Case Scenario: **Injury from a Gas Explosion in a Steel Reheat Furnace**

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Expert's Job Assignment: To assist with the case by the plaintiff against any third party equipment suppliers and various contractors.

Case Synopsis

A worker in a rolling mill operation was injured by the explosion of a steel reheat furnace. This furnace blew up because it was full of natural gas when a pilot flame was initiated. He was about 40 feet away and suffered extensive injuries from the blast.

Expert analysis

1. NFPA 86, entitled "Standards for Ovens and Furnaces", has a section 8.9, entitled "Combustion Safeguards (Flame Supervision). Sub paragraph 8.9.1 states "Each burner flame shall have a combustion safeguard…that is interlocked into the combustion safety circuitry in accordance with the following:
    (1) The flame supervision shall not be required…when the zone temperature is greater than 1400^0F…and the following criteria are met:
        (a) When the zone temperature drops to less than 1400^0F the burner is interlocked to allow its operation only if flame supervision has been re-established.
        (b) A 1400^0F bypass controller is used to meet the requirement of 8.9.1 (1) (a)."
2. The electrical elementary diagrams for this furnace showed two such 1400^0F bypass controllers in the circuit. They were designed to be in series with each other in the branch of the circuit that did the by-passing of the flame supervision circuitry. This would require them both to register that the required temperature had been reached.
3. The two "1400^0F bypass controller" contacts were to come from two different devices. One was an auxiliary contact on a temperature chart recorder; the other was a normally open contact on a dedicated temperature sensing device that was intended to sense the 1400^0F bypass temperature level.
4. The contact on the temperature chart recorder was never wired into the circuit.
5. The dedicated1400^0F bypass controller had logos of both the Canadian Standards Association and Factory Mutual on its case. The items listed below show that this device was deficient in that it did not conform to all requirements of the named two organizations.
6. The internal mechanism in the dedicated 1400^0F bypass controller was a single pole double throw (SPDT) relay. It was wired so that the external terminal block connections had the common contact screw terminal adjacent to and between the two screw terminals for the normally open (NO) and normally closed (NC) contacts. These adjacent screw terminals were separated by very thin and weak plastic barriers.
7. The external terminal block on the dedicated 1400^0F bypass controller contained screw type terminals that did not have the capability to contain any strands of stranded wiring connections. In fact they had no "strand-retaining" capability at all. The Canadian Standards Association C22.2 in Section 4 "Construction", states in item 4.4: "A wiring terminal intended for use with a stranded conductor shall be such that all strands of the conductor will be contained." Clearly this unit then was not meant to be wired with stranded wire. The installation electrician should have put termination lugs

on the wires. If this had been done this failure would not have happened, since the short circuit occurred when some of the strands from terminal #9 (the NO contact) came in contact with some of those on terminal #8 (the common contact terminal) after the barrier between the two terminals was broken.

8. The installation electrician did not use compression lugs to facilitate the termination of the stranded wire on the screw type terminals of the 1400^0F bypass controller.
9. The installation electrician inserted the stranded wire on the right-hand side of the NO screw terminal so that the clockwise twisting of the terminal screw (to tighten it) tended to splay the strands out instead of wrapping them into the terminal. The Canadian Standards Association C22.2 in Section 4 "Construction" requires, in item 4.6, that the wiring be wrapped "clockwise" around the screw. Here again the installation electrician installed the wires on the wrong direction. I believe that the tightening of the screw forced the wires out and into the adjacent barrier, thus breaking it.
10. At least one strand of the wire on the terminal for the NO contact was touching the terminal for the common contact, so that the output was showing the 1400^0F bypass contact to be closed at all times.
11. The plastic barrier on the dedicated 1400^0F bypass controller between the terminal screw for the normally open contact and the common wire terminal's screw was broken. Other such terminal barriers on other 1400^0F bypass controllers for this multi-zone furnace were also broken. Factory Mutual standards #7610, for Flame Sensing Systems, in Section 3, "General Requirements", subsection 3.3, "Physical, Structural, and Operational Requirements" states in item 3.2.3: "Electrical contacts, terminals, and other vulnerable components shall be adequately protected from damage and expected atmospheric conditions." The unit in question was damaged in that inter-terminal barriers were broken. There are pictures of other controllers in the same installation that also had broken barriers. The exemplar unit that I purchased was similarly damaged. It is obvious that this requirement has not been met.
12. The Canadian Standards Association C22.2 in Section 4 "Construction", subsection 4.9 "Spacings", in item 4.9.5 states: "A barrier...shall be permitted...provided that it is...of adequate mechanical strength if...likely to be subjected to mechanical damage..." Here again the subject device had not been strong enough to withstand the rigors of its environment.

Expert Opinion

1. The omission of the redundant 1400^0F bypass controller in the temperature chart recorder that was supposed to be in series with the one from the dedicated 1400^0F bypass controller should have been discovered during the start-up check-out of the electrical circuit. My opinion was that this omission was the responsibility of the contractor that did the original installation.
2. The omission of the compression lug on the stranded wire was a definite factor in this accident. My opinion was that this omission was the responsibility of the contractor that did the original installation.
3. Had the initial start-up check-out been done properly, that wayward strand of wire that was causing a false "1400^0F temperature signal" would have been caught. My opinion was that this omission was the responsibility of the contractor that did the original installation.
4. If the external terminals for the contacts on the SPDT relay in the dedicated 1400^0F bypass controller had not been located on adjacent terminals this accident would not have happened. My opinion was that the manufacturer of the 1400^0F bypass controller was at fault for marketing a device that was deficient.
5. If the plastic barriers between adjacent terminals on the external terminal strips on the 1400^0F bypass controller been stronger, the barrier between the common and NO contact on the relay would not have been broken. Note that the Factory Mutual standards, section 3.2.3. My opinion was that the manufacturer of the 1400^0F bypass controller was at fault for marketing a device that was deficient.

Results of this Investigation

Because of at least the following, this case was not pursued to a conclusion:

1. The original contractors were no longer in business.
2. It could not be positively determined if the splayed strands on the dedicated 1400^0F bypass controller terminal had been caused to be that way because of the original installation, or if the normal maintenance work had been the source of this anomaly.