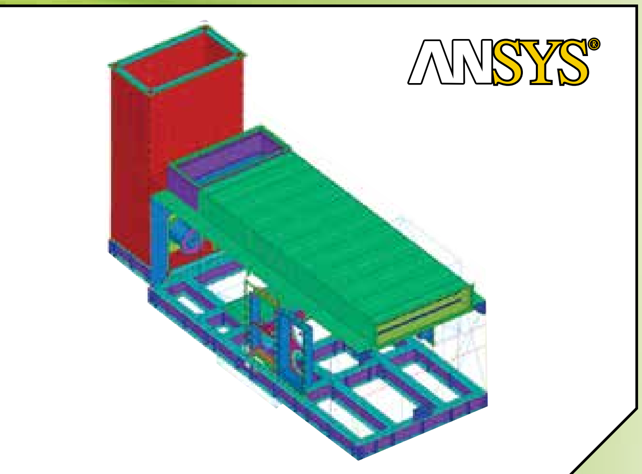

Figure 1. Backup Power System Enclosure and Skid Model

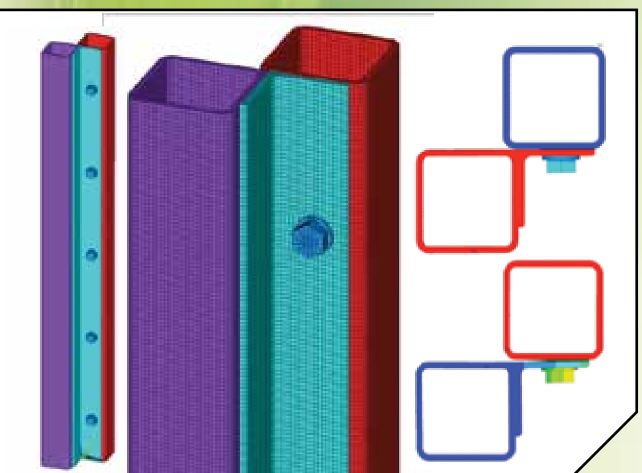

Figure 2. Frame Bolting Flange Model and Unit Load Displacement Results

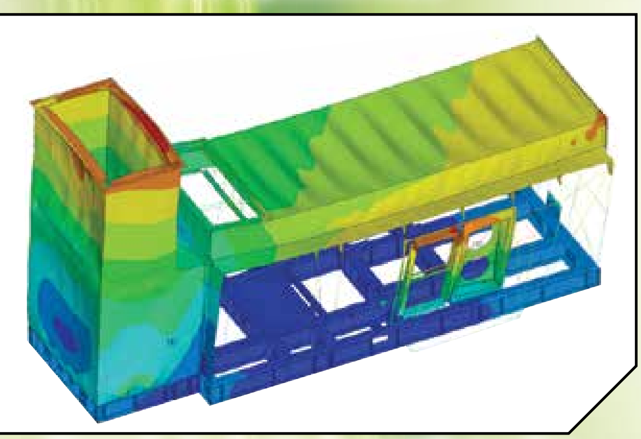

Figure 3. Resultant Displacement Contours Due to Operating and Seismic Loads

For more information, please contact:

Call Toll Free
877-4SI-POWER
877-474-7693

Visit our website at:
www.structint.com

Email: ***info@structint.com***

Structural Integrity Associates, Inc.®

Seismic Qualification of an Enclosure and Skid for an Emergency Backup Power System

Nuclear power plant emergency backup power systems must remain fully functional following a major earthquake combined with a loss of offsite power. The system, related components and structure housing the equipment are classified as Seismic Category 1 and are designed to withstand the effects of a safe shutdown earthquake (SSE) without the loss of safety function. Structural Integrity (SI) was engaged by Engine Systems, Inc. (ESI) to perform the seismic qualification of a backup power system for a new plant design. In addition to the components and piping, we qualified the skid, enclosure and exhaust plenum for the system.

A prototype of the system, including the skid and enclosure, was successfully built and tested in 2010 at ESI prior to final seismic qualification of the enclosure and skid. Based on preliminary analysis and our review of the prototype enclosure design, some changes were needed to the structural system of the enclosure. None of the structural changes were to interfere with or alter the performance characteristics of the previously tested system. We worked with the enclosure manufacturer and ESI to develop an improved lateral system for the enclosure and exhaust plenum that would impose no changes to the air handling or acoustic performance of the system.

Seismic qualification of the enclosure and skid was performed by analysis using ANSYS. The structure and skid were qualified together, using a global model. Load combinations and acceptance criteria were applied in accordance with ANSI/AISC N690-1994(R2004), Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities. Seismic load cases were analyzed by the response spectrum method using mode superposition.

The finite element model of the enclosure and skid, shown in Figure 1, is composed of 64,800 beam, shell, contact, spring and lumped mass elements. Nodes were located at plate mid-planes and at plate-frame joint locations. Beam sections were offset to maintain accurate position of member centerlines and include any eccentricity in load transfer between members. Large web cutouts for piping were modeled at perimeter members of the skid. Pipe supports attached to the skid were modeled with beams and tied to the skid with rigid constraints or discrete elements.

Bolts were modeled with short beams connected to and sharing nodes with main frame members. Bolt stiffness and tying conditions were set based on the results of local connection models, such as those shown in Figure 2. Equipment was modeled as lumped masses with computed inertial properties. Non-structural mass was added through real constants, section properties and increased material densities. The weight of each major assembly was calibrated to match target weights computed in a detailed calculation based on CAD drawings.

The operating temperature distribution for the enclosure and exhaust plenum was obtained from a thermal model of the exhaust plenum wall and heat transfer analysis of the structure. Temperature expansion stresses and connection forces were superimposed with dead, live and seismic loads to obtain the final member and connection forces and moments. The final deformed shape of the structure for one of the load combinations is shown in Figure 3. Final predicted lateral deflection is close to 1/10th that of the preliminary design.