We often see specifications that call for switchgear "to be suitable for use in seismic zone X", where X may be any number from 0 to 4, depending on the location of the final installation of the switchgear. Unfortunately there is no ANSI standard that defines "suitable for use in seismic zone X". Seismic requirements for nuclear generating station equipment, which do exist in standards, are not stated in terms of seismic zones, but are site specific.

ANSI Standard A58.1-1982, *Minimum Design Loads for Buildings and Other Structures*, gives some guidance for the seismic loading that various items must withstand, using the basic formula:

\[ F_p = Z I C_p W_p \]

where \( F_p \) is the lateral force to be designed for,

\( Z \) is the seismic zone coefficient, which varies from 0.125 for Zone 0 to 1 for Zone 4,

\( I \) is the occupancy factor, which varies from 1 for Category I to 1.5 for Category III,

\( C_p \) is the horizontal force factor, which is 0.3 for all machinery in a building,

and \( W_p \) is the weight of the equipment.

From basic mechanics, Force = Mass x Acceleration. In the above formula, \( F_p \) is a force, \( W_p \) is a weight, which is the product of a mass and the acceleration of gravity, or g. It follows that the product of \( Z \), \( I \) and \( C_p \) is a dimensionless coefficient for g. For a worst case situation, where the switchgear is installed in a critical occupancy in Zone 4, the value of this coefficient is 1 x 1.5 x 0.3, or 0.45. Since seismic testing is performed in terms of acceleration rather than force applied, the test level for a worst case installation should be 0.45 g.

The other aspect of suitability is the performance of the equipment under the specified conditions. Here, we have absolutely no guidance from ANSI standards. Based on past experience and input from various users, Powell has decided that the following are reasonable criteria for suitability:
1) There shall be no structural damage that prevents normal operation of the equipment after the event.

2) No doors or covers shall open during the event.

3) The circuit breakers shall not open or close during the event except on command.

4) The circuit breakers shall not move from the fully connected position during the event.

5) After the event, it shall be possible to open and close the circuit breakers and rack them into and out of the connected position.

6) Primary and control fuses shall remain in their fuse clips.

7) Transformer rollout drawers shall not come open during the event.

8) After the event, primary circuits shall withstand a 27 kV power frequency withstand test (hipot). The value of 27 kV is chosen because it is the power frequency withstand voltage specified for field testing of 15 kV metal-clad switchgear.

About four years ago, Powell had samples of PowlVac® metal-clad switchgear tested for the ability to withstand Zone 4 seismic forces. These samples were single-unit equipments, to give the narrowest structure possible, and had the heaviest circuit breakers installed in the highest positions in which they are ever used. They were therefore worst-case seismic samples.

Based on the requirements of ANSI A58.1-1982, we chose to use 0.45 g as the zero period acceleration (ZPA) value for these tests. The seismic experts at Southwest Research Institute in San Antonio took this value and developed a required response spectrum (RRS) that peaked at about 1.8 g at 3.5 Hz for vertical acceleration and about 1.9 g at 2.5 Hz for horizontal acceleration, with a minimum value of 0.45 g (the ZPA) at frequencies above 32-33 Hz. Full seismic tests were done by Southwest Research Institute at these values of acceleration.

The eight criteria listed on the previous page were used to judge the performance of the equipment under seismic test. In addition, the circuit breakers were successfully closed and tripped on command during the seismic test. Except for a minor problem with the transformer rollout drawer, the equipment performed as required. The rollout drawer fastening system was reinforced, and the equipment performed successfully on retest.
Based on these tests, standard PowlVac® metal-clad switchgear is suitable for use in seismic zones 0, 1 and 2. With the addition of holding clips at the transformer rollout drawers, PowlVac® is suitable for use in zones 3 and 4.

Baldwin Bridger, P.E.
Technical Director