Buckeye Power Sales
Reliable Power Professionals Since 1947

Engine-driven generator systems are designed to provide standby electrical power for a wide range of applications. Many of these applications are defined as critical for life and infrastructure; such applications would include hospitals, communications, data centers, government facilities, airports, power plants, police, and fire stations. The primary power source can go offline for a variety of reasons, including weather and equipment failure. Natural disasters can result in widespread power interruptions to critical infrastructures a modern society relies upon. One particular natural disaster, earthquakes, can result in widespread destruction of the electrical distribution. International Building Codes (IBC) now require generator systems to undergo shake testing to receive a certification of operation in areas prone to earthquakes. This information sheet discusses the operation of a shake-test table, the forces a generator system has to manage without failure during a quake, and areas subject to seismic IBC codes.

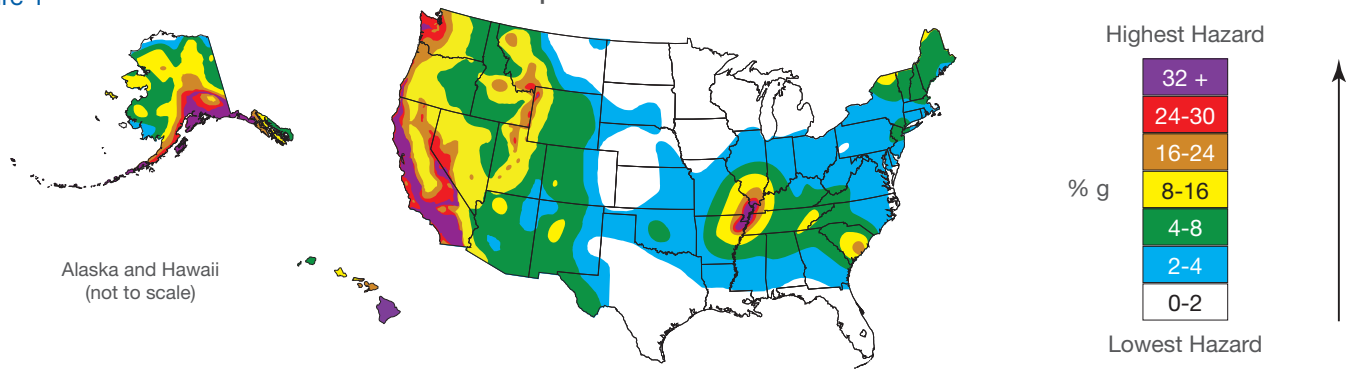
1.0 APPROVED SHAKE TEST FACILITIES:

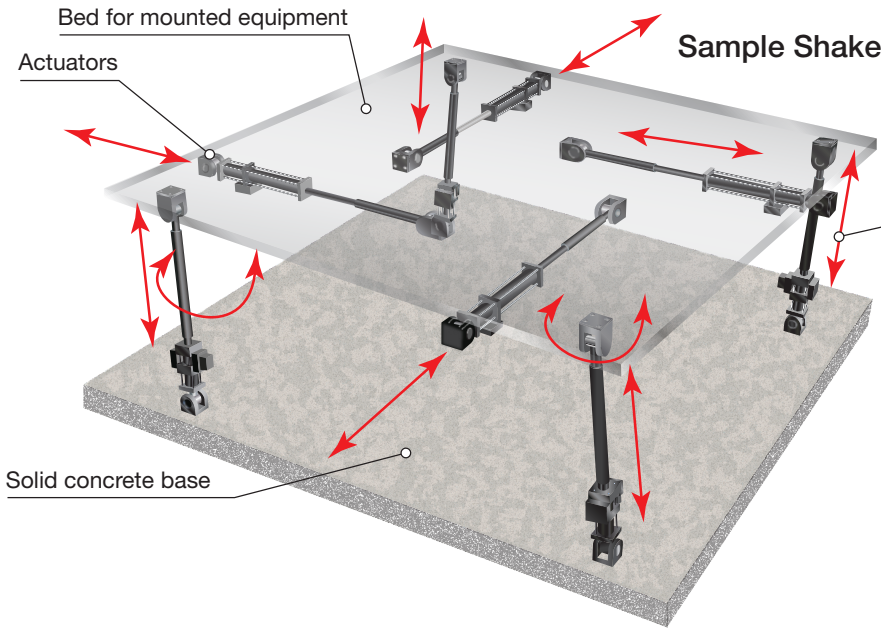
A generator manufacturer must submit their equipment to an approved test facility to receive International Building Code certification for operation in a seismic area. These facilities are equipped with test equipment that can simulate the g-force generators would be subjected to during a seismic event. The generator package is mounted to a Shake Table to simulate the forces the generator could experience during a seismic event.

Seismic Areas and Shake Table Operation

Figure 1

USGS Map of Seismic Hazard in the United States





Sample Shake Table for Simulating Seismic Events

The 8-actuators move-in coordination to simulate the up, down, side, and rotation movements a seismic event will produce.

By digitally mapping known seismic events, the equipment can be tested to minimum specifications set by regulatory bodies. This verifies that equipment can withstand the g-forces an earthquake produces.

Figure 2

1.1 APPROVED TEST FACILITIES:

Various accredited organizations are recognized, both within the US and Internationally, to not only define the specifications equipment/buildings have to be built to, but also to approve a facility's ability to test equipment to the required standards. These include:

- **Non-Profit** - International Accreditation Service, In. (IAS)
  - International Code Council (ICC) generates the International Building Code (IBC).
- **Governmental** - At the National Level, the Department of Energy and local states such as California

1.2 PRINCIPAL ORGANIZATION SETTING CODES FOR OPERATING IN SEISMIC AREAS:

Generally, regulatory bodies and jurisdictions within the US have adopted the IBC codes for equipment and structures located in seismic areas. To be certified for operation in seismic areas, the generator manufacturer's generators must meet Section 1708.5 of the IBC (all versions).

2.0 Seismic Forces a Generator Has to Withstand:

The United States Geological Survey (USGS) has created a Long-term National Hazard Map, ***see Figure 1***. The map shows peak ground accelerations having a 2 percent probability of being exceeded in 50 years for a firm rock site. The map is based on the most recent USGS models for the conterminous U.S. (2018), Hawaii (1998), and Alaska (2007). The models are based on seismicity and fault-slip rates and consider the frequency of earthquakes of various magnitudes. Locally, the hazard may be more significant than shown because site geology may amplify ground motions. ***(Sources/Usage: USGS Public Domain) https://www.usgs.gov/programs/earthquake-hazards/hazards)***

The USGS can set probabilities of the forces equipment will be subjected to from data gathered from prior earthquakes

2.1 G-FORCES GENERATORS EXPERIENCE DURING AN EARTHQUAKE:

Earthquakes are generated as different tectonic plates of the earth's crust rub up against each other. The resultant forces buildings and equipment are subject to vary due to the earthquake's depth, the plate's movement, and the type of ground in a particular area. As the ground moves, g-forces are experienced in several 3-dimensional axes: up, down, and from side to side.

2.2 VARIABLE G-FORCES GENERATORS EXPERIENCE DURING AN EARTHQUAKE DUE TO LOCATION:

Shake Maps are drawn up based on ground level. However, it must be noted that when a generator is mounted on the top of a building, these forces can be amplified significantly.

3.0 HOW SHAKE TABLES SIMULATE G-FORCES GENERATED BY AN EARTHQUAKE:

A shake table is an approved method of simulating the 3-dimensional forces a generator and connected pieces of equipment will experience during an earthquake. During an earthquake, a seismic wave of energy travels through the Earth. The shake table simulates the ground motions of earthquakes.

3.1 SHAKE TABLE OPERATION:

Mechanical devices, called actuators, are connected to the shake table bed. The usual shake table design is for two actuators to shake the table in the horizontal X-axis, then two actuators to shake the table in the horizontal Y-axis, and another two actuators to shake the table in the Z-axis up and down, the table using the actuators can also simulate rotation. The combined effect of moving the actuators in sequence enables the simulation of ground movement produced by an earthquake. ***See Figure 2***.

3.2 RECREATING KNOWN EARTHQUAKE EVENTS:

Geologists have the measuring equipment to record various seismic events. The measurements of known ground movements of actual earthquakes of various sizes on the Richter scale can be digitalized. This digital information can then be fed into the controls of the shake table to simulate the ground movement of known earthquakes of different magnitudes.

3.3 SHAKE LEVELS TO OBTAIN CERTIFICATION:

The IBC codes set certification standards based on recorded and projected ground movements in various seismic areas defined by the USGS.

3.4 USING SHAKE TABLES TO TEST EQUIPMENT:

In addition to using shake tables to obtain IBC certification, manufacturers can test new design criteria for specific materials and/or equipment assemblies. Shake tables have demonstrated that the best way to protect buildings and equipment from earthquakes is to isolate the structures rather than rigidly mount them to the ground.

4.0 MOUNTING A GENERATOR ASSEMBLY TO THE SHAKE TABLE:

To obtain IBC approval, the whole assembly has to be tested. Therefore, all the equipment that is going to be connected to the generator assembly has to be mounted on the shake table. This includes enclosures, mounted controls, and any connected accessories.

4.1 MOUNTING TO THE SHAKE TABLE:

The generator will be mounted to the shake bed with the required vibration isolator mounts used to minimize vibration transmitted to other assemblies. If approved, these will be the specified minimum mounts.

4.2 CONNECTED EQUIPMENT:

As stated, the generator is tested as a complete assembly. This will test all connections, strapping, etc.

To fulfill our commitment to be the leading supplier in the power generation industry, the Buckeye Power Sales team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our Information Sheets are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

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