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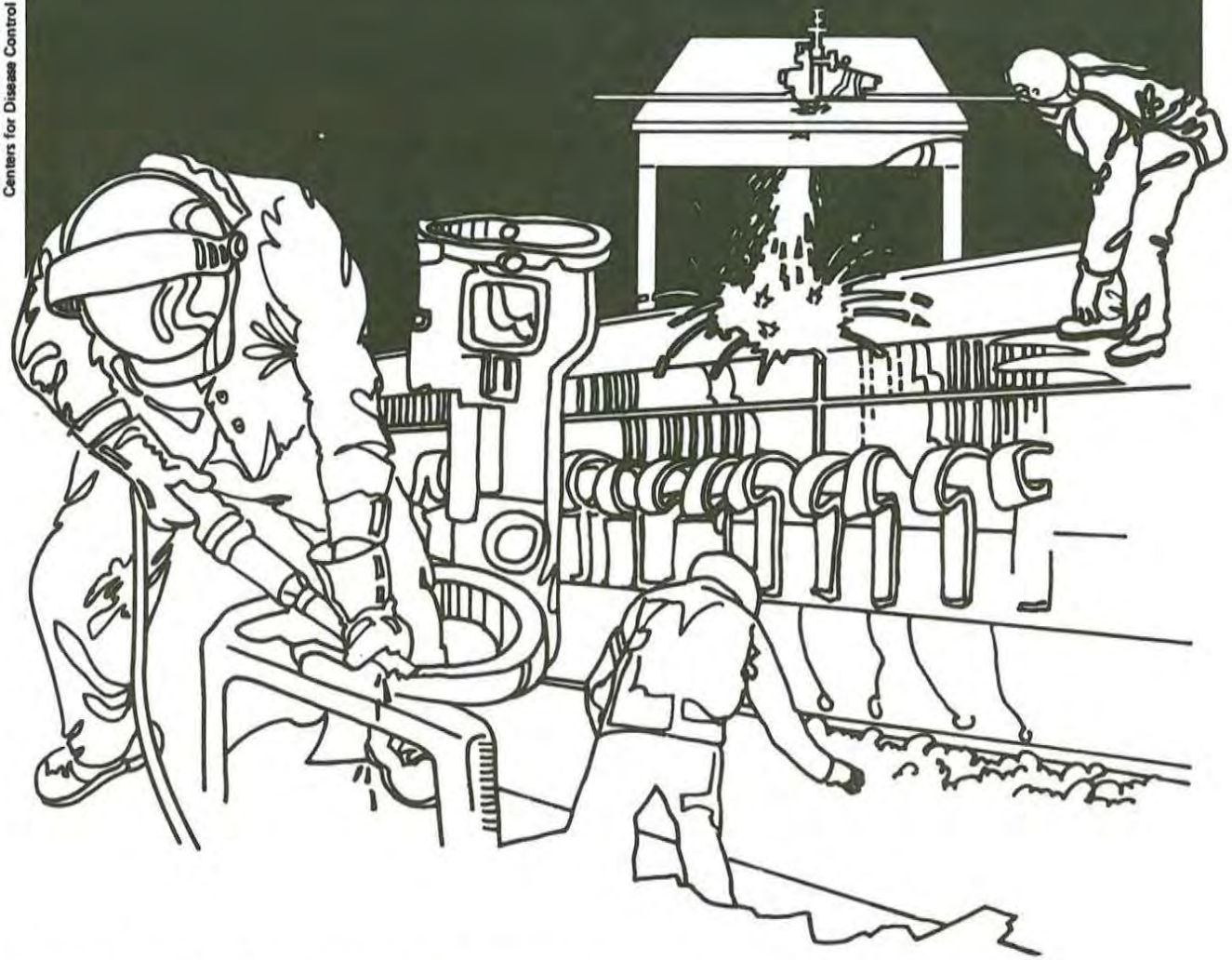

Health Hazard Evaluation Report

HETA 82-391-1303
MITCHELL PLASTICS, INC.
CHESWICK, PENNSYLVANIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial nygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 82-391-1303
May 1983
MITCHELL PLASTICS, INCORPORATED
CHESWICK, PENNSYLVANIA

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I. SUMMARY

In September 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate formaldehyde exposure of mold press operators during the injection molding of acetal resin at Mitchell Plastics, Incorporated, Cheswick, Pennsylvania. Health complaints reported by the workers included headaches, sore throats, and skin rashes.

On November 8-10, 1982, NIOSH conducted a combined environmental and medical evaluation at the plant. A bulk sample of Celcon® acetal resin was obtained and qualitatively analyzed at operating temperatures for formaldehyde and other volatile substances. Air samples for formaldehyde were collected, two each from the Celcon® mold press operator, and directly above the mold head, where maximum concentrations were expected. Two area air background samples were also collected from the main office and outdoors. Medical interviews were conducted with 18 workers from the molding department to relate worker exposure with reported health effects.

Analysis of the emission products generated during heating of the resin at normal operating temperatures indicated that formaldehyde was the major decomposition product. Therefore, environmental sampling was limited to formaldehyde. Air samples for formaldehyde ranged up to 0.084 ppm; the highest levels were measured in samples from the mold press operators. Progressively lower levels were measured in samples obtained from the mold head, main office and outdoors. The levels measured for the mold press operators are below those which would normally produce irritative symptoms in exposed workers. NIOSH currently recommends that formaldehyde be handled as a potential human carcinogen, with exposures kept as low as feasible. The current OSHA permissible exposure limit is 3 ppm as an 8 hour time-weighted average.

NIOSH interviewed all employees who worked near the Celcon® mold press. While eye irritation was the most frequent health problem reported by press operators (40%), the prevalence of throat irritation for the same group was low (10%). This pattern of health effects is atypical for exposure to low formaldehyde concentrations, which more commonly causes noticeable dryness of the nose and throat and only moderate eye irritation.

Based on the information obtained during the survey, NIOSH has determined that the mold press operators running Celcon® acetal resin were not exposed to airborne formaldehyde concentrations high enough to cause substantial irritant effects. Recommendations to prevent skin rashes due to resins and fibrous glass are presented in Section VIII of this report.

KEYWORDS: SIC 3070 (Miscellaneous Plastic Products), formaldehyde, Celcon®, acetal resin, injection molding, skin rashes.

II. INTRODUCTION

On September 27, 1982 the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from a representative of Local 46 - International Molders and Allied Workers Union. The requestor was concerned about potential worker exposure to formaldehyde during the injection molding of acetal resin at Mitchell Plastics, Incorporated, Cheswick, Pennsylvania. Workers were reportedly experiencing headaches, sore throats and skin rashes.

On November 8-9, 1982, NIOSH investigators conducted a combined industrial hygiene and medical evaluation at the plant. Environmental samples for formaldehyde were collected and a bulk sample of acetal resin was obtained for subsequent laboratory testing at operating temperatures. Medical questionnaires were administered to employees in the molding department to determine work related health problems.

A summary of survey activities and findings were presented to both company and union representatives in letters dated November 12, 1982 and February 10, 1983.

III. BACKGROUND

A. Plant Description

Mitchell Plastics, Incorporated (MPI), Cheswick, Pennsylvania, produces a variety of custom plastic products by injection molding. MPI has been in operation since 1965 and has been at its present location since 1978. The company has been using acetal resins, namely Celcon® and Delrin®, for about 12 years, and to their knowledge this has been the first time workers had complained about their use. (Celcon® and Delrin® are trade names of Celanese Chemical Company and E.I. Du Pont de Nemours Company, respectively.) At the time of the evaluation Celcon® was the only acetal resin being molded; its use was scheduled especially for the NIOSH evaluation. The resin was used in one injection molding machine to make a relatively small part (ratchet for helmet visor). No more than two molding machines are used at any given time to make products from acetal resin. Other plastics molded during the survey included polyurethane and polycarbonate.

The plant employs 16 production workers including 10 mold press operators, 4 material handlers and set-up persons, an inspector, and a shipper. The mold press operators normally rotate machines on a daily basis. Production spans 3 shifts/day, 5 days/week.

B. Process Description

Acetal resin, in pellet form, is mixed with reground scrap and manually added into a heated hopper (80-85°C) above a reciprocating screw injection molding machine. The heated pellets are screw fed into a heated chamber (190 to 200°C) yielding a viscous liquid. In this form the resin is injected into a water-cooled mold (30-35°C) where it conforms to the interior cavity of the mold. After a specified time, the mold opens and the molded part is removed, trimmed, and bulk packaged for subsequent shipment to the customer.

IV. METHODS AND MATERIALS

A. Environmental

The evaluation of thermal decomposition products was made from bulk sample, and personal and general air sample analyses. A bulk sample of Celcon® resin was qualitatively analyzed for volatile components released at molding temperatures. The air samples were collected from the mold press operator and directly above the mold head, which appeared to be the most likely potential source of vapor release during the molding operation. Since formaldehyde is a ubiquitous environmental contaminant, air samples also were collected from the main office area and outdoors for comparison.

1. Analysis of Bulk Samples

Celcon® resin pellets were submitted for thermogravimetric (TGA) and gas chromatographic/mass spectrographic (GC/MS) analyses. Thermogravimetric analysis was conducted in duplicate on resin samples, each consisting of two pellets (approximate weight of each sample was 28 milligrams). The samples were placed on a Du Pont Model 950 Thermogravimetric Analyzer and heated at a rate of 10°C/min. to about 195°C, the temperature of the hottest region of the injection molding machine. After equilibrium, an isothermal, time-based program was initiated and continued for five hours. Sample weighings were recorded after 2, 4 and 5 hours of heating.

GC/MS analyses were employed to provide a qualitative assessment of volatile decomposition products released at molding temperatures. A sample of the resin was placed in a micro-tube furnace operating at approximately 200°C. As the sample was heated at this temperature an inert gas (argon) was passed over the heated sample and into one of four sampling devices - a direct reading formaldehyde detector tube, a charcoal tube, a silica gel tube, and a benzylethanolamine (BEA) coated XAD-2 resin tube. Sampling flow rates ranged from 0.10 to 0.40 liters per minute (lpm). The charcoal tube, silica gel tube, and BEA coated tube were desorbed with carbon disulfide, ethanol, and isooctane, respectively. These samples were analyzed by gas chromatography (equipped with a flame ionization detector) using a 30 meter DB-1 fused silica capillary column (splitless mode). The samples were further analyzed by GC/MS.

2. Analysis of Air Samples

During the two day survey NIOSH collected eight air samples for formaldehyde, one each day from the mold press operator, mold head, main office, and outdoors. These eight samples were collected using midget impingers containing 20 milliliters of 1% sodium bisulfite solution. The impingers were connected to a personal sampling pump calibrated at a flowrate of 1.0 lpm. The solution was analyzed spectrophotometrically according to NIOSH Method P&CAM 125.[1] The limit of detection for the analysis was reported at 0.002 milligrams per sample.

B. Medical

NIOSH administered a non-directed medical questionnaire on an individual basis to all employees who worked near the Celcon® injection mold press. The purpose of the questionnaire was to identify how many employees during the preceding year had experienced eye, nose, or throat irritation suggestive of formaldehyde exposure.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Formaldehyde

The health effects of formaldehyde can result from acute or chronic exposure. The effects of acute exposure are primarily mucous membrane irritation. Symptoms first noted include eye and upper respiratory tract irritation (burning, tearing eyes; nose and throat irritation). These symptoms can occur as low as about 0.1 part per million (ppm).[2] Dermatitis associated with formaldehyde vapor, solutions or formaldehyde-containing resins has been documented.[2,3] Formaldehyde is a primary skin irritant but may also cause allergic dermatitis in concentrations below those likely to cause primary irritant effects.

Allergic effects include skin sensitization and possibly, asthma or asthma-like symptoms.[4,5] There is considerable evidence that formaldehyde can produce skin sensitization in man, especially in persons occupationally exposed through skin contact.[6] Eczematous contact dermatitis, when acute, is characterized by redness, swelling, vesiculation and oozing with itching. In the chronic form, affected areas of the skin may become dry, thickened, and fissured.[7]

The National Research Council's Committee on Toxicology suggested that less than 20% of an exposed human population would react to formaldehyde concentrations below 0.25 ppm with slight irritation of the eyes, nose and throat and possibly a slight decrease in nasal mucous flow.[3] At present, there is no evidence of a threshold level for the irritant effects of formaldehyde in human populations.

A recent study conducted by the Chemical Industry Institute of Toxicology (CIIT) in which rats and mice exposed to formaldehyde vapors developed nasal cancer has raised concerns about its carcinogenic potential in humans.

The current OSHA standard for formaldehyde exposure is 3 ppm, as a time-weighted average (TWA) for an 8-hour workday. On the basis of the CIIT study findings ACGIH and NIOSH currently recommend that formaldehyde be treated as a potential human carcinogen. ACGIH currently proposes a TLV of 1 ppm as a ceiling limit.[9] NIOSH, however, recommends that exposures be reduced to the lowest feasible level.

VI. RESULTS AND DISCUSSION

A. Environmental

1. Bulk Sample Analysis

Thermogravimetric analysis of the bulk sample of Celcon® resin revealed that the sample lost weight at an increasing rate during the five hour heating period at 192°C. After two hours the sample lost an average of 1.6% of its weight; after four hours, 8% of its weight; and after five hours, 21% of its weight. Weight loss during the TGA analysis indicated sample decomposition i.e., production of volatile gases and vapors.

GC/MS analyses of vapors generated during controlled heating of the Celcon® resin (at approximately 200°C) indicated that formaldehyde was the major constituent. The formaldehyde detector tube gave a very rapid and positive reaction for formaldehyde. Moreover, a large amount of the formaldehyde reaction product (3-benzyloxazolidine) was detected and identified on the BEA coated tube. Except for possibly a small amount of acetaldehyde, no other aldehydes were detected. The only other minor components detected on the charcoal and silica gel tubes were trioxane (a cyclic trimer of formaldehyde, $C_3 H_6 O_3$) and possibly some higher molecular weight polymeric trioxane units.

2. Analysis of Air Samples

Formaldehyde air sampling results are presented in Table I. Detectable levels were measured in seven of the eight air samples, with concentrations ranging from 0.005 to 0.084 ppm. The highest levels were measured in samples collected from the mold press operators, with progressively lower levels measured for the air samples collected from above the mold head, main office, and outdoors. The air levels were well within the current OSHA standard of 3 ppm and the current ACGIH TLV of 1 ppm, which were primarily set to prevent irritation symptoms.

In reviewing the air sampling data it is interesting to note that the formaldehyde levels for the personal samples were higher than the levels measured at the mold head. The higher exposure levels for the mold press operators may suggest that workers are being exposed to formaldehyde from other sources. One likely source could be from cigarette smoke present in the break room. Since the operators wore the sampling devices the entire shift including breaks it is possible that the samples picked up formaldehyde from cigarette smoke present in this area. Although no measurements were taken in the break room, estimates of formaldehyde levels from the burning of cigarettes in confined areas have been reported in the range of 1.5 to 2.1 ppm.[10] Another study reported formaldehyde levels up to 0.23 ppm in a 30 M^3 chamber after five cigarettes were smoked.[3]

The findings of this survey demonstrate that the injection molding of Celcon® resin under normal operating conditions presents no acute health hazard to mold press operators. This corroborates the finding of a previous NIOSH health hazard evaluation conducted at a facility also engaged on the injection molding of Celcon® acetal resin.[11]

Generally speaking, volatile emissions from injection molding operations are usually not a problem because of the strict quality control measures required for production. The virtually enclosed nature of the process minimizes the release of volatile decomposition products such as formaldehyde. It is usually under upset conditions for example, where the mold is overheated, that thermal decomposition is a problem. This would be immediately obvious since it would result in a defective product. Although no testing was conducted with Delrin®, similar results would be expected since both resins are generically the same.

B. Medical

Employees who work near the Celcon® mold press include press operators (10), material handlers and process set-up men (4), and supervisors and managers (4). The mean ages of these groups were 39, 23, and 36 years, respectively, and their mean job durations were 8.9, 4.0, and 9.5 years, respectively. All press operators were female; all material handlers, set-up men, supervisors, and managers were male.

During the previous year, seven employees experienced at least one health problem which might be consistent with exposure to a chemical irritant. Of the three material handlers, one reported a facial rash when working with fibrous glass and a forearm rash when working with certain pelleted plastics containing a blue dye. Another material handler reported an elbow rash which he associated with no specific exposure. Five of the ten press operators experienced at least one of the following: burning eyes (4), headache (2), dry throat (1), nasal discharge (1), or skin rash (1). Two operators sought medical help for eye irritation.

Rotation of all operators among the various plastic injection mold presses is routine, with the amount of time spent at each machine varying from a few days to a few weeks, depending on the product. A comparison group of operators with no exposure to the Celcon® injection process thus was unavailable. Of all job groups, however, press operators spend the most time working in close proximity to the injection process and therefore have the greatest exposure to formaldehyde vapors associated with the process. Four operators (40%) reported eye irritation. Of these, one reported constant eye irritation whenever working with the Celcon® resin; two reported occasional eye irritation; and one reported an ongoing history of eye irritation, with onset prior to employment at this factory. When considered as a group, these reports are consistent with operator exposure to an irritant vapor. This exposure, however, does not necessarily involve formaldehyde, as only one press operator reported a dry throat and another reported a runny, rather than a dry nose. Formaldehyde vapors at higher concentrations (0.5 - 1.5 ppm) than those documented in this factory typically produce noticeable dryness of the nose and throat in addition to moderate eye irritation.[3] In view of the low formaldehyde levels measured, the prevalence and spectrum of health effects reported by press operators suggest that their eye irritation and other symptoms may be due to some vapor other than formaldehyde. GC/MS analyses of the Celcon® resin indicated that a trace of acetaldehyde is emitted on heating; this emission, however, would be well below the lowest level (50 ppm) associated with irritant effects. Eye irritation among press operators at this factory remains unexplained.

VII. RECOMMENDATIONS

1. Material handlers should wear gloves when working with fibrous glass or other known contact irritants.

2. Formaldehyde should be regarded as a potential human carcinogen. Exposures should be kept as low as practicable, consistent with the levels present during the time of the NIOSH survey, through the continued use of engineering and administrative controls.

VIII. REFERENCES

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1. Mitchell Plastics, Incorporated, Cheswick, Pennsylvania
2. International Molders and Allied Workers Union, Local 46
3. International Molders and Allied Workers Union, Headquarters
4. NIOSH, Region III
5. OSHA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table I

Formaldehyde Concentrations

Mitchell Plastics, Incorporated
Cheswick, Pennsylvania
HETA 82-391

November 9-10, 1982

Date	Sample Description	Sample Time (min.)	Sample Volume (M^3)	Formaldehyde Concentration (ppm)
11-9-82	Operator, Mold Press #12	475	0.475	0.084
11-10-82	Operator, Mold Press #12	400	0.400	0.059
11-9-82	Process Sample, Above Mold, Press #12	467	0.467	0.049
11-10-82	Process Sample, Above Mold, Press #12	420	0.420	0.052
11-9-82	Area Sample, Main Office	460	0.460	0.032
11-10-82	Area Sample, Main Office	400	0.400	0.031
11-9-82	Area Sample, Front Lawn	330	0.330	<0.006
11-10-82	Area Sample, Front Lawn	400	0.400	0.005

Evaluation Criteria: see text

Analytical limit of detection (ALOD): 0.002 mg/sample
Environmental limit of detection: ALOD divided by sample volume

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