A JOURNEY TO ENHANCED SAFETY

DAVID DEROCHER, EATON, USA, EXPLAINS HOW THE ELECTRICAL SAFETY INITIATIVE AT A CANADIAN CEMENT PLANT DRIVES PRODUCTION RELIABILITY.

The Lehigh cement plant in Edmonton, Alberta, Canada is one of 14 Lehigh cement-producing facilities in North America owned by the parent company, HeidelbergCement AG of Heidelberg, Germany. With HeidelbergCement’s acquisition of Italcementi in July of this year, Lehigh Hanson now operates five additional cement plants that were formerly part of Essroc, Italcementi’s North American subsidiary. In addition, as part of that acquisition, the company also has an additional cement plant (joint-venture) in Quebec.

One of the core values of the multi-site Lehigh Cement business includes a culture of adopting industry-leading safety standards designed to ensure employees are out of harm’s way. In 2010, the company’s North American Cement Technical Group teamed with Plant Operations to implement an arc flash compliance programme for all facilities in the US and Canada. The initiative was completed for all 13 plants in 2012.

Because its primary business is producing cement, not performing arc flash studies, the company solicited assistance from Eaton, a global technology leader in services and solutions that makes electrical power operate more efficiently, reliably, safely and sustainably. Eaton engineering services, coupled with a comprehensive portfolio of electrical power distribution and control product solutions designed
to reduce or mitigate arc flash hazards, compelled Lehigh Cement to select the global supplier as their preferred business partner, completing multi-site power systems and arc flash studies at all 13 Lehigh Cement North American plants.

**An overview of Arc Flash Hazards**

For many decades, the danger of shock hazards or electrocution has been well understood. An electrical shock occurs when the human body comes in contact with an energised conductor. During a shock event, current travels through the body toward ground, and it takes only milliamperes of current to cause serious injury or death. Perhaps the even greater electrical hazard that is somewhat less understood is arc flash. Unlike a shock incident, arc flash is the result of a rapid release of energy due to an arcing fault between phase bus bars, neutral or system ground. An arc flash event – typically the result of human error while persons are working on or near energised electrical equipment – is usually caused by a dropped tool or accidental contact of a test probe between an energised conductor and ground.

The energy discharge from an arc flash is massive, resulting in an energy release at temperatures exceeding that of the sun’s surface, as well as explosive pressure waves, shrapnel, and toxic gases (Figure 1). The destructive power of an arc flash can be immense, as an enormous amount of concentrated radiant energy explodes outward from electrical equipment in an arc flash event. Solid copper conductors are vaporised, expanding to 67,000 times their original mass, creating a superheated ball of plasma gas that can severely burn a worker’s body. If the arc releases sufficient energy, a worker’s non-flame-resistant clothing will ignite. Workers wearing flame-resistant clothing can also sustain burns if the arc releases energy above the thermal rating of the flame-resistant fabric.

**Deliverables from the Arc Flash Study**

The Lehigh Cement Technical Group issued an Authorisation for Expenditure (AFE) Scope of Work – Arc Flash Compliance document that was sent to various suppliers with interest in proposing to do the work. The scope of the work for the Edmonton site and others first included field collection of data, through a site survey of the electrical system by a power systems engineer. Following data collection, the engineer completed a power systems model of the site, calculating the short circuit current available at every electrical point of the system and ensuring that all protective devices were coordinated. System coordination or discrimination means that should a fault on the system occur during operation, the protective device (either fuse or circuit breaker) nearest to the fault would interrupt the fault, isolating the problem area rather than taking the entire plant out of service.

Finally, the arc flash hazard analysis was completed. This included an additional system
analysis that calculated the incident or heat energy measured in calories per centimeter squared (cal/cm²) at each openable panel of the plant electrical system. As a point of reference, the heat energy associated with 1 cal/cm² is roughly equal to the heat that would be felt from a lighted match held about 1 cm from your finger for one second. The calculated amount of heat energy at each panel is a function of the plant electrical system capacity, the fault clearing time of the next upstream circuit protective device and the distance of the worker from the arc flash event.

The heat energy is determined based on an industry standard published by the Institute of Electrical and Electronic Engineers – IEEE Standard 1584: Guide for Performing Arc Flash Hazard Calculations – 2002. The calculated arc flash hazard and shock hazard are printed on a label that is affixed to every openable panel. The required personal protective equipment (PPE) that a worker should wear if working on or near the panel while energised is clearly designated on the affixed label (Figure 2). Two additional standards that apply here are The National Fire Protection Association NFPA 70E: Standard for Electrical Safety in the Workplace – 2015 and the harmonised Canadian Standards Association CSA Z462: Workplace Electrical Safety – 2015. The Lehigh AFE for Arc Flash Compliance also required field implementation, including labels and site safety training to familiarise plant electricians with the completed study, protective clothing, updated safety practices and Workplace Safety Standards.

**Operational impact on the Lehigh Edmonton Plant**

After the Arc Flash Compliance programme and site safety training was implemented at Lehigh Edmonton, workplace safety for the plant electricians made a giant leap forward. Electrical arc flash hazards that were previously unrecognised were now quantified and visible to operators before they began energised work. Proper PPE was issued to plant electricians including 8 cal/cm² arc rated clothing as daily uniforms and a special 40 cal/cm² suit when performing energised work, where higher levels of PPE were determined to be required.

After several months, site operations learned that although the highest levels of PPE inherently offered the highest degree of protection from an arc flash event, the higher 40 cal/cm² level of protection was also very unwieldy and costly in terms of time required to perform energised work. It also introduced added risks such as heat stress and loss of dexterity required to perform electrical tasks such as troubleshooting. If energised work was determined to be necessary, working on energised equipment with a lower arc flash hazard and suitable lower levels of PPE was the best alternative (Figure 3). Realising that many of the electrical substations serving critical loads were determined to have calculated incident arc flash energy in excess of 40 cal/cm², the arc flash label affixed to those substation’s 600-volt panels designated a ‘DANGER’, arc flash level denoting that there was no commercially available PPE a site electrician could wear and be considered safe.
while working with energised equipment. In these instances, the only alternative was turning off the power, which created a new set of challenges, especially in the pyro-processing area of the plant where continuous operation was required.

Lehigh again turned to engineers from Eaton to address these operational issues. A total of 10 critical substations were identified where the arc flash hazards were excessive. The electrical panels for these were considered as candidates for system improvements, using various technology-based solutions to manage the arc flash hazard down to lower the PPE requirement. To achieve this, existing circuit protective devices were replaced, generally by more modern counterparts.

In several of the identified high hazard substations, a primary medium-voltage fuse in a fused load-break switch assembly was retrofitted with a high performance vacuum breaker (Figure 4). Adding this functionality, along with updated electronic protective relays, offered enhanced protection and device clearing times that reduced the substation secondary bus arc flash energy from levels over 100 cal/cm² to levels below 8 cal/cm². In addition, the arc flash incident energy available at critical low-voltage motor control centers was reduced by the addition of power circuit breaker feeder incorporating trip units with a new arc flash reduction maintenance switch. This allowed electricians to set the feeder circuit breaker to a fast tripping maintenance setting prior to performing energised work in downstream electrical equipment.

**A hidden benefit**

After the critical electrical substations were upgraded, Lehigh Edmonton's electrical maintenance employees were very pleased. The company's focused commitment to employee safety was obvious, given the visible investment to upgrade the plant's electrical infrastructure. As a result, employees were better able to focus on operating the plant more efficiently and effectively. One unexpected benefit was a dramatic improvement in operating uptime. Unexpected outages dropped significantly and today the plant operational uptime is above 92%, elevating Lehigh Edmonton as a new benchmark performer amongst its industry peers.

The dramatic safety and operational improvements can be attributed to the electrical/instrumentation projects supervisor at Lehigh Edmonton with support from the plant manager. Since both of these gentlemen are engineers, there was a clear understanding and appreciation for the value of a safe and reliable electrical distribution and control system. Typically, these assets are some of the most overlooked in the global cement industry, but that is not the case at the Lehigh Cement Plant in Edmonton. 🎉