Flexible interconnections for generator set AC power cables and conduits

> White paper

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Power Generation

Generator sets vibrate. A seemingly obvious statement, but one with considerable implications in relation to interconnections between the generator set and surrounding structure. Interconnections between a generator set and a building, housing, foundation or other structure must be flexible and able to absorb the vibration movement of the unit. If they are not, they can fail, causing damage, down time for the generator and potential dangers to personnel. Flexible interconnections include mechanical connections such as fuel lines, exhaust pipes and air ducts. They also include electrical connections for power, control, auxiliaries, etc. The purpose of this technical topic is to review and highlight the requirements and importance of flexible connections to generator sets with specific attention to the AC power connections.

In general, designers of installations for, and installers of, generator sets seem cognizant of the need for flexible interconnection points between the generator set and surrounding structures. In practice these interconnections would seem to be designed and installed adequately. A lack of reported problems or failures in this area supports these assertions. It has recently come to the attention of Cummins Power Generation that occasionally AC power connection schemes have not possessed adequate flexibility for the applications. These conditions are primarily notable where generator sets are at higher voltages, i.e. 5 kV and 15 kV, where the cables become quite stiff, or in cases where conduits are believed to be flexible but actually provide little flexibility.

Understanding the issue

Often the engine/alternator combination is mounted to a skid rail using vibration isolators integral to the design. Alternatively, and sometimes in addition to these isolators, spring type isolators are placed between the chassis and the foundation. When there is a sub base fuel tank, the isolators are often placed between the skid and tank. Any of these and other variations are designed to accomplish the same task of isolating vibrations from the structure or foundation and preventing the forces from damaging the generator set equipment. In doing so they all allow movement of the engine/alternator and anything that is attached to it, with respect to the foundation. These movements can be large and visible to the eye or minimal and higher in frequency. In any case, a solid connection between the engine/alternator and the surrounding structure will be subject to the forces of this movement and may break, bend or fatigue over time. If the inadequate connections themselves do not fail, it is possible the forces will be transmitted to generator set components and the condition will manifest itself as a failure of one of them. Even a generator set that is solidly mounted and without isolators can vibrate enough to require flexible interconnections.

FIGURE 1

One of the keys to understanding the subtleties of achieving adequate flexibility is to realize that the vibration movement is three dimensional. Engine firing pulses and rotation of crankshaft and generator rotor, even when balanced, create movement directly or indirectly in three dimensions. This means there is three dimensional movement between generator set components such as the output box and the foundation or structure. Some types of cables, conduits or installation arrangement will absorb movement in two dimensions but not three. FIGURE 1 illustrates this in reference to conduits standing vertically. In the two horizontal dimensions the conduit will move and absorb vibration. Vertically however, vibration movement is in a direction that attempts to compress or stretch along the length of the conduits. This direction of movement often cannot be absorbed. In this case there is a perception of good vibration isolation but this is not correct, resulting in potential failure.

In FIGURE 1, note that the conduit is liquid tight conduit, generally considered somewhat flexible. The pictured installation imposes the compression/stretching forces mentioned earlier, which this conduit cannot absorb. In this case the “stiff” connection between the output box and the concrete translates into movement and stress upon the sheet metal box, contributing to metal fatigue. Due to the stiffness of the HV cables, they also experience the same stresses, and if the conduits were decoupled the cables would experience higher stress levels. These stresses can be transmitted to the cable connection bushings and could lead to serious failure.

Startup or shutdown of a generator set often produces movement that is more exaggerated than the vibration during continuous operation. In this case the amount of movement (dimension) can be more critical than the frequency or short duration. So the flexible connections must have enough movement capability to absorb start and stopping conditions as well as running conditions. To try to put a defined specification on this is impossible from a practical standpoint. Each unit will vary from other designs and from one to the next of the same design. Also the installation design may vary considerably. Unique considerations such as specialized equipment or seismic zone installation may also need to be considered. A good rule of thumb is to include at least one bend in the conduits and cables. The addition of one bend will add the third dimension of movement capability.

Solutions

As mentioned, one solution to assure the ability to absorb in three dimensions is to include at least one bend in flexible conduit and/or cables, within bend limits of the conduit and cable, of course, between the generator set connection enclosure and the first clamping point at the foundation or structure (FIGURE 2). With the addition of only one bend, three dimensional movement is allowed.

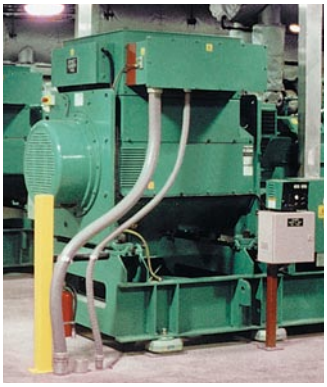

FIGURE 2

A potential solution is to utilize cable trays or wireways, instead of conduit buried in concrete. FIGURE 3 is an example where this type of installation allows vertical movement along with the horizontal flexibility of the sheathed cable itself. Note that in this case, in essence a single bend has been included as the cable leaves the wireway. This bend plus the wireway construction, allows for movement in any dimension. This same approach could apply for bottom cable entry with a wireway beneath. A conduit with a bend in a concrete floor will not provide for this movement because the bend is restricted by the concrete and conduit.

FIGURE 3

Another possible alternative is to utilize a cable of increased flexibility. This type of cable is not allowed in conduit and so requires an additional junction point between the cables leaving the conduits and the generator connection box. An example of such an arrangement is illustrated in FIGURE 4 where flexible

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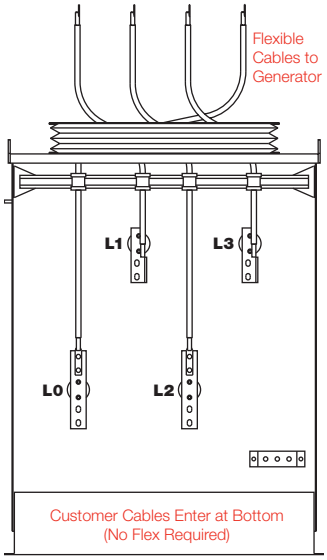

FIGURE 4

leads and bellows absorb vibration movement. (Conduits and associated wiring is not shown).

Summary

Flexible cable connections to generator sets are required to allow for three dimensional vibration movement between the generator set and the foundation or surrounding structure where cables and conduits are secured. Lack of adequate flexibility can result in damage or failure of the cables, conduits and/or terminations; or can result in excessive forces being transferred to other components of the generator set or to the surrounding structure. The presence of at least one bend in flexible conduits or cables between the generator set and the last securing point to surrounding structure will allow for three dimensional movement. Assurance of adequate flexible characteristics of materials used is also key. Always follow electrical codes and other codes applicable to the installation.

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