STORM POWER COMPONENTS

Applications Note

Busbar Design Considerations for Mitigating Vibration, Shock and Expansion

As a wise old engineer once said, "nothing is perfectly flat". In a similar sense, from a vibration, shock, and expansion perspective, "nothing is perfectly still." No matter how small, there will always be some movement in every situation.

From a designer's standpoint, dealing with inevitable movement is a two-step process.

- Step one is to understand the "budget" for movement by determining how much will result in either failure of the product being designed or the system it goes into.
- Step two is to incorporate mitigation methods that will bring vibration, shock, and expansion within the allowable parameters, while also managing the cost of mitigation to meet overall business objectives.

This article explores the key considerations for both assessing the sources of vibration, shock and expansion and designing appropriate mitigation methods to avoid exceeding required limits.

Understanding Characteristics of Vibration, Shock and Expansion

From a busbar design standpoint, one of the first considerations is the nature of the forces being experienced by the busbar and its surrounding system.

For example, are they operational or non-operational? Designing a busbar to survive transport and installation is very different than designing it to survive as part of a critical system that will be launched into space. Or designing for naval shipboard deployments could subject the busbar and system to massive shock forces from enemy shells hitting the hull.

The frequency and constancy of the forces are also very important. Accommodating some flex for movement to position and connect the busbar one time is very different than designing a busbar for constant vibration at varying intervals and frequencies in an electric vehicle, wind turbine, or aircraft.

Another related source of shock and expansion involves whether the system will be powered up and down frequently, which can induce surges of stress in the busbar.

One very important factor that is sometimes overlooked is the size of the busbars. Storm Power produces some of the largest laminated busbars in the world and, at lengths up to 20 feet or more, the potential for internally generated vibration and expansion stresses becomes a very important consideration. This can require advanced tiedown strategies, which will be discussed later.

Conforming to Mandated Requirements and Specifications

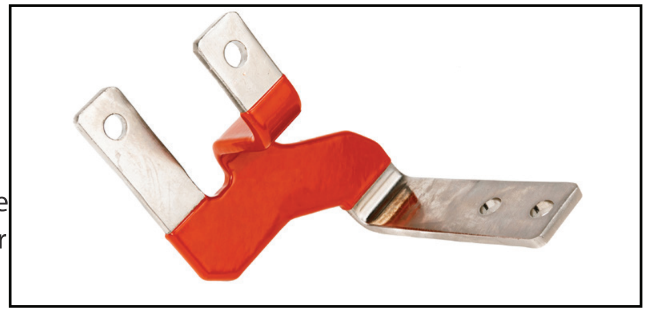
Of course, designers also need to consider the various regulatory requirements, quality specs, testing standards, such as AS9100:D and ISO 9001:2015, and customer specific mandates that need to be complied with for design acceptance. For example, many companies rely on and require compliance with MIL-STD-810 when it comes to shock and vibration because it is comprehensive, detailed and widely accepted. MIL-STD-810 is maintained by a Tri-Service partnership that includes the United States Air Force, Army, and Navy, and details a battery of Test Methods for the entire range of environmental conditions that could be encountered in military deployment of systems and components.

While MIL-STD-810 is not a commercial standard, most companies in highly critical non-military arenas, such as aerospace, have adopted it. However, the key factor is to confirm that busbar suppliers actually are testing their designs to meet the standard, as Storm Power consistently does through both internal and third-party testing using certified methods and labs.

Design Methodologies to Mitigate Vibration, Shock and Expansion

Mitigation strategies fall into a variety of categories including:

- Optimizing geometric design of busbars.
- Incorporating flexible elements, such as flexbraid.
- Designing interconnects to accommodate stress factors.
- Locating mounting points to minimize and manage stress points.
- Minimizing expansion mismatches between different materials.

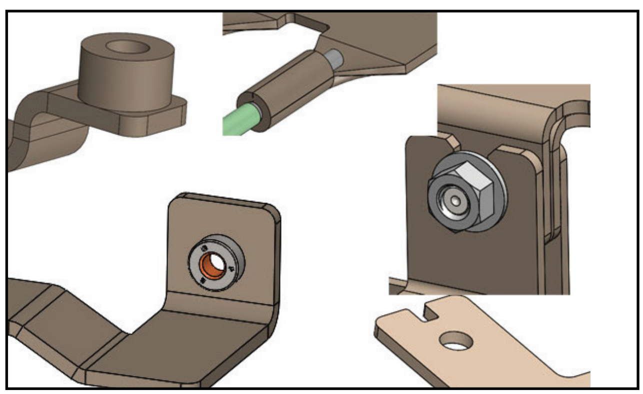


Geometric Design Considerations:

A fundamental mitigation approach is tailoring the busbar's physical design to manage stresses from expansion and/or vibration. For example, something as simple as adding a bend or "hump" form in the busbar can act as a shock absorber that diverts stress away from other sensitive areas, such as connection points.

Incorporating Flexible Elements:

Another effective method to combat stress is the use of flexible elements within the busbar design. For example, flexbraids can bend and twist without breaking or losing their conductivity. This flexibility is crucial in applications where components may move or vibrate, as it allows for a reliable electrical connection without the risk of fatigue or damage.



Designing Interconnects to Accommodate Stress:

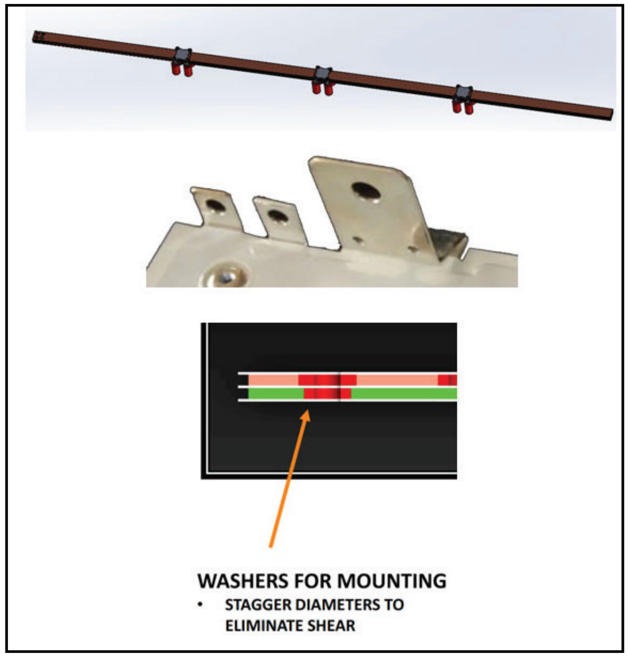
For any busbar, the points of interconnection are both critical to proper electrical functioning and are key areas where stresses occur. Designers must understand both the busbar level issues and the system level connection requirements. While there are a wide range of connection methods available, such as tabs, terminals, crimping, bolts, standoffs, etc., the designer needs to choose the optimal method that not only withstands vibration but also fits the size, space, and configuration issues required by the system design.

Locating & Designing Mounting Points to Manage Stress:

Mounting points are another critical factor in overall management of vibration and stress. The distance between tie-down points and the mounting designs can be keys to success or failure of the busbar itself.

As makers of the longest laminated busbars in the world, Storm Power engineers are at the leading edge of understanding how mounting points can help reduce stress in key areas by allowing some movement in others. For example, designers can use round holes at the endpoints to minimize movement but use slotted holes at mid-points to allow movement and stress release.

Also, when creating tie-down points that pass through laminated busbars, it is important to stagger the location and diameter of holes and washer to eliminate the potential for pull-through that can damage the layers' electrical integrity. When appropriate, adding clamps to the tie-down points can also increase resistance to stress.



Minimizing Expansion Mismatches Between Different Materials

Finally, busbar designers need to consider how the use of different materials can impact stress factors. For example, if copper termination points on the busbar are bolted to aluminum connector points in the system, the differences between material expansion can induce additional stresses, since aluminum is more volatile than copper. On the other hand, copper and stainless steel have more similar expansion characteristics so the material-induced stresses would be lessened.

Summary

As can be seen, the issues of managing vibration, shock, and expansion for busbar designs run the gamut from relatively obvious to quite complex. It's not just a single factor that can make the difference, but many related issues that interact with each other to create stresses and also to mitigate them. Typically, a comprehensive application-specific approach is needed, where the busbar experts take the time to really understand the system level context and requirements before deciding on the best approach for mitigating stresses while also achieving the functional and cost objectives.

Proactive measures to avoid and mitigate stresses are key to overall success of the end products and systems, especially those that are deployed in harsh environments, or in some cases such as aerospace may be sent on years long missions where no human intervention for repair is possible.

At Storm Power Components, our engineering teams have decades of experience with designing complex busbars that have proven reliable in the most demanding of deployments. This is because we always start with the end goal of the system in mind and then bring our knowledge, experience and creativity together in a holistic manner to achieve those goals while cost-effectively managing potential stresses from vibration, shock and expansion.