PRELIMINARY SURVEY REPORT:

CONTROL TECHNOLOGY FOR FORMALDEHYDE EMISSIONS

AT

Drexel Heritage Plant 60
Morganton, North Carolina

REPORT WRITTEN BY:
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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway
Cincinnati, Ohio 45226

PURPOSE OF SURVEY: To observe the processes and associated controls for veneering wood panels using heated-platen presses, with emphasis on the factors affecting the control of formaldehyde emissions during these operations.

DATE OF SURVEY: August 31, 1982

SURVEY CONDUCTED BY: Vincent D. Mortimer, Jr.
Bruce A. Hollett

EMPLOYER REPRESENTATIVES CONTACTED: Jesse Tallent, Plant Manager
W. Haskell Reid, Manager, Corporate Loss Prevention

EMPLOYEE REPRESENTATIVES CONTACTED: Sam Lowman, Plant Safety Committee Representative

STANDARD INDUSTRIAL CLASSIFICATION OF PLANT: 2435: Hardwood Veneer and Plywood
2436: Softwood Veneer and Plywood

ANALYTICAL WORK PERFORMED BY: Robert Phillips, NIOSH/IWSB
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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. NIOSH was formally created by the Occupational Safety and Health Act of 1970. This legislation--which also gave rise to the Occupational Safety and Health Administration (OSHA) in the Department of Labor--called for a separate organization, NIOSH, to provide for research and education programs related to occupational safety and health. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards.

This research study began as an assessment of occupational health hazard controls associated with the industrial use of adhesives. Plants in the aerospace, automotive, footwear, wood products, and some other industries were visited to observe the relation of the workers to the use of adhesives in the manufacturing processes and the types of controls being used. This preliminary work identified hot-process veneering with urea-formaldehyde resin adhesives as the operation which could benefit most from control technology research.

Formaldehyde, a commonly used substance in industry and the life sciences, has long been recognized as a potential irritant of the eyes, nose, and skin. In the last few years, the results of some animal toxicity studies have shown a relationship between formaldehyde exposure and cancer in some laboratory animals. It is not known how long it will be until the risk of cancer for humans exposed to formaldehyde is determined. In the meantime, as a prudent public health measure, plants should reduce occupational exposure to formaldehyde as much as possible with engineering controls and work practices. However, little information is available on the relative effectiveness of available methods for controlling exposure to formaldehyde in manufacturing wood panels.

In response to this need, the Engineering Control Technology Branch of NIOSH is studying the control of formaldehyde emissions from hot-process veneering operations which use a urea-formaldehyde resin adhesive. The goals of this study are to evaluate a number of different approaches which some furniture and wood-panel manufacturing firms have taken to control these emissions, and then to disseminate useful information and practicable recommendations on effective methods for controlling occupational formaldehyde exposure.

The research is being conducted primarily by performing a series of in-depth field surveys, which are preceded by a number of preliminary surveys. This preliminary survey of Drexel Heritage Plant 60 was conducted on August 31, 1982 to assess their operations and associated controls for possible inclusion in the in-depth study phase of the project. The following report documents the information pertinent to that assessment.

GENERAL INFORMATION ABOUT THE PLANT

Drexel Heritage Furnishings Inc. operates a number of plants and manufactures a full line of household furniture. Plant 60 produces flat and curved veneered panels for use by other Drexel Heritage plants. They use both "hot-press" and "R/F press" processes. The normal production level averages between 20,000 and 30,000 square feet of panels per day. Most of the panels are produced by the hot-press process. The facilities include a "fancy-face" department which prepares sheets of veneer stock featuring decorative veneer patterns.

The building encloses over 87,000 square feet of floor space. The press operations occupy less than a fifth of this area. Figure 1 shows the office area, with a lunch room on the floor above, separated from the main area of the plant by a brick wall. The building is heated by overhead steam radiators; the fancy face room and the office area are air conditioned. Filtered air from the sawdust collection system is returned to the building in winter, and wood scrap fuels the steam boiler.

Total employment at the time of the survey was approximately 150, with less than a fourth of this number in administration or maintenance. Two shifts were running: one from 7:00 in the morning till 3:30, the other from 3:30 till midnight. Approximately 50 people were assigned to the glue room, the department which glued and pressed the panels; and about three-fourths of these worked the first shift.

PROCESS DESCRIPTION

The simplest veneered panel consists of three plies, a face and a back veneer glued to each side of a core. Additional plies may be added to make a panel which is stronger and more stable dimensionally. An established way to achieve a high rate of production is to reduce the glue-curing time by heating the glue while pressure is being applied to the panels. One way to do this is to heat the metal plates which apply the pressure, generally referred to as a "hot-press" process. Another way is to generate heat in the glue-line with radio-frequency (R/F) radiation in much the same way that food is cooked in a microwave oven. In this "R/F-press" process, the hydraulic press only applies pressure. "Cold-press" processes, those for which pressure is applied while the boards are maintained between 60^{o} and 100^{o}F, require much longer periods of time for the glue to cure.

For most applications, the glue which currently provides the best performance for the least cost is a urea-formaldehyde (U/F) resin adhesive. The core may be veneer, particleboard ("chip-core"), fiberboard, or a piece of edge-glued solid-wood "lumber-core." Almost all particleboard and fiberboard are made with formaldehyde resin binders, and a formaldehyde resin glue may be used to assemble lumber-core. To improve the appearance of a panel, the core may be "banded" with solid wood edges prior to veneering. Here again, the adhesive may contain formaldehyde. A variety of hardwoods and softwoods, including oak, walnut, poplar, and pine, are used for veneer stock. Some plastic laminates are being used for certain products; usually these panels are cold-pressed.

The veneers are received in flitch form, thin strips bundled together as they were cut from the log. The veneer flitches are pressed, trimmed, and joined into sheets, which are then cut to the proper size for the panel

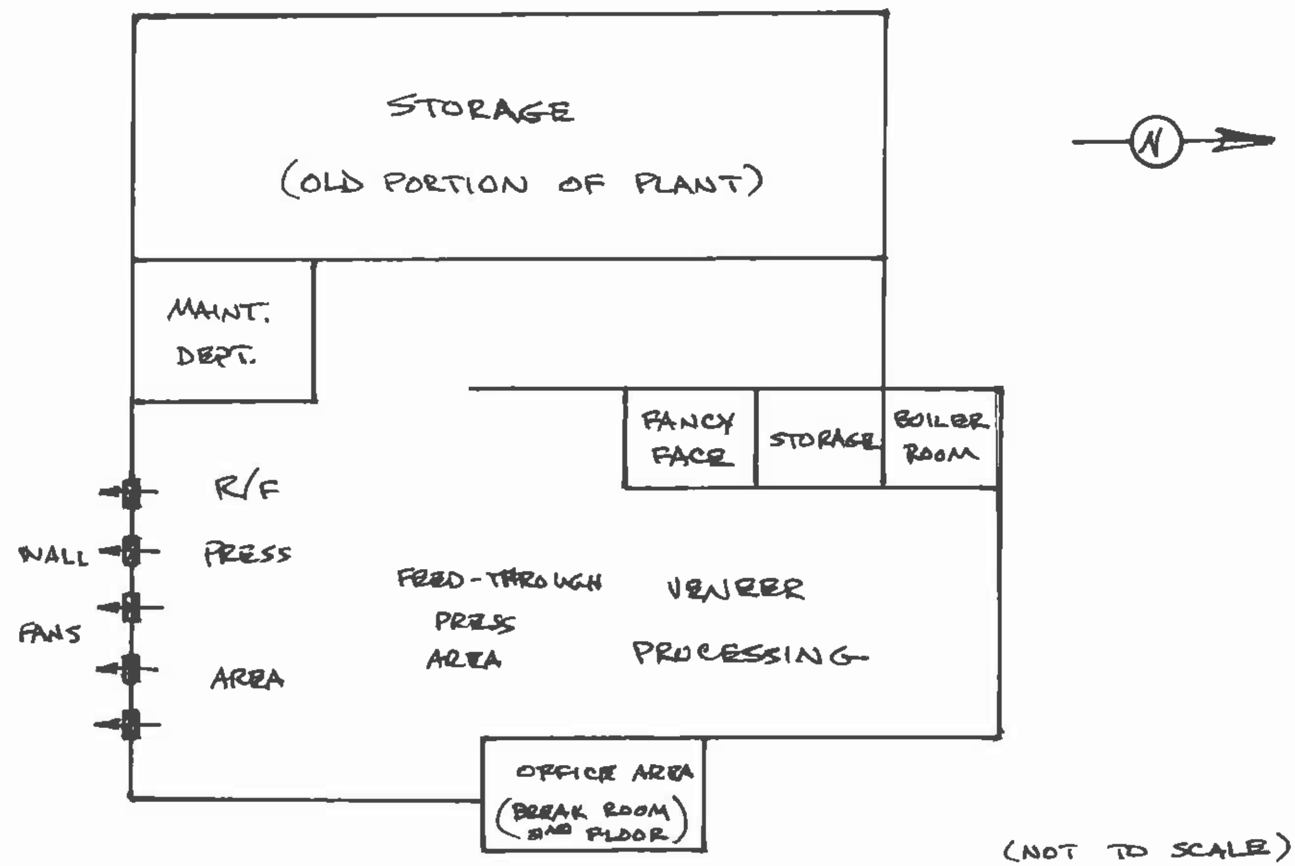

Figure 1. Layout of Plant

being produced. The core stock is received already cut into pieces of the appropriate nominal size. The cores are first banded, if necessary, and then trimmed to the desired size. This plant does not have facilities for manufacturing lumber-core.

About 60% of the flat panels produced use chip-core, and about two-thirds of this quantity is 3-ply. The remainder is lumber-core. Very little fiberboard is used. Five-ply panels, from all types of cores, make up about 60% of the total production. Occasionally, some seven-ply panels are made.

Flat panels are produced on two Friz feed-through presses. Heat and pressure are applied for from less than 2 to over 3 minutes, depending on the panels being processed. Chip-core must be pressed longer than lumber-core, and five-ply panels are pressed longer than three-ply. Between 45 and 60 square feet of one type of panel can be pressed at a time. Two workers are required to operate each press: a loader and an unloader. One additional worker inspects the pressed panels and records information on the production log for both presses.

The panels are prepared for pressing by one of the two glue-spreader crews. Two or three people are assigned to each glue spreader. The appropriate layers are passed through the glue spreader, and the stack of panels is built-up like a pile of sandwiches. The stack is moved to the loading end of a press on roller conveyors.

The loader places a single layer of panels on a conveyor belt approximately six-feet wide. When he has filled an area approximately 10 feet long, a load is ready for the press. When the press opens, this next load of boards is moved into the press as the newly pressed panels are conveyed out of the press onto the inspection platform. After the pressed panels have been inspected, they are stacked by the unloader and moved to the loading dock to await removal to another plant.

Curved panels may range from 3 to 25 plys of veneer stock (no core as in the flat panels); however, over 80% of this product consists of either 9 or 11 plies. Curved panel production is usually less than 1000 square feet per day; however, the large number of plies in each panel increases the average glueline square-footage by about tenfold.

Curved panels are produced on one of three R/F presses. Pressure is applied for from less than 2 to over 3 minutes, depending on the size and number of plies of the panels being processed; R/F power is applied to heat the gluelines during approximately the first half of this period. If the panels are small or consist of a relatively few number of plies, more than one panel may be pressed at a time.

Only one worker is required to operate an R/F press. The R/F press operators load and unload their press and participate in the lay-up of the panels. The presses are loaded and unloaded from the same side. Newly pressed panels are stacked on a pallet close to the press until being removed to another section of the plant to await shipment.

Glue is mixed for the two operations on a separate platform constructed over each press area. One worker on each shift is responsible for both glue-mix stations. The two glues have different recipes, but they both contain almost 90 percent urea-formaldehyde resin. The remainder is mostly hardener plus a small amount of water or ammonia. The resin and additives are supplied by Southeastern Adhesives, Inc.

Formaldehyde is emitted while the boards are being pressed, although the escape of vapors seems somewhat restricted by the closed press. Consequently, much formaldehyde vapor is released when the press opens. The emission of formaldehyde from the hot boards continues as the boards are unloaded, stacked, and cooled.

The cold resin does not give off much formaldehyde; thus, mixing and spreading the glue are not considered to be significant sources. Edge gluing operations for banding, which are characterized by much smaller glue lines and more mechanization, are also not considered significant emitters of formaldehyde.

CONTROL MEASURES

A canopy hood, measuring 9 1/2 ft by 19 ft, was installed about 4 ft above the inspection platform of each feed-through press circa 1972. Each hood is exhausted through a 42-inch duct to a fan on the roof. A short (less than 3-ft) outlet section above the fan is covered by a rain cap. A free-action butterfly damper seals each duct when not in use.

Five wall fans have been installed along the south wall above the curved panel press area since 1975. The fans, appoximately 4 ft in diameter, are about 15 ft above the floor. One is positioned where the glue-mix platform for the R/F presses attaches to the wall.

A small canopy hood covers a small mixer on the main floor close to the large R/F press. This mixing station and its ventilation were not in use during our survey.

Auxiliary fans are placed throughout the plant, wherever additional (cooling) air movement is desired. One of these was positioned at the end of the inspection platform for feed-through press 2 to blow cool air on the worker unloading panels from this press.

A few ceiling vents were present; however, the only make-up air is the filtered air returned from the dust collection system in winter. Loading dock doors are often opened, especially during periods of warm weather.

OCCUPATIONAL HEALTH AND SAFETY PROGRAM

Drexel Heritage does not have a corporate industrial hygienist. An industrial hygiene survey was performed for this plant in April of 1981 through the Aetna Insurance Company, their worker's compensation insurance carrier, as a loss prevention service. The single sample taken for formaldehyde measured a breathing zone exposure of 0.5 parts formaldehyde per million parts of air (ppm) over a period of 5 hours.

Some of the workers in the glue room wear gloves and aprons. The glue-mix man wears an apron and, at certain times, goggles and gloves. A plant safety committee, having both management and employee representatives, conducts inspections and meets monthly. The supervisors discuss safety topics suggested by the corporate loss prevention department at their monthly meeting. A fire brigade has been organized in each plant.

Each employee completes a questionnaire covering pertinent medical information after to being hired. Audiometric screening is administered to noise-exposed workers yearly. Written procedures are available for each job. New employees are trained by the assistant foreman in the section.

ASSESSMENT OF CONTROLS

Air Movement

Airflow at selected points was measured with a hot-wire anemometer and/or observed using a smoke tube. Measurable air velocities under the hood and thermal rise velocities along the face of the presses were generally less than 100 ft/min. By contrast, horizontal velocities on the order of 500 ft/min are generated by auxiliary fans.

Air movement, as observed with a smoke tube, was generally slow and random, except in the circulation pattern under the canopy hood created by an auxiliary fan. This strong circulation caused roll-out of air close to the press, just above the platform on the inside (press-1 side) of press 2. The fan, which was positioned to blow cooling air across the worker stacking boards from press 2, drew its supply air from the take-off region of press 1.

The calculated exhaust flow rate from the canopy hoods over the feed-through presses averaged approximately 12,000 cfm for each hood, giving an average capture velocity across the opening of each canopy of less than 75 ft/min. Desiring, only approximate values on this preliminary survey, these values were determined from the measured average velocity of the exhaust stream flowing through the opening between the top of the stack and the rain cap. An anemometer traverse of the canopy opening was ruled out due to the variable, low-velocity air currents crossing the face of the canopy hood.

CEA Sampling

The air at various points in the room was analyzed for formaldehyde using a CEA-555 Organic Vapor Monitor to ascertain the order of magnitude of representative formaldehyde concentrations. The CEA-555 continuously analyzes a sampled airstream for formaldehyde, employing a colorimetric procedure. Thus, this method is appropriate for evaluating short-term and ceiling exposures, but it has not yet been validated for determining compliance with standards. Also, only area samples were taken with this instrument on this survey. Therefore, these results should not be directly compared to any OSHA standards.

The standard "CEA 555-FO: Formaldehyde in Air" procedure was followed. The full-scale calibration for the CEA-555 that day was 5 ppm; the full-scale rise time for responding to the calibration input was approximately 5 minutes. The sampling locations are diagrammed in Figure 3. Press activity during this sampling was not noted.

Some peak values between 2 and 3 ppm were measured on the operator side of the large R/F press. The measured concentration on the back side of this unit did not exceed 0.5 ppm. For feed-through press 2, values on the loading side and on the unloading side near the desk did not exceed 1 ppm. Some peaks exceeding 1.5 ppm were recorded near the inspection platform. No values were recorded greater than 3 ppm; however, this instrument will not detect short peaks of high concentration, and feed-through press 1 was not operating on the day of our survey.

Solid Sorbent Tube Sampling

Personal and area samples for formaldehyde were collected using Supelco XAD-2 Formaldehyde Resin tubes and low-flow pumps calibrated for approximately 50 milliliters of air per minute (ml/min). The solid sorbent tubes were analyzed for formaldehyde according to NIOSH method P&CAM-354. This procedure involves desorption of a formaldehyde reaction product from the sorbent coating and analysis by capillary-column gas chromatography with flame ionization detection. The limit of quantification for this method is typically 5 micrograms of formaldehyde per tube. Theoretically, sampling at the maximum rate (for this method) of 50 ml/min for over 3 hours should detect concentrations less than 0.5 ppm.

The measured ambient concentrations for feed-through press 2 and the glue-mix platform above the curved panel area and the personal exposures for the feed-through press loader and unloader were all less than 1 ppm. The personal sample for the operator of the large R/F press and the area sample at his work station measured approximately 1.1 and 1.5 ppm, respectively.

Passive Monitors

Some side-by-side samples were collected using two different types of passive monitors to obtain comparison field data with these devices. Results for one type of monitor ranged from less than 0.5 ppm to approximately 1.5 ppm; those for the other, from less than 0.25 to 1 ppm. For both types, the measured concentrations followed the trend of the solid sorbent tube results, although not necessarily proportionally. Since this method has not been validated by NIOSH, the results will not be further used to assess the effectiveness of controls for this survey, but will contribute to a separate NIOSH evaluation of passive monitors.

CONCLUSIONS AND RECOMMENDATIONS

The primary methods of formaldehyde exposure control are canopy hoods over the feed-through press inspection platforms and general ventilation in the area of the R/F presses. However, each hood captures only some of the emissions which rise from the platform. The volumetric airflow rate is insufficient to capture vapors much beyond the boundary of the large canopy opening; and the auxiliary fan, in addition to cooling the unloader and ventilating his breathing zone, blows emissions into the plant which would otherwise have risen vertically into the capture zone of the hood.

With this arrangement and under the conditions on the day of the survey, partial-shift time-weighted average formaldehyde concentrations were all less than 0.5 ppm except for around the large R/F press. Some peak concentrations were measured to be greater than 1 ppm around both the feed-through press and the R/F press, but none were measured greater than 3 ppm.

The R/F presses are significant generators of formadehyde vapors, especially during the unloading operation, and additional controls should be considered. Hot panels emit an appreciable quantity of formaldehyde until they have cooled, and this fact should be considered in designing a ventilation system for any hot-process press. One of the objectives of our study is to address the problem of recurring peak exposures inherent with the discharge of hot boards from the press and their subsequent handling by the workers.

This plant offers the opportunity to study a canopy hood over an unloading platform. However, with no supplied make-up air, it is not known what effect the closing of doors and windows would have on the airflow within the plant. Moreover, it may be possible to position the auxiliary fans so that they contribute more effectively in controlling exposures.