Painting Trades Study
Progress Report

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ABSTRACT

A NIOSH study of health hazards of workers applying paints and coatings was begun in 1978. The study was strated because of reports of adverse health effects including bronchitis and chest x-ray changes in an earlier NIOSH pilot study.

A literature review was conducted and nine industries that have painting operations were selected for study: construction/maintenance, auto manufacturing, shipbuilding, and furniture manufacturing, appliance manufacturing, railroad car manufacturing, aircraft manufacturing and maintenance, bus, truck, farm, and construction machinery manufacturing, metal furniture manufacturing. Fifty-one walk through surveys to obtain information on paint usage and exposure, completeness of personnel records and other basic information were conducted in the nine industries.

The information obtained in the walk through surveys is being analyzed in order to decide which industries and specific sites are most suitable for indepth industrial hygiene and/or retrospective cohort mortality studies. Cross-sectional medical studies may be conducted if warranted by early results of the mortality or industrial hygiene studies.

Purpose of the Painting Contract

A NIOSH study of health hazards of workers applying paints and coatings was begun in 1978. The purpose of this study is to evaluate, on an industrywide basis, possible health effects resulting from worker exposures to a variety of coating processes. It is a three phase study, including industrial hygiene, epidemiological, and cross-sectional medical surveys.

Background

The study was initiated for several reasons:

1. Only a limited amount of significant research has been conducted to estimate acute and chronic effects caused by exposure to paints and coatings.

2. During the past decade, there has been a growing concern that the materials in coatings may present potential health hazards to workers applying the coatings on a regular basis, for example, i.e. metallic pigments and additives, certain catalysts and activators, and solvents.

3. Several recent but limited occupational studies have suggested that painters experience an increased risk of developing certain diseases, including among others, central nervous system and respiratory effects, and cancer (1-8).

The motivating force behind the project was a pilot study conducted under a NIOSH contract in 1975 by Mt. Sinai (1) which clinically surveyed 1000

members of the International Brotherhood of Painters and Allied Trades (I.B.P.A.T.). The study results indicated that among the various trades included in the union (e.g. general painter, dry wall construction workers, wood finishers, paint factory workers and many others, Table 1), anesthetic effects on the central nervous system were more frequently reported among general painters, particularly those who had reported working with epoxy paints, and among those classified as metal painters and sandblasters.

The study also reported symptoms of respiratory irritation, such as increased frequency of bronchitis as seen among sandblasters and paint factory workers. Chest x-ray changes such as plural thickening or the occurrence of small rounded opacities were more frequent among general painters, paint manufacturers, and sandblasters.

Although this study had many inherent limitations - since it focused largely on construction painting and related trades - it did indicate a need to look more carefully at the potential hazards of paints, paint application processes, and the mortality and morbidity experience of involved workers.

However, it should be said again that at least part of the impetus for the present study was the lack of well defined and controlled studies relating to application of paint.

Scope and Limitations

For the purpose of this study, we have defined the "painting" industry to include those establishments that use coating products in the finishing of manufactured products and in new construction, building maintenance, and rehabilitation, specifically excluding paint manufacturing. We have also

The papers included in these Proceedings were printed as they were submitted to this office.

Appropriate portions of the discussions, working groups and plenary session were sent to the participants for editing. The style of editing varied, as could be expected. To the extent possible, we have attempted to arrive at a consistent format.

defined paint as "a mixture of pigment or vehicle (as oil or water) applied to a surface to form a thin film adhering to a substrate". The group of finishes which are considered treatments because they penetrate the surface, and a variety of other specialized finishing processes (e.g. metalizing) were excluded from the study.

While attempting to define the areas of study or scope of the project, we became aware of the immense variety of coatings used in construction/ maintenance or for product finishing, the number of raw materials used in paint manufacture, the variety of application methods, and the variety of settings in which paint is applied. Although we have tried to maintain a broad perspective on these aspects during this study, we have necessarily had to pre-select at several stages, the coating types to study, the environments and settings in which to study the associated hazards, and the specific sites and populations to be included. Although this may have caused us to overlook significant aspects of paint application which deserved study, given the complexity of the subject and funding limitations, this was unavoidable.

ACCOMPLISHMENTS

Selection of Study Sites

The initial task was to select groups of painters which would be reasonably representative of all painters in the United States, or failing that, to select groups to study which would be representative of the largest number of painters, or those with the most hazardous exposures.

The criteria developed to facilitate group selection followed a three point decision scheme based on resin type, industrial use and the availability of a study population:

(1) Resins - paints are frequently classified by resin type. We concentrated mainly on those (5-7) resin types which were in widespread and increasing use, or those which exhibited unique toxicity in other studies or case reports.

Table 2 shows the estimated total 1974 consumption of resins in paints and coatings (9). The three resin types in largest use-were alkyd vinyl, and acrylic. Although of substantially lower volume usage, epoxy and urethane paints were also selected because of their reported toxicity and potential hazards in use, as well as their projected increasing use in industry. Cellulosic based paints were also selected because it was known that these were used primarily, and in fact nearly exclusively, in the wood furniture industry.

2. Industrial Use - the selection of industries to study was then based on the type and volume of resin used, and the extent of exposure based on the method of application, number of workers exposed, and the projected usage.

3. Population at Risk - additional criteria for the final selection of industries were those related to selecting populations for mortality studies, based on the size and stability of the population, the length of use of the selected paints (or age of the industry), and information obtained prior to actual site visits

on the condition and availability of records.

After examining approximately 18-20 different industrial categories, including architectural and maintenance painting, and eliminating several due to such factors as having unusual or unique coating processes, or difficulties in identifying suitable sites or populations, nine possible areas were chosen for study (Table 3)

In summary, each of the illustrated industrial areas were selected for study based on their high volume use of the selected paint resin types, the number of painters in the industry, application methods, and potential exposure. Also, it became obvious that by working within these chosen industrial categories, we could assess effects of exposure to many other paint resin types not originally selected for study.

Groups 9 and 10 - Construction and Maintenance, and the Mortality Study of the IBPAT Membership, are included as separate treatments of the same "category". Because of the apparent lack of large, stable workforce or adequate records documenting worker exposure at work sites or contractor offices, we investigated whether the mortality studies could be conducted using available records of the international painter's union. In conjunction with this study, industrial hygiene studies were to be conducted to explore potential exposures at a number of construction/maintenance worksites identified by the union.

Subsequently, thirty-nine walk through surveys were conducted in the eight manufacturing industries, five in each industry (4 in ship building), and surveys were conducted at all eleven construction/maintenance sites identified, for a total of 50 walk through surveys conducted. These sites,

including plant and construction locations, were selected in general to include (to the extent possible) the multiple environments present in each industry, and to include where possible large, medium, and some small establishments. However, this was not possible in all categories due to the limited amount of painting being done and the small number of workers at some of the smallest sites.

Walk Through Survey Results

Table 4 presents an overall summary of the findings in the nine areas examined in the walk through surveys. This is presented primarily to show examples of some of the data and criteria we used in selecting industries for in-depth epidemiology studies. These include: the number of painters and "halo" workers potentially exposed (as of measure of total U.S. impact) and the percent of total production workers who are painters, the degree of potential exposure, and an assessment of the workforce and records available for study. Not shown but additional important criteria used were the types of coatings used, the kinds of potential hazards seen, and the use of the newer kinds of coatings in increasing use.

A brief look at this summary indicates the following:

1. The three categories with the largest number of painters are in order: construction and maintenance, automobile manufacturing, and wood furniture. This, among other factors, led to the selection of construction and wood furniture for in-depth studies. Automobile OEM was a viable potential study, but exposures were subjectively low, and records would be difficult to search.

2. Metal furniture and appliances were ruled out because the

number of painters was low, hazardous exposures were (subjectively) low, and records were marginal.

3. Railroad equipment manufacturing was ruled out because of the small population available for study, and poor to marginal records. Worker exposures, however, were judged to be relatively high and potentially hazardous.

4. This left large transportation equipment, aircraft, and ship building. Although all exhibited variable and potentially hazardous exposures, aircraft was selected because of the availability of records at one site, and in particular because of the extensive use of the urethane paints, which are in increasing use in several other industries.

The characteristics of painting in each of the three selected industries (wood furniture, aircraft, construction/maintenance) and additional reasons for the selection of each, are discussed below.

Wood Furniture Finishing

Table 5 presents some of the characteristics of finishing processes in the Wood Furniture Industry. Previous research in this industry does not address the problem of the finisher. Most work concentrates on the hazards and effects of wood dust exposure rather than those caused by finishing products. Our planned studies concentrating in this area of the industry will complement the research already investigating wood and wood dust exposures.

Nitrocellulose lacquers are traditionally utilized in the furniture

finishing process. Although other finish types may be adopted, nitrocellulose is the finish of choice. In many operations, the finish is applied by hand or using a hand-held conventional air or airless spray technique.

Environmental controls are usually limited to back draft booths, with minimal use of personal protective equipment despite the fact that workers often conduct sanding and wiping operations outside the booths. This may cause worker exposure to evaporating solvent vapors.

The primary hazards, based on subjective observations and material safety data sheets on the products in use, were exposure to complex mixtures of aliphatic and aromatic hydrocarbons, ketones, plus other solvents and chemicals. It was our impression that although local exhaust was extensively used, overall control of solvent vapors in many instances was marginal. Confirmation of this, of course, would require extensive environmental surveys of several of these sites.

Finally, a few of the sites were found to contain data suitable for a retrospective mortality study of wood furniture finishers. This part of the furniture industry is composed of a large number of highly skilled workers who remain classified as a finisher once the person is identified as such. Therefore, it is felt that long term finishers will have been exposed to the nitrocellulose lacquers despite the rather high mobility of the workforce. The cohort is anticipated to include approximately 4500-5000 workers, working over an estimated 30 years.

Aircraft Manufacturing

Comprehensive surveys in the aircraft industry (Table 6) should provide data on the chronic and acute health effects of urethane-type coatings, as well as zinc chromate and epoxy constituents. Although used as top coatings on aircraft for approximately 20 years, other industries are just beginning to use urethanes with any frequency. Because of their durability and fast-curing nature, urethanes are coming into increasing use and should be more extensively investigated to ensure proper worker protection in the future. Several health hazard evaluations conducted by NIOSH in the past few years, and other reports, have indicated that exposure to free isocyanate may occur in the use and application of these paints (10-13). Also, a recently published PMR study of zinc chromate exposed painters in the aircraft overhaul industry has indicated an increased risk of lung cancer in these workers (16)..

Urethane (usually 2-part applied by handheld air apray) are the most frequently used topcoats; primers vary depending on the geographical area and type of aircraft service intended but often include zinc chromate and/or epoxy primers. Small parts painting is usually done in ventilated booths but whole aircraft (particularly large aircraft) are done in hangars with variable ventilation. Personal protection is extensively used due to the difficulties in using engineering controls. Principal potential exposures include solvents, lead and/or zinc chromate, methylene chloride (frequent in paint stripping formulations), and isocyanates (frequently in pre-polymer form).

Currently, a study to assess the feasibility of conducting a mortality investigation in the aircraft manufacturing industry is underway. Results

of the inquiry will be released within the next few weeks.

Construction/Maintenance Painting Studies of construction and maintenance painting would help to characterize exposures and disease processes in the single largest group of painters in the United States, and would include situations (along with wood finishing) similar to those in which non-professional painters may engage. Previous research is limited to the Mt. Sinai pilot study cited earlier, and several reports from Sweden which have indicated psychiatic and neurological changes among house painters (14-15).

Table 7 summarizes environmental findings from nine of the walk through surveys conducted at the eleven construction/maintenance sites. The 11 sites included visits to two contractor's offices to examine feasibility of using contractor records for a potential epidemiology study; actual working sites were not visited.

The remaining nine sites can be classified as new construction painting only, or maintenance painting only. Maintenance painting sites included four sites under five contractors, one of which involved a complex of commercial buildings, and three involved industrial maintenance painting. Maintenance painting of building complexes uses 70%-80% flat water based paints applied with roller or brush, and lesser quantities of solvent based enamels are used. The painting is often done in unventilated areas with inadequate or no respiratory protection and solvent exposures potentially could be quite high; it should be noted that some so-called "water base" paints do contain volatile toxics such as glycol ethers.

Maintenance painting in industry requires a large variety of paint types depending on the application, geographical area, etc., but typical were 2

system epoxy, latex, alkyd enamels, epoxy polyamides, and (at chemical/refinery locations) additional types such inorganic zinc primers, vinyls, and rarely, urethanes. They are usually applied by brush, or handheld air or airless spray, often in open areas (outdoors) or in closed rooms of spaces with variable ventilation and degree of respiratory protection. Potential exposure include solvents (MEK, Toluene, MIBK, Xylene, Methylene Chloride), inorganic zinc, chromates and (since these painters are often involved in surface preparation) silica from abrasive blasting. In general, respiratory protection and work practices were better controlled at the industrial sites.

Four sites of construction painting were also visited; two were power plants, (one coal, one nuclear), one was a nuclear waste treatment facility, and one was a large home/apartment complex. In the home/apartment painting, latex and alkyd enamel were applied by brush and roller in closed, unventilated spaces, and with little or no respiratory protection. At the power plant, 2 part epoxies are extensively used (particularly at the nuclear facilities) and are applied in rooms or spaces with variable ventilation by brush, roller, or spray. At the coal powered plant, polyurethane coatings and zinc chromate primers are also used. In all of the industrial construction sites, respirators of various types are available on demand, but are only occasionally required for specific jobs (e.g. tank lining, sandblasting). Potential exposures in home/apartment painting are primarily volatile organics, but in the case of the industrial construction painting, also include various solvents and zinc chromate and rarely NCO from polyurethanes, sensitizing agents (amines, glycidyl ethers) present in epoxies and free silica.

The mortality study of the membership of the International Brotherhood of Painters and Allied Trades (IBPAT) includes a cohort size of approximately 300,000. Deaths are identified through the death benefit and disability records available at the union. The anticipated number of deaths are estimated at 12,000 for the cohort. This population size should yield stable mortality rates even for rare causes of death.

IN-DEPTH STUDIES

In summary, three industrial categories were chosen for in-depth epidemiological study; namely wood furniture, aircraft, and construction/maintenance. The mortality studies will utilize the records of the IBPAT (the international painters union), the records of one large site in the aircraft industry, and those of possibly two or more sites in the wood furniture industry. In each of these categories, three plants or construction locations will be selected for participation in the comprehensive industrial hygiene surveys. In addition, industrial hygiene surveys will be conducted at approximately one representative site in each of the remaining industries, for a total of 15 surveys. Cross-sectional medical studies will be conducted as warranted following completion of the industrial hygiene surveys and the release of at least the preliminary findings of the mortality studies.

The planned studies should increase the available information concerning both the potential and existing hazards of paint application in the workplace. However, the studies will necessarily fall short of achieving an in-depth evaluation of all the hazards involved, given the inherent variability of conditions and processes between industries and even between

plants in the same industry.

Also, environmental conditions and paint processes have changed, and will continue to change, in many of the industries surveyed, making it difficult to correlate specific causes of death or illness with specific exposures. Evaluation of past exposures in many cases will rely on historical data obtained and kept by individual companies (sparse or nonexistent in many cases), and available histories of process changes, engineering controls, work practices, and use of protective equipment.

At the present time, the NIOSH contractor (Johns Hopkins University) is preparing a detailed protocol for the total in-depth study. This protocol will undergo extensive internal and external technical and statistical review.

We anticipate beginning the in-depth industrial hygiene and epidemiological studies in the fall of 1980. Cross-sectional medical surveys, if warranted, will begin approximately one year later and will be based on the findings of the industrial hygiene studies, and possibly on the basis of early results of the mortality studies. Given these parameters we estimate that the final report of the study will be released in mid-1982.

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INVESTIGATION OF HEALTH HAZARDS IN THE PAINTING TRADES

NIOSH CONTRACT 210-77-0096

THE JOHNS HOPKINS UNIVERSITY
SCHOOL OF HYGIENE AND PUBLIC HEALTH

1978 - 1982

SELECTED INDUSTRIES

1. Wood Furniture Finishing
2. Aircraft
3. Construction/Maintenance

IMPETUS FOR STUDY

1. Limited Research
2. Growing Concern About Hazards
3. Recent Studies
4. NIOSH Pilot Study (1975)

SCOPE

PAINTING INDUSTRY: "Those establishments which use coating products in the finishing of manufactured products and in new construction, building maintenance, and rehabilitation".

PAINT: "A mixture of pigment or vehicle (as oil or water) which can be applied or spread over a surface to form a thin film or coating which adheres to the substrate (base material)".

SITE SELECTION

DECISION SCHEME:

1. Select Coatings for Study by Resin Type
2. Survey Industrial Use
3. Survey Populations Available

SITE SELECTION

INDUSTRIAL USE:

1. Resin/Paint Type Used
2. Volume of Use
3. Extent of Exposure
   a. Application Method
   b. No. Current Painters
   c. Projected Usage

SITE SELECTION

POPULATION AT RISK

1. Population Size and Stability
2. No. of Years of Painting (Plant Age)
3. Records

TABLE 1

IBPAT TRADE MEMBERS

Trade	Reported Symptoms	Trade	Reported Symptoms
1. General Painter	CNS, X-ray changes	6. Sandblasters	CNS, respiratory, X-ray changes
2. Drywall Construction Workers		7. Glaziers	
3. Wood Finishers		8. Sign Painters	
4. Metal Painters	CNS, respiratory	9. Scenic Artists	
5. Paint Factory Workers		10. Carpet Layers	

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TABLE 2

ESTIMATED TOTAL CONSUMPTION OF RESINS IN PAINTS AND COATINGS - 1974

(Millions of Pounds)

Alkyd	750.0
Vinyl (Water-based)	292.0
Acrylic (Water-based)	228.9
Acrylic (Powder)	90.0
Epoxy (Reactive)	76.6
Amino	73.7
Vinyl (Solvent-based)	64.1
Acrylic (T/P Solvent)	62.0
Linseed Oil	57.6
Cellulosic (Solvent-based)	55.1
Urethane (Reactive)	48.4

TABLE 3

WALK THROUGH SURVEYS

	Industry	No. of Sites
1.	Aircraft Manufacturing	5
2.	Wood Furniture	5
3.	Major Appliance Manufacturing	5
4.	Metal Furniture and Fixtures	5
6.	Large Transportation Equipment	5
7.	Shipbuilding	4
8.	Automobile O.E.M.	5
9.	Construction/Maintenance	11
10.	Mortality Study - IBPAT	--
	Total	50

Table 4

Industry	Total Painters and Halo #	%	Method of Application	Potential Exposure	Personnel & Other Records
1. Auto O.E.M.	31,590	9	Manual Air Spray Dipping	Probably Low	Adequate
2. Large Transport Equipment	5,020	2	Manual Spray Dipping Flow Coating	Highly Variable	Adequate
3. Aircraft	3,780	3.5	Manual Air Spray	Highly Variable	Adequate in two
4. Shipbuilding	4,260	3	Manual Spray (air, airless)	Variable	Poor to Adequate
5. Railroad Equip.	1,000	2.7	Manual Air Spray	High	Poor to Adequate
6. Wood Furn.	21,632	16.9	Manual Spray (air, airless)	Medium	Adequate
7. Metal Furn.	8,213	4.3	Automatic Manual Spray	Low	Marginal
8. Appliances	4,740	3.0	Auto Electrostatic, manual Electrostatic	Low	Marginal
9. Construction/ Maintenance	195,000	N.A.	All	Highly Variable	N.A.

TABLE 5

WOOD FURNITURE FINISHING

Previous Research - Limited

Resin Type - Nitrocellulose Lacquers (20 + years use)

Application Method - *Handheld Conventional, air or airless Spray Techniques;
*Back Draft Booths

Personal Protection - *Minimal, Heavy Reliance on Engineering Control

Hazards - *Aliphatic, Aromatic Hydrocarbons
*Ketones
*Other Solvents

Cohort Availability - *Relatively Sckilled Worker Stays in Same Type Job;
*Many Halo Exposures
*Followup to 30 Years
*Estimated 4500-5000 Persons

TABLE 6

AIRCRAFT MANUFACTURING

Previous Research - *Health Hazard Evaluations
*PMR Study of Zinc Chromate Exposed Workers (16)

Resin Type - Urethane Topcoats (20 + years use)
Zinc Chromate, Epoxy Primers

Application Methods - *Handheld, Conventional Air Spray
*Booths or Large Hangars

Personal Protection - Used Extensively

Hazards - *Urethanes (NCO, frequently pre-polymer)
*Lead
*Zinc Chromate
*Solvents
*Methylene Chloride

Cohort Availability - Feasibility Assessment

TABLE 7

CONSTRUCTION-MAINTENANCE

IBPAT MORTALITY

Previous Research - *Pilot Study by Mt. Sinai (1975)
*Scandinavian Studies of House Painters

	Maintenance	Construction
Resin Type -	*Alkyds	*Alkyd
	*Acrylics	*Acrylic
	*Vinyls	*Vinyl
	*Epoxy; Epoxy Polyamide	*Epoxy (Reactive)
	*Urethane	*Urethane
	*Inorganic Zinc Primers	*Zinc Chromate Primers

Application - Varies with Job Requirements

Personal Protection - Variable, Available but not Required

Hazards -	*Solvents	*Solvents
	*Inorganic Zinc	*Zinc Chromate
	*Chromate	*NCO (rare)
	*Silica	Silica
	*NCO	Sensitizing Agents
	*Sensitizing Agents (Amines, Gycidyl Ethers)	

Cohort Availability - 300,000 Current and Previous Union Members; Potentially 12,000 Deaths

Discussion

Dr. Keefer (NCI): On one of your slides, you singled out methylene chloride which is used so much in stripping operations. It was listed together with several other chemicals that I though were known to be particularly hazardous. Do you have any comments on the toxicity and hazards associated with methylene chloride itself? I am back two or three years ago when some of the people from Dow and elsewhere, I think, cleared the material as a carcinogen. I just wondered if you have any special reasons for indicting it in this way.

Mr. Zaebst (NIOSH): The list of chemicals shown in the slide just gave some examples of some of the hazards seen. Methylene chloride has been studied in several NIOSH health hazard evaluations involving several different aircraft overhaul and construction facilities. Overexposures were found. As far as the toxicology, I believe that it should be looked at in more detail.

Dr. Bridbord (NIOSH): We do have some time for discussion, if anyone would like to comment on any of the four papers or ask additional questions. Please come to the microphone, if you do.

Dr. Kraybill (NCI): I would like to ask a question of Larry Keefer. Methylene chloride is now being tested and I was not familiar with the Dow statement. Did they clear methylene chloride? They did a study?

Dr. Keefer (NCI): All I recall is that Chemical Engineering News a few years ago had a small column which said that Dow's recent studies show that methylene chloride is not carcinogenic. Other than that, I really cannot say. I have not seen any original data.

Dr. Cantor (EPA): I do not think that they ever published that information I think they made it available through a testing program. It was a small local inhalation study. It was more pharmacokinetics than anything else. I think it was a simple bioassay. The NCI testing program had methylene chloride on test halfway through a two year gavage study. I think they were right in the process of starting a new study.

Dr. Keefer (NCI): I have a news clipping. You can read it if you would like. But that is all I have.

NIOSH

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