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Health Hazards and Control of an Epoxy Resin Operation

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THE EPOXY resins are strong and resilient plastics that have interested engineers since they first appeared in 1950. Thermosetting and heat-resistant, these plastics when cast and heat-cured are especially useful in applications requiring resistance to shock and vibration. They are also—unfortunately—somewhat toxic, since tertiary and tetra-amines released during the uncured, or wet, state cause allergic reactions in almost all personnel exposed. The epoxy resins are therefore an industrial hygiene problem of some importance; a problem that, unless non-toxic hardeners are developed, can be expected to increase as these resins come into wider and wider use. An excellent paper discussing experimental data and chemical characteristics of many of the epoxy resins appears in the February issue of the *A.M.A. Archives of Industrial Health.*

When epoxy resins were first investigated by Sandia Corporation, the ordnance contractor to the Atomic Energy Commission, nothing was known of their toxic effects. The first indication of toxicity occurred in January 1951 and appeared as an inflammation of the eyes and forearms of a plastics shop employee. In the procedure used at that time, the plastic was poured over fiberglas formed on a solid mold and, if necessary, was smoothed with the hand; the procedure had been used for a number of years with polyester resins with only occasional cases of dermatitis, primarily because of carelessness while handling cleaning solvents. The inflammation was therefore diagnosed at first as no more than a contact condition, and the employee was temporarily withdrawn from work on plastics. Recurrence of the condition when the employee returned, even though he cooperated fully in avoiding contact, was the first suggestion that epoxy resins were hyperallergens and thus an industrial hygiene problem.

Plastics shop personnel, on this indication, were then advised to follow a precautionary program such as is used in radiochemistry laboratories, that is: (1) put on clean coveralls each morning and observe extreme personal cleanliness; (2) keep hands out of the solvents being used to clean up tools or spills (contact with plastic solvents is believed to be responsible for most of the allergies); (3) wash hands with soap and water if uncured material is touched; (4) take showers at the end of the shift; (5) cover the floor or work benches with heavy butcher paper wherever the uncured material is being mixed or handled; (6) wear rubber gloves during all wet layup operations; and (7) do not smoke or eat in the area where layups are being made.

Alleviation of the problem was also sought through improvements to ventilation in the plastics shop, which at the time was small and crowded. However, the industrial hygiene division found that since exhaust air was largely overbalanced by supplied air, eddying could not be prevented and thus a draft could not be maintained away from workers. Because work on epoxy resins was thought to be exploratory only and probably temporary, approval could not be obtained for a program to improve ventilation and other working conditions.

That personal hygiene and care in handling were not sufficient became clear as one after the other of the plastics shop personnel became sensitized. Although some improvements were made to the ventilation and personnel cooperated fully, the allergies continued—not by direct contacts but by fumes of the amines given off by the wet plastic. The allergies also tended to cause a sensitization to the formerly innocuous polyester resins.

As the epoxy resins received greater attention from development engineers and the "temporary" work continued, almost two-thirds of the personnel became sensitized. Drastic action was precipitated finally when an order for some very large shapes was received. The industrial hygiene division, after reviewing the procedure required, closed the shop until adequate space and ventilation could be provided.

After management was informed of the past situation and the situation that could be expected if operations continued without improvement, approval for a new area with much more space and much better facilities was obtained. Setting up the new area afforded an opportunity to plan operations with industrial hygiene requirements fully in mind. Since not all the ducting and



FIGURE 1. Plastics

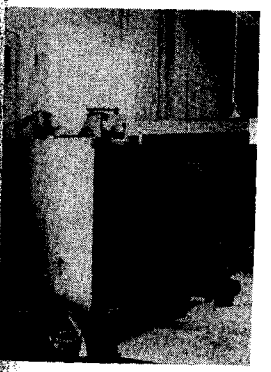


FIGURE 2. Plastics sho

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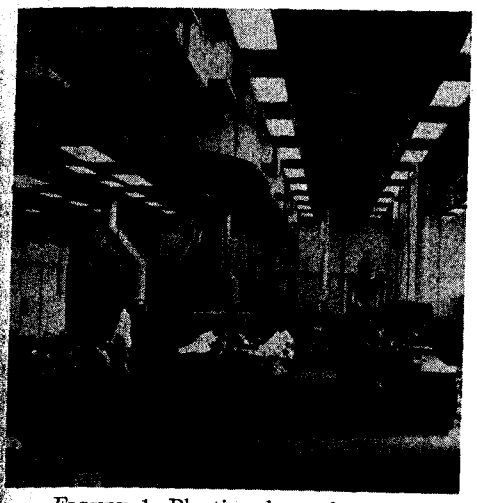


FIGURE 1. Plastics shop—dry area

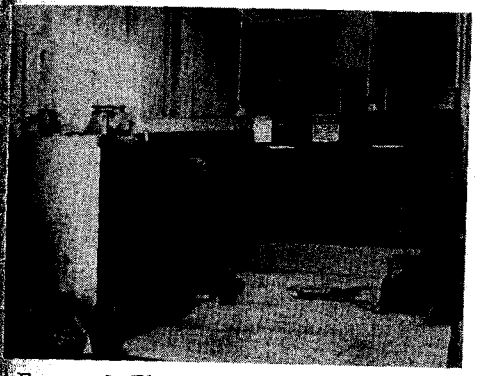


FIGURE 2. Plastics shop—wet layup area

haust facilities desired were commercially
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industrial hygienists.

One of the principal design considerations was
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ovide an area in which personnel who had be-
me sensitized could still work. This arrange-
ent permitted the retention of several workers
who would otherwise have had to be transferred.

Figures 1 and 2 show the new plastics shop.
The area in which dry operations are carried out
is shown in Figure 1. Figure 2 shows the water-
wall and bake-out oven in the area where fumes
may be evolved which we call the "wet layup"
area.

The exhaust system has a total capacity of about 60,000 cubic feet per minute. An input system with a capacity of 50,000 cubic feet per minute provides makeup air to replace that exhausted. This makeup air is supplied through the overhead ducts visible in the two figures. One change to the exhaust system was made

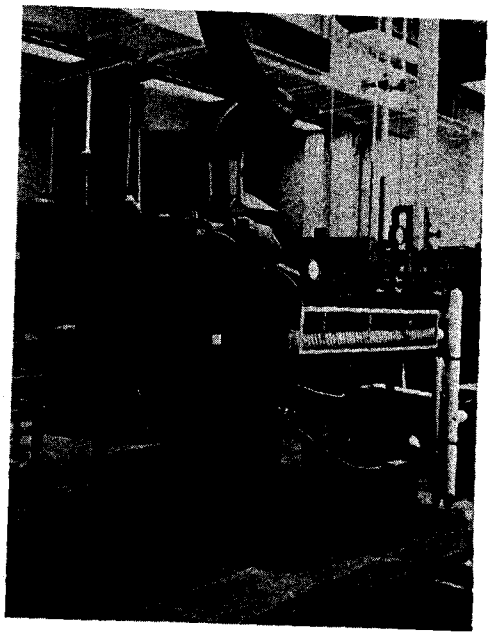


FIGURE 3. Fifty-ton press

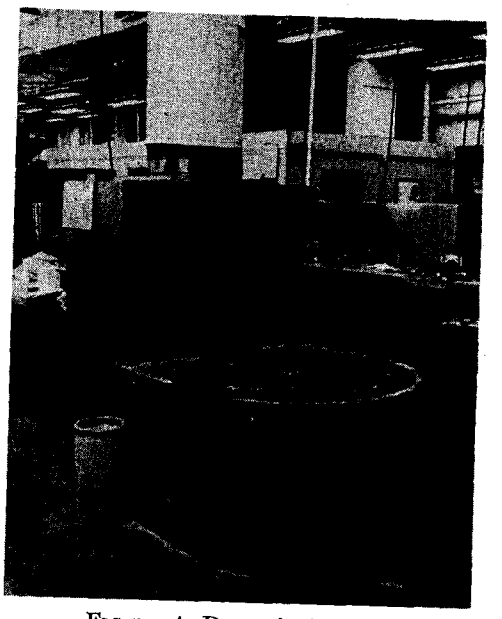


FIGURE 4. Down-draft table

after these photographs were taken. With exhaust blowers located, as shown, near the input to the duct, duct pressure was greater than room pressure and any leakage in ductwork resulted in pumping of amine fumes back into the shop over a period of time. Blowers have therefore been located near the outlet so that negative duct pressure is maintained.

The major feature of the area in which wet plastics are handled is the water-wall in Figure 2. This area is 15 feet deep from the water tank to the outer edge of the hood. Exhaust capacity is 24,000 cubic feet per minute. All mixing and wet layup are done in this area. Workers in this area wear surgical gloves taped to their coverall sleeves to ensure that hands and arms do not come in contact with the plastic; goggles and safety glasses need not be worn. When there is no possibility of splashing of solvent or plastic, wet layup may be carried out without these safety devices, which are required elsewhere in Sandia Corporation on all machining and chemical operations. This procedure was begun after it was observed that inflammation and irritation from epoxy resins was worse when these safety devices were worn, apparently because of the concentration of fumes behind the safety glasses or face shields.

Since resin spills are an important source of inadvertent contacts, cleanliness in the area is essential. In the water-wall area not only is butcher paper used under the mold but the floor covering, a plastic film, is scraped off and replaced once a month.

Figure 3 shows a 50-ton press in which some curing operations are carried out and which therefore requires an exhaust system. Since the top bed of the press moves up and down, flexible ductwork was required. The press had to be further modified by the addition of sheet-metal panels to restrict the flow of air to the immediate area around the plastic.

Figure 4 shows a down-draft table with a rotating top. In addition to the flow of air through the top grate, air may be drawn across the work when the square panel in the front of the unit is removed. Baffles are provided in this outlet so that the down-draft flow is not stopped when the panel is removed.

After the improvements were completed, no cases of sensitization occurred in the plastics shop. The few cases that have occurred at Sandia Corporation were the result either of carelessness in handling or of working in areas that were not approved.

In summary, the experience of Sandia Corporation in its work with the epoxy resins suggests the following recommendations:

(1) High standards of both personal and work-area cleanliness must be maintained. The work area must be kept free of spills; when spills do occur, they must be cleaned up immediately.

(2) Personnel should be made well aware of effects of the material with which they are working. The responsibility to ensure that personnel are educated in the characteristics of the material will belong to both the industrial hygienist and the plastics shop supervisor.

(3) Both the industrial hygienist and the supervisor should be able to recognize the early symptoms of sensitization. Personnel with these symptoms should report immediately to the industrial physician, since early diagnosis and treatment are important.

(4) In a large plant or laboratory, personnel outside the plastics shop must be made aware by industrial hygienists of the potential hazards of the epoxy resins and warned not to begin small operations with these plastics without adequate safeguards. In Sandia Corporation this information and other industrial hygiene information is distributed plant-wide in "Industrial Hygiene Bulletins."

Although proper industrial hygiene practices come close to eliminating the epoxy resins as a health hazard, an even more hopeful approach is the substitution of low-toxicity aliphatic amines for the toxic agents. In a recent article[2] Ingberman, Walton, Pitt, and Paul indicate that the hydroxyalkyl hardeners do not cause sensitization. Progress in this area may sometime reduce or eliminate the problem. Until that time, however, the epoxy resins must continue to warrant the attention of the industrial hygienist.

References

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2. Ingberman, A. K., Walton, R. K., Pitt, C. F., and Paul, M. N.: Low-toxicity aliphatic amines as cross-linking agents for polyepoxy resins. *Ind. Eng. Chem., 49:* 1105 (July 1957).

HYGIENIC

I. Hygienic Standards

A. Recommended max concentration (8 vapor per million pa (ppm).[1] One part been recommended. experience and med necessary for confirm
(1) Basis for Recor studies and lim industry.[1, 2, 4]

B. Severity of hazar
(1) *Health*: High f chronic exposure a strong respirat Acute exposures bronchitis and Symptoms can recovery may b occurred.[2] Sym affected workers ing, respiratory charge, eye an These probably acute exposures. may cause chron
(2) *Fire and Explos* when concentrat per cent.[1] Explo when chlorine dic materials. Explo caused by sparks partial pressure Will detonate i 100°C.

C. Short exposure T exposures of rats to a hours daily resulted exposure to approxi hours daily for 10 we effect.[1] Animals su posures to 20 ppm, exhibited symptoms. ppm is irritating and (1 fatal) resulted f than 19 ppm.[2]