APPENDIX 3.9A

SEISMIC CONSIDERATIONS FOR EQUIPMENT SPECIFICATIONS

For seismic Category I equipment and supports, the vendor must demonstrate the equipment's ability to perform its required function during and after the time that it is subjected to the forces resulting from the seismic conditions. This can be accomplished in various ways. Two methods commonly used are to:

a) predict the equipment's performance by mathematical analysis, or

b) test the equipment under simulated seismic conditions.

If properly justified, other methods may be used. The documentation provided for the equipment must clearly justify the choice of analysis method.

Mathematical Analysis Method

This method should be used for equipment which can be modeled to predict its response.

The analysis method should consist of the following:

a) Model the equipment and supports with sufficient degrees of freedom to ensure adequate representation.

b) Determine the natural frequencies and mode shapes of the equipment and supports as it will be mounted in service.

c) The following damping factors should be used in the seismic analysis:

	Percent Critical Damping	
	OBE	SSE
Welded Steel Plate Assemblies	1	1
Welded Steel Framed Structures	2	2
Bolted or Riveted steel framed structures	2.5	2.5
Reinforced concrete equipment supports	2	5

d) If the equipment and supports are capable of being lumped into a single mass, and if the natural period is certified to be less than 0.03 seconds, it may be analyzed statically, and the equipment shall be designed to safely withstand the following loading conditions:

1) The operating basis earthquake (OBE) seismic load shall consist of the most severe combination of a horizontal seismic load coefficient of .50g, which can act in either of the two major horizontal directions, acting simultaneously with a vertical seismic load coefficient of .34g, which can act upward or downward.

2) The safe shutdown earthquake (SSE) seismic load shall consist of the most severe combination of a horizontal seismic load assuming a coefficient of 1.00 g, and a vertical seismic load assuming a coefficient of .67g acting as above.

All seismic loads may be assumed to act at the center of gravity of the equipment.

3) The unit stresses induced from the earthquake seismic loads shall be combined in accordance with the applicable equipment codes. If the codes are not specific, the seismic loads shall be added directly to the unit stresses from other applicable loading. The Allowable unit stresses shall not be increased due to the addition of the OBE seismic load. The allowable unit stresses may be increased due to the addition of the SSE seismic load to a limiting value that will cause no loss of function.

e) If the equipment model is a multidegree of freedom model, and the natural periods of the equipment (including its supports) are less than 0.03 seconds, it may be analyzed statically. In this static analysis, the seismic forces on each component of the equipment are obtained by concentrating its mass at its center of gravity and designing to the loading conditions in c) above.

f) If the natural period of the equipment and supports is not less than 0.03 seconds, then the vendor shall perform a dynamic analysis using the response spectra model analysis technique (floor response spectra are supplied) or a time history modal analysis (time history input is supplied). Other methods of analysis, may be used if properly justified. The vendor shall perform a stress analysis using the inertia forces or the equivalent static loads obtained from the dynamic analysis for each mode.

The square root of the sum of the squares method should normally be used to combine the modal responses when the response spectrum modal analysis technique is employed. In those cases, however, where modal frequencies are closely spaced, the responses of the closely spaced modes should be combined by the sum of the absolute values method and, in turn, combined with the responses of the remaining significant modes by the square root of the sum of the squares method.

If the time history modal analysis is used, the maximum responses should be determined by obtaining the greatest sum of the response of all significant modes at a particular time.

In each of the preceding analyses, each of the two major horizontal directions should be considered separately, but simultaneously with the vertical direction in the most conservative manner.

g) The analysis should include evaluation of the effects of the calculated stresses on mechanical strength, alignment, electrical performance, and non-interruption of the functional requirements of the equipment during a SSE.

Testing

The vendor shall perform seismic tests by subjecting the equipment to vibratory motion which conservatively simulates that to be seen at the equipment mounting during a SSE. The equipment to be tested should be mounted on the vibration generator in a manner that simulates the intended service mounting. The vibration motion should be applied to each of the three major perpendicular axes independently unless symmetry justifies less. The equipment being tested must demonstrate its ability to perform its intended function and sufficient monitoring equipment should be used to evaluate performance before during and following the test.

The vendor shall submit his detailed testing procedures for approval. Actual testing shall generally involve the following procedures:

a) Perform a low amplitude frequency search to determine potential resonance regions.

b) Test the equipment at these resonance frequencies with amplitude and test duration equivalent to that produced by the floor time-history motions. The sine beat test is the preferred method of testing; however, other methods of testing are permitted if properly justified.

The vendor shall subject his equipment to the seismic response indicated above and submit evidence (test data) which substantiates that the equipment and accessories will not suffer loss of function due to these seismic considerations.

Documentation

The vendor shall provide documentation explaining his methods of seismic analysis or testing, and the results for each piece of equipment supplied.

If the natural period of the equipment was mathematically determined and found to be greater than .03 seconds, the vendor must provide the modeling method used, as well as the mass point locations, spring constants and section moduli to facilitate total system seismic analysis by the non-NSSS. In any case, the vendor must supply support loadings (static and dynamic at the equipment bases), and anchor bolt sizes and locations to meet the above seismic considerations. If the equipment was tested and the natural periods are greater than .03 seconds, the vendor must provide a mathematical model with mass points locations, spring constants, and section moduli of the equipment to be used in the non-NSSS piping seismic analysis.