PRELIMINARY SURVEY REPORT:

CONTROL TECHNOLOGY FOR FORMALDEHYDE EMISSIONS

AT

Baker Furniture Company
Mocksville, 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:	September 2, 1982
SURVEY CONDUCTED BY:	Vincent D. Mortimer, Jr. Bruce A. Hollett
EMPLOYER REPRESENTATIVES CONTACTED:	Mike Hinshaw, Plant Manager Jerry Hudson, Facilities Engineer
EMPLOYEE REPRESENTATIVES CONTACTED:	Haywood Heath, Safety Committee Member
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	2435: Hardwood Veneer and Plywood 2436: Softwood Veneer and Plywood
ANALYTICAL WORK PERFORMED BY:	Robert Phillips, NIOSH/IWSB Utah Biomedical Test Laboratory, Salt Lake City, Utah

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 Baker Furniture's Mocksville Plant 8 was conducted on September 2, 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

The Mocksville plant has been in operation since 1964 manufacturing high quality occassional furniture, such as small desks, tables, and chests. About

1978, they began producing the veneered panels for all Baker Furniture plants in the Southeast. The hot-press process is used exclusively for flat panels. There is some R/F laminating of small parts and frames. Production averages less than 5000 square feet of panels per day. Baker Furniture is affilated with the North American Philips Corporation.

The veneering operation are located in the north end of the main building. They occupy between 10 and 20 percent of the total floor space, which is on the order of 175,000 square feet. (See Figure 1.) An office area, which includes a break room for employees, is located approximately midway along the east wall. The production facilities include a "fancy-face" department which prepares sheets of veneer stock featuring decorative veneer patterns. The building is heated with oil furnaces; the office area is air-conditioned. Filtered air from the sawdust collection system is returned to the building in winter.

At the time of the survey, the total plant employment of 150 included 15 administrative and 2 maintenance employees. The veneer department consists of 35 workers, and 8 were assigned to the hot press operation. There is one shift, running from 7:00 in the morning until 3:30, with a half-hour lunch break at 11:30.

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" processess, those for which pressure is applied while the boards--and glue--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 a sheet of veneer, particleboard ("chip-core") or 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, tnin 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 being

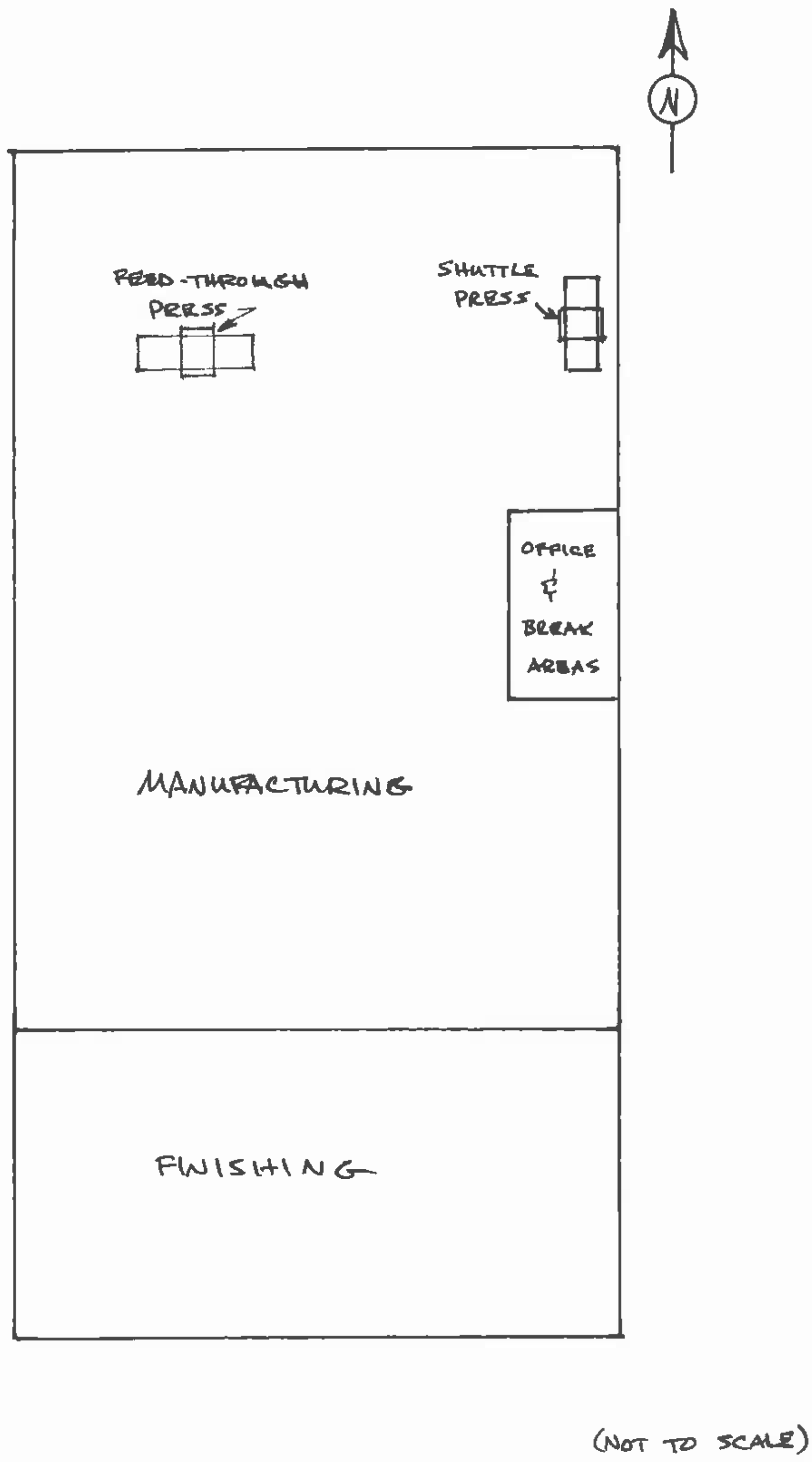

Figure 1. Layout of Plant

produced. Core stock is received already cut into pieces of the appropriate nominal size and banded, if desired. This plant does not have facilities for manufacturing lumber-core.

About 70% of the flat panels produced use chip-core, and about half of this quantity is banded. The remainder is lumber-core; very little fiberboard is used. Five-ply panels, from all types of cores, make up most of the total production. Large curved panels are not made here, the only other veneering involves small parts and frames.

Hot-press veneering is accomplished mostly on a Wemhoner feed-through press. Heat and pressure are applied for from less than 2 to over 3 minutes, depending on the panels being processed. Two workers are assigned to the Wemhoner: a loader and an unloader. The process is highly automated.

A steam-heated, two-level shuttle press is still used, but mostly for flattening sheets of veneer. It is used for pressing panels only when the feed-through press is not being used.

The panels are prepared for pressing by the glue-spreader crew. Two or three people are assigned to the 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 worker that loads the feed-through press places a single layer of panels on a conveyor-belt loading platform approximately 5 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 an articulated unloading platform. The boards can then be unloaded by running the conveyor belt while raising the end of the platform, causing the panels to run off the end of the conveyor onto a stack on the staging platform. From here, the unloader restacks the boards on a pallet.

Glue is mixed in 50-pound batches by the hot-press loader. Over 80 percent of the glue is urea-formaldehyde resin. The remainder is mostly hardener plus a small amount of water and ammonia in summer.

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 and the panels are discharged from the press. 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 usually not considered to be significant sources.

CONTROL MEASURES

A canopy hood, measuring approximately 13 by 7 1/2 feet, is installed over the feed-through press. This hood has a center baffle blocking about a fourth of the opening. The baffle was inserted to reduce rollout around the outer margin of the canopy. There is also a canopy hood over the shuttle press. Each hood is vented through a 14- or 16-inch circular duct to a separate fan on the roof. These hoods have been in place for about 1 year.

General ventilation is provided mainly by open doors at the north end of the building and the extensive local exhaust ventilation for controlling sawdust from the wood-working operations elsewhere in the plant. The general airflow around the feed-through press is from north to south, although the velocity is low (less than 100 ft/min) and variable.

Auxiliary fans are used to provide additional cooling air. Some of these are attached to roof-support columns; the others are floor models, which may be positioned by the workers.

OCCUPATIONAL HEALTH AND SAFETY PROGRAM

Baker Furniture does not have an industrial hygienist, and routine air sampling in the plant is not performed. The facilities engineer, who works out of the Andrews, North Carolina plant, handles ventilation system design and installation; he visits this plant every other week. Industrial hygiene services could be provided on request by the Workers Compensation carrier, the Travelers Insurance Company. They already conduct semi-annual safety inspections.

Hearing tests are given annually to noise-exposed workers by a nurse from one of the other plants--all the other plants have a Licenced Practical Nurse on duty. No other periodic medical monitoring is performed. Pre-employment physicals are given to all employees by a general-practice group of physicians in Mocksville.

Workers in the glue room are not required to wear any protective equipment, although workers in other areas of the plant may be required to wear safety glasses and hearing protection. A plant safety committee, having both management and employee representatives, conducts inspections and meets monthly.

ASSESSMENT OF CONTROLS

Air Movement

Airflow at selected points around the feed-through press was measured with a hot-wire anemometer and/or observed using a smoke tube. Measurable velocities across the opening of the canopy hood were generally between 20 and 60 ft/min. Rollout was observed at some location around the outside edge of the 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 parts formaldehyde per million parts of air (ppm); the full-scale rise time for responding to the calibration input was approximately 5 minutes.

Formaldehyde concentrations ranging from less than 1 ppm to between 1 and 2 ppm were measured around the feed-through press in the morning, when press activity was light. Concentrations between 1 and 3 ppm were measured around the glue-mixing station, loading platform, and unloading area in the afternoon, when most of the production took place.

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.

Personal samples were collected for the loader and the unloader. Area samples were placed on the desk by the control panel, on the other side of the press from this location, and adjacent to the unloading platform. All samples were below the limit of quantification for the analytical procedure. Based on the volume of air which was drawn through the sample tubes, time-weighted average concentrations on this day are expected to be less than 0.5 ppm.

Passive Monitors

Three side-by-side samples were collected using each of two different types of passive monitors to obtain comparison field data with these devices. Results for one type of monitor ranged from approximately 0.3 ppm to 0.6 ppm; those for the other, from approximately 0.1 to 0.5 ppm. However, there were no discernable trends between the two sets or with the solid sorbent tube results. 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 local exhaust ventilation. To some degree, auxiliary fans and general ventilation help disperse vapors not captured by the canopy hood. However, the general airflow through the space between the press and the face of the canopy may carry some emission into the plant instead of allowing them to rise into the capture zone of the hood.

With this arrangement and under the condition on the day of the survey, half-shift time-weighted-average formaldehyde concentrations were all less than 0.5 ppm. Some peak concentrations were measured to be greater than 1 ppm around both the feed-through press and the glue-mixing area, but none were greater than 3 ppm.

The fact that there was no provision for capturing emissions from the hot boards during the unloading operation did not seem to create a problem in this plant on the day of the survey. However, hot panels do emit an appreciable quantity of formaldehyde during unloading and while cooling, as demonstrated by some of the peak concentrations measured; 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 a feed-through press. However, the low production rate may preclude an accurate evaluation of control system effectiveness.