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In-skid anti-vibration mount (AVM)

White Paper

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Mechanical vibration and shock are present, to varying degrees, in virtually all locations where equipment and people function. Some vibrations are desirable, while others are not. Excessive vibrations in equipment can not only damage the equipment itself but also decrease functionality. In the case of generator sets, excessive vibration can cause disruption of power delivery.

Undesirable vibrations are typically those resulting in unwanted transmitted forces to adjoining structures and noise. There are various methods for isolating and reducing (if not eliminating) these vibrations, including:

- The equipment or source of vibration
- The support structure to which the transmitted vibration is to be minimized
- The resilient member which is interposed between the equipment and the support structure to absorb the vibration

The major source of vibration in a combustion engine driven generator set is the engine itself, which will shake at whole and half multiples of the engine speed due to the back and forth motion of the pistons and the varying cylinder pressures. Vibration isolators for generator sets are commonly categorized as follows:

Isolators based on type of construction of the mount itself

Elastomeric/rubber isolators: These solutions basically use an elastomer to absorb the vibration. They are well adapted for use in shock isolators because of their high energy storage capacity.

Opinions vary widely as to the maximum permissible static strain. Conservatively speaking, elastomers should not be continuously strained more than 10 to 15% in compression, and even lower in shear. This rule of thumb is often used to determine the maximum load capacity of a given isolator.

Rubber mounts typically have better damping capabilities than spring mounts. As such, the force transmitted through a rubber mount is higher, but the greater damping reduces resonant motions resulting in lower alternating displacements during transient events. Rubber mounts can also

be made in a wide variety of shapes, allowing their stiffness characteristics to be tailored for a particular application.

A common concern with rubber mounts is the effect of temperature on the stiffness of the rubber. Although it is true that, at elevated temperatures, all types of rubber will undergo degradation reactions, these temperatures are well beyond the operating conditions of a generator set. Typical operating conditions for neoprene ranges from -40 to 225 F, with a variance in stiffness of around 15-20%, so the changes in isolation capacity are minimal.

Spring Isolator: This uses metal springs to absorb vibration. Metal spring vibration isolators are required for mounting generator sets that do not include integral vibration isolators. These typically provide vibration isolation of over 95%, and are widely used.

Isolators based on location of the mounts

Between the equipment and the skid: These are referred to as 'In-skid' vibration isolators or 'in-skid' anti-vibration mounts (AVMs). Because of their location in between the in-skid and the generator set, AVMs offer vibration isolation to the skid as well.

That translates to lesser vibration transmitted to the skid and, therefore, to the components mounted on the skid. The benefits of in-skid AVMs include lesser fatigue induced in these components, and lower noise to legibility of displays if and when they are mounted off of the skid. In-skid AVMs are typically comprised of elastomeric/rubber isolators.

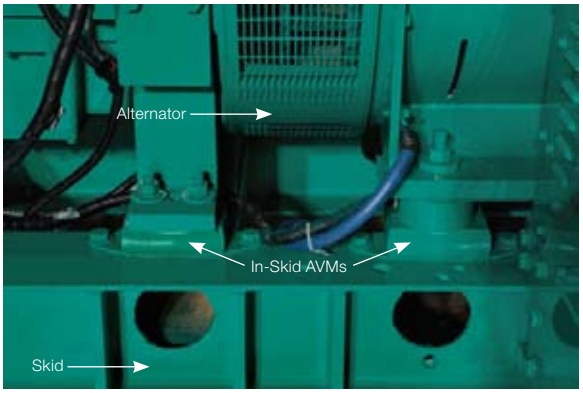

Figure 1: In-skid anti-vibration mounts (AVMs) are located between the components and the skid.

Between the skid and the foundation: These are meant for isolation of the transmitted vibrations from the generator set as a whole unit to the foundation. Depending on the need for vibration isolation and other relevant criterion, either rubber or steel spring isolators are used.

Most applications in the United States use steel springs for such a configuration. It is worth noting that spring isolators sit between the skid/chassis (entire generator set) and the mounting pad. The upside to this situation is that the engine and alternator are solidly mounted to the skid. The connection between these two components therefore gets a good amount of strength as both components are solidly bolted to the skid.

On the downside, there is absolutely no reduction in the force transmitted from the engine and alternator to the skid and any component mounted on the skid (e.g. the controls pedestal) will experience the same levels of vibration as the engine and alternator.

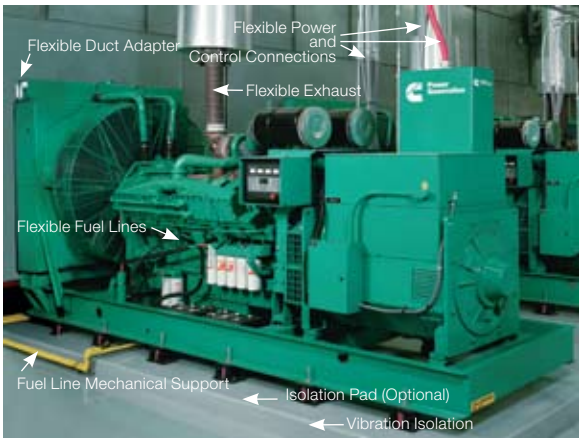

Figure 2: A typical installation of a generator set using under skid spring vibration isolators.

Advantages of in-skid AVMs:

Despite the higher vibration isolation offered by spring isolators, in-skid vibration mounts do offer some significant advantages:

Vibration isolation characteristics: Rubber mounts tend to be stiffer, and when no other resonant behaviors are present, rubber mounts tend to offer 85% vibration isolation.

Seismic compliance: Requirements for seismic certification place part of the responsibility on the product itself, and part on installation. In simpler terms, a seismic certified product must have assurance of a seismic installation, which, in the case of under-skid isolators, is achieved using restrained isolators.

Usage of in-skid AVMs: Allows for the product to be seismic certified in it's entirety at the factory which could be considered a reduction in risk of mounting non-seismic isolators.

Figure 3 shows a FAIL SAFE in-skid anti-vibration mount. It is basically a captive mount, which would prevent the isolator from being dislodged from its mounting position. This rubber mount would sit on top of the skid with the stud going all the way through. A nut is placed on this stud on the other side of the skid which prevents the mount from being lifted off of its seating position. A clearance between this nut and the underside of the side ensures that there is no metal to metal contact between the stud and the skid during normal operation.

IN-SKID ANTI-VIBRATION MOUNT FAIL SAFE

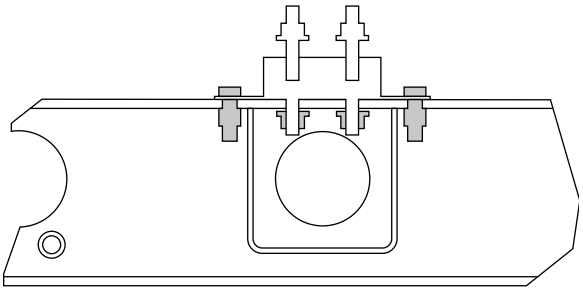

Figure 3: A fail safe feature on the in-skid AVM's make them captive mounts enabling them to comply with seismic codes.

Ease of installation: Generator sets with in-skid isolators can be placed directly on level ground at the installation site, making installation quicker and easier. Regardless of where the generator set is installed, shimming may be necessary so that the generator set sits flat on the ground. "Shims" may be either thin steel plates or very stiff thin rubber sheets. This "leveling" process is easier to do when there is no soft isolation between the skid base and the foundation. A shim would also be effective in avoiding water accumulation, and for addressing any concerns about rust formation arising from the entire skid coming in direct contact with the mounting pad.

Costs: This is a two fold benefit. First, rubber isolators offer a cost advantage compared to spring isolators.

Secondly, since the generator set with an in-skid isolator can be mounted directly on the concrete, it reduces installation time, as well as the parts required.

Product integrity from the factory: A ready-to-install product rolls off the assembly line, resulting in fewer hassles at job sites. This would be especially true in cases where the contractor is responsible of choosing and sourcing spring isolators for generator sets with out in-skid AVMs.

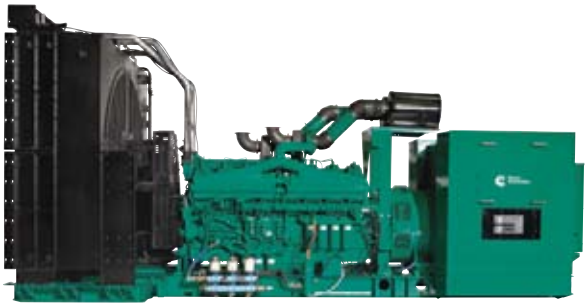

Figure 4: The DQGAF generator set.

Isolator selection criteria

If the in-skid AVM is not available from the generator set manufacturer, under-skid AVMs have to be selected properly to meet the seismic or building requirements. Generally speaking, the following considerations play an important role in the selection of an AVM:

Weight, size, and center of fravity of the generator set to be isolated: The weight of the unit and location of center of gravity will have a direct bearing on selecting an isolator with the correct load capacity, and in determining if the same capacity isolators are applicable at all mounting locations.

Types of dynamic disturbances to be isolated: In order to make an educated selection or design of a vibration isolator, this type of information must be defined.

Allowable system response: This can be expressed in terms of the vibration level versus frequency or the maximum shock loading which the generator set can endure without malfunctioning or breaking.

Ambient environment: The environment in which the generator set is to be used is very important to the selection of an isolator. Temperature variation and

About the author

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Aniruddha has an M.S. in Automotive Engineering from Lawrence Technological University (Southfield, MI) and a B.S. in Mechanical Engineering from University of Pune (India). He has held positions in research & development, market research, engineering, and product development with various automotive companies.

other environmental factors, such as humidity and atmospheric pressure, can cause a variation in the performance of the isolator:

Service life: The length of time for which an isolator is expected to function effectively is another strong determining factor in the selection of the isolator. Vibration isolators may have a finite life depending on the loads imposed on them. The prediction of the life of a vibration isolator depends on the distribution of loads along the generator set structure.

Target vibration isolation: Sometimes the permissible amount of transmitted vibration, or a certain percentage of vibration isolation, will require a particular type of vibration isolator. Such limits tend to push towards the selection of a spring isolator as spring isolators offer greater vibration isolation than rubber mounts if properly applied. Proper mount selection is necessary to avoid the scenario where two mounting systems interact with each other. A factory solution will typically address this concern.

Isolators are available in various stiffness and load ratings. Isolators with low stiffness values (if all other factors remain constant) will generally lower the natural frequency of the system, offering better isolation. Isolators with higher stiffness values (if all other factors remain constant) will generally raise the natural frequency of the system.

Choosing improper isolators may result in higher vibration levels at each component of the generator set and the natural frequencies of the isolators must be tuned according to the weight and vibration characteristics of the generator set.

Conclusion

Engine driven generator sets produce vibrations, just as most machinery with moving and rotating parts. The transmission of these vibrations should me minimized to avoid nuisance from noise and vibration, as well as physical damage to the generator set itself and the structure supporting the generator set.

More importantly, reducing vibration helps the generator set to achieve its main purpose, which is to produce reliable electric power. Such vibration isolation can be achieved by the use of anti-vibration mounts. Consulting and specifying engineers can be valuable in selecting the type of vibration isolation system based on a sound knowledge of the different types of AVMs on the market. They will help to explain differences in noise, vibration and harshness (known in the industry as NVH), as well curtailment and transmissions between the different AVMs.

The two types of AVMs widely used are:

- In-skid rubber mounts
- Under skid springs

The term ‘efficiency’ may not be the right way to differentiate between the respective performances of these systems. Having said that, and assuming that no other resonant behaviors are present, rubber mounts tend to offer 85% vibration isolation whereas spring mounts typically offer over 95% vibration isolation.

Both types of vibration mounts offer pros and cons in terms of ease of installation, product integrity and levels of isolation offered.

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