PRELIMINARY PLANT VISIT
INDUSTRIAL HYGIENE REPORT

Formaldehyde Production Facilities
Tenneco Chemicals, Inc.
Fords, New Jersey

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PREPARED FOR:
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1. INTRODUCTION

This report describes a preliminary industrial hygiene survey conducted at the Tenneco Chemicals, Inc. plant located in Fords, New Jersey. This plant was selected for such a survey because of its large production capacity of about 185 million pounds of formaldehyde per year, its use of silver and metal oxide catalysts and its northeast location.

1.1 PLANT PERSONNEL CONTACTED

The plant visit described in this report was conducted by Glen Barrett (GEOMET Technologies, Inc.), and Dave Dunn (Monsanto Research Corporation), on October 1, 1981. Tenneco Chemicals personnel contacted in connection with the visit included Dr. John Hochstrasser, corporate manager of industrial hygiene, Mr. Robert Lareau, acting plant manager, Mr. F. S. Klopp, director of operations, Mr. Barry Schlegel, supervisor of industrial hygiene field studies, Mr. John Mahon, technical superintendent, and Mr. Jack Goyette, production engineer.

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 two formaldehyde units, following the process flow.

No samples or measurements were taken during the walkthrough survey. The plant visit concluded with a closing conference in which information obtained and team observations during the walkthrough were discussed.

2. BACKGROUND

2.1 GENERAL APPROACH

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

A limited number of volunteers will be chosen from among 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 the residence. This portion of the study will be 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 either personal or area monitors, or both. They will include those contaminants found in the workplace as well as others commonly found in the ambient and residential environments.

The workplace control technology study will be focused on 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 by observing work practices; examining equipment condition, engineering controls (e.g., ventilation), monitoring devices, and personal protective equipment; and conducting air sampling and analysis. The costs of controls versus their effectiveness will also be examined.

The following two subsections briefly describe the objectives of the two segments of this project. The first is the industrial hygiene/control technology assessment segment, which comprises two phases, a preliminary walk-through survey (the subject of this report) and a detailed survey. The second is the 24-hour exposure profile segment, which is designed to study the exposures of formaldehyde production workers and office workers in the workplace, the residence, and in-transit environments.

2.2 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 in controlling 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 inter- and intraindustry transfer of control technology, and

- identify processes for which engineering controls are not available, are ineffective, or where further research and development is needed, and indicate priorities for application of control technology.

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

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

The objectives of these 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 describing the findings from the first two objectives, and

- select 4 or 5 candidate plants from the original 12 plants for later detailed industrial hygiene surveys, based upon the findings from the first two objectives.

2.2.2 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, describing worker practices and evaluating the engineering controls used by the plant.

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

2.3 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 THE PLANT

The Tenneco Chemicals plant at Fords, New Jersey, is located in an industrial setting near Perth Amboy, New Jersey. The plant, which is unionized, has been operating since the 1930s. In addition to several other organic chemicals, the plant produces 46 and 50-percent formaldehyde solution using two production units. The Formox® (metal oxide catalyst) unit which has a capacity of about 120 million pounds of formaldehyde per year has been operating since 1968. The silver catalyst unit has been producing about 60 million pounds of formaldehyde per year since the 1930s. The formaldehyde is used on-site and is also shipped to customers.

Figure 1 shows a layout of the Fords Plant. The Formox unit shown in Figure 2 is contained in a separate open air structure apart from the other plant operations. The unit has an enclosed control room adjacent to the structure that houses the workers' locker room, unit quality control laboratory, and the control room. The shift storage tanks for the formaldehyde produced are located adjacent to the structure housing the two reactors and the absorber on the opposite side from the control room. The truck-loading area is located between the the formaldehyde storage tanks.

The silver catalyst unit is located in an enclosed building shown in Figure 3 on the west side of the plant. This building also houses a second process that uses the formaldehyde produced by this unit. The control area for the formaldehyde unit is situated in the midst of the unit operation; a small office area is provided for the supervisor. The reactors, absorber, and distillation columns are completely enclosed by the building. The methanol starting material is stored outside in four small horizontal tanks. A shift storage tank is located inside the building and a larger formaldehyde bulk storage area is adjacent to the building.

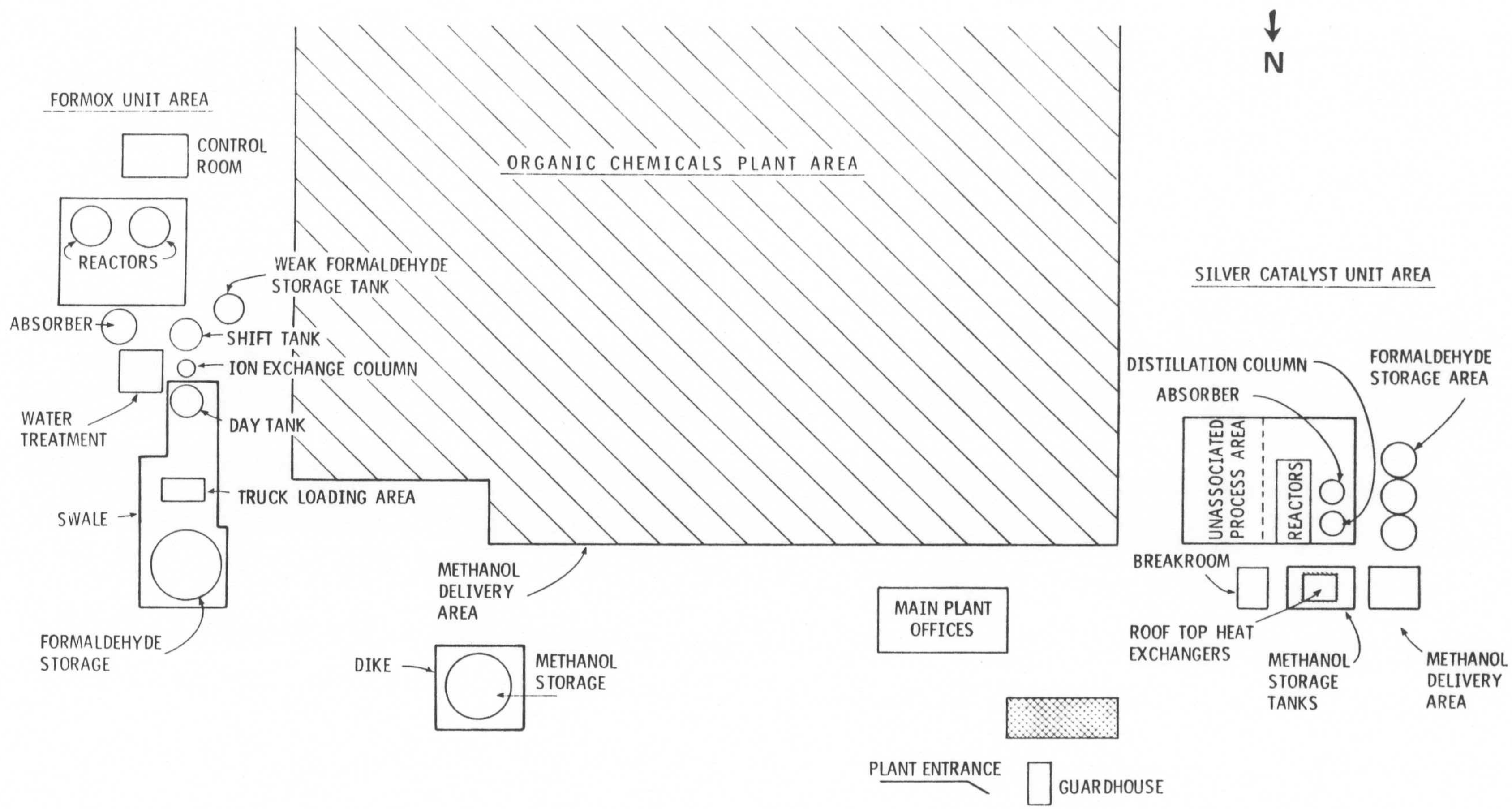

Figure 1. Layout of Tenneco's Fords, New Jersey Plant.

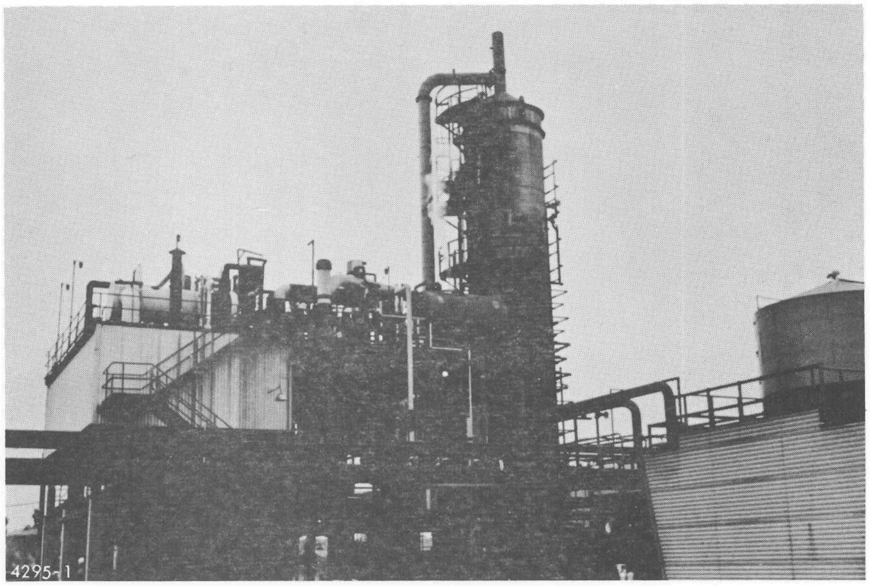

Figure 2. FORMOX® formaldehyde unit.

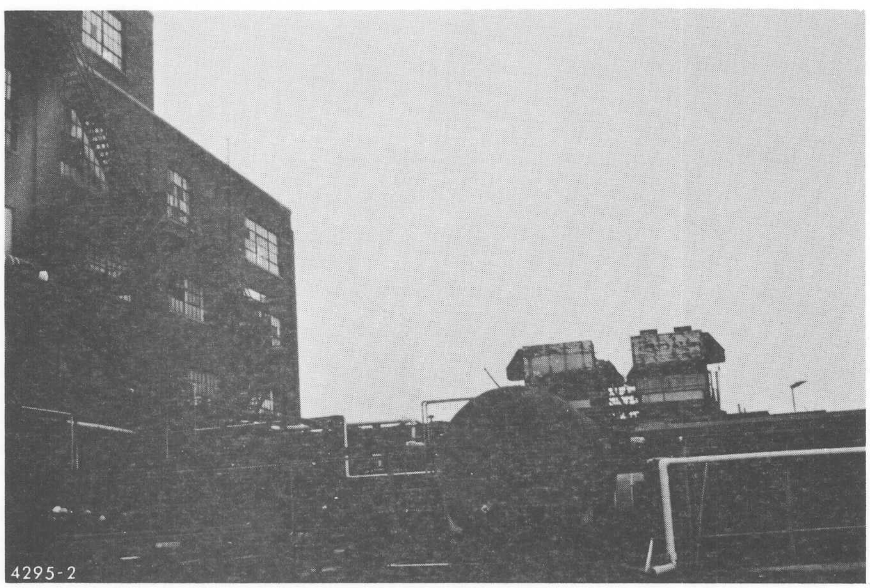

Figure 3. Silver formaldehyde unit area. Absorber heat exchangers are located on top of the building to right.

The general plant offices including the offices of the plant manager, the first aid room and offices of the production supervisors are in a separate building approximately 200 feet from the silver catalyst unit and 800 feet from the Formox unit.

The two formaldehyde production units at the plant operate on a 7-day-per-week, 24-hour-per-day schedule using four shifts. Each unit uses one operator per shift. The operator of the silver catalyst unit also assists with the adjacent process. The operators are supervised by a total of four shift foremen spread over the 24-hour period. Two truck-loading operators and one maintenance operator are also employed, bringing the total number of workers regularly associated with the units to 15.

Operator responsibilities include controlling the process, reporting maintenance problems, and transferring the formaldehyde to storage. Operators may also be used to change the catalytic beds in the units. The loading operators are responsible for loading the tank trucks used to ship the formaldehyde, sampling the blended solution, and general maintenance.

Methanol is delivered by plant trucks and drivers, and formaldehyde is shipped via outside trucks and drivers. The drivers are responsible for unloading methanol but not for loading any material. Approximately 40 maintenance workers support the plant, but none is assigned directly to either formaldehyde unit.

4. PROCESS DESCRIPTION

Formaldehyde is produced at the Fords Plant by two different processes, one using a metal oxide catalyst and a second using a silver catalyst. The metal oxide unit uses the Formox® process developed by Reichhold Chemicals to produce formaldehyde through direct catalytic oxidation of methanol. The Formox® process generally has an efficiency greater than 99 percent for conversion of methanol to formaldehyde. The silver catalyst process is based on a dehydrogenation-oxidation reaction of methanol and has a lower yield than the metal oxide process. As a result, a large amount of methanol is recovered with the product formaldehyde, and a distillation column to remove and recover methanol for reuse is needed to produce a useable formaldehyde solution.

The Formox unit is shown schematically in Figure 4. Two large, parallel packed-tube reactors are used. Methanol, delivered by truck and stored in a bulk storage tank, is injected into the airstream and vaporized in one of two parallel vaporizers and combined with filtered air. This methanol-air mixture enters the respective reactor where it passes through the packed tubes and is oxidized to formaldehyde. Heat from the reactors is recovered by a heat exchange system that uses Dowtherm A® as a heat transfer fluid that is vaporized, then condensed after generating low pressure steam in a boiler. The formaldehyde vapors leaving the reactors pass through a single aftercooler and are then absorbed in water in a single absorber that can be seen in Figure 2. The formaldehyde solution is stored in a bulk storage tank prior to an ion exchange purification step which removes formic acid from the solution. The purified formaldehyde solution is stored in bulk storage tanks until it is shipped out by tank trucks. Blending to reduce the formaldehyde content and methanol addition as required by the customer is handled during the loading step.

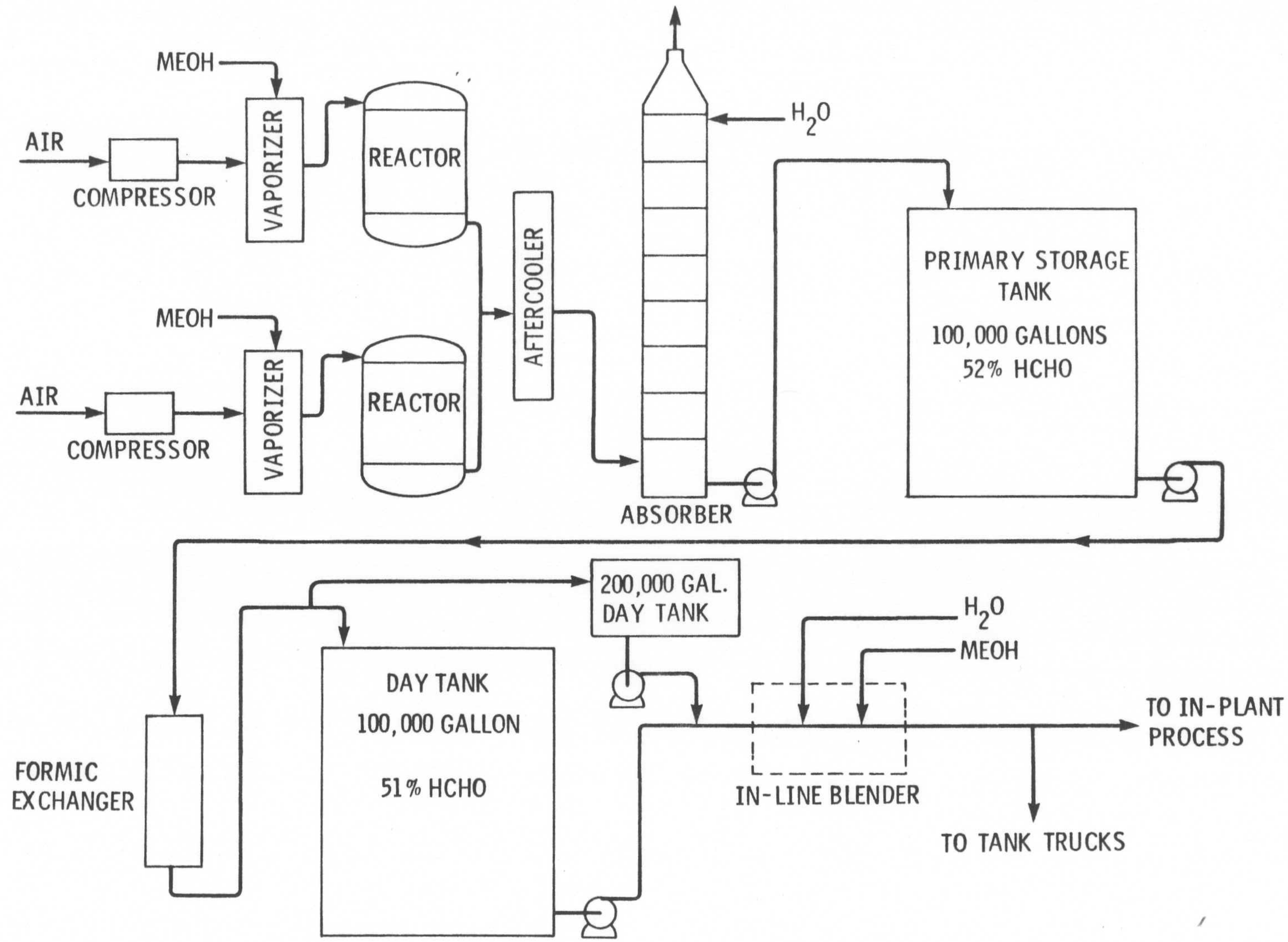

Figure 4. Schematic diagram of the Formox unit.

In the silver catalyst unit, shown schematically in Figure 5, methanol is pumped from the storage tanks to the vaporizer where it is vaporized, and mixed with filtered air by sparging air into liquid methanol. The methanol-air mixture is fed through headers to reactors that contain the silver catalyst which converts the methanol to formaldehyde. The process is under negative pressure pulling air through the unit and discouraging methanol and formaldehyde vapor leaks from the process. Heat from the hot gases is recovered in a steam generator. The cooled gas then enters an absorber column where formaldehyde and methanol is absorbed in water and recovered as a 40 percent formaldehyde solution. The solution is concentrated to a 46 percent formaldehyde solution in water by methanol removal in a 60-plate tray stripper before it is sent to storage for later use in onsite production processes.

The Formox unit has been operating as described since 1968. The silver catalyst unit has been operating since the 1930s and has gone through several process changes, including a 50% capacity increase in 1962.

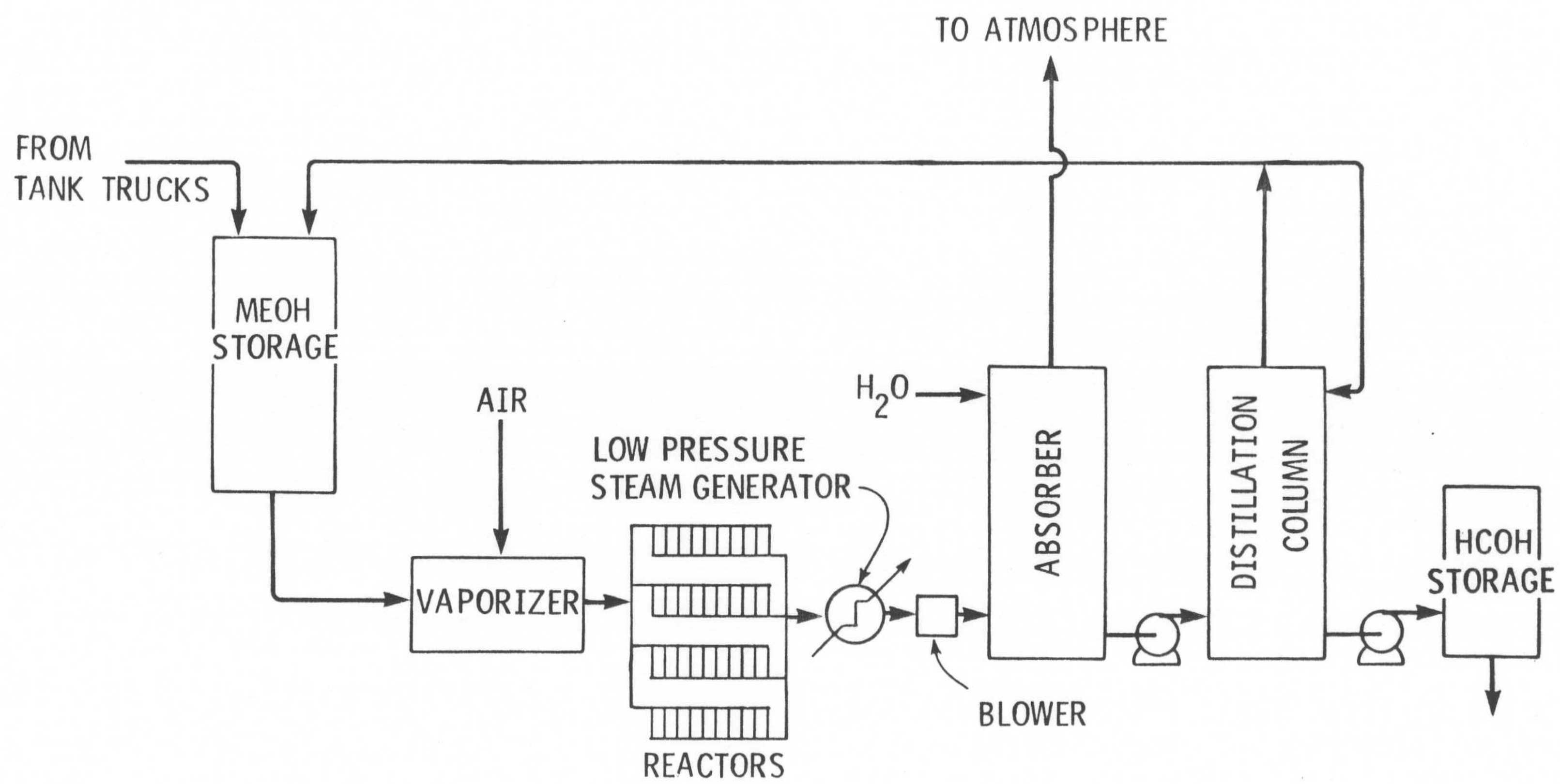

Figure 5. Schematic diagram of the silver catalyst formaldehyde unit.

5. DESCRIPTION OF THE INDUSTRIAL HYGIENE (IH) PROGRAM

The Tenneco Chemicals IH program at all facilities is monitored by the Tenneco Chemicals Corporate Medical Director, Dr. R. E. Gosztonyi. Dr. John Hochstrasser, the Corporate Manager of Industrial Hygiene, actively directs the IH program at all facilities. Dr. Hochstrasser is assisted by Mr. Barry Schlegel, Supervisor, Industrial Hygiene Field Studies and Mr. W. Philip Osen, Supervisor, Environmental Health Laboratory.

Compliance monitoring has been conducted and IH baseline sampling data have been obtained at the Fords plant during the past two years. The monitoring and sampling are normally handled by corporate IH personnel. The results of this sampling program are discussed in Section 6.

The formaldehyde plant has a low employee turnover rate of approximately one person per year in the formaldehyde operation. New operators are trained on the job for two to four weeks by the department supervisor, who describes the responsibilities to the new operator and closely supervises his activity during the training session until he judges the new operator to be competent. A written operating procedure for each operation is also available and includes safety and health items for which the operator is responsible.

The plant has an active safety program that has been prepared by the plant personnel. Safety glasses, hard hats, and safety shoes are required for all workers in the plant. Safe operating procedures have been developed for process sampling, catalyst replacement, tank cleaning, and tank truck loading. A two-volume manual on respiratory protection, a safety manual and an emergency procedure manual, which includes spill emergencies, have been prepared to coordinate activities in these areas.

The use of personal protective equipment is required when appropriate: this equipment includes splash-proof goggles and rubber gloves for process sampling; a disposable Tyvec suit, supplied-air respirators, and gloves for catalyst replacement; full-face gas mask, rubber coat and gloves for tank cleaning; and splashproof goggles for tank truck loading. Eyewash and shower stations are available in key locations throughout the units and loading area. Locker rooms and showers are also available.

The medical program at the plant consists of yearly physical examinations for all employees. These include a pulmonary function test, hearing test, eye examination, chest X-ray, blood test and a medical history questionnaire. The plant employs a part-time on-site nurse who treats and maintains records on the plant personnel. If problems are discovered by medical surveillance, the corporate medical director becomes involved.

6. SAMPLE DATA

Plant baseline data to define the worker exposure to formaldehyde during normal work situations are currently being generated under Mr. Schlegel's direction. Areas sampled included the formaldehyde loading area near the Formox unit and the silver catalyst unit area. More specifically, samples are being obtained in the truck loading operator control room, the areas above and below the loading platform, the truck hatch area during loading, and the silver catalyst unit control area. Sampling is being conducted using impingers (water absorbing reagent) for a sample duration of 30 to 40 minutes. A personal sample using impingers was taken during the truck-loading operation, but no results were obtained due to sampling method difficulties. No other personal samples have been taken for formaldehyde. The area samples generally showed less than 1 ppm TWA; the highest concentration was found in the sample taken at the tank truck hatch (~1 ppm TWA). No methanol IH sampling has been conducted.

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 is achieved by totally enclosing the process.

Leaks and spills of process vapors and solutions can occur from the mechanical equipment used. Odors from leaks were detected during the walk-through of the silver catalyst unit, and these were likely due to packing gland leaks at the absorber.

7.1 METHANOL UNLOADING AND HANDLING

Methanol is delivered to the plant by tank trucks owned by the plant and driven by plant drivers. The methanol is bottom unloaded from the trucks by the drivers into either a large bulk storage tank that supplies the Formox unit or into one of several smaller horizontal bulk storage tanks that feed the silver catalyst unit. The Formox methanol storage tank is located in an open area. The silver catalyst methanol storage tanks are located close to several buildings and other storage tanks. These two storage areas are located at opposite ends of the plant.

Quick-connect adapters to prevent spills and reduce exposure and cement dikes to contain accidental spills are used at both areas. The tanks at the silver catalyst area also have external level gauges as shown in Figure 6. No methanol leaks were apparent in this area.

7.2 CONTROL AREAS

The Formox control area is in a building separate from and adjacent to the unit and includes the process controls, a sample analysis

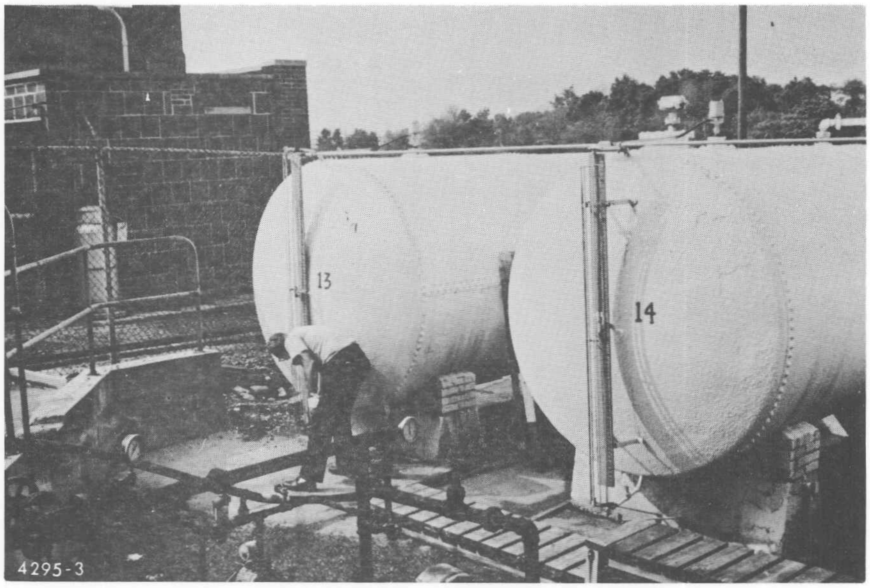

Figure 6. Silver catalyst unit methanol storage tanks with external level gauges.

area, and a locker room with shower. The operators monitor the process from a control board that records operating conditions and alerts the operator to problems. Product samples are analyzed in a laboratory hood that is vented to the roof. A velometer test during an OSHA survey on this hood indicated an inward face velocity of 150-200 feet per minute. Exposure in this area, where the sample analysis is conducted once every two hours could occur. However no significant exposure is anticipated in this area.

The silver catalyst unit control area shown in Figure 7 is located on the second floor of the building housing the unit and is situated between the methanol vaporizer and the absorption and distillation columns. The operators monitor the unit from a control board that alerts the operator to problems and allows correction of most problems without leaving the control area. The operator also takes process samples to monitor the process directly. The silver catalyst formaldehyde unit operator is also responsible for operating the hexamethylenetetramine process located in an adjacent area. This sharing of the operator reduces the amount of time he spends

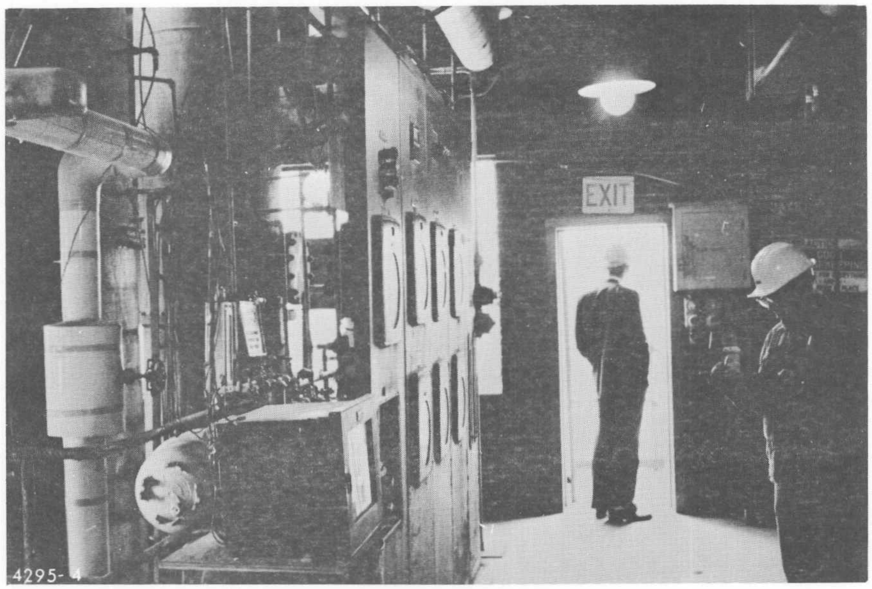

Figure 7. Control area for silver formaldehyde unit. Absorber and distillation columns are on the left.

on one unit. No process samples are analyzed by the operator at this unit. Instead, all process samples, (about two per day) are sent to the plant central laboratory. Exposure at the silver catalyst formaldehyde control board is limited but is possible due to its location. No formaldehyde or methanol odors were detected in this area during the walk-through.

7.3 PROCESS AREAS

The Formox unit is operated as a closed system, from the vaporization of the methanol through the aftercooler. The open-air structure as shown in Figure 1 in which the unit is located provides natural ventilation and dispersion of any leaks from the gasketed flange piping. No formaldehyde or methanol odors were detected in this area. The absorber column vents to the atmosphere but has little exposure potential to the worker since it is approximately 30 feet above the top level of the structure. The absorber also has sample ports at several points on the column; these are used occasionally but present very little exposure potential under normal operating circumstances. Formaldehyde is drawn off the bottom of the absorber and pumped to the tanks using "leakproof" dynamic (nonmechanical) seal pumps like the one shown in Figure 8. The absorber sample point to determine the solution concentration shown in Figure 9 is located just after the pump. Samples are collected using a narrow mouth sample bottle; the purge solution is discarded into a special waste disposal line that goes to the wastewater treatment plant. Exposure potential in this area is reduced because of the very good performance of the "leak proof" dynamic seal. The sampling point and procedure does create some exposure potential, but only small amounts of paraformaldehyde were noticed on the ground and no formaldehyde odor was detected in this area.

The silver catalyst unit process area is not as well controlled as the Formox unit. This is due to the age of the equipment used and the area in which it is located. As already mentioned, the unit is in an enclosed brick structure (see Figure 3) that severely reduces ventilation. This allows containment of formaldehyde vapors in certain areas. The process equipment and piping systems from the bulk storage tanks to the aftercooler are completely enclosed and under negative pressure, presenting no exposure hazard. No methanol or formaldehyde odor was detected in areas around the vaporizer, reactors, and aftercooler. However, some formaldehyde vapors were smelled around the absorber and distillation column area. These vapors were strongest on the first floor of the building near the bottom of the absorber where a sample point is located (see Figure 10) and also near the interior storage tanks. In these areas, team members experienced eye irritation due to the formaldehyde vapors. The formaldehyde leaks were associated with the centrifugal pumps used to transfer the formaldehyde to the storage tanks. These pumps use packed seals and even though the packing

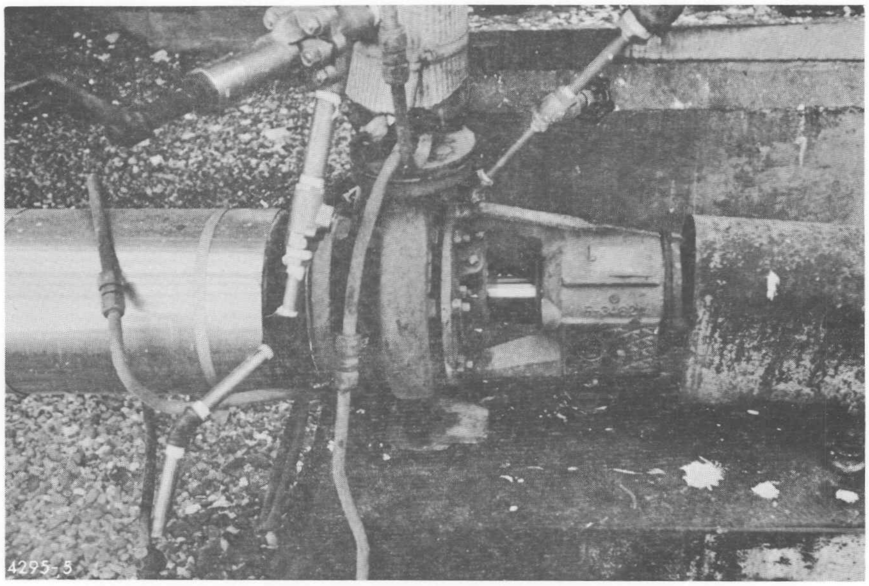

Figure 8. Leakproof pump (Allis Chalmers CSO pump with Dynamic Seal) used in the Formox product lines.

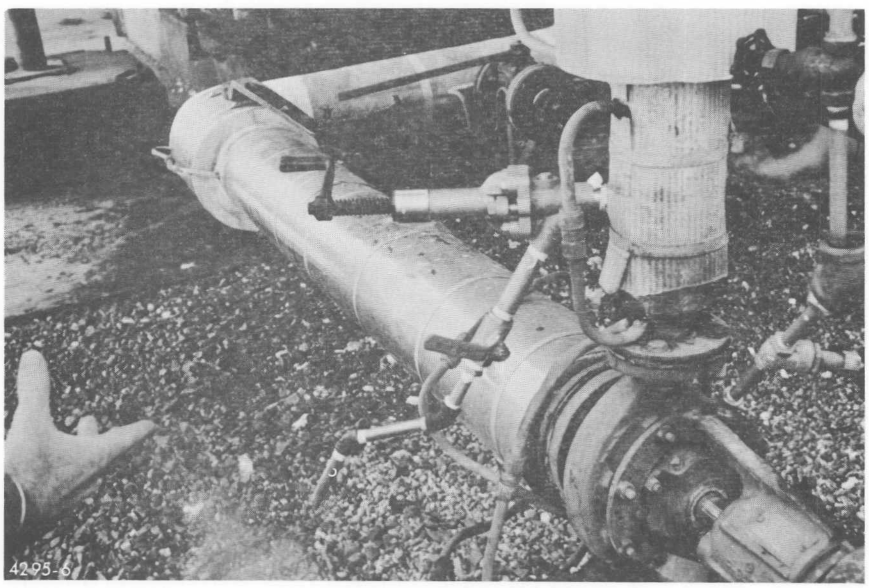

Figure 9. Absorber sample point with piston type line cleaner and ball valve.

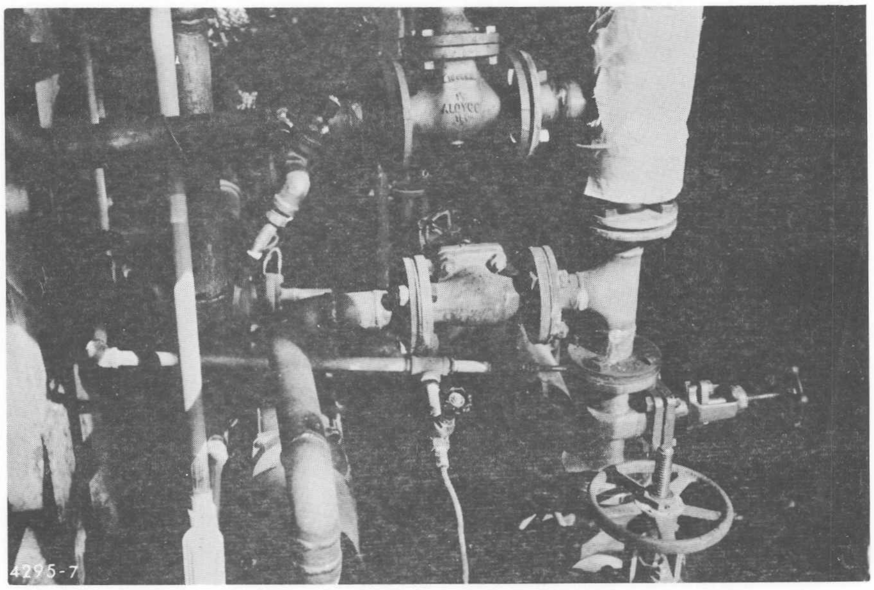

Figure 10. Sample point for silver catalyst unit methanol stripper. Note the small paraformaldehyde formation on the valve.

had recently been replaced the formaldehyde solution continued to leak. A water wash for the pump seals had been provided to reduce the formaldehyde exposure to the workers.

A sample point for the absorber product was located just after the centrifugal pump as shown in Figure 11. Also shown is the water wash nozzle, visible just above the pump housing.

7.4 STORAGE AREAS

The Formox storage area for formaldehyde consists of a bermed area where two 100,000 gallon storage tanks are located. Another large tank is also used for storage and located in a diked area near the truck loading station. The three storage tanks are vented into a scrubber which removes formaldehyde vapors and the exposure hazard to the worker. Also located in the first area is an ion exchange unit that removes the formic acid from the formaldehyde solution.

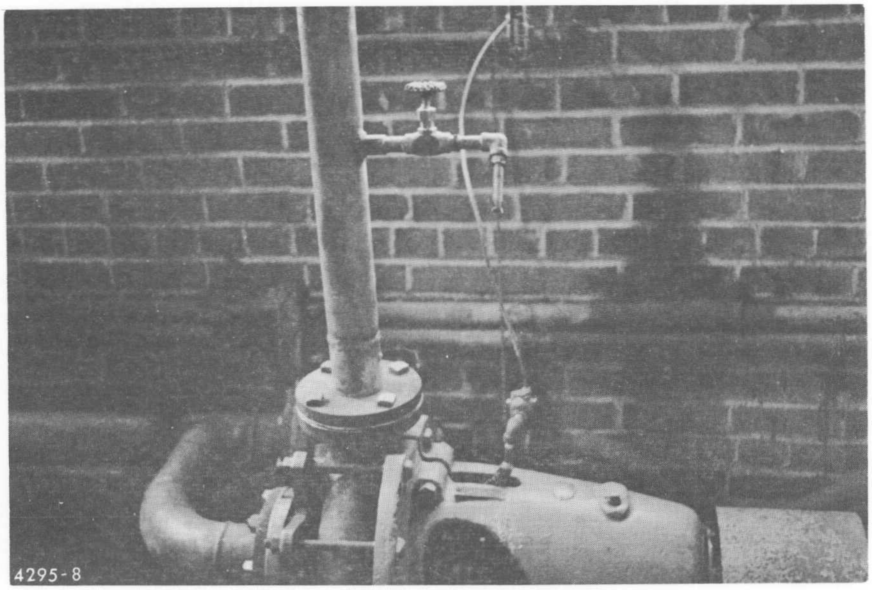

Figure 11. Product sample point for the silver production unit (absorber). Also visible is the water wash supplied to the pump.

The formaldehyde solution is pumped from the tanks using single-mechanical-seal centrifugal pumps. Several visible paraformaldehyde formations were seen around the pumps, and a slight formaldehyde odor was detected in the area. The plant is considering replacing the old pumps as they wear out with "leakproof" type pumps. The tanks, whose levels are determined by Varec gauges, are sampled from a sample point in the bottom of each tank using the same procedure as for the absorber sample point.

The large tank storage area is located adjacent to the truck loading facility and provides the large storage capacity needed for weekends when the plant does not ship formaldehyde. This tank is in a large, diked area and uses single-mechanical-seal pumps to transfer the solution to the trucks or to other processes on site. No formaldehyde odors were detected near this large tank.

The storage tanks for the silver catalyst unit are located adjacent to the building housing the unit. These old tanks use a beam balance (Figure 12) to determine the quantity of formaldehyde solution in the tanks. The tanks are vented to the atmosphere and use single-mechanical-seal centrifugal pumps to transfer the solution to the hexamethylenetetramine process. No formaldehyde odor was detected in this area.

7.5 TRUCK LOADING FACILITY

The truck loading facility is situated between the large formaldehyde storage tank and the smaller tanks used by the Formox unit. The facility is an open structure, except for the control room (Figure 13), and has bays to handle two trucks at a time. The truck loading operator works from above, opening the tank truck hatches and inserting a dip pipe and swivel connection into the truck, shown in Figure 14. To protect the operator, a flexible vacuum tube is also placed just inside the hatch to draw formaldehyde vapors out of the tank and vent them through the roof. As an added precaution, a pedestal fan is provided for additional ventilation. An eyewash and shower station is also available on the platform.

The operator is responsible for blending the formaldehyde solution in the tank truck as it is being filled. This is done automatically from inside of the central room. However, quality control requires taking a sample from each truck. This is done by the operator who takes a sample from the truck by using a long dipstick.

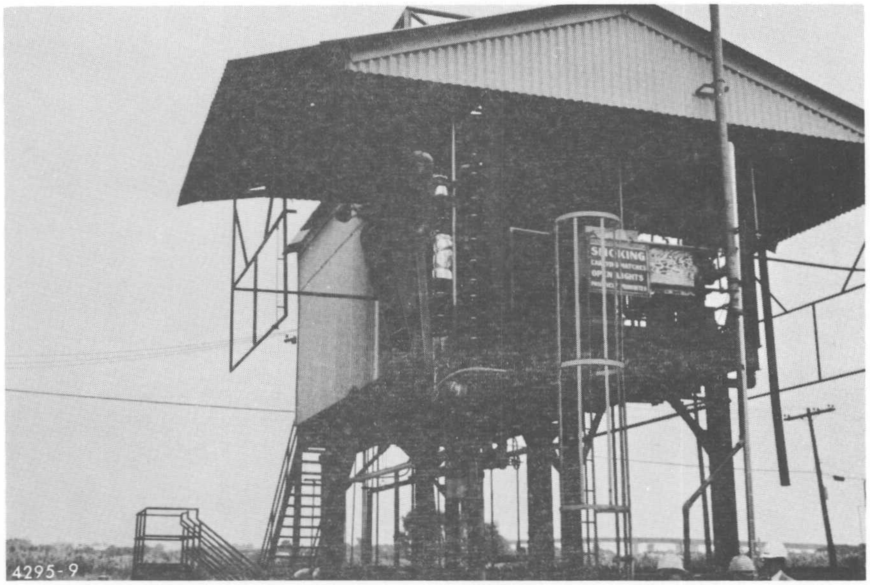

Figure 12. Open air truck loading area with enclosed workroom in rear of structure.

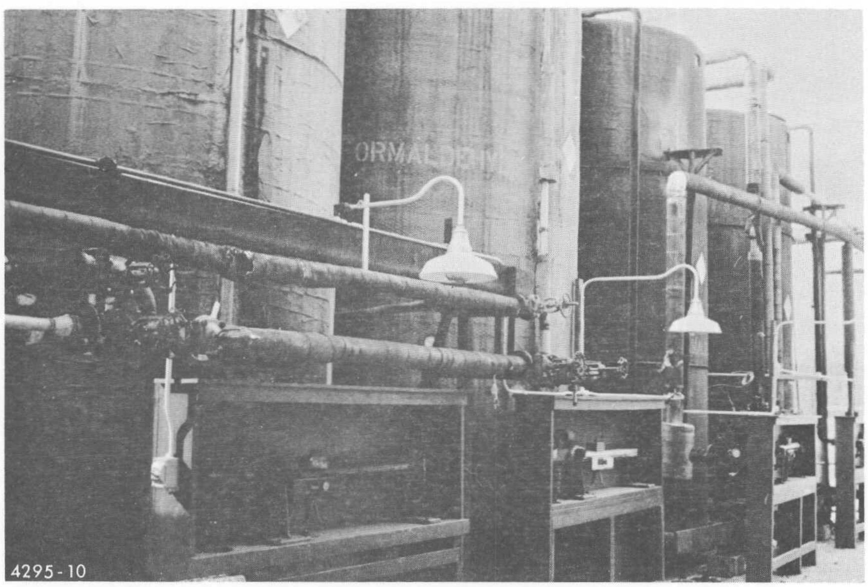

Figure 13. Silver catalyst production unit storage tanks.

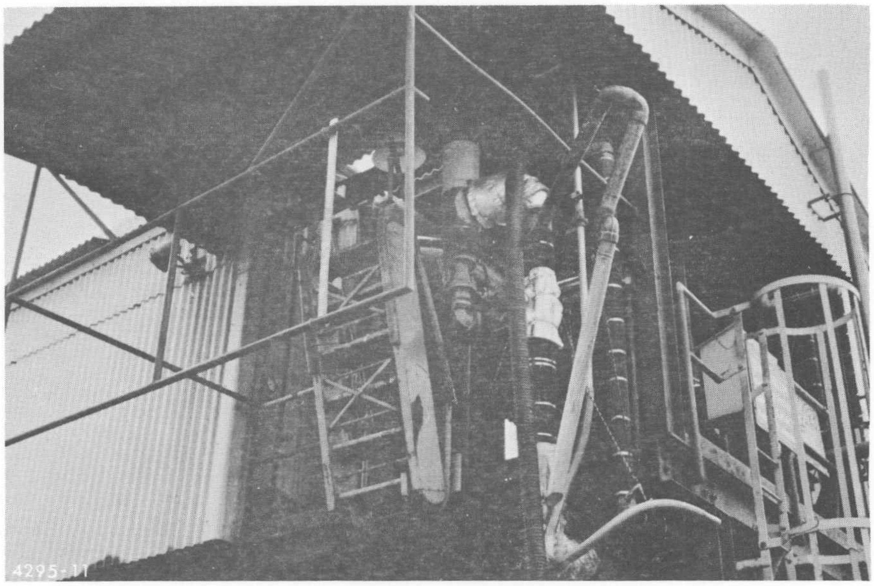

Figure 14. Truckloading area showing the swivel-jointed dip pipe and vacuum line used to reduce worker exposure hazard.

8. CONCLUSIONS AND RECOMMENDATIONS

The plant demonstrates an effective control program for the Formox unit and, for the most part, for the silver catalyst unit as well. Slight formaldehyde odors were detected in very few areas in the Formox unit, which is evidence that the maintenance program is working well. Maintenance at the silver catalyst unit also appears to be effective, but the deterioration of the equipment due to its age is beginning to show. No large paraformaldehyde formations were seen in either unit. Emergency protection, personal protective equipment, and the worker education programs demonstrate good industrial hygiene practices and a good awareness of the potential exposure points.

There are several potential problem areas in the silver unit, the largest being the use of packed seals for the volatile formaldehyde solution coming from the absorber. The packed seal pumps are difficult to maintain and result in product solution leaks and vapor emissions. A second potential problem area in the silver catalyst unit is the interior storage tank area. Spills and leaks in this area generate a pervading odor of formaldehyde. It is recommended that greater effort be made to control the formaldehyde vapors in the silver unit by improving housekeeping and maintenance or replacing equipment.