Abstract – The scope of a typical Arc Flash Hazard Analysis often extends well beyond the conventional limits of a short circuit evaluation. When evaluating equipment such as motor control centers (MCCs) and bus ducts, each individual feeder circuit should be evaluated to determine the incident energy for the downstream protected locations. Depending on the impedance between the overcurrent protection and the downstream location considered, the arcing fault current may be reduced to the extent that the overcurrent device will respond relatively slowly. To evaluate every cable drop from a bus duct and every feeder circuit in an MCC requires extensive effort that is often avoided by implementing inaccurate assumptions and invalid shortcuts. As a result, this paper will consider the possibility of limiting the required calculations by making accurate generalizations to identify a reduced number of circuits that merit a detailed analysis.

Index Terms – Arc Flash Hazard, Worst-Case Scenario, Incident Energy

I. INTRODUCTION

Performing an Arc Flash Analysis for a new or existing electrical distribution system can be a daunting task. Efforts have been made to limit the required scope of the evaluation, but portions of a system are often overlooked on the basis of faulty assumptions. Overlooked areas could have dangerous incident energy levels. The scope of the evaluation may be reduced to manageable size, but any assumption must be carefully scrutinized to guarantee an accurate determination of the Arc Flash Hazard. This paper discusses a method to generalize the arc flash calculations for select areas of a power distribution system. A specific application of this general method is presented in this paper as an example.

A. Defining the Scope of Arc Flash Analysis

NFPA 70E Standard for Electrical Safety in the Workplace 2004 Edition references the equations from the IEEE Std. 1584™-2002 as a method to quantify the incident energy available during an arc flash event. The equations in IEEE Std. 1584™-2002 are applicable for a voltage range of 208 V – 15000 V, three-phase and for a range of bolted fault current magnitudes between 700 A and 106,000 A. In addition, IEEE Std. 1584™-2002 states that, "equipment below 240 V need not be considered unless it involves at least one 125 kVA or larger low-impedance transformer in its immediate power supply." [2]

Equipment locations that are "likely to require examination, adjustment, servicing, or maintenance while energized should be field marked to warn qualified persons of potential electric arc flash hazards." [4] Typically, this includes switchboards, panelboards, industrial control panels, and motor control centers. Other work locations such as bus ducts, splitters and disconnect switches should be considered if energized parts above 50 V may be exposed by qualified personnel. (Unqualified personnel should never be permitted to access energized equipment.)

B. Building a Software Model for Arc Flash Analysis

A commercial software package is usually the most efficient and most accurate way to calculate the potential incident energy throughout a power system. When constructing a software model for arc flash analysis, it is important to include an accurate fault contribution model (utility sources and rotating machines), a complete impedance model (transformers, cables, and bus ducts), and a complete overcurrent protection model (fuses, relays, and circuit breakers).

For each location within the power system, the worst-case model will be represented by a unique operating configuration. What is often overlooked is that a lower magnitude of fault current typically results in a longer operating time of the upstream overcurrent protection, which may then result in a higher level of incident energy and a greater Arc Flash Hazard. Therefore, the power system included in the software model must be represented as accurately as possible.

II. DEFINING THE PROBLEM

This presents a logistical challenge when attempting to determine the arc flash hazard for locations downstream of low-voltage distribution equipment such as MCC’s, panelboards, and bus ducts. If each of the individual circuits is represented, the software model can become extremely cumbersome and extensive. For example, a model accurately extensive enough to provide meaningful Arc Flash Calculations for a bus duct requires the modeling of each individual bus plug, each section of bus duct between the plugs and the cables from the duct to the load. Even when current limiting devices protect these locations, there is no guarantee (without knowledge of fault levels) that these devices will operate in the current limiting region of the tripping characteristic. Some circuits may be rightly eliminated from the model, but these circuits cannot be identified until the available fault current has been determined for the distribution location (bus duct, MCC or panelboard.)
A. Accurate Fault Calculations

Because the Arc Flash calculations are used to prescribe protective equipment for qualified workers, great care must be taken to ensure that the contribution model is able to represent the worst-case scenario in terms of the Arc Flash Hazard.

The available fault currents calculated throughout a power system are determined by the source contributions and are limited by the system impedances between these contributing sources and the location of a fault event.

The primary source of fault current in a typical short circuit model is the utility or the primary generation supplying power to a facility. When a facility is powered by a utility source, the available fault current information is often obtained as the maximum available current. IEEE Std. 1584™-2002 requires the consideration of “the maximum and the minimum available short circuit currents.”

When constructing a model for the purpose of Short Circuit Analysis and Protective Device Coordination, the fault contribution model is often based on conservatively high calculations of current magnitudes such as utility design values. For example, the utility contribution may be determined by the maximum let-through current of the largest (kVA) transformer with the lowest impedance that the utility company is permitted to install. This information may provide conservative results for evaluation of interrupting ratings, but does not provide complete or adequate results for the Arc Flash calculations.

Other contributing sources in a power system include local generators and motors (rotating machines.) In the Arc Flash model, these contributions must be considered in the appropriate configurations to represent the maximum and minimum available fault current magnitude for each location in the system model. For example, a total maximum contribution may be represented by the maximum utility (source) contribution and the system motors running at full-load current prior to the simulation of the bolted fault. Similarly, the total minimum contribution may be represented by the minimum utility or generator contribution with the minimum number of motors (rotating loads) in operation. Additionally, rotating machine contributions, unlike the utility contribution, will decay rapidly and may not be present for the entire duration of the arc flash event. The short circuit contribution of an induction motor should only be considered for the first 3-5 cycles (0.05s – 0.0833s) of the event duration. Should the arc flash event last for a time period greater than 0.05s to 0.0833s, the modeling software should be able to take this into consideration.

Obtained from a complete contribution model, the 3-phase bolted fault current values provide the starting point for accurate Arc Flash calculations at each system location. Bolted fault current magnitudes are calculated at each bus or node location and represent the sum total of all contributions. In the event of a low-voltage (<1000 V) Arc Flash incident, the current flowing into the fault is not equal to the bolted fault current represented by the short circuit model. This arcing fault current is calculated using the IEEE Std. 1584™-2002 equations (1) and (2) presented below and is based on the portion of the calculated bolted fault current which flows through the upstream overcurrent protective device. [2]

For applications with a system voltage under 1000 V solve the equation (1):

$$I_g = K + 0.662I_a + 0.983I_{bf} - 0.00304G$$

where

- $I_g$ is the log$_{10}$
- $I_a$ is arcing current (kA)
- $K$ is –0.153 for open configurations and is –0.097 for box configurations
- $I_{bf}$ is bolted fault current for three-phase faults (symmetrical RMS) (kA)
- $V$ is system voltage (kV)
- $G$ is the gap between conductors, (mm)

For applications with a system voltages from 1000 V up to and including 15,000 V, solve the equation (2):

$$I_g = 0.00402 + 0.983 I_{bf}$$

For system voltages greater than 1000 V, there is no distinction between open and box configurations. Also, for system voltages above 15,000 V, the arcing fault current is considered equal to the bolted fault current.

Table 1 shows the calculated bolted fault current will be significantly reduced by the impedance of the arc when system voltage is less than 1000 V.

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>Bolted Fault Current (kA)</th>
<th>Arcing Fault Current* (kA)</th>
<th>% of Bolted Fault Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.208</td>
<td>10.00</td>
<td>4.35</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>20.00</td>
<td>7.08</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>30.00</td>
<td>9.41</td>
<td>31%</td>
</tr>
<tr>
<td></td>
<td>40.00</td>
<td>11.51</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>13.47</td>
<td>27%</td>
</tr>
<tr>
<td>0.480</td>
<td>10.00</td>
<td>6.56</td>
<td>66%</td>
</tr>
<tr>
<td></td>
<td>20.00</td>
<td>11.85</td>
<td>59%</td>
</tr>
<tr>
<td></td>
<td>30.00</td>
<td>16.76</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td>40.00</td>
<td>21.43</td>
<td>54%</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>25.93</td>
<td>52%</td>
</tr>
<tr>
<td>0.600</td>
<td>10.00</td>
<td>7.86</td>
<td>79%</td>
</tr>
<tr>
<td></td>
<td>20.00</td>
<td>14.88</td>
<td>74%</td>
</tr>
<tr>
<td></td>
<td>30.00</td>
<td>21.62</td>
<td>72%</td>
</tr>
<tr>
<td></td>
<td>40.00</td>
<td>28.19</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>34.62</td>
<td>69%</td>
</tr>
<tr>
<td>&gt;1.00 up to 15.00</td>
<td>10.00</td>
<td>9.71</td>
<td>97%</td>
</tr>
<tr>
<td></td>
<td>20.00</td>
<td>19.18</td>
<td>96%</td>
</tr>
<tr>
<td></td>
<td>30.00</td>
<td>28.58</td>
<td>95%</td>
</tr>
<tr>
<td></td>
<td>40.00</td>
<td>37.92</td>
<td>95%</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>47.22</td>
<td>94%</td>
</tr>
</tbody>
</table>

* Arcing fault current was calculated based on the equations given in IEEE 1584-2004a. For the low-voltage calculations, a box
configuration was assumed with a gap between conductors of 25mm and system is considered solidly grounded.

IEEE Std. 1584™-2002 also requires that the arcing fault magnitude be further reduced to 85% of the calculated value. A corresponding clearing time is selected for both the 85% value and the 100% value. This is done because it is very difficult to accurately predict the arcing current and a small change in current could result in a significant change in clearing time.

To illustrate this, the time-current curve of a typical 480 V, 200 A thermal-magnetic molded-case circuit breaker (MCCB) is shown in Figure 1. Notice the change in breaker clearing time when transitioning from the instantaneous (magnetic) portion of the curve to the long time (thermal) portion of the curve. This “threshold point” is defined as the value of current where the protective device transitions from fast to slow clearing time. For molded case circuit breakers (MCCB) or motor circuit protectors (MCP), the threshold point is where instantaneous tripping may not occur. For current limiting fuses (CLF), the threshold point is the minimum current which will cause current limiting action.

As illustrated in Figure 1, when the fault current is reduced to a value just below this threshold point, the maximum clearing time is increased from roughly 0.021 seconds to 2.1 seconds. One can easily see that decreasing the fault current will typically increase the clearing time of the upstream protective device, which often results in higher calculated incident energy values. This makes accurate fault current calculations essential when performing an arc flash hazard analysis.

As illustrated above, the clearing time and resulting incident energy are highly dependent on the calculated arcing fault current. Therefore, the power system engineer must evaluate not only the major equipment locations (switchgear, switchboards, panelboards and MCCs), but all locations downstream where energized work may be performed, which often leads to a very extensive computer model. In order to decrease the size of the required model (and the associated amount of data collection) some creative generalizations can be made without reducing the accuracy of the resulting calculations.

III. DEMONSTRATION OF THE PROBLEM

A. Old Paradigm for Assumptions

Before considering these applicable generalizations and assumptions, it is instructive to consider the paradigm that is historically associated with a Short Circuit Analysis and a Protective Device Coordination Study. This traditional approach is no longer valid when performing an Arc Flash Analysis.

The Arc Flash calculations are based on several constant values defined by the physical parameters of the equipment location for which an analysis is performed. The two most important system variables, however, will change according to the system configuration as represented in the software model. These two variables are the calculated fault current magnitude and the clearing time of the protective device responsible for the isolation of the fault location. When an Arc Flash incident occurs, the magnitude of the fault current flowing through the

![Figure 1: Instantaneous Pickup Point of Typical 200A Molded Case Circuit Breaker](image1)

A similar characteristic is illustrated for a typical 480 V, 200 A Class J fuse in Figure 2. As the fault current is reduced below the threshold point of the fuse, the maximum clearing time will increase to a value above 0.01 seconds.

![Figure 2: Current Limiting Point of Typical 200A Class J Fuse](image2)

As illustrated above, the clearing time and resulting incident energy are highly dependent on the calculated arcing fault current. Therefore, the power system engineer must evaluate not only the major equipment locations (switchgear, switchboards, panelboards and MCCs), but all locations downstream where energized work may be performed, which often leads to a very extensive computer model. In order to decrease the size of the required model (and the associated amount of data collection) some creative generalizations can be made without reducing the accuracy of the resulting calculations.

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arc will determine the clearing time of the overcurrent protection.

Prior to beginning an Arc Flash Analysis, accurate system data must be gathered for incorporation into the software model. When building a Short Circuit model for evaluation of equipment interrupting and withstand ratings, assumptions are easily accepted to determine the worst-case scenario. For example, if the length of a conductor is unknown, a conservatively short assumption will yield the highest fault current duty calculation for the device to be evaluated. For Arc Flash Analysis, however, the greatest fault current magnitude may provide the worst-case calculation or it may result in a dangerously erroneous result because the high magnitude of fault current will lead to the conclusion that a rapid clearing time of the upstream overcurrent protection will occur.

For coordination purposes, the overcurrent protection model may only include the larger adjustable devices associated with a given system location, since most devices 200 A and less have fixed trip curves. However, for the Arc Flash model, every overcurrent protective device responsible for the reduction of the arc flash hazard, adjustable or not, must be accurately modeled in the system.

B. Goals of Arc Flash Analysis

When performing an Arc Flash Hazard Analysis, it is important to consider several goals of the study and results. The primary goal is determining the Hazard Risk Category (HRC) associated with all locations in the distribution system where energized work may be performed. The HRC is required to define the Personal Protective Equipment (PPE) that should be worn when working on or near energized electrical equipment. An Arc Flash Hazard is quantified according to the incident energy (cal/cm²) calculated at a specific working distance for each system location. As summarized in Table 2 NFPA 70E-2004 Table 130.7(C)(11) defines five (5) HRC’s, which correspond to ranges of calculated energy (cal/cm²). [1] Each of these HRC’s is associated with specific requirements for PPE.

<table>
<thead>
<tr>
<th>Hazard Risk Category (HRC)</th>
<th>Incident Energy From (cal/cm²)</th>
<th>Incident Energy To (cal/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&gt; 0</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>&lt; 8</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>&lt; 25</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>&lt; 40</td>
</tr>
</tbody>
</table>

Table 2: Hazard Risk Categories (HRC)

The second goal of an arc flash analysis is to determine the ideal settings and current ratings for the overcurrent protective devices in the system. The operating times of the phase overcurrent protective devices are based on arcing current flow and are used to determine the Hazard Risk Category for each location analyzed.

When performing an Arc Flash Hazard Analysis the settings of these overcurrent devices define the magnitude of the downstream hazards. For the maximum reduction of the Arc Flash Hazard, all devices should be configured to provide the most rapid clearing time. This, of course, eliminates the coordination interval required for selective fault clearing and such a configuration should not be recommended. Considering all of the factors involved, the Power Systems Engineer is required to determine overcurrent protective device settings that provide overcurrent coordination and equipment protection as well as the lowest possible incident energy at all work locations.

Upon the determination of the optimum settings for the overcurrent protection and the resulting Arc Flash Hazard at each location analyzed, the Power Systems Engineer is able to investigate possible solutions to reduce the Arc Flash Hazards. These solutions may include the recommendation of additional or replacement overcurrent protective devices, the implementation of procedures to provide safer access to energized equipment, and/or the installation of solutions that either increase worker distance or decrease protective device clearing time.

Upon the completion of an Arc Flash Analysis, the results of the calculations must be clearly presented. Warning labels, applied to the outside of equipment enclosures, are often considered to be the most effective means of displaying the results of the Arc Flash Analysis for qualified persons. Article 110.16 of the National Electric Code (NEC) 2005 requires industrial and commercial electrical equipment to “be field marked to warn qualified persons of potential electric arc flash hazards.” [4] Specific quantities, ranges, boundaries, and Hazard Risk Categories are not expressly required by the NEC. Many facilities have found that by presenting the Arc Flash Hazard warning and listing the Hazard Risk Category (HRC) on a prominently displayed label enables qualified persons to easily determine the appropriate PPE requirements.

C. Current Limiting Devices and the Arc Hazard

Current limiting devices are very important for equipment protection when they operate to prevent equipment damage under a high magnitude fault condition.

Current limiting protective devices (fuses or circuit breakers) are often recommended as a means of reducing the arc flash hazard. However, care should be taken when such devices are considered as solutions to a hazardous situation. If the arcing fault current magnitude will always be great enough to cause operation in the current limiting range, then rapid clearing will dramatically reduce the potential exposure to a dangerous amount of incident energy. If however, under any circumstances, the arcing fault current is not high enough to drive the overcurrent device into the current limiting range, such devices should not be recommended as a solution to an arc flash hazard. When a fast clearing time is determined on the basis of a calculated arcing fault current magnitude at the physical location of a current-limiting device, it is a common mistake to assume that the device will operate just as quickly when a fault occurs at a protected location further downstream. Instead, the fault current flowing through the current limiting device will be significantly reduced by the impedance of the cable (often very small in comparison with the ampacity of the equipment bus) supplying individual loads or smaller pieces of distribution equipment. To accurately determine the incident energy and corresponding HRC for the downstream locations, the impedance of the feeder circuit must be considered.
III. SOLUTION TO THE PROBLEM

In order to reduce the overall scope of the Arc Flash Hazard Analysis, one must limit the required number of calculations. Below is a description of a generalization method developed by the authors to reduce the effort required to provide a comprehensive analysis at a specific location. Similar methods may be applied at other industrial or commercial locations.

A. Making Accurate Generalizations

Using accurate generalizations, an Arc Flash study can include all equipment locations that are likely to require examination, adjustment, servicing, or maintenance while energized. Using the following steps, this analysis can be performed without the need to model every location using the following steps:

Step 1. Detailed analysis from the Utility feeder connections down to MCC’s, bus ducts, splitters or panels (600 V or less) fed by overcurrent devices (fuse or trip rating) that are sized at 200 Amps or larger. Future enhancements of the generalization method may allow an increase above 200 A. Detailed analysis can be accomplished using a commercial software package to develop a model that provides the following for each location that is studied:

- Bolted Fault magnitude and X/R ratio
- Arcing fault magnitude
- Protective device clearing time and duration of the arc flash
- Flash Protection boundary
- Incident Energy calculated at a working distance (cal/cm²)
- Hazard Risk Category (HRC) based on NFPA 70E-2004, Table 130.7(C)(11), (see Table 2) [1]

Step 2. Extend the analysis to locations fed from MCC’s, bus ducts, splitters or panels. This can be accomplished by:

1. Using the results from Step 1 in a spreadsheet to calculate the maximum cable length for each feeder size from MCC’s, bus ducts, splitters or panels.
2. Conducting a site survey to find all feeders that are longer than the maximum cable length in the spreadsheet.
3. Collect data for the feeders that exceed the maximum length. This includes protective device and conductor data.
4. Add these feeders and locations to the model developed in Step 1.

The spreadsheet calculates a conductor size based on the feeder trip or fuse amp rating which is converted to a conductor size based on:

- 80% rated protective equipment (molded case breaker or fuse)
- Copper conductor, 75°C insulation in magnetic conduit.

From the conductor size, the spreadsheet calculates the maximum circuit length, which equates to an impedance. The impedance is used to calculate a fault level at the end of the feeder. The spreadsheet determines a circuit length that will cause the HRC at the MCC’s, bus ducts, splitters or panels to increase at the end of a feeder to the next category or HRC. This is accomplished by comparing the calculated arcing fault current to the threshold point of the protective device at the line end of the feeder.

- If the fault current at the load end of the feeder is higher than the threshold point, then the HRC at the load end bus location does not increase to the next category
- If the fault current at the load end of the feeder is lower than the threshold point, then the HRC at the load end bus location may increase to the next category and further analysis is required.

The spreadsheet model uses conservative values for threshold point:

- 50 X trip rating for MCCB trip ratings from 15 Amp to 225 Amp
- 20 X trip rating for MCCB trip ratings from 250 Amp to 600 Amp
- 20 X trip for MCP trip ratings from 3 Amp to 1200 Amp
- 25 X fuse amp rating for CLF from 15 to 600 Amp

B. Applying the Method at an Industrial Facility

The above method is illustrated by an example from an Arc Flash Hazard Analysis study at an industrial location. Step 1 was performed from the Utility connection at 27.6 kV down to a total of 280 locations at 600 V or below (MCC’s and panels sized at 200 Amp or larger). In Step 2, a spreadsheet was developed for these 280 locations for protective device types MCCB, MCP and CLF. The spreadsheet included calculations of the maximum cable length from each of the 280 locations out to a distance where the HRC will not increase to the next category. The maximum cable length (feet) is reported on the spreadsheet for each location called the “Bus Name” and was provided for standard ratings of protective devices.

An example of one of the rows of the spreadsheet is illustrated in Table 3 below. Note that Table 3 only shows only a few of the trip ratings included, the actual spreadsheet included all of the standard trip ratings that would be found in this type of equipment. Table 3 shows maximum cable length for MCCB’s with trip units rated from 15 to 60 Amp. For the Bus Name “200 A WIRE TR”, the hazard risk category level will not rise above HRC = 0 as long as a 20 Amp feeder breaker’s cable distance is less than 160 feet. If there is a 60 Amp feeder breaker at “200 A WIRE TR”, then the downstream HRC = 0 as long as the cable distance is less than 100 feet.

<table>
<thead>
<tr>
<th>Bus Name</th>
<th>Voltage (V)</th>
<th>Bolted Fault (kA)</th>
<th>X/R</th>
<th>HRC</th>
<th>Trip Rating in Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 A WIRE TR</td>
<td>600</td>
<td>13.18</td>
<td>1.798</td>
<td>0</td>
<td>140 feet 160 feet 160 feet 110 feet 130 feet 100 feet</td>
</tr>
</tbody>
</table>

A site survey was performed to identify the number of sub-feeders which exceeded the distances in the spreadsheet. A conservative estimate of the total number of sub-feeders was obtained by assuming that there were at least 5 at each of the
An estimated total of 1400 (280 x 5) locations required investigation on site to determine if the circuit length exceeded the values in the spreadsheet. The results of the site survey indicated that there were only 85 feeders where the circuit length was exceeded. For each of the 85 additional feeders, additional data gathering at the site was required to enable the power system engineer to add them to the commercial software package model that was created in Step 1. This additional information is summarized below:

1. Circuit Name
2. Feeder Protective Device Manufacturer
3. Feeder Trip unit or Fuse Ampere rating
4. Feeder Length
5. Feeder Configuration, one of the following:
   • conduit (Magnetic or non-magnetic)
   • free air spacing

The result of the additional analysis in the commercial software package revealed that out of the 85 new sub-feeders that were modeled, there were only 17 small panel locations where the HRC was higher than the HRC at the upstream MCC or panel location. Based on this analysis, it was concluded that all other small panel locations in the power system that were fed from panels and MCC’s would have the same HRC as the upstream location that feeds them.

The electrical workers at this site were instructed that there were only 17 small panel locations where the HRC level was higher than the location from where they were fed. This information was recorded in the Arc Flash report (see Table 4 below). If a small panel location downstream of a panel or MCC did not have an Arc Flash Hazard label, and the small panel was not on the list of locations in Table 4 then it would have the same HRC rating as the panel or MCC from which it was fed.

| Table 4: Small panel Locations Where HRC Was Higher than the Upstream Location |
|-------------------------------|------------------|---------------------|
| Label # | Bus Name | Protective Device Name |
| 255 | *57EP104 | PD-57EP906-104 |
| 256 | *57EP105 | PD-57EP906-133 |
| 266 | *57EP107 | PD-57EP906-107 |
| 268 | *57EP113 | PD-57EP905-113 |
| 269 | *57EP133 | PD-57EP904-133 |
| 270 | *LP11&LP13 66 | PD7/9/11/13 |
| 271 | *LP12&LP14 66 | PD8/10/12/14 |
| 272 | *LP7&LP9 66 | PD7/9/11/13 |
| 273 | *LP8&LP10 66 | PD8/10/12/14 |
| 274 | PANEL-RP-3A | PD-RDP3A-RP3A |
| 275 | PANEL-RP-3B | PD-RDP3A-RP3B |
| 276 | PANEL-RP-3C | PD-RDP3A-RP3C |
| 277 | RDP-3C | PD-RDP3A-RDP3C |
| 278 | RP-4A | PD-RDP3A-RP4A |
| 279 | WELDRECEPT | PD-PDP12B-WELD |

Thus a reduction in the small panel locations that required detailed analysis of \((1400-85)/1400 \times 100\% = 94\%\).

There are also savings in additional onsite data gathering and entry of information into the computer model. In addition, there are savings in the reduction of additional arc flash hazard warning labels and the associated cost of installing these labels. In this example, only 17 additional arc flash hazard warning labels were required for the small panels.

V. CONCLUSION

Performing an Arc Flash Hazard Analysis for all equipment locations that are likely to require examination, adjustment, servicing, or maintenance while energized can prove to be an enormous task. Developing innovate methods to reduce the scope of work without sacrificing the accuracy of the results is the goal of every engineer. This paper has presented a method that can be used to help reduce the amount of equipment locations that must be analyzed using a commercial software package. The industrial example presented reduced the number of small feeder locations that required a detailed analysis by 94%.

This resulted in a large reduction of onsite data collection, detailed modeling and arc flash warning labels.

ACKNOWLEDGEMENT

The authors thank W. S. Vilcheck for his sponsorship, advice, and encouragement.

REFERENCES

[1] Electrical Safety Requirements for Employee Workplaces, NFPA 70E-2004 © NFPA.

C. Summary of Savings in Industrial Example

For the example presented in this paper, applying accurate generalizations reduced the total number of locations that needed to be added to the computer model from 1400 to 85.
BIOGRAPHIES

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