Electrocution on a Press Due to Poor Grounding

The accident investigated in this article occurred during a maintenance operation. The deceased was replacing the dies on a press, which was designed to cut material into specific shapes for further processing. It was reported that the deceased had reached into the press below the die area for a dropped piece of equipment with his left hand, when his right calf came into contact with the exit conveyor frame. The exit conveyor was a separate unit, neither physically nor electrically attached to the press. Evidently, there was a source of voltage that had energized the conveyor frame, thus resulting in his death.

Event Ambient Conditions

The factory's electrical supply feed was from an incoming 480-volt, three-phase system. It had a ground fault protective feature on the incoming 480-volt lines. The press and the conveyor were fed at 240 volts from a three-phase delta-delta step-down transformer. Thus, the entire building electrical system was not protected by the line-side ground fault feature. The secondary of the transformer had one line grounded. The voltage reading at the supply switch for the press was that the center phase read 0.4 volts to ground; the other two phases read 240 volts to ground.

At the press, there was no electrical fault that was concerned with the press itself. The 240-volt, three-phase grounded delta feed to it was reported to have been shut off when the accident occurred. With power off to the press, no voltage to ground was found anywhere on the press. Also, the resistance to ground (the building steel) from the press was measured to be 0.075 ohms.

The grounding of the press was through the green wire of a four-wire flex cable that fed into the contactor box located on top of the press (Figure 1). This ground wire was there at the time of the accident. After the accident, a maintenance technician had installed a ground to the inside of the disconnect switch that fed this control box on the press. Both of these ground wires were grounded from being bolted to the inside of the junction box in the truss area where the flex cable is connected to feed the press. Thus, they are tied electrically to the building steel, as was one leg of the 240-volt delta transformer secondary (noted above).

Prior to the accident, the conveyor was grounded by being connected to a driven "ground rod" located at the exit end of the conveyor. After the accident, the facility's maintenance technician had run a bare stranded wire from the ground rod of the conveyor (and thus the grounding system for the conveyor) to the base of the press. This gave the conveyor an adequate ground through the press to the building steel (Figure 2). Measurements taken during the investigation with this added ground wire disconnected showed that the "ground rod" had a resistance of about 90 ohms to the building steel framework. Note that if the conveyor had been energized at 120 volts, with

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

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a ground as poor as that which is noted, the current drain would have been small. Using I = V/R, at 90 ohms ground resistance, the current would have been about 1.33 amps. This would not trip a 15-amp circuit breaker, thus the conveyor frame would not have been de-energized automatically, and at the time of the accident, the conveyor had not been effectively grounded. (With the added bare wire connected, that was installed after the accident, the resistance to ground from the conveyor was 0.075 ohms.)

Post-accident activities had included much repair and recircuiting. Because of the competence of the maintenance personnel, and what was reported to have been done, the accident scene was determined not to have been misrepresented. Also, no evidence of leakage voltage to either the conveyor or the press was found. At the time of the accident, it was reported that the press disconnect switch was in the "off" position and the conveyor was not running.

Event Analysis

At the time of the accident, the press was solidly and effectively grounded and the exit conveyor was not, since it was connected to a ground rod that had high resistance to the building and thus to the electrical system ground. Note that section 250.110 of the National Electrical Code requires that the non-current-carrying parts of equipment be grounded. Further, the definition of "effective grounding" requires that the resistance of the grounding system be low enough to prevent elevated voltages on the equipment framework. Thus, the low value of resultant ground current noted earlier would not have prevented elevated voltages on the conveyor framework.

The exit conveyor must have been energized by an intermittent electrical connection through faulty wiring of some nature. This could have been a fault in the wiring of the conveyor, but no such faults were reported. It may also have been caused by a frayed extension cord on an electrical power tool that the deceased could have laid on the conveyor for easy access while he was working.

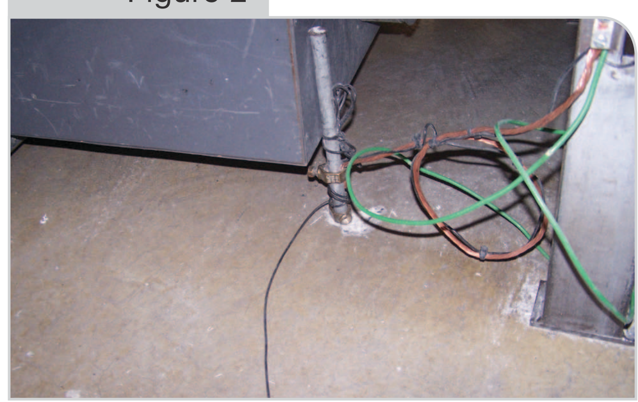
As noted, since the resistance to ground of the conveyor grounding was as high as it was, the ground current was not high enough to trip a normal branch circuit breaker rated at 15 or 20 amps. There were no ground fault interrupter-type circuit breakers on the 240-volt side of the step-down transformer.

Figure 1

Grounding of the press.

The major contributor to the accident was the improper grounding of the conveyor frame. Had it been properly grounded, then whatever caused the frame to be energized would have caused a high-current short, which would have tripped the supply circuit protective device, thus removing the dangerous condition.

Figure 2



Grounding of the conveyor.

Using a driven ground rod instead of connecting the conveyor to the building framework, either directly or by interconnecting to other pieces of the machinery, was the basic mistake made. All grounding systems must be effectively bonded together in order to achieve the electrical safety that all codes require. ✦