Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 25-26, 2007

Seismic Qualification for Class 1E Safety-Related Containment Recirculation Fan Cooler and Motor Assembly

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1. Introduction

The purpose of this study is to seismically qualify the Class 1E safety-related Containment Recirculation Fan Cooler. The equipment to be qualified herein is Class 1E safety-related CRFC Fan and Motor Assembly for use in harsh environment in KORI 1 Nuclear Power Plant. The CRFC's are installed inside the Containment Building, elevations 86 and 97 feet. Two of the units are installed in the up flow configuration, while the remaining two units are installed in the down flow configuration [1,2]. The test specimen motor meets the requirements of IEEE Standard 334-1994 for similarity between the type test specimen and the motors being qualified [5].

The qualification test was performed in the following sequence.

- Receiving Inspection
- Motor Functional Tests
- Motor Vibration Assembly (CRFC Unit)
- CRFC Unit Operability Check
- Seismic Simulation
- Post-Test Inspection

2. Qualification Requirements

Seismic qualification requirements for the equipment include the Seismic Response Spectra (SRS) curve. CRFC RRS included that OBE horizontal & vertical RRS, SSE horizontal & vertical RRS and add 10% margin to the resultant worst–case OBE RRS in accordance with IEEE Standard 323-1983 presented as Figure1 [4].

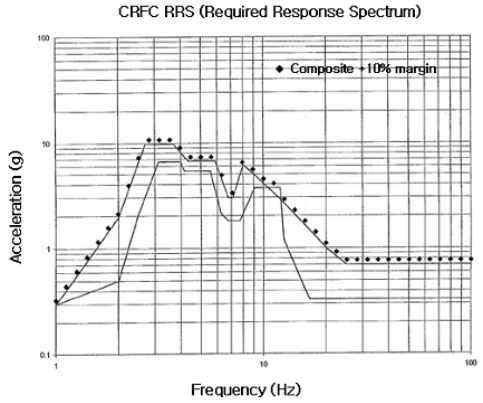

Figure 1. Composite Worst-Case Horizontal and Vertical OBE and SSE RRS (Includes 10% Margin)- OBE Damping=0.5%, SSE Damping=1.0%

The classification of the equipment is Class 1E since it performs a safety-related function that these of the CRFC's at KORI 1 is to maintain the design temperature in the containment building during the normal operating mode and post-accident period. The Acceptance Criteria should be met the purposes of qualification effort [3].

3. Results

3.1. Receiving Inspection

The specimen components ware no visible shipping or other damage and met the Acceptance Criteria.

3.2. Motor Vibration Aging

The test specimen motor was subjected to vibration aging per IEEE Standard 334-1994. The motor shaft was oriented vertically and fixture was welded to a shaker table. Motion consisted of a single-axis sine dwell at 60 Hz with an input acceleration of 1.5 times the acceleration of gravity that produced peak-to-peak amplitude of approximately 8 mils (0.2 mm). The motor was unpowered during the test. Electrical, mechanical and structural integrity of the motor were not compromised during the 60 minute duration vibration test.

3.3. Test Specimen Fan and Motor Assembly and Operability Check

The CRFC's unit test specimen (motor, fan and main motor power terminal box) was assembled and the motor was powered with approximately 491 VAC, 3phase, 60 Hz and allowed to operate until the speed and current had stabilized. Rotational speed and current in each phase were measured [3].

3.4. Seismic Simulation

The test fixture was welded directly to the Triaxial Seismic Simulation Table such that the motor shaft was oriented and the horizontal axes of the test specimen were collinear with the horizontal axes of the test table. Nine response accelerometers were located on the test specimen CRFC Unit in order to monitor seismic response of the equipment. These photographs are included in the Figure 2.

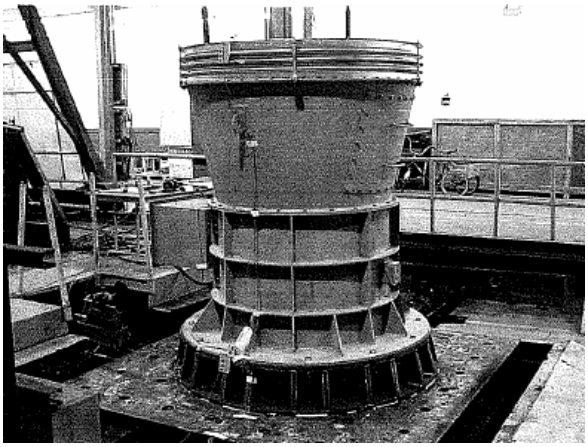

Figure 2. Test setup for Seismic Testing

TRS plots of the specimen response accelerometers analyzed at 0.5%, 1%, 2%, 3% and 5% damping for a representative OBE Test and the SSE Test.

The test specimen motor was powered with approximately 491 VAC, 3 Phase, 60 Hz to operate the test specimen during the five OBE tests and the SSE test. A low level single-axis sine sweep test from 1 Hz to 50 Hz was performed in each of the three orthogonal axes for determination of resonant frequencies. The table motion was analyzed by a response spectrum analyzer and 1/6 octave intervals over the frequency range of 1 to 100 Hz. The CRFC Unit was operated at high speed during the five OBE Tests and at the low speed during the SSE test.

The following Figure 3 and 4 shows the results of OBE (Run 4) and SSE (Run 9) Tests. One anomaly was identified during OBE No.1 and the SSE during the OBE one point of the TRS (0.826g at 1.413 Hz) was slightly lower than the RRS (0.835g at 1.413 Hz) by 0.009g or 1.08%. During SSE, one point of the TRS (0.444g at 1.122 Hz) was slightly lower than the RRS (0.448g at 1.122 Hz) by 0.004g or 0.89% and No damage to the CRFC Unit was observed as a result of seismic testing.

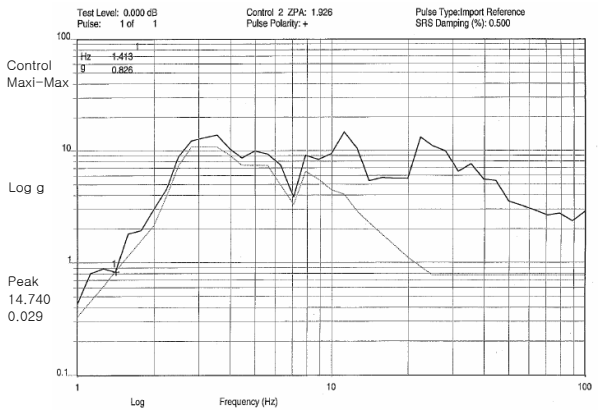

Figure 3. OBE(Run 4) Testing in the side-to-side direction perpendicular to the fan shaft.

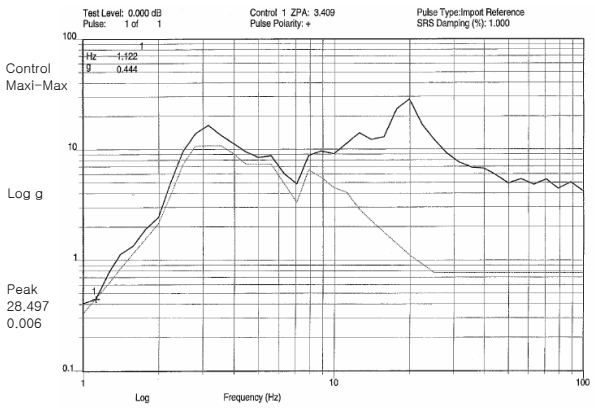

Figure 4. SSE(Run 9) Testing in the front-to-side direction perpendicular to the fan shaft.

4. Conclusion

One anomaly was identified during the Seismic Simulation. During OBE No.1 and the SSE test, the test Response Spectra (TRS) fell below the Required Response Spectra (RRS) at one point during each test run. The adjacent 1/6-octave points are higher than the RRS and that the adjacent 1/3-octave points are at least 10% above the RRS in both cases. As concluded in Notice of Anomaly No.1, this criterion meets the seismic qualification requirement specified in IEEE Standard 344-1987.

After Post-Seismic Functional Test and Post-Test Inspection was performed, no effect on seismic qualification of the CRFC Unit.

Therefore, CRFC Unit is seismically qualified for use in either the up flow or down flow configuration inside the Containment Building at KORI 1 Nuclear Power Plant in the seismic environment.

REFERENCES

[1] 10 CFR 21, “Reporting of Defects and Noncompliance”.
[2] 10 CFR 50 Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants”.
[3] ASME NQA-1, “Quality Assurance Program Requirements for Nuclear Facilities”.
[4] IEEE 323-1983, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations”.
[5] IEEE 334-1994, “IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations”.
[6] NRC Regulatory Guide 1.100, Revision 1, “Seismic Qualification of Electric Equipment for Nuclear Power Plants”.