A case study in solving SCCR issues

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ABSTRACT

Not only does the National Electrical Code (NEC®) require proper equipment and machinery short-circuit protection, it is also critical for safety of personnel and fire prevention. Proper planning in the design phase can avoid challenging jobsite corrections, and can often result in minimal-to-no impact on design, layout and material costs. Viking Masek, based in Oostburg, WI, manufactures custom automated packaging equipment. They recently had a project that needed a 65,000 amp Short-Circuit Current Rating (SCCR). Working with the circuit protection experts at Eaton's Bussmann division, an SCCR analysis of their design was performed. It identified several “weak link” components that limited the panel’s SCCR to just 5,000 amps. These weak links were resolved when Viking Masek made several component substitutions that included using a UL 98 Listed Bussmann™ series Compact Circuit Protector disconnect switch with Class CC fuses that permitted applying a 200,000 amp SCCR to several Rockwell Automation Kinetix 5500 servo drives. This and other component changes improved the overall panel SCCR to 65,000 amps without impacting the panel layout or material costs.

This case study will break down the SCCR analysis made for this project, highlight how the solutions were determined and demonstrate how proper planning can help achieve SCCR compliance with the NEC.

BACKGROUND

Machinery and equipment manufacturers are likely to be familiar with the term SCCR (Short-Circuit Current Rating). SCCR is the amount of short-circuit current an industrial control panel can safely withstand in the event of a short circuit. The National Electrical Code has driven awareness of this important rating since it became a requirement in 2005.

Properly applying short-circuit protection is extremely important. Consider a fuse or circuit breaker. These are overcurrent protective devices and have what is known as an “interrupting rating”. This value defines the maximum amount of short-circuit current the device can safely “interrupt”. Applying a fuse or circuit breaker to a condition where the short-circuit current exceeds its interrupting rating is a serious misapplication. The inability to safely interrupt a short-circuit event can result in disastrous consequences, including hazards such as fire, shock and arc blast. It’s critical that the fuse or circuit breaker be properly applied to avoid these dangers.

But what about devices that are not designed to interrupt a short-circuit event, such as motor starters, power distribution blocks, disconnects, and others? What happens to these devices during a short-circuit event? These devices will also experience the effects of the extremely rapid increase in current during a short-circuit event. However, they are not designed to operate or function under such high current conditions. Since these devices cannot interrupt or withstand short-circuit current on their own, it is critical that they be applied with the proper overcurrent protective device, such as a fuse or circuit breaker. These overcurrent protective devices act to open the circuit in a safe manner, but they do not operate instantaneously. Some level of the rapidly increasing short-circuit current will pass through before the overcurrent protective device can open the circuit and end the rapid current rise. The current that passes through before the overcurrent protective device can open the circuit is often referred to as the “let-through” current. The amount of let-through current depends on the overcurrent device used and the level of available short-circuit current. Some overcurrent protective devices respond more quickly than others.
This means that the ability of a motor starter, distribution block, or other device to safely endure a short-circuit event highly depends on being paired with the proper overcurrent protective device. The specific type of overcurrent protection necessary for a device to safely endure a short-circuit event can only be determined by testing that device in combination with a specified overcurrent protective device at defined voltage and short-circuit current levels. The result of a successful test is known as the component’s short-circuit current rating. A device that is applied in a condition where the available short-circuit current exceeds its ability to endure the high currents of a short-circuit event may also result in disastrous consequences similar to that of a misapplied fuse or breaker: arc blast, flying debris, shock and fire hazard. These devices must also be properly applied with the specified overcurrent protective device. To see a video of what can happen when panels are applied where their SCCR is inadequate, go to www.eaton.com/bussmannseries/sccr.

The overcurrent protective devices’ interrupting rating and the components' SCCR are then considered in determining the overall short-circuit current rating of the industrial control panel of the equipment. However, many equipment manufacturers struggle with this determination process. Conceptually, equipment SCCR evaluation seems simple, as it uses a “weakest link” approach that defines the equipment’s overall SCCR value to be equal to the lowest rated component value. However, many engineers struggle when and where to apply the current-limiting rules that raise SCCR values, and a single mistake can result in an incorrect panel rating. Engineers also struggle with locating component SCCR information, which makes it difficult to find suitable substitutions to address low SCCR without requiring significant changes to the panel layout and/or overall material costs. The last major challenge to achieving SCCR compliance is the limited information about the available short-circuit current (also known as the available fault current) at the location in the electrical system where the equipment is being installed. The NEC requires that the equipment not be installed where the available short-circuit current exceeds its short-circuit current rating (NEC 409.22).

These challenges not only increase the effort to design the compliant electrical controls for equipment and machinery, but they can also result in larger panels and increased material costs if a suitable solution cannot be found. Availability of the requisite component rating information, experience in solving SCCR, and access to knowledgeable resources are key to achieving a compliant SCCR solution in a timely manner while maintaining a competitive design.

It is important to also note that 2017 NEC code changes will impact how engineers address SCCR. The new code will require the available short-circuit current be marked on the panel or documented at the time of installation. For more information about the specific code changes and their impact on equipment design and approach, see publication number 10508 at www.eaton.com/bussmannseries.
A significant challenge for any OEM is to understand, interpret and correctly apply the guidelines in the UL 508A standard for industrial control panels. UL 508A Supplement SB contains an approved method for determining equipment SCCR along with an accepted and recognized evaluation process. However, this is often misunderstood or misinterpreted, and results in determining an incorrect equipment SCCR. In a recent survey, over 50 percent of OEMs acknowledged that they struggle with properly applying UL 508A.

Another challenge facing OEMs is finding components with the right SCCR to fix the “weak links” limiting equipment SCCR. Finding the right component solution is the most significant factor regarding the impact on the design, layout and material cost adjustments. Most often, the OEM does not have the part in their hands to check its component SCCR marking and has to rely upon information from the manufacturer. Even today, with all that the internet offers, issues with finding SCCR information persist. Nearly eight out of ten OEMs surveyed expressed difficulty in finding this information.

Manufacturer Viking Masek approached Eaton’s Bussmann Division for assistance with determining the SCCR of their MS400 vertical form fill seal machine, and suggestions on how it could be raised to 65 kA. The Eaton Bussmann Application Engineering team provides free SCCR analysis, and was requested to help achieve SCCR compliance. The team performed an SCCR analysis using the Eaton Bussmann series OSCAR™ 2.1 SCCR analysis software, and determined the panel’s design possessed just a 5 kA SCCR.

Initial analysis from the OSCAR 2.1 SCCR analysis software reveals weak links that must be addressed to achieve the desired 65 kA.
OSCAR 2.1 applied the component SCCR values based on the circuit protective devices used, as well as the impact of the current limiting devices in the circuit. The analysis revealed the following, identifying which components must be addressed to achieve the desired 65 kA equipment SCCR value:

1) The miniature circuit breakers/supplementary protectors, rated at 10 kA, must be replaced with overcurrent protective devices having an interrupting rating not less than 65 kA and with comparable dimensions.

2) The Kinetix 5500 servos had a 5 kA rating as applied. The presence of the current-limiting 30 amp Class J fuse in the feeder circuit is not able to improve the 5 kA rating. This required further investigation to resolve.

3) Although the power circuit components downstream of the power transformer had SCCR values less than 65 kA, the 10 kVA power transformer raised their ratings to a level sufficient to achieve the desired 65 kA equipment SCCR.

THE SOLUTION

The Eaton Bussmann Application Engineering team researched design solutions to address the weak links limiting the panel’s SCCR below 65 kA, starting with the miniature circuit breakers/supplementary protectors. Considering the size, functionality and costs of these existing components, the Bussmann series Compact Circuit Protector (CCP) solution, with KTK-R Class CC fuses, provided the best solution when compared with a molded case circuit breaker or a fuse and fuse block solution. This component substitution not only raised the interrupting rating to 200 kA, it did so without any significant impact on costs or the panel layout.

Next, a solution was sought for the 5 kA SCCR rating determined for the Rockwell Automation Kinetix servo drives. The design consisted of the Kinetix model 2198-H040-ERS, 2198-H025-ERS, 2198-H015-ERS and 2198-H008-ERS servo drives, which have a 200 kA SCCR value when applied with a specified overcurrent protective device. As applied in the existing design, the servos being fed by a single circuit breaker resulted in a 5 kA SCCR value. Upon reviewing the instruction manual 2198-UM001G-EN-P, it was determined that a 200 kA SCCR value could be applied using specified fuses as the overcurrent protection to the servos grouped by model number. As per the servo instruction manual, the circuit was reconfigured, and protected by the specified fuse. All except the 40 A servo drives were fed by UL 98 Listed Compact Circuit Protector disconnect switches using several ampacities of Bussmann series KTK-R Class CC fuses. The 40 A servo drives were fed with Bussmann series Low-Peak LPJ-35SP Class J fuses.
Excerpt from Rockwell Automation Publication 2198-UM001G-EN-P (March 2016) detailing circuit protection requirements for the Kinetix 5500 servo drives.

The design also contained a 480 V:240/120 V power transformer. According to the OSCAR 2.1 analysis, the components downstream of this transformer resulted in a suitable SCCR value. This determination was made by applying the UL 508A SB4.3.1 current limitation rules, which in simple terms state that the devices (overcurrent protective devices and others) will result in an SCCR value equal to the interrupting rating of the overcurrent protection on the primary of the transformer if all the devices downstream of the transformer have a respective interrupting rating or component SCCR not less than the fault current on the transformer’s secondary as defined in table SB4.3 (for single phase). Based on the transformer’s voltage and size, it was determined that the amount of available fault current on the transformer secondary was less than the downstream component SCCR, allowing the lineside overcurrent protective device interrupting rating (in this case, 200 kA) to be applied to these downstream components.

Excerpt from UL 508A that defines the secondary available short-circuit current on the secondary of the 10kVA transformer to be 2,980 amps.
The use of the power transformer improves the rating of the downstream devices to 200 kA.

With all the device issues addressed, the revised panel design was then analyzed in the OSCAR 2.1 software, and resulted in a new, higher SCCR of 65 kA. Based on this analysis, the following improvements were realized:

1) The 10 kA rated miniature circuit breakers/supplementary protectors that prevented a 65 kA panel rating were replaced with the Compact Circuit Protector using Class CC fuses, which improved the respective devices interrupting rating to 200 kA.

2) The SCCR of the servo drives improved to 200 kA after reconfiguring the circuit and applying the specified fuses as per the instruction manual.

**OSCAR 2.1 SCCR analysis software calculates the SCCR, applying the component SCCRs and the transformer/current limiting rules.**
### Customer Examples - Request and Examples

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<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Volts</th>
<th>Amps</th>
<th>IR</th>
<th>Final SCCR</th>
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<tbody>
<tr>
<td>VIXING MASEK MS400</td>
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<td></td>
<td></td>
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<td>65kA SCCR</td>
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### Result

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<th>Part Number</th>
<th>Device Description</th>
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<th>Adjusted SCCR</th>
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<tbody>
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<td>104R-H30-1753</td>
<td>Disconnect</td>
<td>480 / 277</td>
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<td>2</td>
<td>Supply - Main Supply</td>
<td>LPI-J0SP</td>
<td>CLASS - J</td>
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<td>Wire Jumper - Feeder on Main Supply</td>
<td>Bus Bar</td>
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<tr>
<td>4</td>
<td>Branch - Branch Connected to Feeder off Main Supply</td>
<td>140M-C2-E25 + 100-C09</td>
<td>1.6-2.5A Type F CMC</td>
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<td>5</td>
<td>Branch - Branch Connected to Feeder off Main Supply</td>
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<td>Fusible Disconnect</td>
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<td>6</td>
<td>Sub Feeder - Sub-Feeder off Feeder</td>
<td>KTK-R-6</td>
<td>CLASS - CC</td>
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<td>6</td>
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<tr>
<td>7</td>
<td>Sub Feeder - Sub-Feeder off Feeder</td>
<td>CCP-3-30CC</td>
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<td>CLASS - CC</td>
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<td>Supplementary Protector</td>
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<td>11</td>
<td>Branch - Branch Connected to Sub Feeder</td>
<td>1492-SPP1C100</td>
<td>Transformer adjusts SCCR from 10kA to 200kA</td>
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### Comments

- Transformer adjusts SCCR from 10kA to 200kA

### Adjusted SCCR

- Circuit Breaker
- Supplementary Protector
- Transformer adjusts SCCR from 10kA to 200kA

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**OSCAR 2.1 SCCR analysis software documents the SCCR analysis, indicating the resulting SCCR contribution for each component, including the specific overcurrent protective device that raises the component SCCR.**
OSCAR 2.1 SCCR Compliance Application contains over 60,000 parts and over 25,000 combinations of SCCR, including nearly 10,000 Rockwell Automation products and nearly 3,000 associated combinations of SCCR. Using its vast database, OSCAR found the component SCCR of the servos and the interrupting ratings for the overcurrent protective devices. Based on the configuration, OSCAR then applied the transformer and current-limiting rules to adjust component ratings accordingly. The overall panel SCCR was then determined, and summarized in a report.

**BENEFITS**

Safety is key for all those involved with electrical equipment, whether it be the industrial engineer or consultant specifying the equipment requirement, the engineer designing the equipment, the electrician installing the equipment, the inspector approving the equipment, the operator using the equipment, the maintenance personnel maintaining the equipment, or the owner providing a safe working environment. Although SCCR compliance may be challenging at times, proper short-circuit protection is a critical element of machine/equipment safety.

For Viking Masek, their panel’s SCCR was improved from 5 kA to 65 kA with just a few component changes and minimal adjustment to the servo drives’ circuit position. Viking Masek can now send their MS400 equipment to the customer’s jobsite and be confident it is suitably designed for fault current levels up to 65 kA.

Using the OSCAR 2.1 report feature, the SCCR analysis validated the panel’s enhanced SCCR, component by component, to aid in the equipment’s installation and verification phase during the inspection and approval process.

With the right resources and tools, SCCR compliance can be more easily achieved with minimal to no impact to design layout and costs. Supporting software tools such as the Bussmann series OSCAR 2.1 SCCR analysis software, and no-cost resources, such as the Application Engineering team at Eaton’s Bussmann Division, make solving SCCR challenges easier. For more information or free assistance, contact the Application Engineering team at (855) BUSSMANN or email FuseTech@Eaton.com, or visit www.eaton.com/bussmannseries/sccr.

**AUTHORS’ BIOS**

Joe Graveline is senior applications engineer with the Bussmann Division of Eaton. Joe has over 25 years of experience in the field of electrical design, automation, and application sales support. He provides application support and product information on a wide variety of products made by Bussmann to industry professionals including sales channel partners, consulting engineers, OEMs, designers, specifiers and consumers. He also coordinates training for Bussmann series product distributors, OEMs and consulting engineers. Joe has previously held positions with ABB and Mitsubishi Electric and is a member of NFPA and IAEI.

Erik Barnes is the Marketing Manager for the Bussmann Division of Eaton. He has worked for Eaton for 14 years in several roles with an electrical application focus. Erik has written numerous application papers and led initiatives to create innovative application tools such as SCCR Protection Suite, Selective Coordination Designer 1.0 and others.