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Occupational Fatality Associated with a Robot — Michigan

On July 21, 1984, a 34-year-old male worker in Michigan was operating an automated die-casting system that included an industrial robot. At approximately 1:15 p.m., he was found pinned between the back end of the robot and a 4-inch-diameter steel safety pole used to restrict undesired arm movement by the robot. The robot stalled, applying sustained pressure to the chest of the operator, who experienced cardiopulmonary arrest. After emergency rescue efforts by personnel from the company, the city fire department, and the city emergency medical service, the worker was admitted comatose to a local hospital, where he died 5 days later.

An investigation by the medical examiner revealed no physical signs of crush injury; radiographs of bones and internal organs were negative, as was a test for blood-alcohol. The cause of death was identified as necrosis of the brain due to cardiopulmonary arrest. At the request of the medical examiner, a team from the National Institute for Occupational Safety and Health (NIOSH) investigated the workplace and interviewed managers, union representatives, co-workers, rescuers, and the medical examiner.

The company had 24 die-cast machines, two of which were automated with robots. The operator, who had 15 years' experience in die-casting operations, had completed a 1-week robotic training course, including a discussion of safety issues, approximately 1 month before the incident. His co-workers considered him a most adept operator.

On the day of the incident, the robot was programmed to extract a casting from a die-cast machine, dip it into a quench tank, and insert it into a trim press. This entire cycle, involving 27 computer programmed steps, required approximately 1 minute to complete. Two sides of the robot's "work envelope" were surrounded by a safety rail with an electrical interlock gate. At approximately 1 p.m., the operator had entered the work envelope of the robot, probably by climbing over, under, or around the safety rail. His reason for doing so is unknown. Because an air gun was found beside the operator, he may have been trying to clean up "flash" and scrap metal that had accumulated on the floor; however, that task was usually done by another employee when the robot was on hold. Although the operator had received instructions during the training course and warnings on the job against such entry, fellow workers had occasionally seen him inside the work envelope while the robot was operating and had cautioned him about this prohibited activity. After the fatality, the employer replaced the safety rail with a chain link fence to further restrict entry into the work envelope of the robot.

Several factors may have contributed to this fatal incident: (1) the behavior of the operator suggests a great confidence in his ability to interact safely with the functioning robot and may have led to unwarranted overconfidence; (2) the safety rail used to separate workers from the

Occupational Fatality — Continued

robot was probably less effective in preventing deliberate entry than unintentional entry; (3) neither the operator nor the other workers seemed to recognize the hazard posed by the fixed pole in the robotic work area that enabled a potentially fatal "pinch point" between the moving back of the robot and the pole.

Reported by Div of Safety Research, National Institute for Occupational Safety and Health, CDC.

Editorial Note: Based on information available to NIOSH, this is the first documented case of a robot-related fatality in the United States. In two cases reported in Japan, the workers sustained extensive crush injuries (*1*). Although an industrial robot was first used in the United States in 1961 (*2*), the use of robots has increased most significantly since the late 1970s (*3*). In 1982, an estimated 6,200 industrial robots were used in U.S. workplaces, comprising 22% of the worldwide total (*3*). In the United Kingdom, the largest proportion of robots (35.2%) used in 1982 was for welding, while only 3.0% were used for die casting (*3*). Two surveys of nonfatal occupational injuries associated with robots showed that unauthorized entry into the robotic work envelope accounted for 11.2% of all such injuries in Japan (*4*) and for 5.1% in Sweden (*5*). In both surveys, the largest proportion of injuries occurred during programming or repairing of the robot.

Robotics have evolved in the workplace in response to economic and ergonomic factors. Future accelerated use of this technology is anticipated and will give rise to potential hazards (*6*). The robot-related death reported here suggests several changes in the design and installation of robotic equipment and in the training and supervision of workers that could prevent such incidents in all establishments that now use or anticipate using robots (*7*). The failure of employees to recognize hazards associated with robots is an important problem. While workers may easily identify hazards associated with the working zone of a robot's more obvious moving parts (or "arms"), they may be less aware of the dangers associated with movement of other elements of the robot assembly. In the present case, the operator was trapped between a fixed object (safety pole) and the rear end of the robot, an area often assumed to be out of the danger zone associated with a robot's working arm. Recognizing and planning for all potential hazards in the operation is essential. Because robots generally require more space than humans who perform the same tasks, placing robots in existing production lines creates space utilization problems. Therefore, the space requirements must be thoroughly understood so that workers know about and are shielded from inadequate clearances and dangerous "pinch points." These issues must be considered in advance to avoid creating new danger zones for personnel who operate, maintain, and service robotic systems.

The investigation reported here was conducted as part of the Fatal Accident Circumstances and Epidemiology (FACE) Program of NIOSH (*8*). For further information, contact: Division of Safety Research, NIOSH, Morgantown, West Virginia 26505.

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