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JUNE 1991
RUBBERMAID, INC.
REYNOLDS, INDIANA

NIOSH INVESTIGATORS:
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I. SUMMARY

On May 7, 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from a management representative of Rubbermaid, Inc., Reynolds, Indiana. This plant manufactures thermoset microwave cookware and other molded plastic products. NIOSH evaluated potential exposures to ***styrene*** and ***formaldehyde*** in the Compounding and Pressroom Departments, and ***total and respirable dust*** in the Compounding Department.

On May 24, 1990, NIOSH investigators conducted a walk-through survey of Rubbermaid. On June 19 NIOSH conducted an initial health hazard evaluation at Rubbermaid for the contaminants listed above. Two short-term (24-minute samples) ***styrene*** exposures were measured to be 186 and 142 parts per million (ppm). These exceeded both the NIOSH and the Occupational Safety and Health Administration (OSHA) short-term criteria of 100 ppm. Two full-shift exposures were both 8 ppm, and 11 area styrene samples ranged from <1 to 3 ppm. Seven area samples collected in the Pressroom for ***formaldehyde*** ranged from 0.5 to 1.0 ppm, and averaged 0.6 ppm. A two and one-half hour personal breathing zone (personal) sample for ***total dust*** showed a 31 milligram per cubic meter (mg/m^3) result.

A second follow-up evaluation was performed on August 2, 1990. Personal and area samples for airborne ***styrene*** were collected in the Compounding and Pressroom Departments. Concentrations in the Pressroom were quite low (<1 to 7.6 ppm). The highest personal exposure was 7.6 ppm. Personal exposure concentrations of 29.0 and 32.0 ppm were measured in the Compounding Department. These are all below the NIOSH Recommended Exposure Limit (REL) and OSHA Permissible Exposure Limit (PEL) of 50.0 ppm. ***Formaldehyde*** levels in the Compounding room were 0.1 (area sample) and 0.2 (personal sample) ppm. Measurements in the Pressroom showed area concentrations of 0.2, 0.5, and 0.8 ppm, and personal exposures ranging from 0.3 to 0.6 ppm (0.5 ppm average). NIOSH recommends that formaldehyde exposure be reduced to the lowest feasible limit. All measurements were below the OSHA PEL of 1.0 ppm (8-hour time-weighted average). Personal ***respirable dust and total dust*** exposures to the

melamine compounding powder were 0.4 and 7.7 mg/m³ respectively. These are below the OSHA PELs and the American Conference of Governmental Industrial Hygienists' (ACGIHs) Threshold Limit Values (TLV).

Based on the results of these evaluations, it was determined that short-term exposures to styrene and full-shift exposures to formaldehyde pose potential health hazards to workers at this plant. Personal protective equipment and ventilation controls are recommended.

KEYWORDS: SIC 3089 (Plastics Products), styrene, formaldehyde, melamine, polyester resin, dust, thermoset cookware, ventilation.

II. INTRODUCTION

On May 7, 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from a management representative of Rubbermaid, Inc., Reynolds, Indiana. Rubbermaid manufactures thermoset microwave cookware and other molded plastic products at this plant. NIOSH was requested to evaluate airborne concentrations of total and respirable dust, formaldehyde, and styrene. No health effects were reported in the request.

On May 24, 1990, NIOSH investigators conducted a walk-through survey of the plant. On June 19 a follow-up evaluation was conducted. Personal breathing zone (**PBZ**) and area samples for styrene and dust, and area samples for formaldehyde were collected in the Compounding, Pressing, and Product Process Departments. The results from this evaluation were reported in August 14, 1990, by letter report (enclosed in Appendix A).

On August 2, 1990, NIOSH investigators conducted a second follow-up evaluation to measure personal formaldehyde exposures, and further evaluate styrene and dust exposures. This report will present the overall findings from this evaluation.

III. BACKGROUND

The Rubbermaid, Inc., facility in Reynolds, Indiana is a single story building where about 175 people are employed, of whom 150 work in production areas, manufacturing thermoset (irreversibly hardened) plastic cookware products.

The production area is divided into three departments (Figure 1). In the Compounding Department, the primary constituents of the plastics are weighed, mixed, blended, extruded and placed in crates for transport to the Pressroom Department where they are molded into the desired shape. Pieces are then sent to the Product Process Department where parts are trimmed and packaged. The office area (adjacent to production) is used by about 25 employees for administrative and research purposes.

The highest potential for exposure to airborne styrene was in the Compounding Department where styrene-containing polyester resins are used. These resins are dispensed from a 55 gallon drum, into a blade mixer, and then blended with catalyst, filler, modifier, pigments, reinforcer, and shrink control materials to form the primary batch. The blade mixer was equipped with local exhaust ventilation. The primary batch is manually dumped from the mixer into a cart for transport to an extruder. The material is fed into the extruder, cut to the desired length by the extruder operator, and placed in cartons for transport to the pressroom.

The highest potential for exposure to airborne formaldehyde was in the Pressing Department where melamine-based tablets are compressed with

heated dies into desired products. Formaldehyde gas is evolved as a product from the breakdown of melamine during this process. All but two of the presses (G1 and G2 in Figure 1) had some type of local exhaust ventilation. Before the melamine tablets were placed in the press they were preheated for about a minute in small ovens near the presses. When these ovens were opened there was also the potential for exposure to airborne formaldehyde. All but one of these ovens had local exhaust ventilation on two sides. One oven had an exhaust on only one side.

The melamine-based tablets were formed in an enclosed room (pre-form room) in the Compounding Department, equipped with a plastic curtain at the entrance to prevent dust from escaping to the rest of the Compounding Department. Melamine powder was fed to a press from a bin in the room through a vacuum apparatus on the roof of the room. After the powder was compressed into tablets, they were taken by the operator and stacked into crates for transport to the Pressing Department. A protective suit and respirator were provided for this press operator. Their use was at his discretion. Rubbermaid had no respiratory protection policy (as described in CFR 29, Part 1910, §1910.134) in place at this facility.

IV. EVALUATION DESIGN AND METHODS

Nine full-shift samples were collected for styrene (five general area and four personal exposure) and 10 full-shift samples were collected for formaldehyde (four general area and six personal exposure). Four dust samples were collected, two general area and two personal exposure (one total dust and one respirable dust sample of each kind).

Airborne styrene samples were collected on a solid sorbent tube (150 milligrams (**mg**) of activated charcoal) connected via Tygon™ tubing to battery-powered vacuum pumps calibrated at a flow rate of 0.2 liters per minute (**ℓpm**). The charcoal tubes were analyzed utilizing gas chromatography (**GC**) and a flame ionization detector (**FID**) according to NIOSH method 1501.[1] Styrene was desorbed from the charcoal using a toluene, carbon disulfide mixture (99:1). The sample was separated using a 30 meter (**m**) x 0.32 millimeter (**mm**) fused silica capillary coated column. The limit of detection (**LOD**) was 0.01 mg per sample. The limit of quantitation (**LOQ**) was 0.03 mg per sample (0.08 parts per million (**ppm**) for a 85 ℓ sample).

Airborne formaldehyde was collected on a solid sorbent tube (Orbo-23) connected via Tygon™ tubing to battery-powered vacuum pumps calibrated at a flow rate of 0.05 ℓpm. These sorbent tubes were analyzed via GC/FID according to NIOSH method 2541.[2] The LOD was 1 microgram (**µg**) per sample. The LOQ was 3.0 µg per sample (0.11 ppm for a 23-ℓ sample). Area and personal samples for total and respirable dust were collected on tared 37-mm filters connected via Tygon™ tubing to battery-powered pumps. The total dust pumps were calibrated at a flow rate of 2.0 ℓpm. Sample weights were determined by weighing the samples and filters on an

electrobalance and subtracting the tare weights of the filters (NIOSH method 0500[3]). The air samples for respirable dust were collected on filters mounted in 10-mm Dorr-Oliver nylon cyclones, which remove the non-respirable particles (particles >10 microns (**µm**) mass median diameter) from the sample air stream (NIOSH method 0600[4]). The pump for the respirable fraction was calibrated at 1.7 ℓpm. The LOD for both methods was 0.01 mg per sample (0.014 mg/m³ for a 700-ℓ sample).

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH investigators 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).

Three primary sources of environmental evaluation criteria are used in judging workplace exposures. 1) NIOSH Criteria Documents and Recommended Exposure Limits (**REL**), 2) the American Conference of Governmental Industrial Hygienists' (**ACGIH**) Threshold Limit Values (**TLV**), and 3) the Occupational Safety and Health Administration (**OSHA**) Permissible Exposure Limits (**PEL**).[5,6,7]

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 (**STEL**) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

A. Styrene

Styrene is readily absorbed by the respiratory and gastrointestinal systems and by the skin. Exposures to styrene have caused central nervous system depression; subjective complaints included headache, fatigue, sleepiness, nausea, malaise, difficulty in concentrating, and a feeling of intoxication. Decrements in balance, coordination, and manual dexterity tests have also been reported, as have slower reaction times and abnormal Electroencephacograms (EEGs). Styrene vapor is also an irritant to the eyes and upper respiratory system, and liquid styrene is a skin irritant. Various clinical studies have suggested that styrene exposure has affected liver function.[8]

Limited human data suggest that styrene might be teratogenic, but several studies with experimental animals indicate that it is not. Most,

but not all, in vitro studies suggest that styrene is not mutagenic, but some mammalian studies, including observations of several groups of styrene workers, suggest cytogenic changes may result from working with styrene. An increased rate of spontaneous abortions was observed in one group of fiberglass reinforced polyester workers, but not in another group. Styrene has been associated with an increase in lung tumors (although not consistently among species) in two experimental animal studies, while another study showed an elevation, though not statistically significant, in the combined incidence of leukemia and lymphosarcoma in female rats. Mortality studies of styrene workers have shown no excesses in overall cancer incidence. However, excesses of deaths, though not statistically significant, have been reported in the specific cancer categories "Lymphatic and Hematopoietic, except Leukemia" and "Leukemia."[8]

Most of the styrene absorbed by humans is excreted in the urine as mandelic and phenylglyoxylic acids, and the urinary concentrations of the two or of just mandelic acid reflect amounts of styrene absorbed through the respiratory tract and through the skin (as well as through the gastrointestinal tract, if poor hygiene and work practices allow ingestion).[8]

The current OSHA PEL for styrene is 50 ppm as an 8-hour TWA, with a STEL of 100 ppm.[7] The ACGIH and NIOSH criteria for styrene are the same as the OSHA Standard.[5,6]

B. Formaldehyde

Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat, and nose; headaches; nausea; congestion; asthma; and skin rashes. It is difficult to ascribe particular health effects to specific concentrations of formaldehyde to which people are exposed, because of variability in subjective responses and complaints. Irritation symptoms may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperreactivity developed specifically to formaldehyde are uncommon.[9]

Formaldehyde vapor has been found to cause a rare form of cancer in Fischer 344 rats exposed to a 15 ppm concentration for 6 hours per day, 5 days per week, for 24 months. Whether these results can be extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot be drawn with sufficient confidence from published mortality studies of occupationally exposed adults as to whether or not formaldehyde is a carcinogen. Studies of long-term human occupational exposure to formaldehyde

have not detected an increase in nasal cancer. Nevertheless, the animal results have prompted NIOSH to recommend that formaldehyde be considered a potential occupational carcinogen and that workplace exposures be reduced to the lowest feasible limit.[10]

OSHA has recently reduced its PEL for formaldehyde to 1.0 ppm as a TWA during an 8-hour shift, with a 0.5 ppm action limit. In addition, a 15-min STEL was set at 2.0 ppm.[7] The ACGIH has given formaldehyde an A2 designation, indicating that ACGIH considers formaldehyde a suspected human carcinogen. The ACGIH TLV/TWA for formaldehyde is 1.0 ppm and the TLV/STEL is 2.0 ppm.[6] The ACGIH has issued a Notice of Intended Change for formaldehyde of 0.3 ppm for a TLV/TWA.[6] If, after two years, no evidence comes to light that questions the appropriateness of the proposed change, the value will be considered for adoption into the TLV listing.

C. Nuisance Particulate

Nuisance particulates refer to a number of non-fibrogenic dusts or particulates which are common air contaminants and, as such, are normally found in the occupational environment. The potential for eliciting adverse health effects is primarily dependent on the diameter of the inhaled dust particle. The human respirable range for particulate matter is generally considered to extend from 0.5 to 5.0 µm; only a few dust particles greater than 5.0 µm in diameter will be deposited in the respiratory tract, while particles less than 0.5 µm leave the lung without producing local adverse health effects. Inhalation of nuisance particulates normally will not cause adverse effects in the lung; however, excessive airborne concentrations may reduce visibility in the work environment and may also promote irritation of the eyes, nose, throat and lungs.

NIOSH currently supports the ACGIH 8-hour TWA/TLV of 10 mg/m³ for total dust containing no asbestos and less than 1% crystalline silica.[5] The present OSHA standard is 15 mg/m³ for total dust, or 5 mg/m³ for respirable dust and is also expressed as an 8-hour TWA exposure.[7]

VI. RESULTS

PBZ and area sample results for styrene, formaldehyde and dust are presented in Tables 1-3. NIOSH RELs, ACGIH TLVs and OSHA PELs are referenced at the bottom of each table.

Table 1 presents airborne styrene concentrations measured in both departments. The four PBZ samples collected for styrene range from 1.6 to 32.0 ppm. The five area samples range from 0.71 to 19.0 ppm. The highest personal exposure was in the Compounding Department. None of the styrene concentrations exceed the NIOSH REL of 50.0 ppm.

Table 2 presents PBZ and area airborne formaldehyde concentrations measured in the Compounding and Pressroom Departments. The area concentration measurements ranged from 0.1 to 0.8 ppm, with the highest concentration occurring in the Pressroom near the presses. Personal exposures ranged from 0.2 to 0.6 ppm, and averaged 0.5 ppm. NIOSH recommends that exposures to formaldehyde be reduced to the lowest feasible limit. None of the samples exceed the OSHA PEL of 1.0 ppm, although one area sample result approached it. Half (three of six) of the personal sample results equalled or exceeded the 0.5 ppm OSHA action level, which triggers activities from the Standard which must be complied with (CFR 29, Part 1910, §1910.1048). These include periodic employee monitoring, notification of workers of monitoring results , and the right for an employee representative to observe employee monitoring.
Table 3 contains exposure concentrations for total and respirable dust. These samples were collected in the Melamine Pre-form Room (1.6 mg/m³ total dust, 0.3 mg/m³ respirable dust) and in the Compounding Department (7.7 mg/m³ total dust, 0.4 mg/m³ respirable dust). None of the four samples exceed the ACGIH TLVs or OSHA PEL for total or respirable dust.

VII. DISCUSSION

The highest personal styrene exposure measured (32.0 ppm, NIOSH REL 50 ppm) was to an operator in the Compounding Department. This worker operated the machine that forms small slugs from the styrene-containing resin. The slug-making operation is not run continuously but in batches depending on product demand. Based on the intermittent use of this process, short-term exposure measurement should be performed. An area sample near this operation that was collected during the same time period showed a concentration of 19.0 ppm. A local exhaust or exhausted enclosure for this process would be prudent for lowering exposure to the compounder operator, and to limit emissions to the general air.

The batch mixer, who prepared the large batches of styrene-based resin, had an exposure to styrene of 29.0 ppm over a full work-shift. Considering that this is a task performed on an intermittent batch basis, this employee could be exposed to short-term concentrations which should be considered. High short-term exposures exceeding the NIOSH, OSHA, and ACGIH STEL criteria (186 and 142 ppm) were measured for this job during the first follow-up evaluation (Appendix A, Table I). Smoke tube observations indicated that the exhaust ventilation slots around the perimeter of the batch mixer were working; however, this operator and the area environment would benefit from more effective local exhaust control or an exhausted enclosure. Until better ventilation control is in place, this operator should wear respiratory protection during the high exposure phases of this job, such as when cleaning the mixers.

The airborne styrene measurements that were taken in the Pressroom Department were all quite low and indicate that very little styrene is emitted during the heat-pressing of the styrene-resin slugs.

While none of the formaldehyde measurements exceeded the OSHA PEL of 1.0 ppm, there were some that approached this level in both follow-up evaluations. The highest level measured during the second follow-up was an area sample (0.8 ppm) that was collected between presses 403 and 404 (see Figure 1). Personal exposures averaged above the OSHA PEL action level. All the data indicate that local ventilation at the presses and pre-heat ovens is not as effective as it should be. One of the preheat ovens had a local exhaust hood on only one side of the oven, and two of the presses had no local exhaust. In addition, maintenance of these ventilation systems was not systematic. These systems need regular maintenance to ensure that they operate at top efficiency. Debris was allowed to obstruct the openings of several exhaust slots.

The two airborne formaldehyde samples collected from the Melamine Preform Room were both below the action level (0.1 and 0.2 ppm). The primary hazard here is melamine powder dust that is generated when pellets are formed. The enclosure that was built for this operation seemed to be effective when used properly. Even though exposure concentrations for this machine operator were low (1.6 mg/m^3 for total dust and 0.27 mg/m^3 for respirable dust) the enclosure was not properly used on the day of sampling. The plastic curtain at the front of the enclosure was pulled up onto the roof of the room. This reduces the effectiveness of the dust enclosure. Dust measurements in the enclosure in the Compounding Department were below ACGIH and OSHA criteria. A 2.5-h PBZ sample collected while a worker performed a pre-weighing task in the compounding area during the first follow-up evaluation measured an exposure of 31 mg/m^3 to total dust (Appendix A, Table III). It would be prudent to wear respiratory protection during these dusty tasks.

VIII. RECOMMENDATIONS

The following recommendations are made to help reduce the potential for exposure to styrene, formaldehyde, and dust, and to ensure the safety of the workers at Rubbermaid, Inc. These recommendations are based on the environmental sampling results and observations made during the evaluation.

1. Existing local exhaust systems at the presses and pre-heat ovens should be evaluated by a ventilation contractor experienced with these types of systems for proper design and operation. Systems should be designed and constructed on those currently without them.

2. A maintenance program should be developed for the local exhaust systems, to ensure their optimum performance. Debris, such as plastic trimmings from the pressing operation, should not be allowed to accumulate and degrade performance of these systems.

3. In the Compounding Department, the batch mixer should be covered when it is not in operation. The effectiveness of the existing slot ventilation for high short-term emissions should also be evaluated by a ventilation expert. The possibility of enclosing this operation should be considered.

4. The plastic curtain for the Melamine Preform Room should be hanging down at all times and should not be pulled onto the roof of the enclosure.

5. The exhaust hood for the vacuum loader on the roof of the Melamine Preform Room was not in place on the day of sampling. For this local exhaust duct to work properly it should be in place directly over the vacuum so that dust is captured and removed.

6. Until the high vapor and dusty operations are under better control using ventilation, respiratory protection should be used by the molding compound batch mixer and the preweigher in the compound area. A respiratory protection program, as described in CFR 29, part 1910, §1910.134 will be required.

7. A storage refrigerator in a smaller building behind the main building contained various chemicals. The glass door of the refrigerator was badly cracked with much of the glass missing. For effective temperature maintenance of these chemicals the door should be repaired.

8. Short-term styrene exposure to workers in the Compounding Department should be measured.

IX. REFERENCES

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Copies of this report have been sent to:

1) Rubbermaid; Reynolds, Indiana
2) Rubbermaid; Wooster, Ohio
3) OSHA
4) Others as requested

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 1

Aiborne Exposure Concentrations for Styrene
Rubbermaid, Inc.
Reynolds, Indiana
August 2, 1990

HETA 90-261

Job/Location	Sample Time (minutes)	Sample Volume (liters)	Concentration* (ppm)
Area/Turntable Assembly	413	82.6	0.7
Area A	129	25.8	1.6
Operator/Press Dept	434	86.8	1.6
Area/Compound Dept	414	82.8	2.6
Area/Press Dept (401 & 402)	411	82.2	3.7
Operator/Press Dept (401 & 402)	433	86.6	7.6
Area/Compound Dept	406	81.2	19.0
Batch Mixer/Compound Dept	264	52.8	29.0
Operator/Compound Dept	400	80.0	32.0
Evaluation Criteria:		NIOSH REL	50.0
		OSHA PEL	100.0
		ACGIH TLV	50.0

*Averaged over the duration of the sample time

Table 2

Aiborne Exposure Concentrations for Formaldehyde
Rubbermaid, Inc.
Reynolds, Indiana
August 2, 1990

HETA 90-261

Job/Location	Sample Time (minutes)	Sample Volume (liters)	Concentration* (ppm)
Area/Melamine Preform Room	458	22.9	0.1
Operator/Melamine Preform	454	22.7	0.2
Area/Press Dept (404)	455	22.8	0.2
Operator/Press Dept (403)	461	23.1	0.3
Operator/Press Dept (404)	462	23.1	0.4
Operator/Press Dept (D-1)	469	23.5	0.5
Area/Press Dept/by oven (D-3)	443	22.2	0.5
Operator/Press Dept (D-3)	455	22.8	0.5
Operator/Press Dept (D-3)	457	22.9	0.6
Area/Press Dept (403 & 404)	443	22.2	0.8
Evaluation Criteria:		NIOSH REL	LFL**
		OSHA PEL	1.0
		ACGIH TLV	1.0

*Averaged over the duration of the sample time
**LFL: Lowest Feasible Level

Table 3

Airborne Exposure Concentration for Total and Respirable Dust
Rubbermaid, Inc.
Reynolds, Indiana
August2, 1990

HETA 90-261

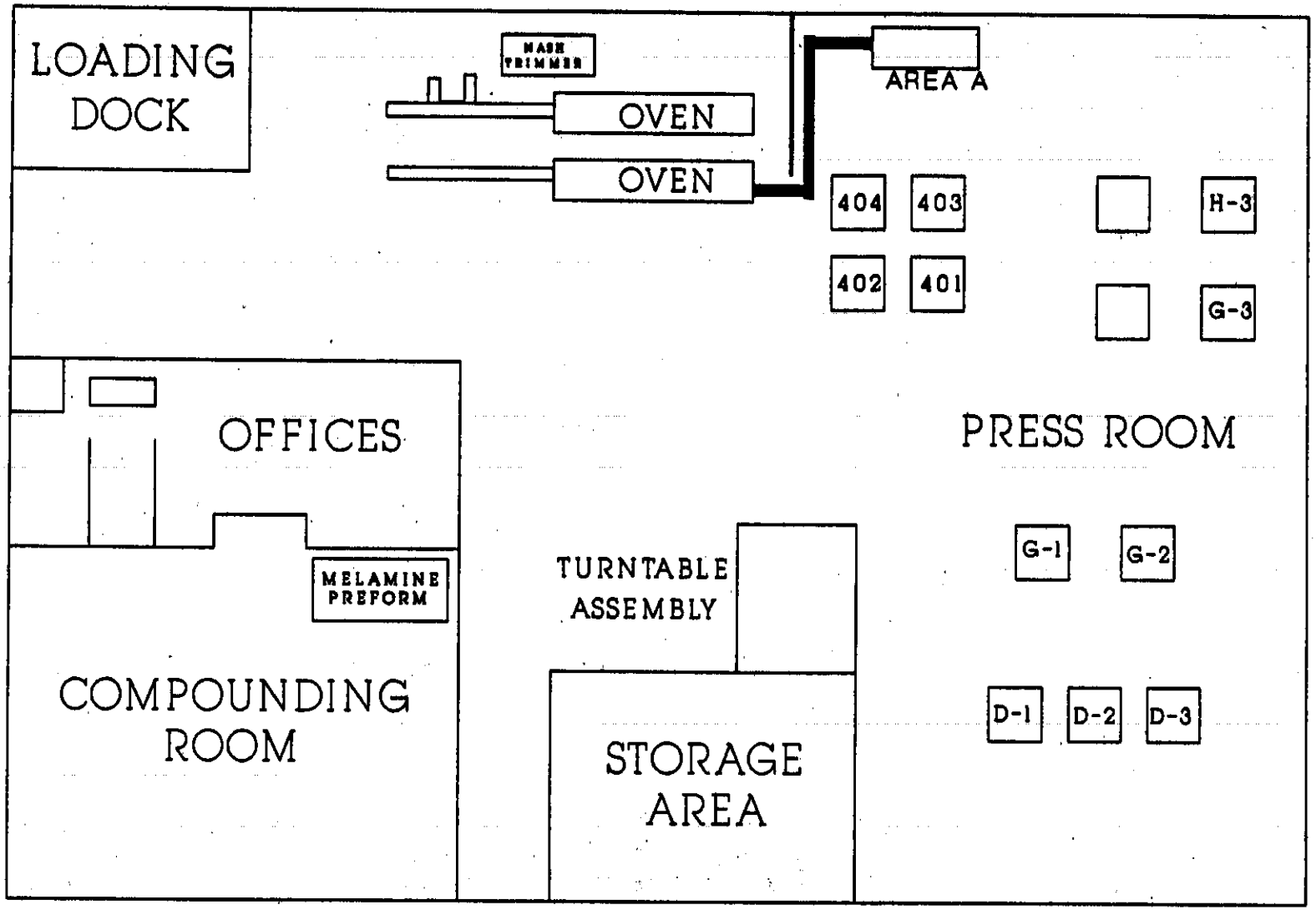
Job/Location	Sample Type (personal/area)	Sample Time (minutes)	Sample Volume (liters)	Concentration* Total Dust (mg/m^3)	Concentration* Respirable Dust (mg/m^3)
Melamine Preform Room	area	432	864	1.6	---
Melamine Preform Room	area	432	734	___	0.3
Preweigher/Compound Dept	personal	21	42	7.7	___
Preweigher/Compound Dept	personal	21	35	___	0.4
Evaluation Criteria:			OSHA PEL ACGIH TLV	15.0 10.0	5.0

*Averaged over the duration of the sample time

Figure 1 RUBBERMAID, INC. REYNOLDS, IN

HETA 90-261

6/19/90



APPENDIX A

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
National Institute for
Occupational Safety & Health
Robert A. Taft Laboratories
4676 Columbia Parkway
Cincinnati OH 45226-1998

COPY

August 14, 1990
HETA 90-261

Mr. Paul Fisher
Rubbermaid, Inc.
1147 Akron Road
Wooster, Ohio 44691

Dear Mr. Fisher:

This letter is to inform you of the results of a Health Hazard Evaluation that was conducted at your Reynolds, Indiana plant on June 19, 1990. Air samples were taken to evaluate exposure to total and respirable dust, styrene, and formaldehyde. This letter reports the results which we discussed during our telephone conversation on July 23.

Table I presents results from sampling and analysis for styrene. Table II presents data on formaldehyde concentrations from area samples collected throughout the plant. Table III presents the results from total and respirable dust sampling.

Methods

Airborne styrene samples were collected on a solid sorbent (150 milligrams of activated charcoal) tube connected via Tygon tubing to battery powered pumps calibrated at a flow rate of 0.2 liters per minute (lpm). The charcoal tubes were analyzed via gas chromatography according to NIOSH method 1501. Styrene is desorbed from the charcoal using a toluene, carbon disulfide mixture (99:1). The sample is run through a 30m x 0.32mm fused silica capillary coated column and analyzed with a flame ionization detector. The limit of detection (LOD) was 0.01 mg per sample. The limit of quantitation (LOQ) was 0.03 mg per sample (0.08 ppm for an 85 liter sample).

Airborne formaldehyde was sampled by drawing air through a glass impinger containing 20 ml of 1.0% aqueous sodium bisulfite solution. The glass impinger was connected to a battery-powered pump that was calibrated at a flow rate of 800 cc/min. At the laboratory, this solution was then analyzed by reaction with sulfuric acid and chromotropic acid and subsequent quantitation by visible absorption spectrophotometry in accordance with NIOSH method 3500. The LOD was 0.2 micrograms per sample, while the LOQ was 0.41 micrograms per sample (1 part per billion for a 290 liter sample).

Personal breathing zone and area air samples for total dust were collected on preweighed 37 millimeter filters connected via Tygon tubing to battery powered pumps that were calibrated at a flow rate of 2.0 lpm. The total

weight of each sample was determined by weighing the sample plus the filter on an electrobalance and subtracting the previously-determined tare weights of the filters. The LOD was 0.01 mg per sample (0.014 mg/m^3 for a 700 liter sample). An area air sample for respirable dust was collected in a similar manner but a 10mm Dorr-Oliver nylon cyclone was used to remove the non-respirable particulates. The pump for the respirable fraction was calibrated at 1.7 lpm.

Exposure Criteria

A. Styrene

Exposure to styrene may be irritating to the eyes, nose, throat, and skin. Respiratory tract irritation has been reported in persons exposed to vapor concentrations in excess of about 190 parts per million. Higher exposures depress the central nervous system. Prolonged or repeated skin contact may cause dermatitis due to defatting action.

The current OSHA standard for styrene is a permissible exposure limit (PEL) of 100 ppm as an 8-hour TWA, with a ceiling level of 200 ppm and an acceptable peak of 600 ppm for 5 minutes in any three-hour period. The current American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour Threshold Limit Value/Time-Weighted Average (TLV/TWA) for styrene is 50 ppm. The TLV/TWA is a time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. The NIOSH Recommended Exposure Limit (REL) for occupational exposure to styrene is 50 ppm for up to a 10-hour TWA. In addition, NIOSH recommends a ceiling concentration of 100 ppm for styrene, as measured during any 15-minute period.

B. Formaldehyde

Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat, and nose; headaches; nausea; congestion; asthma; and skin rashes. It is difficult to ascribe particular health effects to specific concentrations of formaldehyde to which people are exposed, because of variability in subjective responses and complaints. Irritation may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperreactivity developed specifically to formaldehyde are uncommon. Formaldehyde vapor has been found to cause a rare form of cancer in Fischer 344 rats exposed to a 15 ppm concentration for 6 hours per day, 5 days per week, for 24 months. Whether these results can be extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot be drawn with sufficient confidence from published mortality studies of occupationally exposed adults as to whether or not formaldehyde is a carcinogen. Studies of long term human occupational exposure to formaldehyde have not detected an

increase in nasal cancer. Nevertheless, the animal results have prompted NIOSH to recommend that formaldehyde be considered a potential occupational carcinogen and that workplace exposures be reduced to the lowest feasible limit. OSHA has recently reduced its PEL for formaldehyde to 1.0 ppm as a TWA during an 8-hour shift. In addition, a 15-minute short term exposure limit (STEL) was set at 2.0 ppm. The ACGIH has given formaldehyde an A2 designation, indicating that ACGIH considers formaldehyde a suspected human carcinogen. The ACGIH TLV for formaldehyde is 1.0 ppm as an 8-hour TWA and 2.0 ppm as a 15-minute STEL.

Formaldehyde is currently listed in the 1989-90 ACGIH "Notice of Intended Changes" at a proposed ceiling TWA-A2 value of 0.3 ppm. If, after two years, no evidence comes to light that questions the appropriateness of the proposed change, the value will be reconsidered for adoption into the TLV listing.

C. Nuisance Particulate

Nuisance particulates refer to a number of non-fibrogenic dusts or particulates which are common air contaminants and, as such, are normally found in the occupational environment. The potential for eliciting adverse health effects is primarily dependents on the diameter of the inhaled dust particle. The human respirable range for particualte matter is generally considered to extend from 0.5 to 5.0 microns; only a few dust particles greater than 5.0 microns in diameter will be deposited in the respiratory tract, while particles less than 0.5 microns leave the lung without producing local adverse health effects. Inhalation of nuisance particulates normally will not cause adverse effects in the lung; however, excessive airborne concentrations may reduce visibility in the work environment and may also promote irritation of the eyes, nose, throat and lungs.

NIOSH currently supports the ACGIH 8-hour, TWA TLV of 10 mg/m^3 for total dust containing no asbestos and less than 1% crystalline silica. The present OSHA standard is 15 mg/m^3 for total dust, or 5 mg/m^3 for respirable dust and is also expressed as an 8-hour, TWA exposure.

Results

Air sample results for styrene, formaldehyde and nuisance particulates are presented in Tables I-III. NIOSH RELs, ACGIH TLVs and OSHA PELs are referenced at the bottom of each table.

Table I presents personal breathing zone and area air sampling 8-hour TWA exposures to styrene in various parts of the plant. The values range from .28 ppm in the conference room to 186 ppm as a short term exposure of the mixer cleaner. The four highest exposures indicated in Table I were all from the same person. The remainder of the levels recorded are well below the NIOSH REL of 50 ppm. It is apparent from the data that the batch mixer and the mixer cleaner, which in this instance was the same person, are exposed to high short term levels of styrene. When cleaning the

mixers, the level of airborne exposure to styrene was significantly higher than the NIOSH recommended ceiling limit of 100 ppm over a 15-minute period.

Table II presents area air exposure concentrations for formaldehyde as an 8-hour TWA concentration. These values range from 0.01 ppm, measured outside the building, to 0.91 ppm near one of the presses. Although these levels are below the OSHA PEL and ACGIH TLV of 1.0 ppm, they are significant, considering that the samples were collected several feet from the presses, which are the source of formaldehyde emanation. NIOSH recommends that exposure to formaldehyde be kept to the lowest feasible limit because of its potential as a human carcinogen.

Table III presents results from air sampling for total and respirable dust at four locations in the plant. The levels ranged from 0.25 mg/m^3 to 31.3 mg/m^3 for total dust and the respirable dust sample collected was 0.20 mg/m^3. The person preweighing powder in the compounding area was exposed to a very high level of dust (31.3 mg/m^3) for a relatively short period of time (2.5 hours). The remaining levels were all well within the standard set by OSHA of 15.0 mg/m^3 and the ACGIH TLV of 10.0 mg/m^3.

Discussion

When sampling was conducted the bulk molding compound extrusion operation was not being used. Airborne styrene levels that were measured were therefore probably not indicative of typical worker exposure. Airborne styrene samples were taken in the compounding department for the person cleaning the bulk molding compound mixers. When cleaning these mixers, he was exposed to short term airborne concentrations of styrene which were one and one-half to two times the NIOSH STEL for styrene (100 ppm over a 15-minute period). This worker was not wearing gloves so his potential for exposure was higher due to skin contact from using pure styrene to clean the mixers. Airborne styrene concentrations generated at the presses making table inlays and dishes were well below the NIOSH REL (50 ppm). Since pressing operations were basically constant throughout the shift, these levels are probably indicative of the 8-hour TWA for airborne exposure to styrene in the press department.

The melamine preforming and preheating/molding operations were running continuously for nearly the full sample time, and these area samples were collected about 6 to 8 feet from the presses. It is likely that the actual formaldehyde concentrations that the press operators are exposed to are higher than those measured in area sampling, because the source of formaldehyde gas is at the press itself. The operators must reach into the press to remove the product, after molding is complete. and are likely then to be exposed to the highest contentrations of formaldehyde.

The only airborne particulate measurement that causes any concern is of the preweigher in the compound department. Although he preweighs powder for only a small portion of the day, approximately 2 hours, the short-term exposure level was still high enough that the 8-hour TWA would be 9.84 mg/m^3, which is just under the ACGIH TLV of 10.0 mg/m^3. And that is

assuming that this employee was exposed to no other dust for the remainder of his shift. It would be possible to reduce the amount of airborne dust by installing a ventilation system around the scale and weighing area. This issue will be dealt with in greater detail in a report which will contain the results of the follow-up sampling of August 2. The only other "dusty" area of the facility was the melamine preform room and it is apparent from observation and from the data that dust exposures are under control in that area.

Based on the data obtained from our survey on June 19, 1990, we decided to return to obtain more specific measurements in order to determine the levels of airborne formaldehyde to which the press operators are exposed. The data from June 19 also indicates that the preweigher is exposed to high levels of dust. More specific measurements also seemed necessary for this operation in order to more accurately quantitate his exposure to dust. We also decided to take more measurements for airborne styrene, since the compounding operation for the styrene-containing resin was not running on June 19.

This follow-up visit was conducted on August 2, 1990. Personal breathing zone samples for airborne exposure to formaldehyde were collected in both the compounding and press departments. Personal breathing zone samples were also collected for airborne exposure to styrene in both departments. Personal breathing zone samples for total and respirable dust were collected from the preweighing operation in the compounding area and in the melamine preform room. These samples have been sent to the laboratory for analysis and further comments will be made after the arrival of the lab results.

Sincerely yours,

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Hazard Evaluations and Technical Assistance Branch
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HETA 90-261

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Table I
Airborne Exposure Concentrations for Styrene
Rubbermaid, Inc.
Reynolds, Indiana
HETA 90-261

June 19, 1990

Job/Location	Sample Time (minutes)	Sample Volume (liters)	Styrene Concentration* (ppm)
Mixer cleaner/Compound	24	4.8	186
Mixer cleaner/Compound	24	4.8	142
Batch mixer/Compound	53	10.6	53.2
Batch mixer/Compound	53	10.6	44.3
Operator/Press Dept	330	66.0	8.18
Operator/Press Dept	105	21.0	7.60
Area/Compound Dept	432	86.4	2.99
Area/Compound Dept	433	86.6	2.39
Area (G-1)/Press Dept (next to press)	432	87.6	2.14
Area/Compound Dept	339	67.8	2.04
Area/Compound Dept	343	68.6	1.78
Operator/Press Dept	437	87.4	1.72
Area (G-1)/Press Dept (on workbench)	439	87.8	1.28
Area (D-3)/Press Dept (next to press)	436	87.2	0.92
Area (D-3)/Press Dept (on workbench)	440	88.0	0.85
Area/Press Dept	337	67.4	0.59
Conference Room	296	59.2	0.28

Evaluation Criteria:		
	NIOSH REL	50.0
	OSHA PEL	100.0
	ACGIH TLV	50.0

*averaged over the duration of the sample time

Table II
Area Airborne Exposure Concentrations for Formaldehyde
Rubbermaid, Inc.
Reynolds, Indiana
HETA 90-261

June 19, 1990

Location	Sample Time (minutes)	Sample Volume (liters)	Formaldehyde Concentration* (ppm)
Press 401	371	297	0.91
Press H-3	350	280	0.64
Press H-3	352	282	0.64
Press 402	373	298	0.60
Melamine Preform Room	371	297	0.58
Press G-3	373	298	0.49
Press D-1	342	274	0.45
Compounding Dept	334	267	0.13
Outside Building	321	257	0.01

Evaluation Criteria:	
NIOSH REL	LFL**
OSHA PEL	1.0
ACGIH TLV	1.0

*averaged over the duration of the sample time
**LFL: lowest feasible level

Table III
Airborne Exposure Concentration for Total and Respirable Dust
Rubbermaid, Inc.
Reynolds, Indiana
HETA 90-261

June 19, 1990

Job/Location	Sample Type (personal/area)	Sample Time (minutes)	Sample Volume (liters)	Total Dust (mg/m^3)	Respirable Dust (mg/m^3)
Preweigher/Compound	personal	151	302	31.3	NS*
Melamine Preform Room	area	381	762	1.38	NS
Nash Trimmer/Processing	area	348	696	0.40	NS
Press 401/Press Dept	area	344	688	0.25	NS
Melamine Preform Room	area	381	762	NS	0.20
Evaluation Criteria:			OSHA PEL	15.0 mg/m^3	5.0 mg/m^3
			ACGIH TLV	10.0 mg/m^3	

*NS: not sampled for