# 4. SEISMIC EQUIPMENT LIST

## 4.1 GENERAL APPROACH

The methodology and procedures for evaluating the seismic adequacy of systems and components described in the DOE Seismic Evaluation Procedure are based on the observed performance, failure, and response of various types of systems and components during and after actual earthquake motion or simulated earthquake motion on a shake table. Systems and components can be evaluated for seismic adequacy using the methods and procedures in the DOE Seismic Evaluation Procedure provided that the associated guidelines, limitations, requirements, and caveats described in the procedure are satisfied. This chapter provides guidelines and some discussion to aid in preparing a list of systems and components that can be seismically evaluated to meet the intent of DOE Orders and standards. A prescriptive method for developing the Seismic Equipment List (SEL) is not provided in this chapter because each DOE facility may utilize methods which address facility-specific issues. Even though the SEL is intended for all systems and components, it will primarily consist of systems and components which, if damaged or destroyed, could potentially harm the environment, public and/or workers.

DOE Orders and standards on natural phenomena hazards require that all systems and components be seismically evaluated, except for Performance Category (PC)-0 systems and components. All PC-1 through PC-4 systems and components could then be included in the SEL of the facility. However, the DOE Orders and standards use a "graded approach" permitting the level of rigor and thoroughness of seismic adequacy evaluation to vary in proportion to the importance and significance of the systems and components being evaluated. Consistent with this approach and recognizing the impracticality of performing seismic evaluation and upgrading of all DOE facilities simultaneously, DOE Orders and standards permit prioritization of seismic evaluation and upgrading of various systems and components on some rational basis, such as the risk reduction potential associated with the seismic evaluation and upgrading of a particular system or component. DOE Orders and standards also permit some relaxation of the requirements for older-vintage and existing facilities consistent with a backfit principle. The use of the screening methods and procedures described in the DOE Seismic Evaluation Procedure is based on similar principles.

The above-mentioned relaxation and prioritization provisions of DOE Orders and standards permit an SEL that is not all inclusive, even though all PC-1 through PC-4 systems and components could be in the SEL. Considering the availability of resources and the estimated risk-reduction potential, it is acceptable for only certain systems and components to be included in the SEL. Since a rigorous determination of the risk reduction potential for a large number of systems and components is not practical, an approximate and subjective estimation is acceptable. With appropriate guidance from facility management on resource availability and facility mission, the estimation of relative risk-reduction potential and preparation of an SEL can best be performed by a team, the SEL Team. This team should consist of safety professionals, facility system safety engineers, seismic engineers, and facility operators. For some facilities, the SEL Team may need to incorporate the specialized expertise of relay engineers, piping engineers, chemical engineers, or other professionals and facility designers.

The general approach for the development of the SEL requires the consideration of the following items: identification of facility safety requirements, postulated facility conditions, system interaction considerations, and seismic vulnerability considerations. From these considerations, it is anticipated that a preliminary SEL can be developed. To complete the SEL it is recommended that the preliminary SEL undergo an operational review for concurrence by facility operators.

## 4.2 IDENTIFICATION OF FACILITY SAFETY REQUIREMENTS

As discussed earlier, the SEL will contain only a portion of the facility systems and components and, in many cases, the SEL will contain only safety-related systems and components which must function during or after a seismic event. To determine which systems and components belong in the SEL, the selection should be based on the results of accident analyses. These accident analyses should consider all the appropriate facility hazards as required by the applicable DOE Orders, such as DOE Order 420.1 (Ref. 5), DOE Order 5480.23 (Ref. 9) for nuclear facilities, DOE Order 5480.30 (Ref. 66) for nuclear reactors, DOE Order 5480.25 (Ref. 67) for accelerator facilities, and DOE Order 5481.1B (Ref. 68) for nonnuclear facilities.

Accident analyses and their results are typically provided in a Safety Analysis Report (SAR) for the DOE facility being evaluated and the SEL should be based on information provided in the SAR. For a nonreactor nuclear facility, DOE-STD-3009 (Ref. 11) provides guidance on the preparation of a SAR. Using the guidance in DOE-STD-3009 and the appropriate accident analyses in the SAR, systems and components can be differentiated into Safety Class or Safety Significant. The SEL can focus on those facility systems and components which are classified as Safety Class or Safety Significant. These systems and components are typically those which must function during or after a seismic event. For facilities without a SAR, hazard and/or accident analyses comparable to those required for a SAR should be performed to identify systems and components needed to perform safety functions.

Additional guidance for the development of the SEL is provided in DOE-STD-1021 (Ref. 7) and DOE-STD-1027 (Ref. 10). The results of facility hazard classification, safety classification, and performance categorization are considered in DOE-STD-1021. With these considerations, the facility systems and components can be assigned to the appropriate performance category. The SEL can focus on those facility systems and components which are classified above a specified performance category and these systems and components are typically those which must function during or after a seismic event.

## 4.3 POSTULATED FACILITY CONDITIONS

In developing the SEL, the SEL Team will need to postulate facility conditions following a seismic event. These postulated conditions will help the SEL Team to identify systems and components needed following an earthquake and serve as a basis of questions asked during the operational review.

- Offsite Utilities: Offsite utilities such as power, telephone, water, steam and gas supplies should be considered for two conditions:

  1) Offsite utilities are interrupted and are not available for up to 72 hours.

  2) Offsite utilities are uninterrupted.

- Seismic Induced Accidents: Postulate seismic induced accidents, such as fire and criticality, unless a hazard analysis is performed to show that such events are not credible.

- Single Active Failure: Postulate random or seismically induced failure of any single active component on the SEL.

- Operator Actions: Consider operator actions, as necessary, provided the following conditions are met:

  1) Procedures and training are in place.

  2) Procedures take into account the environment which will result from the postulated earthquake.

  3) Operator actions utilize seismically qualified components and instrument alarms.

  4) Egress routes are confirmed viable by seismic review. An alternate egress route must be included in operator action procedures, unless a single route is structurally qualified (including opening of doors and emergency lighting). In addition, access routes for the operator to activate alarms may be required.

- Other Accidents: Do not postulate that other natural phenomena hazards (extreme winds, floods) or man-made accidents (sabotage, plane-crash) occur simultaneously with the earthquake.

## 4.4 SYSTEM INTERACTION CONSIDERATIONS

In preparing the SEL for a facility, system safety will be the primary consideration and the safety professionals and system engineers in the SEL Team will have the primary responsibility of selecting systems and components that must be seismically evaluated. This is a primary consideration for facilities that contain, store, or process nuclear or chemically hazardous materials. For such facilities, the responsibility of the system engineers of the SEL Team will be to grade the candidate systems and components according to their safety significance in relation to the consequences of their failure during or following a seismic event. Such grading may be performed on the basis of system safety studies, if any, associated with the development of SARs and with DOE-STD-1021 (Ref. 7). In addition to the data on conventional safety classification or seismic performance categorization of systems and components, additional data on the approximate number of on-site and off-site individuals that are likely to be adversely affected and the extent of potential damage to the environment will be useful in assessing the relative safety significance of the systems and components.

The SEL Team, especially the safety professionals and system engineers, should also include the following considerations in their evaluation of safety significance of the systems and components:

- Seismic Interaction Effects: The effect of one failure of a systems or component on the performance of other safety-related systems and components should be considered.

- Common-Cause Failure Effects: Since a seismic event affects all systems and components within a facility, several non-safety related systems and components may fail and result in the unacceptable performance or failure of a safety-related systems or component. The effects of such common-cause failure on non-safety related systems and components should be considered.

- Performance During a Seismic Event: Not all safety-related systems and components need to continuously function during a seismic event to meet their safety requirement, as long as they perform their safety-related function after the event. Functional failure of such systems and components during a seismic event is obviously not significant compared to those systems and components, such as some switches and relays, which must function during the event.

## 4.5 SEISMIC VULNERABILITY CONSIDERATIONS

In developing the SEL, structural and seismic vulnerability considerations are also important. In general, the systems and components that are inherently or generically susceptible to seismic failure or malfunction should get more attention in the evaluation process than those that are inherently rugged. The determination and assessment of seismic weakness or ruggedness for the purpose of preparing the SEL will be the responsibility of the SEL Team, especially the seismic engineers. The seismic engineers will consider: (1) the structural configuration of the system or component in relation to its function, (2) its potential failure mode (ductile or brittle, large displacement, vibration sensitivity, unacceptable function even though stress or displacement is within acceptable limits, etc.), (3) generic performance during past earthquakes or during shake table test, and (4) the actual attachment and support conditions of the system or component.

A systematic walkthrough is recommended to evaluate the seismic ruggedness of the systems and components and their support and anchorage. The Walkthrough Screening Evaluation Field Guide (Ref. 23) discussed in Section 1.4 can aid this process. A brief review of seismic design documents and records is also necessary to assess the seismic vulnerability of the systems and components. Based on such walkthrough and document review, the seismic engineer of the SEL Team will subjectively evaluate the relative seismic vulnerability of the systems and components that are included in the SEL prepared by the safety professionals and system engineers. As a result of this seismic vulnerability evaluation, each system or component of the SEL, which was prepared on the basis of safety considerations, will have a qualitative seismic vulnerability rating which, when combined with the system safety significance, can provide an assessment of the relative risk associated with the seismic event.

## 4.6 OPERATIONAL REVIEW

The SEL prepared from the considerations discussed in Sections 4.2, 4.3, 4.4 and 4.5 should be reviewed by the SEL Team for operational and functional considerations. The facility operators will specially review the completeness of the list to ensure that the systems and components whose functionality and integrity are assumed essential for personnel and public safety by the operating personnel are included in the SEL. To assist the SEL Team and facility operators in reviewing the preliminary SEL, the following questions are suggested:

- What are the hazards to the public, workers, or environment upon failure of facility systems and components?
- What are the confinement systems in place to protect the public or environment from facility operations or accidents?
- What are the procedures in the event of a loss of off-site power?
- What are the facility emergency response and evacuation procedures, monitors, alarms, and routes for a major seismic event?
- Are there essential instrumentation and controls for vital components needed to provide confinement?
- What type of fire protection system does the facility have (wet systems, dry systems, any functional requirements of any pumps)?
- What type of monitoring systems and components does the facility have (continuous air monitors, high-radiation area monitors, stack monitors, and associated operational requirements)?

- What type of alarm systems does the facility have?
- What, if any, are the operational requirements for components in the confinement systems?
- Is any operator intervention required to operate the vital components for confinement?
- What success paths are available for placing any hazardous operations into a safe state including those requiring operator action?
- Upon loss of off-site power, what is the failure state of active confinement systems (e.g., will air be needed to re-open dampers)?
- Are there any highly important and expensive experiments or unique components that if lost, would jeopardize the mission of the facility due to excessive downtime?
- Are there significant common-cause interaction effects?
- What support systems do facility systems and components depend on to fulfill their safety functions?
- What defense-in-depth features are required for the facility systems and components?

Information to help answer the above questions may be in the facility SAR or other related safety documents. After addressing these questions in the operational review and revising the preliminary SEL based on the answers to the questions, the final SEL can be developed.