

## SEISMIC QUALIFICATION TESTING OF CLASS I ELECTRIC EQUIPMENT

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## SUMMARY

The safety of nuclear power stations during and following an earthquake is a matter of technical concern to power plant designers and owners and to regulatory agencies, and of emotional concern to some members of the general public. Since the safety of the plant is tied closely to the performance of the Class I electrical equipment, proof of the performance of such equipment has been the subject of much study. The licensing process for nuclear stations requires plant owners (and hence plant and equipment designers) to provide such proof for both normal and abnormal conditions. The design of nuclear power generating stations requires the consideration of many types of possible accident situations in order to ensure that the health and safety of the public is protected from the release of large quantities of radioactive materials. The consideration of earthquake effects is particularly important because the forces can be extremely large and all parts of the power station are affected simultaneously.

Modern dynamic analysis techniques incorporated into digital computer programs have proven to be valuable tools for predicting the response to earthquake excitation of building structures, piping systems, and many types of mechanical equipment. Electrical equipment, however, often consists of a light frame structure supporting flexible racks and panels which contain a variety of components such as transformers, relays, switches and meters. Analytical techniques can be used to determine the adequacy of the basic structure of an electrical equipment cabinet to survive an earthquake, but it is impractical, if not impossible, to determine by analysis whether the electrical components will perform reliably during a seismic event. For this reason, reliance most often is placed upon the use of tests which simulate the earthquake disturbance and during which measurements of performance of the equipment are made.

In the early days of seismic testing, the only method of simulation was that which had been used for many decades for military equipment expected to undergo continuous vibration. The "Continuous Test" applied sine wave acceleration for a period of about 30 seconds at a number of discrete frequencies. Since earthquake motion tends to be random; each frequency component tends to be present for only a very short time. The continuous test was felt to be excessively conservative since it allowed acceleration buildup in less than critically damped structures and occasionally caused fatigue failure. An alternate method was developed called the "Sine Beat Test" which consisted of sine waves at the frequency of interest as in the continuous test but modulated to produce short bursts with the time between each burst long enough to allow the equipment under test to come to rest. The degree of conservatism can be controlled by varying the number of cycles per beat.

In addition to these methods, two others have also been used on occasion. One is momentary input test, which is essentially a decaying sine wave, and the other is the random time-history of an actual earthquake fed into a tape-controlled vibration machine.

All the methods except the last have the deficiency of not exciting more than a single resonance frequency at a time, and hence of possibly not being sufficiently conservative. For this reason the controlling IEEE document<sup>(1)</sup> is currently being rewritten, and it is expected that heavy emphasis will be placed upon random excitation methods in the revised standard. The paper will describe the requirements of the standard and discuss the recommended testing methods.

<sup>(1)</sup> IEEE 344-1971, "Guide for Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations," IEEE, 345 E. 47th St., New York, N.Y. 10017.

