Connecting to Thermal Batteries

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Abstract

Through the years the emphasis in thermal battery improvement has been focused on materials and processes. Little attention has been paid to exactly how the electrical connections are made to the battery. Reserve batteries can be particularly difficult to verify installation electrically due to the absence of voltage at the terminals. However, the right mechanical interface can error proof the electrical connections. Certain interconnect methods are prone to damage during handling and may actually compromise battery integrity during installation. In addition to improved reliability, an optimized interconnect design can result in more space for active materials.

This paper will discuss the various interconnect methods EaglePicher has used on thermal batteries and their associated benefits and drawbacks over a range of criteria that includes system installation.

Keywords

Thermal Batteries; D-Subminiature; MIL-DTL-38999; Terminal; Flex Circuit; Error Proofing

The Problem

Power sources require connections. As many changes have come about in thermal battery materials and modeling little attention seems to have been paid to the interface with the rest of the system as little change has been made over the last twenty years.

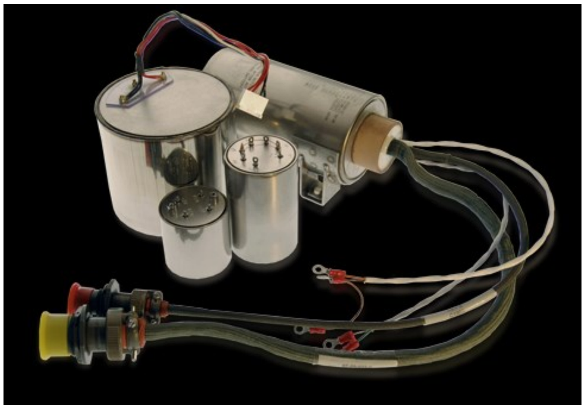

Figure 1: A collection of EaglePicher batteries showing different connection methods.

Connecting to a thermal battery requires a system that is reliable and can endure the heat dissipated by the battery during activation. Another complication, and perhaps the greatest one, is that, unlike other components, the quality of the connection once completed cannot be verified by a simple continuity test. Just as important, is verifying the proper polarity of the connection. Over the years various tests have been attempted to validate thermal battery polarity with mixed results. Without a voltage present at installation, connection validation must be made mechanically as it cannot be validated electrically. At the same time, the connection method needs to protect the adjacent feature that ensures the long shelf life inherent to thermal batteries: the glass to metal seals. There are several options that have been tried;

some with good history, but others that may need to be left behind.

Flattened and Pierced Terminals

Spend any time with thermal batteries and you have most likely experienced flattened and pierced terminals. As perhaps the lowest cost solution, they definitely have an appeal. However, they require a trained technician to install. Unfortunately, mis-wiring can be an incredibly common issue. Verification can be performed via shorts testing. Visual inspection is also an option, especially if unique wire colors are used. However, unique wire colors complicate material procurement. The increased complexity of supplying multiple wire colors can make this option less viable.

Threaded Terminals

The use of threaded terminals has been preferred for some programs. The mating harness will utilize MS25036 or similar terminal lugs installed with the appropriate nut and washer. The popularity of this option has always been a mystery. The most delicate feature of a thermal battery is the glass to metal seal. Threaded terminals call for the terminal lug to be torqued in place to make sure the connection is permanent. If not performed carefully there is the opportunity to twist the terminal in the seal thereby compromising the very seal that is key to a battery's long shelf life. One of the main advantages is that this method does not require certified solder technicians to install. Perhaps it is this very reason the threaded terminals seem to be very popular with first time thermal battery customers. An asymmetrical terminal arrangement and/or different terminal sizes can be an error proofing approach if the mating lugs are constrained in a geometry that can only be installed properly.

Wired Pig Tail

Another approach that has not been incredibly common is the attachment of a short harness that is attached to the battery prior to delivery. An advantage here is for applications where the battery is installed in a difficult to reach area the short harness can move the connection to a location where a positive connection can be made and inspected. A wide range of connection types can be incorporated at the mating end of the harness: D38999, D-subminiature, terminal lugs and possibly even commercial "front release" style connectors. In these designs the battery itself typically uses flattened and pierced terminals. Something to consider is total manufacturing lead time. If a manufacturer is being engaged to fabricate a wiring harness it may be more practical for the harness to terminate at the battery instead of only near it. Depending on the complexity of the interface, it can take many weeks to install small harnesses after battery assembly. Unfortunately, any method that uses discreet terminals is prone to the same unverifiable continuity and polarity issues.

Connector Style Battery Header

A solution that is becoming more popular is the use of integral connector style battery headers. Initially almost exclusively D38999 "round" style connectors were used, but now D-subminiature styles have been incorporated. In contrast to wiring design standards that require socket contacts on power sources these have nearly universally made use of pin style contacts. This is due to the difficulty of obtaining an hermetic seal with sockets as well as the potential for leak test errors. Polarity features in the design of the connectors ensure proper connection at the next assembly. Also, there is no need for time consuming post assembly of attaching the harness either for shipment or for Lot Acceptance Testing as the electrical interface is ready as soon as the battery is completed.

What may dissuade potential customers from connector style headers could be the additional costs. However, a thorough cost analyses could determine the added header costs are offset by reduced labor and lead time. The other disadvantages of connector style headers have more to do with the specifics of the implementation. For instance, it has been the author's experience that the friction fit of the D-subminiature series wears relatively quickly. As the jackposts can be tedious to engage they are not always fully mated. On the other hand, D38999 connectors are relatively simple and mate easily. The required color bands provide yet another error proofing to validate a complete connection.

Use of D38999 style headers is also not without issues. However, this can mainly be overcome by some simple selections. The use of connectors with small (20 awg and 22 awg) contacts can be somewhat delicate with pins getting bent during handling and installation. As the batteries tend to be one of the pricier components in these systems a better choice can be made. Batteries that use larger contacts (16 awg and 12 awg) have proven to be more robust as these designs are rarely, if ever, returned for bent contacts.

Flex Harness

With the primary drawback being the lead time to design and the quantity sensitivity procurement the flex harness has some definite advantages. This is especially pertinent in limited volume next assemblies. Here again, the use of asymmetric layouts provides mechanical error proofing for the electrical continuity and polarity. Also, flex harnesses require skilled technicians to solder the connections. Unfortunately, the most common defect experienced is the overlooking of a solder connection.

Figure 2: Soldered flex harness on a Thermal Battery.

Application Specific Solutions

There are times the existing solutions do not meet the requirements. EaglePicher has at times developed unique solutions. In a D38999 connector the outer shell is either threaded or uses a bayonet pin to engage the inner contacts of the mating connector. An alternate is to have a central threaded feature surrounded by contacts. Engaging the threads mates the contacts. Once again, asymmetric geometry is critical to making the correct connections. To be compatible in the application it was designed for the other end makes use of a common D-Subminiature connector.

Figure 3: Custom solution with threaded stud surrounded by contacts.

Conclusion

As has been presented here there are several options for making connections to thermal batteries. The cost and benefit analysis of these solution may also hinge on the particular program's phase [1]. It has been the author's observation that programs tend to hold to the first solution utilized and may overlook opportunities for improvement.

Acknowledgement

The unique interconnect described in Application Specific Solutions was designed and developed by long-time EaglePicher employee Romeo Saltat.

References

[1] Bhakta, D. *et al. Alternatives to Custom Thermal Batteries* 40th Power Sources Conference, Paper 30.5, 2002.