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AC & DC Breaker Interrupting Capacity Tutorial as it Relates to Utility Battery Chargers

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Introduction:

The purpose of this paper is to provide some practical guidance and solutions when selecting AIC ratings for circuit breakers used in battery chargers for typical utility applications. In this case we are specifically concerned with the determination related to selecting circuit breaker interrupting capacity ratings for the ac and dc sides of a battery charger. The circuit breaker is often oversized for the application and may exceed the actual needs.

Relevant Definitions:

Fault current – This refers to the current that flows through a device or appliance when a short circuit occurs electrically downstream of the device.

Circuit breaker – Those devices used to protect the input and output of the battery charger from an overcurrent event. These devices are further used as both ac and dc on and off switches.

Fuses – Those devices which protect the input and output of the battery charger from an overcurrent event but do not have the switching capability of a circuit breaker. When fuses are used to protect a device they must be replaced after a fault protection event in order to provide the required protection.

AIC (Amps Interrupting Capacity) – As this relates to a circuit breaker device, states the maximum fault current that a circuit breaker may safely experience without welding the contacts or otherwise causing injury or damage.

SCCR (Short Circuit Current Rating) – Often confused with AIC ratings this refers to the maximum current that may be experienced at the input of a device or appliance without causing injury or damage.

Circuit Breaker Coordination – The process used to evaluate electrical characteristics of circuit breakers (and fuses) used in the circuit from the utility feeder input to the actual appliance. All circuit breakers and fuses in the stream need to be sized and evaluated so as to accommodate their position in the circuit to ensure proper coordination and the desired protection.

Overview:

After determining the battery charger size and all the details such as ac input, dc output, options and alarms one of the added options that can significantly increase the cost of a battery charger is to add higher than required AIC ratings for the input or output circuit breakers. Typically, breakers with higher AIC ratings are selected through either misunderstanding or an overly cautious approach. In order to help simplify this process and make the selection easier we will be referring to both good engineering practices and the most recent edition of the National Electric Code as published by

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NFPA. Please note that this paper is not a substitute for referring to the actual National Electric Code. Further in this explanation we will reference other documents and papers that deal with this issue from related perspectives.

Determining Interrupting Capacity for input AC breakers:
According to Para 110.10, which is a subset of Article 110 of the NEC, it states that a circuit breaker for equipment use must be so sized that it may interrupt a fault level sufficient to accommodate the available current at the line terminals. That said the methods for applying overcurrent protection to devices and appliances is more clearly stated in Article 240 of the NEC. This section of the NEC specifically discusses the general requirements for overcurrent protection in devices whose voltages do not exceed 1000 volts. There is a further definition in this section that separates devices of 800Amps or less from those over 800 Amps. As such we will limit our presentation to devices that are less than 1000 volts and 800Amps or less.

When considering a fault current it is important to note that the fault current from the feed to the appliance diminishes based on the various components along the path. By referring to the UL 508 standard you can determine what UL claims about AIC ratings for a feeder through panel to appliance.

Typical Panel AIC Rating Example:
Typically, if you trace a circuit from feeder, through the wire sizes, various lugs and connectors, other circuit breakers etc. it is realistic that the AIC at the feeder will be much larger than that at the appliance. When looking at a large 3 phase distribution panel with a 480VAC input it is typically assumed that the fault at the feed will be 65kAIC. Moving further down that circuit when you pass through the main panel breaker and then the branch breakers the typical AIC rating will drop to about 22kAIC. The typical AIC requirement drops to about 10kAIC on the load side of the distribution breaker. Add one more appliance breaker and your exposure drops to less than 5kAIC. Therefore if the appliance experiences a fault, the maximum possible let through current it would experience at the appliance input would be less than 5kAIC. Typically, in a distribution circuit, this is the location electrically where the battery charger would appear.

Based on the above typical example it would be unreasonable to provide a medium or high AIC rated breaker for even the largest of chargers unless the charger was actually connected directly to the feeder and had no distribution breaker panel between its input and the feeder. Further and most notable if the upstream distribution breaker accommodated the fault current there is no reason to require a downstream beaker to also accommodate the same fault. In order to ensure that your installation is in compliance verify the following:

- First, check to see what the distribution panel curves are. These are available from the panel manufacturer. If the panel's branch circuits follow the above example than you are protected with the standard ac circuit breaker.

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- Second, check the breaker feeding the charger ac circuit breaker. This is the breaker that needs to protect the appliance from a fault. The appliance or charger ac circuit breaker is only protecting the charger from a fault that occurs on the load side of that breaker.

Determining the AIC Rating for the charger's DC output circuit breaker:

There is little standardized formal guidance about how to deal with sizing a dc circuit breaker related to interrupting capacity. Typically, when a battery is in the circuit it is assumed that the battery would produce the largest fault current. Further in the case of a battery it is assumed that the short circuit rating of the battery and the interrupting capacity requirement would be the same. In other words, the maximum current that could be achieved from the battery during a fault equals the battery's short circuit rating.

Assuming this is the criteria to be used to determine the charger's dc circuit breaker's required AIC rating several factors are used to determine this value. Typically, we have seen a rule of thumb that indicates roughly a current equal to about 10 times the battery's AH rating would determine the battery's short circuit rating. This would provide a good guess but really does not answer the actual question.

The best way to determine a battery's contribution to a short is to simply request that information from the battery manufacturer. (You could calculate it yourself but I like to use published data since it is readily available). One sample manufacturer I used as an example lists this information in their literature. I will express this in terms of AH rating as it relates to a typical flooded lead acid battery.

Nominal AH rating	Internal Resistance in Milliohms	Short Circuit Current Expected
50	3.730	540
100	1.895	1060
150	1.285	1560
200	0.980	2040

Therefore if using any of the above batteries it is a simple decision that the standard 5kAIC dc circuit breaker would be adequate in all cases.

Other charger dc circuit breaker AIC considerations:

Some additional considerations however would include calculating the anticipated current from the battery, rather than just assuming that the battery's short circuit capability represents the current contribution. If you do this you would end up with our standard AIC rating for the dc breaker almost every time!

A few basics about the charger,

The charger primarily sources the battery; the battery is not supplying power to the charger. *(The charger does draw a small amount of current from the battery but that is not through a circuit that could command the full short circuit of the battery.)* When the charger is operating the battery is the load and the charger is the source. The charger's available current in our case would be 110% of

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rating, or a maximum of 1,100Amps for a 1,000Amp charger. Therefore, our standard dc breakers would be adequate to accommodate a fault from the battery or load side.

If the charger is de-energized, the current required by the charger would be based on the charger's load to the battery. Since the charger's SCR's are not triggered, the only current required by the charger would be to energize the control electronics. The charger control electronics typically require less than 0.5 amperes which is negligible in most cases compared to the system load the battery is required to support.

In Summary:
Higher AIC rated breakers add cost that could be detrimental to the project. From a technical standpoint using higher than required AIC rated breakers neithers causes any detrimental issues nor provides any advantages either. The idea however is to provide what is required and to understand the difference.

Note that in most cases it is not necessary to increase the AIC rating beyond what we would offer as standard. That said, I would not consider offering anything other than a standard AIC rated breaker sunless they are specifically requested.

References:

a) National Electric Code – 2014, NFPA, Quincy, MA
b) Handbook of Batteries – D. Linden & T. Reddy, 3rd Edition, McGraw Hill
c) UL1066-1997, Northbrook, IL, - UL