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:

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

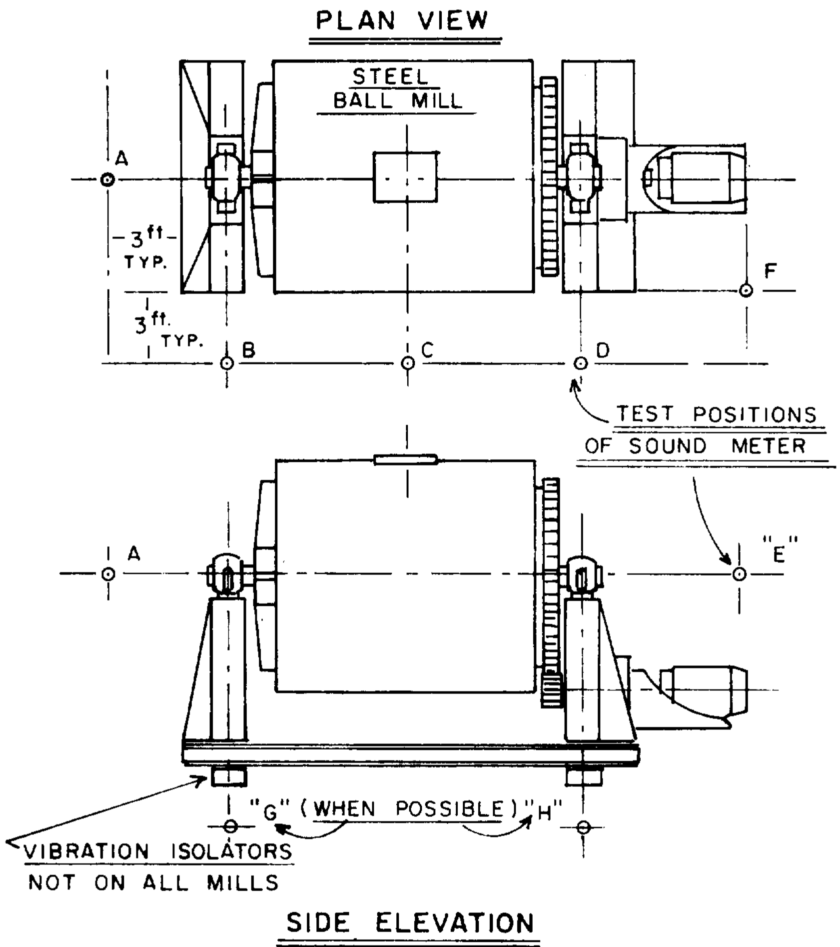
Duration Per Day Hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

* 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

Hi	Av	Lo
93	90.7	90

Pos. B

Hi	Av	Lo
93	91.7	88

Pos. C*

Hi	Av	Lo
106	93	85

Pos. D

Hi	Av	Lo
94	92.7	92.3

Pos. E

Hi	Av	Lo
95	94.1	93

Pos. F

Hi	Av	Lo
94	92.8	92

Pos. G

Hi	Av	Lo
96	92.1	88

Pos. H

Hi	Av	Lo
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]

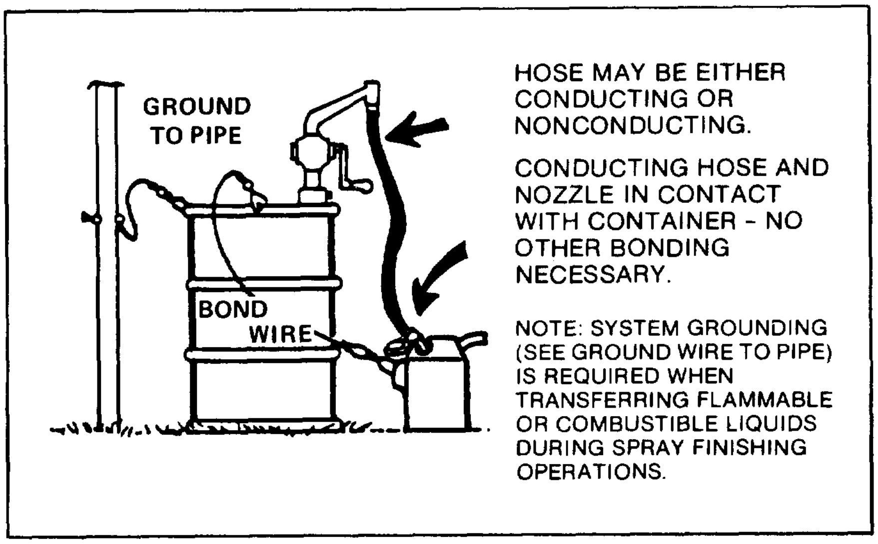


FIGURE IV-3. EXAMPLE OF A SMALL GROUND CLAMP STANDARD ASSEMBLY [32]
(Copyright by The Sherwin-Williams Company. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)

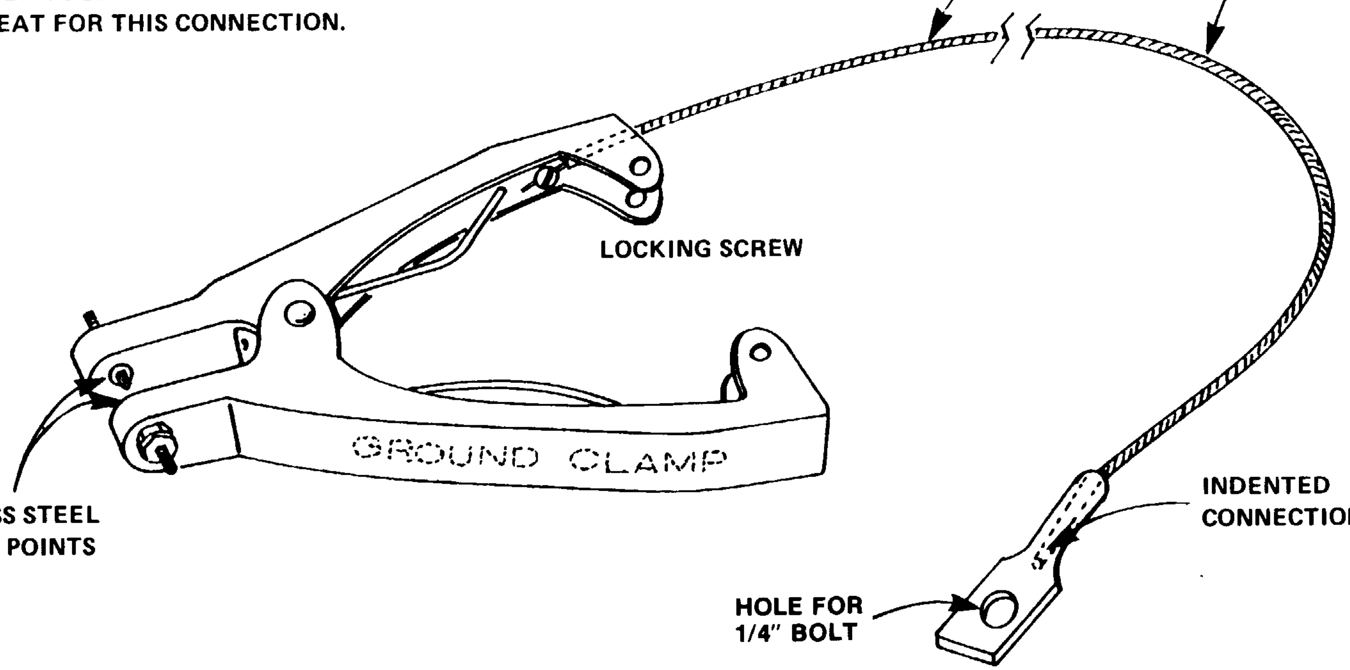


FIGURE IV-4. TYPICAL GROUNDING ARRANGEMENT FOR 55-GALLON DRUMS IN A STORAGE RACK [32]
(Copyright by The Sherwin-Williams Company. Reprinted with permission by the Department of Health and Human Services. Further reproduction prohibited without permission of copyright holder.)

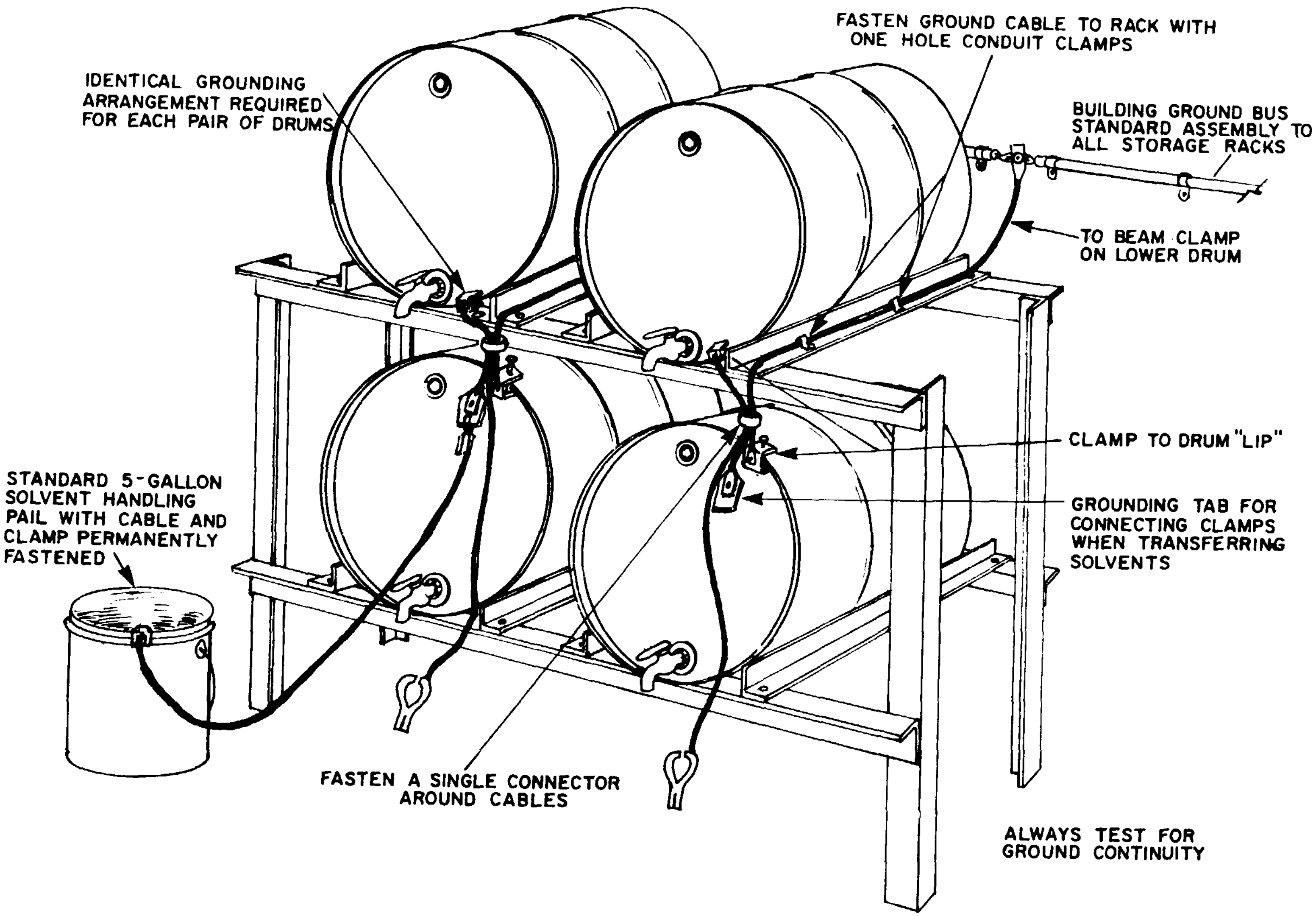


FIGURE IV-5. TYPICAL GROUNDING ARRANGEMENT FOR A BALL MILL CHARGING FITTING [32]

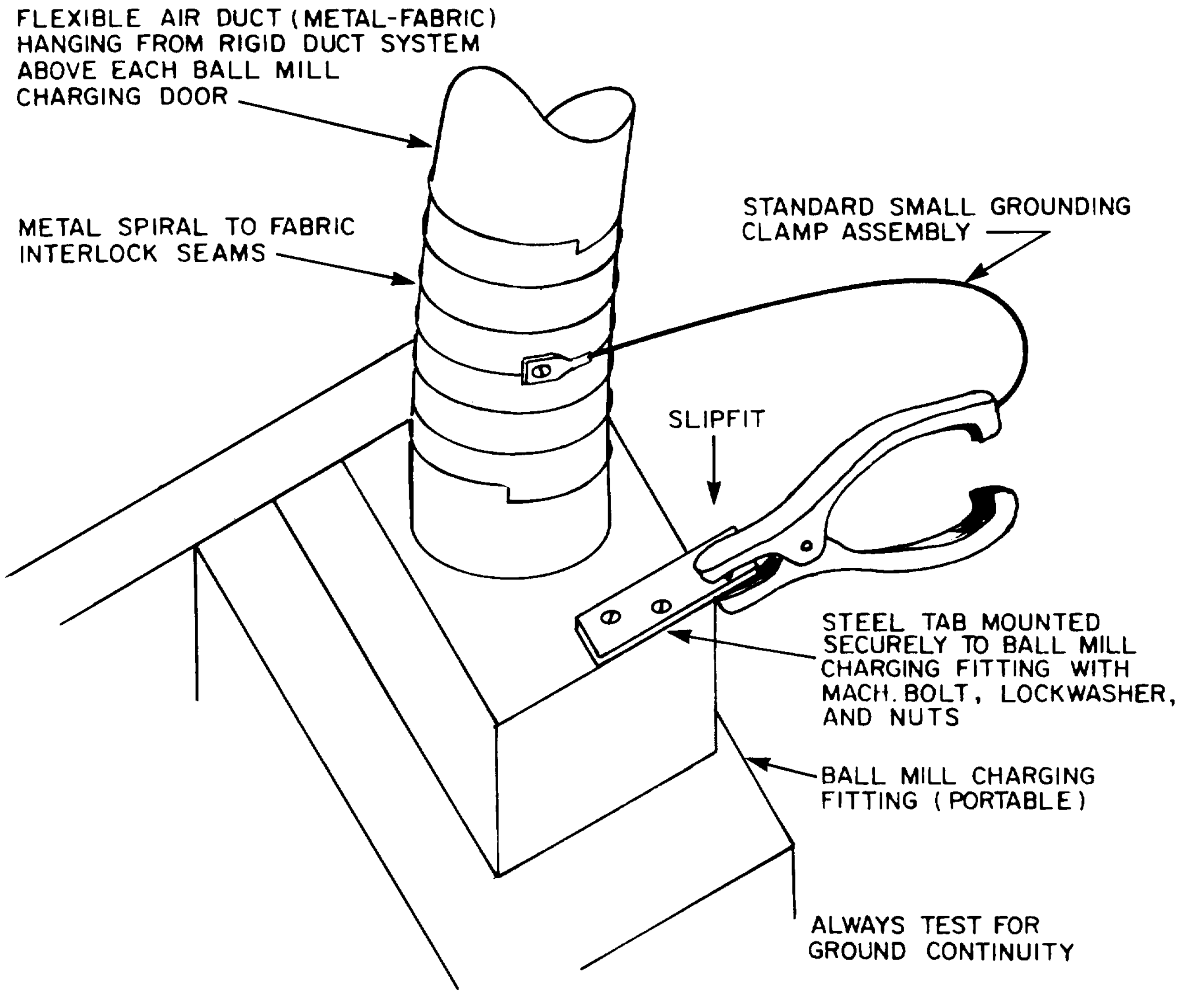
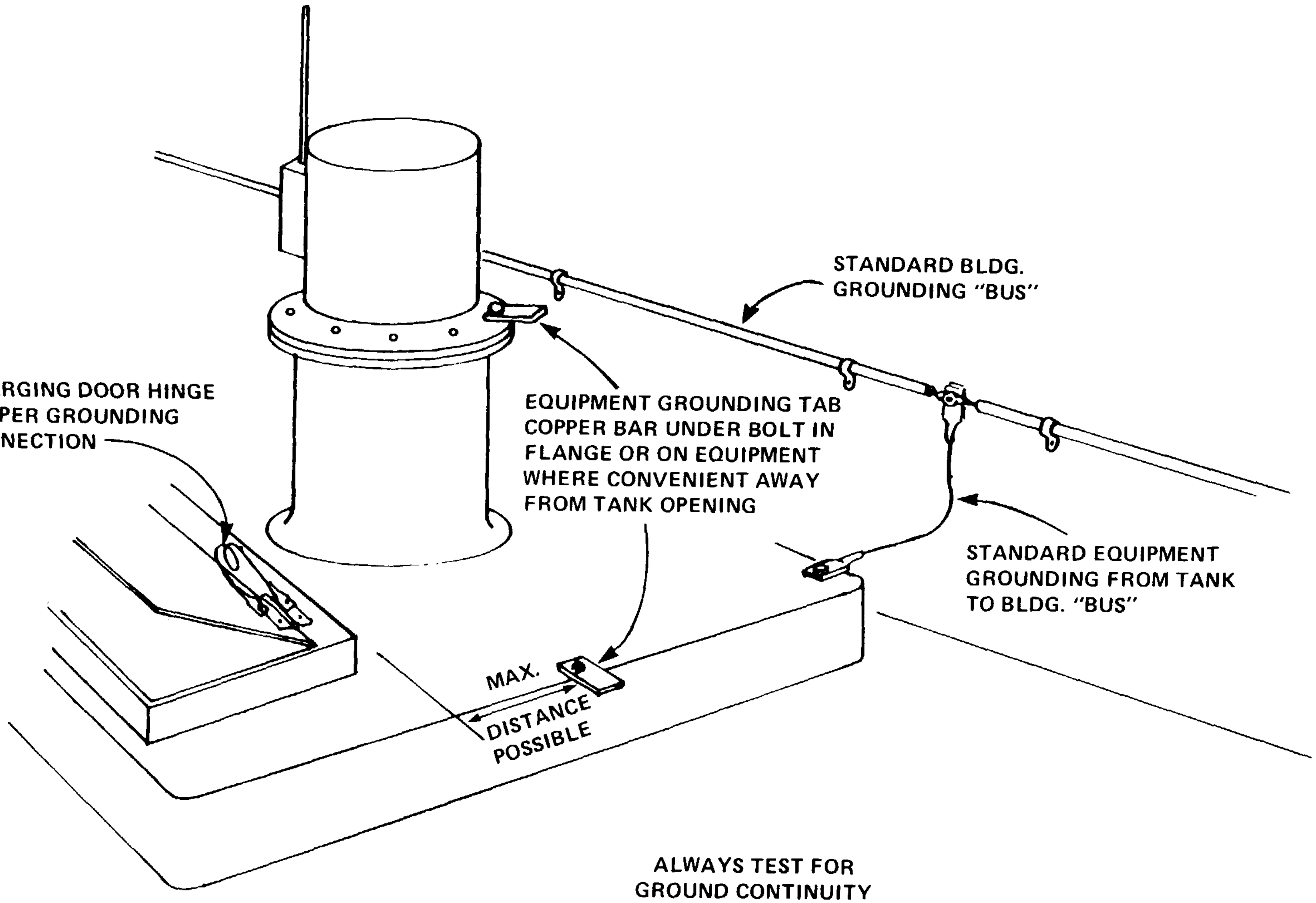


FIGURE IV-6. TYPICAL GROUNDING ARRANGEMENT FOR THINNING OR MIXING EQUIPMENT [32]



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

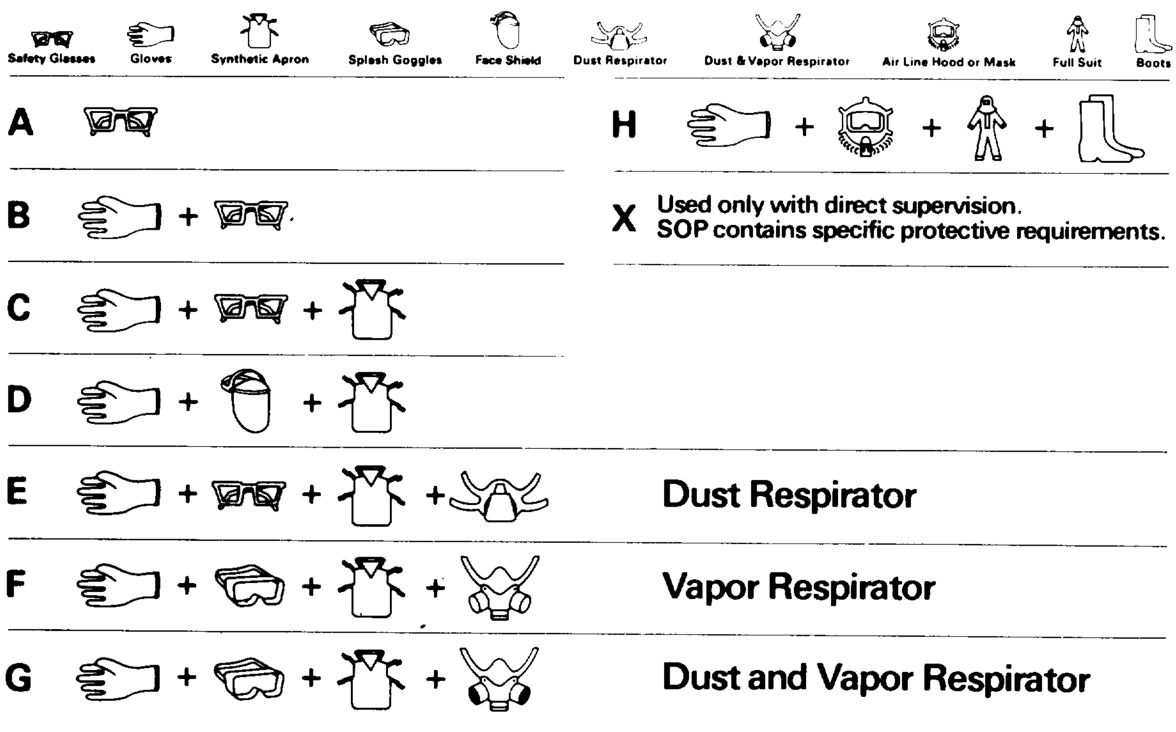
3 Serious Hazard

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]
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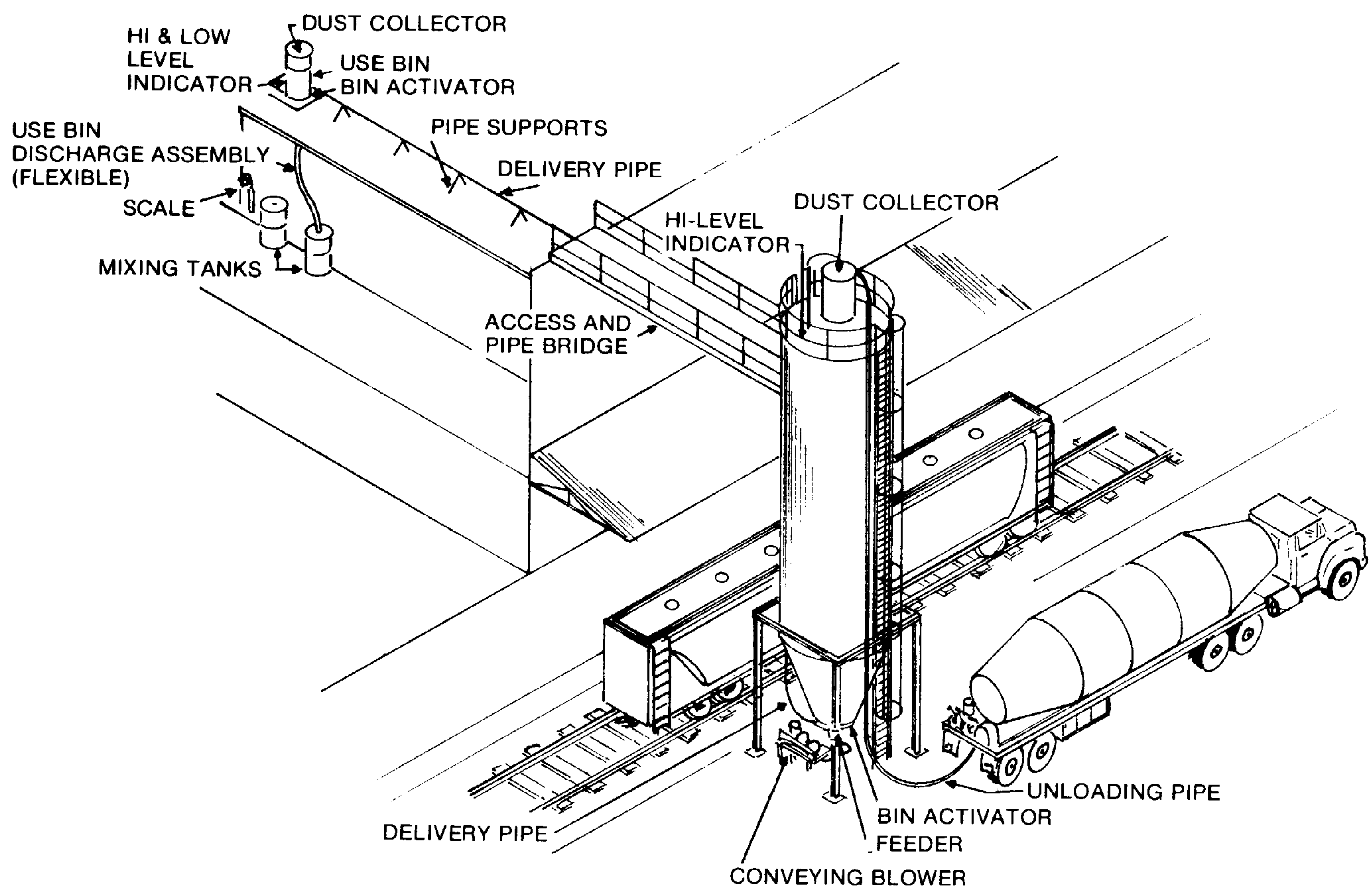


or earth), and restricted worker access to the immediate spill area [55]. Contact with coatings or their components (especially radiation-curable coatings) should be avoided, if possible, but should be followed by the immediate washing of contaminated skin with soap and water, immediate flushing of exposed 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 Criteria for a Recommended Standard....Working in Confined Spaces [57] and the American National Standard: Safety Requirements for Working in Tanks and Other Confined Spaces [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]

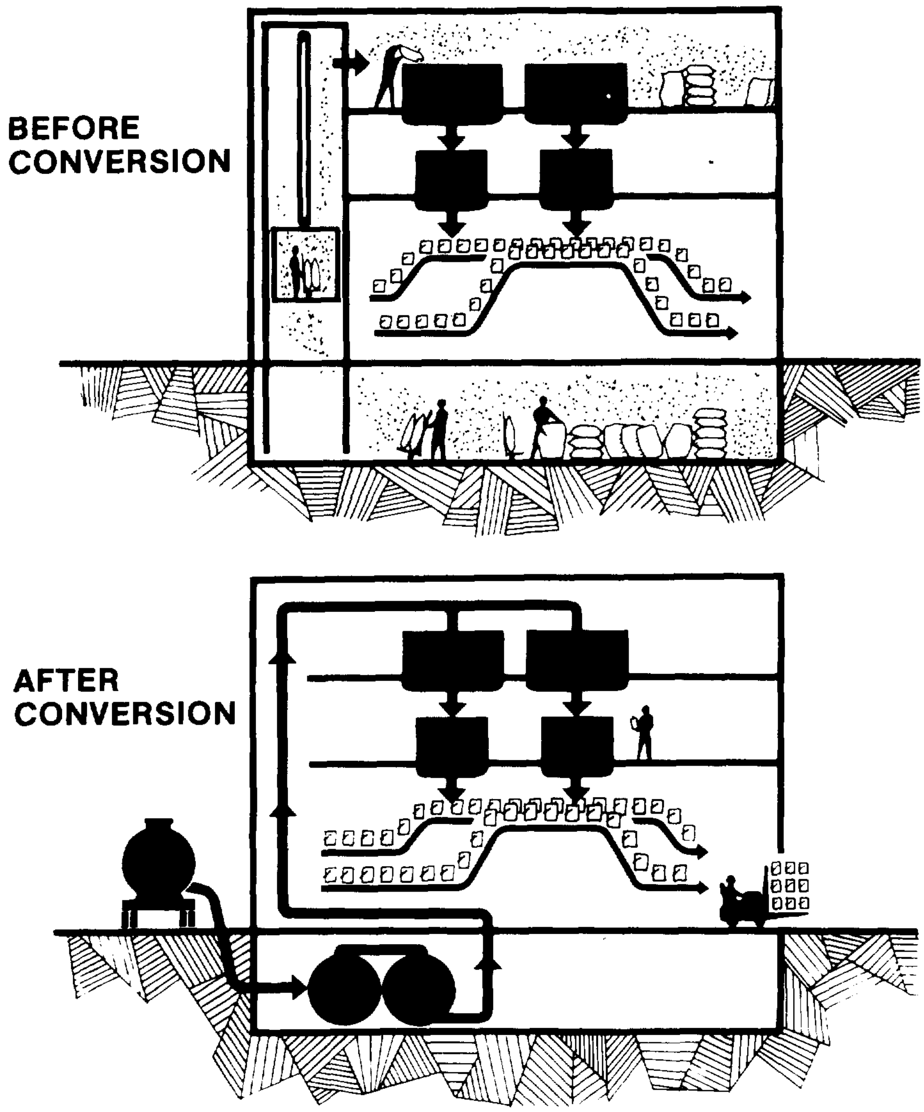


FIGURE IV-10. BAG AND DUST CONTROL SYSTEM
(Adapted from D. B. Sarvadi, written communication, August 1978)

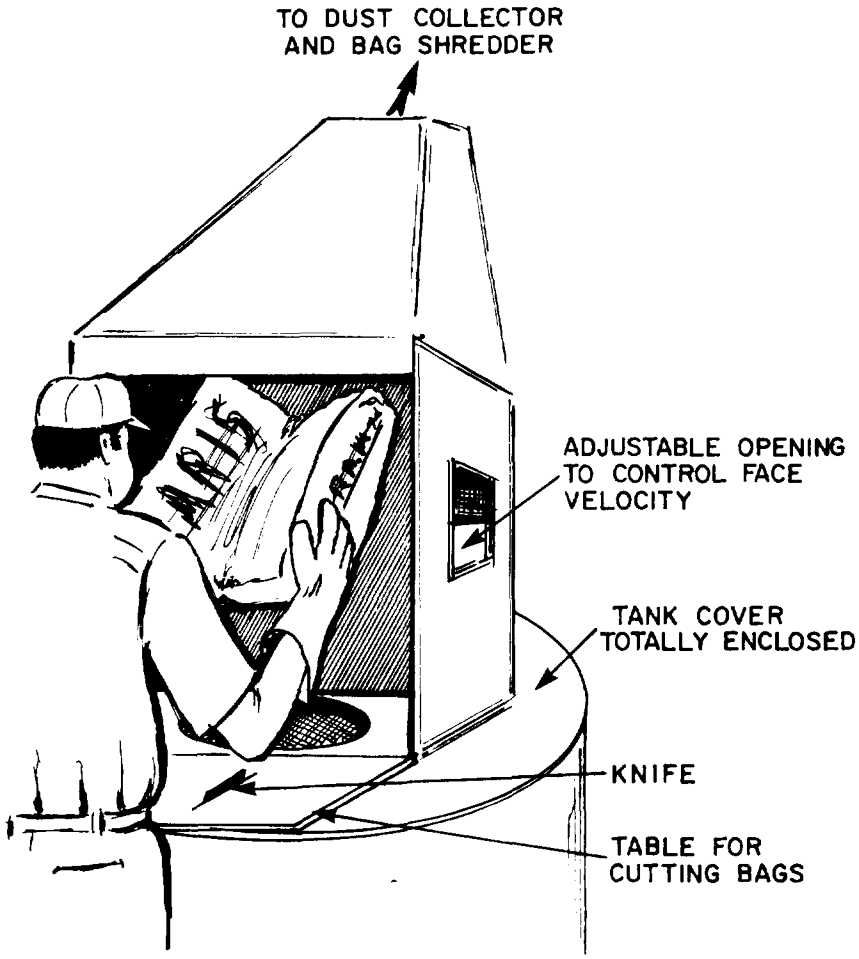
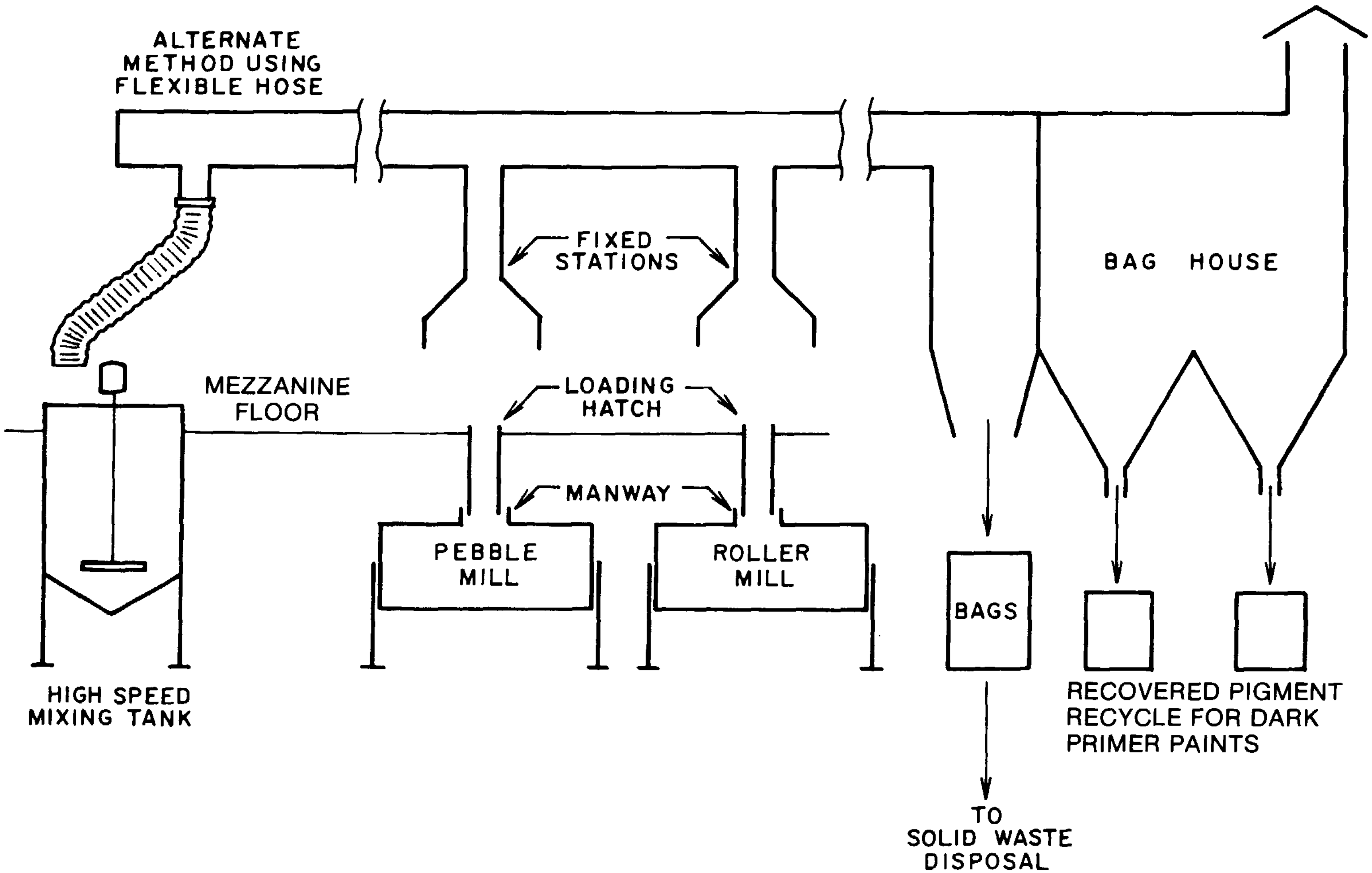


FIGURE IV-11. DISPERSION OPERATION VENTILATION CONTROL [19]

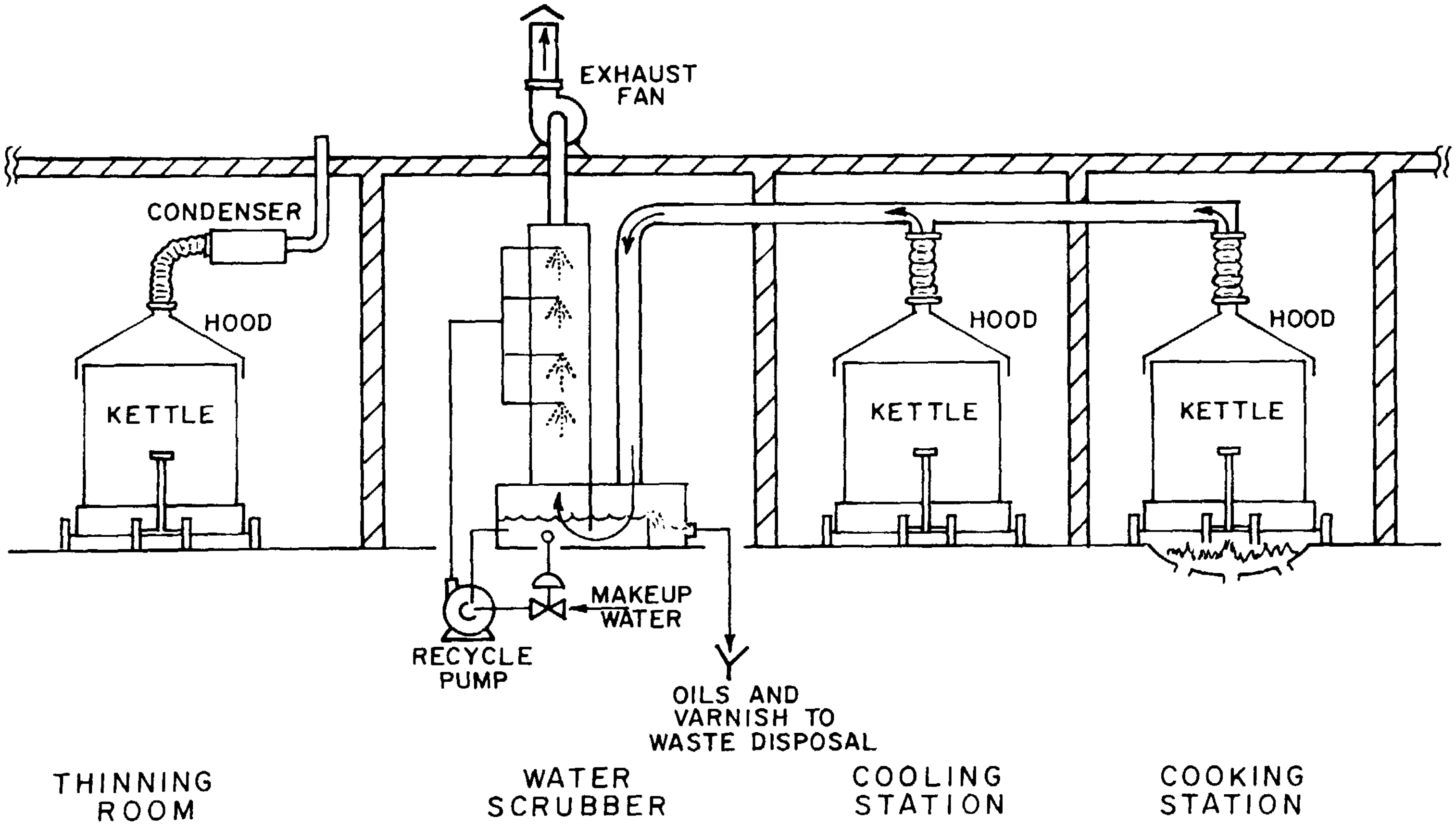


Enclosed equipment, such as ball or pebble mills, is free of vapor release during operation, but this is not the case with high-speed dispersers, which are open to the air. The use of covers and lids on containers can reduce vapor emissions. This is especially true during the thinning, tinting, and shading 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.