Arc Flash Considerations for Power Retrofit

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.

Participants

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Don B. Daily Memorial Fund
To Promote Steel Industry Safety and Health

This article is the third in a series of Safety First articles featuring the reports from the recipients of the 2012 Don B. Daily Memorial Fund. The first article in the series can be found in the October 2013 issue of *Iron & Steel Technology,* and the second article was published in the November 2013 issue.

Project Description

Students on a manufacturing, safety and/or energy career path completed a research project in collaboration with Chad McClimans and James Hardy of Republic Steel.

The project is a research activity focused on the analysis of the arc flash hazard in a specific location of the Republic Steel manufacturing facility in Lorain, Ohio.

Objectives

- Provide an educational experience for four students and one faculty member in the environment, health and safety field within the steel industry.
- Identify the power distribution and components affecting arc flash within a specific location in the plant.
- Identify and recommend appropriate practices and protection, including labeling and barrier distances for the mitigation of the arc flash hazard per NFPA 70E.

Arc Flash Hazards

An electric arc or an arcing fault is a flashover of electrical current through the air from one exposed conductor to another. From an employee hazard standpoint, there is the potential for exposure to a high level of heat from the flash, potentially resulting in a serious burn injury as well as electrical shock. This problem exists in the steel industry, where a large quantity of electrical energy is used to manufacture steel. The demand for a continuous supply of power resulting from manufacturing operations has brought about the need for electrical workers to perform maintenance on exposed live parts of electrical equipment. Personal protection equipment (PPE) exists to provide heat protection from an arc flash up to 40 Cal/cm^2. PPE is unable to protect a worker over this level. Any potential hazard above that amount represents an extreme danger. Engineering solutions must be employed to reduce the arc discharge duration for any arc flash hazards to a safe level, below 40 Cal/cm^2. Even at this level, the use of a "beekeeper's suit" (Figure 1) makes work difficult.

Republic Steel Arc Flash Problem

Republic Steel initiated a multiphase arc flash study of the high-voltage substations and breakers within its Lorain, Ohio, steelmaking facility. This study used a common program called EasyPower to analyze the arc flash danger potential.

Findings from the first phase of the study have identified an extreme danger potential for which no PPE is available. This condition has been identified on the 4S cooling tower 1 and 2 circuits. These circuits are fed from a 15-kV breaker supplying a double-ended 13.8 kV/480 kV supply from the Clinton Power substation.

Currently, Republic Steel must de-energize the upstream feed to this 15-kV breaker prior to servicing the equipment being fed by the breaker. By isolating the upstream breaker, Republic assures the safety of its employees and eliminates the extremely dangerous condition. Consequently, by isolating the breaker upstream, critical operating equipment is also re-energized, preventing the operation of the Republic facility.

Trip packages and corrective engineering to maintain employees' safety, as well as maintain facility operations, must be developed and implemented.

The specific hazard noted in the study was 72.449 Cal/cm^2 for 4S cooling tower 1 and 123.251 Cal/cm^2 for 4S cooling tower 2. Two issues are apparent: (1) the potential for injury is significant and (2) no PPE is capable of protecting the individuals working on this circuit. If work is required, it cannot be done while the circuit is live. The circuit must be re-energized and the plant must be shut down. Both of these issues create an unacceptable situation.

Engineering solutions must be determined to allow continuous operation while protecting the electrical worker. The energy must be reduced to 40 cal/cm^2 or below to allow work on an active electrical circuit.

Republic Steel Arc Flash Solution

Development of a solution to the arc flash issues in the cooling tower circuits was reviewed in conjunction with Karpinski Engineering of Cleveland and Don Neely, area manager of maintenance, Republic Steel.

All scenarios of high-risk arc flash hazards and potential solutions were identified through the EasyPower program. EasyPower is an elaborate and reputable program that Karpinski Engineering uses exclusively while conducting arc flash analysis studies. The program is known for its ability to account for and chart major considerations such as coordination and PPE levels. The electrical landscape at Republic Steel's 4S cooling towers has multiple paths to substations, which offer additional challenges, as a worst-case scenario is required for an accurate arc flash analysis. Upon finding these worst-case scenarios, EasyPower confirmed the 4S tower locations to be extreme danger areas.

The task of creating settings for the EasyPower program required many on-site visits to record all associated breaker settings and nameplate information on

Figure 1

Students evaluate a "beekeeper's suit" while reviewing personal protective equipment.

Figure 2

Clinton Power substation.

the transformers. Additionally, it is common to just "aim high" with the needed MVA ratings in comparable situations, but in the Republic Steel study, the more time-consuming and accurate path of contacting the local utility was taken. Other aspects were assumed with a large margin of error. For instance, half of the load at the substation was considered to be motors, and the actual motor load was not actually investigated.

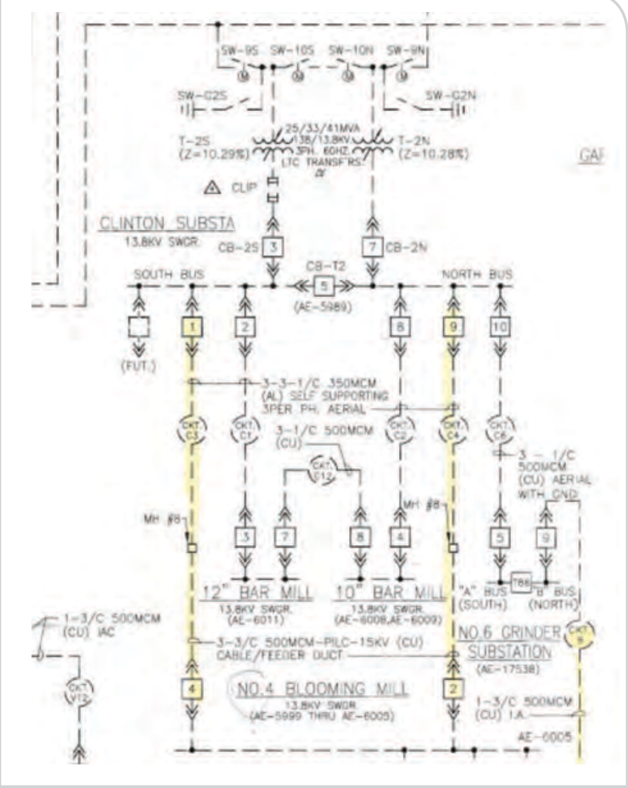
Breaker components are used to open a circuit that experiences a fault. In high-power applications, breakers are sequenced with a higher-current-rating breaker near the substation power source and individual branch circuits protected with lower-rated breakers. The sequencing of the components allows for faults in a specific circuit to be isolated from other branch circuits and allows the other circuits to continue to be supplied with power. If the sequencing is improperly implemented, a higher-level breaker may trip, causing a power outage more widespread than needed to isolate the current fault. The trip point of a breaker has a time-current relationship and is programmable in some cases. An example of a trip curve is shown in Figure 4. It shows a higher current level will cause the breaker to trip in a short time span. By properly sequencing the larger breakers to smaller breakers, faults can be isolated in a branch circuit without shutting down other branch circuits.

To improve the protection of an employee, it is necessary to shut down a fault either faster or at a lower current level. Either situation will reduce the overall exposure to the employee and reduce the extreme danger situation to a level at which an employee can work with an appropriate amount of PPE.

Two replacement components were identified and analyzed in the power circuits to determine if they reduce the arc flash hazard level to a safe level that would allow maintenance under load.

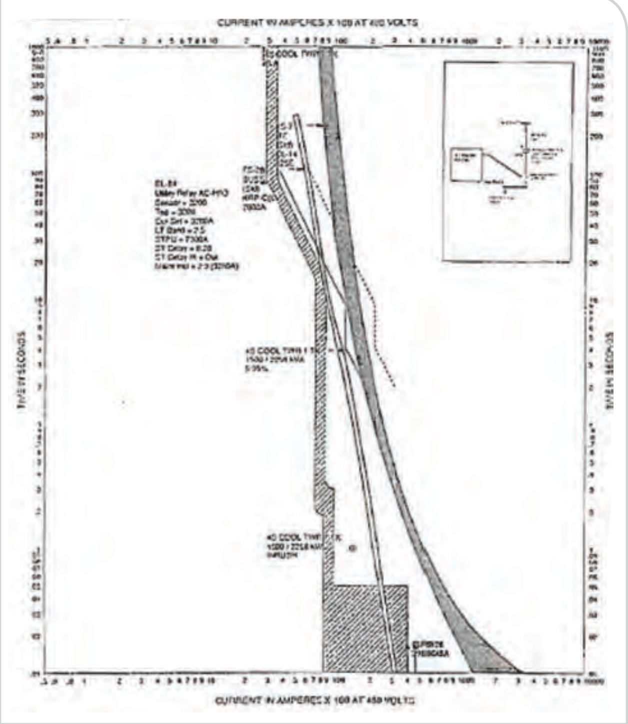
One of the two components of the solution is the AC – Pro Breaker with coordinated setting and Quick Time maintenance setting. This breaker offers normal operation and coordination while in a coordinated setting, but has arc flash ratings nearly beyond that allowable with PPE. The PPE levels as appointed by NFPA 70E are rated from levels 1 to 4. Level 1 is the mildest, allowing the most flexibility and comfort to the user, and level 4 is a beekeeper suit, which is the heaviest protection, but drastically limits the user's mobility and finger function. Placing the switch into service mode reduces the load side of the breaker to 3.0 Cal/cm^2 and puts it into PPE level 1. Placing the switch in maintenance mode cannot be considered a permanent solution, as it alters the timing and coordination of shutdowns. While this setting does protect the user, it reduces the current that may be supplied to the plant, effectively shutting down manufacturing.

Figure 3



Single-line drawing of the Clinton subsystem.

Figure 4

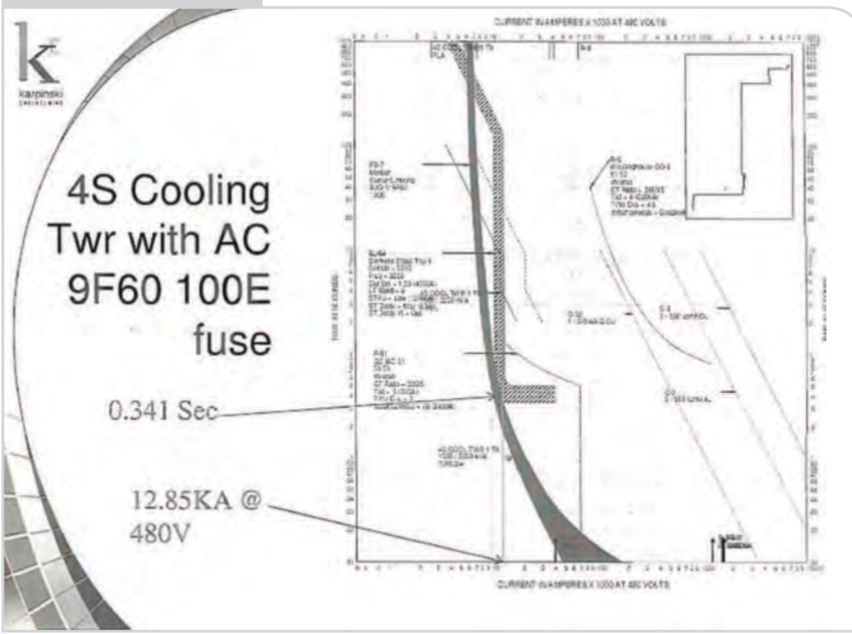


Time-current curve.

The second component suggested is a new style of fuse made by Shawmut. Early challenges before the discovery of the fuse included the inability to work on the hot line side with any level of PPE, as it far exceeded the 40 Cal/cm^2 maximum, with a rating of 72.3 Cal/cm^2. While sizing fuses, it is important to consider transformers. The rule of thumb is to maintain 150% of ratings on the primary side and 125% on the secondary side. The ratings on the transformer on-site would usually not allow a 100-amp fuse to be used, as it does not meet the minimum requirements, but the new 9F60HM100E 100-amp fuse was developed just for the purpose of protecting primary transformers and reducing arc flash, and is able to reduce the danger to PPE level 3 (16.8 cal/cm^2) on the line side. It achieves this with the unique shape of its fuse curve on a time-current graph (Figure 5) from Karpinski Engineering 4S cooling with an AC 9F60 100E fuse. It works by reducing the time-current curve (TCC) characteristic inverse down to the 0.01-second axis.

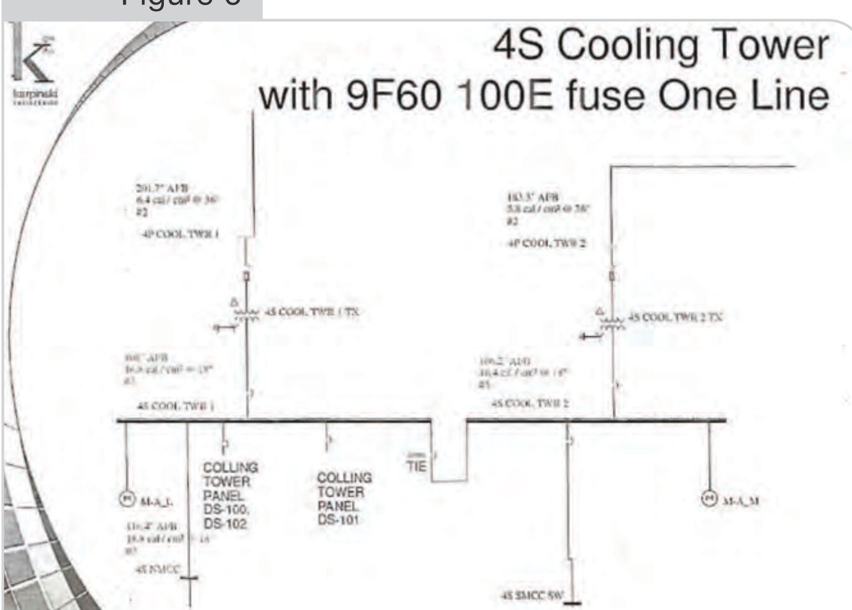
The AC – Pro and the Shawmut fuse working together seem to offer the best solution when considering safety, accessibility and cost. The arc flash hazard has been reduced to a level allowing level 3 PPE.

Figure 5



4S cooling tower with AC 9F60HM100E fuse.

Figure 6



4S tower one-line drawing.

Recommendations

Based on the work of Don Neely and Karpinski Engineering, it is recommended that the components identified be implemented in the 4S tower circuit, as indicated in Figure 6.

New developments in standards and practices are continuously occurring, especially now that more research is being conducted than in the past. This project proves that new technologies are emerging with the goal of increasing safety for personnel and equipment, and an annual review ensures that Republic Steel will always have the highest level of safety for both its equipment and employees.

If not already included, safety audits should include the arc flash hazards as part of the plant's safety program. Safety practices should be implemented throughout every division to ensure a unified approach. ✦