resins	Resins that undergo a chemical change and become hard after heating and cannot be resoftened. When used as a film-former, they are often referred to as convertible film-formers.
Two-Part Catalyzed Coatings	Coatings, usually urethane, formed by catalytic conversion that occurs so rapidly at ambient temperature that the components must be shipped in two separate containers.
Varnishes	Solutions of film-formers in organic solvents, with no pigments.
Vehicle	The liquid portion of a coating material that forms the finished film and binds the pigments in the coating (see film-former).

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
Pigments and Extenders			
Antimony and compounds (as Sb)	0.5 mg/m^3 TWA	0.5 mg/m^3 TWA	Irritation of the skin and mucous membranes, cardiac and respiratory changes [72]
Asbestos	2 $fibers/cm^3$ TWA; 10 $fibers/cm^3$ ceiling	0.1 $fibers/cm^3$ TWA (8-hr), 0.5 $fibers/cm^3$ ceiling	Asbestosis, **lung cancer, mesothelioma** [73]
Barium (soluble compounds)	0.5 mg/m^3 TWA	§	Irritation of the eyes, nose, throat, bronchial tubes, and skin; stomach pains; slow pulse rate; irregular heart beat; ringing in the ears; dizziness; convulsions; muscle spasms [74]
Cadmium	Fume: 0.1 mg/m^3 TWA, 0.3 mg/m^3 ceiling Dust: 0.2 mg/m^3 TWA, 0.6 mg/m^3 ceiling	40 $\mu g/m^3$ TWA, 200 $\mu g/m^3$ ceiling	Lung and kidney damage, emphysema [75]
Carbon black	3.5 mg/m^3 TWA	3.5 mg/m^3 TWA, 0.1 mg/m^3 TWA in presence of polycyclic aromatic hydrocarbons	Lung, heart, and skin effects; **cancer** [76]
Chromium compounds:			
chromium (VI)	100 $\mu g/m^3$ ceiling	**carcinogenic** Cr (VI): 1 $\mu g/m^3$ TWA other Cr (VI): 25 $\mu g/m^3$ TWA, 50 $\mu g/m^3$ ceiling	**Lung cancer**, skin ulcers, lung irritation [77]
metal and insoluble salts (as Cr)	1 mg/m^3 TWA	§	Lung changes [74]
soluble chromic, chromous salts (as Cr)	0.5 mg/m^3 TWA	§	Dermatitis [74]

Cobalt, metal, fume, and dust (as Co)	0.1 mg/m^3 TWA
Copper, dust and mists (as Cu)	1 mg/m^3 TWA
Inert or nuisance dust	15 mg/m^3 TWA (total dust), 5 mg/m^3 TWA (respirable fraction)
Iron oxide fume	10 mg/m^3 TWA
Lead, inorganic fumes and dusts (as Pb)	50 µg/m^3 TWA
Manganese and compounds (as Mn)	5 mg/m^3 (ceiling)
Mercury:	
inorganic (as Hg)	0.1 mg/m^3 ceiling
organo (alkyl) compounds (as Hg)	10 µg/m^3 TWA, 40 µg/m^3 ceiling
Nickel, metal and soluble compounds (as Ni)	1 mg/m^3 TWA
Silica, crystalline	250/% SiO_2+5 in mppcf TWA or 10/% SiO_2+2 in mg/m^3 TWA (respirable quartz); 30/% SiO_2+2 in mg/m^3 TWA (total quartz dust)

NIOSH has concluded that there is insufficient evidence to warrant recommending a new permissible exposure limit	Dermatitis, potential for pulmonary fibrosis [78]
§	Irritation of the eyes and skin, flu-like illness [74]
§	Irritation, slight lung changes [74]
§	Benign pneumoconiosis (siderosis) [74]
100 $\mu g/m^3$ TWA	Kidney, blood, and nervous system effects [79]
§	Flu-like illness called metal fume fever: fever, chills, upset stomach, vomiting, dryness of the throat, cough, weakness, headache; manganese pneumonia: coughing, fever, chills, general aching of the body, chest pains; nervous system effects [74]
0.05 mg/m^3 TWA	Central nervous system and mental effects [80]
§	Irritation of the eyes, respiratory tract, and skin; dysfunction of the central nervous system [74]
15 $\mu g/m^3$ TWA	Skin effects, **lung and nasal cancer** [81]
50 $\mu g/m^3$ TWA (respirable free silica)	Chronic lung disease (silicosis): scarring of lungs, cough, and shortness of breath [82]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
Talc:			
non-asbestos form	20 mppcf TWA	§	Irritation of the eyes, shortness of breath, chronic cough, heart failure [74]
fibrous	see Asbestos	§	See Asbestos
Titanium dioxide	15 mg/m^3 TWA	§	Irritation, slight lung changes [74]
Zinc oxide fume	5 mg/m^3 TWA	5 mg/m^3 TWA, 15 mg/m^3 ceiling	Flu-like illness called metal fume fever: headache, fever, chills, muscle aches, nausea, vomiting, weakness, and tiredness [83]
Solvents			
Alcohols:			
2-butoxy ethanol (butyl Cellosolve®)	50 ppm TWA (skin)	§	Irritation of the eyes, nose, and throat [74]
butyl alcohol	100 ppm TWA	§	Irritation of the eyes, nose, and throat; headache; dizziness; drowsiness; blurred vision [74]
diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50 ppm TWA	50 ppm TWA	Irritation of the eyes, nose, throat, and skin; liver, kidney, and central nervous system effects [84]
ethyl alcohol (ethanol)	1,000 ppm TWA	§	Irritation of the eyes, nose upper respiratory tract, and skin; headache; drowsiness; tremors; fatigue [85]
furfuryl alcohol	50 ppm TWA	50 ppm TWA	Irritation of the eyes, skin, and upper respiratory system; depression of the central nervous system [86]

isobutyl alcohol	100 ppm TWA
isopropyl alcohol	400 ppm TWA
methyl alcohol (methanol)	200 ppm TWA
propyl alcohol	200 ppm TWA
Aliphatic hydrocarbons:	
cyclohexane	300 ppm TWA
heptane (n-heptane)	500 ppm TWA
hexane (n-hexane)	500 ppm TWA
methylcyclohexane	500 ppm TWA
octane	500 ppm TWA
pentane	1,000 ppm TWA

§	Irritation of the eyes, nose, and throat; headache; dizziness; drowsiness; drying and cracking of skin [74]
400 ppm TWA, 800 ppm ceiling	Irritation of the eyes, nose, and throat; drowsiness; headache, incoordination; possible cancer threat in the manufacturing of isopropyl alcohol [87]
200 ppm TWA, 800 ppm ceiling	Irritation of the eyes and skin, headache, dizziness, sleep problems, digestive disturbances, blindness, metabolic acidosis [88]
§	Irritation of the eyes, nose, and throat; drowsiness; headache; incoordination [74]
§	Skin rash, dizziness, nausea [74]
85 ppm TWA, 400 ppm ceiling	Irritation of the eyes, nose, and throat; light-headedness; dizziness; nausea; loss of appetite [89]
100 ppm TWA, 510 ppm ceiling	Irritation of the eyes, nose, and skin; light-headedness; giddiness; nausea; headache [89]
§	Irritation of the eyes, nose, throat, and skin; light-headedness; drowsiness; unconsciousness [74]
75 ppm TWA, 385 ppm ceiling	Irritation of the eyes, nose, and skin; drowsiness; unconsciousness [89]
120 ppm TWA, 610 ppm ceiling	Irritation of the eyes, nose, and skin; drowsiness; unconsciousness [89]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
Aromatic hydrocarbons:			
ethyl benzene	100 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; weakness; dizziness; drowsiness; unconsciousness [74]
naphthalene	10 ppm TWA	§	Irritation of the eyes and skin, abdominal cramps, nausea, vomiting, diarrhea, headache, tiredness, confusion, painful urination, anemia, fever, kidney and liver damage [74]
toluene	200 ppm TWA, 300 ppm acceptable ceiling, 500 ppm maximum peak (10 minutes during 8 hours)	100 ppm TWA (8-hour), 200 ppm ceiling (10 minutes)	Irritation of the eyes, respiratory tract, and skin; fatigue; headache; weakness; confusion; dizziness; drowsiness; numbness; unconsciousness [90]
xylene (xylol)	100 ppm TWA	100 ppm TWA, 200 ppm ceiling (10 minutes)	Irritation of the eyes, nose, throat, and skin; breathing difficulties; dizziness; staggering; drowsiness; unconsciousness; loss of appetite; nausea; vomiting; abdominal pain; reversible eye damage [91]
Chlorinated hydrocarbons:			
methylene chloride	500 ppm TWA, 1,000 ppm acceptable ceiling, 2,000 ppm maximum peak (5 minutes in any 2 hours)	75 ppm TWA, 500 ppm ceiling to be lowered in presence of carbon monoxide	Irritation of the eyes, respiratory tract, and skin; mental confusion; lightheadedness; nausea; vomiting; headache; staggering; unconsciousness; carbon monoxide toxicity [92]

tetrachloroethylene (perchloroethylene)	100 ppm TWA, 200 ppm acceptable ceiling, 600 ppm maximum peak (5 minutes in any 3 hours)
trichloroethylene	100 ppm TWA, 200 ppm acceptable ceiling, 300 ppm maximum peak (5 minutes in any 2 hours)
Dioxane (diethylene dioxide)	100 ppm TWA (skin)
Esters:	
butyl acetate (n-butyl acetate)	150 ppm TWA
sec-butyl acetate	200 ppm TWA
2-ethoxyethyl acetate (Cellosolve® acetate)	100 ppm TWA (skin)
ethyl acetate	400 ppm TWA
isobutyl acetate	100 ppm TWA
isopropyl acetate	250 ppm TWA

50 ppm TWA, 100 ppm ceiling (twice daily)	Nervous system, heart, respiratory, and liver effects [93]
100 ppm TWA, 150 ppm ceiling (10 minutes)	Central nervous system depressant, cancer [94,95]
1 ppm ceiling (30 minutes)	Irritation of the eyes, nose, throat, and skin; drowsiness; dizziness; loss of appetite; headache; nausea; vomiting; stomach pain; liver and kidney damage; **potential human carcinogen** [96]
§	Irritation of the eyes, nose, throat, and skin; weakness; drowsiness; unconsciousness [74]
§	Irritation of the eyes, nose, throat, and skin; weakness; drowsiness; unconsciousness [74]
§	Irritation of the eyes and nose, vomiting, kidney damage, paralysis [74]
§	Irritation of the eyes, nose, throat, and skin; weakness; drowsiness; unconsciousness [74]
§	Irritation of the eyes, nose, throat, and skin; weakness; drowsiness; unconsciousness [74]
§	Irritation of the eyes, nose, throat, and skin; weakness; drowsiness; unconsciousness [74]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
methyl acetate	200 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; headache; drowsiness; unconsciousness; vision disturbances [74]
methyl Cellosolve® acetate (ethylene glycol monomethyl ether acetate)	25 ppm TWA (skin)	§	Irritation of the eyes, respiratory tract and skin; possible kidney damage [74]
n-propyl acetate	200 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; weakness; drowsiness; unconsciousness [74]
Furans:			
tetrahydrofuran	200 ppm TWA	§	Irritation of the eyes and nose, drying of the skin, nausea, dizziness, headache [74]
furfural	5 ppm TWA (skin)	§	Irritation of the eyes, respiratory tract, and skin; unconsciousness; sensitization of the skin; loss of sense of taste; numbness of the tongue [74]
Glycols:			
2-ethoxy ethanol (Cellosolve®)	200 ppm TWA (skin)	Appropriate controls should be instituted to minimize worker exposure	Irritation of the eyes and skin. In animals: liver, kidney, and lung damage; anemia; adverse reproductive effects [97]

methyl Cellosolve® (2-methoxy ethanol)	25 ppm TWA (skin)
methyl Cellosolve® acetate (ethylene glycol monomethyl ether acetate)	25 ppm TWA (skin)
Hydrocarbon mixtures:	
naphtha (coal tar)	400 mg/m^3 TWA
mineral spirits	§§
petroleum distillates (naphtha)	2,000 mg/m^3 TWA
stoddard solvent	2,900 mg/m^3 TWA
Ketones:	
acetone	1,000 ppm TWA
2-butanone (methyl ethyl ketone)	200 ppm TWA
cyclohexanone	50 ppm TWA

Appropriate controls should be instituted to minimize worker exposure	Irritation of the eyes, nose, and throat; drowsiness; weakness; shaking; headache; fatigue; staggering; personality change; anemia; adverse reproductive effects [97]
§	Irritation of the eyes, respiratory tract, and skin; possible kidney damage [74]
§	Irritation of the eyes, nose, and skin; light-headedness; drowsiness; unconsciousness [74]
350 mg/m^3 TWA, 1,800 mg/m^3 ceiling	Irritation of the eyes, nose, throat, and skin; dizziness [56]
350 mg/m^3 TWA, 1,800 mg/m^3 ceiling	Irritation of the eyes, throat, and skin; dizziness; drowsiness; headache; nausea [56]
350 mg/m^3 TWA, 1,800 mg/m^3 ceiling	Irritation of the eyes, nose, throat, and skin; dizziness; unconsciousness [56]
250 ppm TWA	Irritation of the eyes, nose, throat, and skin; upset stomach; vomiting; headache; sleepiness; dizziness; weakness; incoordination; unconsciousness; liver and kidney effects [84]
200 ppm TWA	Irritation of the eyes, nose, throat, and skin; headache; dizziness; upset stomach; vomiting; unconsciousness; liver and kidney effects [84]
25 ppm TWA	Irritation of the eyes, nose, and throat; skin rash; dizziness; unconsciousness; liver and kidney effects [84]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50 ppm TWA	50 ppm TWA	Irritation of the eyes, nose, throat, and skin; central nervous system, liver and kidney effects [84]
diisobutyl ketone	50 ppm TWA	25 ppm TWA	Irritation of the eyes, nose, throat, and skin; headache; dizziness; drowsiness; unconsciousness; liver and kidney effects [84]
ethyl sec-amyl ketone (5-methyl-3-heptanone)	25 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; headache; dizziness; unconsciousness [74]
2-hexanone (methyl butyl ketone)	100 ppm TWA	1 ppm TWA	Irritation of the eyes, nose, throat, and skin; headache; drowsiness; unconsciousness; liver and kidney effects; peripheral neuropathy: weakness, numbness, and tingling of the arms and legs [84]
hexone (methyl isobutyl ketone)	100 ppm TWA	50 ppm TWA	Irritation of the eyes, nose, throat, respiratory tract, and skin; nausea; headache; dizziness; unconsciousness; liver and kidney effects; [84]
isophorone	25 ppm TWA	4 ppm TWA	Irritation of the eyes, nose, throat, and skin; headache; dizziness; faintness; fatigue; malaise; liver and kidney effects [84]

mesityl oxide	25 ppm TWA
methyl (n-amyl) ketone (2-heptanone)	100 ppm TWA
2-pentanone (methyl propyl ketone)	200 ppm TWA
Nitroparaffins:	
2-nitropropane	25 ppm TWA
Quinones:	
quinone (p-benzoquinone)	0.1 ppm TWA
Terpenes:	
turpentine	100 ppm TWA

Film-Forming Components

Acetonitrile	40 ppm TWA
Acrylates:	
ethyl acrylate	25 ppm TWA (skin)
methyl acrylate	10 ppm TWA (skin)

10 ppm TWA	Irritation of the eyes, nose, throat, and skin; dizziness; headache; unconsciousness; damage to liver, kidney, and lungs [84]
100 ppm TWA	Irritation of the eyes, nose, throat, and skin; headache; dizziness; unconsciousness; liver and kidney effects [84]
150 ppm TWA	Irritation of the eyes, nose, throat, and skin; drowsiness; unconsciousness; liver and kidney effects [84]
Handle in the workplace as if it were a **human carcinogen**	**Potential human carcinogen,** liver damage, nausea, vomiting diarrhea, anorexia, headache, dizziness [84]
§	Irritation of the eyes, nose, and throat; skin irritation and ulceration; permanent vision difficulties [74]
§	Irritation of the eyes, nose, throat, lungs, and skin; headache; dizziness; painful urination; unconsciousness; skin sensitization [74]
§	Irritation of the nose and throat, chest tightness, nausea, vomiting, respiratory depression, weakness, convulsions, shock, unconsciousness [74]
§	Irritation of the eyes, nose, throat, lungs, and skin; lung damage [74]
§	Irritation of the eyes, nose, throat, lungs, and skin; lung damage [74]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

	Occupational Exposure Limit*		
Agent	OSHA**	NIOSH Recommended***	Health Effects
methyl methacrylate	100 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; drowsiness; unconsciousness [74]
Acrylonitrile (AN)	2 ppm TWA, 10 ppm ceiling (15 minutes) No skin or eye contact with liquid AN	Handle in the workplace as if it were a human carcinogen	Potential lung and colon carcinogen; damage to the central nervous system, lungs, liver, and kidneys [99,100]
Diisocyanates	toluene-2,4-diisocyanate (TDI) 0.14 mg/m^3 ceiling; methylene bisphenyl isocyanate (MDI) 0.2mg/m^3 ceiling	toluene-2,4-diisocyanate (TDI) 35 μg/m^3 TWA, 140 μg/m^3 ceiling (10 minutes); methylene bisphenyl isocyanate (MDI) 50 μg/m^3 TWA, 200 μg/m^3 ceiling (10 minutes); hexamethylene diisocyanate (HDI) 35 μg/m^3 TWA, 140 μg/m^3 ceiling (10 minutes)	Irritation of the eyes and skin, bronchitis, chest tightness, labored breathing, pulmonary edema, possible sensitization [101,102]
Epichlorohydrin	5 ppm TWA (skin)	Treat in the workplace as if it were a human carcinogen, minimize occupational exposure	Irritation of the eyes, respiratory tract, and skin; coughing; chest congestion; running nose; headache; nausea; vomiting; difficulty breathing; possible sensitization; potential human carcinogen [103,104]
Formaldehyde	3 ppm TWA, 5 ppm acceptable ceiling, 10 ppm maximum peak (30 minutes)	Reduce occupational exposure to lowest feasible limit	Irritation of the eyes and upper respiratory tract, coughing, chest tightness, palpitation of the heart, pulmonary edema, inflammation of the lungs, dermatitis, potential human carcinogen [105,106]

Glycidyl Ethers	allyl glycidyl ether 10 ppm ceiling; isopropyl glycidyl ether 50 ppm TWA; phenyl glycidyl ether 10 ppm TWA; n-butyl glycidyl ether 50 ppm TWA	allyl glycidyl ether 9.6 ppm ceiling; isopropyl glycidyl ether 50 ppm ceiling, phenyl glycidyl ether 1 ppm ceiling; n-butyl glycidyl ether 4.4 ppm ceiling	Irritation of the skin and mucous membranes, potential sensitizer [107]
Styrene	100 ppm TWA, 200 ppm acceptable ceiling, 600 ppm maximum peak (5 minutes in any 3 hours)	50 ppm TWA, 100 ppm ceiling	Irritation of the eyes, nose, throat, and skin; central nervous system depression: headache, fatigue, dizziness, nausea, poor memory, and drowsiness [108]
Vinyl Chloride	1 ppm TWA, 5 ppm ceiling (15 minutes)	Minimum detectable level	Liver cancer [109]
Additives			
Arsenic (inorganic compounds (as As)	10 μg/m^3 TWA	2 μg/m^3 ceiling	Dermatitis, lung and lymphatic cancer [110]
Molybdenum: soluble compounds	5 mg/m^3 TWA	§	Irritation of the eyes, nose, and throat; loss of appetite; incoordination [74]
insoluble compounds	15 mg/m^3 TWA	§	Irritation of the eyes, nose, and throat [74]
Pentachlorophenol	0.5 mg/m^3 TWA (skin)	§	Irritation of the eyes and respiratory tract, bronchitis, weakness, loss of appetite, nausea, vomiting, shortness of breath, chest pain, excessive sweating, headache, dizziness, acne-like skin rash, liver damage [74]
Silver, metal and soluble compounds	0.01 mg/m^3 TWA	§	Irritation of the eyes and skin [74]
Tin (organic compounds as Sn)	0.1 mg/m^3 TWA	0.1 mg/m^3 TWA	Irritation and burns of the skin, eye irritation, headache, vomiting, damage to the nervous system, liver effects [111]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
Tributyl phosphate	5 mg/m^3 TWA	§	Irritation of the eyes, nose, and throat; nausea, headache [185]
Trimellitic anhydride	§§	Exposure should be limited to as few employees as possible, while minimizing exposure levels	Irritation of the eyes, nose respiratory tract, and skin; pulmonary edema; sensitization [112]
Triorthocresyl phosphate	0.1 mg/m^3 TWA	§	Paralysis of the lower arms and legs, nausea, vomiting, diarrhea, abdominal pain [74]
Zinc oxide fume	5 mg/m^3 TWA	5 mg/m^3 TWA, 15 mg/m^3 ceiling	Flu-like illness called metal fume fever: headache, fever, chills, muscle aches, nausea, vomiting, weakness, and tiredness [83]
Zirconium compounds (as Zr)	5 mg/m^3 TWA	§	Skin rash [74]
Other Materials			
Acetic acid	10 ppm TWA	§	Irritation of the eyes, nose, throat, lungs, and skin; possible corrosive effects upon direct contact with liquid [74]
Acrolein	0.1 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; pressure in chest; headache; dizziness; upset stomach [74]
Amines:			
ethanolamine	3 ppm TWA	§	Irritation of the eyes, nose, and skin [74]
triethylamine	25 ppm TWA	§	Irritation of the eyes, nose, throat, and skin [74]

Ammonia	50 ppm TWA	50 ppm ceiling (5 minutes)	Irritation of the eyes, skin, and respiratory system; coughing; chest pain; breathing difficulties [113]
Benzene	10 ppm TWA, 25 ppm acceptable ceiling, 50 ppm maximum peak (10 minutes during 8 hours)	1 ppm ceiling (2 hours)	Blood changes including **leukemia**, skin irritation central nervous system depression [114,115]
Benzoyl peroxide	5 mg/m^3 TWA	5 mg/m^3 TWA	Irritation of the eyes and respiratory tract, skin effects [116]
Beryllium	2 μg/m^3 TWA, 5 μg/m^3 acceptable ceiling, 25 μg/m^3 maximum peak (30 minutes during 8 hours)	Not to exceed 0.5 μg/m^3	**Lung cancer** [117]
Camphor	2 mg/m^3 TWA	§	Irritation of the eyes, sore throat, nausea, vomiting, headache, dizziness, confusion, irrational behavior, convulsions, kidney effects [74]
Carbon monoxide	50 ppm TWA	35 ppm TWA, 200 ppm ceiling (no minimum time)	Headache, nausea, dizziness, weakness, rapid breathing, unconsciousness, heart effects [118]
Carbon tetrachloride	10 ppm TWA, 25 ppm acceptable ceiling, 200 ppm maximum peak (5 minutes in any 4 hours)	2 ppm ceiling (60 minutes)	**Liver cancer** [119]
Chromic acid and chromates (as CrO_3)	100 μg/m^3 ceiling	50 μg/m^3 TWA, 100 μg/m^3 ceiling	Nasal ulceration [120]
Coal tar pitch volatiles	0.2 mg/m^3 TWA (benzene-soluble fraction)	0.1 mg/m^3 TWA (cyclohexane-extractable fraction)	**Lung and skin cancer** [121]
Copper fume (as Cu)	0.1 mg/m^3 TWA	§	Irritation of the eyes, nose, and throat; flu-like illness called metal fume fever: fever, muscle aches, nausea, chills, dry throat, cough, and weakness [74]

(Continued)

VIII. APPENDIX B

SUMMARY OF HEALTH EFFECTS AND EXPOSURE LIMITS FOR SUBSTANCES POTENTIALLY PRESENT IN THE MANUFACTURE OF PAINT AND ALLIED COATING PRODUCTS

Agent	Occupational Exposure Limit*		Health Effects
	OSHA**	NIOSH Recommended***	
Dimethylaniline	5 ppm TWA (skin)	§	Drowsiness, headache, nausea, vomiting [74]
Hydrogen chloride	5 ppm TWA	§	Irritation of the eyes, respiratory tract, and skin; erosion of the teeth [74]
Maleic anhydride	0.25 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; coughing; sneezing; double vision [74]
Methyl chloroform	350 ppm TWA	350 ppm ceiling	Nervous system, liver, and heart effects [122]
Nitrogen dioxide	5 ppm ceiling	1 ppm ceiling	Respiratory and blood effects [123]
Phthalic anhydride	2 ppm TWA	§	Irritation of the eyes, nose, throat, and skin; coughing; sneezing; nosebleeds [74]
Pyridine	5 ppm TWA	§	Irritation of the eyes, respiratory tract, and skin; diarrhea; abdominal pain; nausea; weakness; headache; dizziness; nervousness; damage to the central nervous system, liver, and kidneys [74]
Sodium hydroxide	2 mg/m^3 TWA	2 mg/m^3 ceiling	Irritation and corrosive damage to the eyes, respiratory tract, and skin [124]

Sulfuric acid	1 mg/m^3 TWA	1 mg/m^3 TWA	Irritation of the eyes, nose, throat, and skin; erosion of the teeth [125]
Zinc chloride fume	1 mg/m^3 TWA	§	Shortness of breath, a feeling of constriction in chest, abdominal pain, watering of the eyes, burning of the eyes and throat, coughing with phlegm and bloody sputum, pneumonia [74]

*TWA: time-weighted average; mg/m^3: milligrams of particulate per cubic meter of air; $\mu g/m^3$: micrograms of particulate per cubic meter of air; ppm: parts of vapor or gas per million parts of contaminated air; mppcf: millions of particles per cubic foot of air; SiO_2: crystalline silica; fibers/cm^3: fibers longer than 5 micrometers per cubic centimeter of air.

**OSHA TWA standards are based on up to an 8-hour exposure; substances followed by the designation "skin" refer to the potential contribution to the overall exposure by the cutaneous route.

***NIOSH recommended TWA standards are based on up to a 10-hour exposure unless otherwise noted; NIOSH recommended ceiling standards are based on a 15-minute exposure unless otherwise noted.

§Indicates no existing NIOSH recommended standard.

§§Indicates no existing OSHA standard.

IX. APPENDIX C

MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material shall be provided in the appropriate block of the Material Safety Data Sheet (MSDS).

The product designation is inserted in the block in the upper left corner of the first page to facilitate filing and retrieval. Print in upper case letters as large as possible. It should be printed to read upright with the sheet turned sideways. The product designation is that name or code designation which appears on the label or by which the product is sold or known by workers. The relative numerical hazard ratings and key statements are those determined by the rules in Chapter V, Part B, of the NIOSH publication, A Recommended Standard....An Identification System for Occupationally Hazardous Materials [49]. The company identification may be printed in the upper right corner if desired.

Section I. Production Identification

The manufacturer's name, address, and regular and emergency telephone numbers (including area code) are inserted in the appropriate blocks of Section I. The company listed should be a source of detailed backup information on the hazards of the material(s) covered by the MSDS. The listing of suppliers or wholesale distributors is discouraged. The trade name should be the product designation or common name associated with the material. The synonyms are those commonly used for the product, especially formal chemical nomenclature. Not every known chemical designation or competitor's trade name needs to be listed.

Section II. Hazardous Ingredients

The "materials" listed in Section II shall be those substances which are part of the hazardous product covered by the MSDS and which individually meet any of the criteria defining a hazardous material. Thus, one component of a multicomponent product might be listed because of its toxicity, another component because of its flammability, while a third component could be included both for its toxicity and its reactivity. Note that a MSDS for a single component product must have the name of the material repeated in this section to avoid giving the impression that there are no hazardous ingredients.

Chemical substances should be listed according to their complete name derived from a recognized system of nomenclature. Where possible, avoid using common names and general class names such as "aromatic amine," "safety solvent," or "aliphatic hydrocarbon" when the specific name is known.

The "%" may be the approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, i.e., "10-40% vol." or "10% max. wt." to avoid disclosure of trade secrets.

Toxic hazard data shall be stated in terms of concentration, mode of exposure or test, and animal used, e.g., "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," "permissible exposure from 29 CFR 1910.1000," or, if not available, from other sources such as publications of the American Conference of Governmental Industrial Hygienists (ACGIH) or the American National Standards Institute, Inc. (ANSI). Flashpoint, shock sensitivity, or similar descriptive data may be used to indicate flammability, reactivity, or similar hazardous properties of the material.

Section III. Physical Data

The data in Section III should be for the total mixture and should include the boiling point and melting point in degrees Fahrenheit (Celsius in parentheses); vapor pressure, in conventional millimeters of mercury (mmHg); vapor density of gas or vapor (air=1); solubility in water, in parts/hundred parts of water by weight; specific gravity (water=1); percent volatiles (indicated if by weight or volume) at 70°F (21.1°C); evaporation rate for liquids or sublimable solids, relative to butyl acetate; and appearance and odor. These data are useful for the control of toxic substances. Boiling point, vapor density, percent volatiles, vapor pressure, and evaporation are useful for designing proper ventilation equipment. This information is also useful for design and deployment of adequate fire and spill containment equipment. The appearance and odor may facilitate identification of substances stored in improperly marked containers or when spilled.

Section IV. Fire and Explosion Data

Section IV should contain complete fire and explosion data for the product, including flash point and autoignition temperature in degrees Fahrenheit (Celsius in parentheses); flammable limits, in percent by volume in air; suitable extinguishing media or materials; special firefighting procedures; and unusual fire and explosion hazard information. If the product presents no fire hazard, insert "NO FIRE HAZARD" on the line labeled "Extinguishing Media."

Section V. Health Hazard Information

The "Health Hazard Data" should be a combined estimate of the hazard of the total product. This can be expressed as a TWA concentration, as a permissible exposure, or by some other indication of an acceptable standard. Other data are acceptable, such as lowest LD50 if multiple components are involved.

Under "Routes of Exposure," comments in each category should reflect the potential hazard from absorption by the route in question. Comments should indicate the severity of the effect and the basis for the statement if possible. The basis might be animal studies, analogy with similar products, or human experiences. Comments such as "yes" or "possible" are not helpful. Typical comments might be:

Skin Contact--single short contact, no adverse effects likely; prolonged or repeated contact, possibly mild irritation.

Eye Contact--some pain and mild transient irritation; no corneal scarring.

"Emergency and First Aid Procedures" should be written in lay language and should primarily represent first-aid treatment that could be provided by paramedical personnel or individuals trained in first aid.

Information in the "Notes to Physician" section should include any special medical information which would be of assistance to an attending physician including required or recommended preplacement and periodic medical examinations, diagnostic procedures, and medical management of overexposed workers.

Section VI. Reactivity Data

The comments in Section VI relate to safe storage and handling of hazardous, unstable substances. It is particularly important to highlight instability or incompatibility to common substances or circumstances, such as water, direct sunlight, steel or copper piping, acids, alkalies, etc. "Hazardous Decomposition Products" shall include those products released under fire conditions. It must also include dangerous products produced by aging, such as peroxides in the case of some ethers. Where applicable, shelf life should also be indicated.

Section VII. Spill or Leak Procedures

Detailed procedures for cleanup and disposal should be listed with emphasis on precautions to be taken to protect workers assigned to cleanup detail. Specific neutralizing chemicals or procedures should be described in detail. Disposal methods should be explicit including proper labeling of containers holding residues and ultimate disposal methods such as "sanitary landfill" or "incineration." Warnings such as "comply with local, state, and Federal antipollution ordinances" are proper but not sufficient. Specific procedures shall be identified.

Section VIII. Special Protection Information

Section VIII requires specific information. Statements such as "Yes," "No," or "If necessary" are not informative. Ventilation requirements should be specific as to type and preferred methods. Respirators shall be specified as to type and NIOSH or Mine Safety and Health Administration approval class, i.e., "Supplied air," "Organic vapor canister," etc. Protective equipment must be specified as to type and materials of construction.

Section IX. Special Precautions

"Precautionary Statements" shall consist of the label statements selected for use on the container or placard. Additional information on any aspect of safety or health not covered in other sections should be inserted in Section IX. The lower block can contain references to published guides or in-house procedures for handling and storage. Department of Transportation markings and classifications and other freight, handling, or storage requirements and environmental controls can be noted.

Signature and Filing

Finally, the name and address of the responsible person who completed the MSDS and the date of completion are entered. This will facilitate correction of errors and identify a source of additional information.

The MSDS shall be filed in a location readily accessible to workers exposed to the hazardous substance. The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new workers. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff in planning a safe and healthful work environment and in suggesting appropriate emergency procedures and sources of help in the event of harmful exposure of workers.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION	
MANUFACTURER'S NAME	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.
ADDRESS	
TRADE NAME	
SYNONYMS	

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA

III PHYSICAL DATA			
BOILING POINT, 760 MM HG		MELTING POINT	
SPECIFIC GRAVITY (H_2O=1)		VAPOR PRESSURE	
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H_2O, % BY WT	
% VOLATILES BY VOL		EVAPORATION RATE (BUTYL ACETATE=1)	
APPEARANCE AND ODOR			

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)			AUTOIGNITION TEMPERATURE		
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER		
EXTINGUISHING MEDIA					
SPECIAL FIRE FIGHTING PROCEDURES					
UNUSUAL FIRE AND EXPLOSION HAZARD					

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES

SKIN

INHALATION

INGESTION

NOTES TO PHYSICIAN

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL)

EYE

GLOVES

OTHER CLOTHING AND EQUIPMENT

IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

OTHER HANDLING AND STORAGE REQUIREMENTS

PREPARED BY

ADDRESS:

DATE

X. APPENDIX D

PERTINENT OSHA STANDARDS FOR THE PAINT AND ALLIED COATING PRODUCTS INDUSTRY*

Section (29 CFR)	Title
1910.23	Guarding floor and wall openings and holes.
1910.24	Fixed industrial stairs.
1910.25	Portable wood ladders.
1910.26	Portable metal ladders.
1910.27	Fixed ladders.
1910.36	General requirements for Subpart E - Means of Egress.
1910.37	Means of egress, general.
1910.94	Ventilation.
1910.95	Occupational noise exposure.
1910.97	Nonionizing radiation.
1910.101	Compressed gases (general requirements).
1910.106	Flammable and combustible liquids.
1910.132	General requirements for Subpart I - Personal Protective Equipment.
1910.133	Eye and face protection.
1910.134	Respiratory protection.
1910.135	Occupational head protection.
1910.136	Occupational foot protection.
1910.141	Sanitation.
1910.144	Safety color code for marking physical hazards.
1910.145	Specifications for accident prevention signs and tags.
1910.151	Medical services and first aid.
1910.156	Fire brigades.
1910.157	Portable fire extinguishers.
1910.158	Standpipe and hose systems.
1910.159	Automatic sprinkler systems.
1910.160	Fixed extinguishing systems, general.
1910.161	Fixed extinguishing systems, dry chemical.
1910.162	Fixed extinguishing systems, gaseous agent.
1910.163	Fixed extinguishing systems, water spray and foam.
1910.164	Fire detection systems.
1910.166	Inspection of compressed gas cylinders.
1910.167	Safety relief devices for compressed gas cylinders.
1910.176	Handling materials-general.
1910.178	Powered industrial trucks.
1910.212	General requirements for all machines (part of Subpart O - Machinery and Machine Guarding).

(Continued)

APPENDIX D

PERTINENT OSHA STANDARDS FOR THE PAINT AND ALLIED COATING PRODUCTS INDUSTRY*

Section (29 CFR)	Title
1910.219	Mechanical power-transmission apparatus.
1910.242	Hand and portable powered tools and equipment, general.
1910.243	Guarding of portable powered tools.
1910.244	Other portable tools and equipment.
1910.303	General requirements for Subpart S - Electrical.
1910.304	Wiring design and protection.
1910.305	Wiring methods, components, and equipment for general use.
1910.307	Hazardous (classified) locations.
1910.1000	Air contaminants.
1910.1001	Asbestos.
1910.1002	Coal tar pitch volatiles.
1910.1017	Vinyl chloride.
1910.1025	Lead.
1910.1045	Acrylonitrile.

*Does not include all OSHA regulations that are applicable to the paint and allied coating products industry

KEY WORD INDEX

REFERENCE INDEX

REFERENCE INDEX (CONTINUED)

U.S. GOVERNMENT PRINTING OFFICE 1984 - 659-096/100

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE. $300

Special Fourth Class-Book

U.S. MAIL

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF HHS
HHS 396

Redistribution using indicia is illegal.

DHHS (NIOSH) Publication No. 84-115