2. SCREENING EVALUATION AND WALKDOWN PROCEDURE

2.1 APPROACH IN THE DOE SEISMIC EVALUATION PROCEDURE[1]

The approach used in the DOE Seismic Evaluation Procedure for evaluating the seismic adequacy of equipment in DOE facilities is consistent with the intent of DOE Policy, Orders, and Standards. It is also consistent with the approach in the SQUG GIP (Ref. 1) and the EPRI Seismic Margins Assessment Program (Ref. 18). The four major steps used in the DOE procedure for the majority of the equipment to be evaluated are listed below, along with the chapter(s) of the procedure where these steps are covered in detail:

- Selection of Seismic Evaluation Personnel (Chapter 3)
- Determination of Seismic Equipment List (Chapter 4)
- Screening Evaluation and Walkdown
  - Capacity versus Demand (Chapter 5)
  - Anchorage (Chapter 6)
  - Seismic Interaction (Chapter 7)
  - Equipment Class Evaluations (Chapters 8, 9, and 10)
  - Relay Functionality (Chapter 11)
- Outlier Identification and Resolution (Chapter 12)

The suggested documentation for these reviews is discussed in each of the chapters and in Chapter 13. The remainder of this section summarizes the material covered in Chapters 3 through 13.

An important aspect of the methodology in the DOE Seismic Evaluation Procedure is the use of judgment that results from appropriate training, extensive experience with walkdowns, and review of the reference documents for the SQUG GIP. Guidance and discussion about the use of engineering judgment are provided in References 18, 57, and 58 that discuss the assessment of seismic margins for nuclear power plants. Since the level of expertise will differ with the seismic evaluation personnel as discussed in the following section, it is vital that the personnel identify the equipment that they do and do not have the adequate level of expertise to evaluate and that they evaluate only the equipment for which they have the appropriate experience. Engineers who use the DOE Seismic Evaluation Procedure are responsible for its appropriate application, for their level of training, and for their use of judgment. The developers of the Procedure assume no responsibility for specific applications of the methodology.

2.1.1 Seismic Evaluation Personnel[2]

Individuals from several engineering disciplines, their recommended minimum requirements or qualifications, and their responsibilities for implementing this Seismic Evaluation Procedure are described in Chapter 3. These individuals include: (1) Safety Professionals and Systems Engineers who identify the methods and the equipment needed in the Seismic Equipment List

---

[1] Based on Section 1.3 of SQUG GIP (Ref. 1)
[2] Based on Section 1.3.1 of SQUG GIP (Ref. 1)

(SEL); (2) Operations Personnel who have a comprehensive understanding of the facility layout, the function and operation of the equipment and systems in the facility, and the facility operating procedures; (3) Seismic Capability Engineers (SCEs) who perform the Screening Evaluation and Walkdown of the equipment listed in the SEL; (4) Relay Evaluation Personnel who perform the relay functionality review; and (5) Piping Evaluation Engineers who perform the walkdown and evaluation of piping listed in the SEL.

Since the instructions and requirements contained in this procedure are guidelines and not fixed, inflexible rules, the SCEs must exercise sound engineering judgment during the Screening Evaluation and Walkdown. Therefore, the selection and training of qualified SCEs for participation on the Seismic Review Teams (SRTs) is an important element of the DOE Seismic Evaluation Procedure. The SCEs are expected to exercise engineering judgment based upon an understanding of the guidelines given in the procedure, the basis for these guidelines given in the reference documents and presented in the DOE training course, and their own seismic engineering experience.

Chapter 3 also describes the DOE-developed training course which should be taken by individuals who perform the seismic review of a DOE facility with the DOE Seismic Evaluation Procedure. This course provides assurance that there is a minimum level of understanding and consistency in applying the guidelines contained in this procedure.

2.1.2 Seismic Equipment List

The Seismic Equipment List (SEL) is described in Chapter 4. This list is typically developed by Safety Professionals and Systems Engineers in consultation with Operations Personnel and other engineers. Equipment listed on the SEL is evaluated by SCEs using the screening and walkdown methodology of the Seismic Evaluation Procedure.

Screening guidelines are provided in the DOE Seismic Evaluation Procedure for evaluating the seismic adequacy of most types of equipment which could be listed in the SEL. However, if an item of equipment listed in the SEL is not covered by the screening guidelines, then it is identified as an outlier and evaluated separately as discussed in Chapter 12.

2.1.3 Screening Evaluation and Walkdown[3]

The Screening Evaluation and Walkdown of equipment listed in the SEL is described in Chapters 5 through 11. The purpose of the Screening Evaluation and Walkdown is to screen out from further consideration those items of equipment that pass certain generic, seismic adequacy criteria. The screening evaluation is based heavily on the use of seismic experience data. If the equipment does not pass the screens, other more refined or sophisticated methods for evaluating the seismic adequacy of the equipment may be used as described in Chapter 12.

The procedure for performing the Screening Evaluation and Walkdown is depicted in Figure 2.1-1. As shown in the figure, each of the following four seismic screening guidelines should be used to evaluate the seismic adequacy of an item of equipment:

- Seismic Capacity Compared to Seismic Demand (Chapter 5) - The seismic capacity of the equipment, based on earthquake experience data, generic seismic testing data, or equipment-specific seismic qualification data, should be greater than the seismic demand imposed on the equipment, system, or architectural feature.

---

[3] Based on Section 4.0 of SQUG GIP (Ref. 1)

- Anchorage (Chapter 6) - The equipment anchorage capacity, installation, and stiffness should be adequate to withstand the seismic demand at the equipment location.

- Seismic Interaction (Chapter 7) - The effect of possible seismic spatial interactions with nearby equipment, systems, and structures and interaction from water spray, flooding, and fire hazards should not cause the equipment to fail to perform its intended function.

- Equipment Class Evaluations (Chapters 8, 9, and 10) - In Chapter 8, the equipment must be similar to the equipment in the earthquake experience equipment class or the generic seismic testing equipment class and also meet the intent of the specific caveats for that class of equipment in order to use the seismic capacity defined by the earthquake experience Reference Spectrum or the generic seismic testing GERS. If equipment-specific seismic qualification data is used, then specific restrictions or caveats for that qualification data apply instead. In Chapter 9, the equipment must be similar to the equipment in the earthquake experience equipment class, meet the caveats, and satisfy the screening procedures. In Chapter 10, the equipment must be similar to the equipment classes and be evaluated using the general screening procedures or guidelines.

The evaluation of equipment against each of these four screening guidelines is to be based upon walkdown evaluations, calculations, and other supporting data. While equipment seismic evaluations can generally be performed independently from each other, there are a few areas where an interface with the Relay Functionality Review (Chapter 11) is appropriate:

- Any cabinets containing essential relays, as determined by the relay review in Chapter 11, should be evaluated for seismic adequacy using the guidelines contained in Chapter 8.

- Apply a capacity reduction factor to expansion anchor bolts that secure cabinets containing essential relays. This capacity reduction factor is discussed in Chapter 6.

- Seismic interaction, including even mild bumping, is not allowed on cabinets containing essential relays. This limitation is discussed in Chapters 7, 8, and 11.

- In-cabinet amplification factors for cabinets containing essential relays are to be estimated by the SCEs for use in the Relay Functionality Review.

It is suggested that items of equipment containing essential relays be identified prior to the Screening Evaluation and Walkdown so that the above evaluations may be accomplished during the Screening Evaluation and Walkdown.

2.1.3.1 Seismic Capacity Compared to Seismic Demand[4]

A screening guideline to be satisfied to evaluate the seismic adequacy of an item of equipment is to confirm that the seismic capacity of the equipment is greater than or equal to the seismic demand imposed on it. Chapter 5 addresses the comparison of seismic capacity to seismic demand for the equipment classes discussed in Chapter 8. The seismic capacity of an item of equipment can be compared to a seismic demand spectrum (SDS) defined in terms of an in-structure response spectrum (IRS) with the applicable scale factors. In Chapter 9 and parts of Chapter 10, specific methods for comparing seismic capacity to seismic demand are developed for several classes of equipment. In addition, a comparison of seismic capacity to seismic demand is made in Chapter 6 for the anchorage of the equipment and in Chapter 11 for relays mounted in the equipment.

---

[4] Based on Sections 4.2, 4.2.1, and 4.2.2 of SQUG GIP (Ref. 1)

The seismic capacity of equipment can be represented by a "Reference Spectrum" based on earthquake experience data, or a "Generic Equipment Ruggedness Spectrum" (GERS) based on generic seismic test data. Note that these two methods of representing seismic capacity of equipment can only be used if the equipment meets the intent of the caveats for its equipment class as described in Chapter 8.

Earthquake experience data was obtained by surveying and cataloging the effects of strong ground motion earthquakes on various classes of equipment mounted in conventional facilities and other industrial facilities. The results of this effort are summarized in Reference 35. Based on this work, a "Reference Spectrum" was developed representing the seismic capacity of equipment in the earthquake experience equipment class. A detailed description of the derivation and use of this Reference Spectrum is contained in Reference 19 and this reference should be reviewed by the SCEs before using the Reference Spectrum. The Reference Spectrum, which is shown in Chapter 5, can be used to represent the seismic capacity of equipment in a DOE facility when this equipment is determined to have characteristics similar to the earthquake experience equipment class and meets the intent of the caveats for that class of equipment as defined in Chapter 8. Use of the Reference Spectrum for comparison with a SDS is described in Chapter 5.

A large amount of data was also collected from seismic qualification testing of equipment. This data was used to establish a generic ruggedness level for various equipment classes in the form of Generic Equipment Ruggedness Spectra (GERS). The development of the GERS and the limitations on their use (caveats) are documented in Reference 40. Copies of the non-relay GERS along with a summary of the caveats to be used with them are included in Chapter 8. SCEs should review Reference 40 to understand the basis for the GERS. GERS can be used to represent the seismic capacity of an item of equipment in a DOE facility when this equipment is determined to have characteristics that are similar to the generic testing equipment class and meets the intent of the caveats for that class of equipment as defined in Chapter 8. Use of the GERS for comparison to a SDS is described in Chapter 5.

2.1.3.2 Anchorage Adequacy[5]

A screening guideline to be satisfied to evaluate the seismic adequacy of an item of equipment is to confirm that the anchorage of the equipment is adequate. Lack of anchorage or inadequate anchorage has been a significant cause of equipment failing to function properly during and following past earthquakes.

The screening approach for evaluating the seismic adequacy of equipment anchorage is based upon a combination of inspections, analyses, and engineering judgment. Inspections consist of measurements and visual evaluations of the equipment and its anchorage, supplemented by use of facility documentation and drawings. Analyses should be performed to compare the anchorage capacity to the seismic loads (demand) imposed upon the anchorage. These analyses should be done using the guidelines contained in Chapter 6. Engineering judgment is an important element in the evaluation of equipment anchorage. Guidance for making judgments is included, where appropriate, in Chapter 6 and in the reference documents.

Section 6.4.1 contains methods for determining or estimating the natural frequency and damping of many of the classes of equipment in Chapters 8, 9, and 10. Generic equipment characteristics are provided for motor control centers, low-voltage switchgear, medium-voltage switchgear, transformers, horizontal pumps, vertical pumps, air compressors, motor-generators, batteries on racks, battery chargers and inverters, engine-generators, instrument racks, equipment cabinets, and control panels.

---

[5] Based on Section 4.4 of SQUG GIP (Ref. 1)

There are various combinations of inspections, analyses, and engineering judgment that can be used to evaluate the adequacy of equipment anchorage. The SCEs should select the appropriate combination of elements for each anchorage installation based on the information available. For example, a simple hand calculation may be sufficient for a pump that has only a few, very rugged, anchor bolts in a symmetrical pattern. On the other hand, at times it may be advisable to use one of the anchorage computer codes to determine the loads applied to a multi-cabinet motor control center if its anchorage is not symmetrically located. Likewise a trade-off can be made between the level of inspection performed and the factor of safety used for expansion anchor bolts. These types of trade-offs and others are discussed in Chapter 6.

2.1.3.3 Seismic Interaction[6]

A screening guideline to be satisfied to evaluate the seismic adequacy of an item of equipment is to confirm that there are no adverse seismic spatial interactions with nearby equipment, systems, and structures and interaction from water spray, flooding, and fire hazards that could cause the equipment to fail to perform its intended function. The interactions of concern are potential impact due to proximity, structural failure and falling, and flexibility of attached lines and cables. Guidelines for judging interaction effects when evaluating the seismic adequacy of equipment are presented in Chapter 7.

It is the intent of the seismic interaction evaluation that real (i.e., credible and significant) interaction hazards be identified and evaluated. The interaction evaluations described in Chapter 7 focus on areas of concern based on past earthquake experience. Systems and equipment that have not been specifically designed for seismic loads should not be arbitrarily assumed to fail under earthquake loads; instead, SCEs are expected to differentiate between likely and unlikely interactions, using their judgment and past earthquake experience. In addition, system interaction effects as defined in DOE-STD-1021 (Ref. 7) are also discussed in Chapter 7.

Note that special attention should be given to the seismic interaction of electrical cabinets containing relays. If the relays in the electrical cabinets are essential (i.e., the relays should not chatter during an earthquake), then any impact on the cabinet should be considered an unacceptable seismic interaction and cause for identifying that item of equipment as an outlier. Guidance for evaluating the consequences of relay chatter due to earthquake motions, including cabinet impact interactions, are presented in Chapter 11 and Reference 45.

2.1.3.4 Equipment Class Evaluations[7]

A screening guideline to be satisfied to evaluate the seismic adequacy of an item of equipment is to confirm that (1) the equipment characteristics are generally similar to the earthquake experience equipment class or the generic seismic testing equipment class and (2) the equipment meets the intent of the specific caveats, procedures, or guidelines for the equipment class.

The DOE Seismic Evaluation Procedure has three different types of equipment class evaluations with varying levels of rigor and technical review. Table 2.1-1 lists all the equipment classes contained in the DOE Seismic Evaluation Procedure and the type of evaluation for each equipment class.

---

[6] Based on Section 4.5 of SQUG GIP (Ref. 1)
[7] Based on Section 4.3 of SQUG GIP (Ref. 1)

- Chapter 8 contains caveats that permit the rigorous use of the Reference Spectrum and/or GERS to define the seismic capacity of the equipment classes. The twenty classes of equipment and the procedures in Chapter 8 are from Revision 2 of the SQUG GIP. The procedures in Chapter 8 were independently reviewed by the Senior Seismic Review and Advisory Panel (SSRAP) as part of the SQUG program and were approved by the NRC with a safety evaluation report (Ref. 2).

- Chapter 9 contains equipment class evaluations based on rigorous screening procedures from Revision 2 of the SQUG GIP. The procedures in Chapter 9 were independently reviewed by SSRAP as part of the SQUG program and were approved by the NRC with a safety evaluation report (Ref. 2).

- Chapter 10 contains screening procedures and general guidelines for equipment classes that are not provided in the SQUG GIP and are found at DOE facilities. Sections 10.1.1, 10.4.1, and 10.5.1 contain relatively rigorous screening procedures. Sections 10.2, 10.3.2, 10.5.2, and 10.5.3, on the other hand, contain guidelines that are not rigorous, but are intended to provide cost-effective and achievable techniques for increasing the seismic capacity of equipment classes in those sections. Finally, Sections 10.3.1 and 10.1.2 are summarized versions of several chapters of a DOE document. The technical review of the Sections in Chapter 10 is discussed in Section 1.4.2.

In addition to the classes of equipment in the SQUG GIP, twenty additional classes of equipment were identified as potentially requiring seismic evaluation at DOE sites. These additional classes of equipment were identified based on the responses from questionnaires sent to DOE sites and Chapter 10 contains about half of the identified classes of equipment. As the screening procedures and guidelines for additional classes of equipment are developed and reviewed, they can be added to Chapter 10 of the DOE Seismic Evaluation Procedure. In addition, the rigor of some of the sections in Chapter 10 can be enhanced with further development and review. Other classes of equipment that exist at DOE facilities that could be added to the DOE Seismic Evaluation Procedure include:

electrical equipment - distributed control systems, computer equipment, alarm and security equipment, communication equipment, and miscellaneous electrical equipment

mechanical equipment - ventilation dampers

tanks - elevated tanks, boilers, and miscellaneous tanks

piping and raceway systems - stacks, tubing, bus ducts, and conveyors of material

architectural features - suspended ceilings, cranes, and elevators

switchyard and substation equipment - power transformers, circuit breakers, disconnect switches, current and voltage transformers, surge and lightning arresters, wave traps, capacitor banks, buswork, and miscellaneous switchyard equipment

Table 2.1-1 Equipment Class Evaluations in the DOE Seismic Evaluation Procedure

Section	Equipment Class	Type of Evaluation
	ELECTRICAL EQUIPMENT	
8.1.1	Batteries on Racks	Caveats
8.1.2	Motor Control Centers	Caveats
8.1.3	Low-Voltage Switchgear	Caveats
8.1.4	Medium-Voltage Switchgear	Caveats
8.1.5	Distribution Panels	Caveats
8.1.6	Transformers	Caveats
8.1.7	Battery Chargers and Inverters	Caveats
8.1.8	Instrumentation and Control Panels	Caveats
8.1.9	Instruments on Racks	Caveats
8.1.10	Temperature Sensors	Caveats
	MECHANICAL EQUIPMENT	
8.2.1	Fluid-Operated / Air-Operated Valves	Caveats
8.2.2	Motor-Operated / Solenoid-Operated Valves	Caveats
8.2.3	Horizontal Pumps	Caveats
8.2.4	Vertical Pumps	Caveats
8.2.5	Chillers	Caveats
8.2.6	Air Compressors	Caveats
8.2.7	Motor-Generators	Caveats
8.2.8	Engine-Generators	Caveats
8.2.9	Air Handlers	Caveats
8.2.10	Fans	Caveats
10.2.1	HEPA Filters	General Guidelines
10.2.2	Glove Boxes	General Guidelines
10.2.3	Miscellaneous Machinery	General Guidelines
	TANKS	
9.1.1	Vertical Tanks	Screening Procedure
9.1.2	Horizontal Tanks and Heat Exchangers	Screening Procedure
10.3.1	Underground Tanks	General Guidelines
10.3.2	Canisters and Gas Cylinders	General Guidelines
	PIPING, RACEWAY, AND DUCT SYSTEMS	
9.2.1	Cable and Conduit Raceway Systems	Screening Procedure
10.1.1	Piping	Screening Procedure
10.1.2	Underground Piping	General Guidelines
10.4.1	HVAC Ducts	Screening Procedure
	ARCHITECTURAL FEATURES AND COMPONENTS	
10.5.1	Unreinforced Masonry (URM) Walls	Screening Procedure
10.5.2	Raised Floors	General Guidelines
10.5.3	Storage Racks	General Guidelines

2.1.3.4.1 Rule of the Box[8]

An important aspect of evaluating the seismic adequacy of equipment included within the scope of this procedure is explained by the "rule of the box". "Rule of the box" applies to "normal" components of equipment, or parts of the equipment that are included in the earthquake experience database or shake table tests database. The intent of the "rule of the box" for equipment included in either the earthquake or testing equipment database is that all of the components mounted on or in this equipment are considered to be part of that equipment and do not have to be evaluated separately. Auxiliary components that are not mounted on the item of equipment but are needed by the equipment to fulfill its intended function need to be evaluated separately. Peer review, as discussed in Section 2.2, is needed to evaluate if the earthquake experience database or shake table tests database provides the basis for a particular application of the "rule of the box".

A typical example of the "rule of the box" is a diesel generator which not only includes the engine block and generator, but also all other items of equipment mounted on the diesel generator or on its skid; such as the lubrication system, fuel supply system, cooling system, heaters, starting systems, and local instrumentation and control systems. Components needed by the diesel generator but not included in the "box" (i.e., not mounted on the diesel generator or on its skid) are to be identified and evaluated separately. Typically this would include such items as off-mounted control panels, air-start compressors and tanks, batteries, pumps for circulating coolant and lubricant, day tanks, and switchgear cabinets.

An obvious advantage to the "rule of the box" is that only the major items of equipment need be evaluated for seismic adequacy (and only documented once), i.e., if a major item of equipment is shown to be seismically adequate using the guidelines in this procedure, then all of the parts and components mounted on or in that item of equipment are also considered seismically adequate. Typically, the "rule of the box" applies for components attached to the equipment before the first anchor point of the equipment. However, the SCEs should exercise their judgment and experience to seek out suspicious details or uncommon situations (those which are "out of the ordinary", are not specifically covered in the equipment class evaluations, or are site add-ons) that may make that item of equipment vulnerable to earthquake effects. This evaluation should include any areas of concern within the "box" which could be seismically vulnerable, such as added attachments, missing anchorage, or obviously inadequate anchorage of components.

One exception to the "rule of the box" is relays (and other types of device using contacts in the control circuitry). Even though relays are mounted on or in another larger item, they should be identified and evaluated for seismic adequacy using the procedure described in Chapter 11 since they may be susceptible to chatter during seismic excitation. The relays to be evaluated are identified by first identifying the major item of equipment for the SEL which could be affected if the relays malfunctioned. Then, in Chapter 11, the particular relays used to control these major items of equipment are determined and evaluated for seismic adequacy.

2.1.3.4.2 Equipment Class Evaluations Using Caveats for the Reference Spectrum and/or GERS (Chapter 8)[9]

Chapter 8 contains a summary of equipment class descriptions based on earthquake experience data and generic seismic testing data. These descriptions and the rest of Chapter 8 is from Appendix B of Revision 2 of the SQUG GIP. An item of equipment must have the same general characteristics as the equipment in the earthquake experience equipment class or the generic seismic testing equipment class to apply the methodology in Chapter 8. The intent of this rule is to preclude items

---

[8] Based on Section 3.3.3 of SQUG GIP (Ref. 1)
[9] Based on Section 4.3 of SQUG GIP (Ref. 1)

of equipment with unusual designs and characteristics that have not demonstrated seismic adequacy in earthquakes or tests.

"Caveats" are defined as the set of inclusion and exclusion rules that represent specific characteristics and features particularly important for seismic adequacy of a particular class of equipment. Chapter 8 contains a summary of the caveats for the earthquake experience equipment class and for the generic seismic testing equipment class. If the caveats are satisfied, then the capacity of the equipment class can be represented by the Reference Spectrum and/or the GERS. For these equipment classes, extensive use of earthquake experience and test data permits the rigorous definition of the equipment capacity and evaluation of the seismic adequacy of the equipment. The equipment capacity determined in Chapter 8 is compared to the seismic demand using the provisions of Chapter 5.

The "intent" of the caveats should be met when evaluating an item of equipment as they are not fixed, inflexible rules. Engineering judgment may be used to determine whether the specific seismic concern addressed by the caveat is met. Chapter 8 provides brief discussions of the intent of the caveats. When specific cases are identified where the intent of the caveats are considered to be met, but the specific wording of the caveat rule is not, the reason for this conclusion should be documented.

Note that the caveats in Chapter 8 are not necessarily a complete list of every seismically vulnerable detail that may exist since it is impossible to cover all such situations by meaningful caveats. Instead, the SCEs should exercise their judgment and experience to seek out suspicious details or uncommon situations (not specifically covered by the caveats) which may make equipment vulnerable to earthquake effects. For example, the SCEs should note any areas of concern within the "box" which could be seismically vulnerable such as added attachments, missing or obviously inadequate anchorage of components, heavy objects mounted on the equipment, and components that are known to be seismically sensitive.

The summaries of the equipment class descriptions and caveats in Chapter 8 are based on information contained in References 19, 35, and 40. Additional information on seismic experience data is contained in Chapter 9d of Reference 32. The SCEs should use the summaries in Chapter 8 only after first thoroughly reviewing and understanding the background of the equipment classes and bases for the caveats as described in these references. These references provide more details (such as photographs of the data base equipment) and more discussion than summarized in Chapter 8. Note that in some cases, clarifying remarks have been included in Chapter 8 that are not contained in the reference documents. These clarifying remarks include such things as the reason for including a particular caveat, the intent of the caveat, and recommended allowable limits for stress analysis. The remarks are also based on experience gained during SQUG GIP reviews at operating nuclear power plants and DOE seismic evaluations at DOE facilities and they serve to help guide the SCEs in their judgment.

Certain important caveats from the reference documents are not included in Chapter 8 because they are covered in other sections of the DOE Seismic Evaluation Procedure. These caveats include:

- Equipment should be adequately anchored and base isolation should be carefully evaluated (see Chapter 6).
- Seismic interaction concerns, such as flexibility of attached lines, should not adversely affect the equipment (see Chapter 7).
- Relays for which chatter is not acceptable should be specifically evaluated. Note that although the primary responsibility for conducting the relay evaluation is the Lead Relay Reviewer, the SCEs should be alert for any seismically induced systems effects that may lead to loss of function or malfunction of the equipment being evaluated (see Chapter 11).

In addition, caveats discussing a limiting fundamental frequency of 8 Hz are not included in Chapter 8 because this limiting frequency does not apply with the provisions of Chapter 5.

Chapter 8 is organized by equipment class as listed in Table 2.1-2. For each equipment class, the class description and the caveats applicable to the Reference Spectrum are given first. A plot of the Reference Spectrum is provided in Chapter 5. Next, the class description and the caveats applicable to the GERS are given, when available. Some equipment classes have more than one GERS while other classes have none. A plot of the GERS follows the caveats for each applicable equipment class. While the GERS typically define a higher capacity, the GERS caveats are more restrictive than the reference spectrum caveats.

Table 2.1-2 Equipment Class Evaluations Using Caveats for the Reference Spectrum and/or GERS (SQUG GIP, Reference 1)

Section	Equipment Class	Reference Spectrum	GERS
8.1.1	Batteries on Racks	X	X
8.1.2	Motor Control Centers	X	X
8.1.3	Low-Voltage Switchgear	X	X
8.1.4	Medium-Voltage Switchgear	X	X
8.1.5	Distribution Panels	X	X
8.1.6	Transformers	X	X
8.1.7	Battery Chargers and Inverters	X	X
8.1.8	Instrumentation and Control Panels	X	
8.1.9	Instruments on Racks	X	X
8.1.10	Temperature Sensors	X	
8.2.1	Fluid-Operated / Air-Operated Valves	X	X
8.2.2	Motor-Operated / Solenoid-Operated Valves	X	X
8.2.3	Horizontal Pumps	X	
8.2.4	Vertical Pumps	X	
8.2.5	Chillers	X	
8.2.6	Air Compressors	X	
8.2.7	Motor-Generators	X	
8.2.8	Engine-Generators	X	
8.2.9	Air Handlers	X	
8.2.10	Fans	X	

2.1.3.4.3 Equipment Class Evaluations Using Screening Procedures (Chapter 9)

Chapter 9 contains a summary of equipment class descriptions and parameters based on earthquake experience data, test data, and analytical derivations. The screening procedures in Chapter 9 are from Chapters 7 and 8 of Revision 2 of the SQUG GIP. An item of equipment must have the same general characteristics as the equipment in the evaluation procedures. The intent of this rule is to preclude items of equipment with unusual designs and characteristics that have not demonstrated seismic adequacy in earthquakes or tests.

The screening procedures for evaluating the seismic adequacy of the different equipment classes in Chapter 9 cover those features which experience has shown can be vulnerable to seismic loadings. These procedures are a step-by-step process through which the important equipment parameters and dimensions are determined, seismic performance concerns are evaluated, the equipment capacity is determined, and the equipment capacity is compared to the seismic demand.

The screening procedures in Chapter 9 are based on information contained in References 42, 46, 47, and 50. The SCEs should use the information in Chapter 9 only after first thoroughly reviewing and understanding the background of the equipment classes and bases for the screening procedures as described in these references. These references provide more details and more discussion than summarized in Chapter 9. In some cases, clarifying remarks not contained in the reference documents have been included in Chapter 9. These clarifying remarks are based on experience gained during SQUG GIP reviews at operating nuclear power plants and DOE seismic evaluations at DOE facilities and they serve to help guide the SCEs apply their judgment.

The screening procedures in Chapter 9 are from Revision 2 of the SQUG GIP and Table 2.1-3 lists the equipment classes in Chapter 9.

Table 2.1-3 Equipment Class Evaluations Using Screening Procedures (SQUG GIP, Reference 1)

Section	Equipment Class	Source of Screening Procedure in SQUG GIP
9.1.1	Vertical Tanks	Section 7
9.1.2	Horizontal Tanks and Heat Exchangers	Section 7
9.2.1	Cable and Conduit Raceway Systems	Section 8

2.1.3.4.4 Equipment Class Evaluations Using Screening Procedures or General Guidelines (Chapter 10)

Chapter 10 contains a summary of equipment class descriptions and parameters based on earthquake experience data, test data, and analytical derivations. The classes of equipment contained in Chapter 10 are not from the SQUG GIP. Much of the information in Chapter 10 is from DOE references. Table 2.1-4 lists the principal references and authors for the sections in Chapter 10. An item of equipment must have the same general characteristics as the equipment in the screening procedures and general guidelines. The intent of this rule is to preclude items of equipment with unusual designs and characteristics that have not demonstrated seismic adequacy in earthquakes or tests.

The screening procedures in Sections 10.1.1, 10.4.1, and 10.5.1, for evaluating the seismic adequacy of piping, HVAC ducts, and unreinforced masonry (URM) walls respectively, cover those features which experience has shown can be vulnerable to seismic loading. These procedures are a step-by-step process through which the important equipment parameters and dimensions are determined, seismic performance concerns are evaluated, the equipment capacity is determined, and the equipment capacity is compared to the seismic demand. Sections 10.1.1 and 10.4.1 have been technically reviewed and used extensively at several DOE sites including Savannah River Site and Rocky Flats Environmental Technology Center.

The general guidelines for evaluating the seismic adequacy of the equipment classes in the other sections of Chapter 10 cover those features which experience has shown can be vulnerable to seismic loading. The sections contain practical guidelines and reference to documents that can be used to implement an equipment strengthening and upgrading program. The relatively simple seismic upgrades are designed to provide cost-effective methods of enhancing the seismic safety of the equipment classes in Chapter 10. Sections 10.3.1 and 10.1.2 summarize information from portions of a DOE document that has undergone extensive technical review. Sections 10.2.1,

10.2.2, 10.2.3, 10.3.2, 10.5.2, and 10.5.3, on the other hand, are based on walkdown and seismic strengthening efforts at several DOE sites including Los Alamos National Laboratory and Lawrence Livermore National Laboratory.

Table 2.1-4 Equipment Class Evaluations Using Screening Procedures or General Guidelines

Section	Equipment Class	Principal Reference	Principal Author
10.1.1	Piping	59	G. Antaki, SRS
10.1.2	Underground Piping	29	S. Short, EQE
10.2.1	HEPA Filters		L. Goen, LANL
10.2.2	Glove Boxes		L. Goen, LANL
10.2.3	Miscellaneous Machinery	60	S. Sommer, LLNL
10.3.1	Underground Tanks	29	S. Short, EQE
10.3.2	Canisters and Gas Cylinders	60	R. Murray, LLNL
10.4.1	HVAC Ducts	28	G. Driesen, SRS
10.5.1	Unreinforced Masonry (URM) Walls		R. Murray, LLNL
10.5.2	Raised Floors	60	S. Sommer, LLNL
10.5.3	Storage Racks	60	S. Sommer, LLNL

2.1.4 Outlier Identification and Resolution[10]

Items listed in the SEL that do not pass the screening criteria contained in the Seismic Evaluation Procedure are considered outliers (i.e., they lay outside the cope of coverage for the screening criteria) and should be evaluated further as described in Chapter 12. An outlier may be shown to be adequate for seismic loads by performing evaluations such as the seismic qualification techniques currently being used in some DOE facilities. These additional evaluations and alternate methods should be thoroughly documented to permit independent review.

Methods of outlier resolution are typically more time consuming and expensive than the screening evaluations provided in the Seismic Evaluation Procedure. Also, outlier resolution may be somewhat open-ended because several different options or approaches are available to evaluate seismic adequacy. The most appropriate method of outlier resolution will depend upon a number of factors such as: (1) which of the screening criteria could not be met and by how much, (2) whether the discrepancy lends itself to an analytical evaluation, (3) how extensive the problem is in the facility and in other facilities, or (4) how difficult and expensive it would be to modify, test, or replace the subject items of equipment.

[10] Based on Section 1.3.4 of SQUG GIP (Ref. 1)

2.1.5 Documentation

The suggested types of document which should be used with the DOE Seismic Evaluation Procedure are described in Chapter 13. The five major types of documents are:

- Seismic Equipment List (SEL)
- Screening Evaluation Work Sheets (SEWS)
- Outlier Seismic Evaluation Sheets (OSES)
- Screening Evaluation and Data Sheets (SEDS)
- Equipment Seismic Evaluation Report (ESER)

These documents serve as tools to summarize the results of the Screening Evaluation and Walkdown and to highlight areas in need of further evaluation or upgrading. Other, informal documentation may be used by the SCEs as an aid and these may include calculations, sketches, photographs, audio tapes, and videotapes. The completed OSES, SEWS, SEDS, and ESER constitute the documentation of the Screening Evaluation and Walkdown and reflect the final judgment of the SCEs.

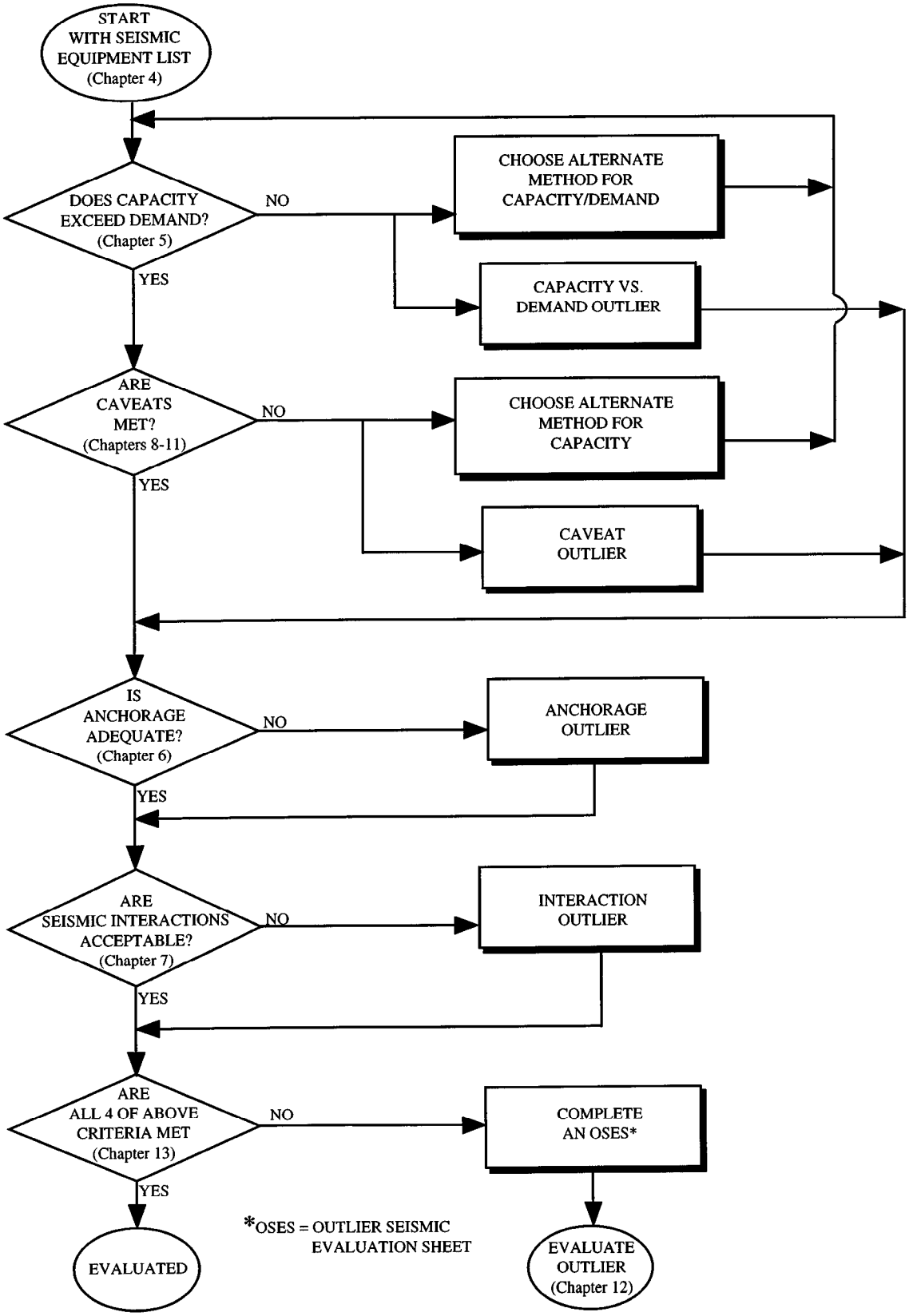

Figure 2.1-1 Overall Procedure for Performing Screening Evaluation and Walkdown (Figure 4-1 of SQUG GIP, Reference 1)

2.2 PEER REVIEW

Peer review is a vitally important component of seismic evaluations of equipment and distribution systems at DOE facilities. The evaluation procedures described in the DOE Seismic Evaluation Procedure involve an extensive use of engineering judgment. This type of judgment must be independently reviewed to ensure that significant details are not overlooked or improperly evaluated. In addition, DOE Orders and Standards discuss that peer review is a necessary element of design and evaluation for natural phenomena hazards. Peer review can be provided by certified SCEs who are independent of the SRT whose evaluation is being reviewed.

Members of a peer review team should be selected and incorporated early in the evaluation process. With review occurring in parallel with evaluations, the peer review team can efficiently study the important facets of the evaluation and provide useful feedback. The peer review team should consist of engineers that have extensive experience with seismic design and evaluation as well as be knowledgeable of the methodology and procedures in the DOE Seismic Evaluation Procedure. Typically, the members of the peer review should be more qualified than the SCEs conducting the equipment evaluations and the members should have conducted many evaluations similar to the ones being reviewed. The size of the peer review team should reflect the scope of the equipment evaluations being reviewed.

The equipment evaluations and the peer review should consider the DOE requirements for quality assurance. These requirements are specified in 10CFR830.120, the DOE Nuclear Safety Management Rule, (Ref. 61) and DOE Order 5700.6C, "Quality Assurance", (Ref. 62). The Rule requires the development of quality assurance programs for DOE nuclear facilities. Information for implementing quality procedures is provided in the Rule and Order. Sections 1.4 and C.8 of DOE-STD-1020 (Ref. 6) provides additional guidance on quality assurance and peer review.

2.3 PREPARATION FOR THE EVALUATION

2.3.1 Systems Engineering and Facility Operations[11]

Experience from facility reviews has demonstrated that preparatory work performed prior to conducting the facility screening evaluations will maximize the effectiveness of the walkdown procedure outlined in Section 2.1. Prior to the walkdown, members of the SRT including the SCEs, systems engineer(s), and facility operations representative(s) should review the facility design documents to familiarize themselves with facility design features and, in particular, those associated with equipment identified in the Seismic Equipment List (SEL). Much of the required initial information is contained in a Safety Analysis Report (SAR) or related report. In addition, piping and instrumentation diagrams (P&IDs), electrical one-line drawings, instrument block diagrams, operating procedures, system descriptions, facility arrangement drawings, and selected topical reports and specifications should be used during the equipment identification and walkdown efforts.

Discussions with facility operations personnel are beneficial in identifying equipment within various safety systems. Systems engineers may wish to consider including equipment that does not have seismic qualification documentation, thereby upgrading its seismic qualification status. Most of the industrial-grade equipment in the earthquake experience data base has been shown to be seismically rugged even though it has not been qualified for seismic loads.

Facility arrangement drawings should be marked with the location of each item of equipment selected for review and provided to the SCEs who will be doing the seismic evaluation. In

[11] Based on Sections E.1 and E.2 of SQUG GIP (Ref. 1)

addition, the SEL, which is described in Chapter 4, should be completed in order to identify the equipment to be seismically evaluated.

2.3.2 Pre-Walkdown Planning[12]

The purpose of pre-walkdown planning is to organize the facility walkdown. Judicious planning will minimize the time spent in the field by the SRT.

The planning process should be performed with active participation from the principal walkdown participants and the facility personnel with experience in the configuration and operation of the facility under review. The following organizations or individuals will typically be involved in the walkdown and should be part of the planning effort:

- Facility Manager
- Safety Professionals and Systems Engineer(s)
- Facility Operations and/or Radiation Protection Personnel
- Seismic Capability Engineers
- Relay Evaluation Personnel
- Piping Evaluation Engineers

Advance planning on when to perform the walkdown is advisable. Walkdowns should not interfere with the normal operation of the facility. Security, radiation level, operations, and maintenance considerations are necessary in deciding when each area of the facility can be visited. Some areas of the facility are inaccessible during normal operation and can only be inspected during outage periods. The Screening Evaluation and Data Sheets (SEDS), discussed in Chapter 13, can be organized by facility location and thereby used as a checklist and itinerary for the walkdown. The itinerary, however, should be flexible to allow the walkdown teams time to revisit certain areas or alter their plans because of difficulties in determining seismic adequacy of particular types of equipment. It is also advisable to provide the walkdown teams with the itineraries in advance so that they can review the items of equipment assigned prior to the walkdown.

Advance planning and preparation are needed to gain access to operating facilities, particularly if contractors are used to conduct the walkdown. The SRT may be required to obtain security clearances, access badges, and radiation training. The walkdown participants may need to be accompanied by facility security and radiation protection personnel; however, such accompaniment is costly, ties up personnel, and tends to interfere with normal facility operations and maintenance. It also increases the number of individuals involved with the walkdown which tends to slow down the pace of the effort. Advance notification and scheduling can streamline the process of gaining facility access. All people concerned with the facility walkdown, including walkdown team members, facility operations personnel, health physics personnel, security personnel and facility staff, should be advised of the dates and duration of the facility walkdown well in advance of the scheduled walkdowns (e.g., two months ahead of time).

The SRT or individual team members may want to have discussions with other facility operations personnel prior to and during the walkdown to clarify the way a system or an item of equipment operates. If possible, these meetings should be planned well in advance so that people

---

[12] Based on Section E.3 of SQUG GIP (Ref. 1)

knowledgeable in the specific areas of concern will be available with a minimum of disruption in the normal operation of the facility.

A summary of all the available seismic design and qualification data should be prepared and provided to the SRT several weeks before their scheduled walkdown. The summary does not have to be formal, but it should be comprehensive. The SCEs performing the walkdown should become thoroughly familiar with the facility seismic design basis. The greater the understanding of the facility seismic design basis and the approaches taken for equipment qualification and anchorage, the easier it will be to exercise judgment and experience to eliminate outliers.

Construction details of the anchorage for the equipment in the SEL are essential for evaluating the seismic adequacy of the equipment. Inspection and evaluation of anchorage are difficult if not impossible without the use of construction drawings, specifications, and bills of materials.

The documents which should be available to the SRT include:

1. The Seismic Equipment List (SEL), prepared using Chapter 4.

2. List of equipment for which prior seismic qualification documentation exists.

3. Summary of the facility seismic design basis, specifically: ground response spectra for the design basis earthquake (DBE) seismic design criteria, amplified in-structure response spectra (IRS), and seismic demand spectra (SDS).

4. Standard details for equipment anchorage.

5. Facility arrangement drawings.

6. Health physics and facility security requirements.

In addition, certain facility design information should be collected to help maximize the benefit of the evaluation. The following provides a checklist of example data that, if appropriate, should be collected prior to the Screening Evaluation and Walkdown procedure:

- Map of site with outline of structures and structure identifiers
- Performance goals for the facility equipment which is listed on the SEL
- Structural drawings for buildings, including current as-built key plans where possible
- Date of construction of facility (including dates of modifications as appropriate)
- Available soils data
- General description of processes housed in the building
- Safety Analysis Reports (SARs)
- Emergency response procedures related to seismic
- Facility procedural requirements including security access

2.3.3 Screening Walkdown Plan[13]

This section describes an approach that can be used to perform the screening evaluation of the equipment listed in the SEL during the facility walkdown. This approach is based on the experience gained in performing facility reviews. This section covers the organization and approach which can be used by the SRT, the degree of inspection to be performed, walkdown logistics, and screening walkdown completion.

2.3.3.1 Organization and Approach of SRT[14]

The number of individuals in each SRT should be limited to permit ready access to inspect equipment and facilitate movement. In addition to the two SCEs, a systems or operations engineer may also be involved in the walkdown as needed by the SRT to provide information on how a system or an item of equipment operates. Health physics and security personnel may also accompany the SRT as the need arises.

Each group of individuals walking down the facility should collectively have:

1. An understanding of the facility layout and location of the various system and equipment scheduled to be evaluated during that walkdown period;

2. An understanding of the scope and objectives of the walkdown including the methodology and procedures;

3. An understanding of the seismic evaluation guidelines including inspection techniques and evaluation criteria;

4. An understanding of the operational aspects of the facility and the importance of the various facility systems and equipment.

SRT decisions concerning equipment seismic adequacy should be made on the spot, if possible, and the walkdown should proceed at a pace consistent with this objective. Decisions to evaluate the seismic adequacy of equipment should be unanimous among the SCEs. Concerns which do not permit seismic evaluation during the screening walkdown should be documented and left for further review to either eliminate the equipment as a required part of the SEL or identify it as an outlier for further evaluation (as described in Chapter 12). During the walkdown, many items of equipment may have evaluation results that are unknown. The SRT should decide what information or additional action is required to resolve the issue and inform the appropriate support staff personnel so that, if possible, the issue may be resolved during the later part of the walkdown.

If several SRTs are used to conduct the screening evaluation and walkdown, then a means for coordinating the activities should be invoked to ensure that all the equipment and activities of the evaluation are covered. This coordinating function could be performed by a single individual or by a committee of individuals from the various SRTs.

2.3.3.2 Degree of Inspection[15]

All of the equipment on the SEL should be reviewed. Exceptions to this may occur (e.g., equipment in very high radiation areas or otherwise inaccessible locations), and each exception

---

[13] Based on Section F.1 of SQUG GIP (Ref. 1)
[14] Based on Section F.2 of SQUG GIP (Ref. 1)
[15] Based on Section F.3 of SQUG GIP (Ref. 1)

should be justified by the SRT. The level or scope of evaluation may vary depending upon the experience and judgment of the SRT.

2.3.3.3 Walkdown Logistics and Cautions[16]

A three-to-four hour kick-off meeting can be scheduled for the beginning of the facility walkdown. This meeting can provide a briefing on the objectives of the walkdown, the organization of the walkdown groups, the planning for the walkdown, and the breakdown of the total list of equipment for which each group was responsible. After this kick-off meeting, the SRTs can commence with the facility walkdown.

Radiation training, including whole body counts and issuance of personnel dosimetry, and facility access requirements, such as obtaining security badges, for the SRT members are done prior to this kick-off meeting. Access to contaminated and radiological areas may require DOE or site-specific Radiological Worker II Training. DOE-sponsored radiological training may reduce delays associated with facility-specific training.

A daily morning meeting should be held in which the SRT reviews the equipment included in that day's walkdown. Anchorage drawings are also reviewed by the SRT. The walkdown can be conducted in morning and afternoon sessions. A meeting can also be held during the lunch break to discuss problem areas and the approaches used by other SRTs. At the option of the facility and the SRTs, it may be desirable to conduct the walkdown outside of normal working hours. In any case, it is not recommended that the walkdown "day" exceed 10 hours.

A short meeting can also be held at the end of each day to discuss the day's walkdown, request information as required from the appropriate support staff personnel, certify the completed documentation, review information retrieved by the support staff so that previously started evaluations could be completed, and organize the next day's activities. Any unknowns are reconciled as soon as possible after the item of equipment had been inspected.

When performing the walkdown, the SRT should have the appropriate tools to collect and record data. These tools included a clip board (e.g., for SEDS and SEWS), a tape measure capable of measuring to 1/16 inch, pencils or pens, and a flashlight. The SRT may wish to use some form of carrying pack to allow hands to be free for climbing ladders, going through crawl spaces.

Other tools may be included depending on the preference of the SRT. For example, a compact camera (subject to facility policy) can be useful to record visual findings, such as each picture frame should have a designation and be fully described. A small audio cassette recorder can be used to record the subject of each picture frame and general notes about the walkdown. More elaborate visual records can be obtained by using a video recorder. However, video equipment is usually cumbersome and expensive, and has not been used extensively in past facility walkdowns. It should also be understood that the use of personal equipment is typically at the individual's own risk. If equipment is contaminated or broken, there is often no compensation by the facility.

The SRT should be aware that there is usually a need for hard hats, safety glasses, hearing protection, and sometimes safety shoes. SRT members should consider wearing light cotton clothing since temperatures inside operating DOE facilities can be relatively high. These conditions can lead to extreme personnel discomfort, especially when protective clothing is required for walkdowns in contaminated and high radiation areas.

---

[16] Based on Section F.4 of SQUG GIP (Ref. 1)

During the walkdown, the SRT should use caution when evaluating equipment due to the many potential dangers. Manufacturer's data should be consulted if there are any questions and/or concerns about the operation of the equipment being evaluated.

- Temporarily inactive mechanical and electrical equipment may activate while being evaluated so all manufacturer's warnings should be carefully followed.

- A common rule for evaluating equipment, especially electrical equipment, is to not break the vertical plane. Since electrical equipment may be energized, only trained personnel should provide access to this type of equipment. It is not appropriate, potentially very dangerous, and usually prohibited by facility policy to open panels on electrical equipment without approval from the appropriate facility personnel.

- Since mechanical and electrical equipment may contain vibration sensitive components, it is inappropriate to test the dynamic characteristics of the equipment by shaking it. If facility personnel indicate that the equipment does not contain vibration sensitive equipment, such as essential relays, then any field testing of the dynamic characteristics should be done within manufacturer recommendations.

- In addition, all placards with hazards control information should be reviewed, understood, and obeyed. The typical information on a hazardous material card (see Figure 2.3-1) includes level of fire hazard, level of health hazard, level of oxidation or reactivity hazard, and special information. If the information or indications on a warning label are not understood, then the appropriate facility personnel, such as hazardous material technicians or fire protection personnel, should be contacted before proceeding.

The basic rules while conducting the walkdown are to use common sense, to avoid dangerous or unpredictable situations, and to obey facility policy and safety procedures.

2.3.3.4 Screening Walkdown Completion[17]

At the completion of the Screening Evaluation and Walkdown, all equipment identified in the SEL and included in the walkdown should be classified as being either evaluated or an outlier. The SEDS should be completed, checked for accuracy, and certified for each item of equipment. The outlier sheets (OSES) should be completed for each item of equipment identified as an outlier. Work sheets (SEWS), if used, should also be checked so that the information noted (judgments, description, and calculations) can be reasonably followed by a reviewer. At the completion of the Screening Evaluation and Walkdown, the SRT should inform the facility management about the walkdown results in detail.

[17] Based on Section F.5 of SQUG GIP (Ref. 1)

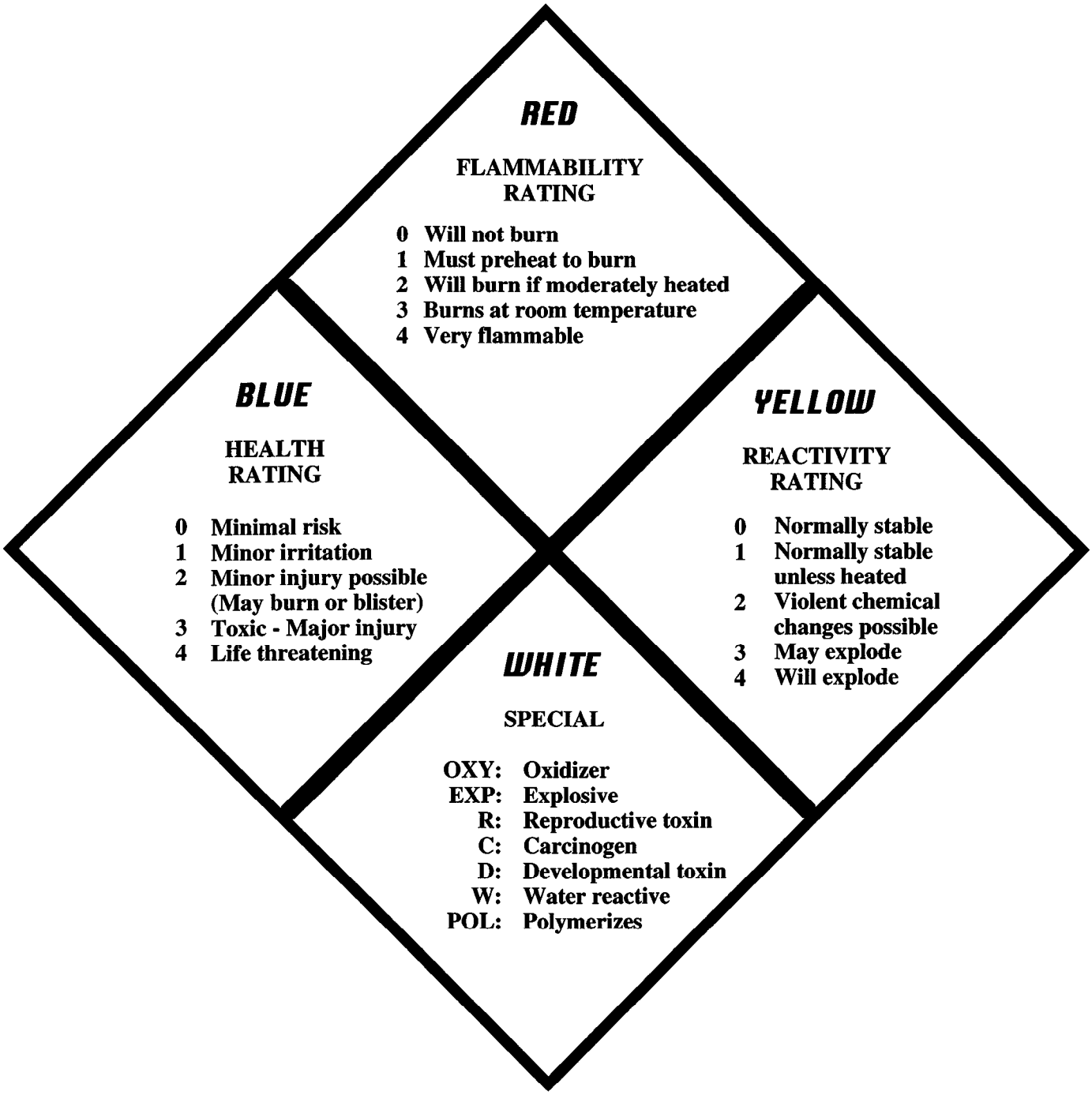

Figure 2.3-1 Hazardous Material Card