Visual Disturbances Related to Amine Exposure

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Visual disturbances among employees at a flexo-printing company prompted its managers to request assistance from the National Institute for Occupational Safety and Health (NIOSH). The facility prints labels on paper or plastic using water-based, UV-cured, and fluorescent inks. The plant had approximately 100 employees working as press operators, rewinder operators, and press assistants. The facility was divided into two printing areas: the line division (approximately 15,000 sq ft) and the prime division (approximately 9,000 sq ft). Although adjacent to one another, the divisions were separated by a concrete wall and flexible-strip doorway curtains.

Line-division employees were reporting eye problems. This division had eight high-speed (400-ft/min) printing presses and used primarily water-based inks for printing less detailed labels, such as those on milk and orange juice containers. Fluorescent inks were used occasionally; UV inks were not used.

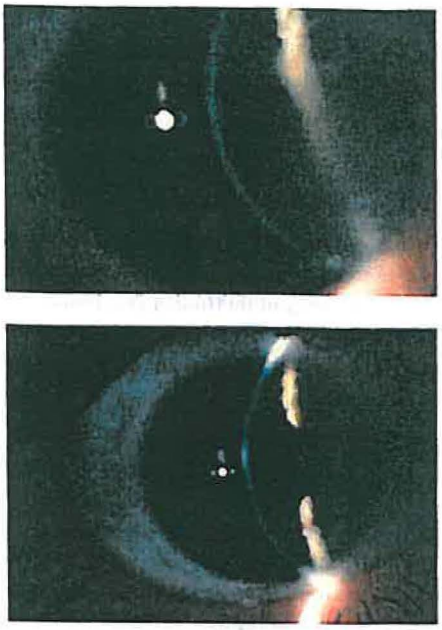
Prime-division employees were not reporting vision problems. This division had seven lower-speed (150- to 175-ft/min) printing presses and primarily used water-based inks to print detailed labels, such as those on cosmetics and automotive products. Fluorescent and UV inks were used in this division. Both divisions used 5-gal pails for holding inks before pumping the inks into troughs.

Managers reported to NIOSH that line-division employees were experiencing intermittent blurred vision at work. One employee was evaluated by an ophthalmologist who found a "film over his eyes." Employees said their blurred vision was like looking through a fog or mist. The effect was most noticeable when looking at lights, causing a halo. Vision changes typically resolved within a couple of hours after leaving work. However, it was difficult for employees to do their jobs and drive home safely. Symptoms were unpredictable, but they seemed to be increasing in frequency. Employees and managers were unable to associate these visual changes with use of a particular substance, but noticed that symptoms were only reported by line-division employees and only on Mondays through Thursdays, when production activity was highest.

After meeting with management and employee representatives, our team monitored the air for chemical exposures and assessed the exhaust ventilation system. We sampled in both divisions to identify air contaminants unique to these production areas. We surveyed employees using a medical questionnaire and performed eye exams on line-division employees and any prime-division employees who had experienced visual disturbances in the past. Eye exams were conducted at the beginning and end of work shifts for one week.

We found an association between visual symptoms and exposure to two chemicals: dimethylaminoethanol (DMAE) in the water-based ink and clean print additive (used to lengthen drying time so the ink did not dry too quickly) and dimethylisopropanolamine (DMIPA) in the pH adjuster. DMAE and DMIPA belong to a class of chemicals called tertiary amines.

Amines, derived from ammonia, are classified as primary, secondary, or tertiary. Tertiary amines irritate skin and mucous membranes and can cause headache, nausea, and faintness when inhaled. Published reports describe reversible effects, including blurred vision, halo vision, or blue-grey vision among people exposed to amines. At this facility, DMAE was found in the inks and in the clean print additive the prime division used to extend the drying time of the inks. No reports of visual disturbances in humans exposed to DMAE were in the scientific literature at the time of our evaluation. Animal experiments have documented corneal clouding, swelling, and ulcer (infection) with exposures to DMAE. DMIPA, which was used in the pH adjuster at this facility, had not been reported to cause visual disturbances in humans. There are no occupational exposure limits (OELs) for DMAE or DMIPA.



***Figures 1 and 2** This employee's cloudy cornea at the end of a work shift (top) was determined to be caused by exposure to dimethylisopropanolamine, a tertiary amine. The same employee's cornea (bottom) is clear the next day.*

We found visual symptoms including blurry, halo, and blue-grey vision; corneal opacity (clouding); and decrements in visual acuity (ability to read the 20/20 vision line of an eye chart) and contrast sensitivity (ability to detect a pattern on a similar

background). *Figure 1* shows an employee's cloudy cornea at the end of a work shift, while *Figure 2* shows clearing of the same cornea the next day. We found that air exhausted from the facility was getting back inside and concluded that ventilation in the line division was inadequate. We recommended covering ink containers and the use of butyl rubber gloves (not latex rubber). Butyl rubber is impermeable to amines, isopropyl alcohol, ammonia, and 2-butoxyethanol (the chemicals in use). We also recommended air monitoring after process changes, or when new chemical products are introduced.

The company immediately reduced the amount of DMIPA used in both divisions by diluting the pH adjuster that contained DMIPA with water and improved ventilation. We, and the company, suspected DMIPA to be the primary cause of the employees' vision problems because we measured higher DMIPA concentrations in the line division (the complaint area). The company eventually replaced the DMIPA-containing product.

Fifteen months after our first evaluation, we returned to the facility to determine whether process changes, such as eliminating DMIPA, had reduced amine exposures. We sampled the air for DMAE and DMIPA and asked employees if they were currently experiencing blurry vision at work. No visual problems were reported. There was little to no DMIPA in the air in either division. DMAE was in the air, but in lower concentrations than we first measured. We concluded that ventilation improvements stopped the re-entry of exhausted air and that the health hazard related to DMIPA and DMAE was gone.

HEALTH EFFECTS AND OCCUPATIONAL EXPOSURE LIMITS

Occupational exposure limits (OELs) suggest levels of exposure to which most employees may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. However, a small percentage of employees may experience adverse health effects even if they are not exposed to substances at levels higher than the OELs because of individual factors such as their personal susceptibility, pre-existing medical conditions, or hypersensitivity (allergy).

Some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the employee to produce health effects even if the occupational exposures are below the exposure limit. Some substances can be absorbed by direct contact with skin and mucous membranes in addition to being inhaled, which contributes to the person's overall exposure.

The Occupational Safety and Health Administration (OSHA) mandates legally enforceable permissible exposure limits (PELs) for workplaces covered by the Occupational Safety and Health Act. However, not all hazardous chemicals have specific OSHA PELs, and the legally enforceable and recommended limits for some substances may not reflect current health-based information.

To eliminate or minimize identified hazards, we encourage, in order of preference, the use of the traditional hierarchy of controls: substitution or elimination of the hazardous agent, engineering controls (local exhaust ventilation, process enclosure, dilution ventilation), administrative controls (limiting time of exposure, employee training, work practice changes, medical surveillance), and personal protective equipment (respiratory protection, gloves, eye protection). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and/or personal protective equipment may be needed.

GENERAL RECOMMENDATIONS

Consider the following actions, listed in order of preference, for reducing anime hazards:

Substitution/elimination Eliminate or substitute amine-containing products with different products. If not possible, dilute the amine-containing product with water as much as possible without reducing the product's effectiveness.

Ventilation Assess the ventilation system to see, for example, whether exhausted air is re-entering the building. Consult an industrial hygienist or ventilation engineer if necessary. Consider ventilation at or near the printing presses (local exhaust ventilation) to capture any airborne contaminants released quickly and efficiently. Cover ink and chemical containers when not in use to reduce the amount of chemicals evaporating into the work environment.

Assessment of personal protective equipment [PPE] use Complete a comprehensive assessment (required by OSHA for all employers) to determine whether hazards are present, or likely to be present, that would require the use of PPE—safety glasses, protective gloves, respirators, and others. Employees must be trained in the use and maintenance of the PPE. OSHA requires written documentation that PPE hazard assessment and employee training have been completed. Information about PPE can be found at www.osha.gov/SLTC/personalprotectiveequipment/index.html.

Skin protection Latex rubber gloves can cause allergies in some people, and some chemicals can permeate them. Instead, wear gloves made of materials such as butyl rubber, if appropriate for your workplace. Consult a reference guide such as "Quick Selection Guide to Chemical Protective Clothing," 5th Ed. (Krister Forsberg, S. Z. Mansdorf) to select appropriate PPE for the chemicals at your facility.

WORKING WITH NIOSH

NIOSH, in the Centers for Disease Control and Prevention (CDC), conducts research and makes recommendations for the prevention of work-related injury and illness. The NIOSH health hazard evaluation (HHE) program is available for employees, employers, or union representatives to ask NIOSH's experts for an investigation of their health and safety concerns.

NIOSH contacts the requestor and discusses the problems and how to solve them. This may result in sending the requestor information, referring them to a more appropriate agency, or making a site visit (which may include environmental sampling and medical testing). If NIOSH makes a site visit, a report is provided that includes specific recommendations and general guidance for following good occupational-health practices. HHE reports are available online at www.cdc.gov/niosh/hhe.

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