Special Considerations When Analyzing Arc Flash Hazard in Systems With Rotary Uninterruptible Power Supply Module

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This **White Paper** describes how Rotary Uninterruptible Power Supply (RUPS) controls can reduce the calculated arc flash hazard.

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Special Considerations When Analyzing Arc Flash Hazard In Systems With Rotary Uninterruptible Power Supply Modules

Overview

Rotary Uninterruptible Power Supply (RUPS) modules are technologically complex. Calculating arc flash hazard on systems containing this equipment requires special attention to the RUPS controls. Otherwise, the arc flash calculations could result in erroneously high values.
An arc flash hazard is a dangerous condition associated with the release of energy caused by an electric arc. To evaluate the arc flash hazard and to determine the personal protective equipment (PPE) necessary to enter the arc flash hazard zone, the engineer performs calculations to determine the incident energy buildup. RUPS modules contribute to upstream faults due to the synchronous motor/generator and flywheel, so their contribution should be included in the incident energy calculation.

The following manufacturer's data is necessary to adequately model the RUPS fault contribution:

1. Generator Technical Data (kW, kVA, V, pf, X", X', X, X2, X_0, t", t', t_a)
2. RUPS Module Choke Specifications (A, X_a, X_b, X_c)
3. Generator Short Circuit Decrement Curve
4. System Sequence of Operations
5. System Configuration (Parallel Redundant, Isolated Redundant, Isolated Parallel, etc)
6. Type of RUPS (Electrically or Mechanically Coupled)

For the purpose of this white paper, CCG developed a model using EasyPower software to analyze an electrically coupled HITEC Diesel RUPS (see fig.1). From the manufacturer's sequence of operation and system configuration, it was determined that the following modes of operation (MO) be included in the calculation of the worst case arc flash levels:

MO-1. RUPS System on Utility: Fault contribution from Utility and RUPS.
MO-2. RUPS System in Maintenance Bypass: Fault contribution from Utility only.
MO-3. RUPS System on Diesel: Fault contribution from RUPS only (Loss of Utility).

The RUPS input breaker (Q1) is usually located in a main switchboard, shown in this example as MSD-A. This breaker is set per the manufacturer recommendations to protect the RUPS from faults coming from the utility source. The MSD-A main breaker (Q7) is set to protect the MSD-A bus and to coordinate with downstream breakers.

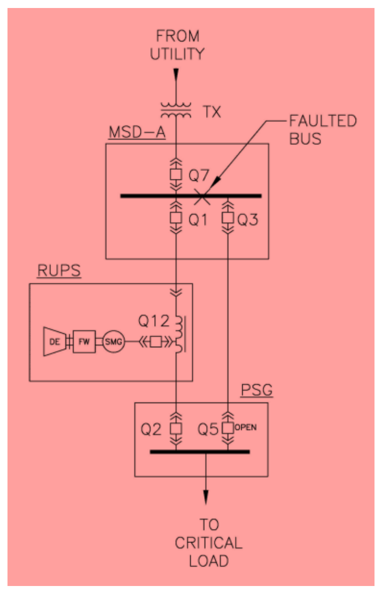

Figure 1

The following tables demonstrate the importance of considering the impact that RUPS Controls have on the arc flash hazard calculation. The model was first evaluated without RUPS Controls and then with RUPS Controls.

ARC Flash Analysis @ Msd-A Without Rups Contols

The Utility contribution is considered in the arc flash calculation until Q7 opens at 0.435 seconds after the initiation of the fault. The RUPS contribution is also considered until Q1 opens after 25.994 seconds.

The following are the analysis results:

MO	Arc Fault Bus	Upstream Trip Device*	Bolted Fault (kA)	Arc Fault (kA)	Trip Time (sec)	Arc Time (sec)	Arc Flash Boundary (inches)	Work Dist (inches)	Incident Energy (cal/cm2)	Required PPE Class
1	MSD-A	Q1	36.058	18.32	25.994	2**	419.3	18	123.9	DANGER
2	MSD-A	Q7	29.122	13.039	0.435	0.435	115.9	18	18.6	#3
3	MSD-A	Q1	6.995	4.676	25.994	2**	153.9	18	28.3	#4

* This column shows the last protection device to trip.

** A two-second time limit is set per IEEE 1584-2002 Annex B.1.2, which states: “It is likely that a person exposed to arc flash will move away quickly (less than two seconds) if it is physically possible.”

Based on these results, no PPE is available to safely work while MSD-A is energized for MO-1. This dangerous condition arises because it takes too long for Q1 to interrupt the fault contribution from the RUPS. This breaker setting cannot be adjusted to open faster because the settings are chosen in such a way that it will not obstruct the RUPS functions.

Arc Flash Analysis @ Msd-A With Rups Contols

The RUPS Controls have several features, which can change the system MO. One of these features is to signal Q1 to open after 150 milliseconds of an out-of-tolerance input. As a consequence, the RUPS contributes to the bus fault for a much shorter duration and this means less incident energy.

To be able to model this feature, we introduced a relay, identified below as CONTROL, which acts like the RUPS controls. This relay has an instantaneous pick up with a delay of 150 milliseconds and it is used to open Q1. This action matches field observations during actual RUPS installations.

The following are the analysis results:

MO	Arc Fault Bus	Upstream Trip Device*	Bolted Fault (kA)	Arc Fault (kA)	Trip Time (sec)	Arc Time (sec)	Arc Flash Boundary (inches)	Work Dist (inches)	Incident Energy (cal/cm2)	Required PPE Class
1	MSD-A	Q7	36.058	15.578	0.435	0.435	132.1	18	22.6	#3
2	MSD-A	Q7	29.122	13.039	0.435	0.435	115.9	18	18.6	#3
3	MSD-A	CONTROL	6.995	4.676	0.150	0.217	34.0	18	3.1	#1

*This column shows the last protection device to trip.

The above results show that the incident energy is actually lower when the RUPS Controls are included in the arc flash analysis.

Conclusion

As systems get more complicated, arc flash analysis has to include not just obvious components, but also control components that reflect a complete RUPS module. Ignoring these features may result in arc flash levels that are higher than the actual ones.