PRELIMINARY PLANT VISIT
INDUSTRIAL HYGIENE REPORT

Formaldehyde Production Facility
Reichhold Chemicals Incorporated
P.O. Box 163
Moncure, North Carolina

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PREPARED FOR:
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1. INTRODUCTION

This preliminary industrial hygiene survey report describes the Reichhold Chemicals plant located in Moncure, North Carolina. This plant was selected for a preliminary industrial hygiene survey because of its moderate production of about 100 million pounds of formaldehyde per year, its use of metal oxide catalyst, and its southeastern location.

1.1 PLANT PERSONNEL CONTACTED

The plant visit described in this report was carried out by Glen Barrett (GTI), Dave Dunn (MRC), and William McKinnery (NIOSH) on September 22, 1981. Reichhold personnel contacted in connection with the visit included Mr. Thomas Madden, Vice President for Governmental Services, and Mr. Don Brown, the Plant Manager.

1.2 SUMMARY OF ACTIVITY

The plant visit team met with plant personnel and held an extended conference during which the process, control technologies, and industrial hygiene programs described in this report were discussed. The group then walked through the formaldehyde unit of the plant, following the process flow. A closing conference was held during which information from the walkthrough was discussed further.

2. BACKGROUND

The National Institute for Occupational Safety and Health (NIOSH) and the U.S. Environmental Protection Agency (EPA) have entered into an Interagency Agreement to perform a study that will determine the levels of pollutants to which workers in the formaldehyde production industry are exposed and that will evaluate the effectiveness of control technologies currently used to minimize exposures. A similar study of the semiconductor industry is being conducted simultaneously. The findings of both studies will be presented as reports summarizing the results of these assessments.

EPA has contracted with Monsanto Research Corporation (MRC) to perform the study on the formaldehyde production industry, under EPA Contract Number 68-03-3025, entitled "Technical and Engineering Services." MRC is being assisted in the study by personnel from GEOMET Technologies, Inc. (GTI).

The study of the formaldehyde industry is being directed toward a cross-section of production facilities. Of principal importance are the assessment of worker exposure to potentially hazardous pollutants in the workplace and an evaluation of control technologies applied to these. The worker exposure (industrial hygiene) study will examine all pollutants associated with formaldehyde production processes. Process materials of concern and the workforce exposed to these will be identified, concentrations evaluated, and the operations and process parameters of the worksite will be characterized.

A limited number of volunteers will be selected from the workers at a few selected sites for the determination of total (24-hour) exposure to air contaminants, including those found in the workplace, in-transit, and in residence. This portion of the study

has been designed in such a way that it can be used to estimate the total average daily exposures of worker populations to air contaminants. These contaminants will be measured by personal and area monitors and will include those contaminants found in the workplace as well as others commonly found in the ambient and residential environments.

The focus of the workplace control technology study will be the assessment of control technology currently in use or available for minimizing worker exposure to harmful chemical or physical agents. The assessment will include examination of processes and process equipment. Control effectiveness will be determined through observation of work practices; examination of the equipment condition and engineering controls (e.g., ventilation), monitoring devices, and personal protective equipment; and air sampling and analysis. The costs of controls versus their effectiveness will also be examined.

The following sections briefly describe the objectives of the two segments of this project: (1) the industrial hygiene/control technology assessment segment comprising two phases, a preliminary walk-through survey and a detailed survey, and (2) the 24-hour exposure profile segment, designed to study the exposures of formaldehyde production and office workers in the workplace, the residence, and the in-transit environments.

2.1 OBJECTIVES OF THE INDUSTRIAL HYGIENE/CONTROL TECHNOLOGY ASSESSMENT (IH/CTA) STUDY SEGMENT

The objectives of the IH/CTA segment are to:

- identify potential hazards to workers,

- evaluate the effects of these potential hazards on workers,
- evaluate the effectiveness of industrial hygiene control programs to control these potential hazards,
- assess current formaldehyde production technology with respect to control of potential exposures of workers,
- identify the best available means to control emissions and potential exposures,
- evaluate the state-of-the-art of control technology in the formaldehyde production industry,
- assist the transfer of control technology inter- and intra-industry, and
- identify processes for which engineering controls are not available or are ineffective, where further research and development are needed, and to indicate priorities for application of control technology.

This segment is divided into two phases, preliminary surveys and detailed surveys. Objectives of these phases are presented below.

2.1.1 Objectives of the Preliminary Industrial Hygiene/Control Technology Survey Phase

The objectives of preliminary surveys are to:

- identify potential exposures to hazardous agents in formaldehyde processes and operations,
- identify control technology currently used by the formaldehyde industry to eliminate or control potential exposures,
- prepare a series of preliminary plant visit reports detailing findings from the first two objectives, and
- select 4-5 candidate plants from the original 12 plants for later detailed industrial hygiene surveys, based upon the findings from the first two objectives.

2.1.2 Objectives of The Detailed Industrial Hygiene/Control Technology Survey Phase

Detailed plant visits comprise the second phase of the industrial hygiene/control technology segment of the study. The objectives of these visits are to:

- observe operator work practices,
- conduct quantitative personal sampling,
- evaluate engineering control techniques used by the industry to reduce exposures, and
- prepare a series of detailed plant visit reports, detailing worker practices and evaluating the engineering controls used by the plant.

This part of the IH/CTA segment will be coordinated with the 24-hr exposure profile at four selected plants.

2.2 OBJECTIVES OF THE 24-HOUR EXPOSURE PROFILE SEGMENT

The objectives of the 24-hour exposure profile segment are to:

- determine the exposure of selected formaldehyde production and office workers to five selected pollutants on a 24-hour basis,
- evaluate these results and identify potential areas of concern due to high exposure, and
- determine the need for further indoor air studies.

3. DESCRIPTION OF PLANT

The Reichhold Chemical Inc. (RCI) Moncure, North Carolina plant is located in an industrial park area. The plant, constructed in 1970, produces 50 percent formaldehyde which is used onsite to produce resins. Some formaldehyde is occasionally shipped offsite to another producer.

The formaldehyde and resin production units, shown in Figure 1, are not enclosed in buildings. A control room used for both units is isolated from the units and located in the main office building. The methanol storage tank is located approximately 200 feet from the formaldehyde unit and connected to it with welded flange piping. The four formaldehyde storage tanks are located approximately 75 feet away and are separated from the production units by a plant road. The main office building houses not only the control room, but also the quality control laboratory, the water quality laboratory, and the plant management offices.

The plant employs 29 workers including 14 workers that are involved with formaldehyde and resin production. Other personnel are involved with shipping or management responsibilities. Eight operators control the resin and formaldehyde units, split between four eight-hour shifts. Operators' responsibilities include unloading the methanol, operation of the formaldehyde and resin units, transferring the formaldehyde to blending and storage tanks, and sampling and analyzing the formaldehyde solution. Maintenance workers at the plant are assigned to day shift only, but are on 24-hour call. Six employees from the shipping department load formaldehyde and resin into tank trucks when shipments are made.

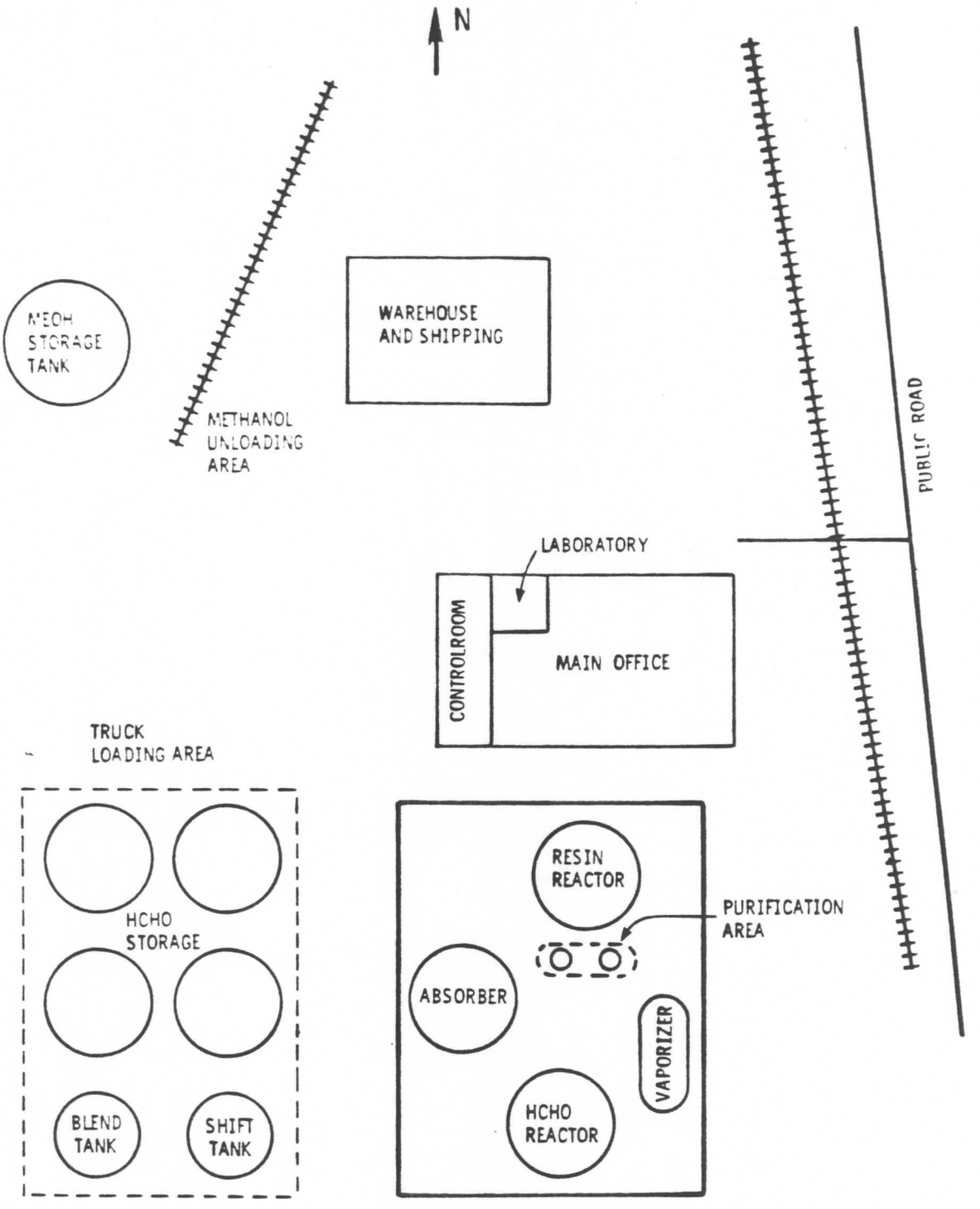

Figure 1. Schematic of the plant area.

4. PROCESS DESCRIPTION

Formaldehyde is manufactured by the patented Formox® process, shown in Figure 2, using a metal oxide catalyst. Methanol, delivered daily to the plant by rail or truck and stored in a bulk storage tank, is pumped into the vaporizer and vaporized. The vaporized methanol is mixed with filtered air and combined with the absorber offgas, then enters the converter where it passes through tubes filled with iron-molybdate oxide catalyst and is oxidized with up to 99% conversion efficiency according to the following exothermic reaction:

$$CH_3OH + \tfrac{1}{2}O_2 \xrightarrow{\text{catalyst}} HCOH + H_2O + 38 \text{ kcal}$$

Dowtherm®, circulated through the converter jacket to control the converter temperature, is used to remove the heat of reaction and produce low pressure steam for on-site consumption. Formaldehyde vapors exit the converter, are cooled in the aftercooler and absorbed in a 25-stage absorber. After formic acid is removed in a purification step, the liquid formaldehyde is transferred to a shift tank. The contents of the shift tank are transferred into the blend tank once per shift to adjust the formaldehyde concentration. The product formaldehyde is stored in one of the tanks in the formaldehyde tank farm. The process has been operating as described since plant startup in 1970.

A picture of the formaldehyde unit is shown in Figure 3. The tall structure in the center is the absorption tower. The converter can be seen on the right side of the structure behind the horizantal storage (Dowtherm) tank.

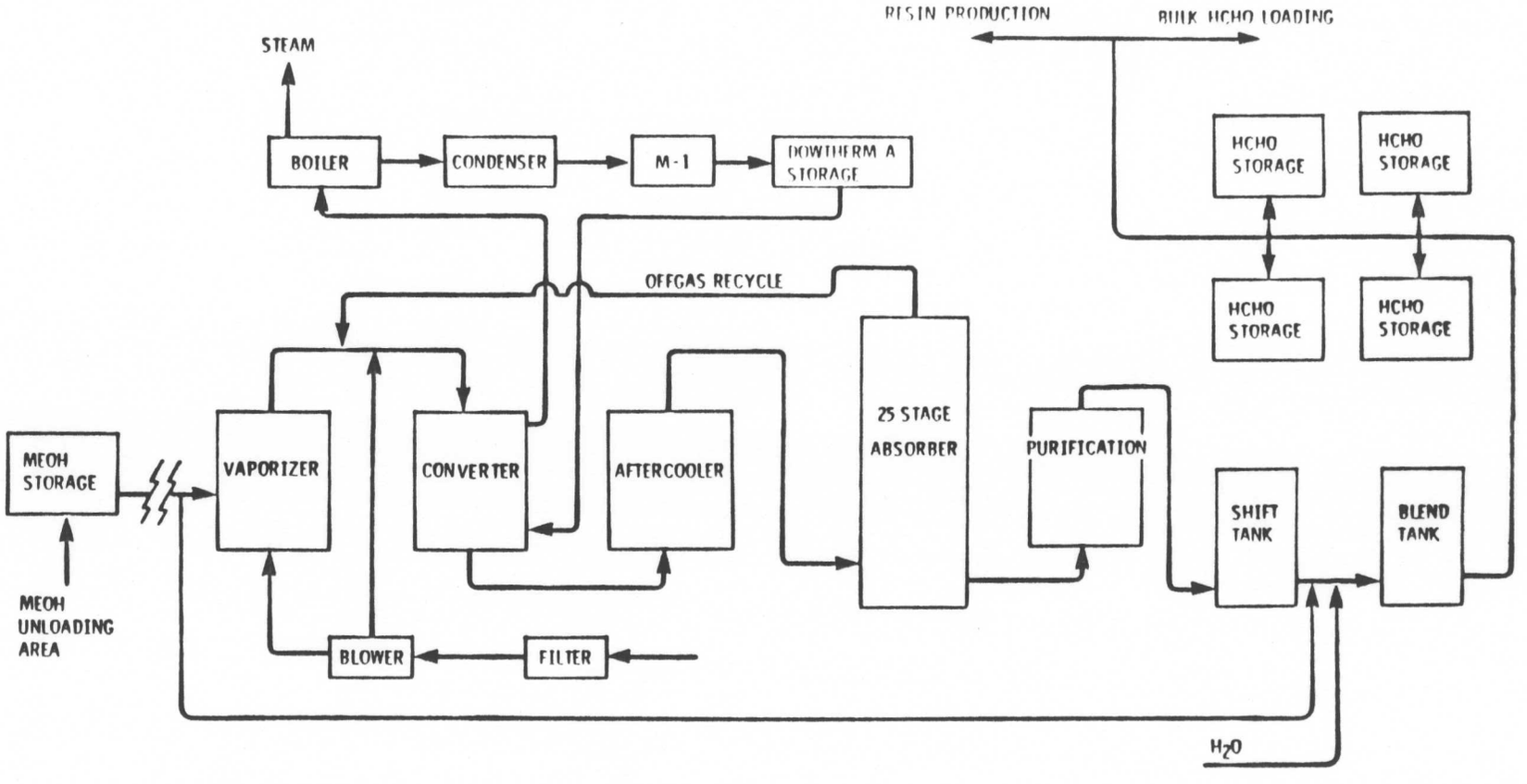

Figure 2. Process schematic, RCI, Moncure, N.C., 1 October 1981.

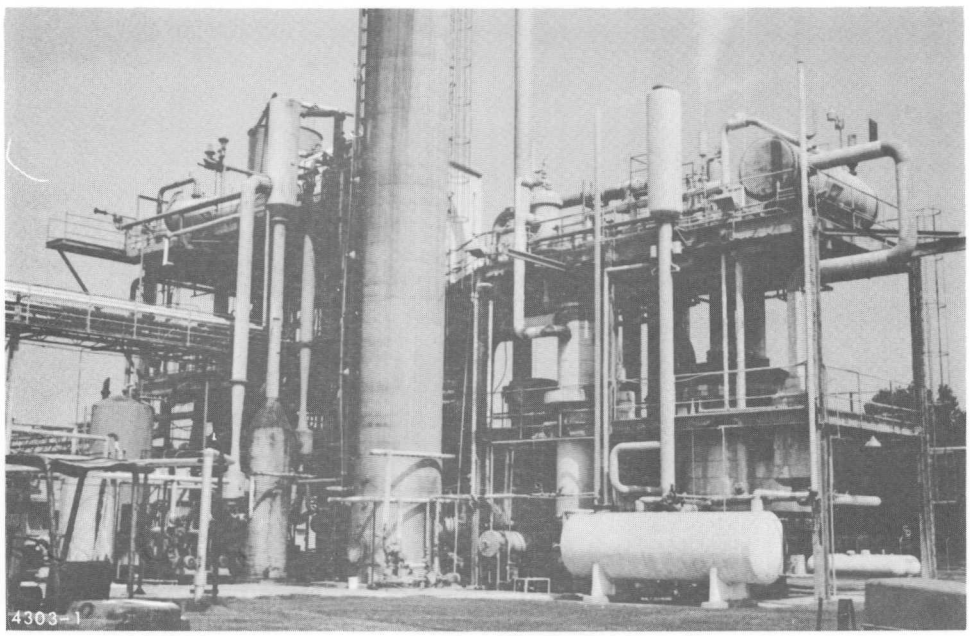

Figure 3. The RCI formaldehyde unit.

5. DESCRIPTION OF PROGRAMS

5.1 INDUSTRIAL HYGIENE AND SAFETY

The Corporate Offices provides interpretations and guidelines to the plant on governmental rules, regulations and corporate policies. It periodically audits the plant program, and may become more involved if unusual circumstances occur. The plant is responsible to the RCI Regional Manager for its safety policies and implements its safety program with considerable independence from the Corporate Office. The plant safety program, funded by the Corporate Office, is normally implemented on a departmental basis where each worker is informed of plant safety policy.

Reichhold does not have a corporate industrial hygienist. The Moncure plant uses an industrial hygienist (IH) from their insurance company on a contract basis. Plant personnel assist the IH during visits and use the AIHA certified corporate analytical lab to analyze the samples. Formaldehyde sampling results are reported in Section 6.

The plant has an informal safety program that is organized departmentally, according to the function of the worker. Safety meetings are held on an as-needed basis with the department supervisor leading the discussions.

Regular maintenance and replacement of worn seals and gaskets is standard. A leak noted during the night shifts is recorded on a work order requesting the repair be done in the morning. For larger leaks, a maintenance worker is called in immediately. Formaldehyde tank entry for cleaning or inspection is rarely required. The tanks are kept in good working order by dissolving

paraformaldehyde buildup with hot water and rotating the use of the tanks. This rotation reduces the paraformaldehyde buildup by limiting the storage time of any one batch of formaldehyde.

Contingency plans for emergencies are well defined and include procedures for fire, flood, and spill. The local volunteer fire department is located 0.5 miles from the plant and the volunteer force includes four Reichhold employees. Spills are controlled by the diking around the major storage tanks and the dike that surrounds the plant. Any spilled material flows into the onsite wastewater aeration pond.

The Moncure plant has had four minor accidents since 1978. In 1978 an operator sustained a phenol exposure when phenol sprayed up his sleeve. In a separate accident that year, a maintenance worker was replacing a valve and was sprayed in the eyes by formaldehyde. In 1980, another maintenance worker was sprayed with formaldehyde while removing insulation from a leaking flange. In the only lost time accident, two workers checking a tank car to be loaded with formaldehyde were sprayed in the face by residual ammonia from the uncleaned tank car. Both workers were lost time recordables by OSHA regulations. No accidents were reported in 1979 or 1981.

5.2 OCCUPATIONAL SAFETY AND HEALTH TRAINING

The new hire program includes a three month on-the-job training program. The training is initiated by assigning the new employee to a shift supervisor who instructs and trains the new employee in operator duties and responsibilities including, operating the process, recognizing problems, proper sampling techniques, and the hazards of the process. Supervision continues until the new employee is capable of operating the process alone. The program has not been continuously active because of the low employee turn-over at the plant. Most of the workers have been with the 11 year old plant for 7 to 10 years.

The plant has two employees who are trained as emergency medical technicians and make up the core of the on-site first aid team which is trained in cardiopulmonary resuscitation and first aid. These employees work different shifts to cover the plant operation more completely.

5.3 PERSONAL PROTECTIVE EQUIPMENT (PPE) AND SAFETY EQUIPMENT

All employees are required to wear safety shoes and hard hats in the operating area. Additional PPE is suggested for the following operations:

Methanol Unloading

Splash proof goggles
Rubber gloves

Formaldehyde Loading

Splash proof goggles
Rubber gloves

Other PPE available for use at the worker discretion includes ear-plugs, face shields, supplied air respirators, self-contained breathing apparatus, and cartridge gas masks. The plant has a written respiratory program that is currently being revised to accommodate the new OSHA workplace air standards applicable to the plant.

5.4 MEDICAL PROGRAM

All employees are given a pre-employment physical examination by a Moncure medical center. No periodic physicals are given except for the renewal of an Emergency Medical Technical registration. Medical service in case of on-site injury, in addition to the first aid team, is available at the center which is located approximately 20 minutes away.

6. SAMPLE DATA

The personnel involved with the formaldehyde unit and its product were sampled in June 1980. The impinger personal sampling method was used; sample duration varied from 145 to 160 minutes. Sample concentrations and job sampled are listed in Table 1. These results are below the Reichhold Company threshold limit value of 2 ppm.

TABLE 1. FORMALDEHYDE SAMPLES

Job description	Formaldehyde concentration, ppm
Chief operator - formaldehyde and resin units	0.11
Operator - formaldehyde and resin units	0.27
Maintenance worker	0.24
Operator loading formaldehyde into a tank truck	0.05

In addition, Reichhold sampled the plant for the major contaminants of concern (formaldehyde and methanol) soon after the plant began operation in 1971. No exposure problems were identified during this monitoring.

OSHA inspected the facility in 1971 and, finding no formaldehyde odor problems, felt it unnecessary to collect formaldehyde samples. Noise levels have not been measured but such measurements are planned for the near future.

7. CONTROL STRATEGY

Several areas of the formaldehyde operation that present exposure potential are discussed below with respect to the applied control technology and the recognition of exposure. Exposure reduction in manufacturing formaldehyde is achieved by the process being enclosed. The exceptions to a totally closed process are the initial open entry point of methanol into the process, the occasional loading of formaldehyde for shipment, and the release of offgases from storage tanks. No qualitative or quantitative measurements to verify exposure levels were taken during the walkthrough.

7.1 METHANOL UNLOADING AND HANDLING

Methanol is unloaded from tank cars and trucks using a quick-connect adapter that is attached to a coupling on the bottom of the transport. The methanol is pumped directly into the bottom of the bulk methanol storage tank. This transfer method reduces the explosion hazard by eliminating electrostatic buildup produced by the free-fall of methanol into the tank.

The level in the storage tank is measured by an external gauge on tank. A centrifugal pump with packed seal on the shaft is used to transfer the methanol into the bulk storage tank. A second pump is used to pump the stored methanol to the vaporizer.

The methanol unloading and storage area is separated from other areas of the plant by approximately 75 feet. Operator exposure in this area is limited to the unloading process, which includes attaching and releasing the flexible transfer hose. No methanol leaks were seen or smelled in this area during the walkthrough survey.

7.2 VAPORIZER AND CONVERTER

The methanol vaporizer and converter shown in Figure 4 are located in the same area of the structure containing the formaldehyde and resin units. These two process operations pose some exposure threat to the worker because of the high temperature involved, and the vaporized state of the methanol and formaldehyde.

The operations are located in the open air structure which allows adequate ventilation of the area. Flanges and high temperature gaskets are used on all connective piping and fittings from the vaporizer to the reactor. No formaldehyde was smelled in this area, however, there was a prominent odor which was identified as Dowtherm A by Mr. Brown, the plant manager. Dowtherm A is a mixture of phenylether and biphenyl and is used by the Moncure plant to cool the reactor and to recover heat from the converter. Exposure to phenylether is currently limited by OSHA to 1 ppm TWA. Biphenyl concentration has been regulated to 0.2 ppm.

7.3 AFTERCOOLER

The hot formaldehyde gases from the converter are cooled in an aftercooler before entering the absorber. The aftercooler is completely enclosed with limited worker exposure hazard.

7.4 ABSORBER

The cooled gases, now at 150°C, enter the bottom of the 25-tray, single pass water absorption column where the formaldehyde is absorbed in water and recovered. The absorber offgases are recycled back to the converter and the 50% formaldehyde solution, after purification and blending is sent to storage. The absorption column has several potential exposure areas which are all well controlled. Column viewports and a sample point, (located on the third floor) had small accumulations of paraformaldehyde, however, no formaldehyde was smelled in this area.

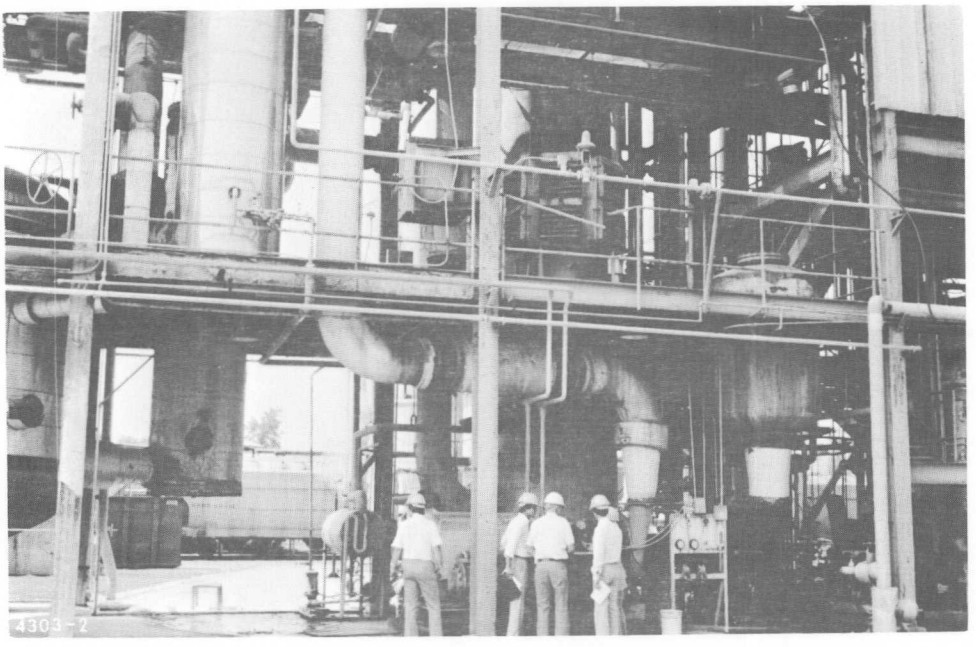

Figure 4. Vaporizer is behind the survey team. Converter is extreme left.

The daily sampling port, shown in Figure 5, is located immediately after the centrifugal pump that transfers the 50% formaldehyde solution to the purification step. The sample is taken after purging the sample line with the formaldehyde solution. This purge is collected in a bucket for disposal as needed.

This Gould centrifugal, single mechanical seal transfer pump showed evidence of minimal formaldehyde leakage. The seal worked well, but still allowed some leakage as evidenced by small paraformaldehyde deposits. Formaldehyde was smelled in this area and eye irritation was noted by one of the survey team members.

The Moncure plant has recognized the problem of formaldehyde leaks at the pump seals (one is shown in Figure 6) and is currently in the process of replacing the high rpm pumps initially used onsite with more efficient low rpm pumps which pump as effectively, but have decreased the formaldehyde leakage, and result in less worker exposure. In addition, the mechanical seals on the pumps are being

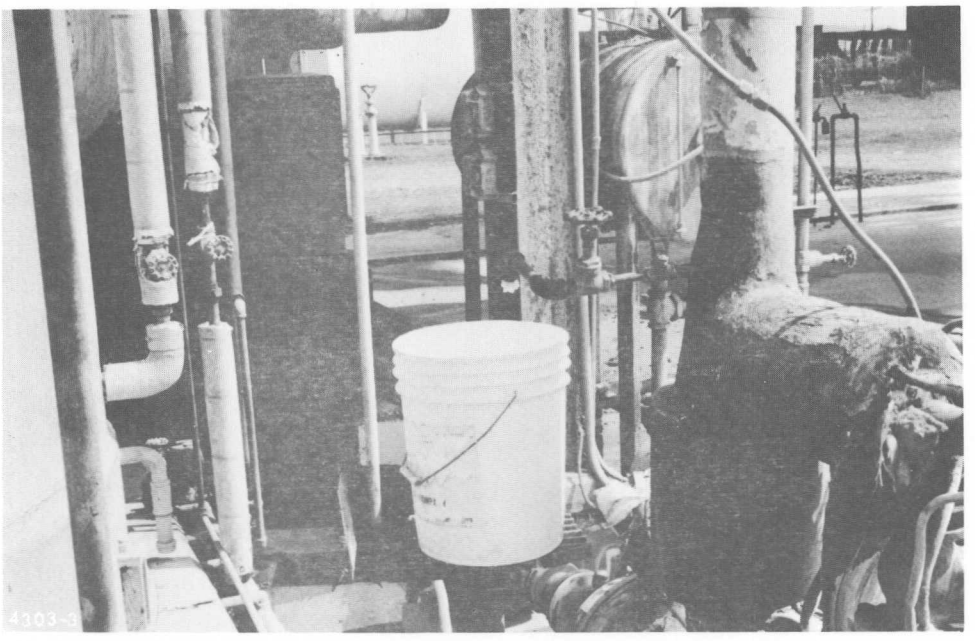

Figure 5. Process sample port and purge bucket. Note the paraformaldehyde formations on sample port.

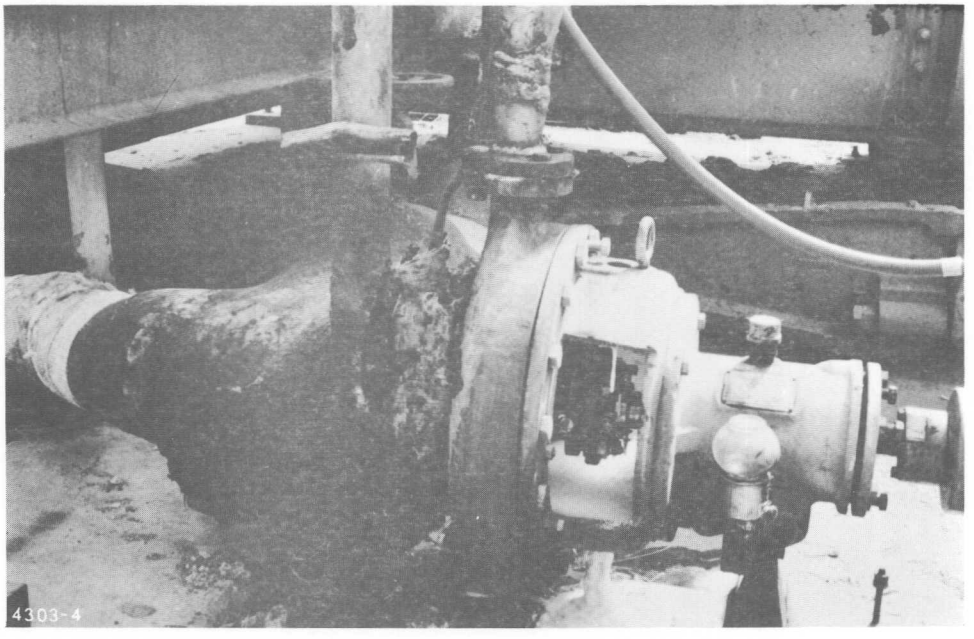

Figure 6. Leaking centrifugal pump. Note paraformaldehyde inside pump housing.

replaced with new, longer-wearing seals as the old ones wear out. This preventive maintenance program further reduces worker exposure.

The formaldehyde solution from the absorber passes through a proprietary purification step prior to delivery to the shift tank. This area was inspected by the survey team. No paraformaldehyde deposits or leaks were seen, and no formaldehyde was smelled in this area by the team members.

7.5 FORMALDEHYDE STORAGE

Formaldehyde is stored in the shift tank and is transferred once per shift to the blending and storage tanks. Pumps similar to the one used on the absorber (centrifugal, single mechanical seal), transfer the solution to the appropriate tank. Blending is done in a separate tank, where methanol, water, or formaldehyde can be added to the solution to produce the desired blend. After blending, the solution is stored in one of four steam-heated storage tanks that are kept at 50°C. The tanks are loaded and emptied on an alternating basis to help prevent paraformaldehyde buildup. If a buildup does occur the tanks are cleaned using hot water to dissolve the paraformaldehyde. Formaldehyde is transferred from these tanks using single mechanical seal centrifugal pumps similar to those described above. Although some small paraformaldehyde deposits were noted, no formaldehyde was smelled in this area.

7.6 TRUCK LOADING AREA

Although the Moncure plant ships formaldehyde on an infrequent basis, a truck loading area has been built and is shown in Figure 7. The area is located adjacent to the formaldehyde storage tanks. The loading area is equipped with a blower that blows the vapors from the open truck port away from the operator. Based on the limited activity, and the low concentrations measured by Reichhold Corporate personnel, this area is not of major concern.

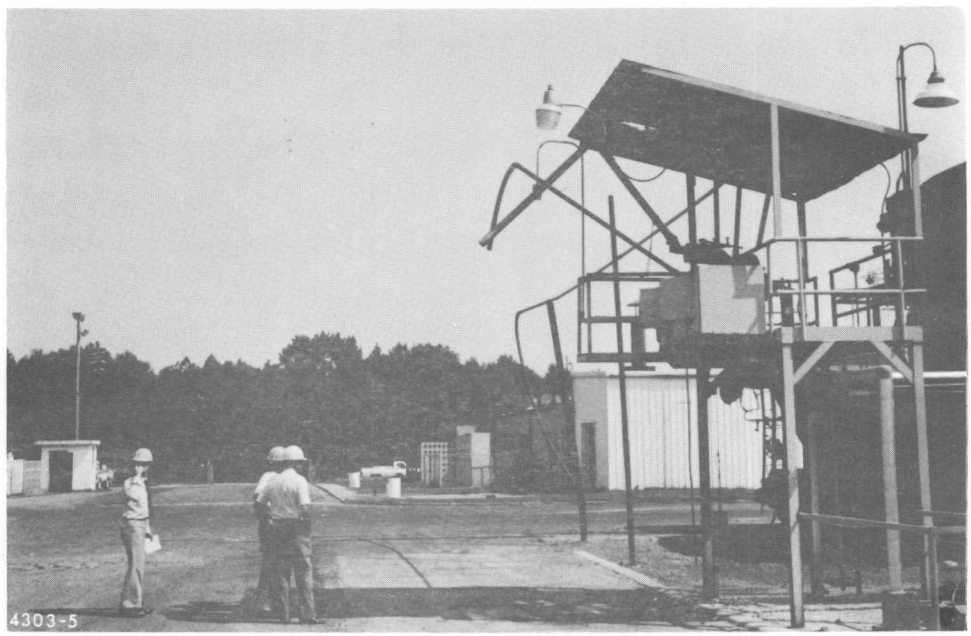

Figure 7. Formaldehyde truck loading area.

7.7 CONTROL ROOM AND LABORATORY AREA

The control room for the formaldehyde and resin units is combined into a single room in the main office building of the plant. The potential for exposure in this room where workers spend a majority of their time should be low. However, the laboratory used to analyze the formaldehyde samples, taken once per shift, is located beside the control room and the samples collected in open beakers are carried through the control room to reach the laboratory. Thus some exposure potential does exist.

The small laboratory next to the control room is used by the operator to prepare, analyze, and discard formaldehyde samples. Ventilation consists of an air conditioning vent in the ceiling as well as

an exhaust/ventilation fan unit in the ceiling. The windows cannot be opened. The operator prepares and analyzes the formaldehyde sample, then discards the sample. Though no formaldehyde was smelled in this area, exposure potential in this area appears to be high. No samples were analyzed during the survey.

8. CONCLUSIONS AND RECOMMENDATIONS

The plant demonstrates an effective engineering control program and takes into account the safety of the worker and the prevention of hazards. All leaks detected appeared to be minor. The industrial hygiene program at the plant shows a good awareness on the Corporate level of procedures required to protect the health of the employee. The plant also demonstrates good awareness of the IH needs, but has problems with worker cooperation with the safety programs.

No significant problem areas in the unit were noted. The lack of eyewash and shower stations within the plant was evident. The poorly ventilated room used as a quality control laboratory may create a problem in some instances and may expose the workers to relatively high formaldehyde concentrations for brief periods of time. Proper ventilation should be installed in this laboratory and a better process sampling and analysis procedure defined.